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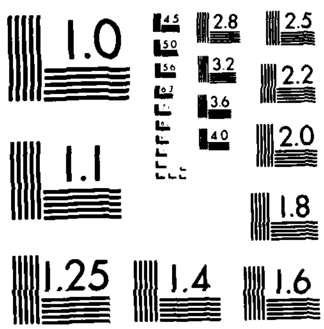


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# IGITAL TROPOSCATTER PERFORMANCE MODEL: SOFTWARE DOCUMENTATION

Contract No. DCA100-80-C-0030
SIGNATRON Reference A288-16

November 1983





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Prepared By:

SIGNATRON, Inc.
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| | |
|---|---|
| Troposcatter | Propagation Prediction |
| Diffraction | Multipath Prediction |
| MD-918 Modem | Error Rate Prediction |
| AN/TRC-170 | Link Analysis |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The software program for the analysis and evaluation of digital troposcatter communication links is described. The computer program TROPO is intended to provide an accurate prediction model of the troposcatter and/or diffraction propagation path at frequencies between 100 MHz and 10 GHz for all types of diversity receiver configurations used in the DCS, and the prediction of the performance of the MD-918 and AN/TRC-170 troposcatter modems. The program can also evaluate the performance of other modems if a performance (over)

19. Abstract (Concluded)

prediction model is provided by the user. TROPO takes into account a number of practical factors such as the effects of RF interference, RF bandwidth constraints, actual diversity antenna geometry, climate and atmospheric characteristics. This document describes the various routines and sub-programs that are used to perform the troposcatter and diffraction path loss, multipath and digital troposcatter link performance calculations.

ORIGINATOR - SUPPLIED KEY WORDS INCLUDE:

## FOREWORD

This document is the Software Documentation report for contract DCA100-80-C-0030 prepared by SIGNATRON, Inc. for the Defense Communications Agency. It contains a description of the subprograms used in TROPO to model the performance of digital troposcatter systems. The theory and analytical models used in the calculations are given in the User's Manual and Final Report. The subprogram descriptions have been grouped according to the major functions performed.

## Table of Contents

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# CHAPTER 1

# INTRODUCTION

This document is the Software Documentation for the Digital Troposcatter Performance Model Computer Program TROPO. The program performs propogation predictions and modem performance predictions based on the models described in the Final Report.

## 1.1 Report organization

The report is organized into ten chapters documenting each of the TROPO subprograms grouped according to the types of calculations they perform and four appendices containing cross-reference information about TROPO and its output.

Chapter 2, Driver, describes the driver for the TROPO program and includes a top level flowchart of TROPO.

Chapter 3, Input, describes the routines that input data and do preliminary calculations and output of the input variables.

Chapter 4, Error Utilities, describes the preliminary data checking and error handling routines.

Chapter 5, Troposcatter Calculations, describes the routines performing troposcatter calculations.

Chapter 6, Diffraction Calculations, describes the routines performing diffraction calculations.

Chapter 7, Climate Variability Calculations, describes the routines performing climate calculations.

Chapter 8, Butterworth Filter Calculations, describes the routines performing filter calculations.

Chapter 9, MD-918 Modem Calculations, describes the routines performing calculations for the MD-918 modem.

Chapter 10, AN/TRC-170 and DAR Modem calculations, describes the routines performing calculations for the AN/TRC-170 and DAR modem calculations.

Chapter 11, Final output, describes the routine that outputs SUMPAG.OUT and the routine that outputs the simulator tap values.

Appendix A, PDP Related Information, is for users running the PDP version of TROPO. It cross-references information about the various files in three subsections:

1) Subprogram / Module Reference Index: This lists each subprogram name alphabetically followed by the file it is in.
2) Module / Subprogram Reference Index: This lists each file name alphabetically followed by the subprograms it contains.
3) Common / Include File Reference Index: This lists each common name alphabetically followed by the include file it is in.

Appendix B, Call Cross-Reference, lists which TROPO routines and Fortran functions each subprogram calls as well as which has called the subprogram.

Appendix C, Global Variable Dictionary, defines each global variable, identifies its type and the common it is contained in. In addition, below each variable is a list of which subprograms have used it and which have given it a new value.

Appendix D, Output Variables, defines each variable output to the output files FOR002.DAT and SUMPAG.OUT.

The index alphabetically lists each subprogram and the page it is described on.

## 1.2 Documentation Structure

The documentation in chapters 2 through 11 has been divided into ten major functions:

1) Driver
2) Data input
3) Data checking
4) Troposcatter calculations
5) Diffraction calculations
6) Climate variability calculations
7) Butterworth filter calculations
8) MD-918 modem calculations
9) AN/TRC-170 and DAR modem calculations
10) Final output

Each subprogram falls into at least one of these sections. In some cases, a routine is used by more than one section. So, if a routine is not in the section you expect, the index can quickly direct you to the right page.

Each subprogram description follows the same form:

| | | |
|---|---|---|
| | 1) Subprogram name: | Subroutine or Function followed by the name of the routine. This does not include calling arguments |
| | 2) Purpose: | Describes the function the routine performs. |
| * | 3) Description: | This is a more extensive description of the routine's function. Also describes coding conventions that you should be aware of, overall coding structure, etc. |
| * | 4) Reference: | Lists outside reference works usually giving a background for and a more in-depth description of the equations used in the code. |
| | 5) Calling sequence: | Variables used in calling the subprogram. |
| | 6) Contained in module: | The name of the source file the subprogram can be found in. |
| | 7) Called by: | Lists which routines call this one. |
| | 8) Calls: | List which routines this one calls. It does not include system routines such as SIN and SQRT or statement functions. Appendix B gives a full listing. |
| | 9) Input arguments: | All values passed to the routine through the calling arguments. This list may overlap the output arguments since some variables may be used for both input and output. |
| | 10) Output arguments: | All values output from the routine through the calling arguments. |
| * | 11) Global variables | All global variables used by the |

| | | | |
|---|---|---|---|
| TSEP(3) | /IODATA/ | R*4 | IODATA.INC |
| | Separation between transmit antennas in meters. | | |
| URH(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas horizontal offsets from great circle plane in meters. | | |
| URL(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas longitudinal offsets in meters. | | |
| URV(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas vertical offsets in meters. | | |
| UTH(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas horizontal offsets in meters. | | |
| UTL(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas longitudinal offsets in meters. | | |
| UTV(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas vertical offsets in meters. | | |

```
     PI              /CONSTA/       R*4     CONSTANTS.INC
                     Constant Pi = 3.141592654.
     UANGLE          /UNIT/         R*4     IODATA.INC
                     Units of angle (deg, mrad).
     UFREQ           /UNIT/         R*4     IODATA.INC
                     Units of frequency (GHz, MHz).
     UHITE           /UNIT/         R*4     IODATA.INC
                     Units of height and diameter (ft, m).

Global variables output to common:
     AR(NRMX)        /ANTENN/       R*4     TROCOM.INC
                     Array of receiver antenna diameters in meters.  AR(1)
                     is equivalent to RDIAM in the input file.
     AT(NTMX)        /ANTENN/       R*4     TROCOM.INC
                     Array of transmitter antenna diameters in meters.
                     AT(1) is equivalent to TDIAM in the input file.
     IBR(NRMX,NRMX)  /SYSTRN/       I*2     TROCOM.INC
                     Channel complex-envelope correlation and
                     cross-correlation calculation indicator array.
                             0 = No calculation
                             1 = Power (correlation) calculation only
                             2 = Power (correlation) per unit delay
                                 spectrum calculation
     IPOLR(NRMX)     /ANTENN/       I*2     TROCOM.INC
                     Array of receiver antenna polarizations.
     IPOLT(NTMX)     /ANTENN/       I*2     TROCOM.INC
                     Array of transmitter antenna polarizations.
     NR              /SYSTRN/       I*2     TROCOM.INC
                     Number of receive ports.
     NT              /SYSTRN/       I*2     TROCOM.INC
                     Number of transmit ports.
     PHDIV           /MCOM4/        R*4     MCOM.INC
                     Squint angle between upper and lower receiver beams in
                     radians.  Default is beamwidth.
     PSIRAO(NRMX)    /ANTENN/       R*4     TROCOM.INC
                     Array of receiver beam azimuths in radians.
     PSIREO(NRMX)    /ANTENN/       R*4     TROCOM.INC
                     Array of receiver beam boresight elevations above
                     radio horizon in radians, ie, angle at which each
                     antenna is aimed relative to the horizon.  PSIREO(1)
                     is the main receive antenna.
     PSITAO(NTMX)    /ANTENN/       R*4     TROCOM.INC
                     Array of transmitter beam azimuths in radians.
     PSITEO(NTMX)    /ANTENN/       R*4     TROCOM.INC
                     Array of transmitter beam boresight elevations above
                     radio horizon in radians, ie, angle at which each
                     antenna is aimed relative to the horizon.  PSITEO(1)
                     is the main transmit antenna.
     RSEP(3)         /IODATA/       R*4     IODATA.INC
                     Separation between receive antennas.
```

## 3.1 ANTGEO

Subprogram name:     Subroutine ANTGEO

Purpose:     Compute antenna geometry parameters for chosen diversity configuration (DIVTYP).

Calling sequence:
```
     CALL ANTGEO (BWR, BWT, HR, HT)
```

Contained in module: ANTGEO

Called by:     INDATA

Calls:     NONE

```
Input arguments:
     HR       R*4     Receiver antenna height above ground.
     HT       R*4     Transmitter antenna height above ground.

Output arguments:
     BWR      R*4     Receiver antenna beamwidth in degrees.
     BWT      R*4     Transmitter antenna beamwidth in degrees.

Global variables input from common:
     ACALC            /IODATA/        L*4     IODATA.INC
                      TRUE if the angles PSITEO and PSIREO are calculated
                      rather than read in.
     CMTPFT           /CONSTA/        R*4     CONSTANTS.INC
                      Meters per foot = 0.3048.
     DIVTYP           /MCOM2/         I*2     MCOM.INC
                      Diversity configuration indicator.  Default is 0.
                       0 = 2 receive antennas; 2S    2S/2F    2S/2A 2S/2A/2F
                       1 = 1 receive antenna;  2A    2F       2F/2A
                       2 = 2 transmit,
                           2 receive antennas; 2S/2P 2S/2P/2A
                       3 = Not used
                       4 = User supplied parameters
                      S = Space  F = Frequency  A = Angle  P = Polarization
     F                /SYSTRN/        R*4     TROCOM.INC
                      Operating frequency in Hz.  Model is accurate between
                      100MHz and 10GHz.
     LERR             /LUNS/          I*2     LUNS.INC
                      Error output unit.
     MET              /UNIT/          R*4     IODATA.INC
                      String 'met ' for units output.
     MHZ              /UNIT/          R*4     IODATA.INC
                      String 'MHz ' for units output.
     MRADNS           /UNIT/          R*4     IODATA.INC
                      String 'mrad' for units output.
```

# CHAPTER 3

# INPUT

This section describes the initial data handling routines:

| Name | Description | User's Manual section |
|---|---|---|
| ANTGEO | Antenna geometry . . . . . . . . | NA |
| ERRIO | I/O Error message output . . . | 2.3, 3.4.3 |
| INDATA | Data input . . . . . . . . . . . | 2.2, 3.2 |
| OUTDAT | Output summary of input data . | 3.4.1 |
| SECTOR | Sector search . . . . . . . . . . | NA |
| UNITCV | Units conversion . . . . . . . . | 2.2 |
| UNITS | Units decoding/encoding . . . . | NA |

The main routine for this section is INDATA.

All data input to TROPO comes from the input file, TROPO.DAT, on unit LIN. A complete description of this file can be found in the User's Manual, section 3.2. OUTDAT writes into the file FOR002.DAT on unit LOUT, which is described in section 3.4.1 of the User's Manual.

NOTE

In most cases the sections in the User's Manual describe the coded equations as well as the theory behind them. NA denotes routines that are programming utilities such as finding indices, setting pointers, etc.

Control indicator for entry or calculation of transmit/receive radio horizon angles THET and THER. Values have following meanings:

0 = Use input THET, THER as reference and actual horizon (default).
1 = Calculate reference horizon using HORANG and K equals 1.33. (Assuming DLT and DLR are non-zero.) (Option not available.)
2 = Calculate reference horizon using HORANG and K equals ERFAC. (Assuming DLT and DLR are non-zero.)
3 = Do not change reference horizons from previous run. (Option not available.)

SEAN /PROPAR/ R*4 TROCOM.INC

Minimum monthly median of refractivity at sea level. Used to calculate ERFAC if non-zero.

```
                              For DIVTYP = 2:
                                 Q(.,1)  Power on path 1 (lower beam) vs. delay.
                                 Q(.,2)  Correlation between convergent paths
                                         (lower beam) vs. delay.
                                 Q(.,3)  Correlation between divergent paths
                                         (lower beam) vs. delay.
                                 Q(.,4)  Correlation between parallel paths
                                         (lower beam) vs. delay.
                                 Q(.,5)  Correlation between crossing paths
                                         (lower beam) vs. delay.
                                 Q(.,6)  Power on path of upper beam vs. delay.
                                 Q(.,7)  Power on diffraction path vs. delay.
      STSNR                   /SUMP/          R*4     SUMP.INC
                              Standard deviation of troposcatter signal long-term
                              SNR distribution in dB.
      TAPW                    /MCOM4/         R*4     MCOM.INC
                              Normalized tapwidth for MD-918.  Default is .5.
                              Range is 0.25 through 1.0
      TEMPA(NCORMX)           /PDATA/         R*4     PDATA.INC
                              Array of average troposcatter signal delays for each
                              beam relative to straight line in seconds.
      TERFAC(3)               /ERAD/          R*4     ERAD.INC
                              The three values of ERFAC when MDIST is 1.
      THER                    /PATHGE/        R*4     TROCOM.INC
                              Radio horizon elevation angle at receive site in
                              radians.
      THET                    /PATHGE/        R*4     TROCOM.INC
                              Radio horizon elevation angle at transmit site in
                              radians.
      TODAY(9)                /TSTAMP/        L*1     IODATA.INC
                              Array used in PDP-11 version to hold date as
                              characters.

  Global variables output to common:
      DELPBZ                  /RZ1/           R*4
                              Resolution of a delay cell in seconds.  Same as DELPB
                              in /PDATA/.
      DELTAR(NRMX)            /ANTENN/        R*4     TROCOM.INC
                              3dB half-beamwidth of each receive antenna in radians.
      DELTAT(NTMX)            /ANTENN/        R*4     TROCOM.INC
                              3dB half-beamwidth of each transmit antenna in
                              radians.
      ERFAC                   /PROPAR/        R*4     TROCOM.INC
                              Yearly median value of effective earth radius factor k
                              in kilometers.  Default is 1.33.
      GRDB(NRMX)              /ANTENN/        R*4     TROCOM.INC
                              Gain of each receive antenna in dBi.
      GTDB(NTMX)              /ANTENN/        R*4     TROCOM.INC
                              Gain of each transmit antenna in dBi.
      ITOFF                   /PROPAR/        I*2     TROCOM.INC
```

```
MODPAT          /MCOM2/         I*2     MCOM.INC
                Propasation/modem flas to select calculation mode.
                Default is 1.
                        0 = Propasation only
                        1 = Propasation + MD-918 modem
                        2 = Propasation + AN/TRC-170 or DAR modem
                        3 = Propasation + user-defined modem
MODSIG          /MCOM2/         I*2     MCOM.INC
                Interference sisnal modulation format.  Default is 1.
                        0 = Analos FDM / FM
                        1 = Disital QPSK
MRAD            /ERAD/          I*2     ERAD.INC
                Loop limit for MRAD. Default is 1.
                (MRAD is 1 for MDIST = 0 and MRAD is 3 for MDIST = 1).
NERT            /MCOM2/         I*2     MCOM.INC
                Bit error rate threshold indicator for yearly fade
                outase probability calculation.  Default is 2.
                        0 = All three thresholds
                        1 = For 10**(-3) only
                        2 = For 10**(-4) only
                        3 = For 10**(-5) only
NOBS            /MCOM2/         I*2     MCOM.INC
                Number of diffraction obstacles. Maximum is 3,
                default is 1.
NOW(8)          /TSTAMP/        L*1     IODATA.INC
                Array used in PDP-11/70 version to hold time of day as
                characters.
NR              /SYSTRN/        I*2     TROCOM.INC
                Number of receive ports.
NRAD            /ERAD/          I*2     ERAD.INC
                ERFAC indicator and loop counter.  Default is 1.
NT              /SYSTRN/        I*2     TROCOM.INC
                Number of transmit ports.
Q(NDELMX,NCORMX) /PDATA/        R*4     PDATA.INC
                Matrix of troposcatter sisnal power and correlation
                per unit delay profiles.
                For DIVTYP = 0:
                   Q(.,1)  Power on lower beam vs. delay.
                   Q(.,2)  Correlation between lower and
                           upper beam vs. delay.
                   Q(.,3)  Correlation between lower beams
                           in antennas 1 & 2 vs. delay.
                   Q(.,4)  Power on upper beam vs. delay.
                   Q(.,7)  Power on diffraction path vs. delay
                For DIVTYP = 1:
                   Q(.,1)  Power on lower beam vs. delay.
                   Q(.,2)  Correlation between lower and
                           upper beam vs. delay.
                   Q(.,3)  Power on upper beam vs. delay
                   Q(.,7)  Power on diffraction path vs. delay.
```

| | | | |
|---|---|---|---|
| A | /PATHGE/ | R*4 | TROCOM.INC |
| | Effective earth radius in meters. | | |
| AA | /PROPAR/ | R*4 | TROCOM.INC |
| | Atmospheric absorption loss in dB. | | |
| BW | /SYSTRN/ | R*4 | TROCOM.INC |
| | Bandwidth in Hertz. Default is 7 MHz. | | |
| D | /PATHGE/ | R*4 | TROCOM.INC |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | |
| DEL | /SUMP/ | R*4 | CURVE.INC |
| | Diffraction path delay relative to a straight line path in seconds. | | |
| DELPB | /PDATA/ | R*4 | PDATA.INC |
| | Resolution of a delay cell in seconds. | | |
| DL(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing distance from each obstacle to transmitter in meters. | | |
| DRATE | /MCOM4/ | R*4 | MCOM.INC |
| | Data rate in bits/second. Default is 6.6E6. | | |
| DS(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array of effective obstacle extents along the great circle path in meters. | | |
| EOF | /CONTRL/ | L*4 | TROCOM.INC |
| | End of TROPO.DAT file found if TRUE. | | |
| F | /SYSTRN/ | R*4 | TROCOM.INC |
| | Operating frequency in Hz. Model is accurate between 100MHz and 10GHz. | | |
| HL(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing elevation of each obstacle above sea level in meters. HL(1) is elevation of transmitter radio horizon HLT. HL(NOBS) is elevation of receiver radio horizon HLR. | | |
| HRN | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive antenna height above sea level in meters. | | |
| HTN | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit antenna height above sea level in meters. | | |
| IBW | /MCOM2/ | I*2 | MCOM.INC |
| | Switch indicating type of RF bandwidth constraint to be used on desired signal. Default is 0.<br>0 = No RF filtering<br>1 = Filter determined from 99% bandwidth constraint<br>2 = Filter chosen to meet FCC Mask. (FCC-19311)<br>3 = Filters are user specified | | |
| LOUT | /LUNS/ | I*2 | LUNS.INC |
| | FOR002.DAT output unit number. | | |
| MDIST | /ERAD/ | I*2 | ERAD.INC |
| | Multipath distribution indicator.<br>0 = Only median multipath spread used(default)<br>1 = Multipath distribution used. (Option not currently available.) | | |

## 2.1 TROPO

Program name: Program TROPO

Purpose: To predict single link digital troposcatter communications system performance for frequencies between 100 Mhz and 10 Ghz.

Description: The routines in TROPO can be grouped into eight major functions:

1) Data input and unit conversion: INDATA.
2) Data checking and error handling: CHKDAT.
3) Troposcatter propagation calculations: ATMOS, TRANSF, ANTPAR, INTLIM, LTCORR, LOOPS and POWER.
4) Diffraction propagation calculations: MDIF and DIFSNR.
5) Transmitter and receiver filter calculations: BUTFIL.
6) MD-918 modem performance calculations: MDTS.
7) AN/TRC-170 and DAR modem performance calculations: TRCIN.
8) Summary page output: SUMPAG.

The program can perform one of the following functions for each run:

1) Troposcatter calculations only
2) Troposcatter and diffraction calculations
3) Troposcatter and interference calculations
4) Propagation (one of above 3) + MD-918 modem
5) Propagation + AN/TRC-170 or DAR modem
6) Propagation + user defined modem

The input files used are:

| Unit no. | File name | Description |
|---|---|---|
| LIN = 1 | TROPO.DAT | The input file. |

The output files used are:

| Unit no. | File name | Description |
|---|---|---|
| LOUT = 2 | FOR002.DAT | The output file. |
| LERR = 2 | FOR002.DAT | The error output file. |
| LDEBUG = 2 | FOR002.DAT | The (debug) output file. |
| LSUM = 3 | SUMPAG.OUT | The summary page file. |
| LTERM = 4 | <user's terminal> | Error messages. |

CALL TROPO

Contained in module: TROPO

Calls:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ANTPAR | ATMOS | BUTFIL | CHKDAT | DIFSNR | INDATA | INTLIM | LOOPS | LTCORR |
| MDIF | MDTS | POWER | SUMPAG | TRANSF | TRCIN | | | |

Global variables input from common:

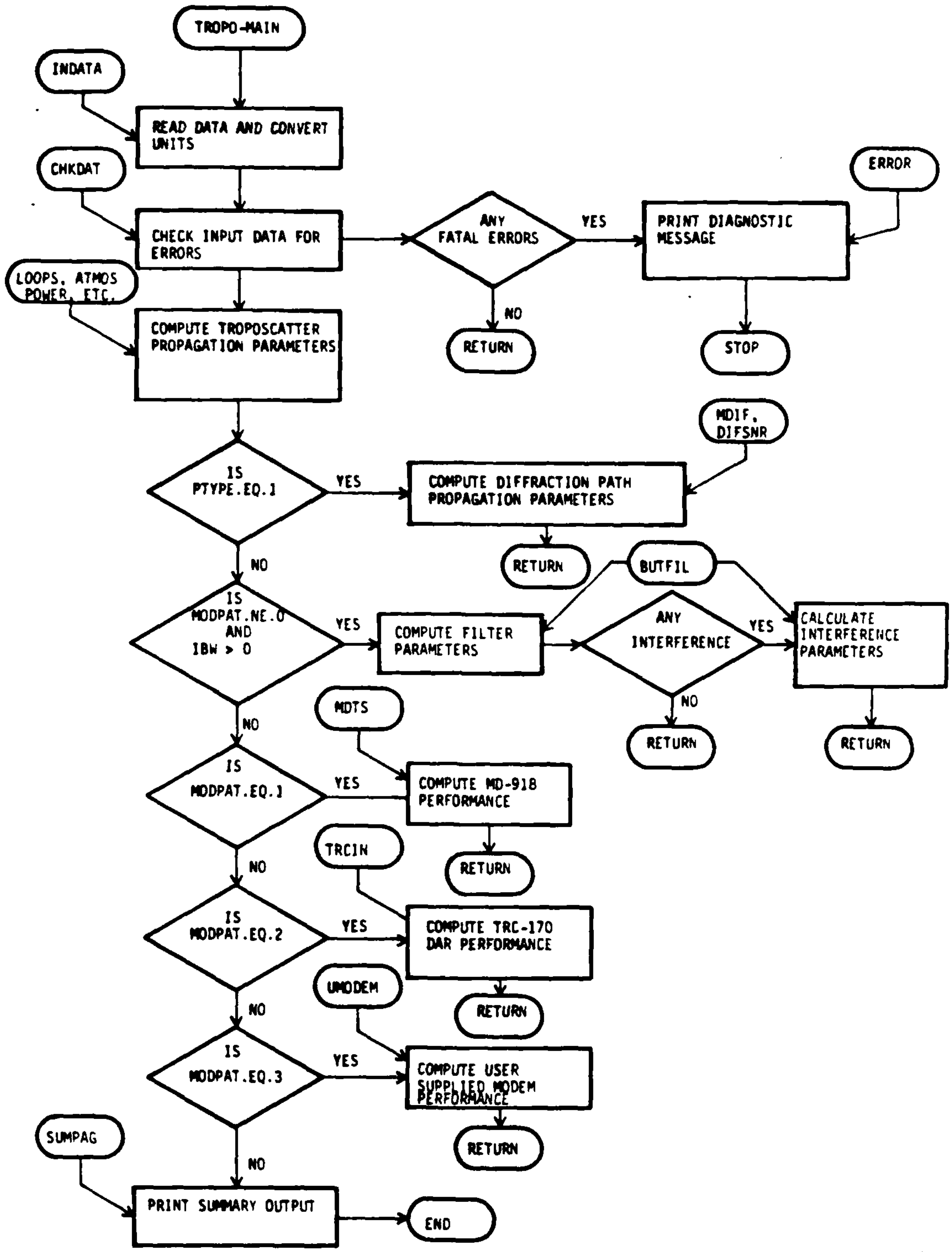



Figure 2-1 Top Level Functional Flow Chart for TROPO Program Calculations

# CHAPTER 2

# DRIVER

This section describes the driver for the TROPO program. Figure 2-1 is a top level flowchart of the TROPO program at a functional level. In most cases the blocks correspond to one or more subprograms. The test blocks (diamonds), except for 'Any Fatal Errors', correspond to logical branches which are decided by the user's choices of input data.

| PDP version | IBM version | Affects (among others) |
|---|---|---|
| PARAMETER | Actual numbers used | TROPAR.INC, TROCOM.INC and DATAINIT.FTN |
| INCLUDE | Commons already included | Any routine accessing a common |
| BYTE | LOGICAL*1 data type | Various routines |
| Leading tab | 5 or 6 spaces | All routines |
| Blank lines | 'C' before line | All routines |
| Separate source files | All sources in 1 file | NA |
| DATE and TIME | No date and time for output | TROPO, OUTDAT, and SUMPAG |
| No RETURN in block data | RETURN at end | DATAINIT.FTN |

Certain FORTRAN compromises have been made in the code to satisfy FORTRAN-H Extended which are acceptable to, though not optimal for, FORTRAN-IV PLUS:

1) IBM does not allow INTEGER*2 variables as arguments to FORTRAN functions which require integer arguments so that INTEGER*4 variables have been used as arguments in such cases.
2) The functions of MIN and MAX have been re-coded in some cases as an alternative to such FORTRAN function calls.
3) The logical unit numbers, LOUT, LIN, etc., are INTEGER*4.
4) The variables in common are listed in decreasing storage size.
5) Data for each common is initialized in block data only.
6) Quoted literals are only used in data statements.
7) Arithmetic expressions were not used in WRITEs, GOTOs and DO loops.
8) Logical variables are LOGICAL*1 or LOGICAL*4 rather than LOGICAL*2.

The error output file, logical unit LERR, is assigned the same unit number as the output file. This can be changed to a unique number so that the errors are written to a separate file. Note that for the PDP version this would also involve changing the task build command file to increase the number of active files (ACTFIL = ) and the largest LUN accessed (UNITS = ). Your system manual will have more information on this. Be aware that this will also increase the size of the task.

Logical unit LSUM is explicitly assigned to the file SUMPAG.OUT by the OPEN statement in subroutine SUMPAG.

Output to the terminal is done on logical unit LTERM which has been set to 4. The default for the terminal is 5 but in order to reduce task size it has been assigned to unit 4 in the task build command file. Note that this assignment can be changed to the system disk if TROPO is to be run in background and as such cannot access the terminal. If the disk is used, a file, FOR004.DAT, will be opened for the error messages normally sent to the terminal. Another option is to set LTERM to the same value as LERR in the block data section to have the messages in the same file.

## 1.5 PDP and IBM coding differences

Throughout this document PDP and IBM refer to versions of the program and not necessarily the computer it is running on. The PDP version was written using many of the features of PDP Fortran that allow SIGNATRON to revise the program easily. The IBM version is more universal since it is closer to ANSI Fortran, which allows it to run on other systems with fewer modifications. The following features are different in the source codes of the two versions:

input from common: routine but not given a new value.

* 12) Global variables output to common: All global variables possibly given a new value by the routine.

All sections of the description, except those marked by a '*', are always present in all routine descriptions whether data follows the section or not.

## 1.3 Fortran IV-PLUS

TROPO is written in Fortran IV-PLUS; therefore, it is necessary that the program link to the Fortran IV-PLUS library. Though it is possible to compile and run under Fortan-77, the output is not guaranteed since Fortran-77 is not a strict superset of Fortran IV-PLUS and the differences in the versions may change the results.

## 1.4 Input and output units

The logical units the TROPO program reads from and writes to files whose associated logical unit numbers are variables passed through the common /LUNS/ in file LUNS.INC. The values are set in the block data section to:

| Name | LUN | Purpose | File name |
|---|---|---|---|
| LIN | 1 | Input file | TROPO.DAT |
| LOUT | 2 | Output file | FOR002.DAT |
| LDEBUG | 2 | Output file | FOR002.DAT |
| LERR | 2 | Error file | FOR002.DAT |
| LSUM | 3 | Summary page | SUMPAG.OUT |
| LTERM | 4 | Error messages | <user's terminal> |

Logical unit LIN is explicitly assigned to the file TROPO.DAT by the OPEN statement in subroutine INDATA.

LOUT is implicitly assigned to the file FOR002.DAT. The PDP-11/70 will assign the default name FOR00n.DAT to any file written to or read from on logical unit n which has not been opened previous to the read or write.

LDEBUG is always assigned to the output file and is present only to distinguish debug write statements from output write statements.

## 3.2 ERRIO

Subprogram name: Subroutine ERRIO

Purpose: Outputs error number and error message to terminal (unit LTERM) and the output file FOR002.DAT (unit LOUT).

Description: Checking for input errors is done throughout TROPO but the messages written from this routine are for initial testing done in the input routines, INDATA, SECTOR, and UNITS. When a fatal error or data inconsistency is found, processing transfers to this subroutine. Most errors found are fatal so processing branches to line 500 to STOP after outputting the message; others are merely warnings and branch to 600 to return to the calling program and continue processing.

The errors are divided in the source code by calling routine so a check of the code or FORMAT statements reveals in which routine the error was encountered.

Note that for all error 999s the calling program has already printed an error message to the output file FOR002.DAT before calling ERRIO.

Calling sequence:
CALL ERRIO (I)

Contained in module: ERRIO

Called by: INDATA SECTOR UNITS

Calls: NONE

Input arguments:
I I*2 Error number.

Output arguments:
NONE

Global variables input from common:
LOUT /LUNS/ I*2 LUNS.INC
FOR002.DAT output unit number.

## 3.3 INDATA

Subprogram name: Subroutine INDATA

Purpose: This subroutine reads the data required for TROPO calculations from the input file TROPO.DAT.

Description: Each section in the source code of INDATA is identified by dashed lines around a section header which correspond with each section in the input file, TROPO.DAT.

There are three types of lines in the input file TROPO.DAT:

1) Sector header
2) Comment
3) Data

A sector header identifies the beginning of each section. Before INDATA reads a section of data, SECTOR searches for the sector header by reading lines until the first four letters match the section wanted. This feature makes the data in each section independent which is necessary when, for exalpe, PTYPE = 0. In this case, INDATA reads in all the TROPOSCATTER data. The next section, DIFFRACTION, is only needed for PTYPE = 1. Since it contains data for some of the same variables just initialized, in order to preserve these values, SECTOR is called to search for the DIFFRACTION sector header which skips over these data lines. From this point INDATA goes on to read the diversity data.

A comment line describes the data that should follow, giving defaults and maximums in some cases. Each begins with a '*' to differentiate these lines from the sector headers. In the code, the statement: READ (LIN,1005) skips over the comment lines in the input file. The number of these reads corresponds to the number of comment lines preceding each data line in the input file.

Most data lines are read in list-directed. This type of read will read digits into the variable until a delimeter (space or comma) is found, eliminating the need for data to be lined up in specific columns as in formatted input. The data type is converted on input to the variable type so that integers may be input for reals. Two consecutive commas (or a leading or trailing comma) inputs no data into the corresponding variable, thus preserving its default value. A slash terminates input for all remaining items in the input list, also preserving their default values. Note, the slash cannot be used for logical or literal data.

Literal data is, in most cases, read into REAL*4 variables with an alpha format descriptor (of the form A[w]). This will put one character into each of the four bytes of the real as though it were a BYTE (LOGICAL*1) array of length four.

CAUTION! When adding new variables to the input file, do not insert them before the units section (HDU, ANGU, etc.) if the data is to be converted by UNITCV to and from MKS units. In subsequent runs, the call to UNITCV comes immediately after these units are deciphered so all values in common are treated as though in MKS units.

Calling sequence:
    CALL INDATA (JPOW,ASEP,CLIMAT,BWT,BWR,PTYPE, JBW,TRCTYP,FJSEP)

Contained in module: INDATA

Called by:    TROPO

Calls:    ANTGEO  ERRIO  OUTDAT  SECTOR  UNITS

Input arguments:
    NONE

Output arguments:

| | | |
|---|---|---|
| JPOW | R*8 | Interference signal power density in dBm/Hz. |
| ASEP | R*4 | Separation between receive antennas in meters. |
| CLIMAT | R*4 | Climate zone indicator. |
| BWT | R*4 | Transmit antenna beamwidth in degrees. |
| BWR | R*4 | Receive antenna beamwidth in degrees. |
| PTYPE | I*2 | Variable which indicates whether propagation mechanism is pure troposcatter (0 or 10) or mixed troposcatter-diffraction (1 or 11). |
| JBW | R*8 | Interfering signal bandwidth in Hz. |
| TRCTYP | R*4 | TRC-170 modem type indicator:<br>0 = 1 frequency DAR modem<br>1 = 2 frequency AN/TRC-170 |
| FJSEP | R*4 | Frequency separation between desired signal and interference signal in Hertz. |

Global variables input from common:

| | | | |
|---|---|---|---|
| A0 | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Radius of the earth in meters = 6367650. | | |
| C0 | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Free space velocity of radio waves = 2.998E8 m/sec. | | |
| CMTPFT | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Meters per foot = 0.3048. | | |
| GHZ | /UNIT/ | R*4 | IODATA.INC |
| | String 'GHz ' for units output. | | |
| KM | /UNIT/ | R*4 | IODATA.INC |
| | String 'km  ' for units output. | | |
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |
| MDIST | /ERAD/ | I*2 | ERAD.INC |

```
                    Multipath distribution indicator.
                           0 = Only median multipath spread used(default)
                           1 = Multipath distribution used.  (Option not
                               currently available.)
     MHZ            /UNIT/          R*4     IODATA.INC
                    String 'MHz ' for units output.
     UDIST          /UNIT/          R*4     IODATA.INC
                    Units of distance (smi, nmi, km).
     UFREQ          /UNIT/          R*4     IODATA.INC
                    Units of frequency (GHz, MHz).

  Global variables output to common:
     A              /PATHGE/        R*4     TROCOM.INC
                    Effective earth radius in meters.
     ACALC          /IODATA/        L*4     IODATA.INC
                    TRUE if the angles PSITEO and PSIREO are calculated
                    rather than read in.
     AR(NRMX)       /ANTENN/        R*4     TROCOM.INC
                    Array of receiver antenna diameters in meters.  AR(1)
                    is equivalent to RDIAM in the input file.
     AT(NTMX)       /ANTENN/        R*4     TROCOM.INC
                    Array of transmitter antenna diameters in meters.
                    AT(1) is equivalent to TDIAM in the input file.
     AVERX          /MCOM4/         R*4     MCOM.INC
                    Average terrain elevation above sea level between
                    receive site and radio horizon, in meters.
     AVETX          /MCOM4/         R*4     MCOM.INC
                    Average terrain elevation above sea level between
                    transmit site and radio horizon, in meters.
     BW             /SYSTRN/        R*4     TROCOM.INC
                    Bandwidth in Hertz.  Default is 7 MHz.
     CHGHR          /IODATA/        L*4     IODATA.INC
                    HR set to AR(1) if TRUE.
     CHGHRE         /IODATA/        L*4     IODATA.INC
                    HRE set to HR if TRUE.
     CHGHT          /IODATA/        L*4     IODATA.INC
                    HT set to AT(1) if TRUE.
     CHGHTE         /IODATA/        L*4     IODATA.INC
                    HTE set to HT if TRUE.
     CN2(NPROF)     /PROPAR/        R*4     TROCOM.INC
                    The atmospheric structure constant height profile in
                    meters to the -2/3 power.
     CODE           /MCOM4/         L*4     MCOM.INC
                    Flag for coding.
     D              /PATHGE/        R*4     TROCOM.INC
                    Great circle distance between transmitter and receiver
                    measured at sea level in meters.
     DELH           /PROPAR/        R*4     TROCOM.INC
                    Spacing of CN2 samples in meters.
     DEMIN          /CURVE/         R*4     CURVE.INC
```

User supplied minima of the 90th percentile variability curve, Y0(90).

DIVTYP /MCOM2/ I*2 MCOM.INC
Diversity configuration indicator. Default is 0.
0 = 2 receive antennas; 2S 2S/2F 2S/2A 2S/2A/2F
1 = 1 receive antenna; 2A 2F 2F/2A
2 = 2 transmit, 2 receive antennas; 2S/2P 2S/2P/2A
3 = Not used
4 = User supplied parameters
S = Space F = Frequency A = Angle P = Polarization

DL(3) /MCOM4/ R*4 MCOM.INC
Array containing distance from each obstacle to transmitter in meters.

DLR /PATHGE/ R*4 TROCOM.INC
Distance from receiver to radio horizon in meters.

DLT /PATHGE/ R*4 TROCOM.INC
Distance from transmitter to radio horizon in meters.

DRATE /MCOM4/ R*4 MCOM.INC
Data rate in bits/second. Default is 6.6E6.

DS(3) /MCOM4/ R*4 MCOM.INC
Array of effective obstacle extents along the great circle path in meters.

ELANG(10) /MCOM4/ R*4 MCOM.INC
Interferer elevation angles in degrees. Default is 0.

EOF /CONTRL/ L*4 TROCOM.INC
End of TROPO.DAT file found if TRUE.

ERFAC /PROPAR/ R*4 TROCOM.INC
Yearly median value of effective earth radius factor k in kilometers. Default is 1.33.

ERR /CONTROL/ R*4 TROCOM.INC
Common volume integration resolution. Default is .001.

F /SYSTRN/ R*4 TROCOM.INC
Operating frequency in Hz. Model is accurate between 100MHz and 10GHz.

FCRX /BUTPAR/ R*4 BUTPAR.INC
Normalized 3dB cut-off frequency of receiver filter.

FCTX /BUTPAR/ R*4 BUTPAR.INC
Normalized 3dB cut-off frequency of transmitter filter.

GPF /CURVE/ R*4 CURVE.INC
Frequency correction factor for user supplied 90th percentile variability curve. Default is 1.

HI(155) /MCOM4/ R*4 MCOM.INC
Array containing NPM(1) evenly-spaced terrain elevation data (in meters) between transmitter and first obstacle followed by NPM(2) evenly-spaced terrain elevation data between first and second obstacle, etc., ending with NPM(NOBS+1) evenly-spaced terrain elevation data between last obstacle and

receive site. The data should be selected such that:
HI(1) = Terrain elevation above sea level at transmit site (HTO).
HI(NPM(I)) = HI (NPM(I)+1) = Elevation of Ith obstacle above sea level (HL(I)).
HI(NPM(NOBS+1)) = Terrain elevation above sea level at receive site (HRO).
In MOTS, HI is used as work space. It is equivalenced to local arrays.

HL(3) /MCOM4/ R*4 MCOM.INC
Array containing elevation of each obstacle above sea level in meters. HL(1) is elevation of transmitter radio horizon HLT. HL(NOBS) is elevation of receiver radio horizon HLR.

HLAV(3) /MCOM4/ R*4 MCOM.INC
Array containing average terrain elevation at each diffraction point in meters.

HLEF(3) /MCOM4/ R*4 MCOM.INC
Array containing effective height of obstacles above average terrain elevation in meters.

HLOW /PROPAR/ R*4 TROCOM.INC
Lowest height above sea level at which CN2 is specified in meters.

HLR /PATHGE/ R*4 TROCOM.INC
Receiver radio horizon elevation above sea level in meters.

HLT /PATHGE/ R*4 TROCOM.INC
Transmit radio horizon elevation above sea level in meters.

HRE /MCOM4/ R*4 MCOM.INC
Effective receiver antenna height above average terrain elevation in meters.

HRN /PATHGE/ R*4 TROCOM.INC
Receive antenna height above sea level in meters.

HTE /MCOM4/ R*4 MCOM.INC
Effective transmitter antenna height above average terrain elevation in meters.

HTN /PATHGE/ R*4 TROCOM.INC
Transmit antenna height above sea level in meters.

IBR(NRMX,NRMX) /SYSTRN/ I*2 TROCOM.INC
Channel complex-envelope correlation and cross-correlation calculation indicator array.
0 = No calculation
1 = Power (correlation) calculation only
2 = Power (correlation) per unit delay spectrum calculation

IBW /MCOM2/ I*2 MCOM.INC
Switch indicating type of RF bandwidth constraint to be used on desired signal. Default is 0.
0 = No RF filtering

1 = Filter determined from 99% bandwidth constraint
2 = Filter chosen to meet FCC Mask. (FCC-19311)
3 = Filters are user specified

ICLIME /MCOM2/ I*2 MCOM.INC
Climate class. Default is 0.
0 = NBS TN-101 climate
1 = MIL-HDBK-417 climate
2 = New, user-supplied climate

IFILRX /BUTPAR/ I*2 BUTPAR.INC
Receiver filter indicator.
0 = MD-918 receiver filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
1 = (not allowed)
2 = AN/TRC-170 receiver filter. Also means filter is a Butterworth.

IFILTX /BUTPAR/ I*2 BUTPAR.INC
Transmitter filter indicator.
0 = MD-918 transmitter filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
1 = AN/TRC-170 transmitter filter. Also means filter is a cascade of Butterworth filter with rectangular impulse response filter of duration equal to half symbol duration.
2 = (not allowed)

IOPEND /CONTRL/ I*2 TROCOM.INC
Number of output files opened.

IPOLR(NRMX) /ANTENN/ I*2 TROCOM.INC
Array of receiver antenna polarizations.

IPOLT(NTMX) /ANTENN/ I*2 TROCOM.INC
Array of transmitter antenna polarizations.

ITOFF /PROPAR/ I*2 TROCOM.INC
Control indicator for entry or calculation of transmit/receive radio horizon angles THET and THER. Values have following meanings:
0 = Use input THET, THER as reference and actual horizon (default).
1 = Calculate reference horizon using HORANG and K equals 1.33. (Assuming DLT and DLR are non-zero.) (Option not available.)
2 = Calculate reference horizon using HORANG and K equals ERFAC. (Assuming DLT and DLR are non-zero.)
3 = Do not change reference horizons from previous run. (Option not available.)

KLIMAT /PROPAR/ I*2 TROCOM.INC
Climate zone indicator. Default is 0.

```
                                0 = User supplied climate
                        NBS TN101 climates
                                1 = Continental temperate (CT)
                                2 = Maritime temperate overland (MTL)
                                3 = Maritime temperate oversea (MTS)
                                4 = Maritime subtropical overland (MSL)
                                5 = Continental temperate time block 2 (CT2)
                                    (winter afternoon hours) - formerly
                                    Maritime subtropical oversea (MSS)
                                6 = Desert, Sahara (DS)
                                7 = Equatorial (EQU)
                                8 = Continental subtropical (CS)
                        MIL-HDBK-417 climates
                                9 = Continental temperate (CT)
                                10 = Maritime temperate overland (MTL)
                                11 = Maritime temperate oversea (MTS)
                                12 = Maritime subtropical (MS)
                                13 = Desert, Sahara (DS)
                                14 = Equatorial (EQU)
                                15 = Continental subtropical (CS)
                                16 = Mediterranean (MED)
                                17 = Polar (POL)
        KPROF           /PROPAR/        I*2     TROCOM.INC
                        Actual number of samples in height profile of
                        structure constant CN2.  Limited to NPROF samples.
        LIN             /LUNS/          I*2     LUNS.INC
                        TROPO.DAT input unit number.
        LINKNO          /IODATA/        I*2     IODATA.INC
                        Link number.
        LISI            /MCOM2/         I*2     MCOM.INC
                        Number of future Intersymbol Interference (ISI)
                        contributors considered in MD-918 performance
                        calculation.  Default is 2.
        LNAME(20)       /IODATA/        I*2     IODATA.INC
                        Link name.  Transmitter site first, receiver site
                        second.  Used as link identifier on output files
                        FOR002.DAT and SUMPAG.OUT.
        MANG            /MCOM2/         I*2     MCOM.INC
                        Number of values of interferer azimuth/elevation pairs
                        (JANG) for which outage calculations are to be made.
                        Default is 1.
        MLAST           /PDATA/         I*2     PDATA.INC
                        Number of simulator taps.  Default is 16.
        MODPAT          /MCOM2/         I*2     MCOM.INC
                        Propagation/modem flag to select calculation mode.
                        Default is 1.
                                0 = Propagation only
                                1 = Propagation + MD-918 modem
                                2 = Propagation + AN/TRC-170 or DAR modem
                                3 = Propagation + user-defined modem
```

```
MODSIG      /MCOM2/       I*2    MCOM.INC
            Interference signal modulation format.  Default is 1.
                    0 = Analog FDM / FM
                    1 = Digital QPSK
MRAD        /ERAD/        I*2    ERAD.INC
            Loop limit for MRAD. Default is 1.
            (MRAD is 1 for MDIST = 0 and MRAD is 3 for MDIST = 1).
NACCU       /CONTRL/      I*2    TROCOM.INC
            Parameter used as truncation point for common
            volume integration termination.  Default is 40.
NANG        /RI2/         I*2    RI2.INC
            NANG is 1 if there is angle diversity (default).
NCLIME      /MCOM2/       I*2    MCOM.INC
            Flag set to 1 if ICLIME equals 2.
NERT        /MCOM2/       I*2    MCOM.INC
            Bit error rate threshold indicator for yearly fade
            outage probability calculation.  Default is 2.
                    0 = All three thresholds
                    1 = For 10**(-3) only
                    2 = For 10**(-4) only
                    3 = For 10**(-5) only
NEWCL(4)    /MCOM2/       I*2    MCOM.INC
            New climate type character string.
NFIG        /MCOM4/       R*4    MCOM.INC
            Receiver noise figure in dB.  Default is 4dB.
NOBS        /MCOM2/       I*2    MCOM.INC
            Number of diffraction obstacles. Maximum is 3,
            default is 1.
NPM(5)      /MCOM2/       I*2    MCOM.INC
            Array containing number of terrain elevation data
            points for calculation of effective antenna heights
            for each section of the diffraction path.
NPOLRX      /BUTPAR/      R*4    BUTPAR.INC
            Number of poles in the receive Butterworth filter.
NPOLTX      /BUTPAR/      I*2    BUTPAR.INC
            Number of poles in the transmit Butterworth filter.
NR          /SYSTRN/      I*2    TROCOM.INC
            Number of receive ports.
NT          /SYSTRN/      I*2    TROCOM.INC
            Number of transmit ports.
NTERR       /MCOM2/       I*2    MCOM.INC
            Control parameter for entry or calculation of
            effective antenna heights (HTE, HRE) and effective
            obstacle heights above average terrain elevation
            (HLEF).
                    0 = HTE and HRE supplied directly
                    1 = AVETX and AVERX supplied
                    2 = HI(.) supplied
PHDIV       /MCOM4/       R*4    MCOM.INC
            Squint angle between upper and lower receiver beams in
```

```
                 radians.  Default is beamwidth.
PSIRAO(NRMX)     /ANTENN/        R*4     TROCOM.INC
                 Array of receiver beam azimuths in radians.
PSIREO(NRMX)     /ANTENN/        R*4     TROCOM.INC
                 Array of receiver beam boresight elevations above
                 radio horizon in radians, ie, angle at which each
                 antenna is aimed relative to the horizon.  PSIREO(1)
                 is the main receive antenna.
PSITAO(NTMX)     /ANTENN/        R*4     TROCOM.INC
                 Array of transmitter beam azimuths in radians.
PSITEO(NTMX)     /ANTENN/        R*4     TROCOM.INC
                 Array of transmitter beam boresight elevations above
                 radio horizon in radians, ie, angle at which each
                 antenna is aimed relative to the horizon.  PSITEO(1)
                 is the main transmit antenna.
PULSE            /RZ/            I*2     RZ.INC
                 Switch controlling MD-918 pulse shape after
                 transmitter-receiver filtering.
                         PULSE = 0   Triangle
                               = 1   OQPSK matched filter
                               = 2   Sinc pulse, bandwidth equal to 1
                               = 5   RF filtering included
                 Set to 0 if IBW = 0 or KGAIN > 1.
                 Set to 5 if IBW > 0 and KGAIN = 1.
PXMIT            /MCOM4/         R*4     MCOM.INC
                 Rated transmission power in dBm.  Default is 70dBm.
RLL              /SYSTRN/        R*4     TROCOM.INC
                 Receiver line losses in dB.  Default is 0 dB.
RSEP(3)          /IODATA/        R*4     IODATA.INC
                 Separation between receive antennas.
SCPARM           /PROPAR/        R*4     TROCOM.INC
                 Wavenumber spectrum slope parameter M.  Default is
                 3.66.
SEAN             /PROPAR/        R*4     TROCOM.INC
                 Minimum monthly median of refractivity at sea level.
                 Used to calculate ERFAC if non-zero.
SP               /MCOM4/         R*4     MCOM.INC
                 Service probability.  Default is .95.
SPE              /PDATA/         R*4     PDATA.INC
                 Tap spacing in nanoseconds.  Default is 67 nsec.
SUPRES           /IODATA/        L*4     IODATA.INC
                 Supress long output in SUMPAG if true.
                 Set to TRUE if PTYPE > 9.
TAPOUT           /PDATA/         L*4     PDATA.INC
                 If true, the simulator tap values are output to the
                 output file, FOR002.DAT.  Default is TRUE.
TAPW             /MCOM4/         R*4     MCOM.INC
                 Normalized tapwidth for MD-918.  Default is .5.
                 Range is 0.25 through 1.0
TERFAC(3)        /ERAD/          R*4     ERAD.INC
```

| | | | |
|---|---|---|---|
| | The three values of ERFAC when MDIST is 1. | | |
| THER | /PATHGE/ | R*4 | TROCOM.INC |
| | Radio horizon elevation angle at receive site in radians. | | |
| THET | /PATHGE/ | R*4 | TROCOM.INC |
| | Radio horizon elevation angle at transmit site in radians. | | |
| TLL | /SYSTRN/ | R*4 | TROCOM.INC |
| | Transmitter line losses in dB. Default is 0 dB. | | |
| TSEP(3) | /IODATA/ | R*4 | IODATA.INC |
| | Separation between transmit antennas in meters. | | |
| URH(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas horizontal offsets from great circle plane in meters. | | |
| URL(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas longitudinal offsets in meters. | | |
| URV(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas vertical offsets in meters. | | |
| UTH(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas horizontal offsets in meters. | | |
| UTL(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas longitudinal offsets in meters. | | |
| UTV(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas vertical offsets in meters. | | |
| WAVLEN | /SYSTRN/ | R*4 | TROCOM.INC |
| | Wavelength in meters. | | |
| WLT | /SYSTRN/ | R*4 | TROCOM.INC |
| | Rated transmission power in Watts. Default is 1000 W. | | |
| XANG(10) | /MCOM4/ | R*4 | MCOM.INC |
| | Interferer azimuth angles in degrees. Default is 0. | | |
| Y900 | /CURVE/ | R*4 | CURVE.INC |
| | User supplied value for 90th percentile variability curve Y0(90) for DE greater than or equal 900 km. Used only when ICLIME is 2. Used to compute the equation for the Y0(90) curve fit. | | |
| YMIN | /CURVE/ | R*4 | CURVE.INC |
| | User supplied value for 90th percentile variability curve Y0(90) for DE equal to DEMIN. Used only when ICLIME is 2. Used to compute the equation for the Y0(90) curve fit. | | |

## 3.4 OUTDAT

Subprogram name: Subroutine OUTDAT

Purpose: Outputs to the output file, FOR002.DAT, parameters read from the input file TROPO.DAT as well as parameters calculated from these in INDATA, UNITS and ANTGEO.

Description: Most numeric values are printed with decimal points lined up. To make formatting easier, the T format is used to place the decimal point in the 57th position. The column to tab to is 57 - the number of integer places, ie, for an I7 format tab to column 50: ...T50,I7.... Therefore the following formulas can be used to calculate x:

| | | |
|---|---|---|
| Integer | Iw or Iw.m | 57 - w |
| Floating point | Fw.m | 57 - (w - (m+1)) |
| Exponential | Ew.m | 57 - (w - (m+5)) |
| Exponential | Ew.mEe | 57 - (w - (m+e+3)) |

where x is the value to use wherever Tx will be used.

Calling sequence:
CALL OUTDAT (CLIMAT,ASEP,JPOW,BWT,BWR,HTO,HRO,HT,HR,PTYPE, JBW,FJSEP,TRCTYP)

Contained in module: OUTDAT

Called by: INDATA

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| CLIMAT | R*4 | Climate zone indicator. |
| ASEP | R*4 | Separation between receive antennas in meters. |
| JPOW | R*8 | Interference signal power density in dKm/Hz. |
| BWT | R*4 | Transmit antenna beamwidth in degrees. |
| BWR | R*4 | Receive antenna beamwidth in degrees. |
| HTO | R*4 | Transmit site elevation above sea level. |
| HRO | R*4 | Receive site elevation above sea level. |
| HT | R*4 | Transmit antenna height above ground. |
| HR | R*4 | Receive antenna height above ground. |
| PTYPE | I*2 | Variable which indicates whether propagation mechanism is pure troposcatter (0 or 10) or mixed troposcatter-diffraction (1 or 11). |
| JBW | R*8 | Interfering signal bandwidth in Hz. |
| FJSEP | R*4 | Frequency separation between signal and interferer in Hz. |
| TRCTYP | R*4 | TRC-170 modem type indicator:<br>0 = 1 frequency DAR modem<br>1 = 2 frequency AN/TRC-170 modem |

```
     Output arguments:
          NONE

     Global variables input from common:
          ACALC           /IODATA/       L*4     IODATA.INC
                          TRUE if the angles PSITEO and PSIREO are calculated
                          rather than read in.
          AR(NRMX)        /ANTENN/       R*4     TROCOM.INC
                          Array of receiver antenna diameters in meters.  AR(1)
                          is equivalent to RDIAM in the input file.
          AT(NTMX)        /ANTENN/       R*4     TROCOM.INC
                          Array of transmitter antenna diameters in meters.
                          AT(1) is equivalent to TDIAM in the input file.
          AVERX           /MCOM4/        R*4     MCOM.INC
                          Average terrain elevation above sea level between
                          receive site and radio horizon, in meters.
          AVETX           /MCOM4/        R*4     MCOM.INC
                          Average terrain elevation above sea level between
                          transmit site and radio horizon, in meters.
          BW              /SYSTRN/       R*4     TROCOM.INC
                          Bandwidth in Hertz.  Default is 7 MHz.
          CHGHR           /IODATA/       L*4     IODATA.INC
                          HR set to AR(1) if TRUE.
          CHGHRE          /IODATA/       L*4     IODATA.INC
                          HRE set to HR if TRUE.
          CHGHT           /IODATA/       L*4     IODATA.INC
                          HT set to AT(1) if TRUE.
          CHGHTE          /IODATA/       L*4     IODATA.INC
                          HTE set to HT if TRUE.
          CN2(NPROF)      /PROPAR/       R*4     TROCOM.INC
                          The atmospheric structure constant height profile in
                          meters to the -2/3 power.
          D               /PATHGE/       R*4     TROCOM.INC
                          Great circle distance between transmitter and receiver
                          measured at sea level in meters.
          DEG             /UNIT/         R*4     IODATA.INC
                          String 'deg ' for units output.
          DELH            /PROPAR/       R*4     TROCOM.INC
                          Spacing of CN2 samples in meters.
          DEMIN           /CURVE/        R*4     CURVE.INC
                          User supplied minima of the 90th percentile
                          variability curve, YO(90).
          DIVTYP          /MCOM2/        I*2     MCOM.INC
                          Diversity configuration indicator.  Default is 0.
                           0 = 2 receive antennas; 2S    2S/2F    2S/2A 2S/2A/2F
                           1 = 1 receive antenna;  2A    2F       2F/2A
                           2 = 2 transmit,
                               2 receive antennas; 2S/2P 2S/2P/2A
                           3 = Not used
```

```
                 4 = User supplied parameters
                 S = Space  F = Frequency  A = Angle  P = Polarization
DL(3)            /MCOM4/          R*4     MCOM.INC
                 Array containing distance from each obstacle to
                 transmitter in meters.
DLR              /PATHGE/         R*4     TROCOM.INC
                 Distance from receiver to radio horizon in meters.
DLT              /PATHGE/         R*4     TROCOM.INC
                 Distance from transmitter to radio horizon in meters.
DRATE            /MCOM4/          R*4     MCOM.INC
                 Data rate in bits/second.  Default is 6.6E6.
DS(3)            /MCOM4/          R*4     MCOM.INC
                 Array of effective obstacle extents along the great
                 circle path in meters.
ELANG(10)        /MCOM4/          R*4     MCOM.INC
                 Interferer elevation angles in degrees.  Default is 0.
ERFAC            /PROPAR/         R*4     TROCOM.INC
                 Yearly median value of effective earth radius factor k
                 in kilometers.  Default is 1.33.
ERR              /CONTROL/        R*4     TROCOM.INC
                 Common volume integration resolution. Default is .001.
F                /SYSTRN/         R*4     TROCOM.INC
                 Operating frequency in Hz.  Model is accurate between
                 100MHz and 10GHz.
FT               /UNIT/           R*4     IODATA.INC
                 String 'ft  ' for units output.
GHZ              /UNIT/           R*4     IODATA.INC
                 String 'GHz ' for units output.
HI(155)          /MCOM4/          R*4     MCOM.INC
                 Array containing NPM(1) evenly-spaced terrain
                 elevation data (in meters) between transmitter and
                 first obstacle followed by NPM(2) evenly-spaced
                 terrain elevation data between first and second
                 obstacle, etc., ending with NPM(NOBS+1) evenly-spaced
                 terrain elevation data between last obstacle and
                 receive site. The data should be selected such that:
                         HI(1) = Terrain elevation above sea level at
                                  transmit site (HTO).
                         HI(NPM(I)) = HI (NPM(I)+1) = Elevation of Ith
                                  obstacle above sea level (HL(I)).
                         HI(NPM(NOBS+1)) = Terrain elevation above sea
                                  level at receive site (HRO).
                 In MDTS, HI is used as work space.  It is equivalenced
                 to local arrays.
HL(3)            /MCOM4/          R*4     MCOM.INC
                 Array containing elevation of each obstacle above sea
                 level in meters.  HL(1) is elevation of transmitter
                 radio horizon HLT.  HL(NOBS) is elevation of receiver
                 radio horizon HLR.
HLAV(3)          /MCOM4/          R*4     MCOM.INC
```

# CHAPTER 4

# ERROR UTILITIES

This section describes the data checking and error handling routines:

| Name | Description | User's Manual section |
|---|---|---|
| CHKDAT | Check data . . . . . . . . . . . | 2.2 |
| ERROR | Error message output . . . . . | 2.3, 3.4.3 |
| SUBID | Subprogram output identifier . | NA |

CHKDAT is only a preliminary data checking routine. More testing is done throughout TROPO, ERROR being called when a warning is to be printed or when a fatal error has been found. ERROR writes oth to the user's terminal and the error output file FOR002.DAT, units LTERM and LERR. FOR002.DAT is described in section 3.4.3 of the User's Manual.

NOTE

In most cases the sections in the User's Manual describe the coded equations as well as the theory behind them. NA denotes routines that are programming utilities such as finding indices, setting pointers, etc.

## 3.7 UNITS

Subprogram name: Subroutine UNITS

Purpose: Determine combination of measurement units requested by the user. UNITS sets LUNITS to a unique number for the combination of distance (statute miles, nautical miles, kilometers), height/diameter (feet, meters), angle (degrees, milliradians), and frequency (Gigahertz, Megahertz). LUNITS is used in subroutines OUTDAT and SUMPAG to output data in the user's units and in UNITCV to convert back and forth to MKS units.

Calling sequence:
    CALL UNITS

Contained in module: UNITS

Called by: INDATA

Calls: ERRIO

Input arguments:
    NONE

Output arguments:
    NONE

Global variables input from common:

```
     DEG            /UNIT/         R*4     IODATA.INC
                    String 'deg ' for units output.
     FT             /UNIT/         R*4     IODATA.INC
                    String 'ft  ' for units output.
     GHZ            /UNIT/         R*4     IODATA.INC
                    String 'GHz ' for units output.
     KM             /UNIT/         R*4     IODATA.INC
                    String 'km  ' for units output.
     LERR           /LUNS/         I*2     LUNS.INC
                    Error output unit.
     MET            /UNIT/         R*4     IODATA.INC
                    String 'met ' for units output.
     MHZ            /UNIT/         R*4     IODATA.INC
                    String 'MHz ' for units output.
     MRADNS         /UNIT/         R*4     IODATA.INC
                    String 'mrad' for units output.
     NMI            /UNIT/         R*4     IODATA.INC
                    String 'nmi ' for units output.
     SMI            /UNIT/         R*4     IODATA.INC
                    String 'smi ' for units output.
```

Global variables output to common:

| | | | |
|---|---|---|---|
| | antenna is aimed relative to the horizon. PSIREO(1) is the main receive antenna. | | |
| PSITAO(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of transmitter beam azimuths in radians. | | |
| PSITEO(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of transmitter beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSITEO(1) is the main transmit antenna. | | |
| THER | /PATHGE/ | R*4 | TROCOM.INC |
| | Radio horizon elevation angle at receive site in radians. | | |
| THET | /PATHGE/ | R*4 | TROCOM.INC |
| | Radio horizon elevation angle at transmit site in radians. | | |
| THETAO | /PATHGE/ | R*4 | TROCOM.INC |
| | Scattering angle at bottom of common volume in radians. | | |
| URH(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas horizontal offsets from great circle plane in meters. | | |
| URL(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas longitudinal offsets in meters. | | |
| URV(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas vertical offsets in meters. | | |
| UTH(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas horizontal offsets in meters. | | |
| UTL(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas longitudinal offsets in meters. | | |
| UTV(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas vertical offsets in meters. | | |
| Y1 | /PATHGE/ | R*4 | TROCOM.INC |
| | Maximum estimated integration length in Y-direction. | | |

| | | | |
|---|---|---|---|
| | HI(NPM(NOBS+1)) = Terrain elevation above sea level at receive site (HRO). In MDTS, HI is used as work space. It is equivalenced to local arrays. | | |
| HL(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing elevation of each obstacle above sea level in meters. HL(1) is elevation of transmitter radio horizon HLT. HL(NOBS) is elevation of receiver radio horizon HLR. | | |
| HLAV(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing average terrain elevation at each diffraction point in meters. | | |
| HLEF(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing effective height of obstacles above average terrain elevation in meters. | | |
| HLOW | /PROPAR/ | R*4 | TROCOM.INC |
| | Lowest height above sea level at which CN2 is specified in meters. | | |
| HLR | /PATHGE/ | R*4 | TROCOM.INC |
| | Receiver radio horizon elevation above sea level in meters. | | |
| HLT | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit radio horizon elevation above sea level in meters. | | |
| HRE | /MCOM4/ | R*4 | MCOM.INC |
| | Effective receiver antenna height above average terrain elevation in meters. | | |
| HRN | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive antenna height above sea level in meters. | | |
| HTE | /MCOM4/ | R*4 | MCOM.INC |
| | Effective transmitter antenna height above average terrain elevation in meters. | | |
| HTN | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit antenna height above sea level in meters. | | |
| PHDIV | /MCOM4/ | R*4 | MCOM.INC |
| | Squint angle between upper and lower receiver beams in radians. Default is beamwidth. | | |
| PHI | /PATHGE/ | R*4 | TROCOM.INC |
| | Diffraction angle in radians. | | |
| PHIR | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive angular distance to minimum scattering point in radians. | | |
| PHIT | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit angular distance to minimum scattering point in radians. | | |
| PSIRAO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of receiver beam azimuths in radians. | | |
| PSIREO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of receiver beam boresight elevations above radio horizon in radians, ie, angle at which each | | |

| | | | | |
|---|---|---|---|---|
| BETA0 | /PATHGE/ | R*4 | TROCOM.INC | |
| | Minimum receive antenna elevation angle measured from receiver-to-transmitter line to receiver horizon line in radians. | | | |
| BETA1 | /PATHGE/ | R*4 | TROCOM.INC | |
| | Maximum receive antenna elevation angle measured from receiver-to-transmitter line to top of common volume in radians. | | | |
| D | /PATHGE/ | R*4 | TROCOM.INC | |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | | |
| DELH | /PROPAR/ | R*4 | TROCOM.INC | |
| | Spacing of CN2 samples in meters. | | | |
| DL(3) | /MCOM4/ | R*4 | MCOM.INC | |
| | Array containing distance from each obstacle to transmitter in meters. | | | |
| DLR | /PATHGE/ | R*4 | TROCOM.INC | |
| | Distance from receiver to radio horizon in meters. | | | |
| DLT | /PATHGE/ | R*4 | TROCOM.INC | |
| | Distance from transmitter to radio horizon in meters. | | | |
| DR | /PATHGE/ | R*4 | TROCOM.INC | |
| | Receiver distance to minimum scattering point in meters. | | | |
| DS(3) | /MCOM4/ | R*4 | MCOM.INC | |
| | Array of effective obstacle extents along the great circle path in meters. | | | |
| DT | /PATHGE/ | R*4 | TROCOM.INC | |
| | Transmit antenna distance to minimum scattering point in meters. | | | |
| F | /SYSTRN/ | R*4 | TROCOM.INC | |
| | Operating frequency in Hz. Model is accurate between 100MHz and 10GHz. | | | |
| HCOM | /PATHGE/ | R*4 | TROCOM.INC | |
| | Effective height of the bottom of the common volume in meters. | | | |
| HHIGH | /PATHGE/ | R*4 | TROCOM.INC | |
| | Effective height of the top of the common volume in meters. | | | |
| HI(155) | /MCOM4/ | R*4 | MCOM.INC | |
| | Array containing NPM(1) evenly-spaced terrain elevation data (in meters) between transmitter and first obstacle followed by NPM(2) evenly-spaced terrain elevation data between first and second obstacle, etc., ending with NPM(NOBS+1) evenly-spaced terrain elevation data between last obstacle and receive site. The data should be selected such that:<br>HI(1) = Terrain elevation above sea level at transmit site (HTO).<br>HI(NPM(I)) = HI (NPM(I)+1) = Elevation of Ith obstacle above sea level (HL(I)). | | | |

```
                    Integer value that specifies the set of units
                    requested by the user.  These units are for path,
                    antenna location, angle, and frequency parameters.
                    Default is 8.  The given units are defined by bit
                    values of LUNITS:
                    Bit no.        Meaning of value 0 / 1
                      0            english / metric
                      1            statute miles / nautical miles
                      2            feet / meters
                      3            mrad / degrees
                      4            GHz / MHz
                    Valid LUNITS values are
                    0 :   stat. miles  - feet   - milliradians - GHz
                    1 :   kilometers   - meters - milliradians - GHz
                    2 :   naut. miles  - feet   - milliradians - GHz
                    8 :   stat. miles  - feet   - degrees      - GHz
                    9 :   kilometers   - meters - degrees      - GHz
                    10:   naut.miles   - feet   - degrees      - GHZ
                    16:   stat. miles  - feet   - milliradians - MHz
                    17:   kilometers   - meters - milliradians - MHz
                    18:   naut. miles  - feet   - milliradians - MHz
                    24:   stat. miles  - feet   - degrees      - MHz
                    25:   kilometers   - meters - degrees      - MHz
                    26:   naut. miles  - feet   - degrees      - MHz
     NR             /SYSTRN/        I*2     TROCOM.INC
                    Number of receive ports.
     NT             /SYSTRN/        I*2     TROCOM.INC
                    Number of transmit ports.

Global variables output to common:
     ALFA0          /PATHGE/        R*4     TROCOM.INC
                    Minimum transmit antenna elevation angle measured from
                    transmitter-to-receiver line to transmit horizon line
                    in radians.
     ALFA1          /PATHGE/        R*4     TROCOM.INC
                    Maximum transmit antenna elevation angle measured from
                    transmitter-to-receiver line to top of common volume
                    in radians.
     AR(NRMX)       /ANTENN/        R*4     TROCOM.INC
                    Array of receiver antenna diameters in meters.  AR(1)
                    is equivalent to RDIAM in the input file.
     AT(NTMX)       /ANTENN/        R*4     TROCOM.INC
                    Array of transmitter antenna diameters in meters.
                    AT(1) is equivalent to TDIAM in the input file.
     AVERX          /MCOM4/         R*4     MCOM.INC
                    Average terrain elevation above sea level between
                    receive site and radio horizon, in meters.
     AVETX          /MCOM4/         R*4     MCOM.INC
                    Average terrain elevation above sea level between
                    transmit site and radio horizon, in meters.
```

## 3.6 UNITCV

Subprogram name: Subroutine UNITCV

Purpose: UNITCV converts data to MKS units if the argument is positive and converts from MKS units to input units (those requested by the user in the input file, TROPO.DAT) if the argument is negative. This allows the user freedom to input in desired units and see the output in the same units but still allow the program to run with the units it expects. MKS units are: meters for height, distance and elvation, seconds for time, radians for angles, and Hz for the operating frequency. Bandwidths and data rates are not converted.

Calling sequence:
CALL UNITCV (IDIR)

Contained in module: UNITCV

Called by: INDATA, SUMPAG

Calls: ERROR

Input arguments:
IDIR I*2 Directive flag:
>0 Convert to MKS units.
<0 Convert to user's units.

Output arguments:
NONE

Global variables input from common:

```
CDEGR      /CONSTA/    R*4   CONSTANTS.INC
           Radians per degree = 0.017453293.
CE3        /CONSTA/    R*4   CONSTANTS.INC
           1 X 10**3 = 1000.
CMTPFT     /CONSTA/    R*4   CONSTANTS.INC
           Meters per foot = 0.3048.
CMTPMI     /CONSTA/    R*4   CONSTANTS.INC
           Meters per statute mile = 1609.344
CMTPNM     /CONSTA/    R*4   CONSTANTS.INC
           Meters per nautical mile = 1852.
IDM        /UNIT/      I*2   IODATA.INC
           0 if degrees, 1 if milliradians.
IME        /UNIT/      I*2   IODATA.INC
           0 if metric units, 1 if English.
IMG        /UNIT/      I*2   IODATA.INC
           0 if MHz, 1 if GHz.
INS        /UNIT/      I*2   IODATA.INC
           0 if nautical miles, 1 if statute miles.
LUNITS     /UNIT/      I*2   IODATA.INC
```

## 3.5 SECTOR

Subprogram name: Subroutine SECTOR

Purpose: Search for a section header.

Description: SECTOR searches for a section header in the input file TROPO.DAT by reading lines until the first four characters on the line match the string passed in Y.

Calling sequence:

```
CALL SECTOR (Y, X)
```

Contained in module: INDATA

Called by: INDATA

Calls: ERRIO

Input arguments:

| | | |
|---|---|---|
| Y | R*4 | Word to search for. |

Output arguments:

| | | |
|---|---|---|
| X | R*4 | Word found. |

Global variables input from common:

| | | | |
|---|---|---|---|
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |

Global variables output to common:

| | | | |
|---|---|---|---|
| LIN | /LUNS/ | I*2 | LUNS.INC |
| | TROPO.DAT input unit number. | | |

2 = Calculate reference horizon using HORANG and K equals ERFAC. (Assuming DLT and DLR are non-zero.)
3 = Do not change reference horizons from previous run. (Option not available.)

characters.

UANGLE /UNIT/ R*4 IODATA.INC
Units of angle (deg, mrad).

UDIST /UNIT/ R*4 IODATA.INC
Units of distance (smi, nmi, km).

UFREQ /UNIT/ R*4 IODATA.INC
Units of frequency (GHz, MHz).

UHITE /UNIT/ R*4 IODATA.INC
Units of height and diameter (ft, m).

URH(NR) /PATHGE/ R*4 TROCOM.INC
Array of receive antennas horizontal offsets from great circle plane in meters.

URL(NR) /PATHGE/ R*4 TROCOM.INC
Array of receive antennas longitudinal offsets in meters.

URV(NR) /PATHGE/ R*4 TROCOM.INC
Array of receive antennas vertical offsets in meters.

UTH(NT) /PATHGE/ R*4 TROCOM.INC
Array of transmit antennas horizontal offsets in meters.

UTL(NT) /PATHGE/ R*4 TROCOM.INC
Array of transmit antennas longitudinal offsets in meters.

UTV(NT) /PATHGE/ R*4 TROCOM.INC
Array of transmit antennas vertical offsets in meters.

WLT /SYSTRN/ R*4 TROCOM.INC
Rated transmission power in Watts. Default is 1000 W.

XANG(10) /MCOM4/ R*4 MCOM.INC
Interferer azimuth angles in degrees. Default is 0.

Y900 /CURVE/ R*4 CURVE.INC
User supplied value for 90th percentile variability curve Y0(90) for DE greater than or equal 900 km. Used only when ICLIME is 2. Used to compute the equation for the Y0(90) curve fit.

YMIN /CURVE/ R*4 CURVE.INC
User supplied value for 90th percentile variability curve Y0(90) for DE equal to DEMIN. Used only when ICLIME is 2. Used to compute the equation for the Y0(90) curve fit.

Global variables output to common:

ITOFF /PROPAR/ I*2 TROCOM.INC
Control indicator for entry or calculation of transmit/receive radio horizon angles THET and THER. Values have following meanings:
- 0 = Use input THET, THER as reference and actual horizon (default).
- 1 = Calculate reference horizon using HORANG and K equals 1.33. (Assuming DLT and DLR are non-zero.) (Option not available.)

| | | | | |
|---|---|---|---|---|
| | effective antenna heights (HTE, HRE) and effective obstacle heights above average terrain elevation (HLEF).<br>0 = HTE and HRE supplied directly<br>1 = AVETX and AVERX supplied<br>2 = HI(.) supplied | | | |
| PHDIV | /MCOM4/ | R*4 | MCOM.INC | |
| | Squint angle between upper and lower receiver beams in radians. Default is beamwidth. | | | |
| PSIRAO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | Array of receiver beam azimuths in radians. | | | |
| PSIREO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | Array of receiver beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSIREO(1) is the main receive antenna. | | | |
| PSITAO(NTMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | Array of transmitter beam azimuths in radians. | | | |
| PSITEO(NTMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | Array of transmitter beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSITEO(1) is the main transmit antenna. | | | |
| PXMIT | /MCOM4/ | R*4 | MCOM.INC | |
| | Rated transmission power in dBm. Default is 70dBm. | | | |
| RLL | /SYSTRN/ | R*4 | TROCOM.INC | |
| | Receiver line losses in dB. Default is 0 dB. | | | |
| SCPARM | /PROPAR/ | R*4 | TROCOM.INC | |
| | Wavenumber spectrum slope parameter M. Default is 3.66. | | | |
| SEAN | /PROPAR/ | R*4 | TROCOM.INC | |
| | Minimum monthly median of refractivity at sea level. Used to calculate ERFAC if non-zero. | | | |
| SMI | /UNIT/ | R*4 | IODATA.INC | |
| | String 'smi ' for units output. | | | |
| SP | /MCOM4/ | R*4 | MCOM.INC | |
| | Service probability. Default is .95. | | | |
| TAPW | /MCOM4/ | R*4 | MCOM.INC | |
| | Normalized tapwidth for MD-918. Default is .5. Range is 0.25 through 1.0 | | | |
| THER | /PATHGE/ | R*4 | TROCOM.INC | |
| | Radio horizon elevation angle at receive site in radians. | | | |
| THET | /PATHGE/ | R*4 | TROCOM.INC | |
| | Radio horizon elevation angle at transmit site in radians. | | | |
| TLL | /SYSTRN/ | R*4 | TROCOM.INC | |
| | Transmitter line losses in dB. Default is 0 dB. | | | |
| TODAY(9) | /TSTAMP/ | L*1 | IODATA.INC | |
| | Array used in PDP-11 version to hold date as | | | |

```
MODPAT        /MCOM2/        I*2    MCOM.INC
              Propagation/modem flag to select calculation mode.
              Default is 1.
                      0 = Propagation only
                      1 = Propagation + MD-918 modem
                      2 = Propagation + AN/TRC-170 or DAR modem
                      3 = Propagation + user-defined modem
MODSIG        /MCOM2/        I*2    MCOM.INC
              Interference signal modulation format.  Default is 1.
                      0 = Analog FDM / FM
                      1 = Digital QPSK
MRADNS        /UNIT/         R*4    IODATA.INC
              String 'mrad' for units output.
NACCU         /CONTRL/       I*2    TROCOM.INC
              Parameter used as truncation point for common
              volume integration termination.  Default is 40.
NCLIME        /MCOM2/        I*2    MCOM.INC
              Flag set to 1 if ICLIME equals 2.
NERT          /MCOM2/        I*2    MCOM.INC
              Bit error rate threshold indicator for yearly fade
              outage probability calculation.  Default is 2.
                      0 = All three thresholds
                      1 = For 10**(-3) only
                      2 = For 10**(-4) only
                      3 = For 10**(-5) only
NEWCL(4)      /MCOM2/        I*2    MCOM.INC
              New climate type character string.
NFIG          /MCOM4/        R*4    MCOM.INC
              Receiver noise figure in dB.  Default is 4dB.
NMI           /UNIT/         R*4    IODATA.INC
              String 'nmi ' for units output.
NOBS          /MCOM2/        I*2    MCOM.INC
              Number of diffraction obstacles. Maximum is 3,
              default is 1.
NOW(8)        /TSTAMP/       L*1    IODATA.INC
              Array used in PDP-11/70 version to hold time of day as
              characters.
NPM(5)        /MCOM2/        I*2    MCOM.INC
              Array containing number of terrain elevation data
              points for calculation of effective antenna heights
              for each section of the diffraction path.
NR            /SYSTRN/       I*2    TROCOM.INC
              Number of receive ports.
NT            /SYSTRN/       I*2    TROCOM.INC
              Number of transmit ports.
NTAP          /MCOM2/        I*2    MCOM.INC
              Number of adaptive forward equalizer taps (AFE) in
              MD-918 modem.  Set to 3 in INDATA.
NTERR         /MCOM2/        I*2    MCOM.INC
              Control parameter for entry or calculation of
```

1 = Interferer covariance matrix calculation done in subroutine JAMCOM

**KM** /UNIT/ R*4 IODATA.INC
String 'km ' for units output.

**KPROF** /PROPAR/ I*2 TROCOM.INC
Actual number of samples in height profile of structure constant CN2. Limited to NPROF samples.

**LISI** /MCOM2/ I*2 MCOM.INC
Number of future Intersymbol Interference (ISI) contributors considered in MD-918 performance calculation. Default is 2.

**LNAME(20)** /IODATA/ I*2 IODATA.INC
Link name. Transmitter site first, receiver site second. Used as link identifier on output files FOR002.DAT and SUMPAG.OUT.

**LOUT** /LUNS/ I*2 LUNS.INC
FOR002.DAT output unit number.

**LUNITS** /UNIT/ I*2 IODATA.INC
Integer value that specifies the set of units requested by the user. These units are for path, antenna location, angle, and frequency parameters. Default is 8. The given units are defined by bit values of LUNITS:

| Bit no. | Meaning of value 0 / 1 |
|---|---|
| 0 | english / metric |
| 1 | statute miles / nautical miles |
| 2 | feet / meters |
| 3 | mrad / degrees |
| 4 | GHz / MHz |

Valid LUNITS values are

| | | | | |
|---|---|---|---|---|
| 0 : | stat. miles | - feet | - milliradians | - GHz |
| 1 : | kilometers | - meters | - milliradians | - GHz |
| 2 : | naut. miles | - feet | - milliradians | - GHz |
| 8 : | stat. miles | - feet | - degrees | - GHz |
| 9 : | kilometers | - meters | - degrees | - GHz |
| 10: | naut.miles | - feet | - degrees | - GHZ |
| 16: | stat. miles | - feet | - milliradians | - MHz |
| 17: | kilometers | - meters | - milliradians | - MHz |
| 18: | naut. miles | - feet | - milliradians | - MHz |
| 24: | stat. miles | - feet | - degrees | - MHz |
| 25: | kilometers | - meters | - degrees | - MHz |
| 26: | naut. miles | - feet | - degrees | - MHz |

**MANG** /MCOM2/ I*2 MCOM.INC
Number of values of interferer azimuth/elevation pairs (JANG) for which outage calculations are to be made. Default is 1.

**MET** /UNIT/ R*4 IODATA.INC
String 'met ' for units output.

**MHZ** /UNIT/ R*4 IODATA.INC
String 'MHz ' for units output.

| | | | |
|---|---|---|---|
| | Array containing average terrain elevation at each diffraction point in meters. | | |
| HLEF(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing effective height of obstacles above average terrain elevation in meters. | | |
| HLOW | /PROPAR/ | R*4 | TROCOM.INC |
| | Lowest height above sea level at which CN2 is specified in meters. | | |
| HLR | /PATHGE/ | R*4 | TROCOM.INC |
| | Receiver radio horizon elevation above sea level in meters. | | |
| HLT | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit radio horizon elevation above sea level in meters. | | |
| HRN | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive antenna height above sea level in meters. | | |
| HTE | /MCOM4/ | R*4 | MCOM.INC |
| | Effective transmitter antenna height above average terrain elevation in meters. | | |
| HTN | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit antenna height above sea level in meters. | | |
| IBR(NRMX,NRMX) | /SYSTRN/ | I*2 | TROCOM.INC |
| | Channel complex-envelope correlation and cross-correlation calculation indicator array.<br>0 = No calculation<br>1 = Power (correlation) calculation only<br>2 = Power (correlation) per unit delay spectrum calculation | | |
| IBW | /MCOM2/ | I*2 | MCOM.INC |
| | Switch indicating type of RF bandwidth constraint to be used on desired signal. Default is 0.<br>0 = No RF filtering<br>1 = Filter determined from 99% bandwidth constraint<br>2 = Filter chosen to meet FCC Mask. (FCC-19311)<br>3 = Filters are user specified | | |
| ICLIME | /MCOM2/ | I*2 | MCOM.INC |
| | Climate class. Default is 0.<br>0 = NBS TN-101 climate<br>1 = MIL-HDBK-417 climate<br>2 = New, user-supplied climate | | |
| IPOLR(NRMX) | /ANTENN/ | I*2 | TROCOM.INC |
| | Array of receiver antenna polarizations. | | |
| IPOLT(NTMX) | /ANTENN/ | I*2 | TROCOM.INC |
| | Array of transmitter antenna polarizations. | | |
| JFILT | /MCOM2/ | I*2 | MCOM.INC |
| | Interference covariance matrix calculation indicator. Only used when IBW equals 0, otherwise ignored. Default is 0.<br>0 = Interferer covariance matrix calculation done in subroutine BOTAC | | |

## 4.1 CHKDAT

Subprogram name: Subroutine CHKDAT

Purpose: Performs a preliminary check of the validity of the data read from the input file TROPO.DAT. Array bounds, path symmetry, and validity of the specified correlations (through the array IBR) are verified. Further checking is done throughout TROPO.

Calling sequence:
CALL CHKDAT

Contained in module: CHKDAT

Called by: TROPO

Calls: ERROR

Input arguments:
NONE

Output arguments:
NONE

Global variables input from common:

```
AR(NRMX)        /ANTENN/        R*4     TROCOM.INC
                Array of receiver antenna diameters in meters.  AR(1)
                is equivalent to RDIAM in the input file.
AT(NTMX)        /ANTENN/        R*4     TROCOM.INC
                Array of transmitter antenna diameters in meters.
                AT(1) is equivalent to TDIAM in the input file.
IBR(NRMX,NRMX)  /SYSTRN/        I*2     TROCOM.INC
                Channel complex-envelope correlation and
                cross-correlation calculation indicator array.
                        0 = No calculation
                        1 = Power (correlation) calculation only
                        2 = Power (correlation) per unit delay
                          spectrum calculation
NR              /SYSTRN/        I*2     TROCOM.INC
                Number of receive ports.
NRMX            Parameter       I*2     TROPAR.INC
                Maximum number of receive ports.
NT              /SYSTRN/        I*2     TROCOM.INC
                Number of transmit ports.
NTMX            Parameter       I*2     TROPAR.INC
                Maximum number of transmit ports.
PSIRAO(NRMX)    /ANTENN/        R*4     TROCOM.INC
                Array of receiver beam azimuths in radians.
PSIREO(NRMX)    /ANTENN/        R*4     TROCOM.INC
                Array of receiver beam boresight elevations above
```

| | | | |
|---|---|---|---|
| | radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSIREO(1) is the main receive antenna. | | |
| PSITAO(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of transmitter beam azimuths in radians. | | |
| PSITEO(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of transmitter beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSITEO(1) is the main transmit antenna. | | |
| URH(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas horizontal offsets from great circle plane in meters. | | |
| URL(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas longitudinal offsets in meters. | | |
| URV(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas vertical offsets in meters. | | |
| UTH(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas horizontal offsets in meters. | | |
| UTL(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas longitudinal offsets in meters. | | |
| UTV(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas vertical offsets in meters. | | |

## 4.2 ERROR

Subprogram name:     Subroutine ERROR

Purpose:     Outputs error number and error message to terminal (unit LTERM) and the output file FOR002.DAT (unit LOUT).

Description: Checking for input errors is done throughout TROPO. When a fatal error or data inconsistency is found, processing transfers to subroutine ERROR. Most errors found are fatal so processing branches to line 500 to STOP after outputting the message; others are merely warnings and branch to 600 to return to the calling program and continue processing.

The errors are divided in the source code by calling routine so a check of the code or FORMAT statements reveals in which routine the error was encountered.

Note that for all error 999s the calling program has already printed an error message to the output file FOR002.DAT before calling ERROR.

Calling sequence:
```
CALL ERROR (I)
```

Contained in module: ERROR

Called by:   ANTPAR   ATMOS   CHANGE   CHKDAT   CLIME   CLIMIL   CLIMIX   DEIND
LOOPS   MATA   MDIF   MDTS   ORDER   RIPROF   SIGIN   SQTMAT   SUMPAG
TRANSF   TRCIN   TRLOSS   UNITCV   UNITS

Calls:       NONE

Input arguments:

| | | |
|---|---|---|
| I | I*2 | Error number. |

Output arguments:
NONE

Global variables input from common:

| | | | |
|---|---|---|---|
| LOUT | /LUNS/ | I*2 | LUNS.INC |
| | FOR002.DAT output unit number. | | |

## 4.3 SUBID

Subprogram name: Subroutine SUBID

Purpose: Subroutine to identify blocks of output or output variables by writing 'SNAME', the subprogram printing such output, to logical unit, LOUT.

Calling sequence:
CALL SUBID (SNAME)

Contained in module: SUBID

Called by:

Calls: NONE

Input arguments:
SNAME R*8 Name of subprogram to output.

Output arguments:
NONE

Global variables input from common:
LOUT /LUNS/ I*2 LUNS.INC
FOR002.DAT output unit number.

# CHAPTER 5

# TROPOSCATTER CALCULATIONS

This section describes the tropospheric scatter calculation routines:

| Name | Description | User's Manual section |
|---|---|---|
| ANTPAR | Antenna parameters . . . . . . | 2.5.2.1 |
| ANTPTR | Antenna pointers . . . . . . . . | NA |
| ATMOS | Atmospheric absorption calculations . . . . . . . . . . | 2.5.2.4 |
| AVTER | Average terrain height . . . . | 2.5.4.7 |
| BEAMPT | Beam pointers . . . . . . . . . | NA |
| DELO | Delay . . . . . . . . . . . . . . | NA |
| ERFC | Complimentary error function . | NA |
| FRQSEP | Frequency separation . . . . . | 2.5.6.3 |
| GPATT | Voltage gain pattern . . . . . | 2.5.2.1 |
| HORANG | Horizon elevation angles . . . | NA |
| INTLIM | Integration limits . . . . . . . | 2.5.2.2 |
| LOOPS | Main routine for common volume integration . . . . . . . . . . | 2.5.6.1 |
| LTCORR | Long term variability correction factor . . . . . . . . | 2.5.7 |
| POWER | Long term RSL and SNR distribution . . . . . . . . . . | 2.5, 2.5.4.6 |
| RGAIN | Receive antenna voltage gain pattern . . . . . . . . . . . . . | 2.5.2 |
| RIPROF | Structure constant profile calculation . . . . . . . . . . | 2.5.2.3 |
| STEPAB | Step size of alpha and beta . . | NA |
| STEPY | Step size of Y . . . . . . . . | NA |
| STPPAR | Step size parameters . . . . . | NA |
| TGAIN | Transmit antenna voltage gain pattern . . . . . . . . . . . . . | 2.5.2 |
| TRANSF | Transform angles and distances | 2.5.2, 2.5.2.2 |
| TRLOSS | Theoretical calculation of basic pathloss . . . . . . . . . | NA |

The main routines for this section are LOOPS and POWER. The troposcatter calculations are described in section 2.5 of the User's Manual.

Figure 2-2 is a top level flowchart for troposcatter propagation parameter calculations at a functional level. In most cases the blocks correspond to one or more subprograms. The test blocks (diamonds) correspond to logical branches which are decided by the user's choices of input data.

NOTE

In most cases the sections in the User's Manual describe the coded equations as well as the theory behind them. NA denotes routines that are programming utilities such as finding indices, setting pointers, etc.

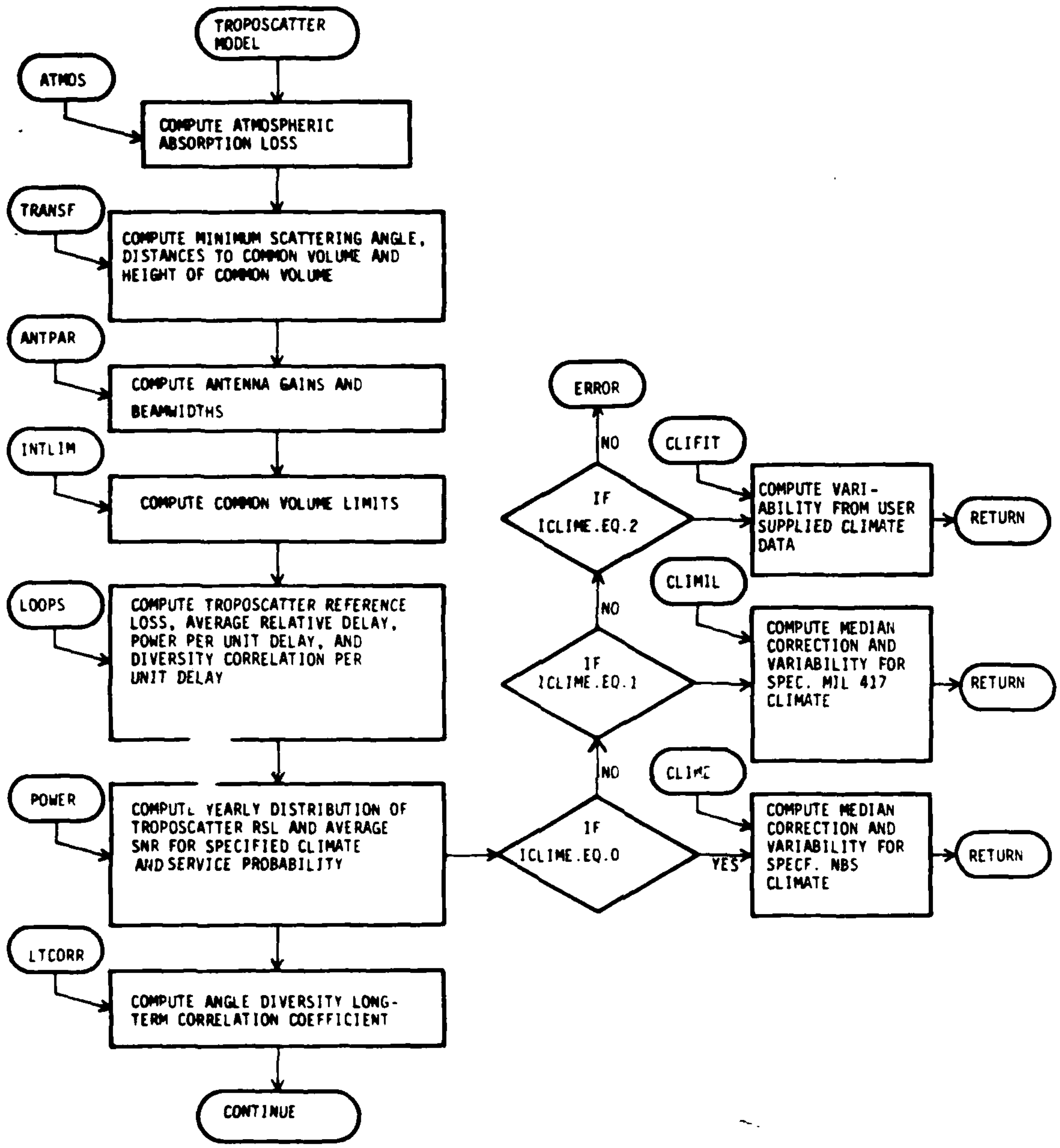



Figure 2-2 Flow Chart for Troposcatter Propagation Parameter Calculations

## 5.1 ANTPAR

Subprogram name: Subroutine ANTPAR

Purpose: For NPORT>0 ANTPAR returns the gain in dB of transmit antenna number NPORT and the 3dB half-beamwidth in radians. For NPORT<0 the values are for receive beam number -NPORT.

Calling sequence:

```
CALL ANTPAR (NPORT,GDB,DEL)
```

Contained in module: ANTPAR

Called by: TROPO

Calls: ERROR

Input arguments:

| | | |
|---|---|---|
| NPORT | I*2 | Antenna number. |

Output arguments:

| | | |
|---|---|---|
| GDB | R*4 | Gain of requested antenna in dB. |
| DEL | R*4 | 3dB half-beamwidth in radians. |

Global variables input from common:

| | | | |
|---|---|---|---|
| AR(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of receiver antenna diameters in meters. AR(1) is equivalent to RDIAM in the input file. | | |
| AT(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of transmitter antenna diameters in meters. AT(1) is equivalent to TDIAM in the input file. | | |
| NRMX | Parameter | I*2 | TROPAR.INC |
| | Maximum number of receive ports. | | |
| NTMX | Parameter | I*2 | TROPAR.INC |
| | Maximum number of transmit ports. | | |
| WAVLEN | /SYSTRN/ | R*4 | TROCOM.INC |
| | Wavelength in meters. | | |

## 5.2 ANTPTR

Subprogram name: Subroutine ANTPTR

Purpose: Set up pointers to distinct antenna locations to avoid duplication of operations in the critical parts of LOOPS.

Calling sequence:
CALL ANTPTR (NPORTS, UH, UV, UL, NANT, LOC)

Contained in module: ANTPTR

Called by: LOOPS, SUMPAG

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| NPORTS | I*2 | Number of transmit or receive ports. |
| UH(NPORTS) | R*4 | Horizontal offsets of antennas. |
| UV(NPORTS) | R*4 | Vertical offsets of antennas. |
| UL(NPORTS) | R*4 | Longitudinal offsets of antennas. |

Output arguments:

| | | |
|---|---|---|
| NANT | I*2 | Number of distinct antenna locations. |
| LOC(NPORTS) | I*2 | Pointers to location of antenna. |

## 5.3 ATMOS

Subprogram name: Subroutine ATMOS

Purpose: Calculate atmospheric attenuation AA in dB for a troposcatter/diffraction path of length D in meters at frequency F in Hz. D must be less than 500 km and F must be less than 35 GHz.

Calling sequence:
CALL ATMOS

Contained in module: ATMOS

Called by: TROPO

Calls: ERROR

Input arguments:
NONE

Output arguments:
NONE

Global variables input from common:

| | | | |
|---|---|---|---|
| D | /PATHGE/ | R*4 | TROCOM.INC |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | |
| F | /SYSTRN/ | R*4 | TROCOM.INC |
| | Operating frequency in Hz. Model is accurate between 100MHz and 10GHz. | | |

Global variables output to common:

| | | | |
|---|---|---|---|
| AA | /PROPAR/ | R*4 | TROCOM.INC |
| | Atmospheric absorption loss in dB. | | |

## 5.4 AVTER

Subprogram name: Subroutine AVTER

Purpose: Routine to calculate average terrain height above sea level at TWO terminal points 1 and 2 given NP evenly spaced terrain elevation data points between them by fitting a straight line to terrain data.

Calling sequence:

```
CALL AVTER (H1AV,H2AV,HI,NP,X0,X20,D)
```

Contained in module: AVTER

Called by: DIFSNR, POWER

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| HI(NP) | R*4 | Array of NP evenly spaced terrain elevations in meters above sea level. |
| NP | I*2 | Number of data points used to calculate average heights. |
| X0 | R*4 | Distance of first terrain height data point from terminal point 1 in meters. |
| X20 | R*4 | Distance of last terrain height point from terminal 1 in meters. |
| D | R*4 | Distance between terminal points 1 and 2 in meters. |

Output arguments:

| | | |
|---|---|---|
| H1AV | R*4 | Average terrain height at terminal 1 in meters. |
| H2AV | R*4 | Average terrain height at terminal 2 in meters. |

## 5.5 BEAMPT

Subprogram name: Subroutine BEAMPT

Purpose: Set up pointers to distinct receive antenna beams to avoid duplication of operations in the critical parts of LOOPS. The pointers are used in LOOPS to calculate angle diversity correlations for a troposcatter receiver.

Calling sequence:
CALL BEAMPT (NPORTS, PSIE, PSIA, NBEAM, IBEAM, JBEAM)

Contained in module: BEAMPT

Called by: LOOPS

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| NPORTS | I*2 | Number of transmit or receive ports. |
| PSIE(NPORTS) | R*4 | Beam boresight elevations above radio horizon. |
| PSIA(NPORTS) | R*4 | Beam azimuths. |

Output arguments:

| | | |
|---|---|---|
| NBEAM | I*2 | Number of distinct beams. |
| IBEAM(NPORTS) | I*2 | Pointers to antenna ports from beam number. IBEAM(I) identifies the lowest numbered port with antenna pattern number I. |
| JBEAM(NPORTS) | I*2 | Pointers to beam number from antenna port. JBEAM(I) is the antenna pattern of antenna port number I. |

## 5.6 DELO

Subprogram name: Subroutine DELO

Purpose: Calculates the delay, relative to DC, from the transmitter to a scattering point to the receiver. The scattering point is characterized by ALFA, BETA, and DC. This delay value is used in the LOOPS integration for the calculation of the delay profile.

Calling sequence:
CALL DELO (ALFA, BETA, DC, DEL)

Contained in module: DELO

Called by: LOOPS

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| ALFA | R*4 | Angle between the transmitter-receiver line and the transmitter-scatterer line in radians. |
| BETA | R*4 | Angle between the receiver-transmitter line and the receiver-scatterer line in radians. |
| DC | R*4 | Delay between transmitter and receiver (straight line, free space) in seconds. |

Output arguments:

| | | |
|---|---|---|
| DEL | R*4 | Transmitter-scatter-receiver delay less the miminum delay DC in seconds. |

## 5.7 ERFC

Subprogram name: Function ERFC

Purpose: Complimentary error function approximation.

Reference: Abramowitz and Stegun, Handbook of Mathematical Functions, 1968, p. 299, 7.1.26.

Calling sequence:
ERFC (X,XLIMIT)

Contained in module: ERFC

Called by: CLIMIX DIFSNR PAVERG POUTAG POWER

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| X | R*4 | Lower limit on integration. |
| XLIMIT | R*4 | Cut-off limit on argument beyond which the function value is zero. |

Output arguments:

| | | |
|---|---|---|
| ERFC | R*4 | Complimentary error function approximation. |

## 5.14 POWER

Subprosram name: Subroutine POWER

Purpose: Calculates the lons term RSL distribution of the troposcatter signal for the specified climate type. It also calculates and prints out the lons term distribution of the SNR per diversity branch for a desired service probability.

Callins sequence:
```
CALL POWER (JPOW,ASEP,TAU22,TAU23,RH1,ELOSS,ASNR,BWT,BWR, PTYPE)
```

Contained in module: POWER

Called by: TROPO

Calls: AVTER CLIME CLIMIL CLIMIX ERFC

Input arsuments:

| | | |
|---|---|---|
| JPOW | R*8 | Interference signal power density in dBm/Hz. |
| ASEP | R*4 | Separation between receive antennas in meters. |
| PTYPE | I*2 | Variable which indicates whether propagation mechanism is pure troposcatter (0 or 10) or mixed troposcatter-diffraction (1 or 11). |
| BWT | R*4 | Transmit antenna beamwidth in desrees. |
| BWR | R*4 | Receive antenna beamwidth in desrees. |

Output arsuments:

| | | |
|---|---|---|
| ELOSS | R*8 | Upper beam squint loss for scatter component in dB or sidelobe loss for interference. |
| TAU22 | R*8 | Delay spread on lower beam in nsec. |
| TAU23 | R*8 | Delay spread on upper beam in nsec. |
| RH1 | R*8 | Correlation coeffiecient between lower and upper beam. |
| ASNR | R*4 | Median and/or yearly averase value of troposcatter signal SNR in dB. |

Global variables input from common:

| | | | |
|---|---|---|---|
| AA | /PROPAR/ | R*4 | TROCOM.INC |
| | Atmospheric absorption loss in dB. | | |
| ALFA0 | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum transmit antenna elevation angle measured from transmitter-to-receiver line to transmit horizon line in radians. | | |
| BETA0 | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum receive antenna elevation angle measured from receiver-to-transmitter line to receiver horizon line in radians. | | |
| BW | /SYSTRN/ | R*4 | TROCOM.INC |
| | Bandwidth in Hertz. Default is 7 MHz. | | |
| C | /PDATA/ | R*4 | PDATA.INC |

```
                      Error output unit.
     PHDIV            /MCOM4/          R*4     MCOM.INC
                      Squint angle between upper and lower receiver beams in
                      radians.  Default is beamwidth.
     THER             /PATHGE/         R*4     TROCOM.INC
                      Radio horizon elevation angle at receive site in
                      radians.
     THETAO           /PATHGE/         R*4     TROCOM.INC
                      Scattering angle at bottom of common volume in
                      radians.

  Global variables output to common:
     CORRLT           /CPLOSS/         R*4     CPL.INC
                      Correlation coefficient for long term variability of
                      lower and upper beams.
```

## 5.13 LTCORR

Subprogram name: Subroutine LTCORR

Purpose: Computes correction factor for SNR due to decorrelation of long term variability between upper and lower beams. (Angle diversity only.)

Calling sequence:

```
CALL LTCORR (CORFAC)
```

Contained in module: LTCORR

Called by: TROPO

Calls: NONE

Input arguments:
NONE

Output arguments:

```
CORFAC  R*4     Correction factor computed by LTCORR.  CORFAC is used
                in subroutine BERCAL to scale STSNR multiplicatively
                when angle diversity is used.
```

Global variables input from common:

```
A               /PATHGE/        R*4     TROCOM.INC
                Effective earth radius in meters.
ALFA0           /PATHGE/        R*4     TROCOM.INC
                Minimum transmit antenna elevation angle measured from
                transmitter-to-receiver line to transmit horizon line
                in radians.
D               /PATHGE/        R*4     TROCOM.INC
                Great circle distance between transmitter and receiver
                measured at sea level in meters.
DIVTYP          /MCOM2/         I*2     MCOM.INC
                Diversity configuration indicator.  Default is 0.
                 0 = 2 receive antennas; 2S    2S/2F    2S/2A 2S/2A/2F
                 1 = 1 receive antenna;  2A    2F       2F/2A
                 2 = 2 transmit,
                     2 receive antennas; 2S/2P 2S/2P/2A
                 3 = Not used
                 4 = User supplied parameters
                S = Space  F = Frequency  A = Angle  P = Polarization
HCOM            /PATHGE/        R*4     TROCOM.INC
                Effective height of the bottom of the common volume in
                meters.
HRN             /PATHGE/        R*4     TROCOM.INC
                Receive antenna height above sea level in meters.
LERR            /LUNS/          I*2     LUNS.INC
```

```
                          Q(.,7)  Power on diffraction path vs. delay
                       For DIVTYP = 1:
                          Q(.,1)  Power on lower beam vs. delay.
                          Q(.,2)  Correlation between lower and
                                  upper beam vs. delay.
                          Q(.,3)  Power on upper beam vs. delay
                          Q(.,7)  Power on diffraction path vs. delay.
                       For DIVTYP = 2:
                          Q(.,1)  Power on path 1 (lower beam) vs. delay.
                          Q(.,2)  Correlation between convergent paths
                                  (lower beam) vs. delay.
                          Q(.,3)  Correlation between divergent paths
                                  (lower beam) vs. delay.
                          Q(.,4)  Correlation between parallel paths
                                  (lower beam) vs. delay.
                          Q(.,5)  Correlation between crossing paths
                                  (lower beam) vs. delay.
                          Q(.,6)  Power on path of upper beam vs. delay.
                          Q(.,7)  Power on diffraction path vs. delay.
QCORR(NCORMX)          /PDATA/        R*4    PDATA.INC
                       Contains elements of covariance matrix, ie, powers and
                       correlations.
                       For DIVTYP = 0:
                          QCORR(1) Power on lower beam
                          QCORR(2) Correlation coefficient between lower
                                   and upper beam.
                          QCORR(3) Correlation coefficient between lower
                                   beams of antennas 1 and 2
                          QCORR(4) Power on upper beam.
                       For DIVTYP = 1:
                          QCORR(1) Power on lower beam
                          QCORR(2) Correlation coefficient between lower
                                   and upper beam.
                          QCORR(3) Power on upper beam.
                       For DIVTYP = 2:
                          QCORR(1) Power on path 1 (lower beam)
                          QCORR(2) Correlation coefficient between convergent
                                   paths.
                          QCORR(3) Correlation coefficient between divergent
                                   paths.
                          QCORR(4) Correlation coefficient between parallel
                                   paths.
                          QCORR(5) Correlation coefficient between crossing
                                   paths.
                          QCORR(6) Power on upper beam.
TEMPA(NCORMX)          /PDATA/        R*4    PDATA.INC
                       Array of average troposcatter signal delays for each
                       beam relative to straight line in seconds.
```

| Variable | Common | Type | Include file | Description |
|---|---|---|---|---|
| C | /PDATA/ | R*4 | PDATA.INC | Proportionality constant in troposcatter path loss calculation. |
| DELPB | /PDATA/ | R*4 | PDATA.INC | Resolution of a delay cell in seconds. |
| FSEP | /PDATA/ | R*4 | PDATA.INC | Frequency separation for uncorrelated frequency diversity in Hz. |
| HCOM | /PATHGE/ | R*4 | TROCOM.INC | Effective height of the bottom of the common volume in meters. |
| I1CORR(NCORMX) | /PDATA/ | I*2 | PDATA.INC | Array of receiving beams involved in the correlation calculations. |
| I2CORR(NCORMX) | /PDATA/ | I*2 | PDATA.INC | Array of receiving beams involved in the correlation calculations. |
| IBLOSS(6) | /CPLOSS/ | I*2 | CPL.INC | Beam number corresponding to CPL(I). |
| ICPL | /CPLOSS/ | I*2 | CPL.INC | Coupling loss count. |
| INEG | /PDATA/ | I*2 | PDATA.INC | Number of negative delay cells encountered in troposcatter integration. It is an error if INEG > 0. |
| IPOS | /PDATA/ | I*2 | PDATA.INC | Number of delay cells exceeding the last allocated array element. This number should be zero or small. IPOS > 0 is not a serious error unless the delay profile calculated has a clear peak in the last delay cell. |
| IPROF(NCORMX) | /PDATA/ | I*2 | PDATA.INC | 0 if the Ith correlation not wanted, 1 if wanted. |
| ITER | /PDATA/ | I*4 | PDATA.INC | Number of integration cells in the common volume integration. |
| NCORR | /PDATA/ | I*2 | PDATA.INC | Number of receive port correlations. |
| PLOSSM | /PDATA/ | R*4 | PDATA.INC | Troposcatter path loss from approximate analytic expression. |
| Q(NDELMX,NCORMX) | /PDATA/ | R*4 | PDATA.INC | Matrix of troposcatter signal power and correlation per unit delay profiles.<br>For DIVTYP = 0:<br>Q(.,1) Power on lower beam vs. delay.<br>Q(.,2) Correlation between lower and upper beam vs. delay.<br>Q(.,3) Correlation between lower beams in antennas 1 & 2 vs. delay.<br>Q(.,4) Power on upper beam vs. delay. |

| | | | | |
|---|---|---|---|---|
| | Number of receive ports. | | | |
| NT | /SYSTRN/ | I*2 | TROCOM.INC | |
| | Number of transmit ports. | | | |
| PSIRAO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | Array of receiver beam azimuths in radians. | | | |
| PSIREO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | Array of receiver beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSIREO(1) is the main receive antenna. | | | |
| PSITAO(NTMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | Array of transmitter beam azimuths in radians. | | | |
| PSITEO(NTMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | Array of transmitter beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSITEO(1) is the main transmit antenna. | | | |
| SCPARM | /PROPAR/ | R*4 | TROCOM.INC | |
| | Wavenumber spectrum slope parameter M. Default is 3.66. | | | |
| THET | /PATHGE/ | R*4 | TROCOM.INC | |
| | Radio horizon elevation angle at transmit site in radians. | | | |
| THETAO | /PATHGE/ | R*4 | TROCOM.INC | |
| | Scattering angle at bottom of common volume in radians. | | | |
| TWOPI | /CONSTA/ | R*4 | CONSTANTS.INC | |
| | 2 X Pi = 6.283185307. | | | |
| URH(NR) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of receive antennas horizontal offsets from great circle plane in meters. | | | |
| URL(NR) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of receive antennas longitudinal offsets in meters. | | | |
| URV(NR) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of receive antennas vertical offsets in meters. | | | |
| UTH(NT) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of transmit antennas horizontal offsets in meters. | | | |
| UTL(NT) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of transmit antennas longitudinal offsets in meters. | | | |
| UTV(NT) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of transmit antennas vertical offsets in meters. | | | |
| WAVLEN | /SYSTRN/ | R*4 | TROCOM.INC | |
| | Wavelength in meters. | | | |
| Y1 | /PATHGE/ | R*4 | TROCOM.INC | |
| | Maximum estimated integration length in Y-direction. | | | |

Global variables output to common:

| | | | |
|---|---|---|---|
| | Array of receiver antenna diameters in meters. AR(1) is equivalent to RDIAM in the input file. | | |
| BETA0 | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum receive antenna elevation angle measured from receiver-to-transmitter line to receiver horizon line in radians. | | |
| BETA1 | /PATHGE/ | R*4 | TROCOM.INC |
| | Maximum receive antenna elevation angle measured from receiver-to-transmitter line to top of common volume in radians. | | |
| BW | /SYSTRN/ | R*4 | TROCOM.INC |
| | Bandwidth in Hertz. Default is 7 MHz. | | |
| CO | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Free space velocity of radio waves = 2.998E8 m/sec. | | |
| D | /PATHGE/ | R*4 | TROCOM.INC |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | |
| DELREF | /PDATA/ | R*4 | PDATA.INC |
| | Minimum delay through the lowest scattering point (relative to straight line delay) in seconds. | | |
| ERR | /CONTROL/ | R*4 | TROCOM.INC |
| | Common volume integration resolution. Default is .001. | | |
| HLOW | /PROPAR/ | R*4 | TROCOM.INC |
| | Lowest height above sea level at which CN2 is specified in meters. | | |
| HTN | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit antenna height above sea level in meters. | | |
| IBR(NRMX,NRMX) | /SYSTRN/ | I*2 | TROCOM.INC |
| | Channel complex-envelope correlation and cross-correlation calculation indicator array.<br>0 = No calculation<br>1 = Power (correlation) calculation only<br>2 = Power (correlation) per unit delay spectrum calculation | | |
| IPOLR(NRMX) | /ANTENN/ | I*2 | TROCOM.INC |
| | Array of receiver antenna polarizations. | | |
| IPOLT(NTMX) | /ANTENN/ | I*2 | TROCOM.INC |
| | Array of transmitter antenna polarizations. | | |
| KPROF | /PROPAR/ | I*2 | TROCOM.INC |
| | Actual number of samples in height profile of structure constant CN2. Limited to NPROF samples. | | |
| NACCU | /CONTRL/ | I*2 | TROCOM.INC |
| | Parameter used as truncation point for common volume integration termination. Default is 40. | | |
| NCORMX | Parameter | I*2 | TROPAR.INC |
| | Maximum number of correlations between receive ports. | | |
| NDELMX | Parameter | I*2 | TROPAR.INC |
| | Maximum number of delay bins in troposcatter power per unit delay profiles. | | |
| NR | /SYSTRN/ | I*2 | TROCOM.INC |

## 5.12 LOOPS

Subprogram name: Subroutine LOOPS

Purpose: This is the key routine performing the integration over the common volume to calculate received power vs. delay at all specified antenna ports and the convolutions between antenna ports vs. delay at all specified antenna ports.

Description: A certain amount of the code is keeping track of which antenna locations are different, eg, space diversity; which antenna beams point differently, ie, angle diversity; which correlations involve space-, angle-, or polarization diversity. The number of correlations is NCORR, and for each correlation, ICORR, the arrays I1CORR and I2CORR point to the receiving ports involved in the integration of correlation number ICORR. An analytical path loss estimate, PLOSSM, is evaluated. Power levels and correlation coefficients are stored in the array QCORR. Average delay (normalized) and delay spread are in the arrays TEMPA and TEMPB. The frequency separation which corresponds to a frequency correlation coefficient of .5 is evaluated.

Calling sequence:
    CALL LOOPS

Contained in module: LOOPS

Called by: TROPO

Calls: ANTPTR, BEAMPT, DELO, ERROR, FRQSEP, RGAIN, RIPROF, SINT, STEPAB, STEPY, STPPAR, TGAIN, TRLOSS

Input arguments:
    NONE

Output arguments:
    NONE

Global variables input from common:

| | | | |
|---|---|---|---|
| A | /PATHGE/ | R*4 | TROCOM.INC |
| | Effective earth radius in meters. | | |
| ALFA0 | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum transmit antenna elevation angle measured from transmitter-to-receiver line to transmit horizon line in radians. | | |
| ALFA1 | /PATHGE/ | R*4 | TROCOM.INC |
| | Maximum transmit antenna elevation angle measured from transmitter-to-receiver line to top of common volume in radians. | | |
| AR(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |

Diffraction angle in radians.

| | | | |
|---|---|---|---|
| Y1 | /PATHGE/ | R*4 | TROCOM.INC |
| | Maximum estimated integration length in Y-direction. | | |

```
     ERR              /CONTROL/      R*4     TROCOM,INC
                      Common volume integration resolution. Default is .001.
     HRN              /PATHGE/       R*4     TROCOM,INC
                      Receive antenna height above sea level in meters.
     HTN              /PATHGE/       R*4     TROCOM,INC
                      Transmit antenna height above sea level in meters.
     NR               /SYSTRN/       I*2     TROCOM,INC
                      Number of receive ports.
     NT               /SYSTRN/       I*2     TROCOM,INC
                      Number of transmit ports.
     PSIRAO(NRMX)     /ANTENN/       R*4     TROCOM,INC
                      Array of receiver beam azimuths in radians.
     PSIREO(NRMX)     /ANTENN/       R*4     TROCOM,INC
                      Array of receiver beam boresight elevations above
                      radio horizon in radians, ie, angle at which each
                      antenna is aimed relative to the horizon.  PSIREO(1)
                      is the main receive antenna.
     PSITAO(NTMX)     /ANTENN/       R*4     TROCOM,INC
                      Array of transmitter beam azimuths in radians.
     PSITEO(NTMX)     /ANTENN/       R*4     TROCOM,INC
                      Array of transmitter beam boresight elevations above
                      radio horizon in radians, ie, angle at which each
                      antenna is aimed relative to the horizon.  PSITEO(1)
                      is the main transmit antenna.
     SCPARM           /PROPAR/       R*4     TROCOM,INC
                      Wavenumber spectrum slope parameter M.  Default is
                      3.66.
     THER             /PATHGE/       R*4     TROCOM,INC
                      Radio horizon elevation angle at receive site in
                      radians.
     THET             /PATHGE/       R*4     TROCOM,INC
                      Radio horizon elevation angle at transmit site in
                      radians.
     THETAO           /PATHGE/       R*4     TROCOM,INC
                      Scattering angle at bottom of common volume in
                      radians.

Global variables output to common:
     ALFA1            /PATHGE/       R*4     TROCOM,INC
                      Maximum transmit antenna elevation angle measured from
                      transmitter-to-receiver line to top of common volume
                      in radians.
     BETA1            /PATHGE/       R*4     TROCOM,INC
                      Maximum receive antenna elevation angle measured from
                      receiver-to-transmitter line to top of common volume
                      in radians.
     HHIGH            /PATHGE/       R*4     TROCOM,INC
                      Effective height of the top of the common volume in
                      meters.
     PHI              /PATHGE/       R*4     TROCOM,INC
```

## 5.11 INTLIM

Subprogram name: Subroutine INTLIM

Purpose: Calculates the limits of common volume integration. Calculates the maximum value, ALFA1, of the angle ALFA, the maximum value, BETA1, of the angle BETA, the maximum height of the common volume, HHIGH, and the maximum value Y1 of the Y coordinate (perpendicular to the great circle plane.)

Calling sequence:
CALL INTLIM

Contained in module: INTLIM

Called by: TROPO

Calls: NONE

Input arguments:
NONE

Output arguments:
NONE

Global variables input from common:

| | | | |
|---|---|---|---|
| A | /PATHGE/ | R*4 | TROCOM.INC |
| | Effective earth radius in meters. | | |
| ALFA0 | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum transmit antenna elevation angle measured from transmitter-to-receiver line to transmit horizon line in radians. | | |
| BETA0 | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum receive antenna elevation angle measured from receiver-to-transmitter line to receiver horizon line in radians. | | |
| D | /PATHGE/ | R*4 | TROCOM.INC |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | |
| DELTAR(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | 3dB half-beamwidth of each receive antenna in radians. | | |
| DELTAT(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | 3dB half-beamwidth of each transmit antenna in radians. | | |
| DR | /PATHGE/ | R*4 | TROCOM.INC |
| | Receiver distance to minimum scattering point in meters. | | |
| DT | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit antenna distance to minimum scattering point in meters. | | |

## 5.10 HORANG

Subprogram name: Subroutine HORANG

Purpose: Compute horizon elevation angle from given horizon distance and height.

Calling sequence:
CALL HORANG (A, D, H, T)

Contained in module: HORANG

Called by: TANGL, TRANSF

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| A | R*4 | Radius of the earth plus height of the antenna in meters. |
| D | R*4 | Horizon distance in meters. |
| H | R*4 | Horizon height above the antenna height in meters. |

Output arguments:

| | | |
|---|---|---|
| T | R*4 | Horizon elevation angle (position above grazing) in radians. |

## 5.9 GPATT

Subprogram name: Subroutine GPATT

Purpose: Voltage directional pattern type 2J1(X) / X. Calculates the voltage gain pattern up to and including the first sidelobe using the formula:

G = 2 * J1(X) / X,

Where:

X is PI * AD * SIN(PSI) / WAVLEN
AD is the antenna diameter
PSI is the angle

To use other antenna patterns, GPATT may be replaced by other subroutines in RGAIN and TGAIN.

Calling sequence:

CALL GPATT (AD, WAVLEN, PSI, Y)

Contained in module: GPATT

Called by: RGAIN, TGAIN

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| AD | R*4 | Antenna diameter in meters. |
| WAVLEN | R*4 | Wavelength in meters. |
| PSI | R*4 | Off-boresight angle in radians. |

Output arguments:

| | | |
|---|---|---|
| Y | R*4 | Relative voltage gain at off-boresight angle PSI. |

Global variables input from common:

| | | | |
|---|---|---|---|
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |

## 5.8 FRQSEP

Subprogram name: Subroutine FRQSEP

Purpose: Compute minimum frequency separation required for uncorrelated frequency diversity operation.

Calling sequence:

```
CALL FRQSEP (N, Q, DELPB, BW, FSEP)
```

Contained in module: FRQSEP

Called by: LOOPS

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| N | I*2 | Number of points in DFT. |
| Q(N) | R*4 | Power per unit delay profile. |
| DELPB | R*4 | Delay interval in seconds. |
| BW | R*4 | Signal bandwidth in Hz. |
| FSEP | R*4 | Estimate of coherance bandwidth in Hz. |

Output arguments:

| | | |
|---|---|---|
| FSEP | R*4 | Minimum frequency separation in Hz. |

| | | | |
|---|---|---|---|
| | Proportionality constant in troposcatter path loss calculation. | | |
| CO | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Free space velocity of radio waves = 2.998E8 m/sec. | | |
| CORRLT | /CPLOSS/ | R*4 | CPL.INC |
| | Correlation coefficient for long term variability of lower and upper beams. | | |
| CPL(6) | /CPLOSS/ | R*4 | CPL.INC |
| | Aperture-to-medium coupling loss array in dB. | | |
| D | /PATHGE/ | R*4 | TROCOM.INC |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | |
| DELPB | /PDATA/ | R*4 | PDATA.INC |
| | Resolution of a delay cell in seconds. | | |
| DELREF | /PDATA/ | R*4 | PDATA.INC |
| | Minimum delay through the lowest scattering point (relative to straight line delay) in seconds. | | |
| DELTAR(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | 3dB half-beamwidth of each receive antenna in radians. | | |
| DELTAT(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | 3dB half-beamwidth of each transmit antenna in radians. | | |
| DIVTYP | /MCOM2/ | I*2 | MCOM.INC |
| | Diversity configuration indicator. Default is 0.<br>0 = 2 receive antennas; 2S 2S/2F 2S/2A 2S/2A/2F<br>1 = 1 receive antenna; 2A 2F 2F/2A<br>2 = 2 transmit,<br>2 receive antennas; 2S/2P 2S/2P/2A<br>3 = Not used<br>4 = User supplied parameters<br>S = Space F = Frequency A = Angle P = Polarization | | |
| DLR | /PATHGE/ | R*4 | TROCOM.INC |
| | Distance from receiver to radio horizon in meters. | | |
| DLT | /PATHGE/ | R*4 | TROCOM.INC |
| | Distance from transmitter to radio horizon in meters. | | |
| DRATE | /MCOM4/ | R*4 | MCOM.INC |
| | Data rate in bits/second. Default is 6.6E6. | | |
| ERFAC | /PROPAR/ | R*4 | TROCOM.INC |
| | Yearly median value of effective earth radius factor k in kilometers. Default is 1.33. | | |
| F | /SYSTRN/ | R*4 | TROCOM.INC |
| | Operating frequency in Hz. Model is accurate between 100MHz and 10GHz. | | |
| GRDB(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Gain of each receive antenna in dBi. | | |
| GTDB(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Gain of each transmit antenna in dBi. | | |
| HI(155) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing NPM(1) evenly-spaced terrain elevation data (in meters) between transmitter and | | |

first obstacle followed by NPM(2) evenly-spaced terrain elevation data between first and second obstacle, etc., ending with NPM(NOBS+1) evenly-spaced terrain elevation data between last obstacle and receive site. The data should be selected such that:

HI(1) = Terrain elevation above sea level at transmit site (HTO).

HI(NPM(I)) = HI (NPM(I)+1) = Elevation of Ith obstacle above sea level (HL(I)).

HI(NPM(NOBS+1)) = Terrain elevation above sea level at receive site (HRO).

In MDTS, HI is used as work space. It is equivalenced to local arrays.

| | | | |
|---|---|---|---|
| HRN | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive antenna height above sea level in meters. | | |
| HTN | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit antenna height above sea level in meters. | | |
| IBLOSS(6) | /CPLOSS/ | I*2 | CPL.INC |
| | Beam number corresponding to CPL(I). | | |
| ICPL | /CPLOSS/ | I*2 | CPL.INC |
| | Coupling loss count. | | |
| ITER | /PDATA/ | I*4 | PDATA.INC |
| | Number of integration cells in the common volume integration. | | |
| KLIMAT | /PROPAR/ | I*2 | TROCOM.INC |

Climate zone indicator. Default is 0.

0 = User supplied climate

NBS TN101 climates

1 = Continental temperate (CT)
2 = Maritime temperate overland (MTL)
3 = Maritime temperate oversea (MTS)
4 = Maritime subtropical overland (MSL)
5 = Continental temperate time block 2 (CT2) (winter afternoon hours) - formerly Maritime subtropical oversea (MSS)
6 = Desert, Sahara (DS)
7 = Equatorial (EQU)
8 = Continental subtropical (CS)

MIL-HDBK-417 climates

9 = Continental temperate (CT)
10 = Maritime temperate overland (MTL)
11 = Maritime temperate oversea (MTS)
12 = Maritime subtropical (MS)
13 = Desert, Sahara (DS)
14 = Equatorial (EQU)
15 = Continental subtropical (CS)
16 = Mediterranean (MED)
17 = Polar (POL)

| | | | |
|---|---|---|---|
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |

```
LOUT            /LUNS/          I*2    LUNS.INC
                FOR002.DAT output unit number.
NDIST           /ERAD/          I*2    ERAD.INC
                Multipath distribution indicator.
                        0 = Only median multipath spread used(default)
                        1 = Multipath distribution used.  (Option not
                            currently available.)
NCORR           /PDATA/         I*2    PDATA.INC
                Number of receive port correlations.
NDELMX          Parameter       I*2    TROPAR.INC
                Maximum number of delay bins in troposcatter power per
                unit delay profiles.
NFIG            /MCOM4/         R*4    MCOM.INC
                Receiver noise figure in dB.  Default is 4dB.
NOBS            /MCOM2/         I*2    MCOM.INC
                Number of diffraction obstacles. Maximum is 3,
                default is 1.
NPM(5)          /MCOM2/         I*2    MCOM.INC
                Array containing number of terrain elevation data
                points for calculation of effective antenna heights
                for each section of the diffraction path.
NRAD            /ERAD/          I*2    ERAD.INC
                ERFAC indicator and loop counter.  Default is 1.
NTERR           /MCOM2/         I*2    MCOM.INC
                Control parameter for entry or calculation of
                effective antenna heights (HTE, HRE) and effective
                obstacle heights above average terrain elevation
                (HLEF).
                        0 = HTE and HRE supplied directly
                        1 = AVETX and AVERX supplied
                        2 = HI(.) supplied
PRAD(3)         /ERAD/          R*4    ERAD.INC
                Fraction of time effective earth radius factor is
                greater than ERFAC; Probability that effective earth
                radius factor is not exceeded.
                        For NRAD = 1    PRAD = 0.5
                                 = 2         = 0.1
                                 = 3         = 0.01
PSIREO(NRMX)    /ANTENN/        R*4    TROCOM.INC
                Array of receiver beam boresight elevations above
                radio horizon in radians, ie, angle at which each
                antenna is aimed relative to the horizon.  PSIREO(1)
                is the main receive antenna.
PSITEO(NTMX)    /ANTENN/        R*4    TROCOM.INC
                Array of transmitter beam boresight elevations above
                radio horizon in radians, ie, angle at which each
                antenna is aimed relative to the horizon.  PSITEO(1)
                is the main transmit antenna.
PXMIT           /MCOM4/         R*4    MCOM.INC
                Rated transmission power in dBm.  Default is 70dBm.
```

```
     QCORR(NCORMX)   /PDATA/          R*4     PDATA.INC
                     Contains elements of covariance matrix, ie, powers and
                     correlations.
                     For DIVTYP = 0:
                        QCORR(1) Power on lower beam
                        QCORR(2) Correlation coefficient between lower
                                 and upper beam.
                        QCORR(3) Correlation coefficient between lower
                                 beams of antennas 1 and 2
                        QCORR(4) Power on upper beam.
                     For DIVTYP = 1:
                        QCORR(1) Power on lower beam
                        QCORR(2) Correlation coefficient between lower
                                 and upper beam.
                        QCORR(3) Power on upper beam.
                     For DIVTYP = 2:
                        QCORR(1) Power on path 1 (lower beam)
                        QCORR(2) Correlation coefficient between convergent
                                 paths.
                        QCORR(3) Correlation coefficient between divergent
                                 paths.
                        QCORR(4) Correlation coefficient between parallel
                                 paths.
                        QCORR(5) Correlation coefficient between crossing
                                 paths.
                        QCORR(6) Power on upper beam.
     RLL             /SYSTRN/         R*4     TROCOM.INC
                     Receiver line losses in dB.  Default is 0 dB.
     SP              /MCOM4/          R*4     MCOM.INC
                     Service probability.  Default is .95.
     SPREAD(NCORMX)  /PDATA/          R*4     PDATA.INC
                     Array of delay spreads (2-sigma) for each beam in
                     seconds.
     TEMPA(NCORMX)   /PDATA/          R*4     PDATA.INC
                     Array of average troposcatter signal delays for each
                     beam relative to straight line in seconds.
     THER            /PATHGE/         R*4     TROCOM.INC
                     Radio horizon elevation angle at receive site in
                     radians.
     THET            /PATHGE/         R*4     TROCOM.INC
                     Radio horizon elevation angle at transmit site in
                     radians.
     TLL             /SYSTRN/         R*4     TROCOM.INC
                     Transmitter line losses in dB.  Default is 0 dB.

Global variables output to common:
     AVERX           /MCOM4/          R*4     MCOM.INC
                     Average terrain elevation above sea level between
                     receive site and radio horizon, in meters.
     AVETX           /MCOM4/          R*4     MCOM.INC
```

```
                Average terrain elevation above sea level between
                transmit site and radio horizon, in meters.
DE              /SUMP/        R*4    CURVE.INC
                Effective distance for troposcatter path in
                kilometers.
DSP1(3)         /SUMP/        R*4    CURVE.INC
                Lower beam troposcatter signal RMS delay spread in
                nanoseconds for percentiles 50, 90 and 99.
DSP2(3)         /SUMP/        R*4    CURVE.INC
                Upper beam troposcatter signal RMS delay spread in
                nanoseconds for percentiles 50, 90 and 99.
HRE             /MCOM4/       R*4    MCOM.INC
                Effective receiver antenna height above average
                terrain elevation in meters.
HTE             /MCOM4/       R*4    MCOM.INC
                Effective transmitter antenna height above average
                terrain elevation in meters.
JQ2M            /MCOM4/       I*2    MCOM.INC
                Pointer to centroid of lower beam troposcatter signal
                power per unit delay profile.
KGAIN           /RZ/          I*2    RZ.INC
                Integer ratio of bandwidth to data rate.
MODPAT          /MCOM2/       I*2    MCOM.INC
                Propagation/modem flag to select calculation mode.
                Default is 1.
                        0 = Propagation only
                        1 = Propagation + MD-918 modem
                        2 = Propagation + AN/TRC-170 or DAR modem
                        3 = Propagation + user-defined modem
NDELQ           /MCOM4/       I*2    MCOM.INC
                Number of non-zero elements of troposcatter power per
                unit delay profiles Q(NDELQ,1).
PLOSS1          /ERAD/        R*4    ERAD.INC
                Reference troposcatter path loss in dB on lower beam
                for NRAD equals 1.
Q(NDELMX,NCORMX) /PDATA/      R*4    PDATA.INC
                Matrix of troposcatter signal power and correlation
                per unit delay profiles.
                For DIVTYP = 0:
                   Q(.,1)  Power on lower beam vs. delay.
                   Q(.,2)  Correlation between lower and
                           upper beam vs. delay.
                   Q(.,3)  Correlation between lower beams
                           in antennas 1 & 2 vs. delay.
                   Q(.,4)  Power on upper beam vs. delay.
                   Q(.,7)  Power on diffraction path vs. delay
                For DIVTYP = 1:
                   Q(.,1)  Power on lower beam vs. delay.
                   Q(.,2)  Correlation between lower and
                           upper beam vs. delay.
```

| | | | |
|---|---|---|---|
| | Q(.,3) Power on upper beam vs. delay | | |
| | Q(.,7) Power on diffraction path vs. delay. | | |
| | For DIVTYP = 2: | | |
| | Q(.,1) Power on path 1 (lower beam) vs. delay. | | |
| | Q(.,2) Correlation between convergent paths (lower beam) vs. delay. | | |
| | Q(.,3) Correlation between divergent paths (lower beam) vs. delay. | | |
| | Q(.,4) Correlation between parallel paths (lower beam) vs. delay. | | |
| | Q(.,5) Correlation between crossing paths (lower beam) vs. delay. | | |
| | Q(.,6) Power on path of upper beam vs. delay. | | |
| | Q(.,7) Power on diffraction path vs. delay. | | |
| STSNR | /SUMP/ | R*4 | SUMP.INC |
| | Standard deviation of troposcatter signal long-term SNR distribution in dB. | | |
| TDIFF | /MCOM4/ | R*4 | MCOM.INC |
| | Normalized relative delay between lower and upper beam. | | |
| TROLOS(3) | /SUMP/ | R*4 | CURVE.INC |
| | Median troposcatter path loss in dB for each value in ERFAC distribution. | | |
| TRORSL(3) | /SUMP/ | R*4 | CURVE.INC |
| | Median troposcatter RSL in dBm for each value in ERFAC distribution. | | |

## 5.15 RGAIN

Subprogram name: Function RGAIN

Purpose: Relative voltage gain for receive aperture I at the off-boresight angle PSI.

Calling sequence:
RGAIN (I, PSI)

Contained in module: RGAIN

Called by: DIFSNR, LOOPS

Calls: GPATT

Input arguments:

| | | |
|---|---|---|
| I | I*2 | Receiving aperture index. |
| PSI | R*4 | Off-boresight angle in radians. |

Output arguments:

| | | |
|---|---|---|
| RGAIN | R*4 | Relative voltage gain for given receive aperture. |

Global variables input from common:

| | | | |
|---|---|---|---|
| AR(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of receiver antenna diameters in meters. AR(1) is equivalent to RDIAM in the input file. | | |
| WAVLEN | /SYSTRN/ | R*4 | TROCOM.INC |
| | Wavelength in meters. | | |

## 5.16 RIPROF

Subprogram name: Subroutine *RIPROF*

Purpose: Calculates a normalized CN2 value for a given point ALFA, BETA. Used when refractive index profile is input by the user.

Calling sequence:
CALL RIPROF (HEIGHT, CN2LOC)

Contained in module: RIPROF

Called by: LOOPS

Calls: ERROR

Input arguments:

| | | |
|---|---|---|
| HEIGHT | R*4 | Height above sea level of the current scattering point. |

Output arguments:

| | | |
|---|---|---|
| CN2LOC | R*4 | Normalized CN2 value. |

Global variables input from common:

| | | | |
|---|---|---|---|
| CN2(NPROF) | /PROPAR/ | R*4 | TROCOM.INC |
| | The atmospheric structure constant height profile in meters to the -2/3 power. | | |
| DELH | /PROPAR/ | R*4 | TROCOM.INC |
| | Spacing of CN2 samples in meters. | | |
| KPROF | /PROPAR/ | I*2 | TROCOM.INC |
| | Actual number of samples in height profile of structure constant CN2. Limited to NPROF samples. | | |

## 5.17 STEPAB

Subprogram name: Function STEPAB

Purpose: Calculates step size of alpha or beta for a given scattering point.

Calling sequence:
STEPAB (THETA)

Contained in module: STEPAB

Called by: LOOPS

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| THETA | R*4 | Scattering angle at bottom of common volume in radians. |

Output arguments:

| | | |
|---|---|---|
| STEPAB | R*4 | Step size of alpha or beta. |

Global variables input from common:

| | | | |
|---|---|---|---|
| BEAM | /STPCOM/ | R*4 | STPCOM.INC |
| | Parameter for determining azimuth and elevation angle step size in common volume integration. | | |
| TFAK | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |

## 5.18 STEPY

Subprogram name: Function STEPY

Purpose: Calculates the step size in the Y direction.

Calling sequence:
STEPY (THETA, Y, ROT, ROR)

Contained in module: STEPY

Called by: LOOPS

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| THETA | R*4 | Scattering angle at point of integration. |
| Y | R*4 | Y coordinate. |
| ROT | R*4 | Distance from transmitter to point of integration. |
| ROR | R*4 | Distance from receiver to point of integration. |

Output arguments:

| | | |
|---|---|---|
| STEPY | R*4 | Step size in the Y direction. |

Global variables input from common:

| | | | |
|---|---|---|---|
| TFAKY1 | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |
| TFAKY2 | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |
| TFAKY3 | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |
| TFAKY4 | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |

## 5.19 STPPAR

Subprogram name: Subroutine STPPAR

Purpose: Initializes parameters required to determine step size of alpha, beta and Y in the common volume integration. Refines step size for space diversity correlation.

Calling sequence:
CALL STPPAR

Contained in module: STPPAR

Called by: LOOPS

Calls: NONE

Input arguments:
NONE

Output arguments:
NONE

Global variables input from common:

```
     DELTAR(NRMX)    /ANTENN/        R*4     TROCOM.INC
                     3dB half-beamwidth of each receive antenna in radians.
     DELTAT(NTMX)    /ANTENN/        R*4     TROCOM.INC
                     3dB half-beamwidth of each transmit antenna in
                     radians.
     DR              /PATHGE/        R*4     TROCOM.INC
                     Receiver distance to minimum scattering point in
                     meters.
     DT              /PATHGE/        R*4     TROCOM.INC
                     Transmit antenna distance to minimum scattering point
                     in meters.
     ERR             /CONTROL/       R*4     TROCOM.INC
                     Common volume integration resolution. Default is .001.
     IBR(NRMX,NRMX)  /SYSTRN/        I*2     TROCOM.INC
                     Channel complex-envelope correlation and
                     cross-correlation calculation indicator array.
                             0 = No calculation
                             1 = Power (correlation) calculation only
                             2 = Power (correlation) per unit delay
                                 spectrum calculation
     IPOLR(NRMX)     /ANTENN/        I*2     TROCOM.INC
                     Array of receiver antenna polarizations.
     NR              /SYSTRN/        I*2     TROCOM.INC
                     Number of receive ports.
     NT              /SYSTRN/        I*2     TROCOM.INC
                     Number of transmit ports.
```

| | | | |
|---|---|---|---|
| SCPARM | /PROPAR/ | R*4 | TROCOM.INC |
| | Wavenumber spectrum slope parameter M. Default is 3.66. | | |
| TWOPI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | 2 X Pi = 6.283185307. | | |
| URH(NR) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of receive antennas horizontal offsets from great circle plane in meters. | | |
| UTH(NT) | /PATHGE/ | R*4 | TROCOM.INC |
| | Array of transmit antennas horizontal offsets in meters. | | |
| WAVLEN | /SYSTRN/ | R*4 | TROCOM.INC |
| | Wavelength in meters. | | |

Global variables output to common:

| | | | |
|---|---|---|---|
| BEAM | /STPCOM/ | R*4 | STPCOM.INC |
| | Parameter for determining azimuth and elevation angle step size in common volume integration. | | |
| TFAK | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |
| TFAKY1 | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |
| TFAKY2 | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |
| TFAKY3 | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |
| TFAKY4 | /STPCOM/ | R*4 | STPCOM.INC |
| | Constant for common volume integration. | | |

## 5.20 TGAIN

Subprogram name: Function TGAIN

Purpose: Calculates relative voltage gain for transmit aperture I at the off-boresight angle PSI.

Calling sequence:
TGAIN (I, PSI)

Contained in module: TGAIN

Called by: DIFSNR, LOOPS

Calls: GPATT

Input arguments:

| | | |
|---|---|---|
| I | I*2 | Transmit aperture index. |
| PSI | R*4 | Off-boresight angle in radians. |

Output arguments:

| | | |
|---|---|---|
| TGAIN | R*4 | Relative voltage gain for given transmit aperture. |

Global variables input from common:

| | | | |
|---|---|---|---|
| AT(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of transmitter antenna diameters in meters. AT(1) is equivalent to TDIAM in the input file. | | |
| WAVLEN | /SYSTRN/ | R*4 | TROCOM.INC |
| | Wavelength in meters. | | |

## 5.21 TRANSF

Subprogram name: Subroutine TRANSF

Purpose: Transform angles and distances to effective earth radius and calculate scattering point assuming that at each site all antennas have a common horizon and minimum scattering point. The different antenna heights are ignored in the calculation of the common volume.

Calling sequence:
CALL TRANSF

Contained in module: TRANSF

Called by: TROPO

Calls: ERROR, HORANG

Input arguments:
NONE

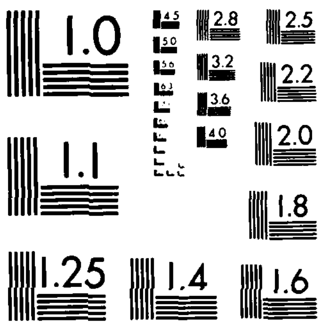
Output arguments:
NONE

Global variables input from common:

| | | | | |
|---|---|---|---|---|
| A | /PATHGE/ | R*4 | TROCOM.INC | |
| | Effective earth radius in meters. | | | |
| A0 | /CONSTA/ | R*4 | CONSTANTS.INC | |
| | Radius of the earth in meters = 6367650. | | | |
| D | /PATHGE/ | R*4 | TROCOM.INC | |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | | |
| DELTAR(NRMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | 3dB half-beamwidth of each receive antenna in radians. | | | |
| DELTAT(NTMX) | /ANTENN/ | R*4 | TROCOM.INC | |
| | 3dB half-beamwidth of each transmit antenna in radians. | | | |
| DLR | /PATHGE/ | R*4 | TROCOM.INC | |
| | Distance from receiver to radio horizon in meters. | | | |
| DLT | /PATHGE/ | R*4 | TROCOM.INC | |
| | Distance from transmitter to radio horizon in meters. | | | |
| ERFAC | /PROPAR/ | R*4 | TROCOM.INC | |
| | Yearly median value of effective earth radius factor k in kilometers. Default is 1.33. | | | |
| ITOFF | /PROPAR/ | I*2 | TROCOM.INC | |
| | Control indicator for entry or calculation of transmit/receive radio horizon angles THET and THER. Values have following meanings:<br>0 = Use input THET, THER as reference and actual horizon (default). | | | |

AD-A151 983 DIGITAL TROPOSCATTER PERFORMANCE MODEL: SOFTWARE DOCUMENTATION(U) SIGNATRON INC LEXINGTON MA P MONSEN ET AL. 28 NOV 83 A-288-16 DCA100-80-C-0030 2/4

UNCLASSIFIED F/G 9/2 NL




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS 1963 A

1 = Calculate reference horizon using HORANG and K equals 1.33. (Assuming DLT and DLR are non-zero.) (Option not available.)
2 = Calculate reference horizon using HORANG and K equals ERFAC. (Assuming DLT and DLR are non-zero.)
3 = Do not change reference horizons from previous run. (Option not available.)

| | | | | |
|---|---|---|---|---|
| NR | /SYSTRN/ | I*2 | TROCOM.INC | Number of receive ports. |
| NT | /SYSTRN/ | I*2 | TROCOM.INC | Number of transmit ports. |
| THER | /PATHGE/ | R*4 | TROCOM.INC | Radio horizon elevation angle at receive site in radians. |
| THET | /PATHGE/ | R*4 | TROCOM.INC | Radio horizon elevation angle at transmit site in radians. |

Global variables output to common:

| | | | | |
|---|---|---|---|---|
| ALFAO | /PATHGE/ | R*4 | TROCOM.INC | Minimum transmit antenna elevation angle measured from transmitter-to-receiver line to transmit horizon line in radians. |
| BETAO | /PATHGE/ | R*4 | TROCOM.INC | Minimum receive antenna elevation angle measured from receiver-to-transmitter line to receiver horizon line in radians. |
| DR | /PATHGE/ | R*4 | TROCOM.INC | Receiver distance to minimum scattering point in meters. |
| DT | /PATHGE/ | R*4 | TROCOM.INC | Transmit antenna distance to minimum scattering point in meters. |
| HCOM | /PATHGE/ | R*4 | TROCOM.INC | Effective height of the bottom of the common volume in meters. |
| HLR | /PATHGE/ | R*4 | TROCOM.INC | Receiver radio horizon elevation above sea level in meters. |
| HLT | /PATHGE/ | R*4 | TROCOM.INC | Transmit radio horizon elevation above sea level in meters. |
| HRN | /PATHGE/ | R*4 | TROCOM.INC | Receive antenna height above sea level in meters. |
| HTN | /PATHGE/ | R*4 | TROCOM.INC | Transmit antenna height above sea level in meters. |
| IRF | /PATHGE/ | I*2 | TROCOM.INC | Parameter which indicates whether reference horizon elevation angles have been calculated (IRF = 1) in |

| | | | |
|---|---|---|---|
| | previous run. It has meaning only when ITOFF = 3. | | |
| PHI | /PATHGE/ | R*4 | TROCOM.INC |
| | Diffraction angle in radians. | | |
| PHIR | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive angular distance to minimum scattering point in radians. | | |
| PHIT | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit angular distance to minimum scattering point in radians. | | |
| PSIREO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of receiver beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSIREO(1) is the main receive antenna. | | |
| PSITEO(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of transmitter beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSITEO(1) is the main transmit antenna. | | |
| S | /PATHGE/ | R*4 | TROCOM.INC |
| | Troposcatter path asymmetry parameter. | | |
| S1 | /PATHGE/ | R*4 | TROCOM.INC |
| | Troposcatter path asymmetry parameter. | | |
| THERRF | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive reference horizon in radians. | | |
| THETAO | /PATHGE/ | R*4 | TROCOM.INC |
| | Scattering angle at bottom of common volume in radians. | | |
| THETRF | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit reference horizon elevation in radians. | | |

## 5.22 TRLOSS

Subprogram name: Subroutine TRLOSS

Purpose: Calculates theoretical pathloss using formulas developed by S. Parl.

Reference: S. Parl, 'New formulas for tropospheric scatter loss',1979, Radio Science, Vol. 14, No. 1, pp. 42-57.

Calling sequence:
CALL TRLOSS (I1, X)

Contained in module: TRLOSS

Called by: LOOPS

Calls: ERROR

Input arguments:

| | | |
|---|---|---|
| I1 | I*2 | Receiver beam number. |

Output arguments:

| | | |
|---|---|---|
| X | R*4 | Theoretical pathloss. |

Global variables input from common:

| | | | |
|---|---|---|---|
| ALFAO | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum transmit antenna elevation angle measured from transmitter-to-receiver line to transmit horizon line in radians. | | |
| BETAO | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum receive antenna elevation angle measured from receiver-to-transmitter line to receiver horizon line in radians. | | |
| D | /PATHGE/ | R*4 | TROCOM.INC |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | |
| DELTAR(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | 3dB half-beamwidth of each receive antenna in radians. | | |
| DELTAT(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | 3dB half-beamwidth of each transmit antenna in radians. | | |
| ICPL | /CPLOSS/ | I*2 | CPL.INC |
| | Coupling loss count. | | |
| PSIRAO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of receiver beam azimuths in radians. | | |
| PSIREO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of receiver beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSIREO(1) | | |

is the main receive antenna.

PSITEO(NTMX) /ANTENN/ R*4 TROCOM.INC
Array of transmitter beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSITEO(1) is the main transmit antenna.

SCPARM /PROPAR/ R*4 TROCOM.INC
Wavenumber spectrum slope parameter M. Default is 3.66.

Global variables output to common:

CPL(6) /CPLOSS/ R*4 CPL.INC
Aperture-to-medium coupling loss array in dB.

# CHAPTER 6

# DIFFRACTION CALCULATIONS

This section describes the diffraction calculation routines:

| Name | Description | User's Manual section |
|---|---|---|
| AVAIL | Pathloss variability . . . . . | 2.6.1 |
| CONVOL | Cumulative distribution . . . . | 2.6.1 |
| DIF1 | Knife-edge diffraction loss . . | 2.6.2 |
| DIFSNR | Diffraction RSL and SNR distribution . . . . . . . . . . | 2.6.1 |
| INTERP | Lagrangian interpolation . . . | NA |
| MDIF | Multiple edge diffraction loss calculations . . . . . . . . . | 2.6, 2.6.2-.3 |
| TANGL | Radio horizon (take-off) angles . . . . . . . . . . . . . | 2.6.2, 2.6.3 |

The main routines for this section are DIFSNR and MDIF. Diffraction calculations are described in section 2.6 of the User's Manual.

Figure 2-3 is a top level flowchart for diffraction propagation parameter calculations at a functional level. In most cases the blocks correspond to one or more subprograms. The test blocks (diamonds) correspond to logical branches which are decided by the user's choices of input data.

NOTE

In most cases the sections in the User's Manual describe the coded equations as well as the theory behind them. NA denotes routines that are programming utilities such as finding indices, setting pointers, etc.

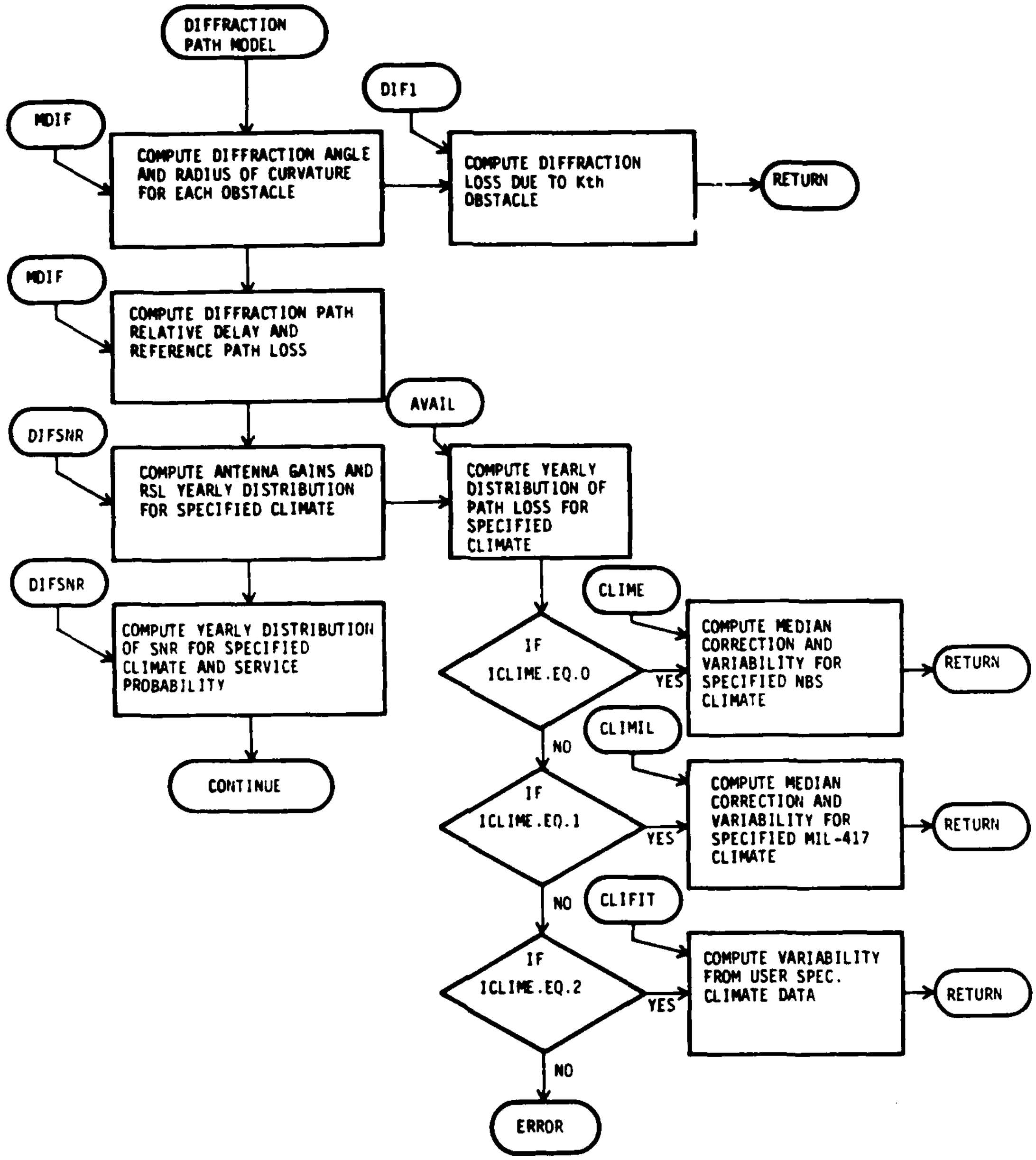



Figure 2-3 Flow Chart for Diffraction Propagation Parameter Calculations

## 6.1 AVAIL

Subprogram name: Subroutine AVAIL

Purpose: Routine to calculate the distribution of the pathloss variability for multiple edge diffraction paths by convolution of the pathloss variability for each section of the path, for a specified climate (KLIMAT).

Calling sequence:
CALL AVAIL (FMHZ,ND,HTE,HRE,DN,LCR,VDE,Y,QT)

Contained in module: AVAIL

Called by: DIFSNR

Calls: CLIME, CLIMIL, CLIMIX, CONVOL, INTERP

Input arguments:

| | | |
|---|---|---|
| FMHZ | R*4 | Frequency in MHz. |
| ND | I*2 | Number of sections in diffraction path 1<ND<6. Equal to number of edges plus one. No limit set. |
| HTE(ND) | R*4 | Array containing transmitter (horizon) heights in meters above average terrain height for each of the ND sections in the diffraction path. |
| HRE(ND) | R*4 | Array containing receiver (horizon) heights in meters above average terrain height for each of the ND sections in the diffraction path. |
| DN(ND) | R*4 | Array containing great circle path length in meters of each section of path. |
| LCR | R*4 | Long term pathloss reference value in dB |

Output arguments:

| | | |
|---|---|---|
| VDE | R*4 | Median correction factor for specified climate in dB. Set to zero when the user specifies yearly median of effective earth radius factor (SEAN = 0). |
| Y(11) | R*4 | Array containing pathloss variability distribution about the median in dB. |
| QT(11) | R*4 | Array containing percent of time pathloss is not exceeded, i.e. time availability |

Global variables input from common:

KLIMAT /PROPAR/ I*2 TROCOM.INC

Climate zone indicator. Default is 0.

0 = User supplied climate

NBS TN101 climates

1 = Continental temperate (CT)
2 = Maritime temperate overland (MTL)
3 = Maritime temperate oversea (MTS)
4 = Maritime subtropical overland (MSL)

```
                                5 = Continental temperate time block 2 (CT2)
                                    (winter afternoon hours) - formerly
                                    Maritime subtropical oversea (MSS)
                                6 = Desert, Sahara (DS)
                                7 = Equatorial (EQU)
                                8 = Continental subtropical (CS)
                        MIL-HDBK-417 climates
                                9 = Continental temperate (CT)
                                10 = Maritime temperate overland (MTL)
                                11 = Maritime temperate oversea (MTS)
                                12 = Maritime subtropical (MS)
                                13 = Desert, Sahara (DS)
                                14 = Equatorial (EQU)
                                15 = Continental subtropical (CS)
                                16 = Mediterranean (MED)
                                17 = Polar (POL)
        LOUT            /LUNS/          I*2     LUNS.INC
                        FOR002.DAT output unit number.
        SEAN            /PROPAR/        R*4     TROCOM.INC
                        Minimum monthly median of refractivity at sea level.
                        Used to calculate ERFAC if non-zero.
```

## 6.2 CONVOL

Subprogram name: Subroutine CONVOL

Purpose: Routine to find the cumulative distribution function of the sum of two independent random variables given the complementary cumulative distribution function of each of the random variables.

Calling sequence:
CALL CONVOL (FA,A,IA,FB,B,IB,FC,C,IC)

Contained in module: AVAIL

Called by: AVAIL

Calls: INTERP

Input arguments:

| | | |
|---|---|---|
| FA(IA) | R*4 | Array containing IA values of complementary cumulative distribution of A. Dimensioned to 50. |
| A(IA) | R*4 | Array containing range of values of random variable A. Dimensioned to 50. |
| IA | I*2 | Number of points in distribution A. Maximum is 50. |
| FB(IB) | R*4 | Array containing IB values of complementary cumulative distribution of B. Dimensioned to 50. |
| B(IB) | R*4 | Array containing range of values of random variable B. Dimensioned to 50. |
| IB | I*2 | Number of points in distribution of B. Maximum is 50. |

Output arguments:

| | | |
|---|---|---|
| FC(50) | R*4 | Array containing 50 values of cumulative distribution of the sum A + B. |
| C(50) | R*4 | Array containing range of values of the sum A + B. |
| IC | I*2 | Number of elements in cumulative distribution of A+B. |

Global variables input from common:

| | | | |
|---|---|---|---|
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |

## 6.3 DIF1

Subprogram name: Subroutine DIF1

Purpose: Computes the diffraction loss due to a single isolated and rounded obstacle.

Calling sequence:

```
CALL DIF1 (R, D1, D2, PHI, F, ATT)
```

Contained in module: MDIF

Called by: MDIF

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| R | R*4 | Radius of curvature of diffracting edge in meters. |
| D1 | R*4 | Distance from source (transmitter) to edge in meters. |
| D2 | R*4 | Distance from observation point (receiver) to edge in meters. |
| PHI | R*4 | Diffraction angle in radians. |
| F | R*4 | Frequency in MHz. |

Output arguments:

| | | |
|---|---|---|
| ATT | R*4 | Diffraction loss in dB. |

Global variables input from common:

| | | | |
|---|---|---|---|
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |

## 6.4 DIFSNR

Subprogram name: Subroutine DIFSNR

Purpose: Routine to calculate the diffraction path loss, RSL and SNR distributions for a given service probability (SP).

Calling sequence:

```
CALL DIFSNR (LCR, OET, OER, BWR, ASNR, DUPOW)
```

Contained in module: DIFSNR

Called by: TROPO

Calls: AVAIL, AVTER, ERFC, RGAIN, TGAIN

Input arguments:

| | | |
|---|---|---|
| LCR | R*4 | Reference value of diffraction path loss in dB. |
| OET | R*4 | Horizon elevation angle at transmit site in radians. |
| OER | R*4 | Horizon elevation angle at receive site in radians. |
| BWR | R*4 | Receive antenna beamwidth in degrees. |

Output arguments:

| | | |
|---|---|---|
| ASNR | R*4 | Median and/or yearly average value of diffraction path SNR in dB. |
| DUPOW | R*4 | Ratio of diffraction signal on upper beam to that on lower beam. |

Global variables input from common:

| | | | |
|---|---|---|---|
| CDEGR | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Radians per degree = 0.017453293. | | |
| D | /PATHGE/ | R*4 | TROCOM.INC |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | |
| DL(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing distance from each obstacle to transmitter in meters. | | |
| DRATE | /MCOM4/ | R*4 | MCOM.INC |
| | Data rate in bits/second. Default is 6.6E6. | | |
| F | /SYSTRN/ | R*4 | TROCOM.INC |
| | Operating frequency in Hz. Model is accurate between 100MHz and 10GHz. | | |
| GRDB(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Gain of each receive antenna in dBi. | | |
| GTDB(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Gain of each transmit antenna in dBi. | | |
| HI(155) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing NPM(1) evenly-spaced terrain elevation data (in meters) between transmitter and first obstacle followed by NPM(2) evenly-spaced | | |

terrain elevation data between first and second obstacle, etc., ending with NPM(NOBS+1) evenly-spaced terrain elevation data between last obstacle and receive site. The data should be selected such that:

HI(1) = Terrain elevation above sea level at transmit site (HTO).

HI(NPM(I)) = HI (NPM(I)+1) = Elevation of Ith obstacle above sea level (HL(I)).

HI(NPM(NOBS+1)) = Terrain elevation above sea level at receive site (HRO).

In MDTS, HI is used as work space. It is equivalenced to local arrays.

| | | | |
|---|---|---|---|
| HL(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing elevation of each obstacle above sea level in meters. HL(1) is elevation of transmitter radio horizon HLT. HL(NOBS) is elevation of receiver radio horizon HLR. | | |
| HLAV(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing average terrain elevation at each diffraction point in meters. | | |
| HLEF(3) | /MCOM4/ | R*4 | MCOM.INC |
| | Array containing effective height of obstacles above average terrain elevation in meters. | | |
| HRE | /MCOM4/ | R*4 | MCOM.INC |
| | Effective receiver antenna height above average terrain elevation in meters. | | |
| HRN | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive antenna height above sea level in meters. | | |
| HTE | /MCOM4/ | R*4 | MCOM.INC |
| | Effective transmitter antenna height above average terrain elevation in meters. | | |
| HTN | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit antenna height above sea level in meters. | | |
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |
| LOUT | /LUNS/ | I*2 | LUNS.INC |
| | FOR002.DAT output unit number. | | |
| NFIG | /MCOM4/ | R*4 | MCOM.INC |
| | Receiver noise figure in dB. Default is 4dB. | | |
| NOBS | /MCOM2/ | I*2 | MCOM.INC |
| | Number of diffraction obstacles. Maximum is 3, default is 1. | | |
| NPM(5) | /MCOM2/ | I*2 | MCOM.INC |
| | Array containing number of terrain elevation data points for calculation of effective antenna heights for each section of the diffraction path. | | |
| NTERR | /MCOM2/ | I*2 | MCOM.INC |
| | Control parameter for entry or calculation of effective antenna heights (HTE, HRE) and effective obstacle heights above average terrain elevation | | |

## 7.8 YINT

Subprogram name: Subroutine YINT

Purpose: Linear interpolation routine to find Y = A * DE + B.
Where: A = (Y2 - Y1) / (X2 - X1) and
B = Y1 - A * X1
For X1 < DE < X2

Calling sequence:

```
CALL YINT (DE,X1,X2,Y1,Y2,Y)
```

Contained in module: CLIME

Called by: CLIME

Calls: *NONE*

Input arguments:

| | | |
|---|---|---|
| DE | R*4 | Effective distance in kilometers. |
| X1 | R*4 | Lower limit for distance interpolation in kilometers. |
| X2 | R*4 | Upper limit for distance interpolation in kilometers, |
| Y1 | R*4 | Path loss variability corresponding to X1 in dB. |
| Y2 | R*4 | Path loss variability corresponding to X2 in dB. |

Output arguments:

| | | |
|---|---|---|
| Y | R*4 | Path loss variability in dB. |

## 7.7 VDECAL

Subprogram name: Subroutine VDECAL

Purpose: Computes the median correction factor, VDE, for the MIL-HDBK-417 climates given the C1, C2, C3, N1, N2, N3, FM, F8 constants in V(I) and the effective distance DE.

Calling sequence:

    CALL VDECAL (V, DE, VDE)

Contained in module: CLIMIL

Called by: CLIMIL

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| V(8) | R*4 | Array containing the constants used in calculating VDE. |
| DE | R*4 | Effective distance in kilometers. |

Output arguments:

| | | |
|---|---|---|
| VDE | R*4 | Median correction factor V(.5,DE) in dB according to KLIMAT. |

## 7.6 VARPOL

Subprogram name: Function VARPOL

Purpose: Computes the value X(F), X2 < X < X1 where: F(X) is a normal distribution function with F(X1) = F1 and F(X2) = F2. The function requires that F2 < F1.

Calling sequence:
VARPOL (F,F1,F2,X1,X2,SIGMA)

Contained in module: CLIMIX

Called by: CLIMIX

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| F | R*4 | Function. |
| F1 | R*4 | Value of function F at X1. |
| F2 | R*4 | Value of function F at X2. |
| X1 | R*4 | Variability about median in dB. |
| X2 | R*4 | Variability about median in dB. |
| SIGMA | R*4 | |

Output arguments:

| | | |
|---|---|---|
| VARPOL | R*4 | Result of interpolation between X2 and X1. |

Global variables input from common:

| | | | |
|---|---|---|---|
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |

## 7.5 DEIND

Subprogram name: Subroutine DEIND

Purpose: Find DE indices for interpolation of climate variability data in look up tables.

Calling sequence:

```
CALL DEIND (DE,I1,I2,LIM,X1,X2,DEINC)
```

Contained in module: CLIME

Called by: CLIME

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| DE | R*4 | Effective distance in kilometers. |
| LIM | I*2 | DE maximum increment. |
| DEINC | R*4 | DE range increment. |

Output arguments:

| | | |
|---|---|---|
| I1 | I*2 | Output index for X1 < DE < X2. |
| I2 | I*2 | Output index for X1 < DE < X2 (for DE = X1, I2 = 0). |
| X1 | R*4 | Output DE range, X1 < DE < X2, where X1 takes the values 0, DEINC, 2*DEINC, . . . , (LIM-) * DEINC. |
| X2 | R*4 | Output DE range, X1 < DE < X2. |

Global variables input from common:

| | | | |
|---|---|---|---|
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |

## 7.4 CLIMIX

Subprogram name: Subroutine CLIMIX

Purpose: Mixed climate variability distribution and VDE computation.

Calling sequence:

```
CALL CLIMIX (DE, YO, KLIM1, KLIM2, FM, VDE)
```

Contained in module: CLIMIX

Called by: POWER

Calls: CLIME, ERFC, VARPOL

Input arguments:

| | | |
|---|---|---|
| DE | R*4 | Effective distance in kilometers. |
| KLIM1 | I*2 | First KLIMAT code to be mixed. |
| KLIM2 | I*2 | Second KLIMAT code to be mixed. |
| FM | R*4 | Frequency in MHz. |

Output arguments:

| | | |
|---|---|---|
| YO(8) | R*4 | Variability distribution function YO(Q). |
| VDE | R*4 | Time variability of basic transmission loss in dB. |

Global variables input from common:

| | | | |
|---|---|---|---|
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |
| LOUT | /LUNS/ | I*2 | LUNS.INC |
| | FOR002.DAT output unit number. | | |

## 7.3 CLIMIL

Subprogram name: Subroutine CLIMIL

Purpose: Set the variability about the median, Y0 array, and the median correction factor, VDE, for MIL-HDBK-417 climates according to KLIMAT.

Calling sequence:
CALL CLIMIL (DE, Y0, KLIMAT, F, VDE)

Contained in module: CLIMIL

Called by: POWER, AVAIL

Calls: CLIFIT, VDECAL

Input arguments:

| | | |
|---|---|---|
| DE | R*4 | Effective distance in kilometers. |
| KLIMAT | I*2 | Climate designation. |
| F | R*4 | Frequency in MHz. |

Output arguments:

| | | |
|---|---|---|
| Y0(8) | R*4 | Variability about median in dB. |
| VDE | R*4 | Median correction factor V(.5,DE) in dB according to KLIMAT. |

Global variables input from common:

| | | | |
|---|---|---|---|
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |

Global variables output to common:

| | | | |
|---|---|---|---|
| DEMIN | /CURVE/ | R*4 | CURVE.INC |
| | User supplied minima of the 90th percentile variability curve, Y0(90). | | |
| Y900 | /CURVE/ | R*4 | CURVE.INC |
| | User supplied value for 90th percentile variability curve Y0(90) for DE greater than or equal 900 km. Used only when ICLIME is 2. Used to compute the equation for the Y0(90) curve fit. | | |
| YMIN | /CURVE/ | R*4 | CURVE.INC |
| | User supplied value for 90th percentile variability curve Y0(90) for DE equal to DEMIN. Used only when ICLIME is 2. Used to compute the equation for the Y0(90) curve fit. | | |

## 7.2 CLIME

Subprogram name: Subroutine CLIME

Purpose: Calculate median correction factor VDE and path loss variability about median YO, given the effective path distance DE, NBS climate designator KLIMAT and frequency F. Set YO array and VDE according to climate code KLIMAT.

Reference: C1, C2, C3, N1, N2, N3, FM, F8 constant data for the NBS climates is from Volume II of National Bureau of Standards technical note 101: 'Transmission Loss Predictions for Tropospheric Communication Circuits', revised 1-01-67.

Calling sequence:
CALL CLIME (DE, YO, KLIMAT, F, VDE)

Contained in module: CLIME

Called by: AVAIL, CLIMIX, POWER

Calls: CLIFIT, DINT, YINT

Input arguments:

| | | |
|---|---|---|
| DE | R*4 | Effective distance in kilometers. |
| KLIMAT | I*2 | Climate designation. |
| F | R*4 | Frequency in MHz. |

Output arguments:

| | | |
|---|---|---|
| YO(8) | R*4 | Variability about median in dB. |
| VDE | R*4 | Median correction factor V(.5, DE) in dB according to climate. |

Global variables input from common:

| | | | |
|---|---|---|---|
| DEMIN | /CURVE/ | R*4 | CURVE.INC |
| | User supplied minima of the 90th percentile variability curve, YO(90). | | |
| GPF | /CURVE/ | R*4 | CURVE.INC |
| | Frequency correction factor for user supplied 90th percentile variability curve. Default is 1. | | |
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |

## 7.1 CLIFIT

Subprogram name: Subroutine CLIFIT

Purpose: Routine to fit Y0(90) curve given the value for Y0(90) for effective distance DE = 0 (YZERO), the values Y0(90) and DE for the minima of the curve (YMIN, DEMIN) and the value of Y0(90) for DE .GE. 900 km (Y900). Note: DEMIN and DE are in kilometers.

Calling sequence:

```
CALL CLIFIT (DE,Y,DC,IFLAG)
```

Contained in module: CLIME

Called by: CLIME, CLIMIL

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| DE | R*4 | Effective distance in kilometers. |
| DC | R*4 | Cut-off distance in kilometers. |
| IFLAG | I*2 | Flag to indicate whether variability curve coefficients are to be printed (IFLAG = 1) or not. |

Output arguments:

| | | |
|---|---|---|
| Y | R*4 | Magnitude of variability Y0(90,DE). |

Global variables input from common:

| | | | |
|---|---|---|---|
| DEMIN | /CURVE/ | R*4 | CURVE.INC |
| | User supplied minima of the 90th percentile variability curve, Y0(90). | | |
| LOUT | /LUNS/ | I*2 | LUNS.INC |
| | FOR002.DAT output unit number. | | |
| Y900 | /CURVE/ | R*4 | CURVE.INC |
| | User supplied value for 90th percentile variability curve Y0(90) for DE greater than or equal 900 km. Used only when ICLIME is 2. Used to compute the equation for the Y0(90) curve fit. | | |
| YMIN | /CURVE/ | R*4 | CURVE.INC |
| | User supplied value for 90th percentile variability curve Y0(90) for DE equal to DEMIN. Used only when ICLIME is 2. Used to compute the equation for the Y0(90) curve fit. | | |

# CHAPTER 7

## CLIMATE VARIABILITY CALCULATIONS

This section describes the climate variability calculation routines:

| Name | Description | User's Manual section |
|---|---|---|
| CLIFIT | Climate curve fit . . . . . . . . | 2.5.4.5 |
| CLIME | Climate main routine . . . . . . | 2.5.3.1 |
| CLIMIL | MIL-HDBK-417 climates . . . . . . | 2.5.3.2, 2.5.4.1, 2.5.4.2 |
| CLIMIX | Mixed climates . . . . . . . . . | 2.5.3.1 |
| DEIND | DE indices . . . . . . . . . . . | NA |
| VARPOL | Interpolation . . . . . . . . . . | NA |
| VDECAL | VDE calculations . . . . . . . . | 2.5.3.1 |
| YINT | Y interpolation . . . . . . . . . | NA |

Climate calculations are described in sections 2.5.3 and 2.5.4 of the User's Manual.

NOTE

In most cases the sections in the User's Manual describe the coded equations as well as the theory behind them. NA denotes routines that are programming utilities such as finding indices, setting pointers, etc.

## 6.7 TANGL

Subprogram name: Subroutine TANGL

Purpose: Calculates radio horizon elevation angles and diffraction angle for a single diffraction path geometry.

Calling sequence:
CALL TANGL (D,HTS,HRS,DLT,DLR,HL,A,OET,OER,AHO,BHO,THETA,DO, X1,X2)

Contained in module: MDIF

Called by: MDIF

Calls: HORANG

Input arguments:

| | | |
|---|---|---|
| D | R*4 | Great circle distance in meters. |
| HTS | R*4 | Transmit terminal elevation above sea level in meters. |
| HRS | R*4 | Receive terminal elevation above sea level in meters. |
| DLT | R*4 | Great circle distance from radio horizon to transmitter (source) in meters. |
| DLR | R*4 | Great circle distance from radio horizon to receiver (observation point) in meters. |
| HL | R*4 | Radio horizon elevation above sea level in meters. |
| A | R*4 | Effective earth radius in meters. |

Output arguments:

| | | |
|---|---|---|
| OET | R*4 | Radio horizon elevation angle of transmit terminal above tangent to terminal site in radians. |
| OER | R*4 | Radio horizon elevation angle of receive terminal above tangent to terminal site in radians. |
| AHO | R*4 | Terminal radio horizon angle above straight line intersecting both terminals in radians. |
| BHO | R*4 | Terminal radio horizon angle above straight line intersecting both terminals in radians. |
| THETA | R*4 | Diffraction angle in radians. |
| DO | R*4 | Slant path range in meters. |
| X1 | R*4 | Distance from source (transmitter) to diffracting edge in meters. |
| X2 | R*4 | Distance from observation point (receiver) to diffracting edge in meters. |

Global variables input from common:

| | | | |
|---|---|---|---|
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |

```
                        Free space velocity of radio waves = 2.998E8 m/sec.
      DELPB             /PDATA/          R*4     PDATA.INC
                        Resolution of a delay cell in seconds.
      LERR              /LUNS/           I*2     LUNS.INC
                        Error output unit.
      LOUT              /LUNS/           I*2     LUNS.INC
                        FOR002.DAT output unit number.
      NDELMX            Parameter        I*2     TROPAR.INC
                        Maximum number of delay bins in troposcatter power per
                        unit delay profiles.
      PI                /CONSTA/         R*4     CONSTANTS.INC
                        Constant Pi = 3.141592654.

   Global variables output to common:
      DELREF            /PDATA/          R*4     PDATA.INC
                        Minimum delay through the lowest scattering point
                        (relative to straight line delay) in seconds.
      Q(NDELMX,NCORMX)  /PDATA/          R*4     PDATA.INC
                        Matrix of troposcatter signal power and correlation
                        per unit delay profiles.
                        For DIVTYP = 0:
                           Q(.,1)  Power on lower beam vs. delay.
                           Q(.,2)  Correlation between lower and
                                   upper beam vs. delay.
                           Q(.,3)  Correlation between lower beams
                                   in antennas 1 & 2 vs. delay.
                           Q(.,4)  Power on upper beam vs. delay.
                           Q(.,7)  Power on diffraction path vs. delay
                        For DIVTYP = 1:
                           Q(.,1)  Power on lower beam vs. delay.
                           Q(.,2)  Correlation between lower and
                                   upper beam vs. delay.
                           Q(.,3)  Power on upper beam vs. delay
                           Q(.,7)  Power on diffraction path vs. delay.
                        For DIVTYP = 2:
                           Q(.,1)  Power on path 1 (lower beam) vs. delay.
                           Q(.,2)  Correlation between convergent paths
                                   (lower beam) vs. delay.
                           Q(.,3)  Correlation between divergent paths
                                   (lower beam) vs. delay.
                           Q(.,4)  Correlation between parallel paths
                                   (lower beam) vs. delay.
                           Q(.,5)  Correlation between crossing paths
                                   (lower beam) vs. delay.
                           Q(.,6)  Power on path of upper beam vs. delay.
                           Q(.,7)  Power on diffraction path vs. delay.
```

## 6.6 MDIF

Subprogram name: Subroutine MDIF

Purpose: Routine to calculate the diffraction angles, relative delay, and basic path loss of a diffraction path with multiple diffraction points.

Calling sequence:

```
CALL MDIF (KD,HL,HTN,HRN,DL,D,DS,F,A,LB,DEL,THET,THER, MODPAT,JQDM)
```

Contained in module: MDIF

Called by: TROPO

Calls: DIF1, ERROR, TANGL

Input arguments:

| | | |
|---|---|---|
| KD | I*2 | Number of diffracting edges. No maximum set. |
| HL(KD) | R*4 | Array containing heights above sea level of the k diffraction points in meters. |
| HTN | R*4 | Transmit antenna height above sea level in meters. |
| HRN | R*4 | Receive antenna height above sea level in meters. |
| DL(KD) | R*4 | Array containing great circle distance from the transmitter to midpoint of each obstacle in meters. |
| D | R*4 | Great circle distance between transmitter and receiver in meters. |
| DS(KD) | R*4 | Array containing effective horizontal extent of each obstacle along great circle path in meters. |
| F | R*4 | Carrier frequency in MHz. |
| A | R*4 | Effective earth radius in meters. |
| MODPAT | I*2 | Indicates whether or not to calculate modem performance.<br>0 = Propagation only<br>1 = Propagation + MD-918 modem<br>2 = Propagation + TRC modem |
| JQDM | I*2 | Index in the multipath profile corresponding to the delay of the specular component. |

Output arguments:

| | | |
|---|---|---|
| LB | R*4 | Long term reference basic path loss in dB. |
| DEL | R*4 | Diffraction path delay relative to slant range delay in seconds. |
| THET | R*4 | Horizon elevation angle at transmit site in radians. |
| THER | R*4 | Horizon elevation angle at receive site in radians. |

Global variables input from common:

| | | | |
|---|---|---|---|
| A0 | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Radius of the earth in meters = 6367650. | | |
| C0 | /CONSTA/ | R*4 | CONSTANTS.INC |

## 6.5 INTERP

Subprogram name: Subroutine INTERP

Purpose: Routine to interpolate using nth order Lagrangian approximation.

Calling sequence:
CALL INTERP (IORD,IDIMX,IDIMA,FX,X,FA,A)

Contained in module: AVAIL

Called by: AVAIL, CONVOL

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| IORD | I*2 | Order of interpolation. |
| IDIMX | I*2 | Dimension of input arrays. Maximum is 101. |
| IDIMA | I*2 | Dimension of output arrays. Maximum is 50. |
| FX(IDIMX) | R*4 | Array containing IDIMX values of dependent variable. Dimensioned to 101. |
| X(IDIMX) | R*4 | Array containing IDIMX values of independent variable in ascending order. Dimensioned to 101. |
| A(IDIMA) | R*4 | Array containing IDIMA values of independent variable after interpolation in ascending order. Dimensioned to 50. |

Output arguments:

| | | |
|---|---|---|
| FA(IDIMA) | R*4 | Array containing IDIMA values of dependent varaiable after interpolation. Dimensioned to 50. |

```
                     (HLEF).
                            0 = HTE and HRE supplied directly
                            1 = AVETX and AVERX supplied
                            2 = HI(.) supplied
     PHDIV           /MCOM4/         R*4     MCOM.INC
                     Squint angle between upper and lower receiver beams in
                     radians.  Default is beamwidth.
     PSIREO(NRMX)    /ANTENN/        R*4     TROCOM.INC
                     Array of receiver beam boresight elevations above
                     radio horizon in radians, ie, angle at which each
                     antenna is aimed relative to the horizon.  PSIREO(1)
                     is the main receive antenna.
     PSITEO(NTMX)    /ANTENN/        R*4     TROCOM.INC
                     Array of transmitter beam boresight elevations above
                     radio horizon in radians, ie, angle at which each
                     antenna is aimed relative to the horizon.  PSITEO(1)
                     is the main transmit antenna.
     PXMIT           /MCOM4/         R*4     MCOM.INC
                     Rated transmission power in dBm.  Default is 70dBm.
     RLL             /SYSTRN/        R*4     TROCOM.INC
                     Receiver line losses in dB.  Default is 0 dB.
     SP              /MCOM4/         R*4     MCOM.INC
                     Service probability.  Default is .95.
     THER            /PATHGE/        R*4     TROCOM.INC
                     Radio horizon elevation angle at receive site in
                     radians.
     THET            /PATHGE/        R*4     TROCOM.INC
                     Radio horizon elevation angle at transmit site in
                     radians.
     TLL             /SYSTRN/        R*4     TROCOM.INC
                     Transmitter line losses in dB.  Default is 0 dB.

Global variables output to common:
     AVERX           /MCOM4/         R*4     MCOM.INC
                     Average terrain elevation above sea level between
                     receive site and radio horizon, in meters.
     AVETX           /MCOM4/         R*4     MCOM.INC
                     Average terrain elevation above sea level between
                     transmit site and radio horizon, in meters.
     DIFLOS(3)       /SUMP/          R*4     CURVE.INC
                     Median diffraction path loss in dB for each value in
                     ERFAC distribution.
     DIFRSL(3)       /SUMP/          R*4     CURVE.INC
                     Median diffraction signal RSL in dBm for each value in
                     ERFAC distribution.
     DSTSNR          /SUMP/          R*4     CURVE.INC
                     Standard deviation of diffracted signal long-term SNR
                     distribution in dB.
```

# CHAPTER 8

## BUTTERWORTH FILTER CALCULATIONS

This section describes the Butterworth filter calculation routines:

| Name | Description | User's Manual section |
|---|---|---|
| A50FCC | FCC filter attenuation relative to 50dB . . . . . . . . | 2.7 |
| BUTFIL | Main filter routine . . . . . . . | 2.7 |
| BWJAM | Interference power spectrum . . | 2.7.3 |
| ENRGF | Energy of filter cascade . . . | 2.7 |
| FCCMSK | FCC 19311 mask compare . . . . | NA |
| FFT | Fast Fourier transform . . . . | NA |
| FUNBW | Bandwidth constraint test . . . | NA |
| FUNJAM | Degradation test . . . . . . . | NA |
| INTERB | Linear interpolation . . . . . | NA |
| PEAK | Impulse response peak . . . . . | NA |
| PSPEC | Power spectrum - Butterworth . | 2.7 |
| PSPEC1 | Power spectrum - receiver . . . | 2.7 |
| PSPEC2 | Power spectrum - interferer-receiver . . . . . . . . . . . | 2.7.3 |
| PSPJ | Power spectrum - interferer . . | 2.7.3 |
| RTMI | Newton's iteration for non-linear equations . . . . . . . | NA |
| SAMPLE | Impulse response . . . . . . . | NA |
| SEARCH | Filter specification . . . . . | NA |
| SPEC | Spectrum - Butterworth . . . . | 2.7 |
| SPEC1 | Spectrum - receiver . . . . . . | 2.7 |
| SPEC2 | Spectrum - transmitter . . . . | 2.7.3 |

The main routine for this section is BUTFIL. These calculations are described in section 2.7 of the User's Manual.

Figure 2-4 is a top level flowchart for filter and interference effects calculations at a functional level. In most cases the blocks correspond to one or more subprograms. The test blocks (diamonds) correspond to logical branches which are decided by the user's choices of input data.

NOTE

In most cases the sections in the User's Manual describe the coded equations as well as the theory behind them. NA denotes routines that are programming utilities such as finding indices, setting pointers, etc.

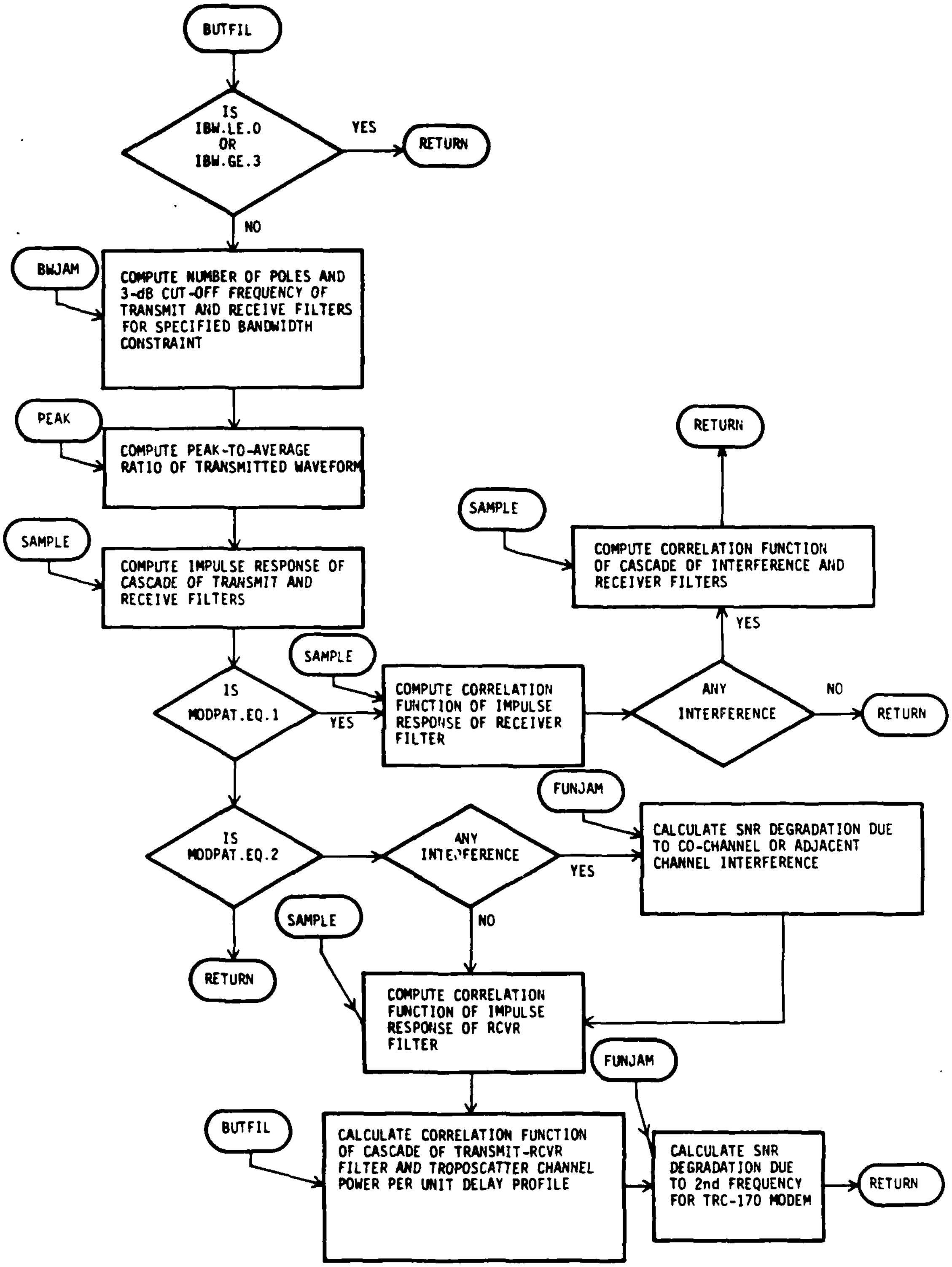



Figure 2-4 Flow Chart for Filter and Interference Effects Calculations

## 8.1 A50FCC

Subprogram name: Function A50FCC

Purpose: Calculates filter attenuation at normalized frequency F relative to 50dB attenuation.

Calling sequence:
A50FCC (F)

Contained in module: BUTFIL

Called by: FCCMSK, FUNBW

Calls: PSPEC

Input arguments:

F R*4 Frequency relative to the center of the band normalized to the symbol rate.

Output arguments:

A50FCC R*4 Filter attenuation at normalized frequency F relative to 50dB attenuation.

Global variables input from common:

FCTX /BUTPAR/ R*4 BUTPAR.INC
Normalized 3dB cut-off frequency of transmitter filter.

IFILTX /BUTPAR/ I*2 BUTPAR.INC
Transmitter filter indicator.
0 = MD-918 transmitter filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
1 = AN/TRC-170 transmitter filter. Also means filter is a cascade of Butterworth filter with rectangular impulse response filter of duration equal to half symbol duration.
2 = (not allowed)

NPOLTX /BUTPAR/ I*2 BUTPAR.INC
Number of poles in the transmit Butterworth filter.

PENERG /BUTPAR/ R*4 BUTPAR.INC
Normalized energy of filter.

RSDB /BUTPAR/ R*4 BUTPAR.INC
10 times the base 10 logarithm of the symbol rate minus 60.

## 8.2 BUTFIL

Subprogram name: Subroutine BUTFIL

Purpose: Calculate filter related parameters for MD-918 and TRC-170 modems.

Calling sequence:

```
CALL BUTFIL (DRATE,BW,IBW,TAPW,TAU22,JPOW1,JBW1,
FJSEP,MODSI1,MODPAT,TRCTYP)
```

Contained in module: BUTFIL

Called by: TROPO

Calls: BWJAM, FUNJAM, PEAK, PSPEC1, PSPEC2, SAMPLE, SPEC1, SPEC2

Input arguments:

```
DRATE   R*4   Data rate in bits/second.
BW      R*4   Signal bandwidth in Hertz.
IBW     I*2   RF bandwidth filtering constraint indicator:
                      0 = no constraint
                      1 = 99% bandwidth constraint
                      2 = FCC 19311 mask
                      3 = user supplied
TAPW    R*4   MD-918 AFE normalized tap spacing.
TAU22   R*8   RMS delay spread of troposcatter signal in lower beam
              in nanoseconds.
JPOW1   R*8   Interfering signal power density in dBm/Hz.
JBW1    R*8   Interfering signal bandwidth in Hertz.
FJSEP   R*4   Frequency separation between desired signal and
              interference signal in Hertz.
MODSI1  I*2   Interference modulation type indicator:
                      0 = FDM/FM
                      1 = QPSK
MODPAT  I*2   Indicates whether or not to calculate modem
              performance.
                      0 = Propagation only
                      1 = Propagation + MD-918 modem
                      2 = Propagation + TRC modem
                      3 = Propagation + user supplied modem
TRCTYP  R*4   AN/TRC-170 modem type indicator:
                      0 = 1 frequency DAR modem
                      1 = 2 frequency AN/TRC-170
```

Output arguments:

```
BW      R*4   99% bandwidth of transmit filter specified by user
              (IBW = 3) in Hertz.
```

Global variables input from common:

```
     LERR            /LUNS/          I*2     LUNS.INC
                     Error output unit.
     LOUT            /LUNS/          I*2     LUNS.INC
                     FOR002.DAT output unit number.
     NPOLRX          /BUTPAR/        R*4     BUTPAR.INC
                     Number of poles in the receive Butterworth filter.
     NPOLTX          /BUTPAR/        I*2     BUTPAR.INC
                     Number of poles in the transmit Butterworth filter.
     NTR             /RZ4/           I*2     RZ4.INC
                     Number of samples for calculating transmit-receive
                     filter impulse response (TRFILT).
     PENERG          /BUTPAR/        R*4     BUTPAR.INC
                     Normalized energy of filter.
     PI              /CONSTA/        R*4     CONSTANTS.INC
                     Constant Pi = 3.141592654.
     PJ              /JAMPAR/        R*4     JAMPAR.INC
                     Normalization constant for interference calculations.
     RCOR(32)        /RZ4/           R*4     RZ4.INC
                     Correlation function of the receive filter in steps
                     equal to the tapwidth (TAPW) for MD-918 modem, or
                     equal to 1/RATE for AN/TRC-170 or DAR modem.

Global variables output to common:
     CONJAM          /JAMPAR/        R*4     JAMPAR.INC
                     Interference constant.
     FCON            /BUTPAR/        R*4     BUTPAR.INC
                     Ratio of bandwidth to twice the symbol rate.
     FCRX            /BUTPAR/        R*4     BUTPAR.INC
                     Normalized 3dB cut-off frequency of receiver filter.
     FCTX            /BUTPAR/        R*4     BUTPAR.INC
                     Normalized 3dB cut-off frequency of transmitter
                     filter.
     FJSEPN          /JAMPAR/        R*4     JAMPAR.INC
                     Normalized frequency separation between the
                     interference signal and the desired signal.
     ICON            /BUTPAR/        I*2     BUTPAR.INC
                        1 = 99% bandwidth constraint
                        2 = FCC-13911 bandwidth constraint
     IFILRX          /BUTPAR/        I*2     BUTPAR.INC
                     Receiver filter indicator.
                             0 = MD-918 receiver filter.  Also means
                                 filter is a Butterworth cascaded with a
                                 rectangular impulse response filter of
                                 duration equal to symbol duration.
                             1 = (not allowed)
                             2 = AN/TRC-170 receiver filter.  Also means
                                 filter is a Butterworth.
     IFILTX          /BUTPAR/        I*2     BUTPAR.INC
                     Transmitter filter indicator.
                             0 = MD-918 transmitter filter.  Also means
```

filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
1 = AN/TRC-170 transmitter filter. Also means filter is a cascade of Butterworth filter with rectangular impulse response filter of duration equal to half symbol duration.
2 = (not allowed)

| | | | |
|---|---|---|---|
| JBW | /JAMPAR/ | R*4 | JAMPAR.INC |
| | 99% interferer bandwidth in MHz. | | |
| JPOW | /JAMPAR/ | R*4 | JAMPAR.INC |
| | Interferer power density in dBm/Hz: -174 or less denotes no interference. Default is -1000 dBm/Hz. | | |
| MODSG | /JAMPAR/ | I*2 | JAMPAR.INC |
| | Interference signal modulation format. Default is 1.<br>0 = Analog FDM / FM<br>1 = Digital QPSK | | |
| NJR | /RZ4/ | I*2 | RZ4.INC |
| | Number of sample points for RJCOR. | | |
| PEAKAV | /RZ4/ | R*4 | RZ4.INC |
| | Peak-to-average loss due to RF filtering in dB. | | |
| RJCOR(129) | /RZ4/ | R*4 | RZ4.INC |
| | Correlation function of interferer-receiver filters at RATE points per symbol interval. | | |
| RSDB | /BUTPAR/ | R*4 | BUTPAR.INC |
| | 10 times the base 10 logarithm of the symbol rate minus 60. | | |
| SNRBW | /RZ4/ | R*4 | RZ4.INC |
| | Signal to noise ratio adjustment for AN/TRC-170 due to limited receive filter bandwidth. | | |
| SNRF2 | /RZ4/ | R*4 | RZ4.INC |
| | Parameter to adjust the signal to noise ratio for degradation due to interference from another frequency. Only for 2-frequency AN/TRC-170 modem. | | |
| SNRJAM | /RZ4/ | R*4 | RZ4.INC |
| | Parameter to adjust the signal to noise ratio of AN/TRC-170 for degradation due to colocated/adjacent channel interference. | | |
| TRFILT(128) | /RZ4/ | R*4 | RZ4.INC |
| | Transmit-receive filter impulse response. | | |
| XTRO | /RZ4/ | R*4 | RZ4.INC |
| | Time origin for transmit-receive filter impulse response (TRFILT), ie, X is TRFILT(X+XTRO). | | |
| XTRINC | /RZ4/ | R*4 | RZ4.INC |
| | Sample interval for calculation of transmit-receive filter impulse response (TRFILT). | | |

## 8.3 BWJAM

Subprogram name: Subroutine BWJAM

Purpose: Specify power spectrum for interference and calculate transmit filter and receive filter parameters. Calculate number of poles and 3dB cut-off frequency of transmit and receive filters for specified bandwidth constraint.

Calling sequence:

```
CALL BWJAM (MODPAT,TRCTYP,FLOWER,FUPPER,NLOWER,NUPPER, IBW,BW,SRATE)
```

Contained in module: BUTFIL

Called by: BUTFIL

Calls: ENRGF, FUNBW, FUNJAM, RTMI, SEARCH

Input arguments:

| | | |
|---|---|---|
| MODPAT | I*2 | Indicates whether or not to calculate modem performance.<br>0 = Propagation only<br>1 = Propagation + MD-918 modem<br>2 = Propagation + TRC modem<br>3 = Propagation + user supplied modem |
| TRCTYP | R*4 | AN/TRC-170 modem type indicator:<br>0 = 1 frequency DAR modem<br>1 = 2 frequency AN/TRC-170 |
| FLOWER | R*4 | Smallest normalized cut-off frequency of interest for Butterworth filter. |
| FUPPER | R*4 | Largest normalized cut-off frequency of interest for Butterworth filter. |
| NLOWER | I*2 | Smallest number of poles of interest for Butterworth filter. |
| NUPPER | I*2 | Largest number of poles of interest for Butterworth filter. |
| IBW | I*2 | RF bandwidth filtering constraint indicator:<br>0 = no constraint<br>1 = 99% bandwidth constraint<br>2 = FCC 19311 mask<br>3 = user supplied |
| BW | R*4 | Signal bandwidth in Hertz. |
| SRATE | R*4 | Symbol rate in symbols/second. |

Output arguments:

Global variables input from common:

| | | | |
|---|---|---|---|
| FCTX | /BUTPAR/ | R*4 | BUTPAR.INC |
| | Normalized 3dB cut-off frequency of transmitter filter. | | |

```
     IFILTX          /BUTPAR/        I*2     BUTPAR.INC
                     Transmitter filter indicator.
                            0 = MD-918 transmitter filter.  Also means
                                filter is a Butterworth cascaded with a
                                rectangular impulse response filter of
                                duration equal to symbol duration.
                            1 = AN/TRC-170 transmitter filter.  Also means
                                filter is a cascade of Butterworth filter
                                with rectangular impulse response filter
                                of duration equal to half symbol duration.
                            2 = (not allowed)
     JBW             /JAMPAR/        R*4     JAMPAR.INC
                     99% interferer bandwidth in MHz.
     JPOW            /JAMPAR/        R*4     JAMPAR.INC
                     Interferer power density in dBm/Hz: -174 or less
                     denotes no interference.  Default is -1000 dBm/Hz.
     LERR            /LUNS/          I*2     LUNS.INC
                     Error output unit.
     MODSG           /JAMPAR/        I*2     JAMPAR.INC
                     Interference signal modulation format.  Default is 1.
                            0 = Analog FDM / FM
                            1 = Digital QPSK
     PENERG          /BUTPAR/        R*4     BUTPAR.INC
                     Normalized energy of filter.

Global variables output to common:
     CONJAM          /JAMPAR/        R*4     JAMPAR.INC
                     Interference constant.
     FCJ             /JAMPAR/        R*4     JAMPAR.INC
                     Normalized 3dB cut-off frequency of QPSK interference
                     filter.
     FCON            /BUTPAR/        R*4     BUTPAR.INC
                     Ratio of bandwidth to twice the symbol rate.
     FCRX            /BUTPAR/        R*4     BUTPAR.INC
                     Normalized 3dB cut-off frequency of receiver filter.
     FMI             /JAMPAR/        R*4     JAMPAR.INC
                     Modulation index for FDM/FM interference.
     ICON            /BUTPAR/        I*2     BUTPAR.INC
                        1 = 99% bandwidth constraint
                        2 = FCC-13911 bandwidth constraint
     NPOLJ           /JAMPAR/        I*2     JAMPAR.INC
                     Number of poles in the QPSK interference filter.
     NPOLRX          /BUTPAR/        R*4     BUTPAR.INC
                     Number of poles in the receive Butterworth filter.
     NPOLTX          /BUTPAR/        I*2     BUTPAR.INC
                     Number of poles in the transmit Butterworth filter.
     PJ              /JAMPAR/        R*4     JAMPAR.INC
                     Normalization constant for interference calculations.
     WFM             /JAMPAR/        R*4     JAMPAR.INC
                     Normalization constant for FDM/FM interference.
```

## 8.4 ENRGF

Subprogram name: Subroutine ENRGF

Purpose: To calculate 'energy' of cascade of Butterworth filter and filter with rectangular impulse response by integrating power spectrum of the cascade of the two filters.

Calling sequence:

CALL ENRGF (NPOLE,FCUT,IFILT,PENERG,FINCR,IERR)

Contained in module: BUTFIL

Called by: BWJAM, FUNBW, FUNJAM

Calls: PSPEC

Input arguments:

| | | |
|---|---|---|
| NPOLE | I*2 | Number of poles of Butterworth filter. |
| FCUT | R*4 | Normalized 3-dB cut off frequency of Butterworth filter. |
| IFILT | I*2 | Rectangular impulse response filter duration flag:<br>0 = symbol duration<br>1 = half-symbol duration<br>2 = no rectangular impulse response filter |
| FINCR | R*4 | Normalized frequency increment for integration. |

Output arguments:

| | | |
|---|---|---|
| PENERG | R*4 | Energy of cascade of the two filters. |
| IERR | I*2 | Error flag: 0 = no error; 1 = integral did not converge. |

## 8.5 FCCMSK

Subprogram name: Subroutine FCCMSK

Purpose: To compare filter attenuation as a function of frequency with FCC 19311 mask.

Calling sequence:
CALL FCCMSK (N1,N2,N3,IERR)

Contained in module: BUTFIL

Called by: FUNBW

Calls: A50FCC

Input arguments:

| | | |
|---|---|---|
| N1 | I*2 | Number of frequencies to be tested in flat 50 dB region. |
| N2 | I*2 | Number of frequencies to be tested in linear attenuation region. |
| N3 | I*2 | Number of frequencies to be tested in flat 80 dB region. |

Output arguments:

| | | |
|---|---|---|
| IERR | I*2 | Error flag. |

Global variables input from common:

| | | | |
|---|---|---|---|
| F50L | /BUTPAR/ | R*4 | BUTPAR.INC |
| | 50dB normalized corner frequency. | | |
| RSDB | /BUTPAR/ | R*4 | BUTPAR.INC |
| | 10 times the base 10 logarithm of the symbol rate minus 60. | | |

## 8.6 FFT

Subprogram name: Subroutine FFT

Purpose: Fast Fourier transform.

Reference: Oppenheim, Shaffer, Digital Signal Processing, p.332.

Calling sequence:

```
CALL FFT (X,M,INDEX)
```

Contained in module: BUTFIL

Called by: SAMPLE

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| X(128) | C*8 | Input sequence. |
| M | I*2 | Log base 2 of number of points in the transform. |
| INDEX | I*2 | Processing switch:<br>1 = Direct FFT<br>-1 = Inverse FFT |

Output arguments:

| | | |
|---|---|---|
| X(128) | C*8 | Output (fourier transformed) sequence. |

Global variables input from common:

| | | | |
|---|---|---|---|
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |

## 8.7 FUNBW

Subprogram name: Function FUNBW

Purpose: To determine whether Butterworth filter with normalized cut-off frequency FC meets 99% or FCC 19311 bandwidth constraint (FUNBW < 0) or not.

Calling sequence:
FUNBW (FC)

Contained in module: BUTFIL

Called by: BUTFIL, BWJAM

Calls: A50FCC, ENRGF, FCCMSK, INTERB, PSPEC

Input arguments:

| | | |
|---|---|---|
| FC | R*4 | Normalized cut-off frequency of Butterworth filter. |

Output arguments:

| | | |
|---|---|---|
| FUNBW | R*4 | Flags whether Butterworth filter with normalized cut-off frequency FC meets 99% or FCC 19311 bandwidth constraint (FUNBW < 0) or not. |

Global variables input from common:

```
FCON          /BUTPAR/      R*4     BUTPAR.INC
              Ratio of bandwidth to twice the symbol rate.
ICON          /BUTPAR/      I*2     BUTPAR.INC
                 1 = 99% bandwidth constraint
                 2 = FCC-13911 bandwidth constraint
IFILTX        /BUTPAR/      I*2     BUTPAR.INC
              Transmitter filter indicator.
                     0 = MD-918 transmitter filter.  Also means
                         filter is a Butterworth cascaded with a
                         rectangular impulse response filter of
                         duration equal to symbol duration.
                     1 = AN/TRC-170 transmitter filter.  Also means
                         filter is a cascade of Butterworth filter
                         with rectangular impulse response filter
                         of duration equal to half symbol duration.
                     2 = (not allowed)
NPOLTX        /BUTPAR/      I*2     BUTPAR.INC
              Number of poles in the transmit Butterworth filter.
PENERG        /BUTPAR/      R*4     BUTPAR.INC
              Normalized energy of filter.
```

Global variables output to common:

```
F50L          /BUTPAR/      R*4     BUTPAR.INC
              50dB normalized corner frequency.
```

## 8.18 SPEC

Subprogram name: C*8 Function SPEC

Purpose: Evaluate the spectrum (Fourier transform of impulse response) at normalized frequency F of the cascade of a Butterworth filter and a filter with a rectangular impulse response.

Calling sequence:
SPEC (F,NPOLE,FCUT,IFILT)

Contained in module: BUTFIL

Called by: SPEC1, SPEC2

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| F | R*4 | Frequency relative to the center of the band normalized to the symbol rate. |
| NPOLE | I*2 | Number of poles of Butterworth filter. |
| FCUT | R*4 | Normalized 3dB cutoff frequency of Butterworth filter. |
| IFILT | I*2 | Rectangular impulse response filter duration flag:<br>0 = symbol duration<br>1 = half-symbol duration<br>2 = response of filter is an impulse |

Output arguments:

| | | |
|---|---|---|
| SPEC | C*8 | Spectrum (Fourier transform of impulse response) at normalized frequency F of the cascade of a Butterworth filter and a filter with a rectangular impulse response. |

Global variables input from common:

| | | | |
|---|---|---|---|
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |

## 8.17 SEARCH

```
Subprogram name:     Subroutine SEARCH

Purpose:     Specify a Butterworth filter with NPOLE poles, where
     NLOWER < NPOLE < NUPPER and 3dB cut-off frequency FCUT is
     FLOWER < FCUT < FUPPER to satisfy the constraint FUN < 0 and to
     mimimize a pulse duration criterion.

Calling sequence:
     CALL SEARCH (IFUN,FUN,FLOWER,FUPPER,NLOWER,NUPPER,FCUT, NPOLE,IERR)

Contained in module: BUTFIL

Called by:   BWJAM

Calls:       RTMI    FUNJAM  FUNBW

Input arguments:
     IFUN    I*2     Process switch:
                        1 = specify transmit filter parameters
                        2 = specify receive filter parameters
     FLOWER  R*4     Lower limit for cut-off frequency, FCUT.
     FUPPER  R*4     Upper limit for cut-off frequency, FCUT.
     NLOWER  I*2     Lower limit for number of poles, NPOLE.
     NUPPER  I*2     Upper limit for number of poles, NPOLE.
     FUN     R*4     Function name:
                        For IFUN = 1, FUN = FUNBW
                        For IFUN = 2, FUN = FUNJAM

Output arguments:
     FCUT    R*4     3-dB cut off frequency of Butterworth filter.
     NPOLE   I*2     Number of poles of Butterworth filter.
     IERR    I*2     Error flag:
                             0 = no error
                             1 = FLOWER is too large
                             2 = FUPPER is too small
                             3 = no solution found

Global variables input from common:
     LERR            /LUNS/          I*2     LUNS.INC
                     Error output unit.
     PI              /CONSTA/        R*4     CONSTANTS.INC
                     Constant Pi = 3.141592654.

Global variables output to common:
     NPOLRX          /BUTPAR/        R*4     BUTPAR.INC
                     Number of poles in the receive Butterworth filter.
     NPOLTX          /BUTPAR/        I*2     BUTPAR.INC
                     Number of poles in the transmit Butterworth filter.
```

## 8.16 SAMPLE

Subprogram name: Subroutine SAMPLE

Purpose: Calculate impulse response of filter with spectrum (Fourier Transform of impulse response) WFUN.

Calling sequence:

```
CALL SAMPLE (WSAMPL,WFUN,RATE,MMIN,MMAX,TMAX,FMAX,NSMPL,IERR)
```

Contained in module: BUTFIL

Called by: BUTFIL

Calls: FFT

Input arguments:

| | | |
|---|---|---|
| RATE | R*4 | Sampling rate in samples/unit of time. |
| MMIN | I*2 | Log base 2 of minimum FFT length to be considered. |
| MMAX | I*2 | Log base 2 of maximum FFT length to be considered. |
| TMAX | R*4 | Maximum length of impulse response. |
| FMAX | R*4 | Maximum frequency in spectrum. |

Output arguments:

| | | |
|---|---|---|
| WSAMPL(128) | R*4 | Impulse response. |
| WFUN | C*8 | Spectrum function name. |
| NSMPL | I*2 | Number of samples in impulse response. |
| IERR | I*2 | Error flag: 0 = no error; 1 = inadequate FFT length. |

## 8.15 RTMI

Subprogram name: Subroutine RTMI

Purpose: IBM SSP Library routine. RTMI solves the general nonlinear equation of the form FCN(x) = 0 by Newton's iteration method.

Calling sequence:

```
CALL RTMI (X,F,FCT,XLI,XRI,EPS,IEND,IER)
```

Contained in module: BUTFIL

Called by: BWJAM, SEARCH

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| FCT | R*4 | Name of external subroutine used. It computes to given argument X and function value F. Parameter list must be X, F. |
| XLI | R*4 | Smallest value of X. |
| XRI | R*4 | Largest value of X. |
| EPS | R*4 | Input value that specifies the upper bound of the error of result X. |
| IEND | I*2 | Maximum number of iteration steps specified. |

Output arguments:

| | | |
|---|---|---|
| X | R*4 | Resultant root of equation f(x) = 0. |
| F | R*4 | Resultant function value at root X. |
| IER | I*2 | Resultant error code:<br>0 = No error.<br>1 = No convergence after IEND iteration steps. |

| | | | |
|---|---|---|---|
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |
| WFM | /JAMPAR/ | R*4 | JAMPAR.INC |
| | Normalization constant for FDM/FM interference. | | |

## 8.14 PSPJ

Subprogram name: Function PSPJ

Purpose: Power spectrum of interferer at frequency F.

Calling sequence:
PSPJ (F)

Contained in module: BUTFIL

Called by: FUNJAM, PSPEC2, PWRSPC

Calls: PSPEC

Input arguments:
F R*4 Frequency relative to the center of the band normalized to the symbol rate.

Output arguments:
PSPJ R*4 Power spectrum of interferer at frequency F.

Global variables input from common:

FCJ /JAMPAR/ R*4 JAMPAR.INC
Normalized 3dB cut-off frequency of QPSK interference filter.

FCTX /BUTPAR/ R*4 BUTPAR.INC
Normalized 3dB cut-off frequency of transmitter filter.

FMI /JAMPAR/ R*4 JAMPAR.INC
Modulation index for FDM/FM interference.

IFILTX /BUTPAR/ I*2 BUTPAR.INC
Transmitter filter indicator.
0 = MD-918 transmitter filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
1 = AN/TRC-170 transmitter filter. Also means filter is a cascade of Butterworth filter with rectangular impulse response filter of duration equal to half symbol duration.
2 = (not allowed)

MODSG /JAMPAR/ I*2 JAMPAR.INC
Interference signal modulation format. Default is 1.
0 = Analog FDM / FM
1 = Digital QPSK

NPOLJ /JAMPAR/ I*2 JAMPAR.INC
Number of poles in the QPSK interference filter.

NPOLTX /BUTPAR/ I*2 BUTPAR.INC
Number of poles in the transmit Butterworth filter.

## 8.13 PSPEC2

Subprogram name: C*8 Function PSPEC2

Purpose: To calculate power spectrum of interferer-receiver filters at normalized frequency F.

Calling sequence:
PSPEC2 (F)

Contained in module: BUTFIL

Called by: BUTFIL

Calls: PSPEC, PSPJ

Input arguments:

| | | |
|---|---|---|
| F | R*4 | Frequency relative to the center of the band normalized to the symbol rate. |

Output arguments:

| | | |
|---|---|---|
| PSPEC2 | C*8 | Power spectrum of interferer-receiver filters at normalized frequency F. |

Global variables input from common:

```
FCRX      /BUTPAR/      R*4    BUTPAR.INC
          Normalized 3dB cut-off frequency of receiver filter.
FJSEPN    /JAMPAR/      R*4    JAMPAR.INC
          Normalized frequency separation between the
          interference signal and the desired signal.
IFILRX    /BUTPAR/      I*2    BUTPAR.INC
          Receiver filter indicator.
                0 = MD-918 receiver filter.  Also means
                    filter is a Butterworth cascaded with a
                    rectangular impulse response filter of
                    duration equal to symbol duration.
                1 = (not allowed)
                2 = AN/TRC-170 receiver filter.  Also means
                    filter is a Butterworth.
NPOLRX    /BUTPAR/      R*4    BUTPAR.INC
          Number of poles in the receive Butterworth filter.
```

## 8.12 PSPEC1

Subprogram name: C*8 Function PSPEC1

Purpose: To calculate power spectrum of receiver filter at normalized frequency F.

Calling sequence:
PSPEC1 (F)

Contained in module: BUTFIL

Called by: BUTFIL

Calls: PSPEC

Input arguments:

| | | |
|---|---|---|
| F | R*4 | Frequency relative to the center of the band normalized to the symbol rate. |

Output arguments:

| | | |
|---|---|---|
| PSPEC1 | C*8 | Power spectrum of receiver filter at normalized frequency F. |

Global variables input from common:

FCRX /BUTPAR/ R*4 BUTPAR.INC
Normalized 3dB cut-off frequency of receiver filter.

IFILRX /BUTPAR/ I*2 BUTPAR.INC
Receiver filter indicator.
- 0 = MD-918 receiver filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
- 1 = (not allowed)
- 2 = AN/TRC-170 receiver filter. Also means filter is a Butterworth.

NPOLRX /BUTPAR/ R*4 BUTPAR.INC
Number of poles in the receive Butterworth filter.

## 8.11 PSPEC

Subprogram name: Function PSPEC

Purpose: To calculate power spectrum of cascade of Butterworth filter with rectangular impulse response filter at normalized frequency F.

Calling sequence:
PSPEC (F,NPOLE,FCUT,IFILT)

Contained in module: BUTFIL

Called by: A50FCC, ENRGF, FUNBW, FUNJAM, PSPEC1, PSPEC2, PSPJ, PWRSPC

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| F | R*4 | Frequency relative to the center of the band normalized to the symbol rate. |
| NPOLE | I*2 | Number of poles of Butterworth filter. |
| FCUT | R*4 | Normalized 3-dB cut off frequency of Butterworth filter. |
| IFILT | I*2 | Rectangular impulse response filter duration flag:<br>0 = symbol duration<br>1 = half-symbol duration<br>2 = impulse response is an impulse. |

Output arguments:

| | | |
|---|---|---|
| PSPEC | R*4 | Power spectrum of cascade of Butterworth filter with rectangular impulse response filter at normalized frequency F. |

Global variables input from common:

| | | | |
|---|---|---|---|
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |

## 8.10 PEAK

Subprogram name: Subroutine PEAK

Purpose: To calculate the peak of the transmitted waveform impulse response.

Calling sequence:

```
CALL PEAK (XMAX,IMAX,X,N)
```

Contained in module: BUTFIL

Called by: BUTFIL

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| X(N) | R*4 | Impulse response of transmitted waveform. Dimensioned to 128. |
| N | I*2 | Number of samples in impulse response. Maximum is 128. |

Output arguments:

| | | |
|---|---|---|
| XMAX | R*4 | Peak value of impulse response. |
| IMAX | I*2 | Index of peak sample. |

## 8.9 INTERB

Subprogram name: Subroutine INTERB

Purpose: Linear interpolation in a table of N pairs (XX,YY).

Calling sequence:

```
CALL INTERB (Y,X,YY,XX,N,IERR)
```

Contained in module: BUTFIL

Called by: FUNBW

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| X | R*4 | Value of x-coordinate for which y-coordinate is desired. |
| YY(N) | R*4 | Tabulated values of y-coordinate corresponding to tabulated x-coordinate. Dimensioned to 30. |
| XX(N) | R*4 | Tabulated value of x-coordinate in decreasing order. Dimensioned to 30. |
| N | I*2 | Number of tabulated values over which interpolation is to be performed. Maximum is 30. |

Output arguments:

| | | |
|---|---|---|
| Y | R*4 | Value of y-coordinate corresponding to x-coordinate. |
| IERR | I*2 | Error flag:<br>0 = no error<br>5 = x-coordinate value greater than largest tabulated value<br>6 = x-coordinate value less than smallest tabulated value |

## 8.8 FUNJAM

Subprogram name: Function FUNJAM

Purpose: To determine whether adjacent channel interference power within receiver bandwidth, calculated by integrating over the product of the interference power spectrum and the receiver filter power spectrum, degrades the SNL by less than 1 dB.

Calling sequence:
FUNJAM (FC)

Contained in module: BUTFIL

Called by: BUTFIL, BWJAM

Calls: ENRGF, PSPEC, PSPJ

Input arguments:
FC R*4 Normalized cut-off frequency of Butterworth filter.

Output arguments:
FUNJAM R*4 Flags whether adjacent channel interference power within receiver bandwidth degrades the SNL by less than 1 dB.

Global variables input from common:

CONJAM /JAMPAR/ R*4 JAMPAR.INC
Interference constant.

FJSEPN /JAMPAR/ R*4 JAMPAR.INC
Normalized frequency separation between the interference signal and the desired signal.

IFILRX /BUTPAR/ I*2 BUTPAR.INC
Receiver filter indicator.
0 = MD-918 receiver filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
1 = (not allowed)
2 = AN/TRC-170 receiver filter. Also means filter is a Butterworth.

NPOLRX /BUTPAR/ R*4 BUTPAR.INC
Number of poles in the receive Butterworth filter.

PJ /JAMPAR/ R*4 JAMPAR.INC
Normalization constant for interference calculations.

| | | | |
|---|---|---|---|
| FCTX | /BUTPAR/ | R*4 | BUTPAR.INC |
| | Normalized 3dB cut-off frequency of transmitter filter. | | |

## 8.19 SPEC1

Subprogram name: C*8 Function SPEC1

Purpose: Evaluate the spectrum (Fourier transform of impulse response) at normalized frequency F of the receiver filter.

Calling sequence:
SPEC1 (F)

Contained in module: BUTFIL

Called by: BUTFIL

Calls: SPEC

Input arguments:

| | | |
|---|---|---|
| F | R*4 | Frequency relative to the center of the band normalized to the symbol rate. |

Output arguments:

| | | |
|---|---|---|
| SPEC1 | C*8 | Spectrum (Fourier transform of impulse response) at normalized frequency F of the receiver filter. |

Global variables input from common:

FCRX /BUTPAR/ R*4 BUTPAR.INC
Normalized 3dB cut-off frequency of receiver filter.

FCTX /BUTPAR/ R*4 BUTPAR.INC
Normalized 3dB cut-off frequency of transmitter filter.

IFILRX /BUTPAR/ I*2 BUTPAR.INC
Receiver filter indicator.
- 0 = MD-918 receiver filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
- 1 = (not allowed)
- 2 = AN/TRC-170 receiver filter. Also means filter is a Butterworth.

IFILTX /BUTPAR/ I*2 BUTPAR.INC
Transmitter filter indicator.
- 0 = MD-918 transmitter filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
- 1 = AN/TRC-170 transmitter filter. Also means filter is a cascade of Butterworth filter with rectangular impulse response filter of duration equal to half symbol duration.
- 2 = (not allowed)

| | | | |
|---|---|---|---|
| NPOLRX | /BUTPAR/ | R*4 | BUTPAR.INC |
| | Number of poles in the receive Butterworth filter. | | |
| NPOLTX | /BUTPAR/ | I*2 | BUTPAR.INC |
| | Number of poles in the transmit Butterworth filter. | | |

## 8.20 SPEC2

Subprogram name: C*8 Function SPEC2

Purpose: To calculate the spectrum (Fourier transform of impulse response) at normalized frequency F of the transmitter filter.

Calling sequence:
SPEC2 (F)

Contained in module: BUTFIL

Called by: BUTFIL

Calls: SPEC

Input arguments:

| | | |
|---|---|---|
| F | R*4 | Frequency relative to the center of the band normalized to the symbol rate. |

Output arguments:

| | | |
|---|---|---|
| SPEC2 | C*8 | Spectrum (Fourier transform of impulse response) at normalized frequency F of the transmitter filter. |

Global variables input from common:

FCTX /BUTPAR/ R*4 BUTPAR.INC
Normalized 3dB cut-off frequency of transmitter filter.

IFILTX /BUTPAR/ I*2 BUTPAR.INC
Transmitter filter indicator.
0 = MD-918 transmitter filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
1 = AN/TRC-170 transmitter filter. Also means filter is a cascade of Butterworth filter with rectangular impulse response filter of duration equal to half symbol duration.
2 = (not allowed)

NPOLTX /BUTPAR/ I*2 BUTPAR.INC
Number of poles in the transmit Butterworth filter.

# CHAPTER 9

## MD-918 MODEM CALCULATIONS

This section describes the MD-918 modem performance calculation routines:

| Name | Description | User's Manual section |
|---|---|---|
| BERCAL | Short term performance calculation . . . . . . . . . . . | 2.8.1 |
| BOTAC | Interference covariance matrices . . . . . . . . . . . . | 2.8.1 |
| CAC | Cascade of filter and channel power impulse response . . . . | NA |
| CAJI | Thermal noise covariance matrix | NA |
| CAKL | Signal covariance matrix C(K,L) | NA |
| CHANGE | Matrix utility . . . . . . . . . | NA |
| DINT | Double integration . . . . . . | NA |
| EIGEN | Eigenvalues and eigenvectors . | 2.8.1 |
| ELMES | Matrix conditioner . . . . . . | 2.9.4 |
| ERLANG | Butterworth filter calculation | NA |
| HQR | Eigenvalues . . . . . . . . . . . | 2.9.4 |
| JAMCOM | Interference covariance matrix | NA |
| MATA | Matrix multiplication . . . . . | NA |
| MATCO | Covariance matrices . . . . . . | NA |
| MDTS | MD-918 modem performance . . . | 2.8 |
| MINV | Matrix inversion . . . . . . . | NA |
| ORDER | Order values in vector . . . . | NA |
| PDFCON | Coefficients of PDF . . . . . . | 2.8.1.3 |
| PROUT | Print out outages and BER . . . | NA |
| PSINE | Sine product . . . . . . . . . | NA |
| PWRSPC | Power spectrum - receiver-interferer . . . . . . . . . . . | 2.7.3 |
| RJCFCN | Receiver-interferer correlation function . . . . . . . . . . . . | 2.7.3 |
| SASEQ | Chip sequence . . . . . . . . . . | NA |
| SIGIN | Set parameters . . . . . . . . . | NA |
| SINC | SINC function . . . . . . . . . . | NA |
| SQTMAT | Matrix square root . . . . . . . | 2.8.1 |

| | | |
|---|---|---|
| TPSPEC | Power spectrum - Butterworth . | 2.7 |
| TPSPJ | Power spectrum - interferer . . | 2.7.3 |
| TSINC | Triangle and SINC convolution . | NA |
| XNOR | Gaussian PDF . . . . . . . . . . | NA |

The main routine for this section is MDTS. The MD-918 calculations are described in section 2.8 of the User's Manual.

Figure 2-5 is a top level flowchart for MD-918 modem performance calculations at a functional level. In most cases the blocks correspond to one or more subprograms. The test blocks (diamonds) correspond to logical branches which are decided by the user's choices of input data.

NOTE

In most cases the sections in the User's Manual describe the coded equations as well as the theory behind them. NA denotes routines that are programming utilities such as finding indices, setting pointers, etc.

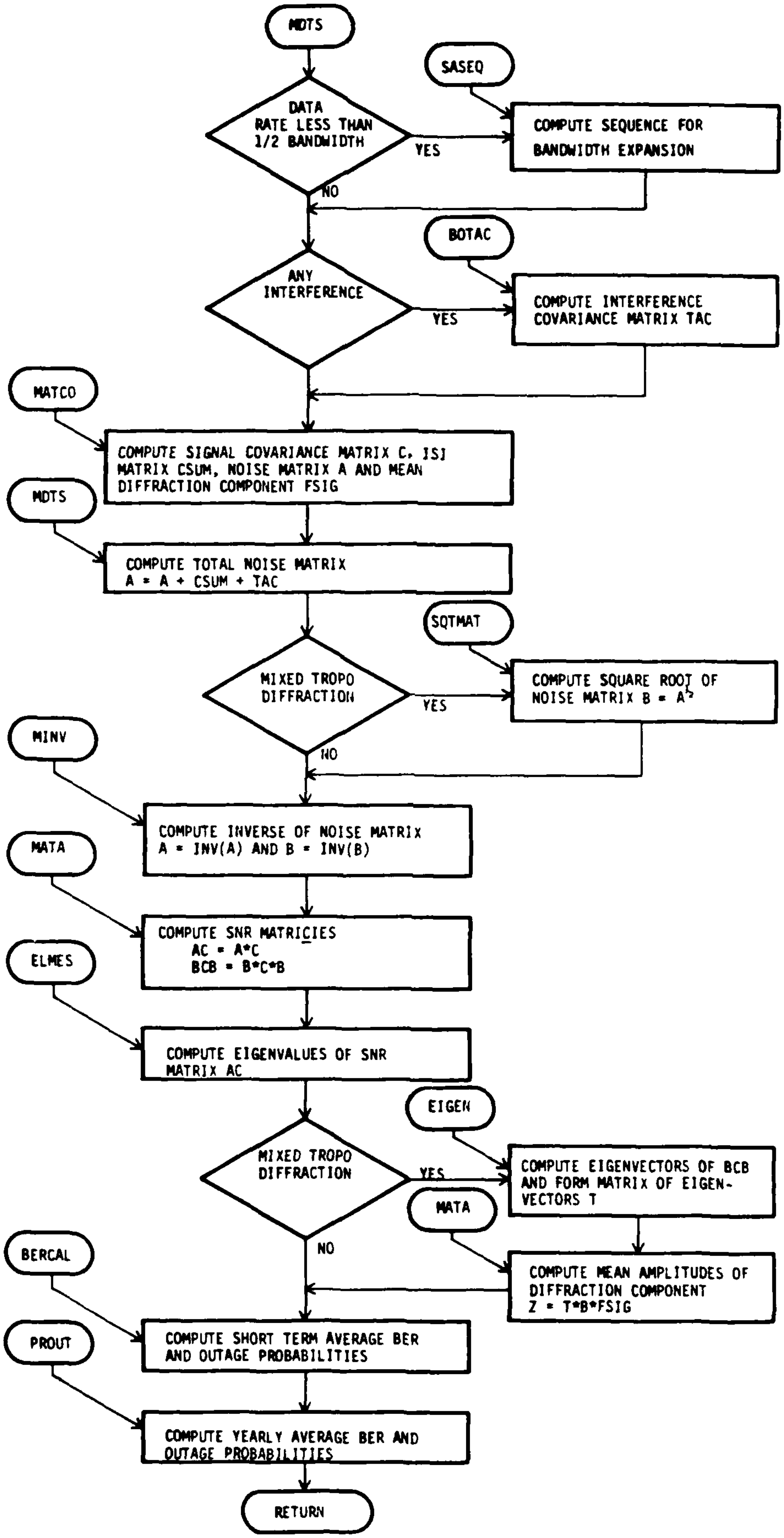



Figure 2-5 Flow Chart for the MD-918 Modem Performance Calculations

## 9.1 BERCAL

Subprogram name: Subroutine BERCAL

Purpose: BERCAL computes the outage probability, fade outage per call minute, average bit error rate and 1000-bit block error probability as a function of mean hourly scatter SNR, specular component SNR, DSNR, for the MD-918 modem. This version accounts for decorrelation of long term fading of main and elevated beams.

Reference: P. Monsen 'Theoretical and measured performance of a DFE modem on a fading multipath channel.', IEEE Transactions on Communications, Vol. COM-25, No. 10, October, 1977, pp. 1144-1153.

Calling sequence:

```
CALL BERCAL(VJ4,JPOW,JSR,CRATE,IBER,SNR,U,BOUT,ABE,
SOUT,NOUT,V,F,K3,K6,ASNR,STSNR,FOUT,CGAIN,CORFAC,IFPKAV,
XSCAT,XDIFR,G,DSNR,ADSNR,DSTSNR,PTYPE,IFDSNR)
```

Contained in module: BERCAL

Called by: MDTS

Calls: ERLANG PDFCON XNOR

Input arguments:

| | | |
|---|---|---|
| VJ4 | R*4 | Gain of strongest implicit diversity branch of elevated beam. |
| JPOW | R*8 | Interferer power density in dBm/Hz. If JPOW is less than -174 dBm (background noise level), BERCAL assumes no interference. |
| JSR | R*8 | Interferer to signal power ratio in dB. |
| CRATE | R*4 | Code rate. |
| IBER | I*2 | Integer counter used to indicate the completion of averaging over distributions of SNR and DSNR (IBER = 2). |
| SNR | R*4 | Mean hourly SNR in dB at which outage probability is to be calculated. |
| F | R*4 | Scatter SNR as a ratio. Includes modem degradation. |
| K3 | I*2 | Pointer, with K6, to blocks of eigenvalues. |
| K6 | I*2 | Pointer, with K3, to blocks of eigenvalues. |
| ASNR | R*4 | Mean of long term distribution of scatter SNR (Eb/No) in dB. |
| STSNR | R*4 | Standard deviation of long term distribution of scatter SNR (Eb/No) in dB. |
| CGAIN(3) | R*4 | Coding gain for each BER threshold. |
| CORFAC | R*4 | Correction factor for STSNR due to decorrelation of long term variability for angle diversity. |

| | | |
|---|---|---|
| IFPKAV | I*2 | Switch to print outage probability as a function of peak scatter SNR (Ep/No) when IFPKAV = 1, or average scatter SNR (Eb/No) when IFPKAV = 0. |
| XSCAT | R*4 | Scatter SNR as a fraction of total power. |
| XDIFR | R*4 | Specular component SNR as a fraction of total power. |
| G | R*4 | Specular component SNR as a ratio. |
| DSNR | R*4 | Specular component SNR in dB. |
| ADSNR | R*4 | Mean of long term distribution of specular component SNR in dB. |
| DSTSNR | R*4 | Standard deviation of long term distribution of specular component SNR in dB. |
| PTYPE | I*2 | Indicates whether path is pure scatter (PTYPE = 0) or mixed scatter/diffraction (PTYPE = 1). |
| IFDSNR | L*4 | Flag indicating which values of DSNR to output. |

Output arguments:

| | | |
|---|---|---|
| U(49) | R*4 | Eigenvalues which are the gains of the implicit diversity paths. The first three gains correspond to the main beam path. |
| BOUT(3,4) | R*4 | Yearly average outage probabilities for the different BER thresholds and diversity configurations specified (see table). |
| ABE(4) | R*4 | Yearly average 1000-bit block error probability for each diversity configuration specified (see table). |
| SOUT | R*4 | Normalization constant for averaging over yearly distribution of SNR and DSNR. |
| NOUT | R*4 | Number of terms in numerical integration over distribution of SNR and DSNR. |
| V(196) | R*8 | Inverse of SNR per implicit diversity. |
| FOUT(3,4) | R*4 | Yearly average fade outage per call minute for the different BER thresholds and diversity configurations specified (see table). |

Global variables input from common:

| | | | |
|---|---|---|---|
| APOW | /MCOM4/ | R*4 | MCOM.INC |
| | Angle diversity squint loss as a ratio. | | |
| BER(3) | /ERAD/ | R*4 | ERAD.INC |
| | Bit error rate thresholds of interest. Set to 1E-3, 1E-4 and 1E-5 in data statement. | | |
| DIVTYP | /MCOM2/ | I*2 | MCOM.INC |
| | Diversity configuration indicator. Default is 0. | | |

```
 0 = 2 receive antennas; 2S    2S/2F    2S/2A 2S/2A/2F
 1 = 1 receive antenna;  2A    2F       2F/2A
 2 = 2 transmit,
     2 receive antennas; 2S/2P 2S/2P/2A
 3 = Not used
```

```
                         4 = User supplied parameters
                        S = Space  F = Frequency  A = Angle  P = Polarization
LOUT                    /LUNS/          I*2     LUNS.INC
                        FOR002.DAT output unit number.
NERT                    /MCOM2/         I*2     MCOM.INC
                        Bit error rate threshold indicator for yearly fade
                        outage probability calculation.  Default is 2.
                              0 = All three thresholds
                              1 = For 10**(-3) only
                              2 = For 10**(-4) only
                              3 = For 10**(-5) only
```

## 9.2 BOTAC

Subprogram name: Subroutine BOTAC

Purpose: Initialize C(KK,KK), A(KK,KK), BOUT(3,4), and ABE(4) arrays. Compute interferer covariance matrix TAC(KK,KK) for JPOW > -174 according to RF filtering specified through parameters IBW and JFILT. IBW specifies whether the receiver has an RF/IF filter (IBW > 0) or not (IBW = 0). If the receiver does not have an RF filter, JFILT indicates whether the interference covariance matrix calculation includes ground reflections (JFILT = 1) or not (JFILT = 0).

Calling sequence:

```
CALL BOTAC (K,KK,K1,JPOW,JBW,TZ,C,A,TAC,BOUT,NOUT,ABE,FOUT,
BWR,ASEP,JANG)
```

Contained in module: BOTAC

Called by: MDTS

Calls: JAMCOM, RJCFCN, TSINC

Input arguments:

| | | |
|---|---|---|
| K | I*2 | Flag: = 1 for K1 = 3; = 0 for K1 = 1. |
| JPOW | R*8 | Interference power density in dBm/Hz. |
| JBW | R*8 | Interference normalized bandwidth. |
| TZ | R*4 | Time delay between interference signal received on two horizontally spaced antennas. It is a function of antenna separation and interferer angle of arrival. (See MDTS.) |
| BWR | R*4 | Receive antenna beamwidth in degrees. |
| ASEP | R*4 | Separation distance between receiving antennas in meters. |
| JANG | R*8 | Interference off-borsight angle of arrival in degrees. |

Output arguments:

| | | |
|---|---|---|
| KK | I*2 | Dimension of A,C, and TAC arrays. Maximum is 14. |
| K1 | I*2 | Number of taps in forward equalizer. |
| C(KK,KK) | R*4 | Signal covariance matrix initialized to zero. Dimensioned as 14x14. |
| A(KK,KK) | R*4 | Noise covariance matrix initialized to zero. Dimensioned as 14x14. |
| TAC(KK,KK) | R*4 | Interferer covariance matrix calculated according to RF filtering specified through IBW and JFILT parameters. Dimensioned as 14x14. |
| BOUT(3,4) | R*4 | Outage probability array initialized to zero. |
| NOUT | R*4 | Number of short term outage probability |

```
                                    calculations initialized to zero.
     ABE(3,4)        R*4     Average block error array initialized to zero.
     FOUT(3,4)       R*4     Fade outage array initialized to zero.

Global variables input from common:
     IBW             /MCOM2/          I*2      MCOM.INC
                     Switch indicating type of RF bandwidth constraint to
                     be used on desired signal.  Default is 0.
                        0 = No RF filtering
                        1 = Filter determined from 99% bandwidth constraint
                        2 = Filter chosen to meet FCC Mask.  (FCC-19311)
                        3 = Filters are user specified
     JFILT           /MCOM2/          I*2      MCOM.INC
                     Interference covariance matrix calculation indicator.
                     Only used when IBW equals 0, otherwise ignored.
                     Default is 0.
                             0 = Interferer covariance matrix calculation
                                 done in subroutine ROTAC
                             1 = Interferer covariance matrix calculation
                                 done in subroutine JAMCOM
     LOUT            /LUNS/           I*2      LUNS.INC
                     FOR002.DAT output unit number.
     NJR             /RZ4/            I*2      RZ4.INC
                     Number of sample points for RJCOR.
     TAPW            /MCOM4/          R*4      MCOM.INC
                     Normalized tapwidth for MD-918.  Default is .5.
                     Range is 0.25 through 1.0
```

## 9.3 CAC

Subprogram name: Function CAC

Purpose: Computes G(XZ-SK) * G(XZ-SL) * ZQ(T0-XZ) when SIGMA > 0 and G(XZ-SK) when SIGMA < 0. G(X) is the impulse response of the cascade of the transmitter and receiver filters and ZQ(X) is the power per unit delay or correlation per unit delay of the perceived scatter signal component.

Calling sequence:
CAC (XZ,SK,SL,SIGMA,T0,ZQ)

Contained in module: DINT

Called by: DINT MATCO

Calls: FILSIX SINC

Input arguments:

| | | |
|---|---|---|
| XZ | R*4 | Normalized time at which function is to be evaluated. |
| SK | R*4 | Tap sampling time relative to AFE center tap. |
| SL | R*4 | Same as SK. |
| SIGMA | R*4 | Normalized delay spread of scatter component. |
| T0 | R*4 | Normalized sampling time for center tap relative to centroid of power per unit delay profile. |
| ZQ | R*4 | Power per unit delay or correlation per unit delay profile for scatter signal. |

Output arguments:

| | | |
|---|---|---|
| CAC | R*4 | Value of G(XZ-SK) * G(XZ-SL) * ZQ(T0-XZ). |

Global variables input from common:

```
DELPBZ          /RZ1/          R*4
                Resolution of a delay cell in seconds.  Same as DELPB
                in /PDATA/.
DIVTYP          /MCOM2/        I*2     MCOM.INC
                Diversity configuration indicator.  Default is 0.
                 0 = 2 receive antennas; 2S    2S/2F    2S/2A 2S/2A/2F
                 1 = 1 receive antenna;  2A    2F       2F/2A
                 2 = 2 transmit,
                     2 receive antennas; 2S/2P 2S/2P/2A
                 3 = Not used
                 4 = User supplied parameters
                S = Space  F = Frequency  A = Angle  P = Polarization
DRATE           /MCOM4/        R*4     MCOM.INC
                Data rate in bits/second.  Default is 6.6E6.
DU(256)         /RZ/           R*8     RZ.INC
                Signal response after PN sequence correlation.
ICORR           /MCOM2/        I*2     MCOM.INC
```

```
                      Multipath profile correlation indicator.  Default
                      is 2.
                         0 = Profile of the form X * exp(-A*X) -- used for
                             debugging
                         1 = Computed multipath profile; no beam correlation
                         2 = Computed multipath profile; beam correlation.
IFILE                 /MCOM2/         I*2     MCOM.INC
                      Pointer to multipath profile.
JQ2M                  /MCOM4/         I*2     MCOM.INC
                      Pointer to centroid of lower beam troposcatter signal
                      power per unit delay profile.
KGAIN                 /RZ/            I*2     RZ.INC
                      Integer ratio of bandwidth to data rate.
NDELQ                 /MCOM4/         I*2     MCOM.INC
                      Number of non-zero elements of troposcatter power per
                      unit delay profiles Q(NDELQ,1).
NIP                   /RZ/            I*2
                      Initialization constant for numerical equalizer
                      covariance matrix calculation.
NTR                   /RZ4/           I*2     RZ4.INC
                      Number of samples for calculating transmit-receive
                      filter impulse response (TRFILT).
PCON                  /RZ/            R*8     RZ.INC
                      Normalization factor for probability integral.
PULSE                 /RZ/            I*2     RZ.INC
                      Switch controlling MD-918 pulse shape after
                      transmitter-receiver filtering.
                              PULSE = 0   Triangle
                                    = 1   OQPSK matched filter
                                    = 2   Sinc pulse, bandwidth equal to 1
                                    = 5   RF filtering included
                      Set to 0 if IBW = 0 or KGAIN > 1.
                      Set to 5 if IBW > 0 and KGAIN = 1.
TRFILT(128)           /RZ4/           R*4     RZ4.INC
                      Transmit-receive filter impulse response.
XTRO                  /RZ4/           R*4     RZ4.INC
                      Time origin for transmit-receive filter impulse
                      response (TRFILT), ie, X is TRFILT(X+XTRO).
XTRINC                /RZ4/           R*4     RZ4.INC
                      Sample interval for calculation of transmit-receive
                      filter impulse response (TRFILT).
```

## 9.4 CAJI

Subprogram name: Subroutine CAJI

Purpose: Calculate thermal noise covariance matrix for AFE taps.

Calling sequence:
CALL CAJI (K,A)

Contained in module: CAJI

Called by: MATCO

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| K | I*2 | Number of taps on either side of center tap of AFE. |

Output arguments:

| | | |
|---|---|---|
| A(14,14) | R*4 | Thermal noise covariance matrix. |

*Global variables input from common:*

```
DU(256)         /RZ/        R*8    RZ.INC
                Signal response after PN sequence correlation.
NB              /RI2/       I*2    RI2.INC
                Number of elements accessed in arrays DU, DX and DY.
PULSE           /RZ/        I*2    RZ.INC
                Switch controlling MD-918 pulse shape after
                transmitter-receiver filtering.
                        PULSE = 0   Triangle
                              = 1   OQPSK matched filter
                              = 2   Sinc pulse, bandwidth equal to 1
                              = 5   RF filtering included
                Set to 0 if IBW = 0 or KGAIN > 1.
                Set to 5 if IBW > 0 and KGAIN = 1.
RCOR(32)        /RZ4/       R*4    RZ4.INC
                Correlation function of the receive filter in steps
                equal to the tapwidth (TAPW) for MD-918 modem, or
                equal to 1/RATE for AN/TRC-170 or DAR modem.
TAPW            /MCOM4/     R*4    MCOM.INC
                Normalized tapwidth for MD-918.  Default is .5.
                Range is 0.25 through 1.0
```

Pointer to multipath profile.

```
     IFPRNT          I*2     Switch to enable debug print out (=1).
     DUPOW           R*4     Ratio of diffraction signal component on upper
                             beam to that on lower beam.
     IFDSNR          L*4     Switch to enable print out of covariance
                             matrices for mixed scatter/diffraction
                             propagation conditions.

Output arguments:
     C(14,14)        R*4     Scatter signal covariance matrix for AFE taps.
     C0(7,7)         R*4     Scatter signal covariance sub-matrix for lower
                             beam AFE taps.
     C1(7,7)         R*4     Scatter signal covariance sub-matrix for upper
                             beam AFE taps.
     C2(7,7)         R*4     ISI covariance matrix for lower beam taps.
     C3(7,7)         R*4     ISI covariance matrix for upper beam taps.
     C4(7,7)         R*4     Scatter signal correlation sub-matrix for
                             lower/upper beam (DIVTYP = 0,1) or crossed
                             paths (DIVTYP = 2).
     CSUM(14,14)     R*4     ISI covariance matrix for AFE taps.
     AF(14,14)       R*4     Thermal noise covariance matrix for AFE taps.
     A(14,14)        R*4     Same as AF.

Global variables input from common:
     DIVTYP          /MCOM2/        I*2     MCOM.INC
                     Diversity configuration indicator.  Default is 0.
                      0 = 2 receive antennas; 2S    2S/2F    2S/2A 2S/2A/2F
                      1 = 1 receive antenna;  2A    2F       2F/2A
                      2 = 2 transmit,
                          2 receive antennas; 2S/2P 2S/2P/2A
                      3 = Not used
                      4 = User supplied parameters
                     S = Space  F = Frequency  A = Angle  P = Polarization
     LDEBUG          /LUNS/         I*2     LUNS.INC
                     Debug output unit.  Always the same as LOUT but used
                     to uniquely identify the write statements.
     LISI            /MCOM2/        I*2     MCOM.INC
                     Number of future Intersymbol Interference (ISI)
                     contributors considered in MD-918 performance
                     calculation.  Default is 2.
     LOUT            /LUNS/         I*2     LUNS.INC
                     FOR002.DAT output unit number.
     TAPW            /MCOM4/        R*4     MCOM.INC
                     Normalized tapwidth for MD-918.  Default is .5.
                     Range is 0.25 through 1.0
     TDIFF           /MCOM4/        R*4     MCOM.INC
                     Normalized relative delay between lower and upper
                     beam.

Global variables output to common:
     IFILE           /MCOM2/        I*2     MCOM.INC
```

## 9.14 MATCO

Subprogram name: Subroutine MATCO

Purpose: To compute the troposcatter signal covariance matrix C and sub-matrices C0, C1, C4; thermal noise covariance matrices A and AF; ISI covariance matrix CSUM, and ISI sum-matrices C2 and C3; and mean diffraction amplitude vector FSIG for the MD-918 AFE taps.

Calling sequence:

```
CALL MATCO (SIGMA,SIGM1,C,C0,C1,C2,C3,C4,CSUM,Q,AF,A,K,K1,
KK,T0,TA,TSCAT,JPOW,ELOSS,XSCAT,XDIFR,PTYPE,JQDM,IFPRNT,DUPOW, IFDSNR)
```

Contained in module: MATCO

Called by: MDTS

Calls: CAC, CAJI, CAKL

Input arguments:

| | | |
|---|---|---|
| SIGMA | R*4 | Normalized delay spread of scatter signal in lower beam. |
| SIGM1 | R*4 | Normalized delay spread of scatter signal in upper beam. |
| Q(100,7) | R*4 | Power per unit delay and correlation per unit delay for scatter signal in each receiving aperture. |
| K | R*4 | Flag: 1 for K1 = 3, 0 for K1 = 1. |
| K1 | R*4 | Number of taps in AFE. |
| KK | R*4 | Total number of correlated taps (dimension of covariance matrix) for angle and/or space diversity. |
| T0 | R*4 | Normalized sampling time (relative to scatter component mean time of arrival) for lower beam. |
| TA | R*4 | Normalized sampling time (relative to scatter component mean time of arrival) for upper beam. |
| TSCAT | R*4 | Normalized relative delay between scatter and diffraction component. |
| JPOW | R*8 | Interference power density in dBm/Hz. |
| ELOSS | R*8 | Squint loss for scatter signal in upper beam in dB. |
| XSCAT | R*4 | Fraction of scatter signal power. |
| XDIFR | R*4 | Fraction of diffraction signal power. |
| PTYPE | R*4 | Indicates whether pure scatter (PTYPE = 0) or mixed scatter/diffraction path (PTYPE = 1). |
| JQDM | R*4 | Index in power per unit delay profile corresponding to delay bin of the specular (diffraction) component. |

## 9.13 MATA

Subprogram name: Subroutine MATA

Purpose: IBM routine for matrix multiplication:
S(M,N) * T(N,L) = ST(M,L).

Calling sequence:

```
CALL MATA (S,T,ST,M,N,L,NSR,NSC,NTR,NTC,NSTR,NSTC)
```

Contained in module: MATOPS

Called by: MDTS, SQTMAT

Calls: ERROR

Input arguments:

| | | |
|---|---|---|
| S(NSR,NSC) | R*4 | Input matrix to be right multiplied by T. |
| T(NTR,NTC) | R*4 | Input matrix. |
| M | I*2 | Number of actual rows of matrices S and ST. |
| N | I*2 | Number of actual columns of matrix S and rows of matrix T. |
| L | I*2 | Number of actual columns of matrices T and ST. |
| NSR | I*2 | Row dimension of matrix S. No maximum set. |
| NSC | I*2 | Column dimension of matrix S. No maximum set. |
| NTR | I*2 | Row dimension of matrix T. No maximum set. |
| NTC | I*2 | Column dimension of matrix T. No maximum set. |
| NSTR | I*2 | Row dimension of matrix ST. No maximum set. |
| NSTC | I*2 | Column dimension of matrix ST. No maximum set |

Output arguments:

| | | |
|---|---|---|
| ST(NSTR,NSTC) | R*4 | Matrix product of S(.) and T(.). |

```
                         is the main receive antenna.
         TAPW            /MCOM4/          R*4     MCOM.INC
                         Normalized tapwidth for MD-918.  Default is .5.
                         Range is 0.25 through 1.0
         THER            /PATHGE/         R*4     TROCOM.INC
                         Radio horizon elevation angle at receive site in
                         radians.

     Global variables output to common:
         A               /PATHGE/         R*4     TROCOM.INC
                         Effective earth radius in meters.
```

## 9.12 JAMCOM

Subprogram name: Subroutine JAMCOM

Purpose: Calculate covariance matrix for one interferer with one direct path and one reflected path. (Reflections off a horizontal surface.) Angles of arrival and delay are assumed identical for both antennas.

Calling sequence:

```
CALL JAMCOM (TAC, BWR, ASEP, JANG)
```

Contained in module: JAMCOM

Called by: BOTAC

Calls: TSINC

Input arguments:

| | | |
|---|---|---|
| BWR | R*4 | 3dB beamwidth of receiving antenna in degrees. |
| ASEP | R*4 | Separation between receiving antennas in meters. |
| JANG | R*8 | Interferer angle of arrival in degrees. |

Output arguments:

| | | |
|---|---|---|
| TAC(14,14) | R*4 | Covariance matrix. |

Global variables input from common:

| | | | |
|---|---|---|---|
| ATTEN | /MCOM4/ | R*4 | MCOM.INC |
| | Ratio of interferer signal amplitude on antenna 2 to that at antenna 1. Set to 1 internally. | | |
| BW | /SYSTRN/ | R*4 | TROCOM.INC |
| | Bandwidth in Hertz. Default is 7 MHz. | | |
| DRATE | /MCOM4/ | R*4 | MCOM.INC |
| | Data rate in bits/second. Default is 6.6E6. | | |
| ELANG(10) | /MCOM4/ | R*4 | MCOM.INC |
| | Interferer elevation angles in degrees. Default is 0. | | |
| HRN | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive antenna height above sea level in meters. | | |
| JREFL | /MCOM2/ | I*2 | MCOM.INC |
| | Indicates whether specular reflection is to be included in interferer covariance matrix calculation (JREFL = 1) or not (JREFL = 0). Default is 0. | | |
| LANG | /MCOM2/ | I*2 | MCOM.INC |
| | Pointer to data array elements containing interferer azimuth and elevation angles. | | |
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |
| PSIREO(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of receiver beam boresight elevations above radio horizon in radians, ie, angle at which each antenna is aimed relative to the horizon. PSIREO(1) | | |

## 9.11 HQR

Subprogram name: Subroutine HQR

Purpose: Find eigenvalues of matrix H.

Calling sequence:
CALL HQR (NM,N,LOW,IGH,H,WR,WI,IERR)

Contained in module: ELMES

Called by: EIGV, MDTS

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| NM | I*2 | Dimension of matrix H. No maximum set. |
| N | I*2 | Dimension of matrix H and arrays WR and WI. No maximum set. |
| LOW | I*2 | Pointer to first row (or column) of square sub-matrix of H. |
| IGH | I*2 | Pointer to last row (or column) of square sub-matrix of H. |
| H(NM,N) | R*8 | Square matrix whose eigenvalues are to be found. |

Output arguments:

| | | |
|---|---|---|
| H(NM,N) | R*8 | Square matrix whose eigenvalues are to be found. |
| WR(N) | R*8 | Real part of eigenvalue. |
| WI(N) | R*8 | Imaginary part of eigenvalue. |
| IERR | I*2 | Error flag. 0 for no error; > 0 for error |

## 9.10 ERLANG

Subprogram name: Function ERLANG

Purpose: For I = 1,2,3 or 4 ERLANG = X**(I-1) * EXP(-A*X) / (I-1)!
otherwise ERLANG = 10**38 for precision limits. If A*X > 85
ERLANG = 0. (Where: I = Integer A; X = Real.)

Calling sequence:
ERLANG (I,A,X)

Contained in module: ERLANG

Called by: BERCAL, PDF, PDFSUM

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| I | I*2 | Argument of factorial and power in ERLANG function. |
| A | R*8 | Parameter of exponent in ERLANG function. |
| X | R*8 | Argument of ERLANG function. |

Output arguments:

| | | |
|---|---|---|
| ERLANG | R*8 | Value of X**(I-1) * EXP(-A*X) / (I-1)!. |

## 9.9 ELMES

Subprogram name: Subroutine ELMES

Purpose: Conditions matrix A prior to HQR finding eigenvalues and eigenvectors.

Calling sequence:
CALL ELMES (NM,N,LOW,IGH,A,INT)

Contained in module: ELMES

Called by: EIGV, MDTS

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| NM | I*2 | Row dimension of matrix A. No maximum set. |
| N | I*2 | Column dimension of matrix A. No maximum set. |
| LOW | I*2 | Pointer to first row (or column) of square sub-matrix. |
| IGH | I*2 | Pointer to last row (or column) of square sub-matrix. Also, dimension of vector INT. No maximum set. |
| A(NM,N) | R*8 | Matrix to be conditioned. |

Output arguments:

| | | |
|---|---|---|
| A(NM,N) | R*8 | Conditioned matrix. |
| INT(IGH) | I*2 | Pointer to lowest value in each row of A. |

## 9.8 EIGEN

Subprogram name: Subroutine EIGEN

Purpose: Compute eigenvalues and eigenvectors of a real symmetric matrix.

Reference: The process used is the diagonalization method originated by Jacobi and adapted by Von Neuman for large computers as found in 'Mathematical Methods for Digital Computers', edited by A. Ralston and H.S. Wilf, John Wiley and Sons, New York, 1962, Chapter 7.

Calling sequence:
CALL EIGEN (A,R,N,MV)

Contained in module: EIGEN

Called by: MDTS SQTMAT

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| A(N) | R*4 | Original matrix (symmetric). Destroyed in computation. Resultant eigenvalues are stored in diagonal of matrix A in descending order. This matrix must be real symmetric and must not be in the same location as matrix R. Matrix A must also be stored in Storage Mode 1, which means that only the upper right triangle is stored by columns through each diagonal element: A(1,1), A(1,2), A(2,2), A(1,3), etc. into vector form. |
| N | I*2 | Order of matrices A and R. No limit set on size. |
| MV | I*2 | Input code.<br>0 = Compute eigenvalues and eigenvectors.<br>1 = Compute eigenvalues only. (R need not be dimensioned but must still appear in calling sequence.) |

Output arguments:

| | | |
|---|---|---|
| A(N) | R*4 | Original matrix (symmetric). Destroyed in computation. Resultant eigenvalues are stored in diagonal of matrix A in descending order. This matrix must be real symmetric (storage mode 1) and must not be in the same location as matrix R. |
| R(N) | R*4 | Resultant matrix of eigenvectors. Stored columnwise, in same sequence as eigenvalues. |

| | | | |
|---|---|---|---|
| NDELQ | /MCOM4/ | I*2 | MCOM.INC |
| | Number of non-zero elements of troposcatter power per unit delay profiles Q(NDELQ,1). | | |
| PULSE | /RZ/ | I*2 | RZ.INC |
| | Switch controlling MD-918 pulse shape after transmitter-receiver filtering.<br>PULSE = 0 Triangle<br>= 1 OQPSK matched filter<br>= 2 Sinc pulse, bandwidth equal to 1<br>= 5 RF filtering included<br>Set to 0 if IBW = 0 or KGAIN > 1.<br>Set to 5 if IBW > 0 and KGAIN = 1. | | |
| TDIFF | /MCOM4/ | R*4 | MCOM.INC |
| | Normalized relative delay between lower and upper beam. | | |

## 9.7 DINT

Subprogram name: Subroutine DINT

Purpose: Integrates CAC = G(X-BK)G(X-BL)Q(TO-X) over (XL,XH) where:
G(X) = Fixed filter response.
Q(X) = Multipath profile.

Calling sequence:
```
CALL DINT (SIGMA,BK,BL,Y,TO,Q,PTYPE,JQDM)
```

Contained in module: DINT

Called by: MDTS CAKL

Calls: CAC

Input arguments:

| | | |
|---|---|---|
| SIGMA | R*4 | Normalized delay spread of scatter component. |
| BK | R*4 | Tap sampling time relative to AFE center tap. |
| BL | R*4 | Same as BK. |
| TO | R*4 | Normalized sampling time for center tap relative to centroid of power per unit delay profile. |
| Q | R*4 | Power per unit delay profile or correlation per unit delay profile. |
| PTYPE | I*2 | Indicates whether path is mixed scatter/diffraction (PTYPE = 1) or pure scatter path (PTYPE = 0). |
| JQDM | I*2 | Index in power per unit delay profile corresponding to delay bin of the specular (diffraction) component. |

Output arguments:

| | | |
|---|---|---|
| Y | R*4 | Result of integration. |

Global variables input from common:

DELPBZ /RZ1/ R*4
Resolution of a delay cell in seconds. Same as DELPB in /PDATA/.

DRATE /MCOM4/ R*4 MCOM.INC
Data rate in bits/second. Default is 6.6E6.

ICORR /MCOM2/ I*2 MCOM.INC
Multipath profile correlation indicator. Default is 2.
- 0 = Profile of the form X * exp(-A*X) -- used for debugging
- 1 = Computed multipath profile; no beam correlation
- 2 = Computed multipath profile; beam correlation.

JQ2M /MCOM4/ I*2 MCOM.INC
Pointer to centroid of lower beam troposcatter signal power per unit delay profile.

KGAIN /RZ/ I*2 RZ.INC
Integer ratio of bandwidth to data rate.

## 9.6 CHANGE

Subprogram name: Subroutine CHANGE

Purpose: Matrix utility operations defined by flag KIND.

Calling sequence:
```
CALL CHANGE (ARRAY,VECTOR,NACT,NDIM,KIND)
```

Contained in module: MATOPS

Called by: MDTS, SQTMAT

Calls: ERROR

Input arguments:

| | | |
|---|---|---|
| ARRAY(NACT,NACT) | R*4 | Two-dimensional array (matrix). No limit set on size. |
| VECTOR(1) | R*4 | One-dimensional array (vector). No limit to size set. |
| NACT | I*2 | Actual physical dimensions of ARRAY in calling program. No maximum set. |
| NDIM | I*2 | Number of rows and columns in input (output) matrix ARRAY. |
| KIND | I*2 | Input flag:<br>1 = Pack symmetric matrix, ARRAY, into VECTOR by columns through each diagonal element.<br>2 = Copy VECTOR into doubly-subscripted ARRAY.<br>3 = Copy only diagonal elements from VECTOR into ARRAY and zero off-diagonal elements (as in a unitary matrix). |

Output arguments:

| | | |
|---|---|---|
| ARRAY(NACT,NACT) | R*4 | Two-dimensional array (matrix). No limit set on size. |
| VECTOR(1) | R*4 | One-dimensional array (vector). No limit to size set. |

## 9.5 CAKL

Subprogram name: Subroutine CAKL

Purpose: Compute scatter signal covariance matrix C(K,L) where:
K,L = (-KK,-KK+1,-KK+2,...,+KK).
Number of rows and columns (AFE taps) is therefore equal to 2*KK+1.
Covariance matrix is defined as integral of:

$$G_i\,(X-KT) * G_j\,(X-LT+(j-i)*DIFF) * Q(TO-X)$$

where $G_i$ and $G_j$ are the impulse response of the cascade of transmitter and receiver filters for diversity ports i and j. Q(X) is the power per unit delay function of the scatter component if i = j and the correlation per unit delay profile otherwise.

Calling sequence:
CALL CAKL (KK,SIGMA,C,TO,DIFF,Q,PTYPE,JQDM)

Contained in module: DINT

Called by: MATCO

Calls: DINT

Input arguments:

| | | |
|---|---|---|
| KK | I*2 | Number of taps on either side of the center tap of the AFE. |
| SIGMA | R*4 | Normalized delay spread of scatter component. |
| TO | R*4 | Normalized sampling time relative to centroid of scatter component power per unit delay profile. TO > 0 increases future ISI. |
| DIFF | R*4 | Delay compensation for angle diversity systems. |
| Q | R*4 | Power per unit delay profile or correlation per unit delay profile. |
| PTYPE | I*2 | Indicates whether path is mixed scatter/diffraction (PTYPE = 1) or pure scatter path (PTYPE = 0). |
| JQDM | I*2 | Index in power per unit delay profile corresponding to delay bin of the specular (diffraction) component. |

Output arguments:

| | | |
|---|---|---|
| C | R*4 | Scatter signal covariance matrix for AFE taps. |

Global variables input from common:

TAPW /MCOM4/ R*4 MCOM.INC
Normalized tapwidth for MD-918. Default is .5.
Range is 0.25 through 1.0

## 9.15 MDTS

Subprogram name: Subroutine MDTS

Purpose: Computes MD-918 modem performance assuming LISI symbols of intersymbol interference (ISI). Performance under mixed scatter/ diffraction propagation conditions also includes the ISI due to the 4th and 5th past symbols. Assumes ISI is Gaussian.

Reference: P. Monsen 'Theoretical and measured performance of a DFE modem on a fading multipath channel.', IEEE Transactions on Communications, Vol. COM-25, No. 10, October, 1977, pp. 1144-1153. See also 'Link analysis plan'. Interim technical report no. CSA-76-8085-3, October 1978, Contract #DAAB07-76-C-8085.

Calling sequence:

```
CALL MDTS (TAU22,TAU23,ELOSS,RHO,ASNR,ADSNR,Q,DUPOW,JPOW,
JBW,BWT,BWR,ASEP,CORFAC,BOUT,FOUT,FJSEP,PTYPE,TEMPA,JQDM)
```

Contained in module: MDTS

Called by: TROPO

Calls:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BERCAL | BOTAC | CHANGE | DINT | EIGEN | ELMES | ERROR | HQR |
| MATA | MATCO | MINV | ORDER | PROUT | SASEQ | SIGIN | SINT |
| SQTMAT | XNOR | | | | | | |

Input arguments:

| | | |
|---|---|---|
| TAU22 | R*8 | Delay spread on lower beam in nsec. |
| TAU23 | R*8 | Delay spread on upper beam in nsec. |
| ELOSS | R*8 | Upper beam squint loss for scatter component in dB or sidelobe loss for interference. |
| RHO | R*8 | Correlation between lower and upper beam long-term variability of scatter component. |
| ASNR | R*4 | Median and/or yearly average value of scatter path SNR in dB. |
| ADSNR | R*4 | Yearly average value of diffraction path SNR in dB. |
| Q(100,7) | R*4 | Multipath delay/correlation profile array. |
| DUPOW | R*4 | Ratio of diffraction component on upper beam to diffraction component on lower beam. |
| JPOW | R*8 | Interference signal power density in dBm/Hz. |
| JBW | R*8 | Interfering signal bandwidth in Hz. |
| BWT | R*4 | Transmit antenna beamwidth in degrees. |
| BWR | R*4 | Receive antenna beamwidth in degrees. |
| ASEP | R*4 | Receiver antenna separation in meters. |
| CORFAC | R*4 | Correction factor computed by LTCORR. CORFAC is used in subroutine BERCAL to scale STSNR multiplicatively when angle diversity is used. |
| FJSEP | R*4 | Frequency separation between desired signal and interference signal in Hertz. |

```
     PTYPE    I*2     Variable which indicates whether propagation
                      mechanism is pure troposcatter (0 or 10) or mixed
                      troposcatter-diffraction (1 or 11).
     TEMPA(7) R*4     Average relative delay of scatter component.
     JQDM     I*2     Index in the multipath profile corresponding to
                      the delay of the specular component.

Output arguments:
     BOUT(3,4)        R*4     Yearly average outage probability for each
                              bit error rate threshold specified and 2S/2F
                              and 2S diversity configurations.
     FOUT(3,4)        R*4     Yearly average fade outage per call minute for
                              each bit error rate threshold specified and
                              2S/2F and 2S diversity configurations.

Global variables input from common:
     CODE             /MCOM4/          L*4     MCOM.INC
                      Flag for coding.
     DEL              /SUMP/           R*4     CURVE.INC
                      Diffraction path delay relative to a straight line
                      path in seconds.
     DIVTYP           /MCOM2/          I*2     MCOM.INC
                      Diversity configuration indicator.  Default is 0.
                       0 = 2 receive antennas; 2S    2S/2F    2S/2A 2S/2A/2F
                       1 = 1 receive antenna;  2A    2F       2F/2A
                       2 = 2 transmit,
                           2 receive antennas; 2S/2P 2S/2P/2A
                       3 = Not used
                       4 = User supplied parameters
                      S = Space  F = Frequency  A = Angle  P = Polarization
     DRATE            /MCOM4/          R*4     MCOM.INC
                      Data rate in bits/second.  Default is 6.6E6.
     DSTSNR           /SUMP/           R*4     CURVE.INC
                      Standard deviation of diffracted signal long-term SNR
                      distribution in dB.
     ELANG(10)        /MCOM4/          R*4     MCOM.INC
                      Interferer elevation angles in degrees.  Default is 0.
     IBW              /MCOM2/          I*2     MCOM.INC
                      Switch indicating type of RF bandwidth constraint to
                      be used on desired signal.  Default is 0.
                         0 = No RF filtering
                         1 = Filter determined from 99% bandwidth constraint
                         2 = Filter chosen to meet FCC Mask.  (FCC-19311)
                         3 = Filters are user specified
     ICORR            /MCOM2/          I*2     MCOM.INC
                      Multipath profile correlation indicator.  Default
                      is 2.
                         0 = Profile of the form X * exp(-A*X) -- used for
                             debugging
                         1 = Computed multipath profile; no beam correlation
```

```
                 2 = Computed multipath profile; beam correlation.
KGAIN           /RZ/             I*2    RZ.INC
                Integer ratio of bandwidth to data rate.
LERR            /LUNS/           I*2    LUNS.INC
                Error output unit.
LOUT            /LUNS/           I*2    LUNS.INC
                FOR002.DAT output unit number.
MANG            /MCOM2/          I*2    MCOM.INC
                Number of values of interferer azimuth/elevation pairs
                (JANG) for which outage calculations are to be made.
                Default is 1.
NANG            /RI2/            I*2    RI2.INC
                NANG is 1 if there is angle diversity (default).
NERT            /MCOM2/          I*2    MCOM.INC
                Bit error rate threshold indicator for yearly fade
                outage probability calculation.  Default is 2.
                        0 = All three thresholds
                        1 = For 10**(-3) only
                        2 = For 10**(-4) only
                        3 = For 10**(-5) only
STSNR           /SUMP/           R*4    SUMP.INC
                Standard deviation of troposcatter signal long-term
                SNR distribution in dB.
XANG(10)        /MCOM4/          R*4    MCOM.INC
                Interferer azimuth angles in degrees.  Default is 0.

Global variables output to common:
APOW            /MCOM4/          R*4    MCOM.INC
                Angle diversity squint loss as a ratio.
IFILE           /MCOM2/          I*2    MCOM.INC
                Pointer to multipath profile.
LANG            /MCOM2/          I*2    MCOM.INC
                Pointer to data array elements containing interferer
                azimuth and elevation angles.
NIP             /RZ/             I*2
                Initialization constant for numerical equalizer
                covariance matrix calculation.
PCON            /RZ/             R*8    RZ.INC
                Normalization factor for probability integral.
PEAKAV          /RZ4/            R*4    RZ4.INC
                Peak-to-average loss due to RF filtering in dB.
TDIFF           /MCOM4/          R*4    MCOM.INC
                Normalized relative delay between lower and upper
                beam.
```

## 9.16 MINV

Subprogram name: Subroutine MINV

Purpose: IBM SSP Library routine. Matrix inversion.

Calling sequence:

```
CALL MINV (C,N,D,NC,ICON,B)
```

Contained in module: MINV

Called by: MDTS

Calls: *NONE*

Input arguments:

| | | |
|---|---|---|
| C(NC,NC) | R*4 | Matrix to be inverted. Also may be returned here. No limit set on size. |
| N | I*2 | Matrix order. |
| NC | I*2 | Size of matrix C. No maximum set. |
| ICON | I*2 | Control flag.<br>0 = Invert C and return determinant in D.<br>1 = Return determinant in D and leave C as is.<br>3 = On output for determinant = 0<br>4 = Ignore determinant = 0 |

Output arguments:

| | | |
|---|---|---|
| C(NC,NC) | R*4 | Matrix to be inverted. Also may be returned here. No limit set on size. |
| D | R*4 | Determinant returned. |
| B(1) | R*4 | Working matrix. |

## 9.17 ORDER

Subprogram name: Subroutine ORDER

Purpose: Store largest N values of R(K) in V(K) in decreasing size and order. For K < I < N+1 V(I) = 0.0.
--> NOTE: Do NOT use for K = N = 1 !!!!

Calling sequence:

```
CALL ORDER (K,R,V,N)
```

Contained in module: ORDER

Called by: EIGV, MDTS

Calls: ERROR

Input arguments:

| | | |
|---|---|---|
| K | I*2 | Dimension of arrays R and V. No maximum set. |
| R(K) | R*8 | Input array. |
| N | I*2 | Number of values to return. |

Output arguments:

| | | |
|---|---|---|
| V(K) | R*8 | Output array. |

Global variables input from common:

| | | | |
|---|---|---|---|
| LERR | /LUNS/ | I*2 | LUNS.INC |
| | Error output unit. | | |

## 9.18 PDFCON

Subprogram name: Subroutine PDFCON

Purpose: Calculate coefficients in partial fractions expansion of Laplace transform F(S) of PDF for SNR, from list of negatives of roots of F(s). On return, roots are in descending order. Coefficients C((N-1)*ID + I) are such that the following two expansions for F(s) are equivalent:

```
   F(s) = (R(1) / (S + R(1)))**NDIV *...* (R(NR) / (S + R(NR)))**NDIV
and,
   F(s) = ...C((N-1)*NDIV + I) / (S + R(N))*NDIV-I + 1 ...
for N = 1,2,...NR; I = 1,2,...NDIV.
```

Reference: K. Miller, 'Engineering Mathematics', Dover Publications, 1963, pp. 214-215.

Calling sequence:
CALL PDFCON (NR,R,NDIV,C)

Contained in module: BERCAL

Called by: BERCAL

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| NR | I*2 | Number of roots. Dimension of vectors R and C. No maximum set on vector sizes but see NDIV for limitations on values. |
| R(NR) | R*8 | Array of NR positive numbers, which are the negatives of the roots of F(s). These are positive numbers. On return, they are ordered in descending order. |
| NDIV | I*2 | Multiplicity of roots. Must be 1, 2 or 4. For NDIV = 4, NR must be 1 or 3. For any illegal combination of NDIV and NR, PDFCON returns C(I) = 0.D0 for I = 1 through NR*NDIV ( = NC). |

Output arguments:

| | | |
|---|---|---|
| C(NR*NDIV) | R*8 | Output array into which PDFCON puts the calculated coefficients. Dimensioned to 24, therefore, NR*NDIV must be no more than 24. |

## 9.19 PROUT

Subprogram name: Subroutine PROUT

Purpose: To output to file FOR002.DAT yearly average outage probability, fade outage per call minute, and 1000-bit block error probability of MD-918 modem for each specified BER threshold and diversity configuration.

Calling sequence:
CALL PROUT (JPOW,DIVTYP,NOUT,N1,N2,SOUT,BOUT,FOUT,ABE,CGAIN, PTYPE)

Contained in module: PROUT

Called by: MDTS

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| JPOW | R*8 | Interference power density in dBm/Hz. |
| DIVTYP | I*2 | Diversity configuration indicator. |
| NOUT | I*2 | Total number of short term calculations performed. |
| N1 | I*2 | Index of largest BER threshold of interest. |
| N2 | I*2 | Index of smallest BER threshold of interest. |
| SOUT | R*4 | Normalization for averaging of short term outage probabilities. |
| BOUT(3,4) | R*4 | Outage probability for each BER threshold and diversity configuration (see table). |
| FOUT(3,4) | R*4 | Fade outage per call minute for each BER threshold and diversity configuration: I = Index for BER threshold; J = Index for varying diversity types, depending on the value of DIVTYP |
| ABE(4) | R*4 | Average 1000-bit block error probability for each diversity configuration. |
| CGAIN | R*4 | Coding gains for each BER threshold. |
| PTYPE | I*2 | Indicates whether pure scatter (= 0) or mixed scatter/diffraction path (= 1). |

Output arguments:

| | | |
|---|---|---|
| BOUT(3,4) | R*4 | Outage probability for each BER threshold and diversity configuration (see table). |
| FOUT(3,4) | R*4 | Fade outage per call minute for each BER threshold and diversity configuration: I = Index for BER threshold; J = Index for varying diversity types, depending on the value of DIVTYP |
| ABE(4) | R*4 | Average 1000-bit block error probability for each diversity configuration. |

Global variables input from common:

```
BER(3)          /ERAD/        R*4    ERAD.INC
                Bit error rate thresholds of interest.  Set to 1E-3,
                1E-4 and 1E-5 in data statement.
LOUT            /LUNS/        I*2    LUNS.INC
                FOR002.DAT output unit number.
MDIST           /ERAD/        I*2    ERAD.INC
                Multipath distribution indicator.
                        0 = Only median multipath spread used(default)
                        1 = Multipath distribution used.  (Option not
                            currently available.)
NRAD            /ERAD/        I*2    ERAD.INC
                ERFAC indicator and loop counter.  Default is 1.
PFACT(3)        /ERAD/        R*4    ERAD.INC
                Cumulative probability distribution for effective
                earth radius factor.
                        For NRAD = 1    PFACT = 0.89
                                 = 2          = 0.1
                                 = 3          = 0.01
```

Global variables output to common:

```
ABEL(4)         /ERAD/        R*4    ERAD.INC
                Cumulative block error probability for each diversity
                configuration as specified by DIVTYP (averaged over
                multipath distribution, if any).
BOUTL(3,4)      /ERAD/        R*4    ERAD.INC
                Cumulative outage probability for each diversity
                configuration and error rate threshold (averaged
                over multipath distribution, if any).
FOUTL(3,4)      /ERAD/        R*4    ERAD.INC
                Cumulative fade outage per call minute for each
                diversity configuration and error rate threshold
                (averaged over multipath distribution, if any).
```

## 9.20 PSINE

Subprogram name: Function PSINE

Purpose: Calculates the product sin(.01 * XJ) * sin(.01 * DIN).

Calling sequence:
PSINE (XJ,DIN)

Contained in module: SINT

Called by: SINT

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| XJ | R*8 | 100 times the argument of the sine function. |
| DIN | R*8 | Difference between the arguments of the two sine functions. |

Output arguments:

| | | |
|---|---|---|
| PSINE | R*4 | The product sin(.01 * XJ) * sin(.01 * DIN). |

## 9.21 PWRSPC

Subprogram name: Function PWRSPC

Purpose: Power spectrum at F for cascade of receiver-interferer filters.

Calling sequence:
PWRSPC (F)

Contained in module: ROTAC

Called by: RJCFCN

Calls: TPSPEC, TPSPJ

Input arguments:

| | | |
|---|---|---|
| F | R*4 | Normalized frequency. |

Output arguments:

| | | |
|---|---|---|
| PWRSPC | R*4 | Power spectrum at F for cascade of receiver-interferer filters. |

Global variables input from common:

FCRX /BUTPAR/ R*4 BUTPAR.INC
Normalized 3dB cut-off frequency of receiver filter.

FJSEPN /JAMPAR/ R*4 JAMPAR.INC
Normalized frequency separation between the interference signal and the desired signal.

IFILRX /BUTPAR/ I*2 BUTPAR.INC
Receiver filter indicator.
- 0 = MD-918 receiver filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration.
- 1 = (not allowed)
- 2 = AN/TRC-170 receiver filter. Also means filter is a Butterworth.

NPOLRX /BUTPAR/ R*4 BUTPAR.INC
Number of poles in the receive Butterworth filter.

## 9.22 RJCFCN

Subprogram name: Function RJCFCN

Purpose: Calculate receiver-interferer correlation function by direct Fourier transform. PWRSUM is calculated as base value for FJSEPN = 0.0 Numerically integrate product of power spectrum, PWRSPC(FREQ), and COS(TWOPI * FREQ * TARG) over frequency interval [0.0, 10.0*FCRX].

Calling sequence:
RJCFCN (TARG,INIT)

Contained in module: BOTAC

Called by: BOTAC

Calls: PWRSPC, TPSPEC

Input arguments:

| | | |
|---|---|---|
| TARG | R*4 | Normalized time argument. |
| INIT | I*2 | Flag to perform initializations and to calculate normalization constant, PWRSUM, during first function call to RJCFCN for each interferer angle. |

Output arguments:

| | | |
|---|---|---|
| RJCFCN | R*4 | Receiver-interferer correlation function. |
| INIT | I*2 | Flag to perform initializations and to calculate normalization constant, PWRSUM, during first function call to RJCFCN for each interferer angle. |

Global variables input from common:

| | | | |
|---|---|---|---|
| FCRX | /BUTPAR/ | R*4 | BUTPAR.INC |
| | Normalized 3dB cut-off frequency of receiver filter. | | |
| TWOPI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | 2 X Pi = 6.283185307. | | |

Global variables output to common:

| | | | |
|---|---|---|---|
| FJSEPN | /JAMPAR/ | R*4 | JAMPAR.INC |
| | Normalized frequency separation between the interference signal and the desired signal. | | |

## 9.23 SASEQ

Subprogram name: Subroutine SASEQ

Purpose: To set the chip sequence ASEQ as a function of the number of chips per thermal bit KGAIN.

Calling sequence:
CALL SASEQ (ASEQ)

Contained in module: SASEQ

Called by: MDTS TRCIN

Calls: NONE

Input arguments:
NONE

Output arguments:

| | | |
|---|---|---|
| ASEQ(30) | I*2 | Chip sequence for bandwidth spreading. |

Global variables input from common:

| | | | |
|---|---|---|---|
| KGAIN | /RZ/ | I*2 | RZ.INC |
| | Integer ratio of bandwidth to data rate. | | |
| LOUT | /LUNS/ | I*2 | LUNS.INC |
| | FOR002.DAT output unit number. | | |

## 9.24 SIGIN

Subprogram name: Subroutine SIGIN

Purpose: Set pulse shape switch PULSE, number of taps K, lower and upper delay spread ratios SIGMA and SIGM1, number of future ISI considered LISI, and the proportionality constant SPOWR.

Calling sequence:
CALL SIGIN (K,SIGMA,SIGM1,TAU22,TAU23,SPOWR)

Contained in module: SIGIN

Called by: MDTS

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| TAU22 | R*8 | Delay spread in lower beam in nanoseconds. |
| TAU23 | R*8 | Delay spread in upper beam in nanoseconds. |

Output arguments:

| | | |
|---|---|---|
| K | I*2 | Number of taps in either side of AFE center tap. |
| SIGMA | R*4 | Ratio of lower beam delay spread to symbol duration. |
| SIGM1 | R*4 | Ratio of upper beam delay spread to symbol duration. |
| SPOWR | R*4 | Proportionality constant used in ISI calculation. |

Global variables input from common:

DRATE /MCOM4/ R*4 MCOM.INC
Data rate in bits/second. Default is 6.6E6.

IBW /MCOM2/ I*2 MCOM.INC
Switch indicating type of RF bandwidth constraint to be used on desired signal. Default is 0.
0 = No RF filtering
1 = Filter determined from 99% bandwidth constraint
2 = Filter chosen to meet FCC Mask. (FCC-19311)
3 = Filters are user specified

ICORR /MCOM2/ I*2 MCOM.INC
Multipath profile correlation indicator. Default is 2.
0 = Profile of the form X * exp(-A*X) -- used for debugging
1 = Computed multipath profile; no beam correlation
2 = Computed multipath profile; beam correlation.

KGAIN /RZ/ I*2 RZ.INC
Integer ratio of bandwidth to data rate.

LERR /LUNS/ I*2 LUNS.INC
Error output unit.

NTAP /MCOM2/ I*2 MCOM.INC
Number of adaptive forward equalizer taps (AFE) in

MD-918 modem. Set to 3 in INDATA.

Global variables output to common:

```
     LISI               /MCOM2/         I*2     MCOM.INC
                        Number of future Intersymbol Interference (ISI)
                        contributors considered in MD-918 performance
                        calculation. Default is 2.
     PULSE              /RZ/            I*2     RZ.INC
                        Switch controlling MD-918 pulse shape after
                        transmitter-receiver filtering.
                               PULSE = 0   Triangle
                                     = 1   OQPSK matched filter
                                     = 2   Sinc pulse, bandwidth equal to 1
                                     = 5   RF filtering included
                        Set to 0 if IBW = 0 or KGAIN > 1.
                        Set to 5 if IBW > 0 and KGAIN = 1.
     TAPW               /MCOM4/         R*4     MCOM.INC
                        Normalized tapwidth for MD-918. Default is .5.
                        Range is 0.25 through 1.0
```

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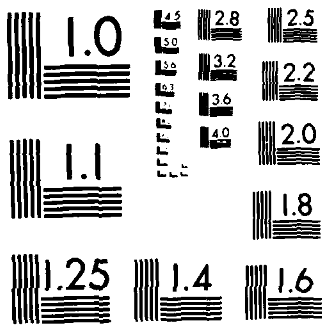


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## 9.25 SINC

Subprogram name: Function SINC

Purpose: SINC = SIN(PI*X) / (PI*X). For X = 0 or
ABS (Numerator - Denominator) < 1.0E-6 SINC = 1.

Calling sequence:
SINC (X)

Contained in module: SINC

Called by: CAC, FILSIX, TSINC

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| X | R*4 | Argument of SINC function. |

Output arguments:

| | | |
|---|---|---|
| SINC | R*4 | Value of SIN(PI*X) / PI*X. |

Global variables input from common:

| | | | |
|---|---|---|---|
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |

## 9.26 SQTMAT

Subprogram name: Subroutine SQTMAT

Purpose: Subroutine to take square root of a symmetric, positive-definite matrix D of order < = 7 by computing:

SQRT(D) = (EMODAL) * SQRT(UNITRY) * (TRANSP(EMODAL)).

Where EMODAL is the matrix containing the eigenvectors of D (the 'modal' matrix) and UNITRY is the matrix containing the eigenvalues of D in its diagonal (the 'unitary' matrix).

Calling sequence:

```
CALL SQTMAT (D,SQRTD,K1)
```

Contained in module: MATOPS

Called by: MDTS

Calls: CHANGE, EIGEN, ERROR, MATA

Input arguments:

| | | |
|---|---|---|
| D(K1,K1) | R*4 | Original matrix: real, symmetric, undisturbed. Dimensioned as 7 X 7. |
| K1 | I*2 | Dimensions of matrix D. Maximum is 7. |

Output arguments:

| | | |
|---|---|---|
| SQRTD | R*4 | Square root matrix. |

## 9.27 TPSPEC

Subprogram name: Function TPSPEC

Purpose: Power spectrum at F for Butterworth * IFILT-type filter.

Calling sequence:
TPSPEC (F,NPOLE,FCUT,IFILT)

Contained in module: BOTAC

Called by: PWRSPC, TPSPJ

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| F | R*4 | Normalized frequency. |
| NPOLE | R*4 | Number of poles of Butterworth filter. |
| FCUT | R*4 | Normalized 3-dB cut-off frequency of Butterworth filter. |
| IFILT | I*2 | Switch that indicates whether rectangular impulse response filter is cascaded with Butterworth filter (= 0,1) or not (= 2). |

Output arguments:

| | | |
|---|---|---|
| TPSPEC | R*4 | Power spectrum for Butterworth * IFILT-type filter. |

Global variables input from common:

| | | | |
|---|---|---|---|
| PI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Constant Pi = 3.141592654. | | |

## 9.28 TPSPJ

Subprogram name: Function TPSPJ

Purpose: Power spectrum of interferer at frequency F.

Calling sequence:
```
     TPSPJ (F)
```

Contained in module: BOTAC

Called by: PWRSPC

Calls: TPSPEC

Input arguments:
```
     F          R*4      Normalized frequency.
```

Output arguments:
```
     TPSPJ      R*4      Power spectrum of interferer at frequency F.
```

Global variables input from common:
```
     FCJ                 /JAMPAR/         R*4      JAMPAR.INC
                         Normalized 3dB cut-off frequency of QPSK interference
                         filter.
     FCTX                /BUTPAR/         R*4      BUTPAR.INC
                         Normalized 3dB cut-off frequency of transmitter
                         filter.
     FMI                 /JAMPAR/         R*4      JAMPAR.INC
                         Modulation index for FDM/FM interference.
     IFILTX              /BUTPAR/         I*2      BUTPAR.INC
                         Transmitter filter indicator.
                                 0 = MD-918 transmitter filter.  Also means
                                     filter is a Butterworth cascaded with a
                                     rectangular impulse response filter of
                                     duration equal to symbol duration.
                                 1 = AN/TRC-170 transmitter filter.  Also means
                                     filter is a cascade of Butterworth filter
                                     with rectangular impulse response filter
                                     of duration equal to half symbol duration.
                                 2 = (not allowed)
     MODSG               /JAMPAR/         I*2      JAMPAR.INC
                         Interference signal modulation format.  Default is 1.
                                 0 = Analog FDM / FM
                                 1 = Digital QPSK
     NPOLJ               /JAMPAR/         I*2      JAMPAR.INC
                         Number of poles in the QPSK interference filter.
     NPOLTX              /BUTPAR/         I*2      BUTPAR.INC
                         Number of poles in the transmit Butterworth filter.
     PI                  /CONSTA/         R*4      CONSTANTS.INC
```

| | | | |
|---|---|---|---|
| | Constant Pi = 3.141592654. | | |
| WFM | /JAMPAR/ | R*4 | JAMPAR.INC |
| | Normalization constant for FDM/FM interference. | | |

## 9.29 TSINC

Subprogram name: Function TSINC

Purpose: TSINC = B * convolution of triangular impulse response filter and waveform with impulse response sinc(B*X) evaluated at the point X.

Calling sequence:
TSINC (B,X)

Contained in module: BOTAC

Called by: BOTAC, JAMCOM

Calls: SINC

Input arguments:

| | | |
|---|---|---|
| B | R*8 | Normalized bandwidth of SINC waveform. |
| X | R*8 | Normalized time argument. |

Output arguments:

| | | |
|---|---|---|
| TSINC | R*4 | Convolution. |

## 9.30 XNOR

Subprogram name: Function XNOR

Purpose: Gaussian PDF with mean SPA and standard deviation SPS. Note, the arguments are single precision though the output is double.

Calling sequence:
XNOR (SPX,SPA,SPS)

Contained in module: XNOR

Called by: BERCAL, MDTS, TRC

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| SPX | R*4 | Value of Gaussian random variable at which PDF is to be calculated. |
| SPA | R*4 | Mean of distribution. |
| SPS | R*4 | Standard deviation of distribution, |

Output arguments:

| | | |
|---|---|---|
| XNOR | R*8 | Gaussian PDF. |

# CHAPTER 10

## AN/TRC-170 MODEM CALCULATIONS

This section describes the AN/TRC-170-DAR modem performance calculation routines:

| Name | Description | User's Manual section |
|---|---|---|
| AVG | Short-term ABER and outage probabilities . . . . . . . . . . | 2.9.5 |
| EIGV | Implicit diversity eigenvalues | 2.9.4 |
| INTERD | Linear interpolation . . . . . | NA |
| P2INT | Correlation of response with itself . . . . . . . . . . . . . | 2.9.4 |
| PAVERG | Conditional aberage bit error probability . . . . . . . . . . . | 2.9.5 |
| PDF | PDF of detection SNR . . . . . | 2.9.4 |
| PDFCOE | PDF coefficients . . . . . . . . | 2.9.4 |
| PDFSUM | PDF integration of SNR . . . . | NA |
| POUTAG | Conditional outage probability | 2.9.5 |
| PROFIL | Power/delay profile . . . . . . . | 2.9.4 |
| TIMAVG | Short-term ABER and outage probability . . . . . . . . . . . | 2.9.5 |
| TIMEQL | Sampling times . . . . . . . . . | 2.9.3 |
| TIMPAR | Steady state sampling time . . | NA |
| TRC | Main TRC routine . . . . . . . . | 2.9.1, 2.9.2 |
| TRCIN | TRC parameters . . . . . . . . . | 2.9.1, 2.9.4 |
| TXPULS | Tx-Rx impulse response . . . . | 2.9.4 |
| VARW | ISI variance . . . . . . . . . . . | 2.9.5 |

The main routine for this section is TRC. The TRC modem performance calculations are described in section 2.9 of the User's Manual.

Figure 2-6 is a top level flowchart for AN/TRC-170-DAR modem performance calculations at a functional level. In most cases the blocks correspond to one or more subprograms. The test blocks (diamonds) correspond to logical branches which are decided by the user's choices of input data.

NOTE

In most cases the sections in the User's Manual describe the coded equations as well as the theory behind them. NA denotes routines that are programming utilities such as finding indices, setting pointers, etc.

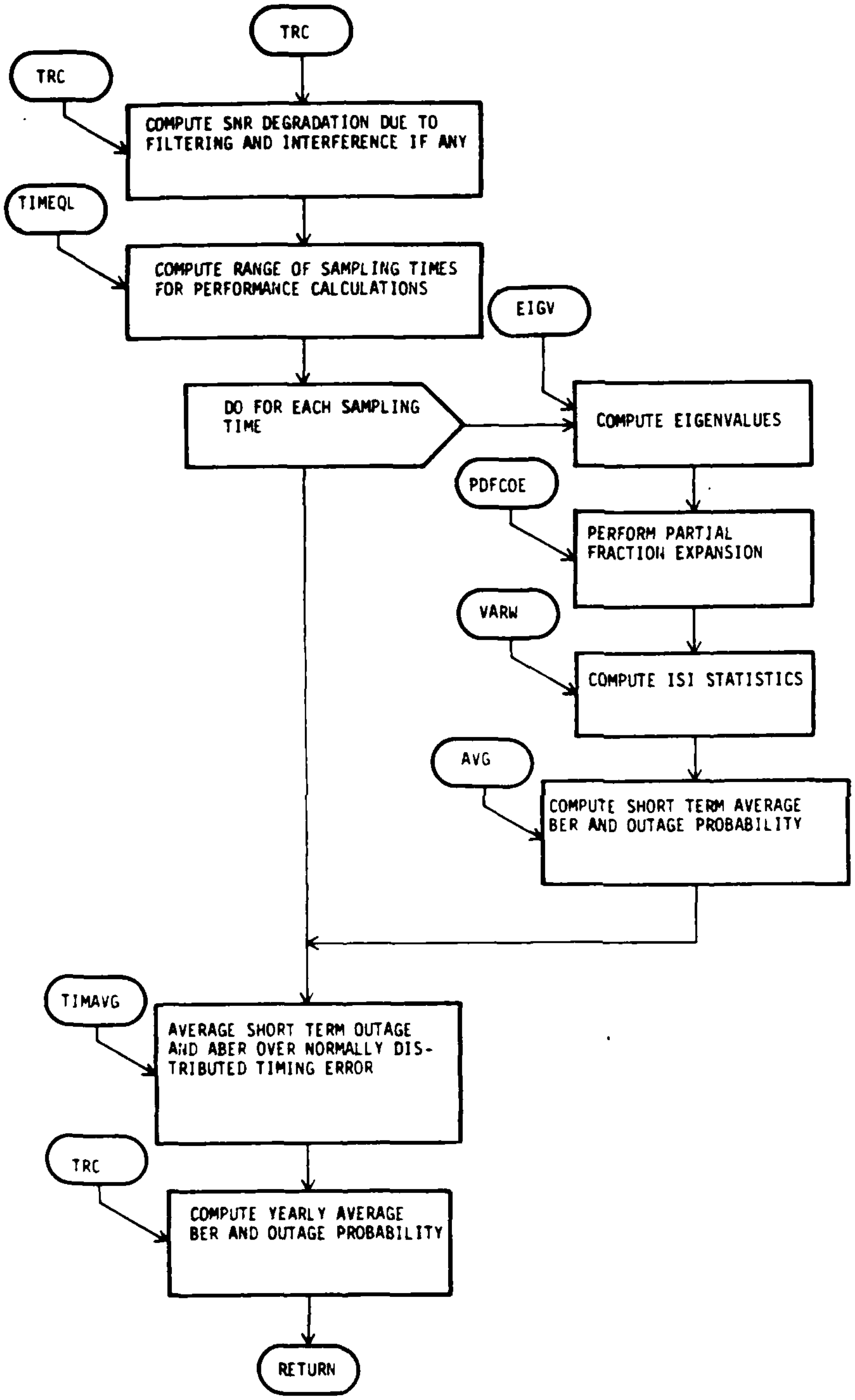


Figure 2-6 Flow Chart for AN/TRC-170-DAR Modem Performance Calculations

## 10.1 AVG

Subprogram name: Subroutine AVG

Purpose: To calculate short-term average bit error rate and short-term outage probability of AN/TRC-170 given the short term average SNR per bit by integrating over the statistics of the instantaneous detection SNR of the modem.

Calling sequence:
CALL AVG (YRUTIN, Y, IERR)

Contained in module: TRC

Called by: TRC

Calls: PDF, YRUTIN

Input arguments:

| | | |
|---|---|---|
| YRUTIN | R*4 | Function name. May be PAVERG or POUTAG. |

Output arguments:

| | | |
|---|---|---|
| Y | R*4 | Twice the average bit error rate if the function requested is PAVERG and outage probability if the function requested is POUTAG. |
| IERR | I*2 | Error flag. |

Global variables input from common:

| | | | |
|---|---|---|---|
| COEFF | /ANSWER/ | R*8 | ANSWER.INC |
| | Partial fraction expansion coefficients for calculation of AN/TRC-170 outage probability. | | |
| NDIVS | /SYSPAR/ | I*2 | SYSPAR.INC |
| | Number of explicit diversity channels for AN/TRC-170. Equal to 4 for 2S/2F and 2 for 2S or 2F. | | |
| NEIGEN | /ANSWER/ | I*2 | ANSWER.INC |
| | Number of implicit diversity eigenvalues (stored in array VEIGV) used in calculation of AN/TRC-170 performance. | | |
| VEIGV(20) | /ANSWER/ | R*8 | ANSWER.INC |
| | Implicit diversity eigenvalues for AN/TRC-170. | | |
| X3INCR | /NUMPAR/ | R*4 | NUMPAR.INC |
| | Step increment for numerical integration. | | |

## 10.2 EIGV

Subprogram name: Subroutine EIGV

Purpose: Calculates the implicit diversity eigenvalues of the AN/TRC-170.

Calling sequence:
CALL EIGV (X2INCR, NV, EIGMIN, IERR)

Contained in module: TRC

Called by: TRC

Calls: ELMES, HQR, ORDER, PROFIL, TXPULS

Input arguments:

| | | |
|---|---|---|
| X2INCR | R*4 | Step increment for numerical integration. |
| NV | I*2 | Number of eigenvalues to be computed. |
| EIGMIN | R*4 | Ratio of smallest to largest eigenvalue of interest. |

Output arguments:

| | | |
|---|---|---|
| IERR | I*2 | Error flag. |

Global variables input from common:

IPROFL /SYSPAR/ I*2 SYSPAR.INC
Parameter that indicates whether troposcatter power per unit delay profile of the form X exp (-A*X) is to be used (IPROFL = 0) or not. Set to zero in TRCIN.

SIGMA /SYSPAR/ R*4 SYSPAR.INC
Half the RMS lower beam delay spread normalized relative to the symbol duration.

TO /SYSPAR/ R*4 SYSPAR.INC
Normalized sampling time for lower beam.

Global variables output to common:

DIVIMP /ANSWER/ R*4 ANSWER.INC
Ratio of square of mean signal energy to variance for AN/TRC-170.

ENMEAN /ANSWER/ R*4 ANSWER.INC
Average received energy.

ENVAR /ANSWER/ R*4 ANSWER.INC
Variance of received energy.

NEIGEN /ANSWER/ I*2 ANSWER.INC
Number of implicit diversity eigenvalues (stored in array VEIGV) used in calculation of AN/TRC-170 performance.

VEIGV(20) /ANSWER/ R*8 ANSWER.INC
Implicit diversity eigenvalues for AN/TRC-170.

## 10.14 TRC

Subprogram name: Subroutine TRC

Purpose: To calculate the short-term BER and outage probability of the AN/TRC-170 or DAR modem as a function of SNR for the specified diversity configuration and BER threshold and the yearly outage probability given the yearly median of the troposcatter signal SNR and its standard deviation.

Calling sequence:

```
CALL TRC (TRCTYP,IBW,PYEAR)
```

Contained in module: TRC

Called by: TRCIN

Calls: AVG, EIGV, PAVERG, PDFCOE, PDFSUM, POUTAG, TIMAVG, TIMEQL, TIMPAR, VARW, XNOR

Input arguments:

| | | |
|---|---|---|
| TRCTYP | R*4 | TRC-170 modem type indicator:<br>0 = 1 frequency DAR modem<br>1 = 2 frequency AN/TRC-170 modem |
| IBW | I*2 | Switch indicating which type of RF bandwidth constraint to be used on desired signal.<br>0 = No RF filtering<br>1 = Filter determined from 99% bandwidth constraint<br>2 = Filter chosen to meet FCC Mask. (FCC-19311)<br>3 = Filters are user specified. |

Output arguments:

| | | |
|---|---|---|
| PYEAR(2,3) | R*4 | Yearly statistics. PYEAR(1,.) is yearly outage probability and PYEAR(2,.) is yearly fade outage probability per call minute for each BER threshold. |

Global variables input from common:

| | | | |
|---|---|---|---|
| ASNR | /SYSPAR/ | R*4 | SYSPAR.INC |
| | Yearly median value of troposcatter short-term average SNR, ie, Eb/No, in dB. | | |
| CDUR | /SYSPAR/ | R*4 | SYSPAR.INC |
| | Duration of transmitted pulse for AN/TRC-170 normalized to signaling interval duration. | | |
| COEFF | /ANSWER/ | R*8 | ANSWER.INC |
| | Partial fraction expansion coefficients for calculation of AN/TRC-170 outage probability. | | |
| EIGMIN | /NUMPAR/ | R*4 | NUMPAR.INC |

## 10.13 TIMPAR

Subprogram name: Function TIMPAR

Purpose: To calculate sampling time at steady state from early-late gate loop.

Calling sequence:
TIMPAR (X2INCR,XINCR)

Contained in module: TRC

Called by: TIMEQL, TRC

Calls: PROFIL, P2INT

Input arguments:

| | | |
|---|---|---|
| X2INCR | R*4 | Step increment for numerical integration. |
| XINCR | R*4 | Step increment for numerical integration. |

Output arguments:

| | | |
|---|---|---|
| TIMPAR | R*4 | Sampling time at steady state from early-late gate loop. |

Global variables input from common:

IPROFL /SYSPAR/ I*2 SYSPAR.INC
Parameter that indicates whether troposcatter power per unit delay profile of the form X exp (-A*X) is to be used (IPROFL = 0) or not. Set to zero in TRCIN.

SIGMA /SYSPAR/ R*4 SYSPAR.INC
Half the RMS lower beam delay spread normalized relative to the symbol duration.

TO /SYSPAR/ R*4 SYSPAR.INC
Normalized sampling time for lower beam.

## 10.12 TIMEQL

Subprogram name: Subroutine TIMEQL

Purpose: To determine the various sampling times for the short-term performance of the AN/TRC-170.

Calling sequence:
```
CALL TIMEQL (TOTO, IT, TPAR, TDEV, X2INCR, XINCR, IERR)
```

Contained in module: TRC

Called by: TRC

Calls: TIMPAR

Input arguments:

| | | |
|---|---|---|
| TDEV | R*4 | Standard deviation of sampling time. |
| X2INCR | R*4 | Step increment for numerical integration. |
| XINCR | R*4 | Step increment for numerical integration. |

Output arguments:

| | | |
|---|---|---|
| TOTO(20) | R*4 | Array of sampling times (normalized to symbol duration) for calculation of short term TRC-170 performance. |
| IT | I*2 | Number of different sampling times to be used in calculation of TRC-170 short term performance. |
| TPAR(20) | R*4 | Sampling times at steady-state for early-late gate loop. |
| IERR | I*2 | Error flag. |

Global variables output to common:

| | | | |
|---|---|---|---|
| TO | /SYSPAR/ | R*4 | SYSPAR.INC |
| | Normalized sampling time for lower beam. | | |

## 10.11 TIMAVG

Subprogram name: Subroutine TIMAVG

Purpose: To average the short-term average bit error rate and short-term outage probability over Gaussian distributed timing jitter.

Calling sequence:
CALL TIMAVG (PERF, TOTO, IT, TDEV, PERAVG, IERR)

Contained in module: TRC

Called by: TRC

Calls: INTERD

Input arguments:

| | | |
|---|---|---|
| PERF(20) | R*4 | Performance measure for each sampling time. |
| TOTO(20) | R*4 | Array of sampling times (normalized to symbol duration) for calculation of short term TRC-170 performance. |
| IT | I*2 | Number of different sampling times to be used in calculation of TRC-170 short term performance. |
| TDEV | R*4 | Standard deviation of timing jitter. |

Output arguments:

| | | |
|---|---|---|
| PERAVG | R*4 | Average of performance measure over Gaussian distributed timing jitter. |
| IERR | I*2 | Error flag: 0 = no error; 1 = error in performance measure calculation. |

## 10.10 PROFIL

Subprogram name: Function PROFIL

Purpose: To calculate the power per unit delay profile of received troposcatter signal. Presently only an exponential profile of the form A*X * EXP(-B*X) is allowed. Power per unit delay profiles calculated in propagation module may be added later.

Calling sequence:
PROFIL (X, IPROFL, SIGMA)

Contained in module: TRC

Called by: EIGV, TIMPAR, VARW

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| X | R*4 | Normalized delay at which profile is to be sampled. |
| IPROFL | I*2 | Switch: 0 = exponential power per unit delay profile to be used. |
| SIGMA | R*4 | Lower beam normalized delay spread. |

Output arguments:

| | | |
|---|---|---|
| PROFIL | R*4 | Power per unit delay profile. |

Standard deviation of future ISI for AN/TRC-170.

## 10.9 POUTAG

Subprogram name: Subroutine POUTAG

Purpose: Calculates the conditional outage probability for a given instantaneous SNR by averaging over ISI due to up to two past and two future symbols.

Calling sequence:
CALL POUTAG (X, OUTISI, IERR)

Contained in module: TRC

Called by: TRC

Calls: ERFC, INTERD

Input arguments:

| | | |
|---|---|---|
| X | R*4 | Instantanous detection SNR. |

Output arguments:

| | | |
|---|---|---|
| OUTISI | R*4 | Conditional outage probability. |
| IERR | I*2 | Error flag. |

Global variables input from common:

IRSN /NUMPAR/ I*2 NUMPAR.INC
Number of values in SNR array RSNRSN(30). Used to calculate ISI statistics for AN/TRC-170. Initially set to 30.

KISI /NUMPAR/ I*2 NUMPAR.INC
Parameter for calculation of AN/TRC-170 outage probability. Set to 6 in data statement.

NTHR /SYSPAR/ I*2 SYSPAR.INC
Pointer to bit error rate threshold for AN/TRC-170 outage probability calculation.

RSNMIN(3) /NUMPAR/ R*4 NUMPAR.INC
SNR threshold corresponding to each bit error rate threshold for AN/TRC-170.

RSNRSN(30) /NUMPAR/ R*4 NUMPAR.INC
Set of SNR values for which solution of transcendental function (UPISIM) is tabulated.

SNR /SYSPAR/ R*4 SYSPAR.INC
Signal to noise ratio.

UPISIM(30,3) /NUMPAR/ R*4 NUMPAR.INC
Solution of transcendental equation for each value of RSNRSN and bit error rate threshold of interest in AN/TRC-170 outage probability calculation.

XAVAR /ANSWER/ R*4 ANSWER.INC
Standard deviation of past ISI for AN/TRC-170.

XBVAR /ANSWER/ R*4 ANSWER.INC

## 10.8 PDFSUM

Subprogram name: Function PDFSUM

Purpose: Integration of the probability density function of the detection SNR.

Calling sequence:
PDFSUM (NDIVS, NEIGEN, VEIGV, COEFF, XINCR)

Contained in module: TRC

Called by: TRC

Calls: ERLANG, PDF

Input arguments:

| | | |
|---|---|---|
| NDIVS | I*2 | Number of explicit diversities. |
| NEIGEN | I*2 | Number of eigenvalues in array VEIGV. Maximum is 20. |
| VEIGV(NEIGEN) | R*8 | Implicit diversity eigenvalues for AN/TRC-170. Dimensioned to 20. |
| COEFF(40) | R*8 | Partial fraction expansion coefficients. |
| XINCR | R*4 | Step increment for numerical integration. |

Output arguments:

| | | |
|---|---|---|
| PDFSUM | R*4 | Integration of the probability density function of the detection SNR. |

## 10.7 PDFCOE

Subprogram name: Subroutine PDFCOE

Purpose: Find partial fraction expansion coefficients of signal gain distribution. C((N-1)*ID + I), of

```
F(s) = (R(1) / (S + R(1)))**ID  * ... *  (R(NU) / (S + R(NU)))**ID
F(s) =  ...C((N - 1) * ID + I) / (S + R(N)) * ID - I + 1 ...
```

for N = 1,2,...NU; I = 1,2,...ID

Calling sequence:

```
CALL PDFCOE (NR, R, NDIVS, C, IERR)
```

Contained in module: TRC

Called by: TRC

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| R(NR) | R*8 | Input root array. R(K) > 0, K = 1,NR. Dimensioned to 20. |
| NR | I*2 | Size of R array. Maximum is 20. Also NR X NDIVS must be less than or equal to 40. |
| NDIVS | I*2 | Number of explicit diversity branches. Value must be such that NR X NDIVS is less than or equal to 40. |

Output arguments:

| | | |
|---|---|---|
| C(NR*NDIVS) | R*8 | Partial fraction expansion coefficients. Dimensioned to 40. |
| IERR | I*2 | Error flag. |

## 10.6 PDF

Subprogram name: Function PDF

Purpose: Computes the probability density function of the detection SNR for the AN/TRC-170.

Calling sequence:
PDF (X, NEIGEN, NDIVS, VEIGV, COEFF)

Contained in module: TRC

Called by: AVG, PDFSUM

Calls: ERLANG

Input arguments:

| | | |
|---|---|---|
| X | R*4 | SNR at which PDF is to be evaluated. |
| NEIGEN | I*2 | Number of eigenvalues in array VEIGV. Maximum is 20. |
| NDIVS | I*2 | Number of explicit diversities. |
| VEIGV(NEIGEN) | R*8 | Implicit diversity eigenvalues for AN/TRC-170. Dimensioned to 20. |
| COEFF(40) | R*8 | Partial fraction expansion coefficients. |

Output arguments:

| | | |
|---|---|---|
| PDF | R*4 | Probability density function of the detection SNR for the AN/TRC-170. |

## 10.5 PAVERG

Subprogram name: Subroutine PAVERG

Purpose: To calculate twice the instantaneous bit error rate (or conditional bit error rate) of the AN/TRC-170 given the instantaneous detection SNR and variance of the ISI.

Calling sequence:

```
CALL PAVERG (X, AVGISI, IERR)
```

Contained in module: TRC

Called by: TRC

Calls: ERFC

Input arguments:

| | | |
|---|---|---|
| X | R*4 | Instantaneous detection SNR. |

Output arguments:

| | | |
|---|---|---|
| AVGISI | R*4 | Twice the instantaneous bit error rate. |
| IERR | I*2 | Error flag |

Global variables input from common:

| | | | |
|---|---|---|---|
| SNR | /SYSPAR/ | R*4 | SYSPAR.INC |
| | Signal to noise ratio. | | |
| VARISI | /ANSWER/ | R*4 | ANSWER.INC |
| | Total ISI variance for AN/TRC-170. | | |

## 10.4 P2INT

Subprogram name: Function P2INT

Purpose: Correlates the transmitter-receiver filter impulse response with a delayed version of itself.

Calling sequence:
P2INT (A, B, XL, XU, XINCR)

Contained in module: TRC

Called by: TIMPAR, VARW

Calls: TXPULS

Input arguments:

| | | |
|---|---|---|
| A | R*4 | Sampling time at the output of the receiver filter. |
| B | R*4 | Delay between correlator inputs. |
| XL | R*4 | Lower integration limit. |
| XU | R*4 | Upper integration limit. |
| XINCR | R*4 | Step increment for numerical integration. |

Output arguments:

| | | |
|---|---|---|
| P2INT | R*4 | Correlation of the transmitter-receiver filter impulse response with a delayed version of itself. |

Global variables input from common:

| | | | |
|---|---|---|---|
| IPULS | /SYSPAR/ | I*2 | SYSPAR.INC |
| | Switch to indicate whether pulse shape at input of the AN/TRC-170 detector includes the effects of RF filters (IPULS = 2) or not (IPULS = 0 or 1). Set to 2 internally. If IBW is 0, set to 1. | | |
| NCHIP | /SYSPAR/ | I*2 | SYSPAR.INC |
| | Number of chips in PN sequence used to expand bandwidth in AN/TRC-170. | | |
| PDUR | /SYSPAR/ | R*4 | SYSPAR.INC |
| | Symbol pulse duration. | | |

## 10.3 INTERD

Subprogram name: Subroutine INTERD

Purpose: Linear interpolation in a table of N pairs (XX,YY).

Calling sequence:
CALL INTERD (Y, X, YY, XX, N, IERR)

Contained in module: TRC

Called by: POUTAG, TIMAVG

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| X | R*4 | Value of x-coordinate for which y-coordinate is desired. |
| YY(N) | R*4 | Tabulated values of y-coordinate corresponding to tabulated x-coordinate. Dimensioned to 30. |
| XX(N) | R*4 | Tabulated values of x-coordinate corresponding to tabulated y-coordinate. Dimensioned to 30. |
| N | I*2 | Number of tabulated values over which interpolation is to be performed. Maximum is 30. |

Output arguments:

| | | |
|---|---|---|
| Y | R*4 | Value of y-coordinate corresponding to X. |
| IERR | I*2 | Error flag.<br>0 = no error<br>5 = x-coordinate value greater than largest tabulated value<br>6 = x-coordinate value less than smallest tabulated value |

Ratio of smallest to largest eisenvalue in AN/TRC-170 performance calculations.

ENMEAN /ANSWER/ R*4 ANSWER.INC
Averase received enersy.

ICHIP(30) /SYSPAR/ I*2 SYSPAR.INC
PN sequence for spectrum spreading when the data rate is much smaller than the bandwidth.

IOPERF /IOUT/ I*2 IOUT.INC
Switch for calculation of performance of AN/TRC-170.
0 = ABER and outase probability
1 = ABER (averase bit error rate) only
2 = Outase probability only
Set to 0 internally.

IOTIME /IOUT/ I*2 IOUT.INC
Switch for calculation of performance of AN/TRC-170.
0 = Short term performance assuming various sampling times.
1 = Short term performance assuming Gaussian timing jitter.
2 = Yearly average performance assuming Gaussian timing jitter.
Set to 2 internally.

IPROFL /SYSPAR/ I*2 SYSPAR.INC
Parameter that indicates whether troposcatter power per unit delay profile of the form X exp (-A*X) is to be used (IPROFL = 0) or not. Set to zero in TRCIN.

IPULS /SYSPAR/ I*2 SYSPAR.INC
Switch to indicate whether pulse shape at input of the AN/TRC-170 detector includes the effects of RF filters (IPULS = 2) or not (IPULS = 0 or 1). Set to 2 internally. If IBW is 0, set to 1.

ISN /IOUT/ I*2 IOUT.INC
Number of SNR values for which short-term performance of AN/TRC-170 is to be performed. Set to 17.

IT /IOUT/ I*2 IOUT.INC
Number of different sampling times to be used in calculation of AN/TRC-170 short term performance.

KISI /NUMPAR/ I*2 NUMPAR.INC
Parameter for calculation of AN/TRC-170 outage probability. Set to 6 in data statement.

LERR /LUNS/ I*2 LUNS.INC
Error output unit.

LOUT /LUNS/ I*2 LUNS.INC
FOR002.DAT output unit number.

NCHIP /SYSPAR/ I*2 SYSPAR.INC
Number of chips in PN sequence used to expand bandwidth in AN/TRC-170.

NDIVS /SYSPAR/ I*2 SYSPAR.INC
Number of explicit diversity channels for AN/TRC-170. Equal to 4 for 2S/2F and 2 for 2S or 2F.

| | | | | |
|---|---|---|---|---|
| NEIGEN | /ANSWER/ | I*2 | ANSWER.INC | |
| | Number of implicit diversity eigenvalues (stored in array VEIGV) used in calculation of AN/TRC-170 performance. | | | |
| NPOINT | /NUMPAR/ | I*2 | NUMPAR.INC | |
| | Number of points for numerical integration. | | | |
| NTH1 | /IOUT/ | I*2 | IOUT.INC | |
| | Pointer to largest bit error rate threshold of interest for AN/TRC-170 outage probability calculation. | | | |
| NTH2 | /IOUT/ | I*2 | IOUT.INC | |
| | Pointer to smallest bit error rate threshold of interest for AN/TRC-170 outage probability calculation. | | | |
| NTHR | /SYSPAR/ | I*2 | SYSPAR.INC | |
| | Pointer to bit error rate threshold for AN/TRC-170 outage probability calculation. | | | |
| NV | /NUMPAR/ | I*2 | NUMPAR.INC | |
| | Normalization parameter for calculation of AN/TRC-170 signal gain. Set to 18. | | | |
| PEAKAV | /RZ4/ | R*4 | RZ4.INC | |
| | Peak-to-average loss due to RF filtering in dB. | | | |
| SIGMA | /SYSPAR/ | R*4 | SYSPAR.INC | |
| | Half the RMS lower beam delay spread normalized relative to the symbol duration. | | | |
| SNDB(2) | /IOUT/ | R*4 | IOUT.INC | |
| | Signal to noise ratio in dB. | | | |
| SNRBW | /RZ4/ | R*4 | RZ4.INC | |
| | Signal to noise ratio adjustment for AN/TRC-170 due to limited receive filter bandwidth. | | | |
| SNRF2 | /RZ4/ | R*4 | RZ4.INC | |
| | Parameter to adjust the signal to noise ratio for degradation due to interference from another frequency. Only for 2-frequency AN/TRC-170 modem. | | | |
| SNRJAM | /RZ4/ | R*4 | RZ4.INC | |
| | Parameter to adjust the signal to noise ratio of AN/TRC-170 for degradation due to colocated/adjacent channel interference. | | | |
| STSNR1 | /SYSPAR/ | R*4 | SYSPAR.INC | |
| | Standard deviation of troposcatter signal long-term SNR distribution in dB. Same as STSNR in /SUMP/. | | | |
| TOTO(20) | /IOUT/ | R*4 | IOUT.INC | |
| | Array of sampling times (normalized to symbol duration) for calculation of short term AN/TRC-170 performance. | | | |
| TDEV | /NUMPAR/ | R*4 | NUMPAR.INC | |
| | Standard deviation of sampling times for AN/TRC-170 performance calculations. | | | |

Global variables output to common:

| | | | | |
|---|---|---|---|---|
| PAVG(20,20) | /ANSWER/ | R*4 | ANSWER.INC | |
| | Short-term average bit error rate for each sampling time and short-term average SNR. | | | |
| PDUR | /SYSPAR/ | R*4 | SYSPAR.INC | |
| | Symbol pulse duration. | | | |
| POUT(20,20,3) | /ANSWER/ | R*4 | ANSWER.INC | |
| | AN/TRC-170 outage probability and average bit error rate as a function of sampling time, short-term average SNR and error rate threshold. | | | |
| SNR | /SYSPAR/ | R*4 | SYSPAR.INC | |
| | Signal to noise ratio. | | | |
| TO | /SYSPAR/ | R*4 | SYSPAR.INC | |
| | Normalized sampling time for lower beam. | | | |
| TPAR(20) | /ANSWER/ | R*4 | ANSWER.INC | |
| | Timing parameter for AN/TRC-170. Calculated when IOTIME is 0. | | | |
| VARAIS | /ANSWER/ | R*4 | ANSWER.INC | |
| | Past ISI variance for AN/TRC-170. | | | |
| VARBIS | /ANSWER/ | R*4 | ANSWER.INC | |
| | Future ISI variance for AN/TRC-170. | | | |
| VARISI | /ANSWER/ | R*4 | ANSWER.INC | |
| | Total ISI variance for AN/TRC-170. | | | |
| VEIGV(20) | /ANSWER/ | R*8 | ANSWER.INC | |
| | Implicit diversity eigenvalues for AN/TRC-170. | | | |
| X2INCR | /NUMPAR/ | R*4 | NUMPAR.INC | |
| | Step increment for numerical integration. | | | |
| XAVAR | /ANSWER/ | R*4 | ANSWER.INC | |
| | Standard deviation of past ISI for AN/TRC-170. | | | |
| XBVAR | /ANSWER/ | R*4 | ANSWER.INC | |
| | Standard deviation of future ISI for AN/TRC-170. | | | |
| XINCR | /NUMPAR/ | R*4 | NUMPAR.INC | |
| | Step increment for numerical integration. | | | |

## 10.15 TRCIN

Subprogram name: Subroutine TRCIN

Purpose: To define parameters for calculation of the AN/TRC-170 or DAR modem troposcatter performance for the data rate and bandwidth specified by the user.

Calling sequence:

```
CALL TRCIN (TRCTYP,BW,IBW,TAU22,DRATE,ASNR1,DSTSNR,NERT, BOUT,FOUT)
```

Contained in module: TRC

Called by: TROPO

Calls: ERROR SASEQ TRC

Input arguments:

| | | |
|---|---|---|
| TRCTYP | R*4 | TRC-170 modem type indicator:<br>0 = 1 frequency DAR modem<br>1 = 2 frequency AN/TRC-170 modem |
| BW | R*4 | Bandwidth in Hz. |
| IBW | I*2 | Switch indicating which type of RF bandwidth constraint to be used on desired signal.<br>0 = No RF filtering<br>1 = Filter determined from 99% bandwidth constraint<br>2 = Filter chosen to meet FCC Mask. (FCC-19311)<br>3 = Filters are user specified. |
| TAU22 | R*8 | Delay spread on lower beam in nsec. |
| DRATE | R*4 | Data rate in bits per seconds. |
| ASNR1 | R*4 | Median and/or yearly average value of troposcatter signal SNR in dB. |
| DSTSNR | R*4 | Standard deviation of troposcatter signal long-term SNR distribution in dB. |
| NERT | I*2 | Bit error rate threshold indicator for yearly outage probability calculations.<br>0 = All three thresholds<br>1 = For 10**(-3) only<br>2 = For 10**(-4) only<br>3 = For 10**(-5) only |

Output arguments:

| | | |
|---|---|---|
| BOUT(3,4) | R*4 | Yearly average outage probability for each bit error rate threshold specified and 2S/2F and 2S diversity configurations. |
| FOUT(3,4) | R*4 | Yearly average fade outage per call minute for each bit error rate threshold specified and 2S/2F and 2S diversity configurations. |

Global variables input from common:

```
     KGAIN           /RZ/            I*2     RZ.INC
                     Integer ratio of bandwidth to data rate.
     LOUT            /LUNS/          I*2     LUNS.INC
                     FOR002.DAT output unit number.
     NTHR            /SYSPAR/        I*2     SYSPAR.INC
                     Pointer to bit error rate threshold for AN/TRC-170
                     outage probability calculation.
```

Global variables output to common:

```
     ASNR            /SYSPAR/        R*4     SYSPAR.INC
                     Yearly median value of troposcatter short-term average
                     SNR, ie, Eb/No, in dB.
     CDUR            /SYSPAR/        R*4     SYSPAR.INC
                     Duration of transmitted pulse for AN/TRC-170
                     normalized to signaling interval duration.
     ICHIP(30)       /SYSPAR/        I*2     SYSPAR.INC
                     PN sequence for spectrum spreading when the data
                     rate is much smaller than the bandwidth.
     IOPERF          /IOUT/          I*2     IOUT.INC
                     Switch for calculation of performance of AN/TRC-170.
                             0 = ABER and outage probability
                             1 = ABER (average bit error rate) only
                             2 = Outage probability only
                     Set to 0 internally.
     IOTIME          /IOUT/          I*2     IOUT.INC
                     Switch for calculation of performance of AN/TRC-170.
                             0 = Short term performance assuming various
                                 sampling times.
                             1 = Short term performance assuming Gaussian
                                 timing jitter.
                             2 = Yearly average performance assuming
                                 Gaussian timing jitter.
                     Set to 2 internally.
     IPROFL          /SYSPAR/        I*2     SYSPAR.INC
                     Parameter that indicates whether troposcatter power
                     per unit delay profile of the form X exp (-A*X) is to
                     be used (IPROFL = 0) or not.  Set to zero in TRCIN.
     IPULS           /SYSPAR/        I*2     SYSPAR.INC
                     Switch to indicate whether pulse shape at input of the
                     AN/TRC-170 detector includes the effects of RF filters
                     (IPULS = 2) or not (IPULS = 0 or 1).  Set to 2
                     internally.  If IBW is 0, set to 1.
     ISN             /IOUT/          I*2     IOUT.INC
                     Number of SNR values for which short-term performance
                     of AN/TRC-170 is to be performed.  Set to 17.
     NCHIP           /SYSPAR/        I*2     SYSPAR.INC
                     Number of chips in PN sequence used to expand
                     bandwidth in AN/TRC-170.
```

| | | | | |
|---|---|---|---|---|
| NDIVS | /SYSPAR/ | I*2 | SYSPAR.INC | |
| | Number of explicit diversity channels for AN/TRC-170. Equal to 4 for 2S/2F and 2 for 2S or 2F. | | | |
| NTH1 | /IOUT/ | I*2 | IOUT.INC | |
| | Pointer to largest bit error rate threshold of interest for AN/TRC-170 outage probability calculation. | | | |
| NTH2 | /IOUT/ | I*2 | IOUT.INC | |
| | Pointer to smallest bit error rate threshold of interest for AN/TRC-170 outage probability calculation. | | | |
| PEAKAV | /RZ4/ | R*4 | RZ4.INC | |
| | Peak-to-average loss due to RF filtering in dB. | | | |
| SIGMA | /SYSPAR/ | R*4 | SYSPAR.INC | |
| | Half the RMS lower beam delay spread normalized relative to the symbol duration. | | | |
| SNDB(2) | /IOUT/ | R*4 | IOUT.INC | |
| | Signal to noise ratio in dB. | | | |
| SNR | /SYSPAR/ | R*4 | SYSPAR.INC | |
| | Signal to noise ratio. | | | |
| STSNR1 | /SYSPAR/ | R*4 | SYSPAR.INC | |
| | Standard deviation of troposcatter signal long-term SNR distribution in dB. Same as STSNR in /SUMP/. | | | |

## 10.16 TXPULS

Subprogram name: Function TXPULS

Purpose: Calculates the impulse response of the cascade of transmitter and receiver filters at time X.

Calling sequence:
TXPULS (X)

Contained in module: TRC

Called by: EIGV, P2INT

Calls: NONE

Input arguments:

| | | |
|---|---|---|
| X | R*4 | Normalized sampling time. |

Output arguments:

| | | |
|---|---|---|
| TXPULS | R*4 | Impulse response of the cascade of transmitter and receiver filters at time X. |

Global variables input from common:

| | | | |
|---|---|---|---|
| CDUR | /SYSPAR/ | R*4 | SYSPAR.INC |
| | Duration of transmitted pulse for AN/TRC-170 normalized to signaling interval duration. | | |
| ICHIP(30) | /SYSPAR/ | I*2 | SYSPAR.INC |
| | PN sequence for spectrum spreading when the data rate is much smaller than the bandwidth. | | |
| IPULS | /SYSPAR/ | I*2 | SYSPAR.INC |
| | Switch to indicate whether pulse shape at input of the AN/TRC-170 detector includes the effects of RF filters (IPULS = 2) or not (IPULS = 0 or 1). Set to 2 internally. If IBW is 0, set to 1. | | |
| NCHIP | /SYSPAR/ | I*2 | SYSPAR.INC |
| | Number of chips in PN sequence used to expand bandwidth in AN/TRC-170. | | |
| NTR | /RZ4/ | I*2 | RZ4.INC |
| | Number of samples for calculating transmit-receive filter impulse response (TRFILT). | | |
| PDUR | /SYSPAR/ | R*4 | SYSPAR.INC |
| | Symbol pulse duration. | | |
| TRFILT(128) | /RZ4/ | R*4 | RZ4.INC |
| | Transmit-receive filter impulse response. | | |
| XTRO | /RZ4/ | R*4 | RZ4.INC |
| | Time origin for transmit-receive filter impulse response (TRFILT), ie, X is TRFILT(X+XTRO)). | | |
| XTRINC | /RZ4/ | R*4 | RZ4.INC |
| | Sample interval for calculation of transmit-receive | | |

filter impulse response (TRFILT).

## 10.17 VARW

Subprogram name: Function VARW

Purpose: Variance of the ISI due to the kth past or future symbol.

Calling sequence:
VARW (K,XINCR,X2INCR)

Contained in module: TRC

Called by: TRC

Calls: PROFIL, P2INT

Input arguments:

| | | |
|---|---|---|
| K | I*2 | ISI symbol indicator: past if positive, future if negative. |
| XINCR | R*4 | Step increment for numerical integration. |
| X2INCR | R*4 | Step increment for numerical integration. |

Output arguments:

| | | |
|---|---|---|
| VARW | R*4 | Variance of the ISI due to the kth past or future symbol. |

Global variables input from common:

| | | | |
|---|---|---|---|
| IPROFL | /SYSPAR/ | I*2 | SYSPAR.INC |
| | Parameter that indicates whether troposcatter power per unit delay profile of the form X exp (-A*X) is to be used (IPROFL = 0) or not. Set to zero in TRCIN. | | |
| NDIVS | /SYSPAR/ | I*2 | SYSPAR.INC |
| | Number of explicit diversity channels for AN/TRC-170. Equal to 4 for 2S/2F and 2 for 2S or 2F. | | |
| SIGMA | /SYSPAR/ | R*4 | SYSPAR.INC |
| | Half the RMS lower beam delay spread normalized relative to the symbol duration. | | |
| TO | /SYSPAR/ | R*4 | SYSPAR.INC |
| | Normalized sampling time for lower beam. | | |

# CHAPTER 11

## FINAL OUTPUT

This section describes the summary page output routines:

| Name | Description | User's Manual section |
|---|---|---|
| SIM | Simulator tap gains . . . . . . . | 2.5.7 |
| SUMPAG | Summary page output . . . . . . . | 3.4.2 |

The main routine for this section is SUMPAG. SUMPAG writes to the file SUMPAG.OUT on unit LSUM. A complete description of this file can be found in section 3.4.2 of the User's Manual.

NOTE

In most cases the sections in the User's Manual describe the coded equations as well as the theory behind them. NA denotes routines that are programming utilities such as finding indices, setting pointers, etc.

## 11.1 SIM

Subprogram name: Subroutine SIM

Purpose: Calculates troposcatter path simulator tap gains in dB, normalized so MAX TAP = 0 dB.

Calling sequence:
CALL SIM

Contained in module: SIM

Called by: SUMPAG

Calls: NONE

Input arguments:
NONE

Output arguments:
NONE

Global variables input from common:

```
DELPB            /PDATA/        R*4    PDATA.INC
                 Resolution of a delay cell in seconds.
DIVTYP           /MCOM2/        I*2    MCOM.INC
                 Diversity configuration indicator.  Default is 0.
                  0 = 2 receive antennas; 2S    2S/2F    2S/2A 2S/2A/2F
                  1 = 1 receive antenna;  2A    2F       2F/2A
                  2 = 2 transmit,
                      2 receive antennas; 2S/2P 2S/2P/2A
                  3 = Not used
                  4 = User supplied parameters
                 S = Space  F = Frequency  A = Angle  P = Polarization
I1CORR(NCORMX)   /PDATA/        I*2    PDATA.INC
                 Array of receiving beams involved in the correlation
                 calculations.
I2CORR(NCORMX)   /PDATA/        I*2    PDATA.INC
                 Array of receiving beams involved in the correlation
                 calculations.
IPROF(NCORMX)    /PDATA/        I*2    PDATA.INC
                 0 if the Ith correlation not wanted, 1 if wanted.
LOUT             /LUNS/         I*2    LUNS.INC
                 FOR002.DAT output unit number.
MLAST            /PDATA/        I*2    PDATA.INC
                 Number of simulator taps.  Default is 16.
NCORMX           Parameter      I*2    TROPAR.INC
                 Maximum number of correlations between receive ports.
NCORR            /PDATA/        I*2    PDATA.INC
                 Number of receive port correlations.
```

```
NDELMX            Parameter       I*2     TROPAR.INC
                  Maximum number of delay bins in troposcatter power per
                  unit delay profiles.
Q(NDELMX,NCORMX) /PDATA/          R*4     PDATA.INC
                  Matrix of troposcatter signal power and correlation
                  per unit delay profiles.
                  For DIVTYP = 0:
                     Q(.,1)  Power on lower beam vs. delay.
                     Q(.,2)  Correlation between lower and
                             upper beam vs. delay.
                     Q(.,3)  Correlation between lower beams
                             in antennas 1 & 2 vs. delay.
                     Q(.,4)  Power on upper beam vs. delay.
                     Q(.,7)  Power on diffraction path vs. delay
                  For DIVTYP = 1:
                     Q(.,1)  Power on lower beam vs. delay.
                     Q(.,2)  Correlation between lower and
                             upper beam vs. delay.
                     Q(.,3)  Power on upper beam vs. delay
                     Q(.,7)  Power on diffraction path vs. delay.
                  For DIVTYP = 2:
                     Q(.,1)  Power on path 1 (lower beam) vs. delay.
                     Q(.,2)  Correlation between convergent paths
                             (lower beam) vs. delay.
                     Q(.,3)  Correlation between divergent paths
                             (lower beam) vs. delay.
                     Q(.,4)  Correlation between parallel paths
                             (lower beam) vs. delay.
                     Q(.,5)  Correlation between crossing paths
                             (lower beam) vs. delay.
                     Q(.,6)  Power on path of upper beam vs. delay.
                     Q(.,7)  Power on diffraction path vs. delay.
SPE               /PDATA/         R*4     PDATA.INC
                  Tap spacing in nanoseconds.  Default is 67 nsec.
```

## 11.2 SUMPAG

Subprogram name: Subroutine SUMPAG

Purpose: Outputs the summary file SUMPAG.OUT.

Description: The data on the first page is the principal link data. A second page is printed for modem information, if one was specified. The third page contains additional information relating to the common volume integration.

Subsequent pages list the delay power impulse response or cross-power (correlation) versus delay. One page is printed for each delay profile requested in the input data (IBR). The units are those specified by LUNITS.

Calling sequence:
CALL SUMPAG (PTYPE, BOUT, FOUT, JPOW, CLIMAT)

Contained in module: SUMPAG

Called by: TROPO

Calls: ANTPTR, ERROR, SIM, UNITCV

Input arguments:

| | | |
|---|---|---|
| PTYPE | I*2 | Variable which indicates whether propagation mechanism is pure troposcatter (0 or 10) or mixed troposcatter-diffraction (1 or 11). |
| BOUT(3,4) | R*4 | Yearly average fade outage probability for each bit error rate threshold specified and 2S/2F and 2S diversity configurations. |
| FOUT(3,4) | R*4 | Yearly average fade outage probability per call minute for each bit error rate threshold specified and 2S/2F and 2S diversity configurations. |
| JPOW | R*8 | Interference signal power density in dBm/Hz. |
| CLIMAT | R*4 | Climate zone indicator. |

Output arguments:

Global variables input from common:

| | | | |
|---|---|---|---|
| AA | /PROPAR/ | R*4 | TROCOM.INC |
| | Atmospheric absorption loss in dB. | | |
| ALFA0 | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum transmit antenna elevation angle measured from transmitter-to-receiver line to transmit horizon line in radians. | | |
| AR(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of receiver antenna diameters in meters. AR(1) | | |

| | | | |
|---|---|---|---|
| | is equivalent to RDIAM in the input file. | | |
| AT(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Array of transmitter antenna diameters in meters. AT(1) is equivalent to TDIAM in the input file. | | |
| BER(3) | /ERAD/ | R*4 | ERAD.INC |
| | Bit error rate thresholds of interest. Set to 1E-3, 1E-4 and 1E-5 in data statement. | | |
| BETA0 | /PATHGE/ | R*4 | TROCOM.INC |
| | Minimum receive antenna elevation angle measured from receiver-to-transmitter line to receiver horizon line in radians. | | |
| BW | /SYSTRN/ | R*4 | TROCOM.INC |
| | Bandwidth in Hertz. Default is 7 MHz. | | |
| C | /PDATA/ | R*4 | PDATA.INC |
| | Proportionality constant in troposcatter path loss calculation. | | |
| D | /PATHGE/ | R*4 | TROCOM.INC |
| | Great circle distance between transmitter and receiver measured at sea level in meters. | | |
| DE | /SUMP/ | R*4 | CURVE.INC |
| | Effective distance for troposcatter path in kilometers. | | |
| DEL | /SUMP/ | R*4 | CURVE.INC |
| | Diffraction path delay relative to a straight line path in seconds. | | |
| DELPB | /PDATA/ | R*4 | PDATA.INC |
| | Resolution of a delay cell in seconds. | | |
| DIFLOS(3) | /SUMP/ | R*4 | CURVE.INC |
| | Median diffraction path loss in dB for each value in ERFAC distribution. | | |
| DIFRSL(3) | /SUMP/ | R*4 | CURVE.INC |
| | Median diffraction signal RSL in dBm for each value in ERFAC distribution. | | |
| DIVTYP | /MCOM2/ | I*2 | MCOM.INC |
| | Diversity configuration indicator. Default is 0.<br>0 = 2 receive antennas; 2S 2S/2F 2S/2A 2S/2A/2F<br>1 = 1 receive antenna; 2A 2F 2F/2A<br>2 = 2 transmit,<br>2 receive antennas; 2S/2P 2S/2P/2A<br>3 = Not used<br>4 = User supplied parameters<br>S = Space F = Frequency A = Angle P = Polarization | | |
| DLR | /PATHGE/ | R*4 | TROCOM.INC |
| | Distance from receiver to radio horizon in meters. | | |
| DLT | /PATHGE/ | R*4 | TROCOM.INC |
| | Distance from transmitter to radio horizon in meters. | | |
| DSTSNR | /SUMP/ | R*4 | CURVE.INC |
| | Standard deviation of diffracted signal long-term SNR distribution in dB. | | |
| ERFAC | /PROPAR/ | R*4 | TROCOM.INC |

```
LOOPS .FTN contains the following subprograms:
   LOOPS , Subroutine

LTCORR.FTN contains the following subprograms:
   LTCORR, Subroutine

MATCO .FTN contains the following subprograms:
   MATCO , Subroutine

MATOPS.FTN contains the following subprograms:
   CHANGE, Subroutine
   MATA  , Subroutine
   SQTMAT, Subroutine

MDIF  .FTN contains the following subprograms:
   TANGL , Subroutine
   DIF1  , Subroutine
   MDIF  , Subroutine

MDTS  .FTN contains the following subprograms:
   MDTS  , Subroutine

MINV  .FTN contains the following subprograms:
   MINV  , Subroutine

ORDER .FTN contains the following subprograms:
   ORDER , Subroutine

OUTDAT.FTN contains the following subprograms:
   OUTDAT, Subroutine

POWER .FTN contains the following subprograms:
   POWER , Subroutine

PROUT .FTN contains the following subprograms:
   PROUT , Subroutine

RGAIN .FTN contains the following subprograms:
   RGAIN , Function

RIPROF.FTN contains the following subprograms:
   RIPROF, Subroutine

SASEQ .FTN contains the following subprograms:
   SASEQ , Subroutine

SIGIN .FTN contains the following subprograms:
   SIGIN , Subroutine
```

```
   VARPOL, Function

DELO  .FTN contains the following subprograms:
   DELO  , Subroutine

DIFSNR.FTN contains the following subprograms:
   DIFSNR, Subroutine

DINT  .FTN contains the following subprograms:
   CAKL  , Subroutine
   DINT  , Subroutine
   CAC   , Function

EIGEN .FTN contains the following subprograms:
   EIGEN , Subroutine

ELMES .FTN contains the following subprograms:
   ELMES , Subroutine
   HQR   , Subroutine

ERFC  .FTN contains the following subprograms:
   ERFC  , Function

ERLANG.FTN contains the following subprograms:
   ERLANG, Function

ERRIO .FTN contains the following subprograms:
   ERRIO , Subroutine

ERROR .FTN contains the following subprograms:
   ERROR , Subroutine

FRQSEP.FTN contains the following subprograms:
   FRQSEP, Subroutine

GPATT .FTN contains the following subprograms:
   GPATT , Subroutine

HORANG.FTN contains the following subprograms:
   HORANG, Subroutine

INDATA.FTN contains the following subprograms:
   INDATA, Subroutine
   SECTOR, Subroutine

INTLIM.FTN contains the following subprograms:
   INTLIM, Subroutine

JAMCOM.FTN contains the following subprograms:
   JAMCOM, Subroutine
```

PDFCON, Subroutine

BOTAC .FTN contains the following subprograms:
BOTAC , Subroutine
TPSPEC, Function
TPSPJ , Function
PWRSPC, Function
RJCFCN, Function
TSINC , Function

BUTFIL.FTN contains the following subprograms:
BUTFIL, Subroutine
A50FCC, Function
BWJAM , Subroutine
ENRGF , Subroutine
FCCMSK, Subroutine
FFT , Subroutine
FUNBW , Function
FUNJAM, Function
INTERB, Subroutine
PEAK , Subroutine
PSPEC , Function
PSPEC1, Function
PSPEC2, Function
PSPJ , Function
RTMI , Subroutine
SAMPLE, Subroutine
SEARCH, Subroutine
SPEC , Function
SPEC1 , Function
SPEC2 , Function

CAJI .FTN contains the following subprograms:
CAJI , Subroutine

CHKDAT.FTN contains the following subprograms:
CHKDAT, Subroutine

CLIME .FTN contains the following subprograms:
CLIME , Subroutine
CLIFIT, Subroutine
YINT , Subroutine
DEIND , Subroutine

CLIMIL.FTN contains the following subprograms:
CLIMIL, Subroutine
VDECAL, Subroutine

CLIMIX.FTN contains the following subprograms:
CLIMIX, Subroutine

| | | |
|---|---|---|
| TGAIN , | Function | TGAIN .FTN |
| TIMAVG, | Subroutine | TRC .FTN |
| TIMEQL, | Subroutine | TRC .FTN |
| TIMPAR, | Function | TRC .FTN |
| TPSPEC, | Function | BOTAC .FTN |
| TPSPJ , | Function | BOTAC .FTN |
| TRANSF, | Subroutine | TRANSF.FTN |
| TRC , | Subroutine | TRC .FTN |
| TRCIN , | Subroutine | TRC .FTN |
| TRLOSS, | Subroutine | TRLOSS.FTN |
| TROPO , | Main program | TROPO .FTN |
| TSINC , | Function | BOTAC .FTN |
| TXPULS, | Function | TRC .FTN |
| UNITCV, | Subroutine | UNITCV.FTN |
| UNITS , | Subroutine | UNITS .FTN |
| VARPDL, | Function | CLIMIX.FTN |
| VARW , | Function | TRC .FTN |
| VDECAL, | Subroutine | CLIMIL.FTN |
| XNOR , | Function | XNOR .FTN |
| YINT , | Subroutine | CLIME .FTN |

## A.2 Module / Subprogram Reference Index

ANTGEO.FTN contains the following subprograms:
ANTGEO, Subroutine

ANTPAR.FTN contains the following subprograms:
ANTPAR, Subroutine

ANTPTR.FTN contains the following subprograms:
ANTPTR, Subroutine

ATMOS .FTN contains the following subprograms:
ATMOS , Subroutine

AVAIL .FTN contains the following subprograms:
AVAIL , Subroutine
CONVOL, Subroutine
INTERP, Subroutine

AVTER .FTN contains the following subprograms:
AVTER , Subroutine

BEAMPT.FTN contains the following subprograms:
BEAMPT, Subroutine

BERCAL.FTN contains the following subprograms:
BERCAL, Subroutine

### A.1 Subprogram / Module Reference Index

| | | |
|---|---|---|
| A50FCC, | Function | BUTFIL.FTN |
| ANTGEO, | Subroutine | ANTGEO.FTN |
| ANTPAR, | Subroutine | ANTPAR.FTN |
| ANTPTR, | Subroutine | ANTPTR.FTN |
| ATMOS , | Subroutine | ATMOS .FTN |
| AVAIL , | Subroutine | AVAIL .FTN |
| AVG , | Subroutine | TRC .FTN |
| AVTER , | Subroutine | AVTER .FTN |
| BEAMPT, | Subroutine | BEAMPT.FTN |
| BERCAL, | Subroutine | BERCAL.FTN |
| BOTAC , | Subroutine | BOTAC .FTN |
| BUTFIL, | Subroutine | BUTFIL.FTN |
| BWJAM , | Subroutine | BUTFIL.FTN |
| CAC , | Function | DINT .FTN |
| CAJI , | Subroutine | CAJI .FTN |
| CAKL , | Subroutine | DINT .FTN |
| CHANGE, | Subroutine | MATOPS.FTN |
| CHKDAT, | Subroutine | CHKDAT.FTN |
| CLIFIT, | Subroutine | CLIME .FTN |
| CLIME , | Subroutine | CLIME .FTN |
| CLIMIL, | Subroutine | CLIMIL.FTN |
| CLIMIX, | Subroutine | CLIMIX.FTN |
| CONVOL, | Subroutine | AVAIL .FTN |
| DEIND , | Subroutine | CLIME .FTN |
| DELO , | Subroutine | DELO .FTN |
| DIF1 , | Subroutine | MDIF .FTN |
| DIFSNR, | Subroutine | DIFSNR.FTN |
| DINT , | Subroutine | DINT .FTN |
| EIGEN , | Subroutine | EIGEN .FTN |
| EIGV , | Subroutine | TRC .FTN |
| ELMES , | Subroutine | ELMES .FTN |
| ENRGF , | Subroutine | BUTFIL.FTN |
| ERFC , | Function | ERFC .FTN |
| ERLANG, | Function | ERLANG.FTN |
| ERRIO , | Subroutine | ERRIO .FTN |
| ERROR , | Subroutine | ERROR .FTN |
| FCCMSK, | Subroutine | BUTFIL.FTN |
| FFT , | Subroutine | BUTFIL.FTN |
| FRQSEP, | Subroutine | FRQSEP.FTN |
| FUNBW , | Function | BUTFIL.FTN |
| FUNJAM, | Function | BUTFIL.FTN |
| GPATT , | Subroutine | GPATT .FTN |
| HORANG, | Subroutine | HORANG.FTN |
| HQR , | Subroutine | ELMES .FTN |
| INDATA, | Subroutine | INDATA.FTN |
| INTERB, | Subroutine | BUTFIL.FTN |
| INTERD, | Subroutine | TRC .FTN |
| INTERP, | Subroutine | AVAIL .FTN |

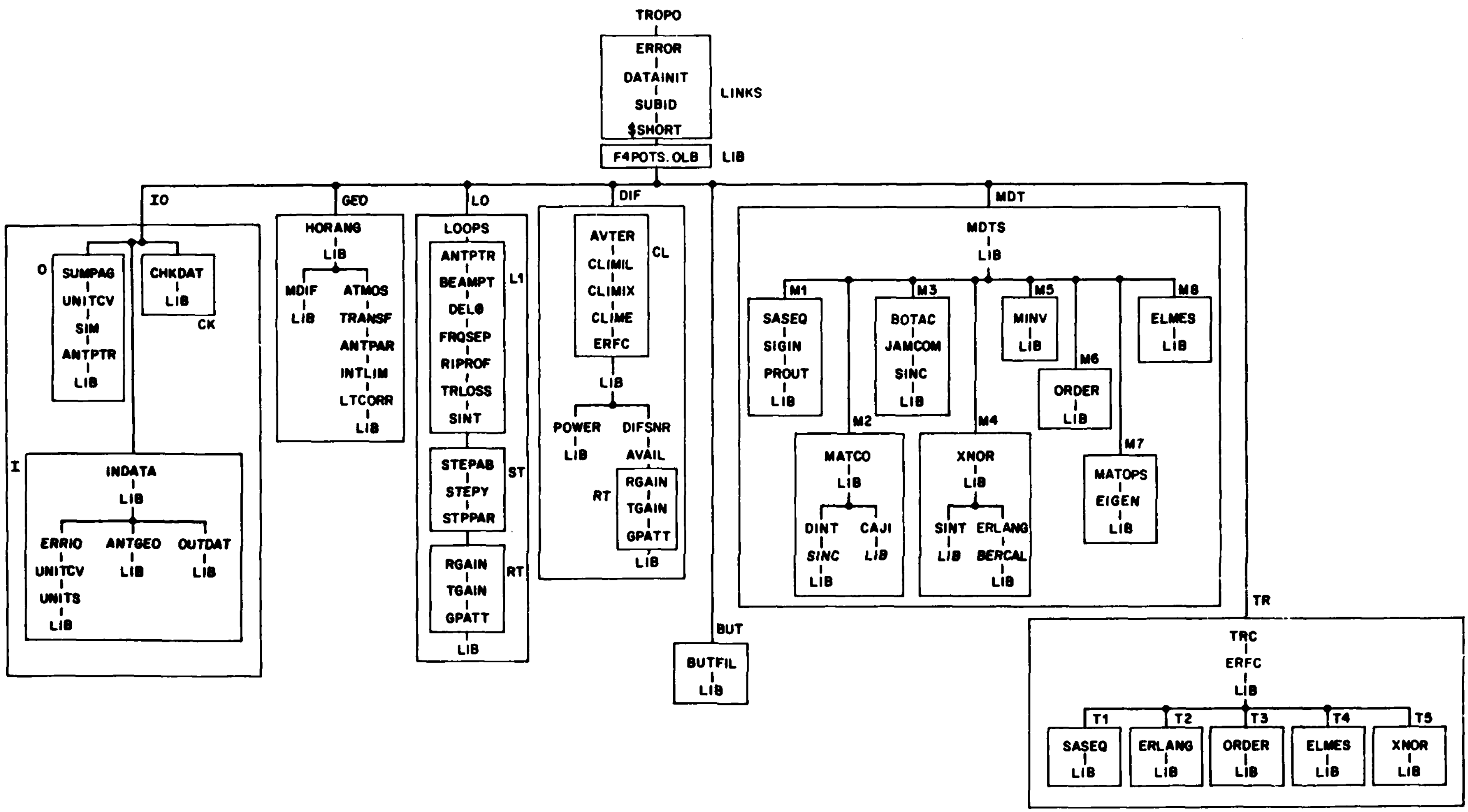


Figure A-1 Diagram of Overlay for PDP-11 Version of TROPO

# APPENDIX A

## PDP RELATED INFORMATION

The following information is only for those who are using the PDP version of TROPO (as opposed to the IBM version). If you are not sure which version you have, see the introduction to this document which describes the differences.

Figure A-1 is a chart of the overlay. The names refer to modules (source file names) rather than subprogram names. (The table in section A.3 lists the subprograms in each module.) TROPO is written in F4P Fortran so it must access the F4POTS module (Fortran library routines). The default library is whatever current version of Fortran is installed on your system. In order to insure that all modules are accessing F4P library functions and not F77 or other version functions, LIB is placed explicitly throughout the overlay. It is not sufficient to have it just in the root. It must be at the end of each branch.

This appendix will also aid in finding a particular subprogram or common. Since the PDP version is divided into modules or source files, finding a particular subprogram that is included in a module of a different name can be difficult. The following three tables will help:

1) The Subprogram / Module Reference Index
   This lists each subroutine or function alphabetically by name followed by the module it is in.
2) The Module / Subprogram Reference Index
   This lists each module and the subprograms it contains.
3) The Common / Include File Reference Index
   This lists each common followed by the include file it is in.

| | | | | |
|---|---|---|---|---|
| UDIST | /UNIT/ | R*4 | IODATA.INC | |
| | Units of distance (smi, nmi, km). | | | |
| UFREQ | /UNIT/ | R*4 | IODATA.INC | |
| | Units of frequency (GHz, MHz). | | | |
| UHITE | /UNIT/ | R*4 | IODATA.INC | |
| | Units of height and diameter (ft, m). | | | |
| URH(NR) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of receive antennas horizontal offsets from great circle plane in meters. | | | |
| URL(NR) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of receive antennas longitudinal offsets in meters. | | | |
| URV(NR) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of receive antennas vertical offsets in meters. | | | |
| UTH(NT) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of transmit antennas horizontal offsets in meters. | | | |
| UTL(NT) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of transmit antennas longitudinal offsets in meters. | | | |
| UTV(NT) | /PATHGE/ | R*4 | TROCOM.INC | |
| | Array of transmit antennas vertical offsets in meters. | | | |
| WLT | /SYSTRN/ | R*4 | TROCOM.INC | |
| | Rated transmission power in Watts. Default is 1000 W. | | | |

Global variables output to common:

| | | | |
|---|---|---|---|
| IOPEND | /CONTRL/ | I*2 | TROCOM.INC |
| | Number of output files opened. | | |

```
                              paths.
                     QCORR(4) Correlation coefficient between parallel
                              paths.
                     QCORR(5) Correlation coefficient between crossing
                              paths.
                     QCORR(6) Power on upper beam.
RLL             /SYSTRN/        R*4     TROCOM.INC
                Receiver line losses in dB.  Default is 0 dB.
S               /PATHGE/        R*4     TROCOM.INC
                Troposcatter path asymmetry parameter.
SCPARM          /PROPAR/        R*4     TROCOM.INC
                Wavenumber spectrum slope parameter M.  Default is
                3.66.
SPREAD(NCORMX)  /PDATA/         R*4     PDATA.INC
                Array of delay spreads (2-sigma) for each beam in
                seconds.
STSNR           /SUMP/          R*4     SUMP.INC
                Standard deviation of troposcatter signal long-term
                SNR distribution in dB.
SUPRES          /IODATA/        L*4     IODATA.INC
                Supress long output in SUMPAG if true.
                Set to TRUE if PTYPE > 9.
TAPOUT          /PDATA/         L*4     PDATA.INC
                If true, the simulator tap values are output to the
                output file, FOR002.DAT.  Default is TRUE.
TEMPA(NCORMX)   /PDATA/         R*4     PDATA.INC
                Array of average troposcatter signal delays for each
                beam relative to straight line in seconds.
THER            /PATHGE/        R*4     TROCOM.INC
                Radio horizon elevation angle at receive site in
                radians.
THET            /PATHGE/        R*4     TROCOM.INC
                Radio horizon elevation angle at transmit site in
                radians.
THETAO          /PATHGE/        R*4     TROCOM.INC
                Scattering angle at bottom of common volume in
                radians.
TLL             /SYSTRN/        R*4     TROCOM.INC
                Transmitter line losses in dB.  Default is 0 dB.
TODAY(9)        /TSTAMP/        L*1     IODATA.INC
                Array used in PDP-11 version to hold date as
                characters.
TROLOS(3)       /SUMP/          R*4     CURVE.INC
                Median troposcatter path loss in dB for each value in
                ERFAC distribution.
TRORSL(3)       /SUMP/          R*4     CURVE.INC
                Median troposcatter RSL in dBm for each value in ERFAC
                distribution.
UANGLE          /UNIT/          R*4     IODATA.INC
                Units of angle (deg, mrad).
```

```
                   is the main transmit antenna.
Q(NDELMX,NCORMX) /PDATA/        R*4     PDATA.INC
                   Matrix of troposcatter signal power and correlation
                   per unit delay profiles.
                   For DIVTYP = 0:
                      Q(.,1)  Power on lower beam vs. delay.
                      Q(.,2)  Correlation between lower and
                              upper beam vs. delay.
                      Q(.,3)  Correlation between lower beams
                              in antennas 1 & 2 vs. delay.
                      Q(.,4)  Power on upper beam vs. delay.
                      Q(.,7)  Power on diffraction path vs. delay
                   For DIVTYP = 1:
                      Q(.,1)  Power on lower beam vs. delay.
                      Q(.,2)  Correlation between lower and
                              upper beam vs. delay.
                      Q(.,3)  Power on upper beam vs. delay
                      Q(.,7)  Power on diffraction path vs. delay.
                   For DIVTYP = 2:
                      Q(.,1)  Power on path 1 (lower beam) vs. delay.
                      Q(.,2)  Correlation between convergent paths
                              (lower beam) vs. delay.
                      Q(.,3)  Correlation between divergent paths
                              (lower beam) vs. delay.
                      Q(.,4)  Correlation between parallel paths
                              (lower beam) vs. delay.
                      Q(.,5)  Correlation between crossing paths
                              (lower beam) vs. delay.
                      Q(.,6)  Power on path of upper beam vs. delay.
                      Q(.,7)  Power on diffraction path vs. delay.
QCORR(NCORMX)      /PDATA/        R*4     PDATA.INC
                   Contains elements of covariance matrix, ie, powers and
                   correlations.
                   For DIVTYP = 0:
                      QCORR(1) Power on lower beam
                      QCORR(2) Correlation coefficient between lower
                               and upper beam.
                      QCORR(3) Correlation coefficient between lower
                               beams of antennas 1 and 2
                      QCORR(4) Power on upper beam.
                   For DIVTYP = 1:
                      QCORR(1) Power on lower beam
                      QCORR(2) Correlation coefficient between lower
                               and upper beam.
                      QCORR(3) Power on upper beam.
                   For DIVTYP = 2:
                      QCORR(1) Power on path 1 (lower beam)
                      QCORR(2) Correlation coefficient between convergent
                               paths.
                      QCORR(3) Correlation coefficient between divergent
```

```
                         Propagation/modem flag to select calculation mode.
                         Default is 1.
                                 0 = Propagation only
                                 1 = Propagation + MD-918 modem
                                 2 = Propagation + AN/TRC-170 or DAR modem
                                 3 = Propagation + user-defined modem
MODSIG                   /MCOM2/          I*2     MCOM.INC
                         Interference signal modulation format.  Default is 1.
                                 0 = Analog FDM / FM
                                 1 = Digital QPSK
NACCU                    /CONTRL/         I*2     TROCOM.INC
                         Parameter used as truncation point for common
                         volume integration termination.  Default is 40.
NCORR                    /PDATA/          I*2     PDATA.INC
                         Number of receive port correlations.
NDELMX                   Parameter        I*2     TROPAR.INC
                         Maximum number of delay bins in troposcatter power per
                         unit delay profiles.
NERT                     /MCOM2/          I*2     MCOM.INC
                         Bit error rate threshold indicator for yearly fade
                         outage probability calculation.  Default is 2.
                                 0 = All three thresholds
                                 1 = For 10**(-3) only
                                 2 = For 10**(-4) only
                                 3 = For 10**(-5) only
NEWCL(4)                 /MCOM2/          I*2     MCOM.INC
                         New climate type character string.
NOW(8)                   /TSTAMP/         L*1     IODATA.INC
                         Array used in PDP-11/70 version to hold time of day as
                         characters.
NR                       /SYSTRN/         I*2     TROCOM.INC
                         Number of receive ports.
NT                       /SYSTRN/         I*2     TROCOM.INC
                         Number of transmit ports.
PLOSSM                   /PDATA/          R*4     PDATA.INC
                         Troposcatter path loss from approximate analytic
                         expression.
PSIRAO(NRMX)             /ANTENN/         R*4     TROCOM.INC
                         Array of receiver beam azimuths in radians.
PSIREO(NRMX)             /ANTENN/         R*4     TROCOM.INC
                         Array of receiver beam boresight elevations above
                         radio horizon in radians, ie, angle at which each
                         antenna is aimed relative to the horizon.  PSIREO(1)
                         is the main receive antenna.
PSITAO(NTMX)             /ANTENN/         R*4     TROCOM.INC
                         Array of transmitter beam azimuths in radians.
PSITEO(NTMX)             /ANTENN/         R*4     TROCOM.INC
                         Array of transmitter beam boresight elevations above
                         radio horizon in radians, ie, angle at which each
                         antenna is aimed relative to the horizon.  PSITEO(1)
```

| | | | | |
|---|---|---|---|---|
| | troposcatter integration. It is an error if INEG > 0. | | | |
| IPOLR(NRMX) | /ANTENN/ | I*2 | TROCOM.INC | |
| | Array of receiver antenna polarizations. | | | |
| IPOLT(NTMX) | /ANTENN/ | I*2 | TROCOM.INC | |
| | Array of transmitter antenna polarizations. | | | |
| IPOS | /PDATA/ | I*2 | PDATA.INC | |
| | Number of delay cells exceeding the last allocated array element. This number should be zero or small. IPOS > 0 is not a serious error unless the delay profile calculated has a clear peak in the last delay cell. | | | |
| IPROF(NCORMX) | /PDATA/ | I*2 | PDATA.INC | |
| | 0 if the Ith correlation not wanted, 1 if wanted. | | | |
| ITER | /PDATA/ | I*4 | PDATA.INC | |
| | Number of integration cells in the common volume integration. | | | |
| LINKNO | /IODATA/ | I*2 | IODATA.INC | |
| | Link number. | | | |
| LNAME(20) | /IODATA/ | I*2 | IODATA.INC | |
| | Link name. Transmitter site first, receiver site second. Used as link identifier on output files FOR002.DAT and SUMPAG.OUT. | | | |
| LSUM | /LUNS/ | I*2 | LUNS.INC | |
| | SUMPAG.OUT output unit number. | | | |
| LUNITS | /UNIT/ | I*2 | IODATA.INC | |
| | Integer value that specifies the set of units requested by the user. These units are for path, antenna location, angle, and frequency parameters. Default is 8. The given units are defined by bit values of LUNITS: | | | |

| Bit no. | Meaning of value 0 / 1 |
|---|---|
| 0 | english / metric |
| 1 | statute miles / nautical miles |
| 2 | feet / meters |
| 3 | mrad / degrees |
| 4 | GHz / MHz |

Valid LUNITS values are

| | | | | |
|---|---|---|---|---|
| 0 : | stat. miles | - feet | - milliradians | - GHz |
| 1 : | kilometers | - meters | - milliradians | - GHz |
| 2 : | naut. miles | - feet | - milliradians | - GHz |
| 8 : | stat. miles | - feet | - degrees | - GHz |
| 9 : | kilometers | - meters | - degrees | - GHz |
| 10: | naut.miles | - feet | - degrees | - GHZ |
| 16: | stat. miles | - feet | - milliradians | - MHz |
| 17: | kilometers | - meters | - milliradians | - MHz |
| 18: | naut. miles | - feet | - milliradians | - MHz |
| 24: | stat. miles | - feet | - degrees | - MHz |
| 25: | kilometers | - meters | - degrees | - MHz |
| 26: | naut. miles | - feet | - degrees | - MHz |

| | | | |
|---|---|---|---|
| MODPAT | /MCOM2/ | I*2 | MCOM.INC |

| | | | |
|---|---|---|---|
| | Yearly median value of effective earth radius factor k in kilometers. Default is 1.33. | | |
| ERR | /CONTROL/ | R*4 | TROCOM.INC |
| | Common volume integration resolution. Default is .001. | | |
| F | /SYSTRN/ | R*4 | TROCOM.INC |
| | Operating frequency in Hz. Model is accurate between 100MHz and 10GHz. | | |
| FSEP | /PDATA/ | R*4 | PDATA.INC |
| | Frequency separation for uncorrelated frequency diversity in Hz. | | |
| GRDB(NRMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Gain of each receive antenna in dBi. | | |
| GTDB(NTMX) | /ANTENN/ | R*4 | TROCOM.INC |
| | Gain of each transmit antenna in dBi. | | |
| HCOM | /PATHGE/ | R*4 | TROCOM.INC |
| | Effective height of the bottom of the common volume in meters. | | |
| HHIGH | /PATHGE/ | R*4 | TROCOM.INC |
| | Effective height of the top of the common volume in meters. | | |
| HLR | /PATHGE/ | R*4 | TROCOM.INC |
| | Receiver radio horizon elevation above sea level in meters. | | |
| HLT | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit radio horizon elevation above sea level in meters. | | |
| HRN | /PATHGE/ | R*4 | TROCOM.INC |
| | Receive antenna height above sea level in meters. | | |
| HTN | /PATHGE/ | R*4 | TROCOM.INC |
| | Transmit antenna height above sea level in meters. | | |
| I1CORR(NCORMX) | /PDATA/ | I*2 | PDATA.INC |
| | Array of receiving beams involved in the correlation calculations. | | |
| I2CORR(NCORMX) | /PDATA/ | I*2 | PDATA.INC |
| | Array of receiving beams involved in the correlation calculations. | | |
| IBR(NRMX,NRMX) | /SYSTRN/ | I*2 | TROCOM.INC |
| | Channel complex-envelope correlation and cross-correlation calculation indicator array.<br>0 = No calculation<br>1 = Power (correlation) calculation only<br>2 = Power (correlation) per unit delay spectrum calculation | | |
| ICLIME | /MCOM2/ | I*2 | MCOM.INC |
| | Climate class. Default is 0.<br>0 = NBS TN-101 climate<br>1 = MIL-HDBK-417 climate<br>2 = New, user-supplied climate | | |
| INEG | /PDATA/ | I*2 | PDATA.INC |
| | Number of negative delay cells encountered in | | |

```
SIM   .FTN contains the following subprograms:
   SIM   , Subroutine

SINC  .FTN contains the following subprograms:
   SINC  , Function

SINT  .FTN contains the following subprograms:
   SINT  , Subroutine
   PSINE , Function

STEPAB.FTN contains the following subprograms:
   STEPAB, Function

STEPY .FTN contains the following subprograms:
   STEPY , Function

STPPAR.FTN contains the following subprograms:
   STPPAR, Subroutine

SUBID .FTN contains the following subprograms:
   SUBID , Subroutine

SUMPAG.FTN contains the following subprograms:
   SUMPAG, Subroutine

TGAIN .FTN contains the following subprograms:
   TGAIN , Function

TRANSF.FTN contains the following subprograms:
   TRANSF, Subroutine

TRC   .FTN contains the following subprograms:
   AVG   , Subroutine
   EIGV  , Subroutine
   INTERD, Subroutine
   PAVERG, Subroutine
   PDF   , Function
   PDFCOE, Subroutine
   PDFSUM, Function
   POUTAG, Subroutine
   PROFIL, Function
   P2INT , Function
   TIMAVG, Subroutine
   TIMEQL, Subroutine
   TIMPAR, Function
   TRC   . Subroutine
   TRCIN , Subroutine
   TXPULS, Function
   VARW  , Function
```

TRLOSS.FTN contains the following subprograms:
   TRLOSS, Subroutine

TROPO .FTN contains the following subprograms:
   TROPO , Main Program

UNITCV.FTN contains the following subprograms:
   UNITCV, Subroutine

UNITS .FTN contains the following subprograms:
   UNITS , Subroutine

XNOR .FTN contains the following subprograms:
   XNOR , Function

## A.3 Common / Include File Reference Index

| | |
|---|---|
| /ANSWER/ | ANSWER.INC |
| /ANTENN/ | TROCOM.INC |
| /BUTPAR/ | BUTPAR.INC |
| /CONSTA/ | CONSTANTS.INC |
| /CONTRL/ | TROCOM.INC |
| /CPLOSS/ | CPL.INC |
| /CURVE/ | CURVE.INC |
| /ERAD/ | ERAD.INC |
| /IODATA/ | IODATA.INC |
| /IOUT/ | IOUT.INC |
| /JAMPAR/ | JAMPAR.INC |
| /LUNS/ | LUNS.INC |
| /MCOM2/ | MCOM.INC |
| /MCOM4/ | MCOM.INC |
| /NUMPAR/ | NUMPAR.INC |
| /PATHGE/ | TROCOM.INC |
| /PDATA/ | PDATA.INC |
| /PROPAR/ | TROCOM.INC |
| /RI2/ | RI2.INC |
| /RZ/ | RZ.INC |
| /RZ1/ | RZ1.INC |
| /RZ4/ | RZ4.INC |
| /STPCOM/ | STPCOM.INC |
| /SUMP/ | SUMP.INC |
| /SYSPAR/ | SYSPAR.INC |
| /SYSTRN/ | TROCOM.INC |
| /TSTAMP/ | IODATA.INC |
| /UNIT/ | IODATA.INC |

# APPENDIX B

# CALL CROSS-REFERENCE

The subprogram cross-reference shows which subprograms call the described subprogram and which subprograms it calls. A similar list appears for each subprogram in the main description of it but the following list also includes system routines such as SIN as well as statement functions. In the following list MAIN refers to the driver or main routine, TROPO.

## B.1 Call Cross-Reference Table

```
ANTGEO
 Is called by the following subprograms:
       INDATA

ANTPAR
 Is called by the following subprograms:
       TROPO
 Calls the following subprgrams:
       ALOG10  ERROR

ANTPTR
 Is called by the following subprograms:
       LOOPS   SUMPAG

ATMOS
 Is called by the following subprograms:
       TROPO
 Calls the following subprgrams:
       ERROR

AVAIL
 Is called by the following subprograms:
       DIFSNR
 Calls the following subprgrams:
       CLIME   CLIMIL  CLIMIX  CONVOL  INTERP  SQRT    SUBID
```

```
AVG
 Is called by the following subprograms:
        TRC
 Calls the following subprgrams:
        PDF     YRUTIN

AVTER
 Is called by the following subprograms:
        DIFSNR  POWER

ASOFCC
 Is called by the following subprograms:
        FCCMSK  FUNBW
 Calls the following subprgrams:
        ALOG10  PSPEC

BEAMPT
 Is called by the following subprograms:
        LOOPS

BERCAL
 Is called by the following subprograms:
        MDTS
 Calls the following subprgrams:
        ALOG10  DABS    DLOG    DLOG10  DMAX1   ERLANG  EXP     PDFCON
        SUBID   XNOR

BOTAC
 Is called by the following subprograms:
        MDTS
 Calls the following subprgrams:
        JAMCOM  RJCFCN  SUBID   TSINC

BUTFIL
 Is called by the following subprograms:
        TROPO
 Calls the following subprgrams:
        ABS     ALOG10  AMAX1   BWJAM   EXP     FUNBW   FUNJAM  F1
        F2      PEAK    PSPEC1  PSPEC2  SAMPLE  SIN     SPEC1   SPEC2
        SQRT    SUBID

BWJAM
 Is called by the following subprograms:
        BUTFIL
 Calls the following subprgrams:
        ALOG10  ENRGF   FUNBW   FUNJAM  RTMI    SEARCH

CAC
 Is called by the following subprograms:
        DINT    MATCO
```

```
 Calls the following subprgrams:
        ABS      DSQRT   SINC

CAJI
 Is called by the following subprograms:
        MATCO
 Calls the following subprgrams:
        ABS      AMAX1   IABS

CAKL
 Is called by the following subprograms:
        MATCO
 Calls the following subprgrams:
        DINT

CHANGE
 Is called by the following subprograms:
        MDTS     SQTMAT
 Calls the following subprgrams:
        ERROR

CHKDAT
 Is called by the following subprograms:
        TROPO
 Calls the following subprgrams:
        ABS      ERROR

CLIFIT
 Is called by the following subprograms:
        CLIME    CLIMIL
 Calls the following subprgrams:
        ABS      EXP      F1       F2       SUBID

CLIME
 Is called by the following subprograms:
        AVAIL    CLIMIX   POWER
 Calls the following subprgrams:
        ALOG10   CLIFIT   DEIND    ERROR    EXP      F2       SIN      YINT

CLIMIL
 Is called by the following subprograms:
        AVAIL    POWER
 Calls the following subprgrams:
        ALOG10   CLIFIT   ERROR    SIN      VDECAL

CLIMIX
 Is called by the following subprograms:
        AVAIL    POWER
 Calls the following subprgrams:
        ABS      CLIME    ERFC     ERROR    SQRT     SUBID    VARPOL
```

CONVOL
Is called by the following subprograms:
AVAIL
Calls the following subprgrams:
INTERP

DEIND
Is called by the following subprograms:
CLIME
Calls the following subprgrams:
ERROR

DELO
Is called by the following subprograms:
LOOPS
Calls the following subprgrams:
COS SIN

DIFSNR
Is called by the following subprograms:
TROPO
Calls the following subprgrams:
ABS ALOG10 AVAIL AVTER ERFC KGAIN SIGN SQRT
SUBID TGAIN

DIF1
Is called by the following subprograms:
MDIF
Calls the following subprgrams:
ABS ALOG10 ATAN COS SQRT

DINT
Is called by the following subprograms:
CAKL MDTS
Calls the following subprgrams:
CAC DFLOAT

EIGEN
Is called by the following subprograms:
MDTS SQTMAT
Calls the following subprgrams:
ABS FLOAT SQRT

EIGV
Is called by the following subprograms:
TRC
Calls the following subprgrams:
ELMES HQR ORDER PROFIL TXPULS

ELMES
 Is called by the followins subprosrams:
 EIGV MDTS
 Calls the followins subprsrams:
 DABS

ENRGF
 Is called by the followins subprosrams:
 BWJAM FUNBW FUNJAM
 Calls the followins subprsrams:
 PSPEC

ERFC
 Is called by the followins subprosrams:
 CLIMIX DIFSNR PAVERG POUTAG POWER
 Calls the followins subprsrams:
 EXP SIGN

ERLANG
 Is called by the followins subprosrams:
 BERCAL PDF PDFSUM
 Calls the followins subprsrams:
 DABS DEXP

ERRIO
 Is called by the followins subprosrams:
 INDATA SECTOR UNITS

ERROR
 Is called by the followins subprosrams:
 ANTPAR ATMOS CHANGE CHKDAT CLIME CLIMIL CLIMIX DEIND
 LOOPS MATA MDIF MDTS ORDER RIPROF SIGIN SQTMAT
 SUMPAG TRANSF TRCIN TRLOSS UNITCV VARPOL

FCCMSK
 Is called by the followins subprosrams:
 FUNBW
 Calls the followins subprsrams:
 ALOG10 A50FCC

FFT
 Is called by the followins subprosrams:
 SAMPLE
 Calls the followins subprsrams:
 CMPLX COS SIN

FRQSEP
 Is called by the followins subprosrams:
 LOOPS
 Calls the followins subprsrams:

```
        ABS     COS     SIN     SQRT

    FUNBW
     Is called by the followins subprosrams:
        BUTFIL  BWJAM
     Calls the followins subprsrams:
        A50FCC  ENRGF   FCCMSK  INTERB  PSPEC

    FUNJAM
     Is called by the followins subprosrams:
        BUTFIL  BWJAM
     Calls the followins subprsrams:
        ALOG10  ENRGF   F1      F2      PSPEC   PSPJ

    GPATT
     Is called by the followins subprosrams:
        RGAIN   TGAIN
     Calls the followins subprsrams:
        ABS     SIN

    HORANG
     Is called by the followins subprosrams:
        TANGL   TRANSF
     Calls the followins subprsrams:
        ASIN    SIN     SQRT

    HQR
     Is called by the followins subprosrams:
        EIGV    MOTS
     Calls the followins subprsrams:
        DABS    DSIGN   DSQRT

    INDATA
     Is called by the followins subprosrams:
        TROPO
     Calls the followins subprsrams:
        ALOG10  AMOD    ANTGEO  ERRIO   EXP     OUTDAT  SECTOR  TRC
        UNITCV  UNITS

    INTERB
     Is called by the followins subprosrams:
        FUNBW

    INTERD
     Is called by the followins subprosrams:
        POUTAG  TIMAVG

    INTERP
     Is called by the followins subprosrams:
        AVAIL   CONVOL
```

```
 Calls the following subprgrams:
        ESTF

INTLIM
 Is called by the following subprograms:
        TROPO
 Calls the following subprgrams:
        AMAX1   AMIN1   COS     SIN     SQRT

JAMCOM
 Is called by the following subprograms:
        BOTAC
 Calls the following subprgrams:
        ACOS    ATAN    COS     SIN     SQRT    TAN     TSINC

LOOPS
 Is called by the following subprograms:
        TROPO
 Calls the following subprgrams:
        ABS     ANTPTR  ASIN    BEAMPT  COS     DELO    ERROR   EXP
        FRQSEP  RGAIN   RIPROF  SIN     SINT    SQRT    STEPAB  STEPY
        STPPAR  TGAIN   TRLOSS

LTCORR
 Is called by the following subprograms:
        TROPO
 Calls the following subprgrams:
        EXP     SIN     SQRT

TROPO
 Calls the following subprgrams:
        ANTPAR  ATMOS   BUTFIL  CHKDAT  DATE    DIFSNR  INDATA  INTLIM
        LOOPS   LTCORR  MDIF    MDTS    POWER   SUBID   SUMPAG  TIME
        TRANSF  TRCIN

MATA
 Is called by the following subprograms:
        MDTS    SQTMAT
 Calls the following subprgrams:
        ERROR

MATCO
 Is called by the following subprograms:
        MDTS
 Calls the following subprgrams:
        CAC     CAJI    CAKL    SUBID

MDIF
 Is called by the following subprograms:
        TROPO
```

```
 Calls the following subprgrams:
        ABS     ALOG10  AMIN1   COS     DIF1    ERROR   SIN     SUBID
        TANGL

MDTS
 Is called by the following subprograms:
        TROPO
 Calls the following subprgrams:
        ACOS    AMOD    BERCAL  BOTAC   CHANGE  COS     DINT    DLOG10
        DSIN    EIGEN   ELMES   ERROR   HQR     MATA    MATCO   MINV
        ORDER   PROUT   SASEQ   SIGIN   SINT    SQTMAT  SUBID   XNOR

MINV
 Is called by the following subprograms:
        MDTS
 Calls the following subprgrams:
        DABS

ORDER
 Is called by the following subprograms:
        EIGV    MDTS
 Calls the following subprgrams:
        ERROR

OUTDAT
 Is called by the following subprograms:
        INDATA
 Calls the following subprgrams:
        DATE    SUBID   TIME

PAVERG
 Is called by the following subprograms:
        TRC
 Calls the following subprgrams:
        ERFC    EXP     SQRT

PDF
 Is called by the following subprograms:
        AVG     PDFSUM
 Calls the following subprgrams:
        ERLANG

PDFCOE
 Is called by the following subprograms:
        TRC
 Calls the following subprgrams:
        EXP

PDFCON
 Is called by the following subprograms:
```

BERCAL
Calls the following subprgrams:
DABS

PDFSUM
Is called by the following subprograms:
TRC
Calls the following subprgrams:
ERLANG PDF

PEAK
Is called by the following subprograms:
BUTFIL
Calls the following subprgrams:
ABS

POUTAG
Is called by the following subprograms:
TRC
Calls the following subprgrams:
ERFC INTERD

POWER
Is called by the following subprograms:
TROPO
Calls the following subprgrams:
ABS ALOG10 AVTER CLIME CLIMIL CLIMIX ERFC SIGN
SQRT SUBID

PROFIL
Is called by the following subprograms:
EIGV TIMPAR VARW
Calls the following subprgrams:
EXP

PROUT
Is called by the following subprograms:
MDTS
Calls the following subprgrams:
SUBID

PSINE
Is called by the following subprograms:
SINT
Calls the following subprgrams:
DSIN F1 F2

PSPEC
Is called by the following subprograms:
A50FCC ENRGF FUNBW FUNJAM PSPEC1 PSPEC2 PSPJ

Calls the followins subprsrams:
SIN

PSPEC1
Is called by the followins subprosrams:
BUTFIL
Calls the followins subprsrams:
CMPLX PSPEC

PSPEC2
Is called by the followins subprosrams:
BUTFIL
Calls the followins subprsrams:
CMPLX PSPEC PSPJ

PSPJ
Is called by the followins subprosrams:
FUNJAM PSPEC2
Calls the followins subprsrams:
EXP PSPEC SQRT

PWRSPC
Is called by the followins subprosrams:
RJCFCN
Calls the followins subprsrams:
TPSPEC TPSPJ

P2INT
Is called by the followins subprosrams:
TIMPAR VARW
Calls the followins subprsrams:
TXPULS

RGAIN
Is called by the followins subprosrams:
DIFSNR LOOPS
Calls the followins subprsrams:
GPATT

RIPROF
Is called by the followins subprosrams:
LOOPS
Calls the followins subprsrams:
ERROR

RJCFCN
Is called by the followins subprosrams:
BOTAC
Calls the followins subprsrams:
COS PWRSPC

RTMI
 Is called by the following subprograms:
 BWJAM SEARCH
 Calls the following subprgrams:
 ABS SIGN

SAMPLE
 Is called by the following subprograms:
 BUTFIL
 Calls the following subprgrams:
 FFT REAL

SASEQ
 Is called by the following subprograms:
 MDTS TRCIN
 Calls the following subprgrams:
 MOD

SEARCH
 Is called by the following subprograms:
 BWJAM
 Calls the following subprgrams:
 RTMI SIN

SECTOR
 Is called by the following subprograms:
 INDATA
 Calls the following subprgrams:
 ERRIO

SIGIN
 Is called by the following subprograms:
 MDTS
 Calls the following subprgrams:
 ERROR EXP

SIM
 Is called by the following subprograms:
 SUMFAG
 Calls the following subprgrams:
 ALOG10 IABS SQRT SUBID

SINC
 Is called by the following subprograms:
 CAC TSINC
 Calls the following subprgrams:
 ABS SIN

SINT

```
 Is called by the following subprograms:
        LOOPS   MDTS
 Calls the following subprgrams:
        IABS    PSINE   SUBID

SPEC
 Is called by the following subprograms:
        SPEC1   SPEC2
 Calls the following subprgrams:
        CMPLX   COS     SIN

SPEC1
 Is called by the following subprograms:
        BUTFIL
 Calls the following subprgrams:
        SPEC

SPEC2
 Is called by the following subprograms:
        BUTFIL
 Calls the following subprgrams:
        SPEC

SQTMAT
 Is called by the following subprograms:
        MDTS
 Calls the following subprgrams:
        CHANGE  EIGEN   ERROR   MATA    SQRT

STEPAB
 Is called by the following subprograms:
        LOOPS

STEPY
 Is called by the following subprograms:
        LOOPS
 Calls the following subprgrams:
        SQRT

STPPAR
 Is called by the following subprograms:
        LOOPS
 Calls the following subprgrams:
        ABS     AMIN1   SQRT

SUBID
 Is called by the following subprograms:
        AVAIL   BERCAL  BOTAC   BUTFIL  CLIFIT  CLIMIX  DIFSNR  TROPO
        MATCO   MDIF    MDTS    OUTDAT  POWER   PROUT   SIM     SINT
        TRC     TRCIN
```

```
                 - Used but not changed in the following subprograms:
                   INTLIM  STPPAR
256)             /RZ/            R*8     RZ.INC
                 Signal response after PN sequence correlation.
                 - Possibly given a new value in the following subprograms:
                   SINT
                 - Used but not changed in the following subprograms:
                   CAC     CAJI
256)             /RZ4/           R*4     RZ4.INC
                 Impulse response of cascade of transmitter and
                 receiver filters, and cascade of interferer and
                 receiver filters.
                 -- Not used --
256)             /RZ4/           R*4     RZ4.INC
                 Autocorrelation of receiver filter.
                 -- Not used --
MIN              /NUMPAR/        R*4     NUMPAR.INC
                 Ratio of smallest to largest eigenvalue in AN/TRC-170
                 performance calculations.
                 - Used but not changed in the following subprograms:
                   TRC
NG(10)           /MCOM4/         R*4     MCOM.INC
                 Interferer elevation angles in degrees.  Default is 0.
                 - Possibly given a new value in the following subprograms:
                   INDATA
                 - Used but not changed in the following subprograms:
                   JAMCOM  MDTS    OUTDAT
EAN              /ANSWER/        R*4     ANSWER.INC
                 Average received energy.
                 - Possibly given a new value in the following subprograms:
                   EIGV
                 - Used but not changed in the following subprograms:
                   TRC
AR               /ANSWER/        R*4     ANSWER.INC
                 Variance of received energy.
                 - Possibly given a new value in the following subprograms:
                   EIGV
                 /CONTRL/        L*4     TROCOM.INC
                 End of TROPO.DAT file found if TRUE.
                 - Possibly given a new value in the following subprograms:
                   INDATA
                 - Used but not changed in the following subprograms:
                   MAIN
AC               /PROPAR/        R*4     TROCOM.INC
                 Yearly median value of effective earth radius factor k
                 in kilometers.  Default is 1.33.
                 - Possibly given a new value in the following subprograms:
                   INDATA  MAIN
                 - Used but not changed in the following subprograms:
                   OUTDAT  POWER   SUMPAG  TRANSF
```

```
                 OUTDAT  POWER   SUMPAG  TRANSF
.T              /PATHGE/        R*4     TROCOM.INC
                Distance from transmitter to radio horizon in meters.
                - Possibly given a new value in the following subprograms:
                  INDATA  UNITCV
                - Used but not changed in the following subprograms:
                  OUTDAT  POWER   SUMPAG  TRANSF
R               /PATHGE/        R*4     TROCOM.INC
                Receiver distance to minimum scattering point in
                meters.
                - Possibly given a new value in the following subprograms:
                  TRANSF  UNITCV
                - Used but not changed in the following subprograms:
                  INTLIM  STPPAR
RATE            /MCOM4/         R*4     MCOM.INC
                Data rate in bits/second.  Default is 6.6E6.
                - Possibly given a new value in the following subprograms:
                  INDATA
                - Used but not changed in the following subprograms:
                  CAC     DIFSNR  DINT    JAMCOM  MAIN    MDTS    OUTDAT  POWER
                  SIGIN
S(3)            /MCOM4/         R*4     MCOM.INC
                Array of effective obstacle extents along the great
                circle path in meters.
                - Possibly given a new value in the following subprograms:
                  INDATA  UNITCV
                - Used but not changed in the following subprograms:
                  MAIN    OUTDAT
SP1(3)          /SUMP/          R*4     CURVE.INC
                Lower beam troposcatter signal RMS delay spread in
                nanoseconds for percentiles 50, 90 and 99.
                - Possibly given a new value in the following subprograms:
                  POWER
SP2(3)          /SUMP/          R*4     CURVE.INC
                Upper beam troposcatter signal RMS delay spread in
                nanoseconds for percentiles 50, 90 and 99.
                - Possibly given a new value in the following subprograms:
                  POWER
STSNR           /SUMP/          R*4     CURVE.INC
                Standard deviation of diffracted signal long-term SNR
                distribution in dB.
                - Possibly given a new value in the following subprograms:
                  DIFSNR
                - Used but not changed in the following subprograms:
                  MDTS    SUMPAG
T               /PATHGE/        R*4     TROCOM.INC
                Transmit antenna distance to minimum scattering point
                in meters.
                - Possibly given a new value in the following subprograms:
                  TRANSF  UNITCV
```

```
                variability curve, YO(90).
                - Possibly given a new value in the following subprograms:
                  CLIMIL  INDATA
                - Used but not changed in the following subprograms:
                  CLIFIT  CLIME   OUTDAT
IFLOS(3)        /SUMP/          R*4     CURVE.INC
                Median diffraction path loss in dB for each value in
                ERFAC distribution.
                - Possibly given a new value in the following subprograms:
                  DIFSNR
                - Used but not changed in the following subprograms:
                  SUMPAG
IFRSL(3)        /SUMP/          R*4     CURVE.INC
                Median diffraction signal RSL in dBm for each value in
                ERFAC distribution.
                - Possibly given a new value in the following subprograms:
                  DIFSNR
                - Used but not changed in the following subprograms:
                  SUMPAG
IVIMP           /ANSWER/        R*4     ANSWER.INC
                Ratio of square of mean signal energy to variance for
                AN/TRC-170.
                - Possibly given a new value in the following subprograms:
                  EIGV
IVTYP           /MCOM2/         I*2     MCOM.INC
                Diversity configuration indicator.  Default is 0.
                 0 = 2 receive antennas; 2S    2S/2F    2S/2A 2S/2A/2F
                 1 = 1 receive antenna;  2A    2F       2F/2A
                 2 = 2 transmit,
                     2 receive antennas; 2S/2P 2S/2P/2A
                 3 = Not used
                 4 = User supplied parameters
                S = Space  F = Frequency  A = Angle  P = Polarization
                - Possibly given a new value in the following subprograms:
                  INDATA
                - Used but not changed in the following subprograms:
                  ANTGEO  BERCAL  CAC     LTCORR  MATCO   MDTS    OUTDAT  POWER
                  SIM     SUMPAG
L(3)            /MCOM4/         R*4     MCOM.INC
                Array containing distance from each obstacle to
                transmitter in meters.
                - Possibly given a new value in the following subprograms:
                  INDATA  UNITCV
                - Used but not changed in the following subprograms:
                  DIFSNR  MAIN    OUTDAT
LR              /PATHGE/        R*4     TROCOM.INC
                Distance from receiver to radio horizon in meters.
                - Possibly given a new value in the following subprograms:
                  INDATA  UNITCV
                - Used but not changed in the following subprograms:
```

```
DEG            /UNIT/          R*4     IODATA.INC
               Strins 'des ' for units output.
               - Used but not chansed in the followins subprosrams:
                 OUTDAT  UNITS
DEL            /SUMP/          R*4     CURVE.INC
               Diffraction path delay relative to a straisht line
               path in seconds.
               - Used but not chansed in the followins subprosrams:
                 MAIN    MDTS    SUMPAG
DELH           /PROPAR/        R*4     TROCOM.INC
               Spacins of CN2 samples in meters.
               - Possibly siven a new value in the followins subprosrams:
                 INDATA  UNITCV
               - Used but not chansed in the followins subprosrams:
                 OUTDAT  RIPROF
DELPB          /PDATA/         R*4     PDATA.INC
               Resolution of a delay cell in seconds.
               - Possibly siven a new value in the followins subprosrams:
                 LOOPS
               - Used but not chansed in the followins subprosrams:
                 MAIN    MDIF    POWER   SIM     SUMPAG
DELPBZ         /RZ1/           R*4
               Resolution of a delay cell in seconds.  Same as DELPB
               in /PDATA/.
               - Possibly siven a new value in the followins subprosrams:
                 MAIN
               - Used but not chansed in the followins subprosrams:
                 CAC     DINT
DELREF         /PDATA/         R*4     PDATA.INC
               Minimum delay throush the lowest scatterins point
               (relative to straisht line delay) in seconds.
               - Possibly siven a new value in the followins subprosrams:
                 MDIF
               - Used but not chansed in the followins subprosrams:
                 LOOPS   POWER
DELTAR(NRMX)   /ANTENN/        R*4     TROCOM.INC
               3dB half-beamwidth of each receive antenna in radians.
               - Possibly siven a new value in the followins subprosrams:
                 MAIN
               - Used but not chansed in the followins subprosrams:
                 INTLIM  POWER   STPPAR  TRANSF  TRLOSS
DELTAT(NTMX)   /ANTENN/        R*4     TROCOM.INC
               3dB half-beamwidth of each transmit antenna in
               radians.
               - Possibly siven a new value in the followins subprosrams:
                 MAIN
               - Used but not chansed in the followins subprosrams:
                 INTLIM  POWER   STPPAR  TRANSF  TRLOSS
DEMIN          /CURVE/         R*4     CURVE.INC
               User supplied minima of the 90th percentile
```

```
                    - Used but not chansed in the followins subprosrams:
                      OUTDAT  RIPROF
CODE                /MCOM4/          L*4     MCOM.INC
                    Flas for codins.
                    - Possibly siven a new value in the followins subprosrams:
                      INDATA
                    - Used but not chansed in the followins subprosrams:
                      MDTS
COEFF               /ANSWER/         R*8     ANSWER.INC
                    Partial fraction expansion coefficients for
                    calculation of AN/TRC-170 outase probability.
                    - Used but not chansed in the followins subprosrams:
                      AVG     TRC
CONJAM              /JAMPAR/         R*4     JAMPAR.INC
                    Interference constant.
                    - Possibly siven a new value in the followins subprosrams:
                      BUTFIL  BWJAM
                    - Used but not chansed in the followins subprosrams:
                      FUNJAM
CORRLT              /CPLOSS/         R*4     CPL.INC
                    Correlation coefficient for lons term variability of
                    lower and upper beams.
                    - Possibly siven a new value in the followins subprosrams:
                      LTCORR
                    - Used but not chansed in the followins subprosrams:
                      POWER
CPL(6)              /CPLOSS/         R*4     CPL.INC
                    Aperture-to-medium couplins loss array in dB.
                    - Possibly siven a new value in the followins subprosrams:
                      TRLOSS
                    - Used but not chansed in the followins subprosrams:
                      POWER
D                   /PATHGE/         R*4     TROCOM.INC
                    Great circle distance between transmitter and receiver
                    measured at sea level in meters.
                    - Possibly siven a new value in the followins subprosrams:
                      INDATA  UNITCV
                    - Used but not chansed in the followins subprosrams:
                      ATMOS   DIFSNR  INTLIM  LOOPS   LTCORR  MAIN    OUTDAT  POWER
                      SUMPAG  TRANSF  TRLOSS
DALT                /RZ4/            R*4     RZ4.INC
                    Samplins interval.
                    -- Not used --
DE                  /SUMP/           R*4     CURVE.INC
                    Effective distance for troposcatter path in
                    kilometers.
                    - Possibly siven a new value in the followins subprosrams:
                      POWER
                    - Used but not chansed in the followins subprosrams:
                      SUMPAG
```

| | | | |
|---|---|---|---|
| | normalized to signaling interval duration. | | |
| | - Possibly given a new value in the following subprograms: TRCIN | | |
| | - Used but not changed in the following subprograms: TRC TXPULS | | |
| CE3 | /CONSTA/ | R*4 | CONSTANTS.INC |
| | 1 X 10**3 = 1000. | | |
| | - Used but not changed in the following subprograms: UNITCV | | |
| CHGHR | /IODATA/ | L*4 | IODATA.INC |
| | HR set to AR(1) if TRUE. | | |
| | - Possibly given a new value in the following subprograms: INDATA | | |
| | - Used but not changed in the following subprograms: OUTDAT | | |
| CHGHRE | /IODATA/ | L*4 | IODATA.INC |
| | HRE set to HR if TRUE. | | |
| | - Possibly given a new value in the following subprograms: INDATA | | |
| | - Used but not changed in the following subprograms: OUTDAT | | |
| CHGHT | /IODATA/ | L*4 | IODATA.INC |
| | HT set to AT(1) if TRUE. | | |
| | - Possibly given a new value in the following subprograms: INDATA | | |
| | - Used but not changed in the following subprograms: OUTDAT | | |
| CHGHTE | /IODATA/ | L*4 | IODATA.INC |
| | HTE set to HT if TRUE. | | |
| | - Possibly given a new value in the following subprograms: INDATA | | |
| | - Used but not changed in the following subprograms: OUTDAT | | |
| CMTPFT | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Meters per foot = 0.3048. | | |
| | - Used but not changed in the following subprograms: ANTGEO INDATA UNITCV | | |
| CMTPMI | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Meters per statute mile = 1609.344 | | |
| | - Used but not changed in the following subprograms: UNITCV | | |
| CMTPNM | /CONSTA/ | R*4 | CONSTANTS.INC |
| | Meters per nautical mile = 1852. | | |
| | - Used but not changed in the following subprograms: UNITCV | | |
| CN2(NPROF) | /PROPAR/ | R*4 | TROCOM.INC |
| | The atmospheric structure constant height profile in meters to the -2/3 power. | | |
| | - Possibly given a new value in the following subprograms: INDATA | | |

```
BER(3)          /ERAD/          R*4     ERAD.INC
                Bit error rate thresholds of interest.  Set to 1E-3,
                1E-4 and 1E-5 in data statement.
                - Used but not changed in the following subprograms:
                  BERCAL  PROUT   SUMPAG
BETA0           /PATHGE/        R*4     TROCOM.INC
                Minimum receive antenna elevation angle measured from
                receiver-to-transmitter line to receiver horizon line
                in radians.
                - Possibly given a new value in the following subprograms:
                  TRANSF  UNITCV
                - Used but not changed in the following subprograms:
                  INTLIM  LOOPS   POWER   SUMPAG  TRLOSS
BETA1           /PATHGE/        R*4     TROCOM.INC
                Maximum receive antenna elevation angle measured from
                receiver-to-transmitter line to top of common volume
                in radians.
                - Possibly given a new value in the following subprograms:
                  INTLIM  UNITCV
                - Used but not changed in the following subprograms:
                  LOOPS
BOUTL(3,4)      /ERAD/          R*4     ERAD.INC
                Cumulative outage probability for each diversity
                configuration and error rate threshold (averaged
                over multipath distribution, if any).
                - Possibly given a new value in the following subprograms:
                  PROUT
BW              /SYSTRN/        R*4     TROCOM.INC
                Bandwidth in Hertz.  Default is 7 MHz.
                - Possibly given a new value in the following subprograms:
                  INDATA
                - Used but not changed in the following subprograms:
                  JAMCOM  LOOPS   MAIN    OUTDAT  POWER   SUMPAG
C               /PDATA/         R*4     PDATA.INC
                Proportionality constant in troposcatter path loss
                calculation.
                - Possibly given a new value in the following subprograms:
                  LOOPS
                - Used but not changed in the following subprograms:
                  POWER   SUMPAG
C0              /CONSTA/        R*4     CONSTANTS.INC
                Free space velocity of radio waves = 2.998E8 m/sec.
                - Used but not changed in the following subprograms:
                  INDATA  LOOPS   MDIF    POWER
CDEGR           /CONSTA/        R*4     CONSTANTS.INC
                Radians per degree = 0.017453293.
                - Used but not changed in the following subprograms:
                  DIFSNR  UNITCV
CDUR            /SYSPAR/        R*4     SYSPAR.INC
                Duration of transmitted pulse for AN/TRC-170
```

```
                        MDTS
                      - Used but not changed in the following subprograms:
                        BERCAL
      AR(NRMX)        /ANTENN/      R*4     TROCOM.INC
                      Array of receiver antenna diameters in meters.  AR(1)
                      is equivalent to RDIAM in the input file.
                      - Possibly given a new value in the following subprograms:
                        ANTGEO  INDATA  UNITCV
                      - Used but not changed in the following subprograms:
                        ANTPAR  CHKDAT  LOOPS   OUTDAT  RGAIN   SUMPAG
      ASNR            /SYSPAR/      R*4     SYSPAR.INC
                      Yearly median value of troposcatter short-term average
                      SNR, ie, Eb/No, in dB.
                      - Possibly given a new value in the following subprograms:
                        TRCIN
                      - Used but not changed in the following subprograms:
                        TRC
      AT(NTMX)        /ANTENN/      R*4     TROCOM.INC
                      Array of transmitter antenna diameters in meters.
                      AT(1) is equivalent to TDIAM in the input file.
                      - Possibly given a new value in the following subprograms:
                        ANTGEO  INDATA  UNITCV
                      - Used but not changed in the following subprograms:
                        ANTPAR  CHKDAT  OUTDAT  SUMPAG  TGAIN
      ATTEN           /MCOM4/       R*4     MCOM.INC
                      Ratio of interferer signal amplitude on antenna
                      2 to that at antenna 1.  Set to 1 internally.
                      - Used but not changed in the following subprograms:
                        JAMCOM
      AVERX           /MCOM4/       R*4     MCOM.INC
                      Average terrain elevation above sea level between
                      receive site and radio horizon, in meters.
                      - Possibly given a new value in the following subprograms:
                        DIFSNR  INDATA  POWER   UNITCV
                      - Used but not changed in the following subprograms:
                        OUTDAT
      AVETX           /MCOM4/       R*4     MCOM.INC
                      Average terrain elevation above sea level between
                      transmit site and radio horizon, in meters.
                      - Possibly given a new value in the following subprograms:
                        DIFSNR  INDATA  POWER   UNITCV
                      - Used but not changed in the following subprograms:
                        OUTDAT
      BEAM            /STPCOM/      R*4     STPCOM.INC
                      Parameter for determining azimuth and elevation angle
                      step size in common volume integration.
                      - Possibly given a new value in the following subprograms:
                        STPPAR
                      - Used but not changed in the following subprograms:
                        STEPAB
```

## C.1 Global Variable Dictionary

```
A               /PATHGE/        R*4     TROCOM.INC
                Effective earth radius in meters.
                - Possibly given a new value in the following subprograms:
                  INDATA  JAMCOM
                - Used but not changed in the following subprograms:
                  INTLIM  LOOPS   LTCORR  MAIN    TRANSF
A0              /CONSTA/        R*4     CONSTANTS.INC
                Radius of the earth in meters = 6367650.
                - Used but not changed in the following subprograms:
                  INDATA  MDIF    TRANSF
AA              /PROPAR/        R*4     TROCOM.INC
                Atmospheric absorption loss in dB.
                - Possibly given a new value in the following subprograms:
                  ATMOS
                - Used but not changed in the following subprograms:
                  MAIN    POWER   SUMPAG
ABEL(4)         /ERAD/          R*4     ERAD.INC
                Cumulative block error probability for each diversity
                configuration as specified by DIVTYP (averaged over
                multipath distribution, if any).
                - Possibly given a new value in the following subprograms:
                  PROUT
ACALC           /IODATA/        L*4     IODATA.INC
                TRUE if the angles PSITEO and PSIREO are calculated
                rather than read in.
                - Possibly given a new value in the following subprograms:
                  INDATA
                - Used but not changed in the following subprograms:
                  ANTGEO  OUTDAT
ALFA0           /PATHGE/        R*4     TROCOM.INC
                Minimum transmit antenna elevation angle measured from
                transmitter-to-receiver line to transmit horizon line
                in radians.
                - Possibly given a new value in the following subprograms:
                  TRANSF  UNITCV
                - Used but not changed in the following subprograms:
                  INTLIM  LOOPS   LTCORR  POWER   SUMPAG  TRLOSS
ALFA1           /PATHGE/        R*4     TROCOM.INC
                Maximum transmit antenna elevation angle measured from
                transmitter-to-receiver line to top of common volume
                in radians.
                - Possibly given a new value in the following subprograms:
                  INTLIM  UNITCV
                - Used but not changed in the following subprograms:
                  LOOPS
APOW            /MCOM4/         R*4     MCOM.INC
                Angle diversity squint loss as a ratio.
                - Possibly given a new value in the following subprograms:
```

IBM version has been preprocessed to do the including of these files that the PDP compiler will do automatically.

The description gives the definition of the variable as well as the maximum, default value, and units where appropriate. In the case of flags all possible legal values are described. Note, the units listed are those used in TROPO for calculations and not necessarily those used for input or output.

The last two sections describe where the variable is given a new value and where it is otherwise used. These sets are mutually exclusive. A subprogram is included in the first list if the variable is used in one or more of the following:

1) on the left side of an arithmetic assignment
2) data statement
3) parameter statement (meaningful only in PDP version)
4) READ or ACCEPT statement

In addition, it may be used in one or both of the following ways, but it MUST have been used in at least one of the above. On the other hand, a subprogram is included in the second list if it is not used in one of the above but is used in one of the following:

1) on the right side of an arithmetic assignment
2) WRITE or TYPE statement

Both lists were generated by a DECUS (Digital Equipment Corporation User's Group) supplied program. Its limitations are that neither list includes:

1) use as arguments in subprogram calls
2) use in any statement when the variable is equivalenced to a common variable. The variables in common /RZ4/ are an example of this.
3) in the case of parameters, use as a dimension of an array.

For these reasons, some variables are listed as 'Not used'. They are actually used in one or more of the limitations just listed. Additionally, any variable apparently not set in any routine has either been used as an argument or has been set in the block data section (file DATAINIT.FTN).

# APPENDIX C

## GLOBAL VARIABLE DICTIONARY

The dictionary describes all variables in common. Each description is of the form:

```
<variable name> /<common name>/         type    <include file>
                Description.
                - Possibly given a new value in the following subprograms:
                  (List of subprograms)
                - Used but not changed in the following subprograms:
                  (List of subprograms)
```

The name is the common variable or parameter name. If the variable is a matrix, the name is followed by dimensions. In some cases these dimensions are parameters. When the PDP compiler finds such a variable in the code it replaces the parameters with their actual numeric values (as given in the file TROPAR.INC). For the IBM version, the code has already been preprocessed by SIGNATRON to use the numeric values so the actual commons will not show the parameters as dimensions but their values.

The common name is the name of the common the variable is contained in. For parameters, the word 'Parameter' is in this spot since these are not in a common.

The type, for variables and parameters, is given as three characters:

| | |
|---|---|
| L*1 | 1 byte LOGICAL (BYTE in the PDP version) |
| L*4 | 4 byte LOGICAL |
| I*2 | 2 byte INTEGER |
| I*4 | 4 byte INTEGER |
| R*4 | 4 byte REAL |
| R*8 | 8 byte REAL |
| C*8 | 8 byte COMPLEX |

The include file name is only meaningful to the PDP users. It is the name of the file containing the common with the variable being described. Again, the

```
        CLIMIX
     Calls the following subprgrams:
        ERROR   EXP     F1      F2      SQRT

    VARW
     Is called by the following subprograms:
        TRC
     Calls the following subprgrams:
        PROFIL  P2INT

    VDECAL
     Is called by the following subprograms:
        CLIMIL
     Calls the following subprgrams:
        EXP     F2

    XNOR
     Is called by the following subprograms:
        BERCAL  MDTS    TRC
     Calls the following subprgrams:
        DABS    DEXP    DSQRT

    YINT
     Is called by the following subprograms:
        CLIME
```

```
 Is called by the following subprograms:
        TROPO
 Calls the following subprgrams:
        ABS      ASIN     ATAN     COS      ERROR    HORANG   SIN      SQRT

TRC
 Is called by the following subprograms:
        INDATA   TRCIN
 Calls the following subprgrams:
        ABS      ALOG10   AVG      EIGV     PAVERG   PDFCOE   PDFSUM   POUTAG
        SQRT     SUBIO    TIMAVG   TIMEQL   TIMPAR   VARW     XNOR

TRCIN
 Is called by the following subprograms:
        TROPO
 Calls the following subprgrams:
        ALOG10   ERROR    SASEQ    SUBID    TRC

TRLOSS
 Is called by the following subprograms:
        LOOPS
 Calls the following subprgrams:
        ABS      ALOG10   AMAX1    ERROR

TSINC
 Is called by the following subprograms:
        BOTAC    JAMCOM
 Calls the following subprgrams:
        DABS     SINC

TXPULS
 Is called by the following subprograms:
        EIGV     P2INT
 Calls the following subprgrams:
        SQRT

UNITCV
 Is called by the following subprograms:
        INDATA   SUMPAG
 Calls the following subprgrams:
        ERROR

UNITS
 Is called by the following subprograms:
        INDATA
 Calls the following subprgrams:
        AMOD     ERRIO

VARPOL
 Is called by the following subprograms:
```

```
SUMPAG
 Is called by the following subprograms:
       TROPO
 Calls the following subprgrams:
       ABS     ALOG10  ANTPTR  ERROR   SIN     UNITCV

TANGL
 Is called by the following subprograms:
       MDIF
 Calls the following subprgrams:
       ABS     ASIN    COS     HORANG  SIN     SQRT

TGAIN
 Is called by the following subprograms:
       DIFSNR  LOOPS
 Calls the following subprgrams:
       GPATT

TIMAVG
 Is called by the following subprograms:
       TRC
 Calls the following subprgrams:
       EXP     INTERD

TIMEQL
 Is called by the following subprograms:
       TRC
 Calls  ne following subprgrams:
       ABS     TIMPAR

TIMPAR
 Is called by the following subprograms:
       TIMEQL  TRC
 Calls the following subprgrams:
       PROFIL  P2INT

TPSPEC
 Is called by the following subprograms:
       PWRSPC  TPSPJ
 Calls the following subprgrams:
       SIN

TPSPJ
 Is called by the following subprograms:
       PWRSPC
 Calls the following subprgrams:
       EXP     SQRT    TPSPEC

TRANSF
```

```
ERR            /CONTROL/       R*4     TROCOM.INC
               Common volume integration resolution. Default is .001.
               - Possibly given a new value in the following subprograms:
                 INDATA
               - Used but not changed in the following subprograms:
                 INTLIM  LOOPS   OUTDAT  STPPAR  SUMPAG
F              /SYSTRN/        R*4     TROCOM.INC
               Operating frequency in Hz.  Model is accurate between
               100MHz and 10GHz.
               - Possibly given a new value in the following subprograms:
                 INDATA  UNITCV
               - Used but not changed in the following subprograms:
                 ANTGEO  ATMOS   DIFSNR  MAIN    OUTDAT  POWER   SUMPAG
F50L           /BUTPAR/        R*4     BUTPAR.INC
               50dB normalized corner frequency.
               - Possibly given a new value in the following subprograms:
                 FUNBW
               - Used but not changed in the following subprograms:
                 FCCMSK
FCJ            /JAMPAR/        R*4     JAMPAR.INC
               Normalized 3dB cut-off frequency of QPSK interference
               filter.
               - Possibly given a new value in the following subprograms:
                 BWJAM
               - Used but not changed in the following subprograms:
                 PSPJ    TPSPJ
FCON           /BUTPAR/        R*4     BUTPAR.INC
               Ratio of bandwidth to twice the symbol rate.
               - Possibly given a new value in the following subprograms:
                 BUTFIL  BWJAM
               - Used but not changed in the following subprograms:
                 FUNBW
FCRX           /BUTPAR/        R*4     BUTPAR.INC
               Normalized 3dB cut-off frequency of receiver filter.
               - Possibly given a new value in the following subprograms:
                 BUTFIL  BWJAM   INDATA
               - Used but not changed in the following subprograms:
                 PSPEC1  PSPEC2  PWRSPC  RJCFCN  SPEC1
FCTX           /BUTPAR/        R*4     BUTPAR.INC
               Normalized 3dB cut-off frequency of transmitter
               filter.
               - Possibly given a new value in the following subprograms:
                 BUTFIL  FUNBW   INDATA
               - Used but not changed in the following subprograms:
                 A50FCC  BWJAM   PSPJ    SPEC1   SPEC2   TPSPJ
FILLER(88)     /RZ4/           R*4     RZ4.INC
               Dummy array to align commons.
               -- Not used --
FJSEPN         /JAMPAR/        R*4     JAMPAR.INC
               Normalized frequency separation between the
```

```
                    interference signal and the desired signal.
                    - Possibly given a new value in the following subprograms:
                      BUTFIL  RJCFCN
                    - Used but not changed in the following subprograms:
                      FUNJAM  PSPEC2  PWRSPC
FMI                 /JAMPAR/        R*4     JAMPAR.INC
                    Modulation index for FDM/FM interference.
                    - Possibly given a new value in the following subprograms:
                      BWJAM
                    - Used but not changed in the following subprograms:
                      PSPJ    TPSPJ
FOUTL(3,4)          /ERAD/          R*4     ERAD.INC
                    Cumulative fade outage per call minute for each
                    diversity configuration and error rate threshold
                    (averaged over multipath distribution, if any).
                    - Possibly given a new value in the following subprograms:
                      PROUT
FSEP                /PDATA/         R*4     PDATA.INC
                    Frequency separation for uncorrelated frequency
                    diversity in Hz.
                    - Possibly given a new value in the following subprograms:
                      LOOPS
                    - Used but not changed in the following subprograms:
                      SUMPAG
FT                  /UNIT/          R*4     IODATA.INC
                    String 'ft  ' for units output.
                    - Used but not changed in the following subprograms:
                      OUTDAT  UNITS
GHZ                 /UNIT/          R*4     IODATA.INC
                    String 'GHz ' for units output.
                    - Used but not changed in the following subprograms:
                      INDATA  OUTDAT  UNITS
GPF                 /CURVE/         R*4     CURVE.INC
                    Frequency correction factor for user supplied 90th
                    percentile variability curve.  Default is 1.
                    - Possibly given a new value in the following subprograms:
                      INDATA
                    - Used but not changed in the following subprograms:
                      CLIME
GRDB(NRMX)          /ANTENN/        R*4     TROCOM.INC
                    Gain of each receive antenna in dBi.
                    - Possibly given a new value in the following subprograms:
                      MAIN
                    - Used but not changed in the following subprograms:
                      DIFSNR  POWER   SUMPAG
GTDB(NTMX)          /ANTENN/        R*4     TROCOM.INC
                    Gain of each transmit antenna in dBi.
                    - Possibly given a new value in the following subprograms:
                      MAIN
                    - Used but not changed in the following subprograms:
```

```
                        DIFSNR  POWER   SUMPAG
      HCOM              /PATHGE/         R*4     TROCOM.INC
                        Effective height of the bottom of the common volume in
                        meters.
                        - Possibly given a new value in the following subprograms:
                          LOOPS   TRANSF  UNITCV
                        - Used but not changed in the following subprograms:
                          LTCORR  SUMPAG
      HHIGH             /PATHGE/         R*4     TROCOM.INC
                        Effective height of the top of the common volume in
                        meters.
                        - Possibly given a new value in the following subprograms:
                          INTLIM  UNITCV
                        - Used but not changed in the following subprograms:
                          SUMPAG
      HI(155)           /MCOM4/          R*4     MCOM.INC
                        Array containing NPM(1) evenly-spaced terrain
                        elevation data (in meters) between transmitter and
                        first obstacle followed by NPM(2) evenly-spaced
                        terrain elevation data between first and second
                        obstacle, etc., ending with NPM(NOBS+1) evenly-spaced
                        terrain elevation data between last obstacle and
                        receive site. The data should be selected such that:
                                HI(1) = Terrain elevation above sea level at
                                         transmit site (HTO).
                                HI(NPM(I)) = HI (NPM(I)+1) = Elevation of Ith
                                         obstacle above sea level (HL(I)).
                                HI(NPM(NOBS+1)) = Terrain elevation above sea
                                         level at receive site (HRO).
                        In MDTS, HI is used as work space.  It is equivalenced
                        to local arrays.
                        - Possibly given a new value in the following subprograms:
                          INDATA  UNITCV
                        - Used but not changed in the following subprograms:
                          DIFSNR  OUTDAT  POWER
      HL(3)             /MCOM4/          R*4     MCOM.INC
                        Array containing elevation of each obstacle above sea
                        level in meters.  HL(1) is elevation of transmitter
                        radio horizon HLT.  HL(NOBS) is elevation of receiver
                        radio horizon HLR.
                        - Possibly given a new value in the following subprograms:
                          INDATA  UNITCV
                        - Used but not changed in the following subprograms:
                          DIFSNR  MAIN    OUTDAT
      HLAV(3)           /MCOM4/          R*4     MCOM.INC
                        Array containing average terrain elevation at each
                        diffraction point in meters.
                        - Possibly given a new value in the following subprograms:
                          INDATA  UNITCV
                        - Used but not changed in the following subprograms:
```

```
                  DIFSNR  OUTDAT
HLEF(3)          /MCOM4/         R*4     MCOM.INC
                 Array containing effective height of obstacles above
                 average terrain elevation in meters.
                 - Possibly given a new value in the following subprograms:
                   INDATA  UNITCV
                 - Used but not changed in the following subprograms:
                   DIFSNR  OUTDAT
HLOW             /PROPAR/        R*4     TROCOM.INC
                 Lowest height above sea level at which CN2 is
                 specified in meters.
                 - Possibly given a new value in the following subprograms:
                   INDATA  UNITCV
                 - Used but not changed in the following subprograms:
                   LOOPS   OUTDAT
HLR              /PATHGE/        R*4     TROCOM.INC
                 Receiver radio horizon elevation above sea level in
                 meters.
                 - Possibly given a new value in the following subprograms:
                   INDATA  TRANSF  UNITCV
                 - Used but not changed in the following subprograms:
                   OUTDAT  SUMPAG
HLT              /PATHGE/        R*4     TROCOM.INC
                 Transmit radio horizon elevation above sea level in
                 meters.
                 - Possibly given a new value in the following subprograms:
                   INDATA  TRANSF  UNITCV
                 - Used but not changed in the following subprograms:
                   OUTDAT  SUMPAG
HRE              /MCOM4/         R*4     MCOM.INC
                 Effective receiver antenna height above average
                 terrain elevation in meters.
                 - Possibly given a new value in the following subprograms:
                   INDATA  POWER   UNITCV
                 - Used but not changed in the following subprograms:
                   DIFSNR
HRN              /PATHGE/        R*4     TROCOM.INC
                 Receive antenna height above sea level in meters.
                 - Possibly given a new value in the following subprograms:
                   INDATA  TRANSF  UNITCV
                 - Used but not changed in the following subprograms:
                   DIFSNR  INTLIM  JAMCOM  LTCORR  MAIN   OUTDAT  POWER   SUMPAG
HTE              /MCOM4/         R*4     MCOM.INC
                 Effective transmitter antenna height above average
                 terrain elevation in meters.
                 - Possibly given a new value in the following subprograms:
                   INDATA  POWER   UNITCV
                 - Used but not changed in the following subprograms:
                   DIFSNR  OUTDAT
HTN              /PATHGE/        R*4     TROCOM.INC
```

```
                    Transmit antenna height above sea level in meters.
                    - Possibly given a new value in the following subprograms:
                      INDATA  TRANSF  UNITCV
                    - Used but not changed in the following subprograms:
                      DIFSNR  INTLIM  LOOPS  MAIN  OUTDAT  POWER  SUMPAG
I1CORR(NCORMX)      /PDATA/         I*2     PDATA.INC
                    Array of receiving beams involved in the correlation
                    calculations.
                    - Possibly given a new value in the following subprograms:
                      LOOPS
                    - Used but not changed in the following subprograms:
                      SIM     SUMPAG
I2CORR(NCORMX)      /PDATA/         I*2     PDATA.INC
                    Array of receiving beams involved in the correlation
                    calculations.
                    - Possibly given a new value in the following subprograms:
                      LOOPS
                    - Used but not changed in the following subprograms:
                      SIM     SUMPAG
IBLOSS(6)           /CPLOSS/        I*2     CPL.INC
                    Beam number corresponding to CPL(I).
                    - Possibly given a new value in the following subprograms:
                      LOOPS
                    - Used but not changed in the following subprograms:
                      POWER
IBR(NRMX,NRMX)      /SYSTRN/        I*2     TROCOM.INC
                    Channel complex-envelope correlation and
                    cross-correlation calculation indicator array.
                            0 = No calculation
                            1 = Power (correlation) calculation only
                            2 = Power (correlation) per unit delay
                                spectrum calculation
                    - Possibly given a new value in the following subprograms:
                      ANTGEO  INDATA
                    - Used but not changed in the following subprograms:
                      CHKDAT  LOOPS  OUTDAT  STPPAR  SUMPAG
IBW                 /MCOM2/         I*2     MCOM.INC
                    Switch indicating type of RF bandwidth constraint to
                    be used on desired signal.  Default is 0.
                       0 = No RF filtering
                       1 = Filter determined from 99% bandwidth constraint
                       2 = Filter chosen to meet FCC Mask.  (FCC-19311)
                       3 = Filters are user specified
                    - Possibly given a new value in the following subprograms:
                      INDATA
                    - Used but not changed in the following subprograms:
                      BOTAC   MAIN   MDTS   OUTDAT  SIGIN
ICHIP(30)           /SYSPAR/        I*2     SYSPAR.INC
                    PN sequence for spectrum spreading when the data
                    rate is much smaller than the bandwidth.
```

```
                - Possibly given a new value in the following subprograms:
                  TRCIN
                - Used but not changed in the following subprograms:
                  TRC     TXPULS
ICLIME          /MCOM2/          I*2     MCOM.INC
                Climate class.  Default is 0.
                   0 = NBS TN-101 climate
                   1 = MIL-HDBK-417 climate
                   2 = New, user-supplied climate
                - Possibly given a new value in the following subprograms:
                  INDATA
                - Used but not changed in the following subprograms:
                  OUTDAT  SUMPAG
ICON            /BUTPAR/         I*2     BUTPAR.INC
                   1 = 99% bandwidth constraint
                   2 = FCC-13911 bandwidth constraint
                - Possibly given a new value in the following subprograms:
                  BUTFIL  BWJAM
                - Used but not changed in the following subprograms:
                  FUNBW
ICORR           /MCOM2/          I*2     MCOM.INC
                Multipath profile correlation indicator.  Default
                is 2.
                   0 = Profile of the form X * exp(-A*X) -- used for
                       debugging
                   1 = Computed multipath profile; no beam correlation
                   2 = Computed multipath profile; beam correlation.
                - Used but not changed in the following subprograms:
                  CAC     DINT    MDTS    SIGIN
ICPL            /CPLOSS/         I*2     CPL.INC
                Coupling loss count.
                - Possibly given a new value in the following subprograms:
                  LOOPS
                - Used but not changed in the following subprograms:
                  POWER   TRLOSS
IDM             /UNIT/           I*2     IODATA.INC
                0 if degrees, 1 if milliradians.
                - Possibly given a new value in the following subprograms:
                  UNITS
                - Used but not changed in the following subprograms:
                  UNITCV
IFILE           /MCOM2/          I*2     MCOM.INC
                Pointer to multipath profile.
                - Possibly given a new value in the following subprograms:
                  MATCO   MDTS
                - Used but not changed in the following subprograms:
                  CAC
IFILRX          /BUTPAR/         I*2     BUTPAR.INC
                Receiver filter indicator.
                        0 = MD-918 receiver filter.  Also means
```

```
                           filter is a Butterworth cascaded with a
                           rectangular impulse response filter of
                           duration equal to symbol duration.
                       1 = (not allowed)
                       2 = AN/TRC-170 receiver filter.  Also means
                           filter is a Butterworth.
                 - Possibly given a new value in the following subprograms:
                   BUTFIL  INDATA
                 - Used but not changed in the following subprograms:
                   FUNJAM  PSPEC1  PSPEC2  PWRSPC  SPEC1
IFILTX           /BUTPAR/        I*2    BUTPAR.INC
                 Transmitter filter indicator.
                       0 = MD-918 transmitter filter.  Also means
                           filter is a Butterworth cascaded with a
                           rectangular impulse response filter of
                           duration equal to symbol duration.
                       1 = AN/TRC-170 transmitter filter.  Also means
                           filter is a cascade of Butterworth filter
                           with rectangular impulse response filter
                           of duration equal to half symbol duration.
                       2 = (not allowed)
                 - Possibly given a new value in the following subprograms:
                   BUTFIL  INDATA
                 - Used but not changed in the following subprograms:
                   A50FCC  BWJAM  FUNBW  PSPJ  SPEC1  SPEC2  TPSPJ
IME              /UNIT/          I*2    IODATA.INC
                 0 if metric units, 1 if English.
                 - Possibly given a new value in the following subprograms:
                   UNITS
                 - Used but not changed in the following subprograms:
                   UNITCV
IMG              /UNIT/          I*2    IODATA.INC
                 0 if MHz, 1 if GHz.
                 - Possibly given a new value in the following subprograms:
                   UNITS
                 - Used but not changed in the following subprograms:
                   UNITCV
INEG             /PDATA/         I*2    PDATA.INC
                 Number of negative delay cells encountered in
                 troposcatter integration.  It is an error if INEG > 0.
                 - Possibly given a new value in the following subprograms:
                   LOOPS
                 - Used but not changed in the following subprograms:
                   SUMPAG
INS              /UNIT/          I*2    IODATA.INC
                 0 if nautical miles, 1 if statute miles.
                 - Possibly given a new value in the following subprograms:
                   UNITS
                 - Used but not changed in the following subprograms:
                   UNITCV
```

```
IOPEND         /CONTRL/        I*2     TROCOM.INC
               Number of output files opened.
               - Possibly given a new value in the following subprograms:
                 INDATA  SUMPAG
IOPERF         /IOUT/          I*2     IOUT.INC
               Switch for calculation of performance of AN/TRC-170.
                       0 = ABER and outage probability
                       1 = ABER (average bit error rate) only
                       2 = Outage probability only
               Set to 0 internally.
               - Possibly given a new value in the following subprograms:
                 TRCIN
               - Used but not changed in the following subprograms:
                 TRC
IOTIME         /IOUT/          I*2     IOUT.INC
               Switch for calculation of performance of AN/TRC-170.
                       0 = Short term performance assuming various
                           sampling times.
                       1 = Short term performance assuming Gaussian
                           timing jitter.
                       2 = Yearly average performance assuming
                           Gaussian timing jitter.
               Set to 2 internally.
               - Possibly given a new value in the following subprograms:
                 TRCIN
               - Used but not changed in the following subprograms:
                 TRC
IPOLR(NRMX)    /ANTENN/        I*2     TROCOM.INC
               Array of receiver antenna polarizations.
               - Possibly given a new value in the following subprograms:
                 ANTGEO  INDATA
               - Used but not changed in the following subprograms:
                 LOOPS   OUTDAT  STPPAR  SUMPAG
IPOLT(NTMX)    /ANTENN/        I*2     TROCOM.INC
               Array of transmitter antenna polarizations.
               - Possibly given a new value in the following subprograms:
                 ANTGEO  INDATA
               - Used but not changed in the following subprograms:
                 LOOPS   OUTDAT  SUMPAG
IPOS           /PDATA/         I*2     PDATA.INC
               Number of delay cells exceeding the last allocated
               array element.  This number should be zero or small.
               IPOS > 0 is not a serious error unless the delay
               profile calculated has a clear peak in the last delay
               cell.
               - Possibly given a new value in the following subprograms:
                 LOOPS
               - Used but not changed in the following subprograms:
                 SUMPAG
IPROF(NCORMX)  /PDATA/         I*2     PDATA.INC
```

0 if the Ith correlation not wanted, 1 if wanted.
- Possibly given a new value in the following subprograms:
  LOOPS
- Used but not changed in the following subprograms:
  SIM SUMPAG

IPROFL /SYSPAR/ I*2 SYSPAR.INC
Parameter that indicates whether troposcatter power per unit delay profile of the form X exp (-A*X) is to be used (IPROFL = 0) or not. Set to zero in TRCIN.
- Possibly given a new value in the following subprograms:
  TRCIN
- Used but not changed in the following subprograms:
  EIGV TIMPAR TRC VARW

IPULS /SYSPAR/ I*2 SYSPAR.INC
Switch to indicate whether pulse shape at input of the AN/TRC-170 detector includes the effects of RF filters (IPULS = 2) or not (IPULS = 0 or 1). Set to 2 internally. If IBW is 0, set to 1.
- Possibly given a new value in the following subprograms:
  TRCIN
- Used but not changed in the following subprograms:
  P2INT TRC TXPULS

IRF /PATHGE/ I*2 TROCOM.INC
Parameter which indicates whether reference horizon elevation angles have been calculated (IRF = 1) in previous run. It has meaning only when ITOFF = 3.
- Possibly given a new value in the following subprograms:
  TRANSF

IRSN /NUMPAR/ I*2 NUMPAR.INC
Number of values in SNR array RSNRSN(30). Used to calculate ISI statistics for AN/TRC-170. Initially set to 30.
- Used but not changed in the following subprograms:
  POUTAG

ISN /IOUT/ I*2 IOUT.INC
Number of SNR values for which short-term performance of AN/TRC-170 is to be performed. Set to 17.
- Possibly given a new value in the following subprograms:
  TRCIN
- Used but not changed in the following subprograms:
  TRC

IT /IOUT/ I*2 IOUT.INC
Number of different sampling times to be used in calculation of AN/TRC-170 short term performance.
- Used but not changed in the following subprograms:
  TRC

ITER /PDATA/ I*4 PDATA.INC
Number of integration cells in the common volume integration.
- Possibly given a new value in the following subprograms:

```
                 LOOPS
                - Used but not changed in the following subprograms:
                  POWER   SUMPAG
ITOFF           /PROPAR/        I*2     TROCOM.INC
                Control indicator for entry or calculation of
                transmit/receive radio horizon angles THET and THER.
                Values have following meanings:
                        0 = Use input THET, THER as reference and
                            actual horizon (default).
                        1 = Calculate reference horizon using HORANG
                            and K equals 1.33.  (Assuming DLT and DLR
                            are non-zero.)  (Option not available.)
                        2 = Calculate reference horizon using HORANG
                            and K equals ERFAC.  (Assuming DLT and DLR
                            are non-zero.)
                        3 = Do not change reference horizons from
                            previous run.  (Option not available.)
                - Possibly given a new value in the following subprograms:
                  INDATA  MAIN    OUTDAT
                - Used but not changed in the following subprograms:
                  TRANSF
JBW             /JAMPAR/        R*4     JAMPAR.INC
                99% interferer bandwidth in MHz.
                - Possibly given a new value in the following subprograms:
                  BUTFIL
                - Used but not changed in the following subprograms:
                  BWJAM
JFILT           /MCOM2/         I*2     MCOM.INC
                Interference covariance matrix calculation indicator.
                Only used when IBW equals 0, otherwise ignored.
                Default is 0.
                        0 = Interferer covariance matrix calculation
                            done in subroutine BOTAC
                        1 = Interferer covariance matrix calculation
                            done in subroutine JAMCOM
                - Used but not changed in the following subprograms:
                  BOTAC   OUTDAT
JPOW            /JAMPAR/        R*4     JAMPAR.INC
                Interferer power density in dBm/Hz: -174 or less
                denotes no interference.  Default is -1000 dBm/Hz.
                - Possibly given a new value in the following subprograms:
                  BUTFIL
                - Used but not changed in the following subprograms:
                  BWJAM
JQ2M            /MCOM4/         I*2     MCOM.INC
                Pointer to centroid of lower beam troposcatter signal
                power per unit delay profile.
                - Possibly given a new value in the following subprograms:
                  POWER
                - Used but not changed in the following subprograms:
```

```
                  CAC     DINT
JREFL            /MCOM2/        I*2     MCOM.INC
                 Indicates whether specular reflection is to be
                 included in interferer covariance matrix calculation
                 (JREFL = 1) or not (JREFL = 0).  Default is 0.
                 - Used but not changed in the following subprograms:
                   JAMCOM
KGAIN            /RZ/           I*2     RZ.INC
                 Integer ratio of bandwidth to data rate.
                 - Possibly given a new value in the following subprograms:
                   POWER
                 - Used but not changed in the following subprograms:
                   CAC     DINT    MDTS    SASEQ   SIGIN   SINT    TRCIN
KISI             /NUMPAR/       I*2     NUMPAR.INC
                 Parameter for calculation of AN/TRC-170 outage
                 probability.  Set to 6 in data statement.
                 - Used but not changed in the following subprograms:
                   POUTAG  TRC
KLIMAT           /PROPAR/       I*2     TROCOM.INC
                 Climate zone indicator.  Default is 0.
                         0 = User supplied climate
                 NBS TN101 climates
                         1 = Continental temperate (CT)
                         2 = Maritime temperate overland (MTL)
                         3 = Maritime temperate oversea (MTS)
                         4 = Maritime subtropical overland (MSL)
                         5 = Continental temperate time block 2 (CT2)
                             (winter afternoon hours) - formerly
                             Maritime subtropical oversea (MSS)
                         6 = Desert, Sahara (DS)
                         7 = Equatorial (EQU)
                         8 = Continental subtropical (CS)
                 MIL-HDBK-417 climates
                         9 = Continental temperate (CT)
                         10 = Maritime temperate overland (MTL)
                         11 = Maritime temperate oversea (MTS)
                         12 = Maritime subtropical (MS)
                         13 = Desert, Sahara (DS)
                         14 = Equatorial (EQU)
                         15 = Continental subtropical (CS)
                         16 = Mediterranean (MED)
                         17 = Polar (POL)
                 - Possibly given a new value in the following subprograms:
                   INDATA
                 - Used but not changed in the following subprograms:
                   AVAIL   POWER
KM               /UNIT/         R*4     IODATA.INC
                 String 'km  ' for units output.
                 - Used but not changed in the following subprograms:
                   INDATA  OUTDAT  UNITS
```

```
ROF          /PROPAR/       I*2    TROCOM.INC
             Actual number of samples in height profile of
             structure constant CN2.  Limited to NPROF samples.
             - Possibly given a new value in the following subprograms:
               INDATA
             - Used but not changed in the following subprograms:
               LOOPS   OUTDAT  RIPROF
NG           /MCOM2/        I*2    MCOM.INC
             Pointer to data array elements containing interferer
             azimuth and elevation angles.
             - Possibly given a new value in the following subprograms:
               MDTS
             - Used but not changed in the following subprograms:
               JAMCOM
EBUG         /LUNS/         I*2    LUNS.INC
             Debug output unit.  Always the same as LOUT but used
             to uniquely identify the write statements.
             - Used but not changed in the following subprograms:
               MATCO
RR           /LUNS/         I*2    LUNS.INC
             Error output unit.
             - Used but not changed in the following subprograms:
               ANTGEO  BUTFIL  BWJAM   CLIME   CLIMIL  CLIMIX  CONVOL  DEIND
               DIFSNR  DIF1    INDATA  LTCORR  MDIF    MDTS    ORDER   POWER
               SEARCH  SECTOR  SIGIN   TANGL   TRC     UNITS
N            /LUNS/         I*2    LUNS.INC
             TROPO.DAT input unit number.
             - Possibly given a new value in the following subprograms:
               INDATA  SECTOR  UNITS
NKNO         /IODATA/       I*2    IODATA.INC
             Link number.
             - Possibly given a new value in the following subprograms:
               INDATA
             - Used but not changed in the following subprograms:
               SUMPAG
SI           /MCOM2/        I*2    MCOM.INC
             Number of future Intersymbol Interference (ISI)
             contributors considered in MD-918 performance
             calculation.  Default is 2.
             - Possibly given a new value in the following subprograms:
               INDATA  SIGIN
             - Used but not changed in the following subprograms:
               MATCO   OUTDAT
AME(20)      /IODATA/       I*2    IODATA.INC
             Link name.  Transmitter site first, receiver site
             second.  Used as link identifier on output files
             FOR002.DAT and SUMPAG.OUT.
             - Possibly given a new value in the following subprograms:
               INDATA
             - Used but not changed in the following subprograms:
```

```
                OUTDAT  SUMPAG
T             /LUNS/          I*2     LUNS.INC
              FOR002.DAT output unit number.
              - Used but not changed in the following subprograms:
                AVAIL   BERCAL  BOTAC   BUTFIL  CLIFIT  CLIMIX  DIFSNR  ERRIO
                ERROR   MAIN    MATCO   MDIF    MDTS    OUTDAT  POWER   PROUT
                SASEQ   SIM     SINT    SUBID   TRC     TRCIN
M             /LUNS/          I*2     LUNS.INC
              SUMPAG.OUT output unit number.
              - Used but not changed in the following subprograms:
                SUMPAG
ITS           /UNIT/          I*2     IODATA.INC
              Integer value that specifies the set of units
              requested by the user.  These units are for path,
              antenna location, angle, and frequency parameters.
              Default is 8.  The given units are defined by bit
              values of LUNITS:
              Bit no.        Meaning of value 0 / 1
                0            english / metric
                1            statute miles / nautical miles
                2            feet / meters
                3            mrad / degrees
                4            GHz / MHz
              Valid LUNITS values are
              0 :   stat. miles  - feet   - milliradians - GHz
              1 :   kilometers   - meters - milliradians - GHz
              2 :   naut. miles  - feet   - milliradians - GHz
              8 :   stat. miles  - feet   - degrees      - GHz
              9 :   kilometers   - meters - degrees      - GHz
              10:   naut.miles   - feet   - degrees      - GHZ
              16:   stat. miles  - feet   - milliradians - MHz
              17:   kilometers   - meters - milliradians - MHz
              18:   naut. miles  - feet   - milliradians - MHz
              24:   stat. miles  - feet   - degrees      - MHz
              25:   kilometers   - meters - degrees      - MHz
              26:   naut. miles  - feet   - degrees      - MHz
              - Possibly given a new value in the following subprograms:
                UNITS
              - Used but not changed in the following subprograms:
                OUTDAT  SUMPAG  UNITCV
G             /MCOM2/         I*2     MCOM.INC
              Number of values of interferer azimuth/elevation pairs
              (JANG) for which outage calculations are to be made.
              Default is 1.
              - Possibly given a new value in the following subprograms:
                INDATA
              - Used but not changed in the following subprograms:
                MDTS    OUTDAT
ST            /ERAD/          I*2     ERAD.INC
              Multipath distribution indicator.
```

```
          0 = Only median multipath spread used(default)
          1 = Multipath distribution used.  (Option not
              currently available.)
    - Used but not changed in the following subprograms:
      INDATA  MAIN    POWER   PROUT
    /UNIT/          R*4     IODATA.INC
    String 'met ' for units output.
    - Used but not changed in the following subprograms:
      ANTGEO  OUTDAT  UNITS
    /UNIT/          R*4     IODATA.INC
    String 'MHz ' for units output.
    - Used but not changed in the following subprograms:
      ANTGEO  INDATA  OUTDAT  UNITS
    /PDATA/         I*2     PDATA.INC
    Number of simulator taps.  Default is 16.
    - Possibly given a new value in the following subprograms:
      INDATA
    - Used but not changed in the following subprograms:
      SIM
T   /MCOM2/         I*2     MCOM.INC
    Propagation/modem flag to select calculation mode.
    Default is 1.
          0 = Propagation only
          1 = Propagation + MD-918 modem
          2 = Propagation + AN/TRC-170 or DAR modem
          3 = Propagation + user-defined modem
    - Possibly given a new value in the following subprograms:
      INDATA  POWER
    - Used but not changed in the following subprograms:
      MAIN    OUTDAT  SUMPAG
;   /JAMPAR/        I*2     JAMPAR.INC
    Interference signal modulation format.  Default is 1.
          0 = Analog FDM / FM
          1 = Digital QPSK
    - Possibly given a new value in the following subprograms:
      BUTFIL
    - Used but not changed in the following subprograms:
      BWJAM   PSPJ    TPSPJ
G   /MCOM2/         I*2     MCOM.INC
    Interference signal modulation format.  Default is 1.
          0 = Analog FDM / FM
          1 = Digital QPSK
    - Possibly given a new value in the following subprograms:
      INDATA
    - Used but not changed in the following subprograms:
      MAIN    OUTDAT  SUMPAG
    /ERAD/          I*2     ERAD.INC
    Loop limit for MRAD. Default is 1.
    (MRAD is 1 for MDIST = 0 and MRAD is 3 for MDIST = 1).
    - Possibly given a new value in the following subprograms:
```

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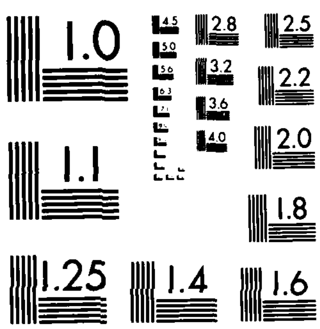


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

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                    INDATA
                  - Used but not changed in the following subprograms:
                    MAIN
MRADNS            /UNIT/          R*4     IODATA.INC
                  String 'mrad' for units output.
                  - Used but not changed in the following subprograms:
                    ANTGEO  OUTDAT  UNITS
NACCU             /CONTRL/        I*2     TROCOM.INC
                  Parameter used as truncation point for common
                  volume integration termination.  Default is 40.
                  - Possibly given a new value in the following subprograms:
                    INDATA
                  - Used but not changed in the following subprograms:
                    LOOPS   OUTDAT  SUMPAG
NANG              /RI2/           I*2     RI2.INC
                  NANG is 1 if there is angle diversity (default).
                  - Possibly given a new value in the following subprograms:
                    INDATA
                  - Used but not changed in the following subprograms:
                    MDTS
NB                /RI2/           I*2     RI2.INC
                  Number of elements accessed in arrays DU, DX and DY.
                  - Used but not changed in the following subprograms:
                    CAJI
NCHIP             /SYSPAR/        I*2     SYSPAR.INC
                  Number of chips in PN sequence used to expand
                  bandwidth in AN/TRC-170.
                  - Possibly given a new value in the following subprograms:
                    TRCIN
                  - Used but not changed in the following subprograms:
                    P2INT   TRC     TXPULS
NCLIME            /MCOM2/         I*2     MCOM.INC
                  Flag set to 1 if ICLIME equals 2.
                  - Possibly given a new value in the following subprograms:
                    INDATA
                  - Used but not changed in the following subprograms:
                    OUTDAT
NCORMX            Parameter       I*2     TROPAR.INC
                  Maximum number of correlations between receive ports.
                  - Used but not changed in the following subprograms:
                    LOOPS   SIM
NCORR             /PDATA/         I*2     PDATA.INC
                  Number of receive port correlations.
                  - Possibly given a new value in the following subprograms:
                    LOOPS
                  - Used but not changed in the following subprograms:
                    POWER   SIM     SUMPAG
NDELMX            Parameter       I*2     TROPAR.INC
                  Maximum number of delay bins in troposcatter power per
                  unit delay profiles.
```

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                       - Used but not changed in the following subprograms:
                         LOOPS   MDIF    POWER   SIM     SUMPAG
      NDELQ            /MCOM4/         I*2     MCOM.INC
                       Number of non-zero elements of troposcatter power per
                       unit delay profiles Q(NDELQ,1).
                       - Possibly given a new value in the following subprograms:
                         POWER
                       - Used but not changed in the following subprograms:
                         CAC     DINT
      NDIVS            /SYSPAR/        I*2     SYSPAR.INC
                       Number of explicit diversity channels for AN/TRC-170.
                       Equal to 4 for 2S/2F and 2 for 2S or 2F.
                       - Possibly given a new value in the following subprograms:
                         TRCIN
                       - Used but not changed in the following subprograms:
                         AVG     TRC     VARW
      NEIGEN           /ANSWER/        I*2     ANSWER.INC
                       Number of implicit diversity eigenvalues (stored in
                       array VEIGV) used in calculation of AN/TRC-170
                       performance.
                       - Possibly given a new value in the following subprograms:
                         EIGV
                       - Used but not changed in the following subprograms:
                         AVG     TRC
      NERT             /MCOM2/         I*2     MCOM.INC
                       Bit error rate threshold indicator for yearly fade
                       outage probability calculation.  Default is 2.
                               0 = All three thresholds
                               1 = For 10**(-3) only
                               2 = For 10**(-4) only
                               3 = For 10**(-5) only
                       - Possibly given a new value in the following subprograms:
                         INDATA
                       - Used but not changed in the following subprograms:
                         BERCAL  MAIN    MDTS    OUTDAT  SUMPAG
      NEWCL(4)         /MCOM2/         I*2     MCOM.INC
                       New climate type character string.
                       - Possibly given a new value in the following subprograms:
                         INDATA
                       - Used but not changed in the following subprograms:
                         OUTDAT  SUMPAG
      NFIG             /MCOM4/         R*4     MCOM.INC
                       Receiver noise figure in dB.  Default is 4dB.
                       - Possibly given a new value in the following subprograms:
                         INDATA
                       - Used but not changed in the following subprograms:
                         DIFSNR  OUTDAT  POWER
      NIP              /RZ/            I*2
                       Initialization constant for numerical equalizer
                       covariance matrix calculation.
```

- Possibly given a new value in the following subprograms:
  MDTS
- Used but not changed in the following subprograms:
  CAC

**NJR** /RZ4/ I*2 RZ4.INC

Number of sample points for RJCOR.
- Possibly given a new value in the following subprograms:
  BUTFIL
- Used but not changed in the following subprograms:
  BOTAC

**NMI** /UNIT/ R*4 IODATA.INC

String 'nmi ' for units output.
- Used but not changed in the following subprograms:
  OUTDAT UNITS

**NOBS** /MCOM2/ I*2 MCOM.INC

Number of diffraction obstacles. Maximum is 3, default is 1.
- Possibly given a new value in the following subprograms:
  INDATA
- Used but not changed in the following subprograms:
  DIFSNR MAIN OUTDAT POWER

**NOW(8)** /TSTAMP/ L*1 IODATA.INC

Array used in PDP-11/70 version to hold time of day as characters.
- Used but not changed in the following subprograms:
  MAIN OUTDAT SUMPAG

**NPM(5)** /MCOM2/ I*2 MCOM.INC

Array containing number of terrain elevation data points for calculation of effective antenna heights for each section of the diffraction path.
- Possibly given a new value in the following subprograms:
  INDATA
- Used but not changed in the following subprograms:
  DIFSNR OUTDAT POWER

**NPOINT** /NUMPAR/ I*2 NUMPAR.INC

Number of points for numerical integration.
- Used but not changed in the following subprograms:
  TRC

**NPOLJ** /JAMPAR/ I*2 JAMPAR.INC

Number of poles in the QPSK interference filter.
- Possibly given a new value in the following subprograms:
  BWJAM
- Used but not changed in the following subprograms:
  PSPJ TPSPJ

**NPOLRX** /BUTPAR/ R*4 BUTPAR.INC

Number of poles in the receive Butterworth filter.
- Possibly given a new value in the following subprograms:
  BWJAM INDATA SEARCH
- Used but not changed in the following subprograms:
  BUTFIL FUNJAM PSPEC1 PSPEC2 PWRSPC SPEC1

**NPOLTX** /BUTPAR/ I*2 BUTPAR.INC
Number of poles in the transmit Butterworth filter.
- Possibly given a new value in the following subprograms:
  BWJAM INDATA SEARCH
- Used but not changed in the following subprograms:
  A50FCC BUTFIL FUNBW PSPJ SPEC1 SPEC2 TPSPJ

**NPROF** Parameter I*2 TROPAR.INC
Dimension of array containing the structure constant height profile (CN2).
-- Not used --

**NR** /SYSTRN/ I*2 TROCOM.INC
Number of receive ports.
- Possibly given a new value in the following subprograms:
  ANTGEO INDATA
- Used but not changed in the following subprograms:
  CHKDAT INTLIM LOOPS MAIN OUTDAT STPPAR SUMPAG TRANSF UNITCV

**NRAD** /ERAD/ I*2 ERAD.INC
ERFAC indicator and loop counter. Default is 1.
- Used but not changed in the following subprograms:
  MAIN POWER PROUT

**NRMX** Parameter I*2 TROPAR.INC
Maximum number of receive ports.
- Used but not changed in the following subprograms:
  ANTPAR CHKDAT

**NT** /SYSTRN/ I*2 TROCOM.INC
Number of transmit ports.
- Possibly given a new value in the following subprograms:
  ANTGEO INDATA
- Used but not changed in the following subprograms:
  CHKDAT INTLIM LOOPS MAIN OUTDAT STPPAR SUMPAG TRANSF UNITCV

**NTAP** /MCOM2/ I*2 MCOM.INC
Number of adaptive forward equalizer taps (AFE) in MD-918 modem. Set to 3 in INDATA.
- Used but not changed in the following subprograms:
  OUTDAT SIGIN

**NTERR** /MCOM2/ I*2 MCOM.INC
Control parameter for entry or calculation of effective antenna heights (HTE, HRE) and effective obstacle heights above average terrain elevation (HLEF).

0 = HTE and HRE supplied directly
1 = AVETX and AVERX supplied
2 = HI(.) supplied

- Possibly given a new value in the following subprograms:
  INDATA
- Used but not changed in the following subprograms:
  DIFSNR OUTDAT POWER

**NTH1** /IOUT/ I*2 IOUT.INC

```
                Pointer to largest bit error rate threshold of
                interest for AN/TRC-170 outage probability
                calculation.
                - Possibly given a new value in the following subprograms:
                  TRCIN
                - Used but not changed in the following subprograms:
                  TRC
NTH2            /IOUT/          I*2     IOUT.INC
                Pointer to smallest bit error rate threshold of
                interest for AN/TRC-170 outage probability
                calculation.
                - Possibly given a new value in the following subprograms:
                  TRCIN
                - Used but not changed in the following subprograms:
                  TRC
NTHR            /SYSPAR/        I*2     SYSPAR.INC
                Pointer to bit error rate threshold for AN/TRC-170
                outage probability calculation.
                - Used but not changed in the following subprograms:
                  POUTAG  TRC     TRCIN
NTMX            Parameter       I*2     TROPAR.INC
                Maximum number of transmit ports.
                - Used but not changed in the following subprograms:
                  ANTPAR  CHKDAT
NTR             /RZ4/           I*2     RZ4.INC
                Number of samples for calculating transmit-receive
                filter impulse response (TRFILT).
                - Used but not changed in the following subprograms:
                  BUTFIL  CAC     TXPULS
NUMVC           /SYSTRN/        I*2     TROCOM.INC
                Number of voice channels in analog troposcatter
                system.  Default is 72.
                -- Not used --
NV              /NUMPAR/        I*2     NUMPAR.INC
                Normalization parameter for calculation of AN/TRC-170
                signal gain.  Set to 18.
                - Used but not changed in the following subprograms:
                  TRC
PAVG(20,20)     /ANSWER/        R*4     ANSWER.INC
                Short-term average bit error rate for each sampling
                time and short-term average SNR.
                - Possibly given a new value in the following subprograms:
                  TRC
PCON            /RZ/            R*8     RZ.INC
                Normalization factor for probability integral.
                - Possibly given a new value in the following subprograms:
                  MDTS
                - Used but not changed in the following subprograms:
                  CAC
PDUR            /SYSPAR/        R*4     SYSPAR.INC
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                  Symbol pulse duration.
                  - Possibly given a new value in the following subprograms:
                    TRC
                  - Used but not changed in the following subprograms:
                    P2INT   TXPULS
PEAKAV            /RZ4/          R*4     RZ4.INC
                  Peak-to-average loss due to RF filtering in dB.
                  - Possibly given a new value in the following subprograms:
                    BUTFIL  MDTS    TRCIN
                  - Used but not changed in the following subprograms:
                    TRC
PENERG            /BUTPAR/       R*4     BUTPAR.INC
                  Normalized energy of filter.
                  - Used but not changed in the following subprograms:
                    A50FCC  BUTFIL  BWJAM   FUNBW
PFACT(3)          /ERAD/         R*4     ERAD.INC
                  Cumulative probability distribution for effective
                  earth radius factor.
                          For NRAD = 1    PFACT = 0.89
                                   = 2          = 0.1
                                   = 3          = 0.01
                  - Used but not changed in the following subprograms:
                    PROUT
PHDIV             /MCOM4/        R*4     MCOM.INC
                  Squint angle between upper and lower receiver beams in
                  radians.  Default is beamwidth.
                  - Possibly given a new value in the following subprograms:
                    ANTGEO  INDATA  UNITCV
                  - Used but not changed in the following subprograms:
                    DIFSNR  LTCORR  OUTDAT
PHI               /PATHGE/       R*4     TROCOM.INC
                  Diffraction angle in radians.
                  - Possibly given a new value in the following subprograms:
                    INTLIM  TRANSF  UNITCV
PHIR              /PATHGE/       R*4     TROCOM.INC
                  Receive angular distance to minimum scattering point
                  in radians.
                  - Possibly given a new value in the following subprograms:
                    TRANSF  UNITCV
PHIT              /PATHGE/       R*4     TROCOM.INC
                  Transmit angular distance to minimum scattering point
                  in radians.
                  - Possibly given a new value in the following subprograms:
                    TRANSF  UNITCV
PI                /CONSTA/       R*4     CONSTANTS.INC
                  Constant Pi = 3.141592654.
                  - Used but not changed in the following subprograms:
                    ANTGEO  BUTFIL  DIF1    FFT     GPATT   JAMCOM  MDIF    PSPEC
                    PSPJ    SEARCH  SINC    SPEC    TPSPEC  TPSPJ   VARPOL
PJ                /JAMPAR/       R*4     JAMPAR.INC
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                Normalization constant for interference calculations.
                - Possibly given a new value in the following subprograms:
                  BWJAM
                - Used but not changed in the following subprograms:
                  BUTFIL  FUNJAM
PLOSS1          /ERAD/          R*4     ERAD.INC
                Reference troposcatter path loss in dB on lower beam
                for NRAD equals 1.
                - Possibly given a new value in the following subprograms:
                  POWER
PLOSSM          /PDATA/         R*4     PDATA.INC
                Troposcatter path loss from approximate analytic
                expression.
                - Possibly given a new value in the following subprograms:
                  LOOPS
                - Used but not changed in the following subprograms:
                  SUMPAG
POUT(20,20,3)   /ANSWER/        R*4     ANSWER.INC
                AN/TRC-170 outage probability and average bit error
                rate as a function of sampling time, short-term
                average SNR and error rate threshold.
                - Possibly given a new value in the following subprograms:
                  TRC
PRAD(3)         /ERAD/          R*4     ERAD.INC
                Fraction of time effective earth radius factor is
                greater than ERFAC; Probability that effective earth
                radius factor is not exceeded.
                        For NRAD = 1    PRAD = 0.5
                                 = 2         = 0.1
                                 = 3         = 0.01
                - Used but not changed in the following subprograms:
                  POWER
PSIRAO(NRMX)    /ANTENN/        R*4     TROCOM.INC
                Array of receiver beam azimuths in radians.
                - Possibly given a new value in the following subprograms:
                  ANTGEO  INDATA  UNITCV
                - Used but not changed in the following subprograms:
                  CHKDAT  INTLIM  LOOPS   OUTDAT  SUMPAG  TRLOSS
PSIREO(NRMX)    /ANTENN/        R*4     TROCOM.INC
                Array of receiver beam boresight elevations above
                radio horizon in radians, ie, angle at which each
                antenna is aimed relative to the horizon.  PSIREO(1)
                is the main receive antenna.
                - Possibly given a new value in the following subprograms:
                  ANTGEO  INDATA  TRANSF  UNITCV
                - Used but not changed in the following subprograms:
                  CHKDAT  DIFSNR  INTLIM  JAMCOM  LOOPS   OUTDAT  POWER   SUMPAG
                  TRLOSS
PSITAO(NTMX)    /ANTENN/        R*4     TROCOM.INC
                Array of transmitter beam azimuths in radians.
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                    - Possibly siven a new value in the following subprograms:
                      ANTGEO  INDATA  UNITCV
                    - Used but not chansed in the following subprograms:
                      CHKDAT  INTLIM  LOOPS   OUTDAT  SUMPAG
PSITEO(NTMX)        /ANTENN/         R*4      TROCOM.INC
                    Array of transmitter beam boresight elevations above
                    radio horizon in radians, ie, angle at which each
                    antenna is aimed relative to the horizon.  PSITEO(1)
                    is the main transmit antenna.
                    - Possibly siven a new value in the following subprograms:
                      ANTGEO  INDATA  TRANSF  UNITCV
                    - Used but not chansed in the following subprograms:
                      CHKDAT  DIFSNR  INTLIM  LOOPS   OUTDAT  POWER   SUMPAG  TRLOSS
PULSE               /RZ/             I*2      RZ.INC
                    Switch controlling MD-918 pulse shape after
                    transmitter-receiver filtering.
                            PULSE = 0   Triangle
                                  = 1   OQPSK matched filter
                                  = 2   Sinc pulse, bandwidth equal to 1
                                  = 5   RF filtering included
                    Set to 0 if IBW = 0 or KGAIN > 1.
                    Set to 5 if IBW > 0 and KGAIN = 1.
                    - Possibly siven a new value in the following subprograms:
                      INDATA  SIGIN
                    - Used but not chansed in the following subprograms:
                      CAC     CAJI    DINT    SINT
PXMIT               /MCOM4/          R*4      MCOM.INC
                    Rated transmission power in dBm.  Default is 70dBm.
                    - Possibly siven a new value in the following subprograms:
                      INDATA
                    - Used but not chansed in the following subprograms:
                      DIFSNR  OUTDAT  POWER
Q(NDELMX,NCORMX) /PDATA/             R*4      PDATA.INC
                    Matrix of troposcatter signal power and correlation
                    per unit delay profiles.
                    For DIVTYP = 0:
                       Q(.,1)  Power on lower beam vs. delay.
                       Q(.,2)  Correlation between lower and
                               upper beam vs. delay.
                       Q(.,3)  Correlation between lower beams
                               in antennas 1 & 2 vs. delay.
                       Q(.,4)  Power on upper beam vs. delay.
                       Q(.,7)  Power on diffraction path vs. delay
                    For DIVTYP = 1:
                       Q(.,1)  Power on lower beam vs. delay.
                       Q(.,2)  Correlation between lower and
                               upper beam vs. delay.
                       Q(.,3)  Power on upper beam vs. delay
                       Q(.,7)  Power on diffraction path vs. delay.
                    For DIVTYP = 2:
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                          Q(.,1)  Power on path 1 (lower beam) vs. delay.
                          Q(.,2)  Correlation between convergent paths
                                  (lower beam) vs. delay.
                          Q(.,3)  Correlation between divergent paths
                                  (lower beam) vs. delay.
                          Q(.,4)  Correlation between parallel paths
                                  (lower beam) vs. delay.
                          Q(.,5)  Correlation between crossing paths
                                  (lower beam) vs. delay.
                          Q(.,6)  Power on path of upper beam vs. delay.
                          Q(.,7)  Power on diffraction path vs. delay.
                       - Possibly given a new value in the following subprograms:
                         LOOPS   MDIF    POWER
                       - Used but not changed in the following subprograms:
                         MAIN    SIM     SUMPAG
QCORR(NCORMX)          /PDATA/         R*4     PDATA.INC
                       Contains elements of covariance matrix, ie, powers and
                       correlations.
                       For DIVTYP = 0:
                          QCORR(1) Power on lower beam
                          QCORR(2) Correlation coefficient between lower
                                   and upper beam.
                          QCORR(3) Correlation coefficient between lower
                                   beams of antennas 1 and 2
                          QCORR(4) Power on upper beam.
                       For DIVTYP = 1:
                          QCORR(1) Power on lower beam
                          QCORR(2) Correlation coefficient between lower
                                   and upper beam.
                          QCORR(3) Power on upper beam.
                       For DIVTYP = 2:
                          QCORR(1) Power on path 1 (lower beam)
                          QCORR(2) Correlation coefficient between convergent
                                   paths.
                          QCORR(3) Correlation coefficient between divergent
                                   paths.
                          QCORR(4) Correlation coefficient between parallel
                                   paths.
                          QCORR(5) Correlation coefficient between crossing
                                   paths.
                          QCORR(6) Power on upper beam.
                       - Possibly given a new value in the following subprograms:
                         LOOPS
                       - Used but not changed in the following subprograms:
                         POWER   SUMPAG
RCOR(32)               /RZ4/           R*4     RZ4.INC
                       Correlation function of the receive filter in steps
                       equal to the tapwidth (TAPW) for MD-918 modem, or
                       equal to 1/RATE for AN/TRC-170 or DAR modem.
                       - Used but not changed in the following subprograms:
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                  BUTFIL  CAJI
RJCOR(129)       /RZ4/          R*4     RZ4.INC
                 Correlation function of interferer-receiver filters at
                 RATE points per symbol interval.
                 - Possibly given a new value in the following subprograms:
                   BUTFIL
RJCORD(129)      /RZ4/          R*4     RZ4.INC
                 Not used anymore but retained to align commons.
                 -- Not used --
RLL              /SYSTRN/       R*4     TROCOM.INC
                 Receiver line losses in dB.  Default is 0 dB.
                 - Possibly given a new value in the following subprograms:
                   INDATA
                 - Used but not changed in the following subprograms:
                   DIFSNR  OUTDAT  POWER   SUMPAG
RSDB             /BUTPAR/       R*4     BUTPAR.INC
                 10 times the base 10 logarithm of the symbol rate
                 minus 60.
                 - Possibly given a new value in the following subprograms:
                   BUTFIL
                 - Used but not changed in the following subprograms:
                   A50FCC  FCCMSK
RSEP(3)          /IODATA/       R*4     IODATA.INC
                 Separation between receive antennas.
                 - Possibly given a new value in the following subprograms:
                   ANTGEO  INDATA
RSNMIN(3)        /NUMPAR/       R*4     NUMPAR.INC
                 SNR threshold corresponding to each bit error rate
                 threshold for AN/TRC-170.
                 - Used but not changed in the following subprograms:
                   POUTAG
RSNRSN(30)       /NUMPAR/       R*4     NUMPAR.INC
                 Set of SNR values for which solution of transcendental
                 function (UPISIM) is tabulated.
                 - Used but not changed in the following subprograms:
                   POUTAG
S                /PATHGE/       R*4     TROCOM.INC
                 Troposcatter path asymmetry parameter.
                 - Possibly given a new value in the following subprograms:
                   TRANSF
                 - Used but not changed in the following subprograms:
                   SUMPAG
S1               /PATHGE/       R*4     TROCOM.INC
                 Troposcatter path asymmetry parameter.
                 - Possibly given a new value in the following subprograms:
                   TRANSF
SCPARM           /PROPAR/       R*4     TROCOM.INC
                 Wavenumber spectrum slope parameter M.  Default is
                 3.66.
                 - Possibly given a new value in the following subprograms:
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                 INDATA
               - Used but not changed in the following subprograms:
                 INTLIM  LOOPS   OUTDAT  STPPAR  SUMPAG  TRLOSS
SEAN           /PROPAR/        R*4     TROCOM.INC
               Minimum monthly median of refractivity at sea level.
               Used to calculate ERFAC if non-zero.
               - Possibly given a new value in the following subprograms:
                 INDATA  MAIN
               - Used but not changed in the following subprograms:
                 AVAIL   OUTDAT
SIGMA          /SYSPAR/        R*4     SYSPAR.INC
               Half the RMS lower beam delay spread normalized
               relative to the symbol duration.
               - Possibly given a new value in the following subprograms:
                 TRCIN
               - Used but not changed in the following subprograms:
                 EIGV    TIMPAR  TRC     VARW
SMI            /UNIT/          R*4     IODATA.INC
               String 'smi ' for units output.
               - Used but not changed in the following subprograms:
                 OUTDAT  UNITS
SNDB(2)        /IOUT/          R*4     IOUT.INC
               Signal to noise ratio in dB.
               - Possibly given a new value in the following subprograms:
                 TRCIN
               - Used but not changed in the following subprograms:
                 TRC
SNR            /SYSPAR/        R*4     SYSPAR.INC
               Signal to noise ratio.
               - Possibly given a new value in the following subprograms:
                 TRC     TRCIN
               - Used but not changed in the following subprograms:
                 PAVERG  POUTAG
SNRBW          /RZ4/           R*4     RZ4.INC
               Signal to noise ratio adjustment for AN/TRC-170 due to
               limited receive filter bandwidth.
               - Possibly given a new value in the following subprograms:
                 BUTFIL
               - Used but not changed in the following subprograms:
                 TRC
SNRF2          /RZ4/           R*4     RZ4.INC
               Parameter to adjust the signal to noise ratio for
               degradation due to interference from another
               frequency.  Only for 2-frequency AN/TRC-170 modem.
               - Possibly given a new value in the following subprograms:
                 BUTFIL
               - Used but not changed in the following subprograms:
                 TRC
SNRJAM         /RZ4/           R*4     RZ4.INC
               Parameter to adjust the signal to noise ratio of
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                  AN/TRC-170 for degradation due to colocated/adjacent
                  channel interference.
                  - Possibly given a new value in the following subprograms:
                    BUTFIL
                  - Used but not changed in the following subprograms:
                    TRC
SP                /MCOM4/         R*4     MCOM.INC
                  Service probability.  Default is .95.
                  - Possibly given a new value in the following subprograms:
                    INDATA
                  - Used but not changed in the following subprograms:
                    DIFSNR  OUTDAT  POWER
SPE               /PDATA/         R*4     PDATA.INC
                  Tap spacing in nanoseconds.  Default is 67 nsec.
                  - Possibly given a new value in the following subprograms:
                    INDATA
                  - Used but not changed in the following subprograms:
                    SIM
SPREAD(NCORMX)    /PDATA/         R*4     PDATA.INC
                  Array of delay spreads (2-sigma) for each beam in
                  seconds.
                  - Used but not changed in the following subprograms:
                    POWER   SUMPAG
STSNR             /SUMP/          R*4     SUMP.INC
                  Standard deviation of troposcatter signal long-term
                  SNR distribution in dB.
                  - Possibly given a new value in the following subprograms:
                    POWER
                  - Used but not changed in the following subprograms:
                    MAIN    MDTS    SUMPAG
STSNR1            /SYSPAR/        R*4     SYSPAR.INC
                  Standard deviation of troposcatter signal long-term
                  SNR distribution in dB.  Same as STSNR in /SUMP/.
                  - Possibly given a new value in the following subprograms:
                    TRCIN
                  - Used but not changed in the following subprograms:
                    TRC
SUPRES            /IODATA/        L*4     IODATA.INC
                  Supress long output in SUMPAG if true.
                  Set to TRUE if PTYPE > 9.
                  - Possibly given a new value in the following subprograms:
                    INDATA
                  - Used but not changed in the following subprograms:
                    SUMPAG
TO                /SYSPAR/        R*4     SYSPAR.INC
                  Normalized sampling time for lower beam.
                  - Possibly given a new value in the following subprograms:
                    TIMEQL  TRC
                  - Used but not changed in the following subprograms:
                    EIGV    TIMPAR  VARW
```

```
SASEQ  (Subroutine) outputs to FOR002.DAT the followins variables:
       IASEQ   I*2    LOC    PN chip sequence.

SIM    (Subroutine) outputs to FOR002.DAT the followins variables:
       I       I*2    LOC    Beam number.
       IC1     I*2    LOC    Beam pointer of tap correlation calculation.
       IC2     I*2    LOC    Beam pointer of tap correlation calculation.
       IQ1     I*2    LOC    Beam pointer of tap sain calculation.
       IQ2     I*2    LOC    Beam pointer of tap sain calculation.
       ISPE    I*2    LOC    Tap spacins in nanoseconds.
       I1CORR  I*2    GLO    Array of receivins beams involved in the
                             correlation calculations.
       I2CORR  I*2    GLO    Array of receivins beams involved in the
                             correlation calculations.
       PCF     R*4    LOC    Power correction factor in dB.
       SNEG    R*4    LOC    Attenuation in dB.
       TEMP1   R*4    LOC    Correlation coefficient.

SINT   (Subroutine) outputs to FOR002.DAT the followins variables:
       DU      R*8    GLO    Signal response after PN sequence correlation.

SUBID  (Subroutine) outputs to FOR002.DAT the followins variables:
       SNAME   R*8    ARG    Name of the subprogram that called SUBID.

SUMPAG (Subroutine) outputs to SUMPAG.OUT the followins variables:
       AA      R*4    GLO    Atmospheric absorption loss in dB.
       ALFAO   R*4    GLO    Minimum elevation angle measured from
                             transmitter-to-receiver line to transmit
                             horizon line in radians.
       AR      R*4    GLO    Array of receiver antenna diameters in meters.
                             AR(1)is equivalent to RDIAM in the input file.
       AT      R*4    GLO    Array of transmit antenna diameters in meters.
                             AT(1)is equivalent to TDIAM in the input file.
       BER     R*4    GLO    Bit error rate thresholds of interest.  Set
                             to 1E-3, 1E-4 and 1E-5 in data statement.
       BETAO   R*4    GLO    Minimum elevation angle measured from
                             receiver-to-transmitter line to receiver
                             horizon line in radians.
       BOUT    R*4    ARG    Yearly average fade outage probability for each
                             bit error rate threshold specified and 2S/2F
                             and 2S diversity configurations.
       CLIMAT  R*4    ARG    Climate zone indicator.
       D       R*4    GLO    Great circle distance between transmitter
                             and receiver measured at sea level in meters.
       DE      R*4    GLO    Effective distance for troposcatter path in
                             kilometers.
       DIFLOS  R*4    GLO    Median diffraction path loss in dB for each
                             value in ERFAC distribution.
       DIFRSL  R*4    GLO    Median diffraction signal RSL in dBm for each
                             value in ERFAC distribution.
```

| | | | |
|---|---|---|---|
| | | | upper beam. |
| RSL | R*4 | LOC | Received signal level distribution of scatter component. |
| SNR | R*4 | LOC | SNR per bit distribution of scatter component in dB. |
| SP | R*4 | GLO | Service probability. Default is .95. |
| STSNR | R*4 | GLO | Standard deviation of troposcatter signal long-term SNR distribution in dB. |
| TAU22 | R*8 | ARG | Delay spread on lower beam in nsec. |
| TAU23 | R*8 | ARG | Delay spread on upper beam in nsec. |
| TEMP1 | R*4 | LOC | Reference pathloss of scatter component on lower beam. |
| TEMP2 | R*4 | LOC | Reference pathloss of scatter component on upper beam. |
| THER | R*4 | GLO | Radio horizon elevation angle at receive site in radians. |
| THET | R*4 | GLO | Radio horizon elevation angle at transmit site in radians. |
| TLOSS | R*4 | LOC | Pathloss distribution of scatter component in dB. |
| VDE | R*4 | ARG | Time variability of basic transmission loss in dB. |
| YO | R*4 | LOC | Variability in the RSL and the path loss about the median. |

PROUT (Subroutine) outputs to FOR002.DAT the following variables:

| | | | |
|---|---|---|---|
| ABE | R*4 | ARG | Average 1000-bit block error probability for each configuration. |
| ABEL | R*4 | GLO | Cumulative block error probability for each diversity configuration as specified by DIVTYP (averaged over multipath distribution, if any). |
| BER | R*4 | GLO | Bit error rate thresholds of interest. Set to 1E-3, 1E-4 and 1E-5 in data statement. |
| BOUT | R*4 | ARG | Outage probability for each BER threshold and diversity configuration. |
| BOUTL | R*4 | GLO | Cumulative outage probability for each diversity configuration and error rate threshold (averaged over multipath distribution, if any). |
| FOUT | R*4 | ARG | Fade outage per call minute for each BER threshold and diversity configuration: |
| FOUTL | R*4 | GLO | Cumulative fade outage per call minute for each diversity configuration and error rate threshold (averaged over multipath distribution, if any). |
| NOUT | I*2 | ARG | Total number of short term calculations performed. |
| P | R*4 | LOC | Same as BER above. |

OUTDAT (Subroutine) outputs to FOR002.DAT the followins variables:
(This output is merely a summary of the input variables which are fully described in section 3.2 of the User's Manual.)

POWER (Subroutine) outputs to FOR002.DAT the followins variables:

| | | | |
|---|---|---|---|
| AA | R*4 | GLO | Atmospheric absorption loss in dB. |
| ASNR | R*4 | ARG | Median and/or yearly average value of troposcatter sisnal SNR in dB. |
| AVERX | R*4 | GLO | Average terrain elevation above sea level between receive site and radio horizon, in meters. |
| AVETX | R*4 | GLO | Average terrain elevation above sea level between transmit site and radio horizon, in meters. |
| BWR | R*4 | ARG | Transmit antenna beamwidth in desrees. |
| BWT | R*4 | ARG | Receive antenna beamwidth in desrees. |
| CORRLT | R*4 | GLO | Correlation coefficient for lons term variability of lower and upper beams. |
| CPL | R*4 | GLO | Correlation coefficient for lons term variability of lower and upper beams. |
| DE | R*4 | GLO | Effective distance for troposcatter path in kilometers. |
| DEL1 | R*4 | LOC | Relative average delay of lower beam in nanoseconds. |
| DEL2 | R*4 | LOC | Relative average delay of upper beam in nanoseconds. |
| DSP1 | R*4 | GLO | Lower beam troposcatter sisnal RMS delay spread in nanoseconds for percentiles 50, 90 and 99. |
| DSP2 | R*4 | GLO | Upper beam troposcatter sisnal RMS delay spread in nanoseconds for percentiles 50, 90 and 99. |
| ERFAC | R*4 | GLO | Yearly median value of effective earth radius factor k in kilometers. Default is 1.33. |
| HRE | R*4 | GLO | Effective receiver antenna heisht above average terrain elevation in meters. |
| HTE | R*4 | GLO | Effective transmitter antenna heisht above average terrain elevation in meters. |
| IBLOSS | I*2 | GLO | Beam number correspondins to CPL(I). |
| ITER | I*2 | GLO | Number of intesration cells in the common volume intesration. |
| PMED | R*4 | LOC | Short term median pathloss. |
| PRAD | R*4 | GLO | Fraction of time effective earth radius factor is sreater than ERFAC; Probability that effective earth radius factor is not exceeded.<br>For NRAD = 1 PRAD = 0.5<br>= 2 = 0.1<br>= 3 = 0.01 |
| RH1 | R*8 | ARG | Correlation coeffiecient between lower and |

MATCO (Subroutine) outputs to FOR002.DAT the following variables:

| | | | |
|---|---|---|---|
| A | R*4 | ARG | Noise matrix for AFE taps. |
| C | R*4 | ARG | Covariance matrix for AFE taps. |
| CSUM | R*4 | ARG | ISI matrix for AFE taps. |

MDIF (Subroutine) outputs to FOR002.DAT the following variables:

| | | | |
|---|---|---|---|
| AV1 | R*4 | LOC | Diffraction loss in dB. |
| AV2 | R*4 | LOC | Diffraction loss in dB. |
| DELE9 | R*4 | LOC | Diffraction path relative delay in nsec. |
| D1E3 | R*4 | LOC | Reference delay in msec. |
| K | I*2 | LOC | Edge number. |
| LB | R*4 | ARG | Long term reference basic path loss in dB. |
| LDIF | R*4 | LOC | Diffraction loss in dB. |
| LF | R*4 | LOC | Free-space loss in dB. |
| PHI | R*4 | LOC | Diffraction angle. |
| RC | R*4 | LOC | Radius of curvature in meters. |

MDTS (Subroutine) outputs to FOR002.DAT the following variables:

| | | | |
|---|---|---|---|
| ASEP | R*4 | ARG | Receiver antenna separation in meters. |
| ASEQ | I*2 | LOC | PN chip sequence. |
| CGAIN | R*4 | LOC | Coding gain at specified error rate threshold. |
| CRATE | R*4 | LOC | Code rate. |
| DBLOSS | R*8 | LOC | Attenuation of interference due to sidelobes of receiving antenna. |
| DEL | R*4 | GLO | Diffraction path delay relative to a straight line path in seconds. |
| DEX | R*8 | LOC | Determinant of SNR matrix. |
| DGRMOD | R*4 | LOC | Modem degradation in dB. |
| DSNR | R*4 | LOC | Diffraction component SNR in dB. |
| FSIG | R*4 | LOC | Mean tap amplitudes. |
| JANG | R*8 | LOC | Interference angle of incidence. |
| JBWX | R*8 | LOC | Interfering signal bandwidth. |
| KGAIN | I*2 | GLO | Integer ratio of bandwidth to data rate. |
| PEAKAV | R*4 | GLO | Peak-to-average loss due to RF filtering in dB. |
| SNR | R*4 | LOC | Scatter component SNR in dB. |
| TDIFF | R*4 | GLO | Normalized relative delay between lower and upper beam. |
| TEMPA | R*4 | ARG | Average relative delay of scatter component. |
| TSCAT | R*4 | LOC | Normalized relative delay of scatter component. |
| TZ | R*4 | LOC | Interferer normalized delay difference on two antennas. |
| TO | R*4 | LOC | Normalized sampling time for AFE center tap. |
| U | R*8 | LOC | Implicit diversity eigenvalues. |
| XDIFR | R*4 | LOC | Fraction of received power due to diffraction component. |
| XSCAT | R*4 | LOC | Fraction of received power due to scatter component. |
| Z | R*4 | LOC | Transformed mean tap values. |

```
                              1 = (not allowed)
                              2 = AN/TRC-170 receiver filter.  Also means
                              filter is a Butterworth.
IFILTX   I*2     GLO          Transmitter filter indicator.
                              0 = MD-918 transmitter filter.  Also means
                                  filter is a Butterworth cascaded with a
                                  rectangular impulse response filter of
                                  duration equal to symbol duration.
                              1 = AN/TRC-170 transmitter filter.  Also means
                                  filter is a cascade of Butterworth filter
                                  with rectangular impulse response filter
                                  of duration equal to half symbol duration.
                              2 = (not allowed)
NPOLRX   I*2     GLO          Number of poles in the receive Butterworth
                              filter.
NPOLTX   I*2     GLO          Number of poles in the transmit Butterworth
                              filter.
PEAKAV   R*4     GLO          Peak-to-average loss due to RF filtering in dB.
TEMP1    R*4     LOC          99% bandwidth in MHz.

CLIFIT (Subroutine) outputs to FOR002.DAT the following variables:
ALFA     R*4     LOC          Constant in user defined 90% variability curve.
BETA     R*4     LOC          Constant in user defined 90% variability curve.
CF       R*4     LOC          Constant in user defined 90% variability curve.
C0       R*4     LOC          Constant in user defined 90% variability curve.
C1       R*4     LOC          Constant in user defined 90% variability curve.
C2       R*4     LOC          Constant in user defined 90% variability curve.

DIFSNR (Subroutine) outputs to FOR002.DAT the following variables:
ASNR     R*4     ARG          Median and/or yearly average value of
                              diffraction path SNR in dB.
DLOSS    R*4     LOC          Diffraction pathloss distribution.
DSTSNR   R*4     GLO          Standard deviation of diffracted signal
                              long-term SNR distribution in dB.
DUPOWL   R*4     LOC          Ratio of diffraction signal on upper beam
                              to that on lower beam in dB.
QT       R*4     LOC          Percentile not exceeded.
RSL      R*4     LOC          Received signal level distribution of
                              diffraction component in dBm.
SNR      R*4     LOC          SNR per bit distribution of diffraction
                              component in dB.
SP       R*4     GLO          Service probability.  Default is .95.

ERRIO  (Subroutine) outputs to FOR002.DAT the following variables:
I        I*2     ARG          Error number.  This is followed by the
                              corresponding error message.

ERROR  (Subroutine) outputs to FOR002.DAT the following variables:
I        I*2     ARG          Error number.  This is followed by the
                              corresponding error message.
```

## UTPUT VARIABLES

### D.1 Output Variable Definitions

AVAIL (Subroutine) outputs to FOR002.DAT the following variables:

| | | | |
|---|---|---|---|
| I | I*2 | LOC | Section of diffraction path with Fresnel zone blockage. |
| PLOSS | R*4 | LOC | Pathloss distribution of diffraction component. |
| QT | R*4 | ARG | Array containing percent of time pathloss is not exceeded, i.e. time availability. |
| SIG | R*4 | LOC | Standard deviation of predicted pathloss. |
| V1 | R*4 | LOC | Variability distribution about reference pathloss for diffraction component. |
| Y | R*4 | ARG | Array containing pathloss variability distribution about the median in dB. |

BERCAL (Subroutine) outputs to FOR002.DAT the following variables:

| | | | |
|---|---|---|---|
| BERAV | R*4 | LOC | Short term average bit error rate. |
| DSNR | R*4 | ARG | Specular component SNR in dB. |
| FCMIN | R*4 | LOC | Fade outage per call minute. |
| ID | I*2 | LOC | Explicit diversities on the main beam. |
| ITOT | I*2 | LOC | Total number of explicity diversities. |
| JPOW | R*8 | ARG | Interferer power density in dBm/Hz. |
| JSR | R*8 | ARG | Interferer to signal power ratio in dB. |
| P | R*8 | LOC | Error rate outage threshold. |
| PFO | R*8 | LOC | Probability that bit error rate exceeds threshold; short term outage probability. |
| SNR | R*4 | ARG | Mean hourly SNR in dB at which outage probability is to be calculated. |
| SUM2 | R*4 | LOC | 2 times average bit error probability if only one independent diversity. Otherwise 1000-bit block error probability. |
| XTYPE | R*8 | LOC | Outputs the string identifying the diversity type. |

BOTAC (Subroutine) outputs to FOR002.DAT the following variables:

| | | | |
|---|---|---|---|
| K1 | I*2 | ARG | Number of taps in forward equalizer. |
| TAC | R*4 | ARG | Interferer covariance matrix calculated according to RF filtering specified through IBW and JFILT parameters. |
| TAPW | R*4 | GLO | Normalized tapwidth for MD-918. Default is .5. Range is 0.25 through 1.0 |

BUTFIL (Subroutine) outputs to FOR002.DAT the following variables:

| | | | |
|---|---|---|---|
| FCUT | R*4 | LOC | Transmission bandwidth in MHz. |
| FCUT1 | R*4 | LOC | Cut-off frequency for the transmitter. |
| FCUT2 | R*4 | LOC | Cut-off frequency for the receiver. |
| IFILRX | I*2 | GLO | Receiver filter indicator.<br>0 = MD-918 receiver filter. Also means filter is a Butterworth cascaded with a rectangular impulse response filter of duration equal to symbol duration. |

# APPENDIX D

## OUTPUT VARIABLES

This appendix describes all variables written to the output files, FOR002.DAT and SUMPAG.OUT. In the following descriptions each variable is identified by type and where it came from, ie, LOC for local, GLO for global, ARG for arguments.

The type, for variables is given as three characters:

| | |
|---|---|
| L*1 | 1 byte LOGICAL (BYTE in the PDP version) |
| L*4 | 4 byte LOGICAL |
| I*2 | 2 byte INTEGER |
| I*4 | 4 byte INTEGER |
| R*4 | 4 byte REAL |
| R*8 | 8 byte REAL |
| C*8 | 8 byte COMPLEX |

```
                    CAC     TXPULS
Y1                  /PATHGE/          R*4     TROCOM.INC
                    Maximum estimated integration length in Y-direction.
                    - Possibly given a new value in the following subprograms:
                      INTLIM  UNITCV
                    - Used but not changed in the following subprograms:
                      LOOPS
Y900                /CURVE/           R*4     CURVE.INC
                    User supplied value for 90th percentile variability
                    curve Y0(90) for DE greater than or equal 900 km.
                    Used only when ICLIME is 2.  Used to compute the
                    equation for the Y0(90) curve fit.
                    - Possibly given a new value in the following subprograms:
                      CLIMIL  INDATA
                    - Used but not changed in the following subprograms:
                      CLIFIT  OUTDAT
YMIN                /CURVE/           R*4     CURVE.INC
                    User supplied value for 90th percentile variability
                    curve Y0(90) for DE equal to DEMIN.  Used only when
                    ICLIME is 2.  Used to compute the equation for the
                    Y0(90) curve fit.
                    - Possibly given a new value in the following subprograms:
                      CLIMIL  INDATA
                    - Used but not changed in the following subprograms:
                      CLIFIT  OUTDAT
YZERO               /CURVE/           R*4     CURVE.INC
                    User supplied value for 90th percentile variability
                    curve Y0(90) for DE equal to 0.  Used only when ICLIME
                    is 2.
                    - Possibly given a new value in the following subprograms:
                      CLIMIL  INDATA
                    - Used but not changed in the following subprograms:
                      CLIFIT  OUTDAT
```

```
                    PSPJ    TPSPJ
WLT                 /SYSTRN/          R*4     TROCOM.INC
                    Rated transmission power in Watts.  Default is 1000 W.
                    - Possibly given a new value in the following subprograms:
                      INDATA
                    - Used but not changed in the following subprograms:
                      OUTDAT  SUMPAG
X2INCR              /NUMPAR/          R*4     NUMPAR.INC
                    Step increment for numerical integration.
                    - Possibly given a new value in the following subprograms:
                      TRC
X3INCR              /NUMPAR/          R*4     NUMPAR.INC
                    Step increment for numerical integration.
                    - Used but not changed in the following subprograms:
                      AVG
XANG(10)            /MCOM4/           R*4     MCOM.INC
                    Interferer azimuth angles in degrees.  Default is 0.
                    - Possibly given a new value in the following subprograms:
                      INDATA
                    - Used but not changed in the following subprograms:
                      MDTS    OUTDAT
XAVAR               /ANSWER/          R*4     ANSWER.INC
                    Standard deviation of past ISI for AN/TRC-170.
                    - Possibly given a new value in the following subprograms:
                      TRC
                    - Used but not changed in the following subprograms:
                      POUTAG
XBVAR               /ANSWER/          R*4     ANSWER.INC
                    Standard deviation of future ISI for AN/TRC-170.
                    - Possibly given a new value in the following subprograms:
                      TRC
                    - Used but not changed in the following subprograms:
                      POUTAG
XINCR               /NUMPAR/          R*4     NUMPAR.INC
                    Step increment for numerical integration.
                    - Possibly given a new value in the following subprograms:
                      TRC
XTRO                /RZ4/             R*4     RZ4.INC
                    Time origin for transmit-receive filter impulse
                    response (TRFILT), ie, X is TRFILT(X+XTRO).
                    - Possibly given a new value in the following subprograms:
                      BUTFIL
                    - Used but not changed in the following subprograms:
                      CAC     TXPULS
XTRINC              /RZ4/             R*4     RZ4.INC
                    Sample interval for calculation of transmit-receive
                    filter impulse response (TRFILT).
                    - Possibly given a new value in the following subprograms:
                      BUTFIL
                    - Used but not changed in the following subprograms:
```

```
                     Array of transmit antennas horizontal offsets in
                     meters.
                     - Possibly siven a new value in the followins subprograms:
                       ANTGEO  INDATA  UNITCV
                     - Used but not chansed in the followins subprograms:
                       CHKDAT  LOOPS   OUTDAT  STPPAR  SUMPAG
UTL(NT)              /PATHGE/       R*4     TROCOM.INC
                     Array of transmit antennas longitudinal offsets in
                     meters.
                     - Possibly siven a new value in the followins subprograms:
                       ANTGEO  INDATA  UNITCV
                     - Used but not chansed in the followins subprograms:
                       CHKDAT  LOOPS   OUTDAT  SUMPAG
UTV(NT)              /PATHGE/       R*4     TROCOM.INC
                     Array of transmit antennas vertical offsets in meters.
                     - Possibly siven a new value in the followins subprograms:
                       ANTGEO  INDATA  UNITCV
                     - Used but not chansed in the followins subprograms:
                       CHKDAT  LOOPS   OUTDAT  SUMPAG
VARAIS               /ANSWER/       R*4     ANSWER.INC
                     Past ISI variance for AN/TRC-170.
                     - Possibly siven a new value in the followins subprograms:
                       TRC
VARBIS               /ANSWER/       R*4     ANSWER.INC
                     Future ISI variance for AN/TRC-170.
                     - Possibly siven a new value in the followins subprograms:
                       TRC
VARISI               /ANSWER/       R*4     ANSWER.INC
                     Total ISI variance for AN/TRC-170.
                     - Possibly siven a new value in the followins subprograms:
                       TRC
                     - Used but not chansed in the followins subprograms:
                       PAVERG
VEIGV(20)            /ANSWER/       R*8     ANSWER.INC
                     Implicit diversity eisenvalues for AN/TRC-170.
                     - Possibly siven a new value in the followins subprograms:
                       EIGV    TRC
                     - Used but not chansed in the followins subprograms:
                       AVG
WAVLEN               /SYSTRN/       R*4     TROCOM.INC
                     Wavelensth in meters.
                     - Possibly siven a new value in the followins subprograms:
                       INDATA
                     - Used but not chansed in the followins subprograms:
                       ANTPAR  LOOPS   RGAIN   STPPAR  TGAIN
WFM                  /JAMPAR/       R*4     JAMPAR.INC
                     Normalization constant for FDM/FM interference.
                     - Possibly siven a new value in the followins subprograms:
                       BWJAM
                     - Used but not chansed in the followins subprograms:
```

```
                    Units of angle (deg, mrad).
                    - Possibly given a new value in the following subprograms:
                      UNITS
                    - Used but not changed in the following subprograms:
                      ANTGEO  OUTDAT  SUMPAG
UDIST               /UNIT/          R*4     IODATA.INC
                    Units of distance (smi, nmi, km).
                    - Possibly given a new value in the following subprograms:
                      UNITS
                    - Used but not changed in the following subprograms:
                      INDATA  OUTDAT  SUMPAG
UFREQ               /UNIT/          R*4     IODATA.INC
                    Units of frequency (GHz, MHz).
                    - Possibly given a new value in the following subprograms:
                      UNITS
                    - Used but not changed in the following subprograms:
                      ANTGEO  INDATA  OUTDAT  SUMPAG
UHITE               /UNIT/          R*4     IODATA.INC
                    Units of height and diameter (ft, m).
                    - Possibly given a new value in the following subprograms:
                      UNITS
                    - Used but not changed in the following subprograms:
                      ANTGEO  OUTDAT  SUMPAG
UPISIM(30,3)        /NUMPAR/        R*4     NUMPAR.INC
                    Solution of transcendental equation for each value of
                    RSNRSN and bit error rate threshold of interest in
                    AN/TRC-170 outage probability calculation.
                    - Used but not changed in the following subprograms:
                      POUTAG
URH(NR)             /PATHGE/        R*4     TROCOM.INC
                    Array of receive antennas horizontal offsets from
                    great circle plane in meters.
                    - Possibly given a new value in the following subprograms:
                      ANTGEO  INDATA  UNITCV
                    - Used but not changed in the following subprograms:
                      CHKDAT  LOOPS   OUTDAT  STPPAR  SUMPAG
URL(NR)             /PATHGE/        R*4     TROCOM.INC
                    Array of receive antennas longitudinal offsets in
                    meters.
                    - Possibly given a new value in the following subprograms:
                      ANTGEO  INDATA  UNITCV
                    - Used but not changed in the following subprograms:
                      CHKDAT  LOOPS   OUTDAT  SUMPAG
URV(NR)             /PATHGE/        R*4     TROCOM.INC
                    Array of receive antennas vertical offsets in meters.
                    - Possibly given a new value in the following subprograms:
                      ANTGEO  INDATA  UNITCV
                    - Used but not changed in the following subprograms:
                      CHKDAT  LOOPS   OUTDAT  SUMPAG
UTH(NT)             /PATHGE/        R*4     TROCOM.INC
```

```
                  INTLIM  LOOPS   LTCORR  SUMPAG
THETRF          /PATHGE/        R*4     TROCOM.INC
                Transmit reference horizon elevation in radians.
                - Possibly given a new value in the following subprograms:
                  TRANSF
TLL             /SYSTRN/        R*4     TROCOM.INC
                Transmitter line losses in dB.  Default is 0 dB.
                - Possibly given a new value in the following subprograms:
                  INDATA
                - Used but not changed in the following subprograms:
                  DIFSNR  OUTDAT  POWER   SUMPAG
TODAY(9)        /TSTAMP/        L*1     IODATA.INC
                Array used in PDP-11 version to hold date as
                characters.
                - Used but not changed in the following subprograms:
                  MAIN    OUTDAT  SUMPAG
TPAR(20)        /ANSWER/        R*4     ANSWER.INC
                Timing parameter for AN/TRC-170.  Calculated when
                IOTIME is 0.
                - Possibly given a new value in the following subprograms:
                  TRC
TRFILT(128)     /RZ4/           R*4     RZ4.INC
                Transmit-receive filter impulse response.
                - Possibly given a new value in the following subprograms:
                  BUTFIL
                - Used but not changed in the following subprograms:
                  CAC     TXPULS
TROLOS(3)       /SUMP/          R*4     CURVE.INC
                Median troposcatter path loss in dB for each value in
                ERFAC distribution.
                - Possibly given a new value in the following subprograms:
                  POWER
                - Used but not changed in the following subprograms:
                  SUMPAG
TRORSL(3)       /SUMP/          R*4     CURVE.INC
                Median troposcatter RSL in dBm for each value in ERFAC
                distribution.
                - Possibly given a new value in the following subprograms:
                  POWER
                - Used but not changed in the following subprograms:
                  SUMPAG
TSEP(3)         /IODATA/        R*4     IODATA.INC
                Separation between transmit antennas in meters.
                - Possibly given a new value in the following subprograms:
                  ANTGEO  INDATA
TWOPI           /CONSTA/        R*4     CONSTANTS.INC
                2 X Pi = 6.283185307.
                - Used but not changed in the following subprograms:
                  LOOPS   RJCFCN  STPPAR
UANGLE          /UNIT/          R*4     IODATA.INC
```

```
                    STEPAB
TFAKY1            /STPCOM/        R*4     STPCOM.INC
                  Constant for common volume integrat.cn.
                  - Possibly given a new value in the following subprograms:
                    STPPAR
                  - Used but not changed in the following subprograms:
                    STEPY
TFAKY2            /STPCOM/        R*4     STPCOM.INC
                  Constant for common volume integration.
                  - Possibly given a new value in the following subprograms:
                    STPPAR
                  - Used but not changed in the following subprograms:
                    STEPY
TFAKY3            /STPCOM/        R*4     STPCOM.INC
                  Constant for common volume integration.
                  - Possibly given a new value in the following subprograms:
                    STPPAR
                  - Used but not changed in the following subprograms:
                    STEPY
TFAKY4            /STPCOM/        R*4     STPCOM.INC
                  Constant for common volume integration.
                  - Possibly given a new value in the following subprograms:
                    STPPAR
                  - Used but not changed in the following subprograms:
                    STEPY
THER              /PATHGE/        R*4     TROCOM.INC
                  Radio horizon elevation angle at receive site in
                  radians.
                  - Possibly given a new value in the following subprograms:
                    INDATA  UNITCV
                  - Used but not changed in the following subprograms:
                    DIFSNR  INTLIM  JAMCOM  LTCORR  MAIN    OUTDAT  POWER   SUMPAG
                    TRANSF
THERRF            /PATHGE/        R*4     TROCOM.INC
                  Receive reference horizon in radians.
                  - Possibly given a new value in the following subprograms:
                    TRANSF
THET              /PATHGE/        R*4     TROCOM.INC
                  Radio horizon elevation angle at transmit site in
                  radians.
                  - Possibly given a new value in the following subprograms:
                    INDATA  UNITCV
                  - Used but not changed in the following subprograms:
                    DIFSNR  INTLIM  LOOPS   MAIN    OUTDAT  POWER   SUMPAG  TRANSF
THETA0            /PATHGE/        R*4     TROCOM.INC
                  Scattering angle at bottom of common volume in
                  radians.
                  - Possibly given a new value in the following subprograms:
                    TRANSF  UNITCV
                  - Used but not changed in the following subprograms:
```

```
TOTO(20)       /IOUT/          R*4    IOUT.INC
               Array of sampling times (normalized to symbol
               duration) for calculation of short term AN/TRC-170
               performance.
               - Used but not changed in the following subprograms:
                 TRC
TAPOUT         /PDATA/         L*4    PDATA.INC
               If true, the simulator tap values are output to the
               output file, FOR002.DAT.  Default is TRUE.
               - Possibly given a new value in the following subprograms:
                 INDATA
               - Used but not changed in the following subprograms:
                 SUMPAG
TAPW           /MCOM4/         R*4    MCOM.INC
               Normalized tapwidth for MD-918.  Default is .5.
               Range is 0.25 through 1.0
               - Possibly given a new value in the following subprograms:
                 INDATA  SIGIN
               - Used but not changed in the following subprograms:
                 BOTAC   CAJI    CAKL    JAMCOM  MAIN    MATCO   OUTDAT
TDEV           /NUMPAR/        R*4    NUMPAR.INC
               Standard deviation of sampling times for AN/TRC-170
               performance calculations.
               - Used but not changed in the following subprograms:
                 TRC
TDIFF          /MCOM4/         R*4    MCOM.INC
               Normalized relative delay between lower and upper
               beam.
               - Possibly given a new value in the following subprograms:
                 MDTS    POWER
               - Used but not changed in the following subprograms:
                 DINT    MATCO
TEMPA(NCORMX)  /PDATA/         R*4    PDATA.INC
               Array of average troposcatter signal delays for each
               beam relative to straight line in seconds.
               - Possibly given a new value in the following subprograms:
                 LOOPS
               - Used but not changed in the following subprograms:
                 MAIN    POWER   SUMPAG
TERFAC(3)      /ERAD/          R*4    ERAD.INC
               The three values of ERFAC when MDIST is 1.
               - Possibly given a new value in the following subprograms:
                 INDATA
               - Used but not changed in the following subprograms:
                 MAIN
TFAK           /STPCOM/        R*4    STPCOM.INC
               Constant for common volume integration.
               - Possibly given a new value in the following subprograms:
                 STPPAR
               - Used but not changed in the following subprograms:
```

| | | | |
|---|---|---|---|
| DIVTYP | I*2 | GLO | Diversity confisuration indicator. Default is 0. |
| DLR | R*4 | GLO | Distance from receiver to radio horizon. |
| DLT | R*4 | GLO | Distance from transmitter to radio horizon. |
| DSTSNR | R*4 | GLO | Standard deviation of diffracted sisnal lons-term SNR distribution in dB. |
| ERFAC | R*4 | GLO | Yearly median value of effective earth radius factor k in kilometers. Default is 1.33. |
| ERR | R*4 | GLO | Intesration resolution. Default is .001. |
| F | R*4 | GLO | Operatins frequency in Hz. |
| FOUT | R*4 | ARG | Yearly averase fade outase probability per call minute for each bit error rate threshold specified and 2S/2F and 2S diversity confisurations. |
| HCOM | R*4 | GLO | Effective heisht of the bottom of the common volume. |
| HHIGH | R*4 | GLO | Effective heisht of the top of the common volume. |
| HLR | R*4 | GLO | Receiver radio horizon elevation above sea level. |
| HLT | R*4 | GLO | Transmit radio horizon elevation above sea level. |
| ITER | I*2 | GLO | Number of intesration cells in the common volume intesration. |
| JPOW | R*8 | ARG | Interference sisnal power density in dBm/Hz. |
| LNAME | I*2 | GLO | Link name. Transmitter site first, receiver site second. Used as link identifier on output files FOR002.DAT and SUMPAG.OUT. |
| LUNITS | I*2 | GLO | Inteser value that specifies the set of units requested by the user. These units are for path, antenna location, ansle, and frequency parameters. Default is 8. |
| NACCU | I*2 | GLO | Parameter used as truncation point for common volume intesration termination. Default is 40. |
| NEWCL | I*2 | GLO | New climate type character strins. |
| NOW | L*1 | GLO | Array used in PDP-11 version to hold time of day as characters. |
| NPAG | I*2 | LOC | Pase number. |
| NT | I*2 | GLO | Number of transmit ports. |
| PSIREO | R*4 | GLO | Array of receiver beam boresisht elevations above radio horizon in radians, ie, ansle at which each antenna is aimed relative to the horizon. PSIREO(1) is the main receive antenna. |
| PSITEO | R*4 | GLO | Array of transmitter beam boresisht elevations above radio horizon in radians, ie, ansle at which each antenna is aimed relative to the horizon. PSITEO(1) is the main transmit antenna. |
| QCORR | R*4 | GLO | Contains elements of covariance matrix, ie, |

| | | | | |
|---|---|---|---|---|
| | | | | powers and correlations. |
| | S | R*4 | GLO | Troposcatter path asymmetry parameter. |
| | SCPARM | R*4 | GLO | Wavenumber spectrum slope parameter M. Default is 3.66. |
| | STSNR | R*4 | GLO | Standard deviation of troposcatter signal long-term SNR distribution in dB. |
| | THER | R*4 | GLO | Radio horizon elevation angle at receive site in radians. |
| | THET | R*4 | GLO | Radio horizon elevation angle at transmit site in radians. |
| | THETAO | R*4 | GLO | Scattering angle at bottom of common volume. |
| | TODAY | L*1 | GLO | Array used in PDP-11 version to hold date as characters. |
| | TROLOS | R*4 | GLO | Median troposcatter path loss in dB for each value in ERFAC distribution. |
| | TRORSL | R*4 | GLO | Median troposcatter RSL in dBm for each value in ERFAC distribution. |
| | UANGLE | R*4 | GLO | Units of angle (deg, mrad). |
| | UDIST | R*4 | GLO | Units of distance (smi, nmi, km). |
| | UFREQ | R*4 | GLO | Units of frequency (GHz, MHz). |
| | UHITE | R*4 | GLO | Units of height and diameter (ft, m). |
| | URV | R*4 | GLO | Array of receive antennas vertical offsets. |
| | UTV | R*4 | GLO | Array of transmit antennas vertical offsets. |
| TRC | (Subroutine) outputs to FOR002.DAT the following variables: | | | |
| | DAUX1 | R*8 | LOC | Implicit diversity eigenvalues for AN/TRC-170. |
| | ENMEAN | R*4 | GLO | Average received energy. |
| | PAVG | R*4 | GLO | Short-term average bit error rate for each sampling time and short-term average SNR. |
| | POUT | R*4 | GLO | AN/TRC-170 outage probability and average bit error rate as a function of sampling time, short-term average SNR and error rate threshold. |
| | PYEAR | R*4 | ARG | Yearly statistics. PYEAR(1,.) is yearly outage probability and PYEAR(2,.) is yearly fade outage probability per call minute for each BER threshold. |
| | SNDB | R*4 | GLO | Signal to noise ratio in dB. |
| | SNRLOS | R*4 | LOC | SNR loss in dB. |
| | TO | R*4 | GLO | Normalized sampling time for lower beam. |
| | TOTO | R*4 | GLO | Array of sampling times (normalized to symbol duration) for calculation of short term AN/TRC-170 performance. |
| | VEIGV | R*8 | GLO | Implicit diversity eigenvalues for AN/TRC-170. |
| | X | R*4 | LOC | Error rate threshold. |
| TRCIN | (Subroutine) outputs to FOR002.DAT the following variables: | | | |
| | BW99 | R*4 | LOC | |
| | CDUR | R*4 | GLO | Duration of transmitted pulse for AN/TRC-170 normalized to signaling interval duration. |

| | | | |
|---|---|---|---|
| IPULS | I*2 | GLO | Switch to indicate whether pulse shape at input of the AN/TRC-170 detector includes the effects of RF filters (IPULS = 2) or not (IPULS = 0 or 1). Set to 2 |
| NCHIP | I*2 | GLO | Number of chips in PN sequence used to expand bandwidth in AN/TRC-170. |
| NDIVS | I*2 | GLO | Number of explicit diversity channels for AN/TRC-170. Equal to 4 for 2S/2F and 2 for 2S or 2F. |
| PEAKAV | R*4 | GLO | Peak-to-average loss due to RF filtering in dB. |
| X | R*4 | LOC | 2*sigma multipath spread/symbol interval. |

TROPO (Program) outputs to FOR002.DAT the following variables:

| | | | |
|---|---|---|---|
| MRAD | I*2 | GLO | Loop limit for MRAD. Default is 1. (MRAD is 1 for MDIST = 0 and MRAD is 3 for MDIST = 1). |
| NOW | L*1 | GLO | Array used in PDP-11 version to hold time of day as characters. |
| NRAD | I*2 | GLO | ERFAC indicator and loop counter. Default is 1. |
| TODAY | L*1 | GLO | Array used in PDP-11 version to hold date as characters. |

SUBPROGRAM INDEX

# END

# FILMED

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# DTIC