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DATA ACQUISITION SOFTWARE FOR DREO's NEAR-FIELD ANTENNA MEASUREMENT FACILITY

by

Claude J. Brochu and Gilbert A. Morin

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ABSTRACT

DREO has built an antenna anechoic facility for microwave and millimetre-wave measurement. The facility includes a spherical near-field antenna measurement system that allows far-field measurement of small antennas and near-field measurement of larger antennas (up to one meter) within the chamber. This report describes the facility including the equipment, the instrumentation, and the DREO Antenna Measurement Acquisition (DAMAS) software that was developed. The purpose of DAMAS is to control the measurement and acquisition process in real-time, and to present the data to the operator. The major objectives of this software development project were the streamlining of the process so that an antenna could be accurately characterized in the minimum amount of time, and the improvement of the reliability of the software.

RÉSUMÉ

DREO a construit une chambre anéchoïque pour effectuer des mesures d'antennes dans la bande des micro-ondes et des ondes millimétriques. Cette installation inclut un système de mesure sphérique à champ proche pour mesurer dans la chambre anéchoïque des petites antennes en champ-lointain et des plus grosses antennes (jusqu'à 1 mètre de diamètre) en champ proche. Ce rapport décrit l'installation incluant l'équipement, l'instrumentation et le logiciel d'acquisition de données pour mesures d'antennes de DREO (DAMAS) qui y a été développé. Les principaux objectifs de ce projet de développement de logiciel étaient de simplifier le processus de mesure de façon à caractériser rapidement une antenne avec grande précision tout en améliorant sa fiabilité.

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EXECUTIVE SUMMARY

The advent of millimetre-wave satellite communications for the military has made it important for DREO to develop an antenna anechoic facility to support its R&D program. The main bands of interest are around 20, 44, and 60 GHz. The new facility is a 6 metre anechoic chamber with a spherical near-field (SNF) system and a receiver that can measure up to 62.5 GHz. The SNF system allows far-field measurements of feeds and small antennas and near-field measurement of larger antennas up to approximately 1 metre diameter. Positioning of the antennas must be obtained with high accuracy. Also, since RF measurements are made while the antenna is continuously moving, the timing control of the acquisition process must be tightly controlled. Because of these stringent requirements, commercial software could not be found. New control and acquisition procedures were developed and real-time software was developed to automate the process. This report describes the DREO Antenna Measurement Acquisition Software (DAMAS) and leads the reader through the use of DAMAS.

DOCUMENT CONVENTION

In Chapter 3 and 4, the following typographic conventions have been used:

<u>Example</u>	<u>Description</u>
Panel Title	Bold type indicates a menu panel title and a sub-panel title;
<i>Command</i>	Words in bold italic represent a measurement parameter or a push-button command;
LOAD	This font is used for computer examples and message output through a dialog box;
"Internal"	" " are used to delimit items selected from a rotary selector for their description;
<Enter>	Angle brackets are used to indicate a control character.

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1 - INTRODUCTION

1.1 Purpose

This report describes the data acquisition software recently developed at the DREO-DFL Antenna Research Laboratory (DDARLing) for the spherical near-field antenna measurement system. It is called DAMAS for DREO Antenna Measurement Acquisition Software. Its purpose is to control the measurement and acquisition process and present the data to the operator in real-time.

1.2 History of DDARLing

DDARLing is a microwave and millimetre-wave anechoic facility located in the David Florida Laboratory (DFL) of the Canadian Space Agency at Shirleys Bay. The facility, a joint DREO and DFL project, started in 1990 [1]. It was developed to support R&D work in the field of antenna, radar cross-section (RCS), and electromagnetic measurement.

DDARLing has been designed and instrumented with the following objectives:

- To study and apply near-field techniques including spherical and planar scanning and near-field to far-field transformations in antenna measurements;
- To study techniques for antenna measurements in the millimetre-wave frequencies;
- To study the application of time-domain impulse response, time-domain gating and transformations between frequency and time-domain in antenna measurements; and
- To develop wideband (2 GHz - 62.5 GHz) precision polarimetric RCS measurement capabilities and expertise.

A fully instrumented anechoic chamber is now available and capable of measurements between 2 and 62.5 GHz. The facility comprises a double-shielded anechoic chamber, a spherical positioner for both near-field and far-field measurement, a vector network analyzer (VNA), and a computer for automatic control and data acquisition.

Some of the research areas under active pursuit are:

- Spherical Near-Field to Far-Field Transformation;

- Near-field errors;
- Positioning accuracy and limitation;
- Measurement speed and productivity gain;
- Data acquisition and control in an R&D environment.

The DDARLing facility not only serves as a measurement technology development laboratory but, more importantly, is used to support development of antenna subsystems for various programs within DND.

1.3 Brief technical description of DDARling

The facility includes an anechoic chamber, positioners, receivers and other necessary equipment to make measurements from 2 GHz to 62.5 GHz with the possibility for extension to higher frequencies. The chamber houses an Orbit 560/860 Roll/Azimuth positioner installation to hold the antenna under test (AUT) and an Orbit 360 positioner for the probe antenna. The RF receiver is a WILTRON 360B vector network analyzer with sweeper, synthesizer and test sets. It is capable of making measurements between .04 GHz and 62.5 GHz. Measurements are fully automated by computers using in-house software. The data acquisition computer is a Hewlett Packard (HP) 9000 model 345 running under the HP Basic operating system (with the HP Basic Plus extension). The in-house software, developed to control the measurement using the spherical near-field system, is the subject of this report. The measured data are transferred to a PC system for post processing by the CASAMS software developed for DFL by CAL Corp. CASAMS does a near-field to far-field transformation on the measured data.

A steel structure to support the positioners and the alignment theodolite has been designed and developed in-house with the collaboration of the CRC Model Shop. This very strong and heavy structure is composed of steel I-beams, wheeled carriages for the positioners, and support rails. The structure was added to improve the accuracy of measurement by reducing the alignment errors and providing better isolation from the building vibrations.

1.4 Data Acquisition Software Manual

This report gives a description of the data acquisition software from a user's perspective. Chapter 2 presents the experimental setup controlled by the software. Chapter 3 presents the software itself and its use in general principles. Chapter 4 describes each menu item in detail. APPENDIX A contains the screen dumps of the program menus. These menus are referred to in Chapter 3 and 4, and they will help understanding the descriptions of the parameters and commands.

2 - EQUIPMENT AND SETUP

2.1 DDARLing

DDARLing is made of 4 principal subsystems:

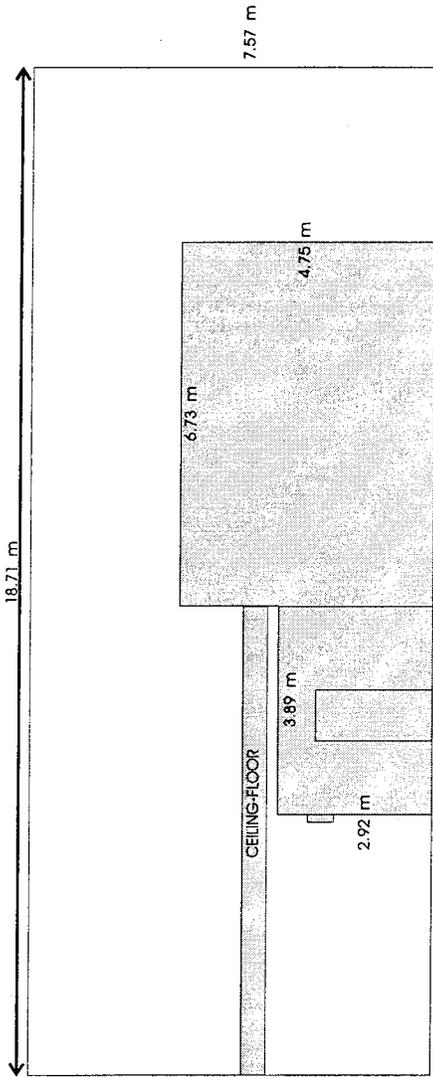
- a) anechoic chamber;
- b) positioning equipment;
- c) RF equipment; and
- d) acquisition and processing computers.

A schematic diagram of the chamber is shown in Figure 2-1. The chamber is double shielded and measures approximately $7 \times 4 \times 5 \text{ m}^3$ (LxWxH). The absorber is 45 cm long and has unpainted tips to reduce scattering at millimetre wave. There is a shielded antechamber with floor space of $1.5 \times 3.5 \text{ m}^2$. The chamber and antechamber can be electromagnetically sealed to allow classified measurements.

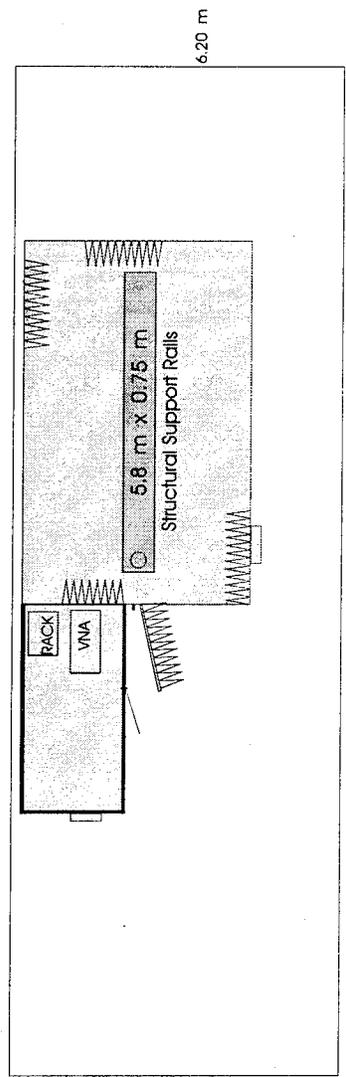
The positioning system is shown on Figure 2-2. It is made of a 7 metre rail supporting 2 positioning towers and the theodolite tower. The antenna-under-test (AUT) tower is a spherical positioner (roll-over-azimuth). The AUT is mounted on the Orbit 560 positioner that has a capacity of about 100 kg. Various alignment fixtures and mirrors are used to align the AUT precisely with the reference coordinate system. The probe tower is a single polarization positioner with a capacity of approximately 20 kg. Both AUT and probe towers can move along the rail for near-field or far-field measurement. The theodolite tower supports an electronic theodolite with its alignment fixture. The theodolite can be used to very accurately align both towers using mirrors, targets, and alignment fixtures.

The RF setups are quite numerous and depend on the exact application at hand. Figures 2-3 and 2-4 show 2 possibilities depending on whether the AUT is in transmit or receive mode respectively. In Figure 2-3, the AUT is attached to the RF source. The probe can be dual-polarized with both polarizations measured simultaneously by the test set. A reference signal is extracted from the source and sent to the receiver for phase locking purposes. In Figure 2-4, the AUT is attached to the receiver. The circuit is similar to the previous one, however, only one polarization can be measured at a time. This slows down the acquisition time when both polarizations are needed.

The computer subsystem is illustrated in Figure 2-5. The HP computer is used for acquisition and the PC computer for processing. The HP computer hooks up directly to the VNA and the Orbit controller. It controls the operation of the equipment and the collection of data with some limited data processing being done at the same time. The collected data are sent over a local network to the PC computer. The PC has a number



ELEVATION



FLOOR PLAN

Figure 2-1. DDARLing Facility.

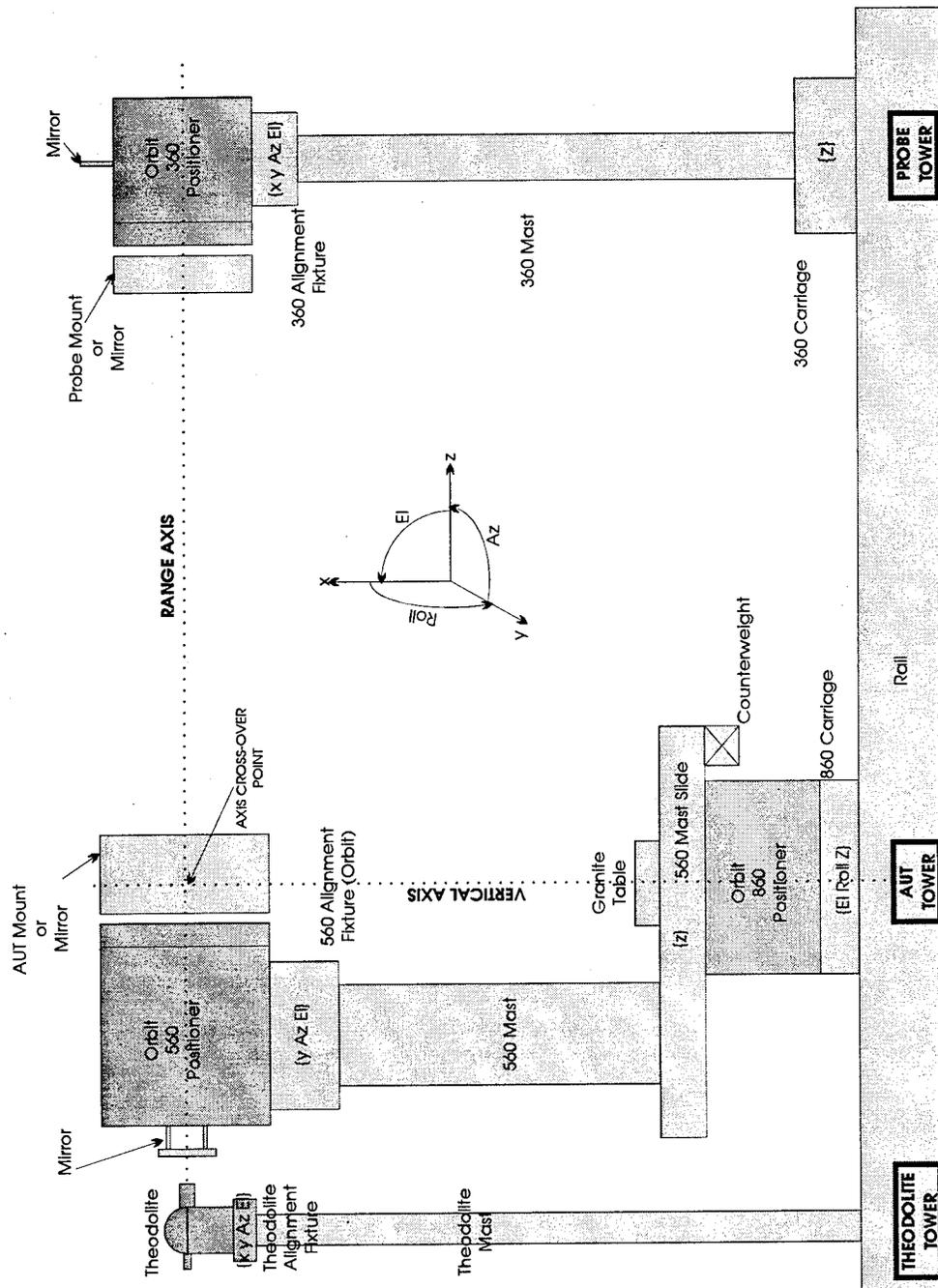


Figure 2-2. Spherical Positioner System

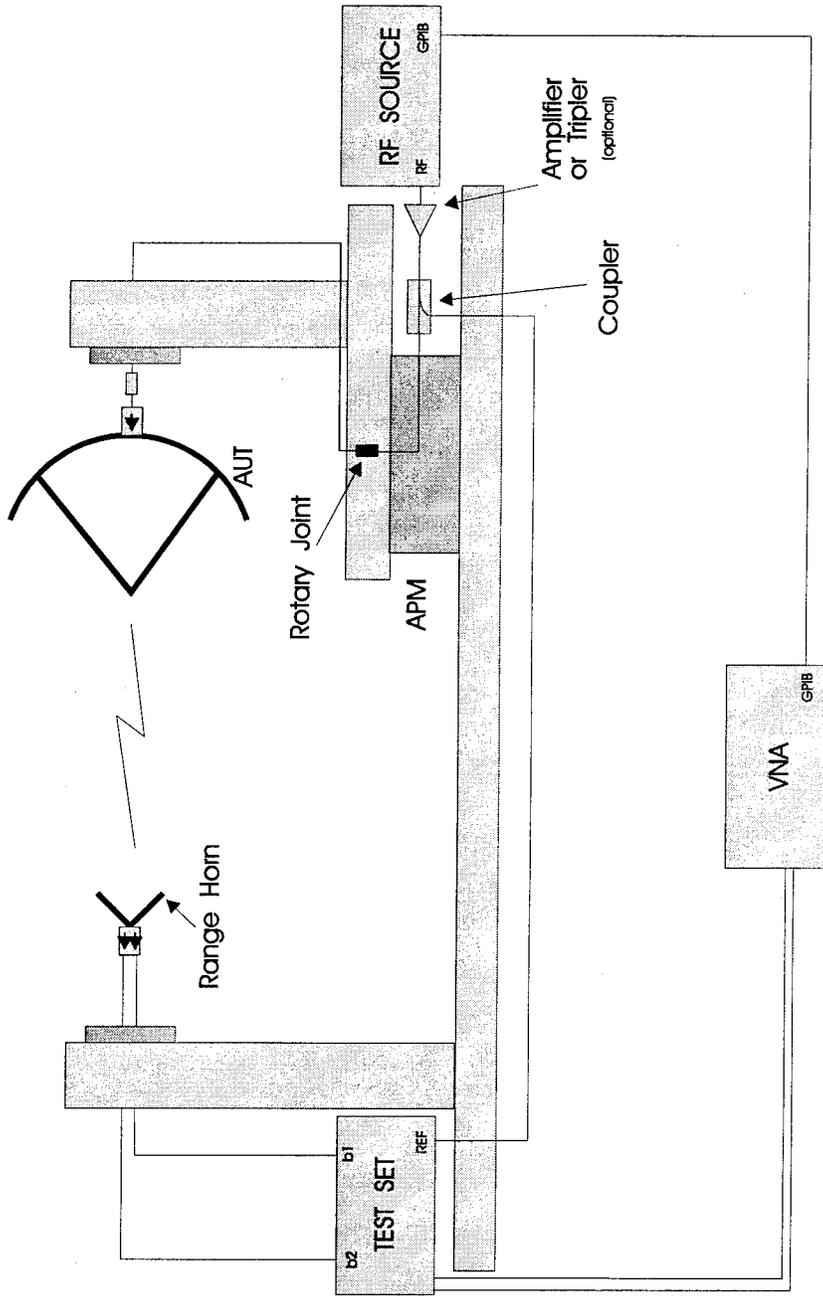


Figure 2-3. RF Setup. AUT in transmit mode.

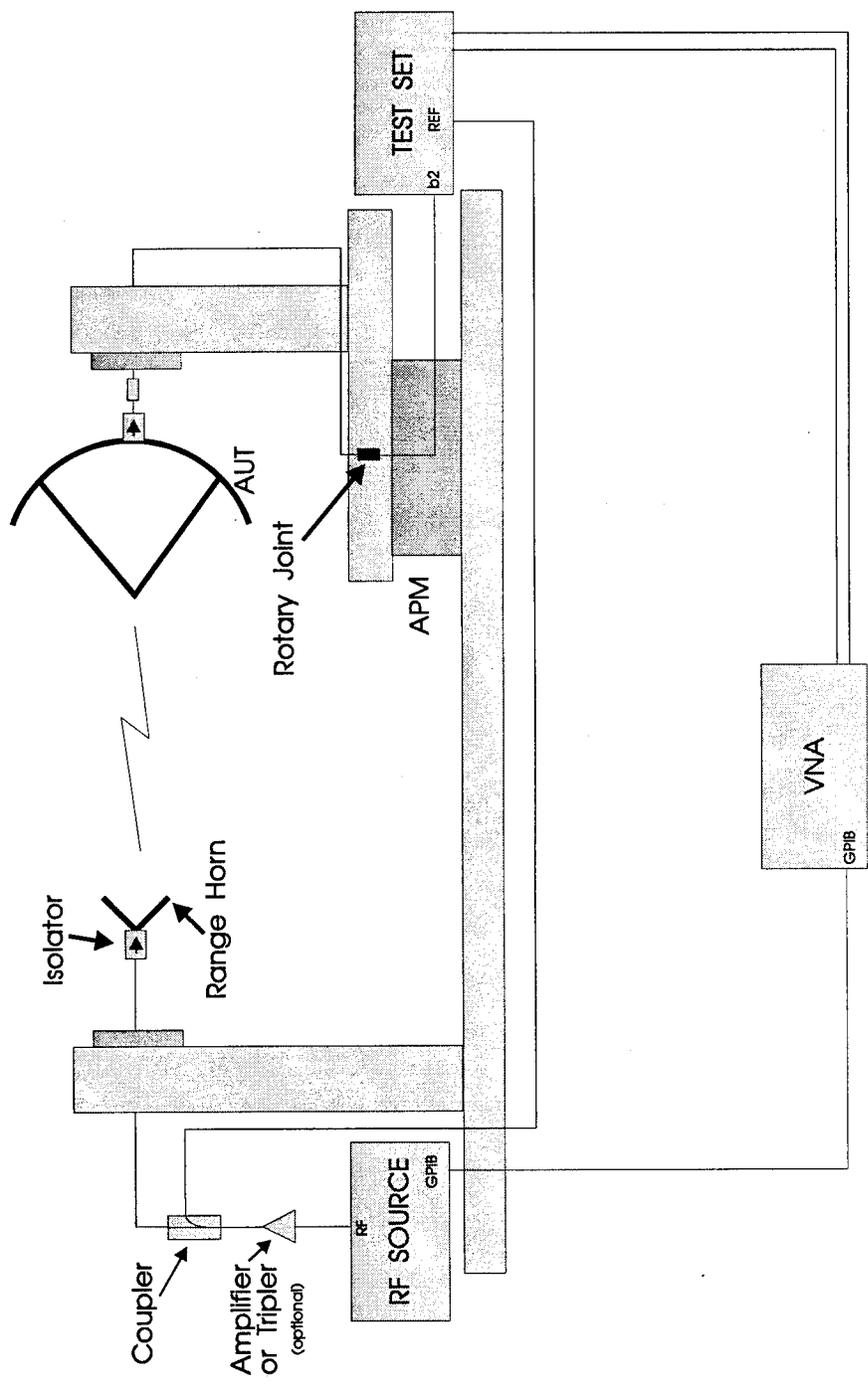


Figure 2-4. RF Setup. AUT in receive mode.

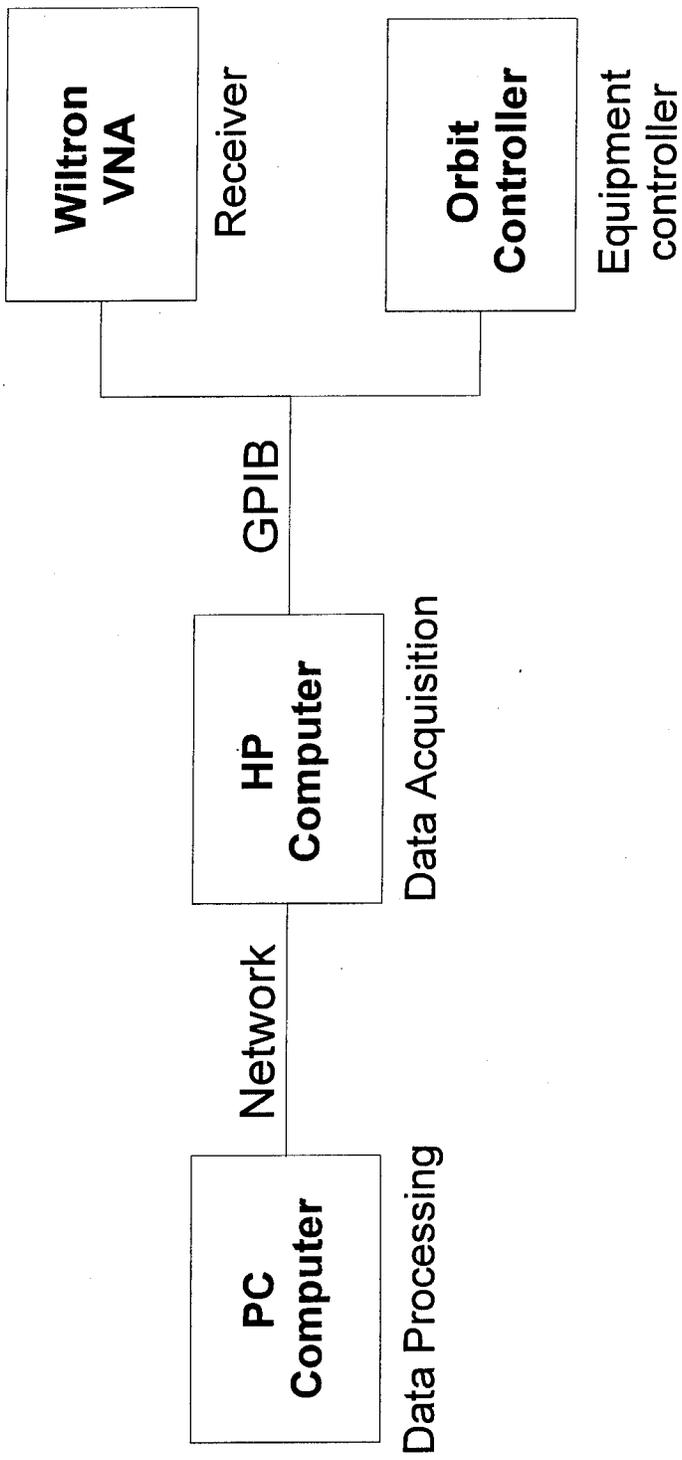


Figure 2-5: Computer connections

of software programs to process the data. In the following sections, the most important pieces of equipment, as far as the acquisition software is concerned, are described in more detail.

2.2 Wiltron - VNA

The RF measurements are accomplished through a WILTRON 360B Vector Network Analyzer (VNA). This instrument has a frequency range of .04 GHz to 62.5 GHz. This type of analyzer has the capability of measuring both magnitude and phase characteristics of networks: amplifiers, attenuators and antennas. A VNA consists of three main units [2]: the control unit, the test set and the signal source. The control unit is multi-functional. It is the system controller, signal processor and data display unit for the network analyzer system. The front panel controls allow the selection of the display options, menu items, test functions, test parameters, measurement enhancement and frequencies. The test set and the signal source are controlled via dedicated signal and control interfaces. The test set routes the stimulus from the source unit to the device under test through one of its test ports, and it samples and measures the incident, reflected and transmitted signals. While several test set types are available, the following two are used in the DDARLing VNA: an active device reversing test set and a frequency converter test set. The first type can measure the scattering parameters of RF components, amplifiers and antennas. The second type is for frequency conversion measurement where mixers are needed to measure the received signals.

An important characteristic of the VNA is its IEEE-488 standard GPIB interface which permits automatic computer control measurement. An external controller by means of the VNA IEEE-488 port may take control of the 360B. The controller can perform all the control panel operations. This capability proved to be very useful for the data acquisition program to remotely set up the VNA for a measurement session.

Other characteristics that are used in the data acquisition program are the VNA versatile measurement triggering modes and the data collection buffer capability. Three triggering modes exist: internal, GPIB and external. The internal mode is the regular mode in which measurements are normally done. In the other two modes, a single frequency measurement is done by external triggering either by the GPIB GET command or by an external TTL pulse sent to the VNA rear "EXT Digital Control" connector. These triggering modes were all implemented in the data acquisition program. The maximum external trigger frequency specified is 100 Hz, but testing demonstrates that often data collection problems occur with a triggering frequency over 85 Hz. This specification is true only when the VNA is configured with the internal IF bandwidth set to maximum and with no data averaging. If, on the other hand, a smaller IF bandwidth is chosen and several measurement averages are taken, each single frequency measurement will take longer and consequently the triggering frequency will decrease.

The other important characteristic, mentioned above, is the internal buffer memory. With this memory, measurement data can be collected for several frequency sweeps until the buffer fills up. The maximum buffer size is 3068 complex double

precision measurements data points. The automatic data collection capability is used with GPIB and external triggering. These capabilities are very important for measurement speed. When these measurement modes are used, the computer loading is very light and consists only of counting the measurement points and reading the positioner angles when required. Measurement data are processed only after a scan is terminated. An important limitation of this method, however, is the maximum number of measurement points allowed. The number of angle increments in a scan multiplied by the number of frequency points measured at each angle increment should be less than or equal to 3068. This could be too small a number in EHF antenna measurements. In this frequency band the measurement points could be very close to each other, so the user must either choose a smaller positioner scan range or use less dense frequency sweeps.

2.3 Orbit Positioners

The DDARLing spherical near-field antenna positioner system is equipped with the following ORBIT Advanced Technologies units: an AL-4706-3A Controller/Programmer, an AL-4146-2 Power Control Unit, and three antenna positioners, the AL-860-1P, the AL-560-1P and the AL-360-15P.

The multiprocessor-based Advanced Positioner Controller/Programmer is a unit designed to provide overall remote control of positioner motion [3]. The Controller/Programmer displays position and performs recording functions. It controls up to 6 axes or positioners. Manual operation is allowed to control speed and direction, and axes selection. The operator can also configure the unit and define operating parameters or request data through functions keys and a numeric key pad in an interactive man/machine dialogue. The Controller/Programmer also accepts commands from a system computer which feeds back measurements and status via a standard IEEE-488 Interface Bus.

The 860 and 560 positioners are assembled together through an 'L' bracket into a Roll-over-Azimuth configuration for spherical antenna measurements (see Figure 2-2). The heavier positioner (860) sits on the floor with its rotation axis vertical. The smaller one (560) is installed at the top of the "L" bracket and has its axis horizontal. Both axes must be orthogonal and must intersect. The AUT fixed to the 560 positioner platen is rolled while the 860 positioner (with its vertical axes of rotation) rotates the complete assembly (560 positioner and AUT) in the Azimuth direction. The third positioner (360), fixed at the top of a vertical post in the same fashion as the 560, also has its rotation axis horizontal. The probe antenna is fixed to the 360 platen and oriented toward the AUT. In spherical near-field or far-field antenna measurements the probe may be rotated to a 0° or 90° position for horizontal or vertical polarization measurement. For accurate measurements both horizontal axes (360 and 560 positioners axis) must be parallel and coincidental. To achieve this, an alignment process is done with a theodolite using alignment techniques developed in-house.

The ORBIT AL-4706-3 is capable of reading position data from two synchro transmitters or and inductosyn (in the DDARLing configuration). The two synchro

transmitters (single speed and double speed) have a reading resolution of $.05^\circ$ and $.025^\circ$ respectively. The inductosyn, which works in combination with the synchros, has a resolution of $.005^\circ$. The angle values are displayed and stored internally with a 3 decimal accuracy in two formats, either 0° to 360° or -180° to $+180^\circ$. The latter format is used in the measurements.

The ORBIT Controller has several motion modes programmed. For the purpose of this report, only the two modes used by the data acquisition program will be described: the tracking mode and the sector mode.

The tracking mode is the mode employed by the controller for pointing purposes. This mode essentially moves the positioner from its present location to a designated final position. The operator must define the direction of rotation or set the condition for the controller to choose the direction according to the shortest path. The positioner halts when the target position has been reached within the boundaries of a predetermined "locking window" around it. The width of the locking window is user defined.

The other motion mode, the sector mode, is specific for antenna measurements. In this mode the positioner scans the space within the limits of the sector. During scanning motion, the controller delivers synchronization (synch) pulses at regular intervals, thereby synchronizing an RF receiver (the Wiltron VNA in the present case) incorporated into the measuring system. The motion stops when the scan has been completed and the positioner has reached the stopping angle within the locking window (as in the tracking mode case). The operator defines the scanning direction and the scanning speed. Also, the initial and final angular values of the scanned sector must be defined, as must the angular interval at which increments (synch pulses) are to be delivered. Lastly, the operator must determine a locking window which will determine the termination condition of the sector scan.

During scanning, the controller issues a signal on the Service Request (SRQ) line of the IEEE-488 GPIB bus at the same time it delivers the synch pulse which occurs when the positioner has crossed an angular increment position. The SRQ bit of the serial poll byte is set and an event value is set to inform the computer that during a scan an increment angle has been attained. The controller then stores in the output buffer the exact position that the positioner was at when the synch signal was sent. The computer, configured to be interrupted by the SRQ signal sent by the hardware line, automatically branches to an interrupt service routine which services the increment event and reads the increment angle position from the ORBIT Controller output buffer. The controller also works in a mode where only the SRQ line is raised, an increment event is generated but no angle position is given. The TTL synch signal issued through a rear panel BNC connector, is always present.

2.4 Computer System and Programming Environment

The computer system used at the DDARLing facility for data acquisition and instrument control includes the following units: an HP 9000 Model 345 2D workstation

with a 16 inch high resolution colour monitor, a SCSI 1.2 GB hard drive, dual floppy drives, an HPIB (also called GPIB) HP 81 MB HD and an HP Laser Jet III printer. The computer has a high resolution 8-plane + 2 overlay planes colour graphic processor board (1280x1024). The memory system is populated with 24 MB of RAM and the following ports are available at the rear: serial, parallel, SCSI, HPIB, and a LAN networking IEEE 802.3 ethernet interface with AUI and thin LAN capability.

The computer runs under the HP BASIC Language System version 6.2. This high performance operating system provides flexibility and capability for varying applications [4]. I/O intensive constructs have been incorporated in the language to provide powerful instrument control. HP BASIC provides an hierarchical file system, complex numbers, matrix operations, DOS file I/O format for files, and a host of other features in the area of human interface. Added to this, there is a compiler which will speed execution time and provide major performance improvements.

The HP BASIC Plus extension is a system of commands, utilities, and applications designed to enhance the HP BASIC program development environment [5]. It offers a user friendly interface and powerful window tools by providing a set of commands to create the Dialogs and Widgets that make an effective user interface. A standard feature is the Dialog which acts, from the program's point of view, as an input statement with a TIMEOUT; from the user's point of view, it appears as a pop-up panel that goes away when the user supplies a response. There several types of dialogs, from the dialog that displays a string to the user (who then clicks a button on the dialog panel to proceed), to a dialogue that shows a file listing and asks for a file selection. Widgets are more flexible items that can be used to build sophisticated user interfaces. You can, for example, put together "virtual instruments" that include: push-buttons, sliders and text; meters and graphics displays; and pulldown menus, that can be controlled by a mouse. A distinctive feature of BASIC Plus is that all actions of the software are initiated by the HP BASIC interrupt system. Each action (such as clicking a PUSHBUTTON or a MENU item, typing return in a STRING widget, etc) generates events which interrupts the program. The major benefit of BASIC Plus is to allow the building of a convenient and powerful window interface.

To make use of the LAN interface, the Network Research Corporation FUSION Network Software has been added to the system. FUSION has a collection of networking utilities and library functions designed to support data transfers and interprocess communications. FUSION has also an API (Application Programming Interface) package by which the user can make non-interactive calls to FUSION FTP within BASIC programs. Files can be transferred back and forth between the system and a remote host, using TCP/IP Standard File Transfer Protocol. Such a capability proves extremely practical for a workstation frequently employed in a data acquisition and control environment in which it must relay data to a remote host for processing. API file transfer routines are embedded within the data acquisition program to transfer measurement data files to the remote PC for later post-processing of the spherical near-field antenna measurement data by CASAMS or other post-processing software.

3 - PROGRAM USAGE FOR SPHERICAL NEAR-FIELD ANTENNA MEASUREMENT

3.1 Program overview

The data acquisition program for Spherical Near-Field Antenna Measurement allows the measurement of antenna patterns using a friendly, structured modular software package. This software has the capability, although limited, of setting up and controlling the Wiltron VNA for RF component measurements.

The program displays on the screen unique "open" menus (see the Figures in APPENDIX A) used to set up various parameters for the measurement activity and for the initialization and control of the Orbit positioners and their Controller, and the Wiltron VNA. An additional menu allows for the setting up of graphics parameters for on-line and off-line plotting of the measured patterns.

While measurements are conducted, measured data are stored into disk files and then transferred to a remote PC, for later post-processing, using the LAN FTP software which was introduced in paragraph 2.4. The measurement parameters defined in these menus are stored in a configuration file which is referred to here as the measurement TEST file. This file is updated after each scan with the program trace variables specifying the polarization and the date and time marks of each measured scan. A LOG file is also created with the purpose of keeping a record of measurement events such as: when a measurement starts, a file is stored, a scan is completed, an error occurred, an FTP transfer is done, etc.

In this chapter, the measurement procedures are described. References are made to specific menu selections and to measurement equipments which were described in the previous chapter. A detailed description of each command can be found in chapter 4 "Menu Reference".

3.2 Program Start-Up

The data acquisition program is loaded into computer memory and runs using the following HP BASIC commands.

```
MSI "/ANT_MEAS_PROG"
```

```
LOAD "DAMAS"
```

```
RUN
```

The MSI (or MASS STORAGE IS) command selects the directory path of the program as the current directory, the LOAD command loads the program into memory, and the RUN command starts the program.

The program starts and displays its main full screen menu panel, the **Measurement Control Panel** (Figure A-1). It then loads the default measurement parameters from the default TEST file "TSTdef.TST" and idles waiting for edits and command events. Editing is accomplished by entering an input parameter into one of the text boxes. Pressing the <Enter> key causes an edit event which will enter the new value into the system. A command event consists of pressing a PUSHBUTTON (PB) widget by moving the mouse over the PB and clicking the left mouse button.

At this point, the user has the option of either creating a new experiment by entering a complete new set of parameters, retrieving a previous measurement TEST file to either continue an unfinished measurement, look at measured antenna patterns, or create a new experiment using parameters similar to a previous test. To view measured patterns, the user must press the *Plot* PB to call the **Plotting Control Panel** to the screen. To start the measurement activity, he must press the *MEASURE* PB command which will call up the **Measurement Window** to the screen. The following paragraphs will demonstrate in more details the steps required to specify the various measurement parameters and to prepare the equipment for measurement.

3.3 Measurement Procedures

3.3.1 Introduction

The antenna measurement process consists of selecting the various basic measurement parameters such as the experiment titles and filenames, the scan parameters, the measurement modes, the output data format for CASAMS files, etc. It also consists of selecting the Orbit positioners and the Wiltron RF receiver initialization parameters. Various other parameters such as the plotting format and the disposition of the measured data files through the LAN is also specified. In the next paragraphs, a description of the parameters and commands in each menu panel is found. A more in-depth description is given in Chapter 4.

3.3.2 Measurement Control Panel Menu

The **Measurement Control Panel** (Figure A-1) contains the main measurement configuration parameters and commands. As mentioned also in 3.2, the user first selects an experiment name in the **TEST file Storage Control** by entering a 6-character Prefix and a directory Path in the designated text boxes. If the TEST file exists, clicking the *Read Config* PB will load into memory the experiment configuration causing the menu to be updated with the new parameters just read. When all measurement parameters are specified and ready to be saved in the TEST file, the user clicks the *Store Config* PB. It is still possible to change the parameter values later but the program will request confirmation through a dialog box to over-write the TEST file with the changed data.

The **Experiment Information** sub-panel is then edited to specify experiment titles and the operator's name. This information is used in the graphics title for the plots traced during measurement. The user follows by going to the **CASAMS Configuration Options** sub-panel to specify the type of antenna *mounting*, spherical or equatorial, and the *Current Device* being measured, either an antenna or a Standard Gain horn. In addition, he must specify if the *Angular Data* is to be included (or not) in the CASAMS files and the *Polarization*, vertical or horizontal, to be sampled next. If both polarizations are measured together, i.e. with a dual polarized probe, the user must specify which one is measured first. In the Two Axis *Scan Mode* with a single polarization probe the measurement is repeated two times. Thus, before each measurement, the polarization measured must be selected with the polarization rotary selector. The rotary selector mechanism is described in paragraph 4.1.

The measurement scanning parameters are defined next. These are found in the **Scan Configuration Table**. As a preliminary, a decision is made to determine if the *First Axis scanning motion* is "Continuous" or "Start and Stop", and if the *scanning mode* to program is to be for "One Axis", "Two Axis" or "Three Axis". "One Axis" scan is not used for spherical measurements. In the "Two Axis" mode, each polarization is measured separately with a single polarization probe, but both polarizations are measured together with a dual polarized probe. The "Three Axis" mode is used to measure both polarizations with a single polarization probe.

There are several scanning parameters to set for each axis. These are the *scan start* and the *scan stop* angles, the angle *increments* and the *number of steps*, the *scan direction* and the positioner *scan velocity*. The *increments* and the *number of steps* parameters are interrelated and specifying one sets the value of the other. The *scan direction* is usually chosen to be "forward". The *scan velocity* selection, however, is very critical in the continuous scanning. The velocity must be adjusted so that the *scan increments* repetition is not too fast for the computer and the Wiltron VNA which are interrupted or triggered by the Orbit Controller signals. Their frequency must be less than 100 Hz. The GPIB hardware cannot allow more than 100 SRQ interrupts per second and, as mentioned in paragraph 2.2, the maximum frequency an external synch pulse can trigger a measurement in the VNA is also less than 100 Hz.

Another important parameter, not yet mentioned above, is the *scan type* which specifies which axis is the First, Second or Third. The "First axis" is the axis that rotates first. It is the so called "scan axis". The setting of the angle *increment* and the *number of steps* is also very critical for the First axis in continuous scanning motion. It depends on the type of the *triggering* mode selected (which are many) for the Wiltron VNA in the **Wiltron Control Panel** (see paragraph 3.3.4 and 4.4 for details). In the "Bus + Internal" triggering mode the *number of steps* of the First axis is equal to the number of angle positions where measurement is done. But in the "Bus & Buff." and "Ext. & Buff." triggering modes, where the Wiltron internal buffer memory is used to collect the data, the *number of steps* is equal to the number of angle positions each measurement must be done times the number of frequencies in the sweep. This is required, because the VNA requires a trigger or an external synch pulse for each frequency measurement when used in this fashion. Furthermore, the maximum value for

the *number of steps* (or the number of synch pulses generated by the Orbit Controller) must be 3068 or less. This number is the maximum size for the VNA internal buffer memory. In addition, the operator must make sure that the *number of steps* is Modulo the number of frequencies because at each nominal scan increment position, a measurement is done for each frequency.

The FTP *Auto Transfer* selection, in the **FTP Control Panel**, is set to specify the frequency of data file transfers through the LAN, i.e. after every scan, at the end of the measurement activity, or no transfer at all. There is also the possibility of manually transferring the files by FTP at a later time.

The Orbit Controller, the Wiltron VNA and the Plotting parameters must now be defined. For that purpose, a block of PB commands, located in the **Other Menus** sub-panel, are available to call up to the screen three full screen size menus. These commands are the subject of the paragraphs 3.3, 3.4 and 3.5 later in this chapter.

Finally, after all setups and adjustment are made, the measurement activity can be started by clicking the **MEASURE** PB in the **Measurement Control Panel** located at the bottom centre of the screen. The configuration, as mentioned above, may be saved beforehand in the TEST file by clicking the **Store Config** button, but it is not absolutely required because the TEST file is always updated after each measurement.

Before clicking the **MEASURE** PB there are still a few more specifications to set. The scan range must be selected with the **MEASURE** selection button. The operator can select to measure "ALL" the scans, a "Subset" of the scans, the "Remaining" scans or simply the "Current" scan. Selecting "ALL" permits the measurement of all the scans of one polarization in a "Two Axis" scan mode, or of both polarizations in a "Three Axis" scan mode. Selecting "Subset", on the other hand, will permit the measurement of only a subset of the scans. The scan subset range is specified in the two input text boxes available in the **Subset Config** area of the sub-panel. Selecting "Remaining" is much like "ALL", with the exception that the measurement starts at the first scan not yet measured. The "Current" scan is the scan as indicated in the **Current Scan** text box.

Test measurements may be done for the purpose of parameter verification. In this case, it may not be necessary to save the data. For that purpose two radio buttons, **Do Not Save** and **Auto-overwrite**, are available to prevent the data file save operation after the scan is measured, and to allow for auto over-writing of the data files when scans are remeasured. The system normally always requires approval from the operator before over-writing any data file.

When the **Measure** PB is clicked measurement does not start immediately because the parameters are checked for difference with the content of the TEST file and other specific parameters are verified for correctness. When everything is fine the **Measurement Window** (see Figure A-2) appears on the screen for the monitoring of the measurement activity. The *scan range*, the *current scan* and two types of *measurement status* read-only boxes are displayed for the benefit of the operator.

In addition, three PB commands *GO*, *STOP*, and *DONE* are available to control the measurement activity. When the *GO* button is clicked to start the measurement, the positioners start the scanning, and during the measurement the status boxes are updated and each pattern measured is displayed on an XY GRAPH widget. The *STOP* button may be used as a panic button to stop all positioner motion at any time. When everything is terminated the *DONE* button is clicked. The **Measurement Window** is erased and control is given back to the main menu.

3.3.3 Orbit Control Panel Menu

The **Orbit Control Panel** menu (Figure A-3) is called when the user is ready to enter the configuration parameters of the positioners and to perform the optical alignment of the positioner axes with a theodolite. From the five sub-panels presented in this menu, two of them, the **Axis Configuration Table** and the **Direct Axis Motion Control** are the menus that will be used mostly to accomplish these operations. The **Scan Configuration Table** would be normally set up at this time, hence, it is a duplicate of the same table found in the main panel menu, and the **Orbit Controller Options** is there only for *Orbit status* display when the positioners are rotated and for some GPIB control operations.

The angle *offset* and the type of angle *encoders* with the angle display format selection are the important items to configure in the **Axis Configuration table**. The offset refers to the angle offset fed to the Orbit Controller to calibrate the Orbit Controller angle display relative to a reference position of a positioner defined to be zero. The offset value is determined using commands in the **Direct Axis Motion Control** sub-panel. The *Offset* text box is editable, so the operator can input its value when known from previous installation.

The *encoder* text box specifies which angle measurement sensor to use in the positioner. There is a choice of three encoders and two angle display formats to choose from depending on the accuracy required for the angle value. The encoders are: the single speed or double speed synchros, and the inductosyn. The angle display format is either 0° to 360° or -180° to +180°. The usual choice of encoder taken from the selection dialog box is the inductosyn with the 180° format or "INDUCT (180)". The inductosyn encoders have an angle resolution of 0.005°.

The **Direct Axis Motion Control** sub-panel presents commands that are very useful in conducting the optical alignment of the positioner's axes and in setting the zero offset. The commands located in the **Position Control** area of the sub-panel are used to move the positioners to positions such as the *scan start* or *scan stop* positions, to a particular *step* of a scan, or to specific positions defined in the two *Goto Angle* text boxes. Relative small step motion, defined in the two *Step* text boxes, can also be programmed to move the positioners in very small increments around a target position with the "+" or "-" PB.

When the zero position of an axis is determined, the *Reset Offset* command is sent for the Controller to reset its offset. Consequently, the *Offset* text box of the current

axis is updated by the program. When all parameters in the table are edited, one of the commands *Send Config* in an axis column or *Send Displ. Axes* is clicked to send the new configuration to the Controller. This last command operates on all three axes described in the table.

Similarly, if the operator changes the configuration by directly programming the Controller, the parameters on the Axis Configuration Table would have to be updated with the *Get Config* PB in an axis column or the *Get Disp. Axis* PB for all three axes.

As a supplementary comment, the angle *offsets* of the positioners carrying the AUT and the probe are not defined during the optical alignment. They are determined only after the antennas have been mounted on the positioners. The azimuth positioner *offset* is, however, determined during optical alignment, i.e. when the roll axis and the theodolite optical axis are horizontal, parallel and collinear or coincidental.

The *Finished* Pb erases the **Orbit Control Panel** and the main control menu is redrawn.

3.3.4 Wiltron Control Panel Menu

The **Wiltron Control Panel** menu (Figure A-4) is used to configure the Wiltron VNA to the measurement specifications. This configuration is executed in two operations. The first one is done using the menu to select the *frequency* sweep, the *triggering* mode and the *channel(s)* to be used. For the second operation, the configuration continues by programming the VNA directly from the front panel keys setting parameters such as the display format, the IF bandwidth, the number of averages, the channel equations, the Test Set selection, etc.

The menu configuration is transferred to the VNA by issuing the *Sent to Wilt* command from the **Measurement Configuration Panel**. When the Wiltron is completely configured the *Get Panel fm Wilt* command is invoked to get from the VNA (to the program) a binary string containing the complete Front Panel Setup (or VNA configuration). This configuration is stored as such in the TEST file, so every time a measurement activity is started, the string is sent back to the VNA to reconfigure it to the measurement specifications.

In antenna measurement, depending on the probe in use, one or two polarizations can be measured simultaneously, thus requesting the use of one or two VNA channels. The *Channel(s)* rotary selector in the **Measurement Configuration Panel** is used for that purpose. Only channel 1 and channel 3 are available for selection in the program.

The VNA is normally triggered internally, a mode where the frequencies are swept continuously. It is also possible to trigger it externally, a mode in which each frequency measurement is triggered by an external TTL pulse or a GPIB command. In the "external" mode the Wiltron, as mentioned earlier in chapter 2, may be programmed to collect the measured data and store it in a special buffer memory. There is then a good variety of possible triggering formats which can be selected through the *Triggering*

rotary selector. The triggering function introduced earlier in paragraph 2.2 is explained in more detail later in 4.4.3.

The frequency sweep is specified simply by entering the frequency values in GHz in the 10 scrollable text boxes reserved for that purpose. First, the **Total** box is used to specify the number of frequencies reserved and to open as many slots in the scrollable frequency list. The maximum number of slots being 501, a number of push-button commands are available for the managing and scrolling of the frequency list.

Other commands and parameter text boxes in the Wiltron menu are dedicated to specifying text strings for output forms to be sent to printer or to the VNA diskette. As these are dedicated to component measurement and not to antenna, the description given later in paragraph 4.4.5 should suffice.

The **Finished** PB erases the **Wiltron Control Panel** and the main control menu is redrawn.

3.3.5 Plotting Control Panel Menu

The **Plotting Control Panel** menu (Figure A-5) is used to set the graphing parameters for on-line tracing of measured patterns during the measurement activity. It is also used to plot the antenna patterns off-line (see Figure A-6) and to print them on the printer (see Figure A-7).

During measurement, after a scan is terminated, a selection of frequency patterns are traced inside an XY GRAPH window. These plots are traced according to the **Plot Format** and the **Plot Axis Configuration** specified by the user. The **Plot Titling Information** contains the graph titles. Although they are initialized with the **Experiment Information** specified in the **Measurement Control Panel**, they can be changed to a more suitable title. This is very useful, especially during off-line tracing. The **Plot Format** specifies that either the magnitude or the phase data will be traced and **Normalization**, if flagged "ON", will cause the patterns to be traced in relation to each other. This may be of some interest during off-line data analysis when comparing patterns as a function of frequency.

The **Plot Axis Configuration** sub-panel is used to setup the labels, the X-Y axis scaling, the position of the grid lines, and the position of the major and minor ticks on the axes. As several frequency patterns are measured simultaneously, in order to make the graph readable, it is necessary to limit the number of traces in the XY GRAPH window. The selection of the frequency samples is done in a manner similar to the selection of frequencies in the **Wiltron Control Panel** by using a scrollable list of text boxes for the frequency sample selection. The **Total** box specifies the number of traces to be defined. The **Sample** column in the **Plot Sample Configuration Panel** is filled with the frequency index, the **Num** column represents, by means of read-only text boxes, the traces sequence numbers, and the **Freq** column lists the frequencies of the selected samples. Some utility PBs are also available to help the user to manage the scrollable list.

The **File Control Storage** sub-panel utility is two-fold. First, it is used to select an experiment and read in its configuration file, and second, to load measured scans for off-line display and printing purposes. The scan loaded is the one specified in the **Load Scan** text box or the "NEXT" or "PREVIOUS" one as indicated in the **Load** selection box. It must be emphasized that the program will load only the polarization indicated in the **Plot Control Panel**. Since the program has the capability to read the TEST file, the user does not have to return to the main menu to specify a new experiment.

The last preparation to be done before plotting the measured scans consists of specifying the **Plot Format** and setting the **Normalization** flag "ON" or "OFF" in the **Plot Control Panel**. Clicking the **Plot** or the **Print** Pbs will generate a graph on the screen or the printer.

To get to another scan, the XY GRAPH window is erased by clicking the System Menu button at the top left hand corner of the window title line and then its **Close** menu button. Clicking the **Load** or **Load Scan** PB will read another scan.

The **Finished** Pb erases the **Plotting Control Panel** and the main control menu is redrawn.

3.3.6 Log File Control Menu

During measurement, several events occur which must be noted, some more important than others, so a LOG file mechanism was implemented. This LOG file is continuously written to keep a record of events such as when a measurement starts, a file is stored, a scan is completed, an error occurs, the trace variable is cleared by the user and scanning restarted at the beginning, an FTP transfer is done, etc. Furthermore, the date and time marks always accompany the notes.

When a measurement break occurs, the operator has the possibility to look at the file contents and to append some user comments (or notes) to the file to explain some facts or events. To get to this feature, the user clicks the **Log File** PB located in the **Other Menus** sub-panel in the main control menu. The **Log File Control** dialog box (Figure A-8) appears on the screen presenting to the user input text boxes and commands for entering notes and controlling the viewing of the LOG file. The user can enter up to 4 lines of notes and append them to the file with the **ADD Note to Log** PB. The **View** command brings the **File view Window** to the screen showing the top portion of the file. Commands are available to read more text to the window and to scroll it with the scroll bar. To terminate with the LOG file function, the **Close** and the **Done** commands are used to close the viewing window and the dialog box respectively.

4 - MENU REFERENCE

4.1 Introduction

This chapter contains a detailed description of parameters and commands of the data acquisition program for the spherical near-field antenna measurement system. The commands are divided into four groups, each group containing commands and parameters specific to the measurement or to some equipment or procedures that must be set up. For each group, a Window or Control Panel Menu is displayed on the screen containing commands or parameters to be defined in an open menu format fashion.

The four groups of menus are: the **Measurement Control Panel**, the **Orbit Control Panel**, the **Wiltron Control Panel**, and the **Plotting Control Panel**. The **Measurement Control Panel**, the main menu panel, is always returned to after an action is terminated or after a secondary menu panel is closed with its **Finished PB**. The Menu Panels are themselves subdivided into several coloured sub-panels which are grouped together by subject or function, commands and parameters.

No menu bar has been implemented in this program. The only exception, however, is for the graphics plots traced in the XY GRAPH widget used to view the antenna patterns after the measurements. This widget has its SYSTEM MENU attribute set to create a system menu box in the upper left corner of the title bar. This system menu has only one menu item, a MENU BUTTON labelled *Close*. It is used to close the graphic window.

The commands are executed through PUSHBUTTON widgets and parameters are input through text boxes or list selection. Text and numeric parameters are entered through text boxes. The list selection is used when a finite list of known values can be chosen for a parameter.

The text boxes are bordered rectangles containing a field of data such as a filename, an operating frequency, a scan angle, etc. A read-write text box is used to enter and change the value of a data field, while a read-only text box presents some existing data, a measurement status or an instrument state. To enter data into a text box it must be placed in edit mode. This is achieved by moving the mouse pointer over the text box. At this point the focus is on the text box and editing is permitted as long as the focus stays on the box. Editing inside a text box is performed the way all text entry is done in HP BASIC. When the data field is correctly entered it must be submitted to the system by pressing the <Enter> key. If the data is not valid (a number out of range for example), a WARNING dialog box appears on the screen with a message specific to the situation. After the *Continue* action button is pressed, the text box returns to its former value and stays in editing mode as long as the mouse pointer stays over the box.

The list selection is performed through the *rotate selection* PB mechanism developed for this program. It is composed of a read-only text box (LABEL widget) and

a small push-button labelled ">". This PB is co-located close to the right of the selection text box. When this PB is pressed the text box displays immediately in sequence the next parameter value if the number of items to select is small. If this number of items to choose is larger than five a LIST dialog box appears on the screen and prompts the operator to select, using the mouse, a specific item from the list provided. After the selection, one of the action buttons **OK** or **Cancel** must be pressed to activate the selection or dismiss the dialog box. The selection text box is then updated according to the selection if the **OK** action button had been activated.

In the **Measurement Control Panel** two **RADIOBUTTON** widgets are used to specify the file storage handling. The **RADIOBUTTON** widget exhibits the properties of an old automobile's radio buttons, that is, when you press one button, the others pop out or are released. When a radio button is activated, one could see a depression on the button caused by a change of colour contour of the diamond shape button. In this application, it is programmed differently, when the first button is clicked "ON", the second one is forced "OFF". The operation of the second radio button, however, has no effect on the first one.

A description of every individual push-button command and of every measurement and device parameter will be given. In the case of repetition or similarity of some of these items the explanation will not be repeated. Command and parameter definitions and explanations might include some details about dialog boxes that pop-up the screen, but their action buttons such as **OK**, **CANCEL**, **CONTINUE**, etc, whose meaning is evident will generally not be commented.

4.2 Measurement Control Panel Menu

The **Measurement Control Panel** Menu (Figure A-1) is the main control menu. This menu is always displayed during measurement except when the other device menus **Orbit**, **Wiltron** or **Plot** are displayed on the screen. These menus are called only to set up some parameters or to display or print previously measured patterns.

This panel contains the main measurement configuration parameters and commands which are organized into seven sub-panels. There is an additional sub-panel dedicated to a set of push-button commands to call the device control menus for specific device parameters to be specified or to manage the LOG file by entering USER comments or viewing the file content. Finally, the *Finished* PB terminates the program. Sub-panel descriptions follow.

4.2.1 TEST File Storage Control

The TEST File Storage Control provides all the commands required to manage the measurement configuration TEST file. The TEST file includes all the test details and the current status of the measurement activity. This file, updated after each scan, contains the trace arrays specifying which scan had been measured along with the time and date of its measurement. The measurement activity can then be stopped and

restarted at a later time with the equipment automatically reset as noted in the test file. Sub-panel descriptions follow.

Prefix, Path, Drive: The three items *Prefix*, *Path* and *Drive* define the full filename of the TEST file. The filename is formed of the *Prefix* text box content with the added ".TST" file extension. The *Prefix* must be six characters long. This format required by CASAMS reserves the two other character spots for the measurement data filename. The other two parameters *Path* and *Drive* refer to the directory path such as "/Dir1/Dir2", and the disk drive ID ":",1400". When a *Prefix* is entered in the text box, the trace arrays are cleared, effectively clearing in memory all records of previous measurements and the **Measurement Control Panel** at the bottom of the screen is updated.

Find PB: This command is used to find the name of an existing TEST file. The FILE Dialog box widget appears allowing the operator to specify the drive, the path of the database directory and the name of the TEST file to be opened by the *Read Config*. PB. Two action buttons **OK** and **Cancel** are available. Pressing **OK** will update the filename text boxes described above and the FILE dialog box will be dismissed.

Read Config PB: This command is used to open an existing TEST file and load the test parameters it contains. The **Measurement Control Panel** menu is then updated with the loaded measurement details. With this new information loaded, the operator could continue unfinished measurements, use the plot menu to view previous patterns, or modify some test parameters to start a new experiment.

Store Config PB: This command is used to store the test details in the TEST file. If the TEST file does not exist, the trace data are cleared, a new TEST file is created and the test parameters defined in the various menus are stored into the file. If the TEST file exists, checks are made to determine whether or not changes have occurred in important sections of the TEST file by comparing the parameters in memory with the ones in the file. In the affirmative, A QUESTION dialog box appears on the screen warning the user of the fact that TEST file changes will occur in areas nn,nn, etc. The user must then decide if either he will continue saving the file, note the fact to the LOG file and continue, or simply stop the *Store Config* operation. If the TEST file exists, the user must also allow it to be overwritten.

Clear Scans PB: When this push-button is activated a dialog box appears with the notification message: "WARNING! This operation will clear n scans. Proceed?" and presents two action buttons, **OK** and **CANCEL**. Pressing **OK** will cause the following changes: the trace arrays are cleared, effectively clearing in memory all records of previous measurements, and the **Measurement Control Panel** at the bottom of the screen is updated. This command will be used when the operator decides to restart the measurements from the start but still wants to keep the LOG file intact.

Clear Scans+Log PB: This command is the same as the previous one but with the addition that the LOG file is also cleared. The notification message for this command is: "WARNING! This operation will clear n scans and delete your LOG file. Proceed?"

Copy TEST to Log PB: With this command the TEST file is appended to the LOG file. The TEST details are preceded by a [TEST start] record block and followed by a [TEST end] ending block.

4.2.2 Experiment Information

This sub-panel groups three input text boxes to enter the **Experiment Information**. The first two labelled *T1* and *T2* are for a 2-line title to be displayed in the title area of the graphics plots of the antenna patterns traced during measurement. The third line labelled *OP* is for the operator's name. A maximum of 40 characters is allowed in each string.

4.2.3 Scan Configuration Table

The **Scan configuration Table** contains the measurement scanning parameters for up to six axes, but displays only the data for three axes. The panel is divided into four columns, including one column for the parameter names and three columns for the parameter values of three chosen axes. Currently, only the axis numbers 1, 2 and 4 can be chosen. These are the axis numbers for the three Orbit positioners at the DDARLing facility. The azimuth positioner AL-860, the roll positioner AL-560, and the probe positioner Al-360. The definition of each parameter follows and applies to each *Axis* column.

Number: This item specifies the physical Orbit axis number.

Label: This is the label attached to the positioners. This text box is read-only.

Scan type: This is the parameter which sets the order of axis operation, i.e. which axis rotates first, second or third. The so-called Scan axis is usually the "First" axis and the Step axis is the "Second". The **Scan type** is selected through a rotary selection PB. The **Scan type** selection list includes: First, Second and Third.

Start, Stop, Incr. and Num. steps: This group of four items constitutes the four parameters required to define a scan. The first two specify the scan start and scan stop angle position. The following one **Incr.** is the angular increment value in degrees for synch pulse generation for the First axis or the angular step for the other axes. Similarly **Num. steps** is the number of angle increments and the number of steps. These last two parameters are interrelated, i.e. when one is defined the other is calculated.

Scan direction: This refers to the direction of rotation of the axis. The **Scan direction** is selected through a rotary selection PB. The selection list includes: Forward, Reverse and Bi-directional.

Scan Vel.: This is to specify the positioner velocity in % of maximum speed. The rotational speed of the three positioners at DDARLing (860, 560, 360) is 1.6 RPM, 2.5 RPM and 15 RPM respectively.

Ret. direction: This refers to the direction taken by the positioner to return to the starting position after a scan is terminated. The return direction selection list includes: Forward, Reverse and Auto. The latter is the direction of the shortest path to the destination.

Ret. Vel.: This is the velocity that the positioner uses when returning to the starting position. This value is generally 99.9%, the maximum value.

File I/O, Read and Write PBs: These commands are not implemented in this version of the program.

Do scan, Continuous and Start and Stop PBs: These commands are used to run the specified axis into only a single scan either in continuous or start and stop motion. The purpose of this command is only for debugging or check.

1st Axis Motion: This parameter refers to the type of scanning motion. The first axis motion is selected through a rotary selection PB. The selection list includes: Continuous, and Start and Stop. In "Continuous" mode, the scan is programmed as a sector scan. The positioner rotates at constant speed between the start and stop positions and the controller delivers synch pulses at regular intervals synchronizing the measurement. In the "Start and Stop" mode, the positioner moves to each increment position and stops; then the measurement is done. This is repeated until the **Stop** position has been reached.

Scan Mode: This parameter specifies the number of axes involved in a scan. The scan mode is selected through a rotary selection PB. The selection list includes: One Axis, Two Axis, and Three Axis. For spherical near-field measurement either two or three axis is chosen. The third axis is normally used for the probe polarization selection when the probe is singly polarized. With a dual polarization probe only a "Two Axis" scan mode is required. If a "Two Axis" scan mode is used with a single polarization probe, the operator must repeat the scans for each polarization. The measured polarization is specified in the **CASAMS Configuration Options** panel.

Do Whole Scan and Do Bound. Scan PBs: These commands are used to run the whole scan or to scan the positioners to their boundary positions in the motion and mode chosen. The purpose of these commands is only for debugging or checking of the positioner motion; no measurements are made.

4.2.4 CASAMS Configuration Options

This sub-panel is dedicated to the specifications of parameters required specifically by the CASAMS post processing program. This information will be stored in diverse headers of the CASAMS files.

Current Device: This parameter specifies which device is currently being measured. The Device selection includes: Antenna or Gain Horn. "Antenna" is selected when the AUT is measured. A "Standard Gain" horn can also be measured. CASAMS uses the

measured data in relation with other data found in a "Standard Gain" horn file to calculate the gain of the antenna.

Mounting: This parameter specifies to CASAMS which antenna mounting is used for the AUT. The selection includes: Polar and Equatorial.

Polarization: This parameter specifies which polarization is currently being measured. This is used to flag the data in the CASAMS files. The on-screen selection includes: H Only; V only; H first + V; and V first + H. The last two selections are used with a dual polarized probe when both polarizations are measured simultaneously or when scanning in "Three Axis" scan mode with a single polarization probe.

Angular Data: This is to specify if the angular data will be included into the CASAMS files along with the measured magnitude and phase data. The Angular data selection includes: Include and Omit.

SGH File: This parameter specifies the Standard Gain horn filename. CASAMS requires this file to get information about the Standard Gain horn. The filename is entered in the text box below the label.

Range (m): This is to specify the range length in meters. CASAMS defines this length to be the distance between the azimuth axis and the phase centre of the probe antenna. The number is entered in the text box below the label.

4.2.5 Device I/O

This sub-panel provides a set of push-button commands to check the GPIB communication links with the Orbit and Wiltron equipment and to clear their internal GPIB buffers. The status of the Orbit controller is displayed after commands are executed. A panic button **Abort** is also available to abort positioner motion if it becomes necessary.

Check Orbit PB: This command checks if the Orbit Controller is in "COMPUTER" mode, if not, an INFORMATION dialog box appears on the screen with a message requesting the operator to put the Controller in "COMPUTER" mode. The **Orbit stat.** text box is updated.

Check Wiltron PB : This command checks the GPIB communication link to the Wiltron. If there is no link a WARNING dialog box appears on the screen with the message: "The GPIB connection to the Wiltron has TIMED OUT!"

Clear Orbit PB: This command sends an Halt command to the Orbit Controller stopping any positioner motion and consequently putting the Controller in stand-by mode. A GPIB CLEAR command is also sent to the Controller clearing the internal buffers.

Clear Wiltron PB: This command resets the Wiltron VNA to its default state.

Orbit Stat.: This read-only text box shows the Orbit Controller status.

Abort PB: This button is not activated all the time. Its function is activated only by routines controlling positioner motion. During measurements, the operator instead will use the **STOP** button located inside the **Measurement Monitoring Panel** of the **Measurement Window** which appears on the screen when the measurement activity starts.

4.2.6 FTP Control Panel

This sub-panel provides access to the commands for the setting up of the File Transfer of measurement data through the LAN. Data can be transferred either manually or automatically during measurement. The operator has the capability of specifying when the transfer is done, after each scan, after a measurement subset or after the measurement activity is terminated. He can also prevent all transfers; in this case the transfer will be done manually. The TEST file and the LOG file are always transferred with the data files. The remote host is currently the DDARLing PC, its host name and IP number are "hardwired" in the code, but this could change if need be. Parameter descriptions follow.

Destination Directory: This text box specifies the directory path of the remote host receiving the transferred files.

Auto Transfer: This is to specify, through a rotary selection push-button, the type of FTP auto-transfer to be performed during measurement. The selection includes: None, After Each, After Subset, and After All.

Send: The **Send** PB is used as a label for the manual FTP **Send** selection. The selection includes: All, Current, Subset. Specifying "All" means that all measurement files actually existing will be transferred to the remote host when the **Send** PB is activated. The meaning of Current is evident in the context. "Subset" means a subset of files as specified in the **Measurement Control Panel** at the bottom of the screen.

Send PB: When this push-button is activated a manual FTP of the measurement files is executed according to the **Send** selection.

Test Link PB: This command is used to test the FTP link through the LAN. A small test file is sent to the remote host as a check. If the FTP link is not enabled a warning message dialog box appears on the screen. To enable the FTP link the following actions must be executed on the DDARLing PC. The PC network running under SUN PC-NFS is started with the command **LOGIN**. Then the command **FTPD** is executed to start the FTP server program on the PC. At this point the PC is dedicated to serving FTP transactions and cannot be used for anything else. This software runs under DOS and not under WINDOWS.

4.2.7 Measurement Control Panel

The **Measurement Control Panel** sub-panel located at the bottom of the screen is used to specify the scans to be measured and the data storage handling. The **Current Scan** number is set by the program to the next scan to be measured. This number, however, can be changed by the operator to any possible value. The range of scans to be measured is specified with the **MEASURE** rotary selector. This selection specifies if all scans, a subset of the scans, the remaining scans or simply the current scan will be measured. Radio buttons are used to specify if the next measurements will be saved, and when measurements are repeated, if the files will be automatically overwritten. A status text box shows the measurement status of the current scan by specifying which polarization has been measured and how many scans remain to be measured.

Current Scan: This text box displays the current scan or the next scan to be measured. The program initializes this parameter but the text box can be edited, the operator can change its content when he wants to measure some other scan.

Status: This read-only text box specifies the measurement status of the current scan, which polarization is measured and how many remain to be measured.

Subset Config: It is possible to measure only a subset of the scans. Two text boxes are available under the **Subset Config** to specify a subset scan range. These scans are defined according to the **steps (incr.)** of the second axis.

Store PB: The function of this push-button is to store the measurement of the current scan. The TEST file, however, is not updated in this instance. This command will be used when a single scan measurement is done and the operator is satisfied of the results, thus preventing a remeasure when the **MEASURE** Remaining command is issued.

Do Not Save and Auto-overwrite Radio buttons: These two interconnected radio buttons are used to set up the fate of the data or the data files after a scan measurement. These two buttons are normally OFF, i.e. data is automatically saved into files and cannot be over-written without an affirmative answer to an over-write request by the program. When **DO NOT Save** is pressed (set to ON) data is not saved after a scan measurement. In this case the other radio button **Auto-overwrite** is forced to OFF. When the latter button is pressed ON, a data file could be over-written when a scan is remeasured.

MEASURE: The **MEASURE** PB is used as a label for the **MEASURE** selection. The selection includes: ALL, Subset, Current and Remaining. This selection permits the operator to specify the range of scan measurement that the system will perform. "ALL" will cause measurement of all scans of one polarization starting at scan 1. If "DUAL" polarization is enable using "Two Axis" mode or single polarization using "Three Axis" mode, all scans for both polarizations will be measured. If data files already exist, they will be over-written only if the radio button selection allows it or if the operator permits it by answering affirmatively to a dialog box request. A "Subset" selection will cause measurement of only a subset of the scans as specified in the **Subset Config** text boxes. The meaning of "Current" and "Remaining" selection is evident.

MEASURE PB: This command starts the last verifications required before actual measurement starts. The program verifies that the parameters configured in the Wiltron, Orbit and CASAMS panels are compatible for a measurement. If they are not, the user is notified through a notification dialog box of the problem situation and measurement is not started. The routine also determines if changes have occurred in important sections of the TEST file by comparing the parameters in memory with the ones in the specified file. When this situation occurs, a dialog box appears on the display warning the user of the fact and requesting him through three action buttons to specify what must be done next. The three actions are: **Continue only**, **Note Log and Continue** or **Cancel**. When everything checks fine, a small **Measurement Window** containing the **Measurement Monitoring Panel** appears on the bottom centre of the screen with read-only text boxes and more commands. These are described in the next paragraph.

4.2.8 Measurement Window

This temporary window (see Figure A-2) appears as mentioned in the above paragraph when the system is ready for measurement. The included **Measurement Monitoring Panel** contains several read-only text boxes informing the user about the measurement activity. They are : Scan Range, Current Scan, Status, Measurement Status and the data files disposition radio button setups. There are also three action buttons to control the measurement: GO, STOP, DONE.

Scan Range: This refers to the range of scans to be measured. In the "Three Axis" mode that range is doubled because the two polarizations are measured.

Current Scan: This specifies the scan currently being measured.

Status: This status is the same measurement status described in the previous paragraph. It concerns the state of polarization measured and the number of remaining scans to be done.

Measurement Status: This status is for equipment status during measurement. Messages like the following can be seen in this text box: "Tracking n", "Sector n", "Stepping n", "Lock Short", "Lock failed", "Stand-by", etc, where "n" is a scan number or an axis number.

Do Not Save and Auto-overwrite: These read-only text boxes specify the radio buttons states which could be either "ON" or "OFF".

GO, STOP, and DONE PB: These push-buttons control the measurement. **GO** starts the measurement. **STOP** is an ABORT button such that when activated, all positioner motion is stopped and the Orbit Controller returns to its Stand-by state. **DONE** is used to return to the **Measurement Control Panel** menu when the measurement activity is terminated. The **Measurement Window** is closed and the main menu commands are reactivated.

During measurement after each scan a graphics plot of the scan pattern is traced inside an XY GRAPH window. The plot is traced according to the format and scaling specified in the **Plotting Control Panel**. This panel will be described in paragraph 4.5.

4.2.9 Other Menus

This panel offers four push-button commands to call three separate full screen menus used to set up the Orbit and Wiltron VNA devices, and the plotting parameters. The fourth command calls for a special dialogue box to control and manage the Log file.

Orbit PB: This command brings to the screen a new full screen window, the **Orbit Control Panel** menu. This menu is described in paragraph 4.3.

Wiltron PB: This command brings to the screen a new full screen window, the **Wiltron Control Panel** menu. This menu is described in paragraph 4.4.

Plot PB: This command brings to the screen a new full screen window, the **Plotting Control Panel** menu. This menu is described in paragraph 4.5.

Log File PB: This command brings to the screen a dialog box for **Log File Control**. This menu is described in paragraph 4.6.

4.2.10 Finished PB

This command terminates the Program.

4.3 Orbit Control Panel Menu

The **Orbit Control Panel** menu (Figure A-3) is a menu used to set up the configuration parameters of each positioner axis and to directly control the motion of the positioners. This menu is used during setup and optical alignment of the equipment. This panel is organized into five sub-panels of which two of them are a repeat of panels found in the **Measurement Control Panel** menu. This panel is closed with the *Finished* command. Sub-panel descriptions follow.

4.3.1 File Storage Control

The functions in this sub-panel are not enabled in the measurement program.

4.3.2 Scan configuration Table

The **Scan Configuration Table** is described above in paragraph 4.2.3.

4.3.3 Axis Configuration Table

The **Axis Configuration Table** is organized the same way as the **Scan Configuration Table** as described in paragraph 4.2.3 with the exception that the parameters are the positioner's configuration parameters.

Number and Label: These two items are described in paragraph 4.2.3.

Offset: This is an angle offset fed to the Orbit Controller to calibrate the angle display relative to a positioner position considered to be at zero degrees. This value is defined when the **Reset Offset** PB (located in the **Direct Axis Motion Control** menu) is activated. This parameter can also be directly entered into the text box when its value is known.

Fwd lim and Rev lim: These two items refers to the Orbit Controller software limits but are not used.

Lock Window (deg): This item is an angle window centred at the target position and extending to both sides of the target. This parameter is used by the Controller operating in track and sector mode to determine when to stop the positioner. The Controller determines that the positioner has reached the target position when its measured position, relative to the target, is within the boundaries of the predetermined "locking window" around it.

Encoder: This parameter specifies the positioner angle measurement sensor and the position display format. As described above in paragraph 2.4, the sensors available are the single and double speed synchro transmitters and the inductosyn. The two display formats for the angles are 0° to 360° and -180° to $+180^{\circ}$.

The angle decoder is selected through a rotary selection PB. The selection list includes: SYN (360), DU SYN (360), INDUCT (360), OP ENC (360), INCL (360), SYN (180), DU SYN (180), INDUCT (180), OP ENC (180), INCL (180). Only SYN, DU SYN and INDUCT are available in the DDARLing system. The inductosyn is the preferred encoder to choose for its accuracy, and the only format acceptable is $\pm 180^{\circ}$. This is the format expected by CASAMS.

Gain and Acceleration: The gain is used as a parameter in the closed-loop position control, and the acceleration/deceleration is the parameter for the open-loop position control. More explanation about these terms can be found in the Orbit AL-4706-3A Controller/Programmer Operation Manual. What is required to know here, in the scope of this report, is that these parameters must have a fairly small value for a smooth positioner motion.

File I/O, Read and Write PBs: These items are not implemented in this version of the program.

HPIB Comm. Send config and Get config PBs: These commands are used to send or receive from the Orbit Controller, an Axis configuration. These transfers are done

through the HPIB communication link and concern only the axis specified in the column where the command is located.

Send Disp. Axes PB: This command sends the configuration parameters of all three axes displayed in the table to the Orbit controller.

Get Disp. Axes PB: This command receives the configuration parameters of all three axes displayed in the table from the Orbit controller.

4.3.4 Direct Axis Motion Control

This sub-panel groups several Orbit commands to move the current positioner (or axis) to a specific position or to a step of the scan defined in the **Scan Configuration Table**. Relative stepping in very small increments is also a possibility. Tracking velocity and direction are specified, and a command is available to reset the angle offset of the current axis. These commands are very useful to the user during positioner setup and the optical alignment exercise where the positioners must be moved often to different fixed positions such as 0°, 90° or 180°.

Axis: This text box specifies the current axis on which the positioner move commands will be applied.

Position (deg): This read-only text box displays the current position of the positioner.

Tracking Control: The tracking control area groups two positioner motion parameters, the motion speed (*Vel. (%)*) given in percent and the motion direction selected through a rotary selection PB. The selection list includes: Forward, Reverse and Auto.

Position Control: The position control area groups a series of push-button commands to move the current positioner to selected positions. The first three PB are related to the scan parameters defined in the **Scan Configuration Table**. They are *Goto Start*, *Goto Stop* and *Goto Stp*. Their meaning is evident, but for the last one the operator must specify a step value. A read-only text box, located to the right of the step value, displays the maximum step value for this axis and its angle value as well in the following format "/2390 (-179)". Other commands such as *Goto Angle* PB and "+" and "-" PB give more flexibility to the user to rotate the positioners. Two text boxes can be used to specify positions to go to, and also two more areas to specify relative steps which may be very small such as .005°.

Reset Offset PB: This command will reset the angle offset of the current positioner in the Controller. This has the effect of changing the 0° position of the positioner. When the command is activated, the current position of the positioner is changed to 0°.

4.3.5 Orbit Controller Options

The **Orbit Controller Options** are described above in paragraph 4.2.5 Device I/O.

4.3.6 *Finished PB*

This command terminates the **Orbit Control Panel** functions. The screen is erased and the main **Measurement Control Panel** returns.

4.4 **Wiltron Control Panel Menu**

The **Wiltron Control Panel** menu (Figure A-4) is used to partially setup the Wiltron VNA. The VNA parameters and functions that can be specified by the program are the frequency, the channel(s) and the triggering selection. After this selection is done, the user sends the frequency list to the VNA and finishes the VNA configuration directly from the front panel. The operator specifies parameters such as the display format, the IF bandwidth, the number of averages, etc. The operator then returns to the computer screen and presses the *Get Panel fm Wilt* PB to read the complete configuration from the VNA. This configuration data is a binary string that will be stored in the TEST file as an INTEGER number array. This array will be sent back to the VNA when the measurement starts to reconfigure it to the measurement specifications.

This panel is organized into five sub-panels of which two are not for antenna measurements. The **Experiment Information** and the **Wiltron Device I/O** (part of the **Miscellaneous Wiltron Options** sub-panel) are exclusively used as a helper to components measurements. Sub-panel descriptions follow.

4.4.1 **File Storage Control**

The functions in this sub-panel are not enabled in the measurement program.

4.4.2 **Experiment Information**

The purpose of this panel is to specify four text output parameters for the VNA printer form used when the VNA display or the data are printed. Each text box is limited to 12 characters. The four items are: *Date*, *Operator*, *Device ID*, and *Model S/N*. An additional fifth item *Insert Time* specifies if and where the time is to be inserted in any one of the four text boxes. The choice is done through a rotary selection. The selection list includes the list of the four items mentioned above and a fifth one "nowhere" which means no date to be inserted. The parameters defined under this section are not for antenna measurement, they will be useful only when doing component measurement with the VNA. Two push-button commands are described below.

Send to Wilt. PB: This command will send the experiment information to the VNA.

Read from file PB: This command is not implemented in this version of the program.

4.4.3 Measurement Configuration Panel

This sub-panel groups the Wiltron VNA configuration parameters that must be set up through program control. The operator selects the VNA channel(s) used for measurement. One channel is selected if one polarization is measured, or two channels if a dual polarization probe is used. The Wiltron triggering mechanism selection follows and then the measurement frequencies are chosen. If only one frequency is specified, the VNA will operate in CW mode. A command is available to send this configuration information to the VNA. Sub-panel descriptions follow.

Channel(s): This command selects the VNA channel(s) to be used during measurement. The selection list includes: Channel 1, Channel 3 and Channel 1&3. Either "Channel 1" or "Channel 3" can be chosen when only one channel is selected.

Triggering: This command selects the Wiltron triggering mechanism and how the data is handled during measurement. The selection is done through a LIST dialog box. The list selection includes: Internal, Bus + Internal, GPIB Bus, Bus & Buff., External, and Ext. & Buff.

The "Internal" triggering is used for start and stop scanning. In this mode the VNA is continuously swept. In the "GPIB Bus" and "External" mode the triggering is done through the HP BASIC "TRIGGER" command or by an external TTL pulse generated by the Orbit Controller at each angle increment. In this mode the VNA must be triggered for every measurement and data is read when the sweep is terminated. This type of triggering is not very reliable and several problems of synchronism showed up during testing. This triggering mode should not be used until the problems associated with its use have been resolved.

The "Bus & Buff." and the "Ext. & Buff." triggering use the VNA internal buffer memory to collect the complex measurement data. In these modes, a TRIGGER command or an external synch pulse triggers a single frequency measurement. As long as there are no more than 3068 data points (number of angle increments multiplied by the number of scans), these two modes can be used safely. The number of data points is specified in the *Incr. (Deg)* text box of the *First AXIS* column in the **Scan Configuration Table**. The Orbit Controller must be configured to interrupt the computer and to output its synch pulse for every frequency. Thus the number of increments *Incr. (Deg)* is the number of points per scan multiplied by the number of frequency points in the sweep. This is the most promising triggering mode in the program. It proved to be very reliable in the tests and permits a very rapid data collection. During this type of measurement, the computer only counts the increments and reads the positioner position at increment time, it does not interfere with the measurement. The only time limitation is the VNA measurement time which, at the fastest measurement time, permits less than 100 measurements per second.

Frequency Data: The **Frequency Data** area of the panel groups a set of commands and text boxes to specify the VNA frequencies. Two methods are used to specify the frequencies. The user enters a value in the *Total* box and in any of the 10 input

frequency text boxes provided, or if the frequencies are separated by a fixed interval, a set of boxes are available to enter the start and stop frequencies in GHz, the interval and the number of frequencies, or a combination of both methods. A maximum of 501 frequencies can be entered. Parameter descriptions follows.

Total: This specify the total number of frequencies. When the *Total* number is changed, the list of frequencies in the 10 scrollable text frequency boxes changed also. The scrollable list is shortened or lengthened accordingly. In the case of lengthening, more boxes are made available to editing and their values are initialized to zero.

Start, stop, interval Freq (GHz) and Num. Points: These are the text boxes used to enter frequency values with a fixed interval.

Fill discrete PB: This command enters *Num. Points* new frequencies in the scrollable frequency list. The *Total* value is increases by as much.

Frequency data table: This a group of 10 editable text boxes used to display a partial (scrollable) list of the selected frequencies.

<, >, t, m, b PBs: This a group of push-button commands used to display or to scroll the list of frequencies. The "<", ">" commands will scroll the list up or down by five items. The *t, m, b* commands, standing for top, middle and bottom, will scroll the list accordingly.

Clear PB: This command clears the list of all frequencies and resets the *Total* to zero.

Sort PB: This command sorts the frequencies by increasing order and eliminates the double values. The *Total* number is adjusted accordingly.

Send to Wilt. PB: This command sends the frequency selection to the VNA.

Read from file PB: This command is not implemented in this version of the program.

4.4.4 Front Panel Setup I/O

This sub-panel contains commands to read or send the VNA front panel setup between the program and the VNA. These commands are required so the VNA can be remotely setup when a measurement activity starts. As mentioned previously, the front panel setup is saved in the TEST file and contains all the VNA configuration parameters. Each time the setup is sent, the VNA is reset as specified in the setup string. Sub-panel descriptions follow.

Read this Panel at: This read-only text box displays the time and date when the VNA front panel setup was last read.

Send Panel to Wilt PB: This command sends the front panel setup stored in the program to the VNA. The frequency, triggering and channel data are transferred as well. This

is required because the front panel binary string is not decoded. It is only stored in the TEST file and used by the program to reset the VNA before a measurement.

Get Panel fm Wilt PB: This command is used to get the configuration parameters from the VNA. These parameters include the frequency list, triggering, channel data and the front panel setup. The date and time mark of this operation is also stored in memory and displayed in the read-only text box located over this PB. This is normally the last command sent so that the front panel binary string contains the complete finalized configuration.

4.4.5 Miscellaneous Wiltron Options

Except for a couple commands already described in the **Measurement Control Panel** menu, the commands in this sub-panel are dedicated to component measurement and apply only to the printing and storing of data to diskette files on the VNA drive.

Clear Wiltron and Check Comm. PBs: These two commands are described in paragraph 4.2.5

Set Link : This command relates to the communication link with the VNA. This link is selected through a rotary selection PB. The selection includes: Local, Remote and Lockout (Local lockout). When a GPIB command is sent to the VNA, the instrument is put into remote mode and the front panel keys are inoperative, however, the operator can re-activate the keys by a special key on the VNA keyboard except when the **Local Lockout** command is sent through the communication link preventing the re-inactivation of the keys.

Set Link PB: This command sets the link to the VNA as selected in the rotary selection text box.

Wiltron Device I/O: This area of the panel groups functions to output VNA data to the printer and for data disk file I/O to the VNA diskette drive. The experiment information as described in paragraph 4.4.2 is part of this output.

Print Screen PB: This command prints the full VNA display screen.

Stop Print PB: This command stops the printing operation in progress.

Store : This relates to the type of VNA data to access to and from the diskette. The selection list includes: Tabular, Calibration and AC data. "Tabular" refers to tabular printout data sent to an ASCII disk file or to tabular data recalled from disk for output to a printer. "Calibration" refers to the storage of calibration and front panel setup information. Finally, "AC Trace" refers to storage of the Active Channel trace memory.

Filename: This editable text box contains the name of the output file that is being generated when the **Store** PB command is sent, or the name of the input file to be accessed from the diskette when the **Read** PB is pressed.

Read and Store PBs: These two commands activate the file I/O operation of the VNA data as specified in the **Store** rotary selection.

4.4.6 **Finished PB**

This command terminates the **Wiltron Control Panel** functions. The screen is erased and the main **Measurement Control Panel** returns.

4.5 **Plotting Control Panel Menu**

The **Plotting Control Panel** menu (Figure A-5) is primarily used to set up the numerous graphing parameters required for the on-line tracing of the antenna patterns during measurement. The graphs are displayed in an XY GRAPH window after each scan and can be observed during measurement. In addition, this panel is used to trace the antenna patterns off-line on the display screen. The order of tracing could be sequential in ascending or descending order, or in any order as selected by the user. The graphics plots can be sent to the printer with the **Print** command. This panel is organized into five sub-panels. Their description follows.

4.5.1 **File Storage Control**

The functions of this panel have already been described in paragraph 4.2.1 **TEST File Storage Control** of the main control menu with the exception of the few commands required to load the data patterns for display. Because of that, only these commands will be described below. The purpose of this panel thus is to load "off-line" any test data in memory for the purpose of viewing or printing.

Load : The **Load** rotary selection refers to the order used to read the scan data. The selection list includes: NEXT and PREVIOUS.

Load PB: This command reads into memory the scan data for the current polarization. the latter is specified in the **Plot Control Panel**. The data is read in the order stated in the **Load** selection box in relation to the current scan value as indicated in the **Load Scan** box. The current scan value is always updated after each read. If the data does not exist, a WARNING dialog box appears on the screen informing the user of this fact.

Load scan: This is used to specify the scan to be loaded by the **Load Scan** PB command. This text box displays the new current scan value after the **Load** command is issued.

Load Scan PB: This command loads the scan as indicated in the text box. Only the polarity specified in the **Polarization** box of the **Plot Control Panel** is loaded in memory.

4.5.2 Plot Titling Information

This sub-panel groups the text boxes used to put a title at the top of the graph. Similar parameters have been defined in paragraph 4.2.2 and their values are used to initialize the contents. The parameters ***T1***, ***T2***, and ***OP*** can be updated by the user to render the graph title more to the point. A read-only parameter ***T3*** has been added to indicate the data polarization of the graph.

4.5.3 Plot Sample Configuration Panel

This sub-panel, organized like the Wiltron **Frequency data** of paragraph 4.4.3, is used to select the frequency of the sample data to be traced on the XY GRAPH window. A group of text boxes arranged in three columns of 10 rows displays a partial list of the frequency samples. Of the three columns titled ***Num***, ***Sample*** and ***Freq. (GHz)***, only the one titled ***Sample*** is editabled. It is used to specify the sample number. The ***Num*** column gives the sequential number of the trace (or curves) and the ***Freq.*** column lists the frequency value of the sample traces.

To specify the samples, the ***Total*** box is edited to set the number of samples or traces to display. When this value is set, that many sample slots are opened for definition.

Total: This parameter specifies the total number of traces to be put on the graph.

Use All PB: This command enters all the frequency samples in the list. The invocation of this command will cause the plot of all the frequency samples to be traced on a single graph. If the number of samples is too big the graph will be extremely crowded with many curves and the display might not be very meaningful.

Clear PB: This command clears the list of frequency samples and sets the ***Total*** parameter to zero.

<, >, t, m, b PBs: This group of commands is used to scroll the list of samples and functions as explained in paragraph 4.4.3.

4.5.4 Plot Axes Configuration

This sub-panel is used to set all the graphing axes parameters. It is organized in a table of 7 columns and three rows. The first row is for the ***X*** axis graphing parameters. It is dedicated to the scan increment angle positions where the measurements are taken. The second row is for the first ***Y1*** axis. The third row is for the second ***Y2*** axis. In the present implementation, however, only one ***Y*** axis tracing is implemented. The ***Ys*** axes are determined by the ***Plot Format*** selection of the **Plot Control Panel**. The column description of the **Axis Configuration** follows.

Axis: The items in this column are only labels stating the type of axis the row represents i.e. X or Y.

Label: This is used to set the display axis labels.

Start and Stop: These two parameters set the lower and upper bound of the traces.

Major: This item sets the position of the grid lines and of the major ticks of the axis by specifying the grid and major tick spacing. It is at the major tick positions that the axis values are labelled.

Minor: This item sets the position of the minor ticks.

Shift: This item can be specified but has not been implemented in the traces.

4.5.5 Plot Control Panel

This sub-panel is used to specify the plot format and the polarization to be plotted on the graph. A normalization flag can also be set to normalize the traces on the display. All traces are of a different colour which is defined by the rank of the sample. Because the background of the graph window is bright white, the sample whose pen number is bright white will not be seen on the graph. Parameter and command descriptions follow.

Plot Format : This item specifies which part of the data is traced. The selection list includes: Magnitude and Phase. In the current implementation of this program, only one format will be traced in a graph i.e. either magnitude or phase, but not both.

Normalization : This item is a flag which specifies if the traces of the data are normalized. The flag is selected to be either ON or OFF.

Polarization : This item refers to the polarization to be traced on the graph. The selection list includes: HORIZONTAL, VERTICAL and DUAL. The "DUAL" traces capability is not implemented in this version of the program.

PLOT PB: This command starts the process of tracing the requested plots on the screen. When this command is invoked an HP BASIC XY GRAPH window (see Figure A-6) appears on the screen and all the requested traces are plotted in the window. The graph stays on the screen as long as necessary. To close the window, the user must activate the system menu button located at the top right corner of the window. A drop down menu appears with a *Close* menu button which, when clicked, results in the XY GRAPH window being erased and the system prepared to access and display new data.

PRINT PB: This command is used to create a hard copy of the graph on the printer. This command generates an HPGL output file which is then sent to the printer (see Figure A-7). The DDARLing printer, a Laser Jet III, accepts such a format.

4.5.6 *Finished PB*

This command terminates the **Plotting Control Panel** functions. The screen is erased and the main Measurement Control Panel returns.

4.6 **Log File Controls**

The **Log File Controls** is a pop-up dialog window (Figure A-8) which appears over the Measurement Control Panel when the *Log File* PB is pressed. This push-button is located in the Other Menus sub-panel of the main panel menu. The purpose of this dialog box is to add user notes to the LOG file and to display its content on the screen so a history of the measurement activities that have occurred can be viewed. The LOG file is continuously written during measurement to keep a record of measurement events such as when a measurement starts, a file is stored, a scan is completed, an error occurred, an FTP transfer is done, etc. The filename of the LOG is formed with the *Prefix* parameter with the .LOG extension attached to it. It is saved in the same directory as the TEST file and the data files.

4.6.1 **User Notes and Viewing Control**

The user notes area includes four input text boxes that the user may use to insert notes and comments into the LOG file. It includes a pushbutton command *Add Notes to Log* the purpose of which is, as the label suggests, to append the notes to the LOG file. The Viewing control area contains two push-buttons for viewing the contents of the file. Finally, the *DONE* command returns control to the main menu panel. Command descriptions follow.

Add Notes to Log PB: When the command is activated all the user notes are appended to the LOG file. Each line is preceded by the line prefix {USER} to identify the type of log info the line contains.

View PB: This command causes the File Viewing Window to appear on the screen and displays the first 15 lines of the LOG file. Two additional commands *More* and *Close* are available to control the viewing and scrolling of the text inside the window. *More* is used to read more data into the window and *Close* closes the Viewing window and returns control to the **Log File controls** panel. The **File Viewing Window** size can be expanded using the sizing border with the mouse. It can be maximized using the maximize button located at the top right corner of the window. A vertical scroll bar with up and down arrows located on the right edge of the window is available to scroll the file content when only a portion of the window's content is visible.

Print PB: The LOG file printing function is not implemented yet.

DONE: This command closes the **Log File Controls** window and returns control to the Main Panel menu.

CONCLUSION

DAMAS, the software described in this document was proven invaluable for precise control and acquisition of accurate data. Three areas of the software development made this program so valuable to the antenna measurement process. The first is the control of the equipment, mostly the positioning equipment and the receiver. This equipment tends to behave in a whimsical fashion when pushed to its limit. A deep knowledge of its behaviour along with an adequate procedure and proper error recovery are necessary to get the most out of it. The second area is the user interface. Because of the large number of parameters to be selected for any measurement and the need to constantly change these parameters to obtain the best measurement possible, it was found necessary to have an interface that significantly speeds up this process and decreases the likelihood of selecting bad parameter values. The third area is the preprocessing and the near real-time presentation of the data. Because preparing for the measurement is often more involved and time consuming than doing the measurement itself, the constant feedback from the software in form of graphics is invaluable to help in the "debugging" of the measurement setup and procedures.

DAMAS, an essential part of the antenna facility, is a living program that will continue to be improved as the equipment is upgraded and the procedures and methodology evolve. Experimenting with different procedures and extensive testing have been an important part in the development of this software, and like any large software project, the job is never finished. The software will continue to evolve but it is believed that the user interface described in this report will remain quite stable and most of the improvements will be invisible to the user except for reliability and accuracy improvements.

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APPENDIX A - MENUS

The screen menus described in this paper are grouped together in this appendix. Their list follows.

Figure A-1	Measurement Control Panel
Figure A-2	Measurement Window
Figure A-3	Orbit Control Panel
Figure A-4	Wiltron Control Panel
Figure A-5	Plotting Control Panel
Figure A-6	XY GRAPH Window
Figure A-7	Sample Print
Figure A-8	LOG File Controls

Measurement Control Panel

TEST File Storage Control

Prefix: TST017

Path: /mikes/TESTdata

Drive: .,1400

CASAMS Configuration Options

Current Device:

Antenna:

Polarization:

H Only:

Mounting:

Angular data:

Experiment Information

T1 Continuous Ext. trig. with buffer

T2 Test with 20 Frequencies

OP Claude Brochu & Mike Flynn

Scan Configuration Table

Parameter	Axis	Axis
Number	1	2
Label	Azimuth	Roll
Scan type	First	Second
Start (deg)	-179	-90
Stop (deg)	-179.4	90
Incr. (deg)	.4	180
Num. steps	900	37
Scan direction	Forward	Forward
Scan vel. (%)	50	99.9
Ret. direction	Auto	Auto
Ret. vel. (%)	99.9	99.9
File I/O	Read	Read
	Write	Write
	Continuous	Continuous
Do scan	Start and Stop	Start and Stop

Device I/O

1st Axis Motion

Continuous:

Measurement Control Panel

Current Scan: 19

Status: H Yes/V Yes (measured), 0 remaining.

Subset Config: to

Auto-overwrite

FTP Control Panel

Destination Directory:

Send:

Subset:

Figure A-1 Measurement Control Panel

Measurement Control Panel

TEST File Storage Control

Prefix: TST017

Path: /mikes/TESTdata

Drive: :1400

CASAMS Configuration Options

SGH file: SGHFILE.DATk

Range (m): 3.5

Mounting: Polar

Angular data: Include

Current Device: Antenna

Polarization: H Only

Device I/O

Experiment Information

I1 Continuous Ext. trig. with buffer

I2 Test with 20 Frequencies

OP Claude Brochu & Mike Flynn

Scan Configuration Table

Parameter	Axis	Axis
Number	1	2
Label	Azimuth	Roll
Scan type	First	Second
Start (deg)	-179	-90
Stop (deg)	-179.4	90
Incr. (deg)	.4	5
Num. steps	900	37

Measurement Window

Measurement Monitoring Panel

Scan Range: 1 to 37

Current Scan: 1

Status: H Yes/V Yes (measured), 37 remaining.

Measurement Status: Auto-SAVE ON

Stand-by: Auto-overwrite OFF

Measurement Control Panel

Current Scan: 19

Status: H Yes/V Yes (measured), 0 remaining.

Subset Config:

2nd Ax: 1 to 37

FTP Control Panel

Destination Directory: D:\CHAMBER

Auto Transfer: After All

Send:

Subset:

Other Menus

Figure A-2 Measurement Window

Wiltron Control Panel

File Storage Control

File /

Drive

Front Panel Setup I/O

Read this panel at 11:14:06 17 Aug 1994

Experiment Information

Date	7 Mar 1994
Operator	Claude Broch
Device ID	<input type="text"/>
Model S/N	<input type="text"/>
Insert Time	Nowhere

Miscellaneous Wiltron Options

Measurement Configuration Panel

Channel(s)

Channel 3

Wiltron Device I/O

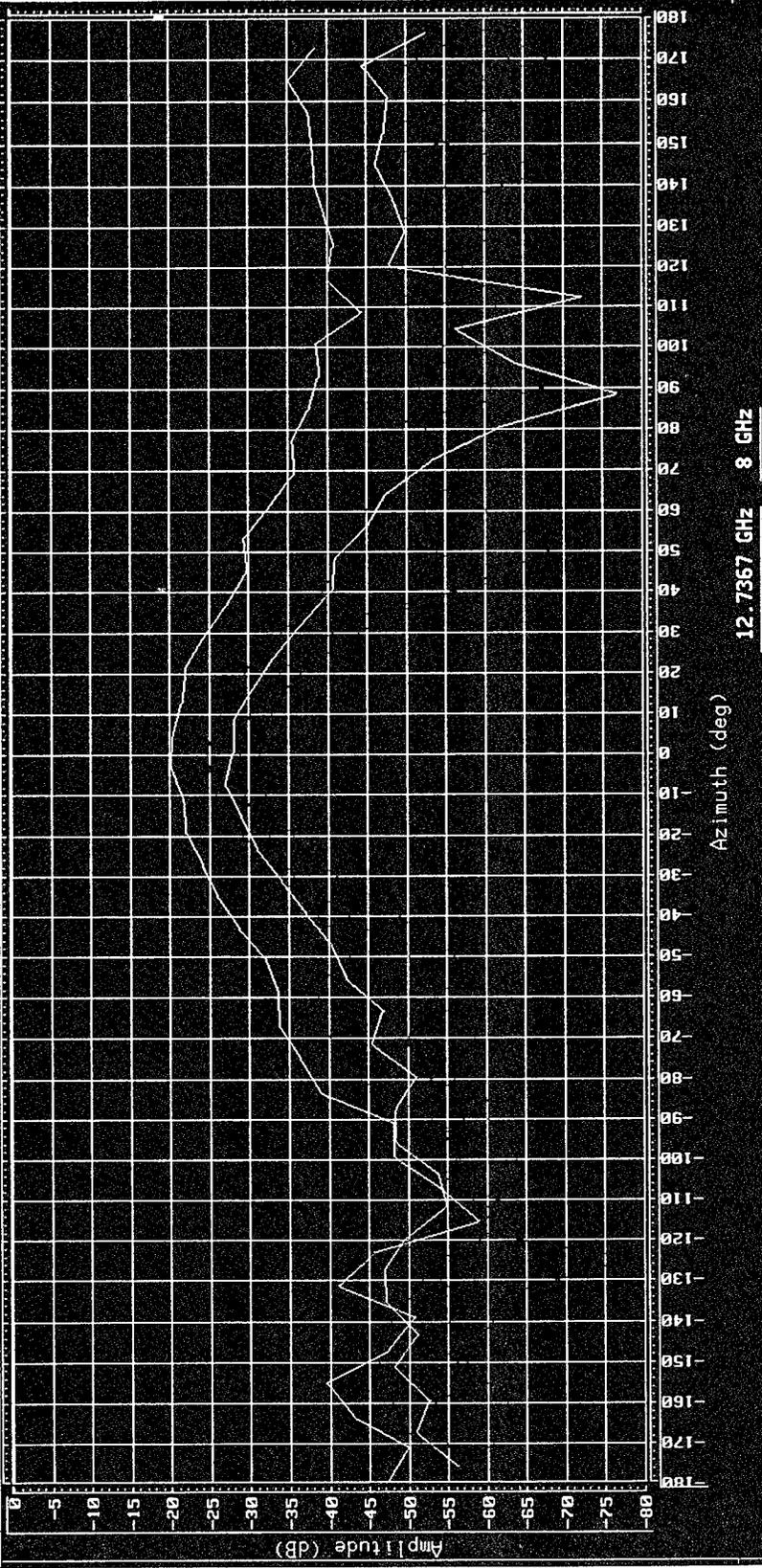
Frequency data

Total	20
Start Freq (Ghz)	8
Stop Freq (Ghz)	17.9997
Interval (Ghz)	.5263
Num. Points	20

1	8
2	8.5263
3	9.0526
4	9.5789
5	10.1052
6	10.6315
7	11.1578
8	11.6841
9	12.2104
10	12.7367

Figure A-4 Wiltron Control Panel

Continuous Ext. trig. with buffer H-Pol, Scan 17



12.7367 GHz 8 GHz

PLOT
PRINT

Polarization
HORIZONTAL

Plot Format
MAGNITUDE
Normalization
ON

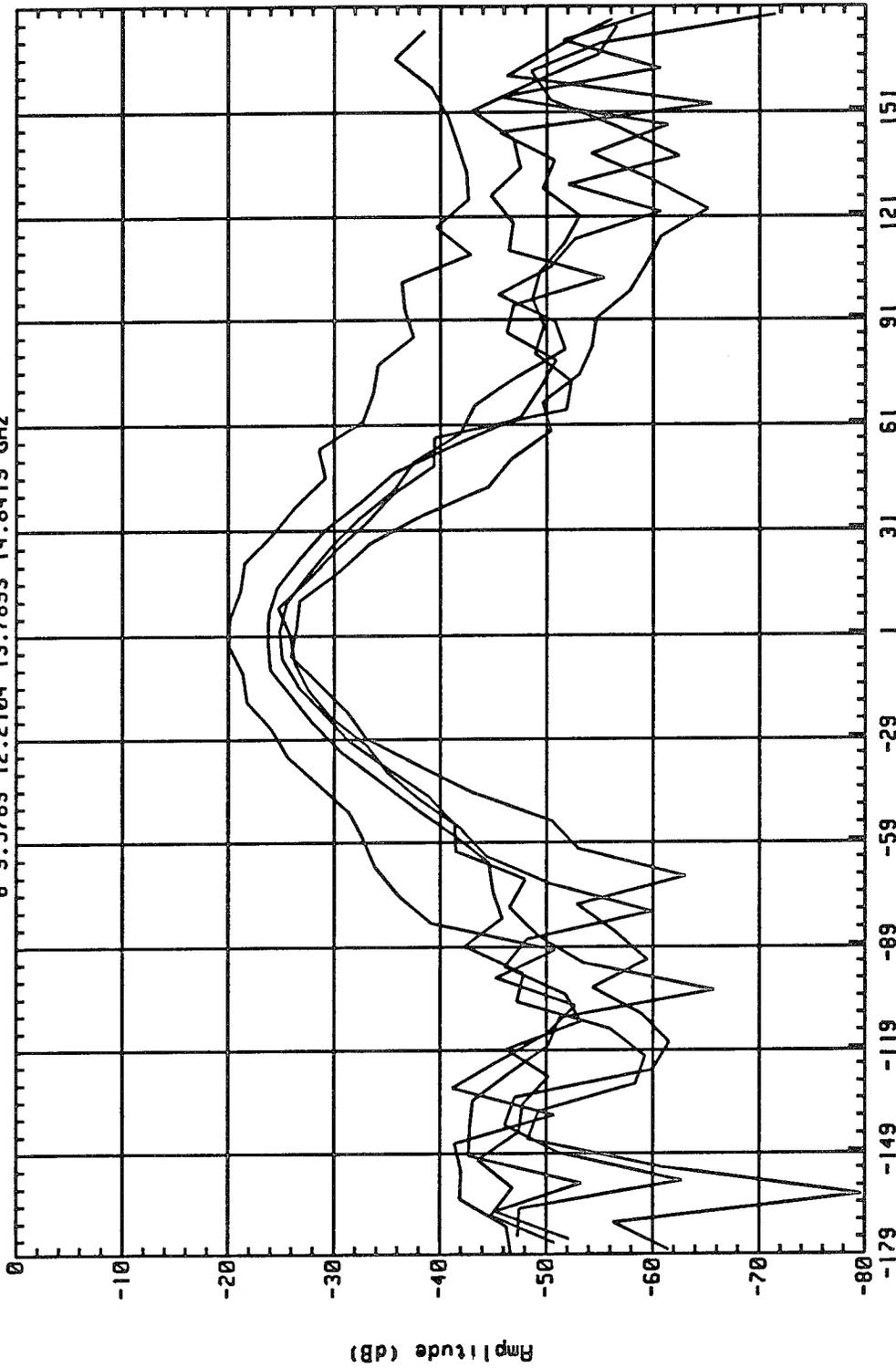
Plot Axes Configuration

AxIs	Label	Start	Stop	Major	Minor	Shift
X	Azimuth (deg)	-179	180	10	5	0
Y1	Amplitude (dB)	-80	0	10	2	0
Y2	Phase (deg)	-180	180	10	5	0

Finished

Figure A-6 XY GRAPH Window

Continuous Ext. trig. with buffer
Test with 20 Frequencies
HORIZONTAL Polarization, Scan 37
θ 9.5789 12.2104 13.7893 14.8419 GHz



Azimuth (deg)

Figure A-7 Sample Print

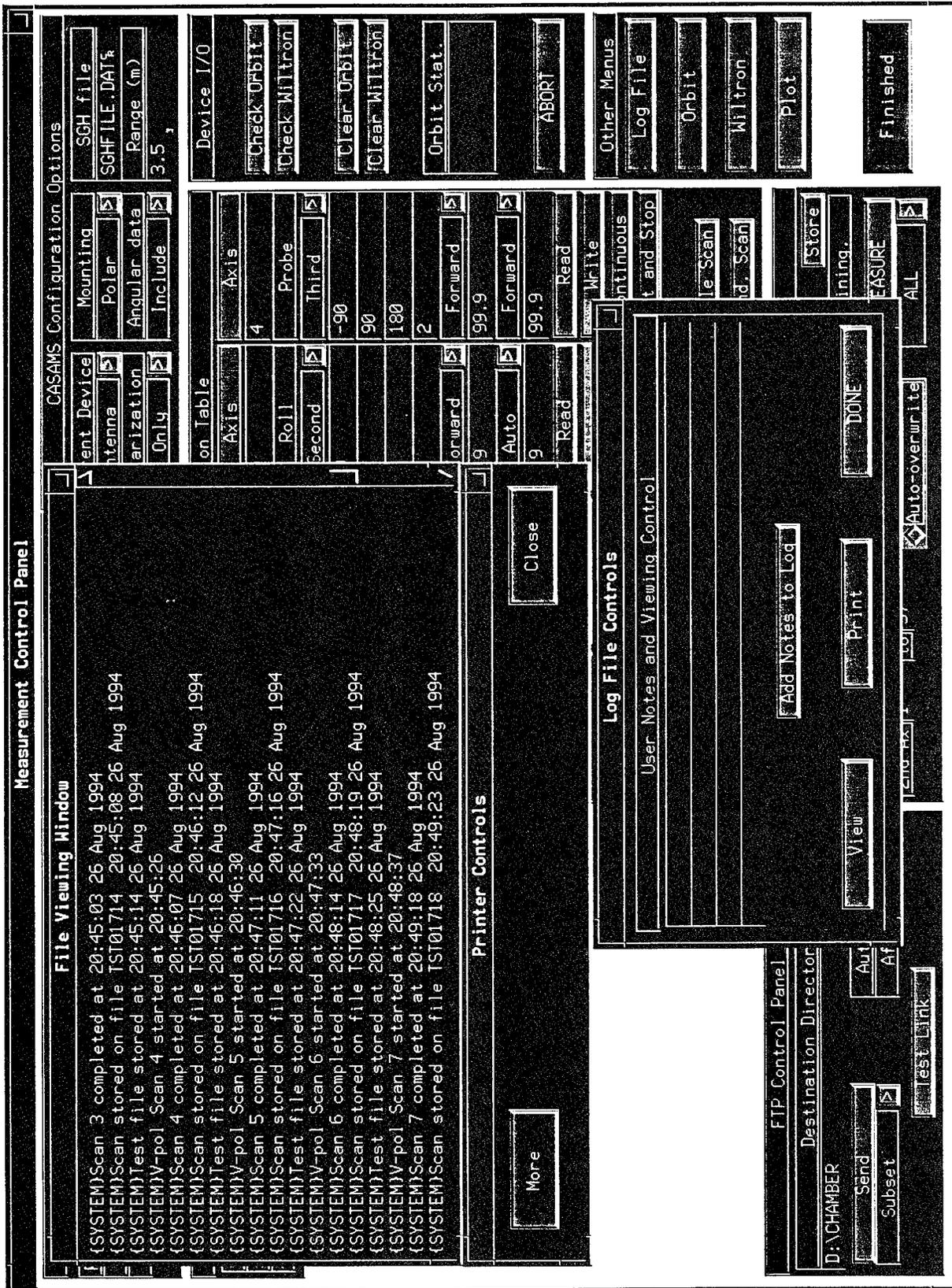


Figure A-8 LOG File Controls

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<p>3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C or U) in parentheses after the title.) Data Acquisition Software for DREO's Near-Field Antenna Measurement Facility (U)</p>		
<p>4. AUTHORS (Last name, first name, middle initial) Brochu, Claude J., Morin, Gilbert A.</p>		
<p>5. DATE OF PUBLICATION (month and year of publication of document) December 1994</p>	<p>6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.) 58</p>	<p>6b. NO. OF REFS (total cited in document) 5</p>
<p>7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.) DREO Report</p>		
<p>8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include the address. Defence Research Establishemnt Ottawa Department of National Defence, Ottawa, Ontario, K1A 0Z4</p>		
<p>9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant) 041LM</p>	<p>9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written)</p>	
<p>10a. ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.) DREO Report 1253</p>	<p>10b. OTHER DOCUMENT NOS. (Any other numbers which may be assigned this document either by the originator or by the sponsor)</p>	
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DREO has built an antenna anechoic facility for microwave and millimetre-wave measurement. The facility includes a spherical near-field antenna measurement system that allows far-field measurement of small antennas and near-field measurement of larger antennas (up to one meter) within the chamber. This report describes the facility including the equipment, the instrumentation, and the DREO Antenna Measurement Acquisition (DAMAS) software that was developed. The purpose of DAMAS is to control the measurement and acquisition process in real-time, and to present the data to the operator. The major objectives of this software development project were the streamlining of the process so that an antenna could be accurately characterized in the minimum amount of time, and the improvement of the reliability of the software.

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