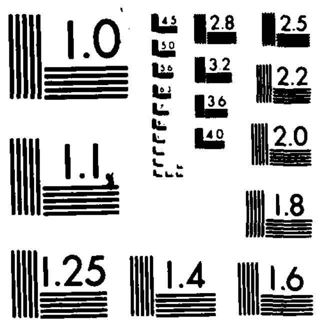
AD-A139 474 DEVELOPMENT OF A COMMAND CONTROL AND COMMUNICATIONS SYSTEM FOR LIGHT AIRCRAFT(U) AIR FORCE GEOPHYSICS LAB HANSCOM AFB MA A R GRIFFIN 05 OCT 83 AFGL-TR-83-0275 1/1

UNCLASSIFIED F/G 17/2.1 NL

END
DATE
FILMED
4-84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

(12)

AFGL-TR-83-0275
INSTRUMENTATION PAPERS, NO. 319

AD A139474

Development of a Command Control and Communications System for Light Aircraft

ALAN R. GRIFFIN

5 October 1983

AEROSPACE INSTRUMENTATION DIVISION PROJECT 7659
AIR FORCE GEOPHYSICS LABORATORY
HANSCOM AFB, MASSACHUSETTS 01731

AIR FORCE SYSTEMS COMMAND, USAF

This report has been reviewed by the ESD Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS).

"This technical report has been reviewed and is approved for publication"

FOR THE COMMANDER

for RALPH J. COWIE
Chief, Balloon Instrumentation Branch
Aerospace Instrumentation Division

C. NEALON STARK
Director
Aerospace Instrumentation Division

Qualified requestors may obtain additional copies from the Defense Technical Information Center. All others should apply to the National Technical Information Service.

If your address has changed, or if you wish to be removed from the mailing list, or if the addressee is no longer employed by your organization, please notify AFGL/DAA, Hanscom AFB MA 01731. This will assist us in maintaining a current mailing list.

Do not return copies of this report unless contractual obligations or notices on a specific document requires that it be returned.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFGL-TR-83-0275	2. GOVT ACCESSION NO. AD-A 39474	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DEVELOPMENT OF A COMMAND CONTROL AND COMMUNICATIONS SYSTEM FOR LIGHT AIRCRAFT		5. TYPE OF REPORT & PERIOD COVERED ~~Scientific.~~ Final.
		6. PERFORMING ORG. REPORT NUMBER IP, No. 319
7. AUTHOR(s) Alan R. Griffin		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Geophysics Laboratory (LCC) Hanscom AFB Massachusetts 01731		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62101F 76591206
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Geophysics Laboratory (LCC) Hanscom AFB Massachusetts 01731		12. REPORT DATE 5 October 1983
		13. NUMBER OF PAGES 32
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Command control
Communications

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

This report describes a state-of-the-art command control and communications system developed for use aboard a light aircraft during high altitude scientific research balloon flights.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Contents

Illustrations

Tables

Development of a Command Control and Communications System for Light Aircraft

1. INTRODUCTION

During high altitude scientific balloon flights, a light airplane (currently a Cessna aircraft) is used to monitor the balloon system during ascent, to report balloon position, and to observe and direct recovery operations after flight termination. A command control and communications rack is operated aboard this plane by Air Force personnel to provide voice communications with the Balloon Control Center and commands to the payload as necessary.

This report describes a new system developed under In-House Work Unit 76591206. The system consists primarily of radio equipment purchased from various manufacturers and integrated into a portable aluminum rack. The purpose of the new system is to replace the out-dated, badly aged system currently in use. A block diagram of the system is shown in Figure 1.

Two primary objectives were met with the new system. The first was a size and weight reduction to make the rack more portable, the second was the use of fully synthesized communications equipment to eliminate recrystalization and retuning every time one of our frequency allocations changed.

(Received for publication 29 September 1983)

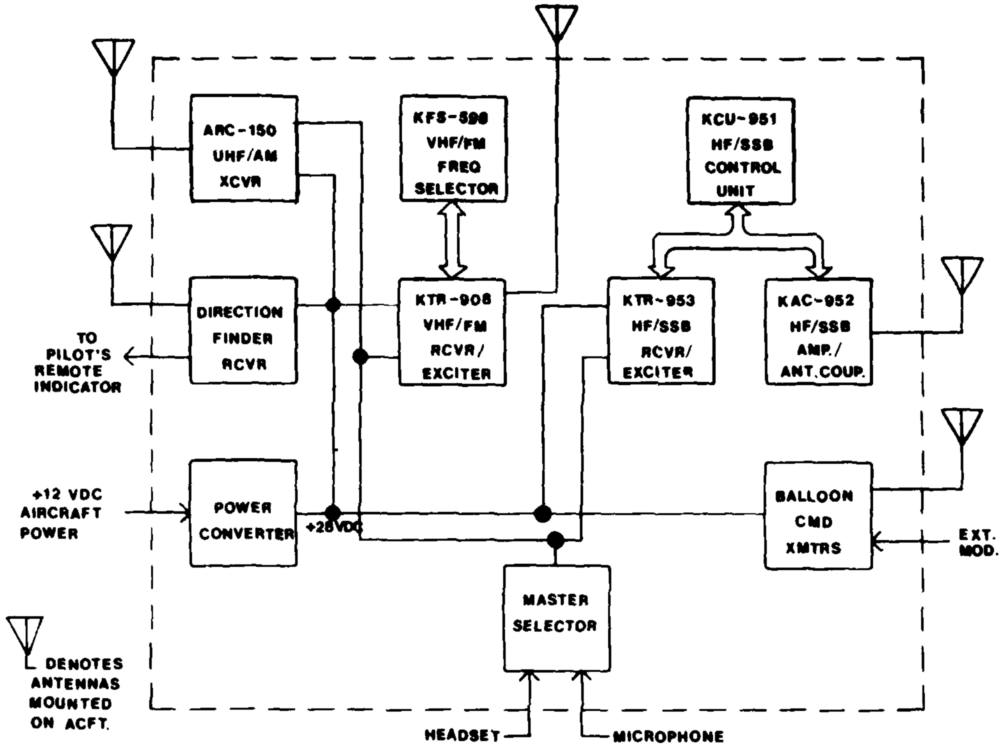


Figure 1. Block Diagram of Command Control and Communications System

2. DESIGN CONSIDERATIONS

The current system in use contains a HF/SSB transceiver, a VHF/FM transceiver, a Direction Finder (DF) Receiver and command consoles for HF and UHF commands. A UHF Transceiver is carried aboard separately because it is too big to fit in the rack. The features that each of these provide are necessary to this system but are restrictive when compared to new, state-of-the-art equipment. Size and weight, maintenance, and versatility have changed drastically.

Although the same features were incorporated into the new system, a different approach was taken to provide some of them. Three new, fully synthesized radio transceivers were purchased in order to provide voice communications on any frequency from 2-30 MHz, 118-152 MHz, or 225-400 MHz. Since all of these transceivers use microelectronics design, size and weight reductions were significant.

This allowed the UHF/AM transceiver to be incorporated into the rack, eliminating a separate, bulky carry-on.

The command control consoles were eliminated from the rack. Since this is a feature only used as necessary, and there are more types of command systems in use now, it was decided that the best approach was to provide external modulation inputs to accommodate any command system desired. The command set chosen for each mission would simply be plugged into the appropriate jack in the aircraft rack and support any command requirements.

The sections that follow describe each piece of equipment in the new system and how it is operated. Performance specifications for each unit are presented in Appendix B.

3. EQUIPMENT DESCRIPTIONS

This section provides descriptions and general operating instructions for each piece of equipment that was incorporated into the new system.

3.1 Magnavox ARC-150 UHF/AM Transceiver

The ARC-150 is a synthesized UHF/AM radio transceiver manufactured for military use by the Magnavox Corporation. It is designed for air-to-air, air-to-ground, or ground-to-ground communications from 225.000 to 399.975 MHz. Within this band it operates on 7000 channels spaced 25 KHz apart and can be pre-programmed for up to 20 preset frequencies. The presets are stored in a non-volatile memory in the radio, even when the power is off. During balloon missions its primary use is for voice communications to the Balloon Control Center and any other support aircraft being flown during the mission (typically, C-130s and helicopters). It may also be used for command control via an external input provided in the rack, if desired. Because it is supported by a military tech order, it can be maintained and serviced by communications squadrons at military installations. Performance specifications for this radio are listed in Table B1.

Figure 2 shows the front panel operating controls for the ARC-150. Power is applied to the unit by rotating switch S1 clockwise to the MAIN position. The other two positions shown (BOTH and ADF) are not used in this system. The desired frequency of operation is set by rotating switches S2 through S6 to the desired numbers. S2 sets 100 MHz increments of the desired frequency, S3 the 10 MHz increments, S4 the 1 MHz increments, S5 the 0.1 MHz increments and S6, the 25 KHz increments. The mode of operation is selected using switch S7. Moving S7 to the left-hand position selects the MANUAL mode of operation as indicated in the window of the switch. In this mode any frequency between 225.000 and 399.975 can be set (using switches S2 through S6) and utilized. When S7 is moved to the center position, the PRESET mode of operation is selected. This allows operation on one of the 20 available preset channels by rotating the Channel Select Switch, S8 to the desired channel number. Since there are usually only a few frequencies authorized for our use in this band, this is the best mode of operation to use. It will prevent accidental operation on an unauthorized frequencies. The third mode of operation that can be selected with S7, the GUARD mode, is not used in the system.

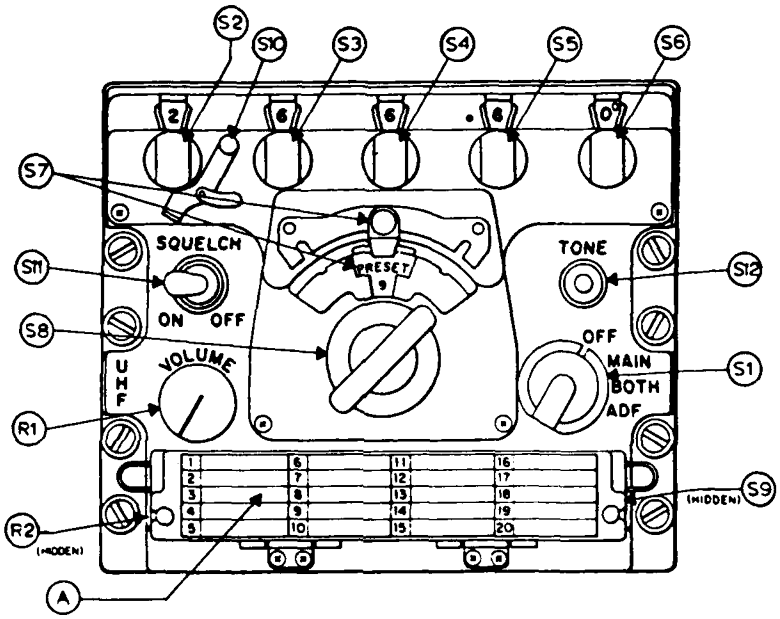


Figure 2. ARC-150 UHF/AM Transceiver Operating Controls

The desired frequencies in the preset mode are programmed as follows:

(1) Set the desired frequency by rotating the Frequency Set Switches, S2 through S6 to the appropriate numbers.

(2) Rotate the Channel Select Switch, S8 to the Desired channel number.

(3) Open the Preset Label Door, A, and depress the Memory Activation Switch, S9.

This stores the desired frequency and channel number into memory. It will remain there, even with power off, until changed by the operator. All 20 preset channels are programmed in the manner just described.

The ARC-150 receiver squelch is adjusted by opening the Preset Label Door, A, and rotating the Main Squelch Control, R2 to the position that provides the quieting desired for the frequency being used. If desired squelch can be disabled by turning the Squelch Disable Switch, S11 to the OFF position. Receiver audio output is adjusted with the Volume Control, R1 (clockwise rotation increases output volume).

One other feature of the ARC-150 that should be noted is the function of the Tone Modulation Switch, S12. Depressing this switch places a 1020 Hz tone on the carrier frequency being used. This is a useful tuning aid to the operator receiving transmissions from this radio.

3.2 King KTR-908 VHF/FM Transceiver

The KTR-908 transceiver is a fully-synthesized, commercial avionics system consisting of the KFS-598 Frequency Selector and the KTR-908 Receiver/Exciter Unit. The KTR-908 contains the receiver, transmitter, frequency synthesizer, and power supply. The KFS-598 is a control head containing the switching electronics and external controls necessary for frequency selection and programming. The system provides two-way communications, in 25 KHz increments, on one of 1359 channels between 118.000 and 151.975 MHz. There are two programmable channels; one active and one standby. The frequencies programmed into these channels remain in memory even when power is off. Performance specifications for this radio are listed in Table B2.

The operating controls for the KTR-908 are shown in Figure 3. To turn the unit ON, rotate the VOL Control, S1, clockwise and adjust for the desired listening level. Receiver squelch is set using the same control (S1). By pulling the control out and rotating it, the desired squelch level can be set. When the control is pushed back in, receiver squelch is automatic at the level previously set.

Two concentric knobs, S2 and S3, are used to set the desired operating frequency. When these controls are rotated either clockwise or counterclockwise (increment or decrement, respectively) the frequency in the Standby Display, D2, will change. The outer Frequency Set Control, S2, changes the MHz portion of the display in 1 MHz increments. The inner Frequency Set Control, S3, changes the KHz portion of the display in 50 KHz increments. By pulling S3 out, the display will change in 25 KHz increments.

Once the desired operating frequency has been programmed into the Standby Display, depressing the Transfer Switch, S4, will place it into the Active Display, D1. Note that this action swaps the contents of the Active and Standby Displays. By programming the Standby Display again, for another desired frequency, it is then possible to switch back and forth between two different frequencies by simply depressing the Transfer Switch, S4.

After programming two desired frequencies, the radio is ready for use. When the transmitter is keyed, a "TX" (see D3) will appear in the display next to the active frequency.

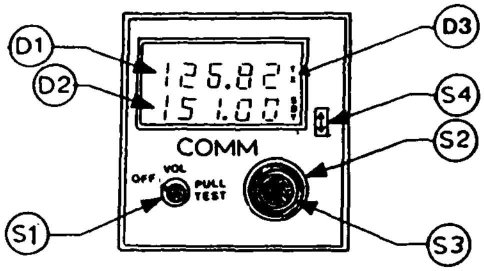


Figure 3. KTR-908 VHF/FM Transceiver Operating Con''ols

3.3 King KHF-950 HF/SSB Transceiver

The King KHF-950 is a microprocessor-based, synthesized, High Frequency/ Single Sideband (HF/SSB) radio transceiver. It provides voice communications between 2.000 and 26.999 MHz in 100 Hz increments. This allows operation on one of 250,000 possible frequencies, ninety-nine of which can be preset as selectable channels. Any one of these preset channels can be programmed to operate as receive only (no transmit), simplex (receive and transmit are the same frequency) or semi-duplex (receive and transmit are different frequencies). As with the other radios in the system, the preset channels are stored in memory even with power off.

The KHF-950 consists of the KAC-952 Power Amplifier/Antenna Coupler, the KTR-953 Receiver/Exciter and the KCU-951 Control Unit. A microcomputer in the system controls the storage of user programmed frequency (including emission mode and channel number), the frequency display, tuning and band switching. Performance characteristics for this transceiver are listed in Table B3.

The operating controls for this system are located on the front panel of the KCU-951 Control Unit. They are shown in Figure 4. Rotating the Volume Control, R1, clockwise applies power to the system and controls the audio output level. When power is turned on, the Frequency Display, D1, is blanked and transmit is disabled until the crystal oven warms up and the frequency synthesizer locks. After this (approximately one minute from a cold start) the receiver frequency will appear in the display. Keying the radio momentarily will initiate the coupler auto-tune sequence. During this sequence the display will be blanked and the "TX" message will flash. The emission mode and channel number will remain in the display.

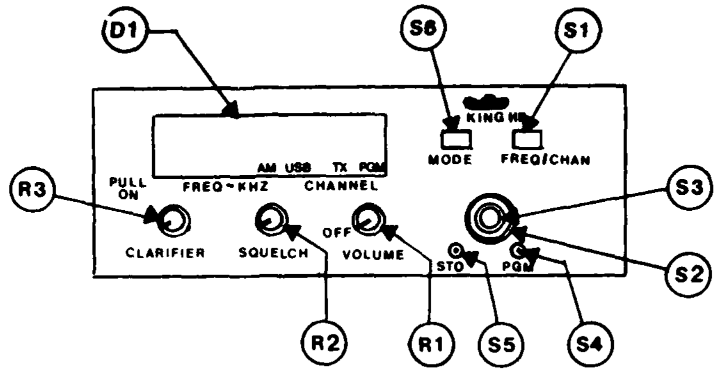


Figure 4. KHF-950 HF/SSB Transceiver Operating Controls

The system is capable of operating in a frequency mode or a channel mode. Alternately depressing and releasing the FREQ/CHAN Switch, S1, will switch between these two modes. In the frequency mode only the operating frequency and the emission type are displayed. Also, only simplex operation is allowed. Basically, a desired frequency and emission type is programmed into the unit and then used to transmit and receive. Two concentric control knobs work in an increment/decrement fashion to set a desired frequency. The outer Frequency Set Control, S2, controls the cursor position which is indicated by the flashing digit in the Display, D1. The inner Frequency Set Control, S3, is used to increment or decrement the flashing digit until the desired number is displayed. A desired frequency is set by moving the cursor position and setting each digit, one at a time. There is a blank position to the right of the frequency display that is used to store the cursor during operation. When the cursor is in this position no digits will be flashing. The emission type is selected by depressing the Emission Mode Select Switch, S6, until the emission type desired (only AM or SSB are available) appears in the Display, D1.

In the channel mode of operation a channel number is displayed in addition to the frequency and emission type. Ninety-nine channels can be programmed in this mode and then selected by rotating the Inner Frequency Set Control, S3, until the desired channel number is displayed. Note that S3 serves two program functions depending on the position of the cursor. If the cursor is in one of the digit positions (flashing) then S3 increments or decrements this digit for frequency set control. When the cursor is in its stored position (no digits flashing) then S3 increments or decrements the channel number. The steps for programming the preset channels are different, depending on whether the channel is to operate as receive only, simplex or semi-duplex. The first step before any programming is to enter the channel mode using the FREQ/CHAN Switch, S1. To program a channel for receive only operation, proceed as follows:

(1) Depress the PGM Switch, S4 (the PGM message will appear in the display).

(2) Select the desired channel number (S3—no digits flashing).

(3) Set the desired frequency (S2 and S3).

(4) Select the emission type (S6).

(5) Depress the STO Switch, S5 once (the TX message will flash on and off in the display).

(6) Release the PGM Switch, S4.

To program a channel for simplex operation:

(1) Depress the PGM Switch, S4 (PGM will appear).

(2) Select the desired channel number (S3—no digits flashing).

(3) Set the desired frequency (S2 and S3).

(4) Select the emission type (S6).

(5) Depress the STO Switch, S5, twice (a flashing TX message will appear on the first actuation and disappear on the second).

(6) Release the PGM Switch, S4.

To program a channel for semi-duplex operation:

(1) Depress the PGM Switch, S4 (PGM will appear).

(2) Select the desired channel number (S3—no digits flashing).

(3) Set the desired receive frequency (S2 and S3).

(4) Select the emission type (S6).

(5) Depress the STO Switch, S5, once (TX will be flashing).

(6) Set the desired transmit Frequency (S2 and S3).

(7) Depress the STO Switch, S5, once (the flashing TX will disappear).

(8) Release the PGM Switch, S4.

Once programmed, the information will remain stored in memory until changed by the user.

The Squelch Control, R2, provides variable squelch threshold control and should be set to the desired level for the frequency being received. The Clarifier Control, R3, functions as a fine tune device during the receive mode of operation. It varies the local oscillator in the radio, slightly, to provide precise tuning to the receive frequency. The control knob must be pulled out to activate and adjust the clarifier.

3.4 L-Tronics VHF Direction Finder Receiver

A UHF beacon transmitter, operating on 242.0 MHz, is flown aboard the payload on each scientific balloon flight. This beacon comes on automatically at flight termination and stays on until turned off by a ground recovery crew. In the event personnel aboard the aircraft lose their visual sighting on the payload, they can turn on the direction finder receiver in the rack and use it to "home" in on the signal being transmitted by the on-board beacon. This feature is especially useful when trying to locate a payload lost on the ground.

The L-Tronics LA Series Direction Finder (DF) Receiver is an independent, crystal-controlled receiver and direction indicator. The indicator is a panel meter that indicates both left and right homing at distances from 50 ft to 50 miles. The unit in use in the aircraft rack is crystalized for 242.0 MHz. Performance specifications for this unit are listed in Table B4. The front panel with user controls is shown in Figure 5.

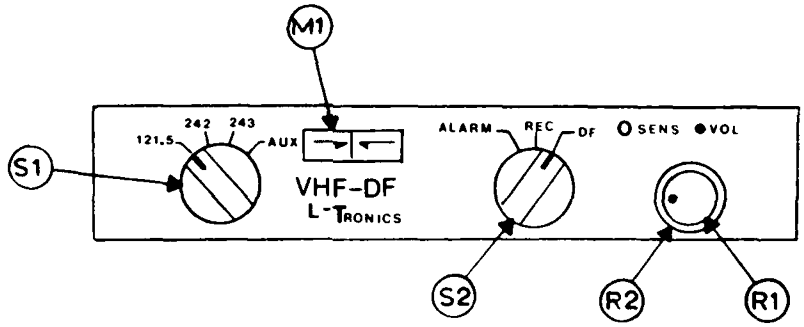


Figure 5. L-Tronics VHF/DF Receiver Operating Controls

Many articles have been written on the art of homing in on beacon transmitters from aircraft. There are many factors that can influence degrade beacon signals (for example, reflections off local terrain or objects such as buildings). This discussion is only intended to provide operating instructions for the DF receiver in this system. As far as the subject of homing goes, let it suffice to say here that there is little that can be done about operating a DF receiver in a poor DF environment except to recognize it and try to realize how it might affect the target location. Doing this may avoid wrong conclusions and time-consuming detours.

Power is applied to the DF set by rotating the Volume Control Knob, R1, clockwise. During operation in this system the Frequency Selector Switch, S1, should be in the 242.0 position. Initially, the Mode Selector Switch, S2, should be in the REC position. When the beacon signal is first heard, it will normally build up or "fade in" over a period of one or two minutes. During this time, Volume Control, R1, should be used to adjust the audio output from the speaker to a comfortable listening level. Starting with minimum sensitivity, advance the SENS

Control, R2, clockwise to obtain a mid-scale signal strength reading on the Panel Meter, M1. When this is obtained, turn the Mode Selector Switch, S2, to the DF position. Deflection of the meter needle now indicates the direction in which to turn the airplane to track the beacon signal. Maintaining the meter needle at "zero" (mid-scale) will maintain track on the beacon signal. As the tracking proceeds, the signal strength in the REC mode should be checked periodically and adjusted, if necessary. Maintaining the proper sensitivity level will prevent overloading of the receiver as the signal gets stronger. One important note; no accuracy is lost by reducing the sensitivity level as long as the beacon signal remains audible.

3.5 Balloon Command Transmitters

Balloon command functions are effected by decoding specific intelligence received via radio waves in a command package on board the balloon payload. Commands are normally sent from the Balloon Control Center from one of several types of command sets. If, for some reason, the control center loses its ability to send commands, the aircraft must be able to step in and send commands as requested. This is done in this system by plugging in the desired command set and keying one of two transmitters in the rack. These transmitters are small, light-weight, commercially manufactured units which will accept an external modulation input from the command set being used. Set-up and operation of the command set is accomplished during preflight system tests.

4. SYSTEM OPERATION

In addition to the operating controls previously described, there are several others necessary to make the various pieces of equipment function as a system. These controls deal with the routing of system power, input and output signals. Figures 6 and 7 show their locations. The controls on the side of the rack (see Figure 6) serve two major functions. The upper section is for connection of the antennas necessary for each radio. The antennas are permanently mounted on the outside skin of the aircraft in various places and shielded coaxial cables are routed from them to the aircraft rack location in the cabin. When the rack is placed on board the aircraft it is a simple matter to connect these cables to the appropriate antenna inputs. The lower section of this end of the rack is the power distribution center. Aircraft power is connected here and distributed via circuit breakers to each piece of equipment in the rack. This is done to protect both the aircraft power system and the equipment in the rack.

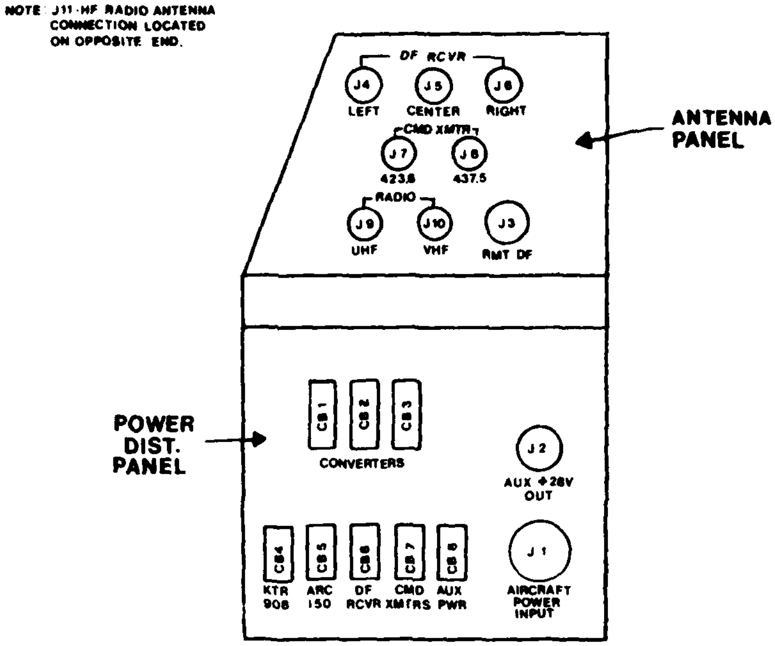


Figure 6. Antenna and Power Distribution Panels

After the rack is placed aboard the plane the following procedure should be used for power and antenna connection:

(1) Connect all antennas to their appropriate jacks (J4 through J11) on the Antenna Panel.

(2) Turn off all equipment in the rack.

(3) Turn off all circuit breakers on the Power Distribution Panel.

(4) Connect aircraft power to the Input Power Connector, J1.

(5) Connect external command set to the Auxiliary Power Output Connector, J2.

(6) Connect the pilot's remote DF to connector J3.

The system is now completely installed in the aircraft and may be powered up as follows:

(1) Turn on the Main Circuit Breaker, CB1.

(2) One at a time, turn on the other circuit breakers in the system, (CB2 through CB6).

(3) Turn on each unit in the rack as necessary.

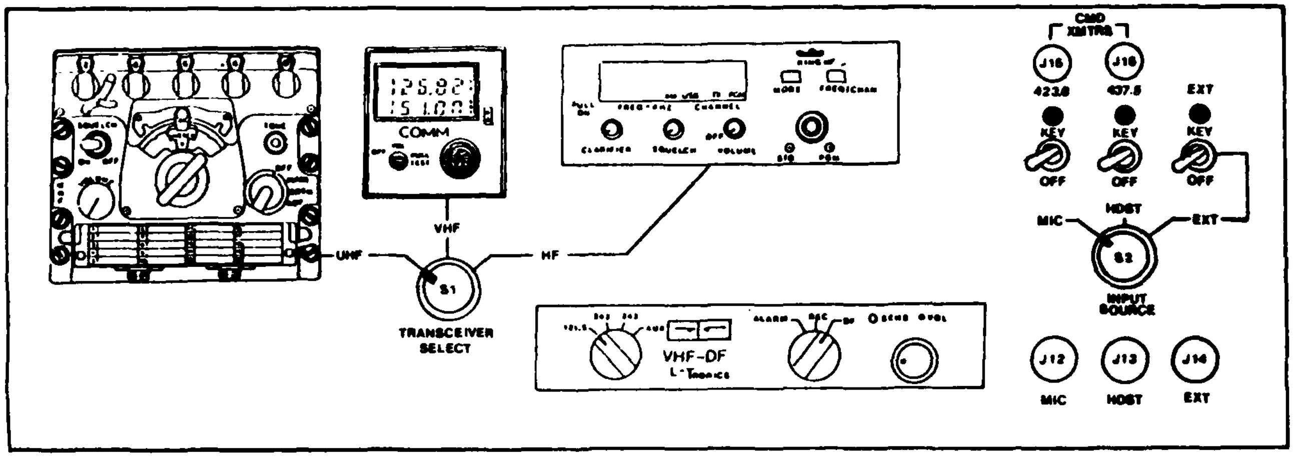


Figure 7. Front Panel Controls

A third set of controls, located on the front panel of the rack (see Figure 7), are used to direct signal traffic into the system. The Transceiver Selector Switch, S1, directs the input device selected by the Input Source Switch, S2, to the desired transceiver. There are three selectable input sources that may be used. For voice communications a microphone or headset plugged into J12 or J13, respectively, may be selected. Which one is used is usually a matter of personal preference. The third selectable source directs an external input, plugged into the External Input Jack, J14, to the desired transceiver. This is used for command sets that are designed to operate within the transceiver frequency bands. In the external mode the External Key Switch, S3, is used in place of the key switches normally found on a microphone or headset.

As discussed in Section 3.5, two balloon command transmitters mounted in the rack provide the capability to send commands from an external command set aboard the aircraft. These transmitters operate on frequencies outside the range of the transceivers in the rack; and most of the command sets currently available are designed for use with them. The external command set being used is plugged into one of the Modulation Input Jacks, J15 or J16, depending on which frequency is desired. The transmitter is then activated with the appropriate key switch, S4 or S5.

The interconnection of these functional controls and the equipment in the rack is shown in a series of schematic wiring diagrams in Appendix A. Each diagram deals with only one piece of equipment in the system. Fabrication of the interconnect wiring in this manner allows removal of each piece of equipment, with its wire harness, without disrupting operation of the rest of the system.

5. CONCLUSION

Clearly, this report was written as an instruction manual geared to operators of the system during scientific balloon flights. This was the overriding consideration because of the system's importance during flight operations. The new system is simpler to use, more cost-effective and provides a great degree of versatility. A final note; there is detailed technical information available on the equipment in this system. It can be found in the manuals listed in the References section of this report (page 19).

References

1. Technical Manual, Intermediate Maintenance Instructions, T.O. 12R2-2ARC150-2, AFLC RAFB, Georgia.

2. Maintenance/Overhaul Manual No. 006-5197-01, KTR-908, Communication Transceiver, Revision 1, 1st printing May 1981, King Radio Corporation, Olathe, Kansas.

3. Maintenance/Overhaul Manual No. 006-5190-02, KHF-950 HF System, Revision 2, First printing February 1981, King Radio Corporation, Olathe, Kansas.

4. Interim Instruction Manual, Aircraft Direction Finders LA Series, Copyright 1975, L-Tronics, Inc., Santa Barbara, California.

Appendix A

Interconnect Wiring Schematics

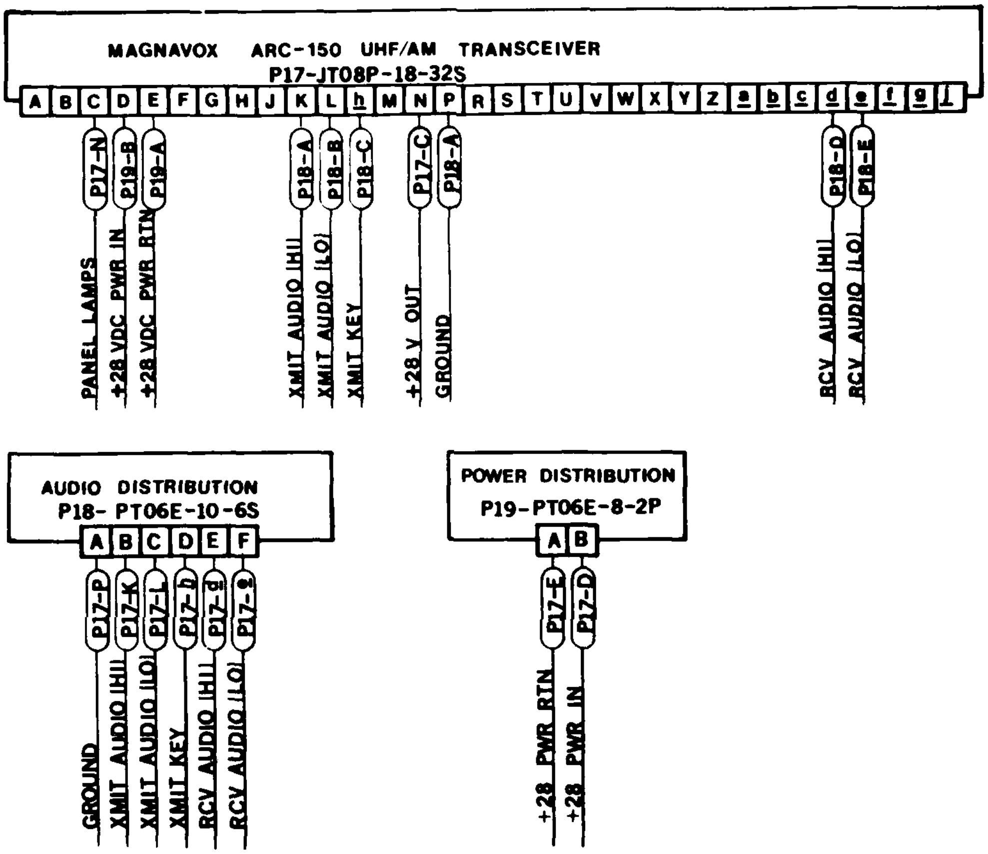


Figure A1. System Interconnect Wiring Diagram, Magnavox ARC-150

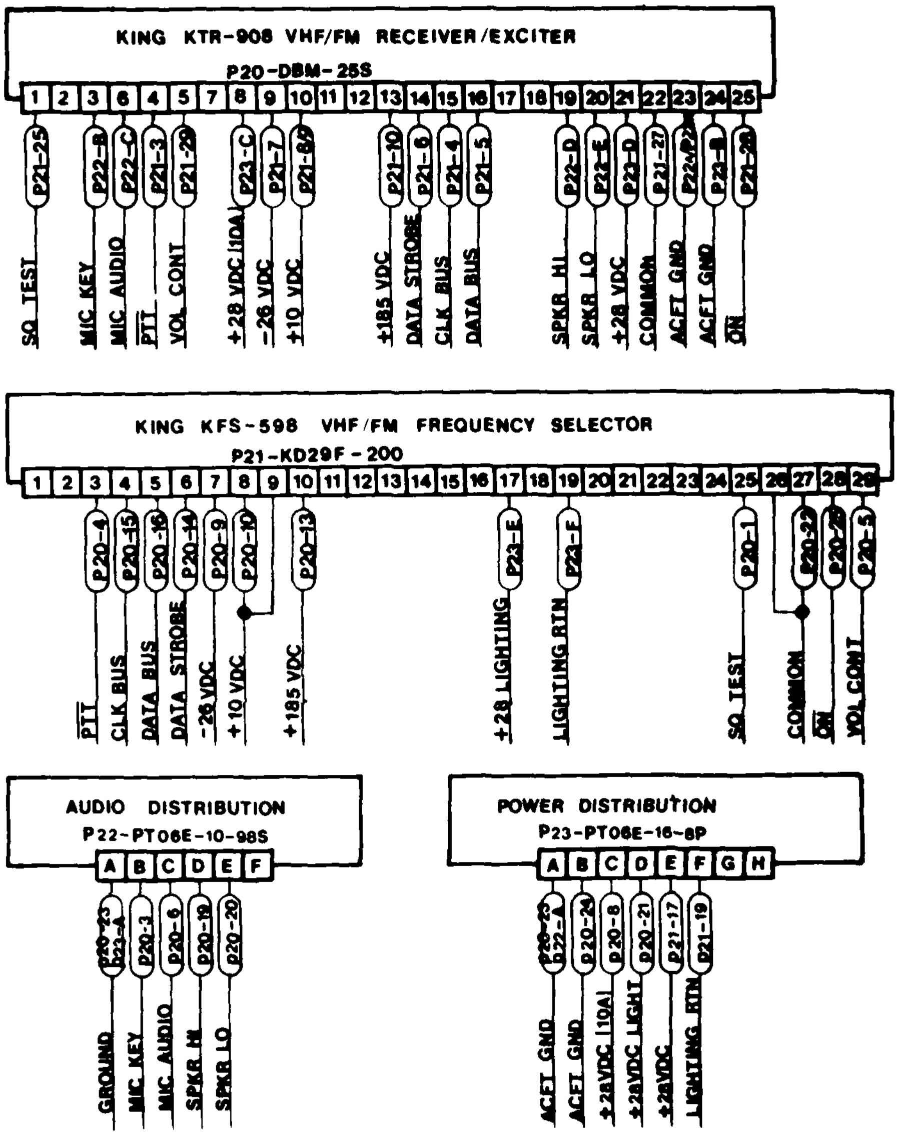


Figure A2. System Interconnect Wiring Diagram, King KTR-908

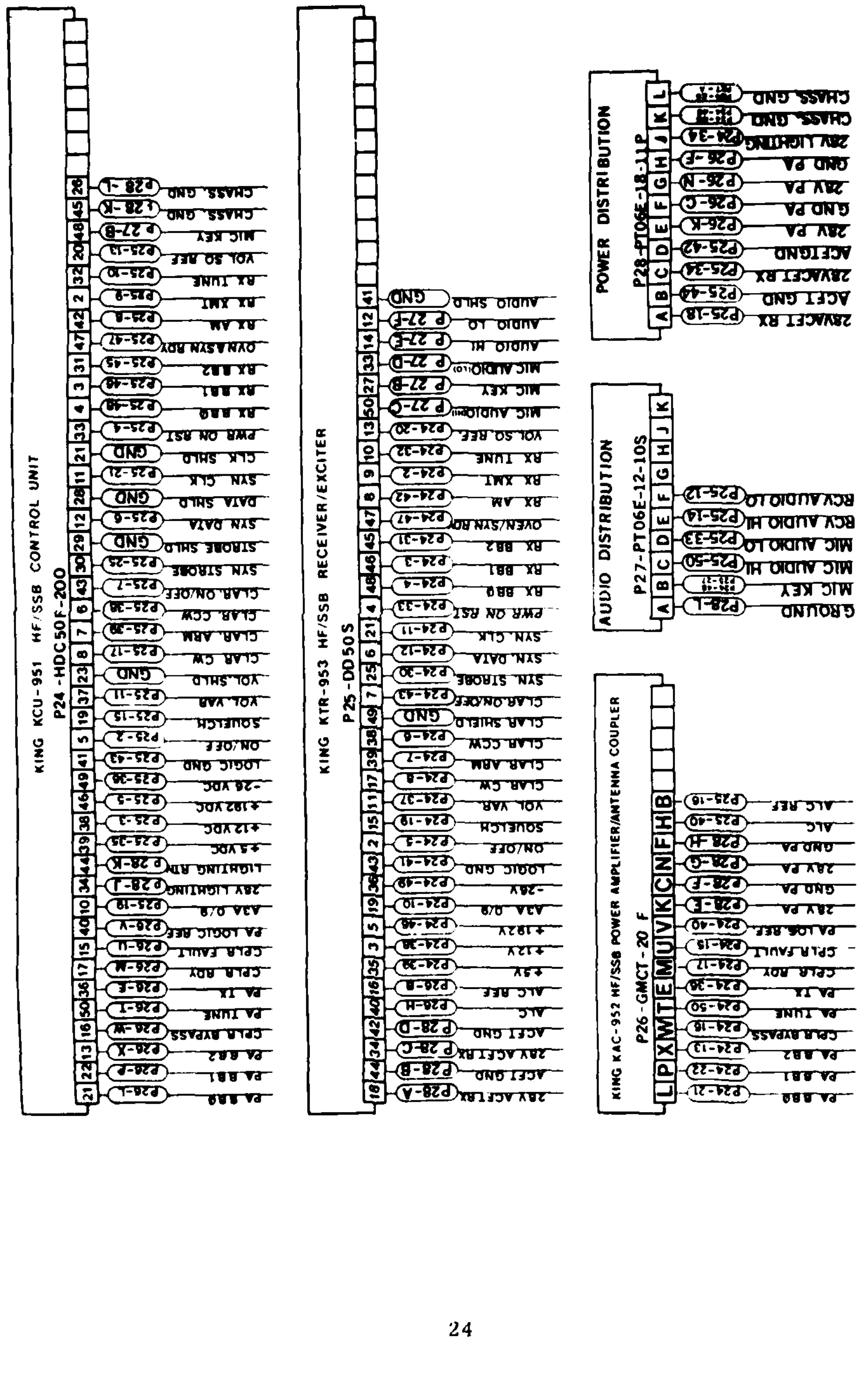


Figure A3. System Interconnect Wiring Diagram, King KHF-950

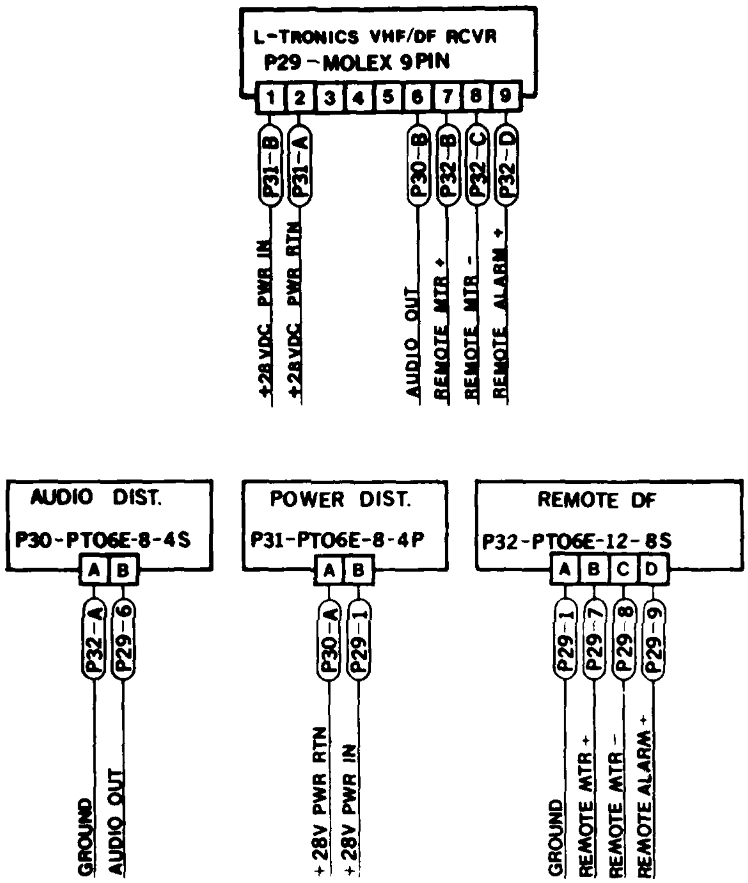


Figure A4. System Interconnect Wiring Diagram, L-Tronics, DF Receiver

Appendix B

Equipment Performance Specifications

Table B1. ARC-150 UHF/AM Transceiver Performance Specifications

General	
Frequency Range	225.000 to 399.975 MHz
Available Channels	7000
Channel Spacing	25 KHz
Preset Channels	Up to 20
Receiver	
Sensitivity	3 μV (30% modulation at 1 KHz) for 10 dB signal plus noise-noise
IF Bandwidth	70 KHz (6 dB), 140 KHz (60 dB)
Audio Output Impedence	500 Ω
Audio Output	0.25 V rms min. into 500 Ω (30% modulation)
Audio Frequency Range	50 to 20,000 Hz
Squelch	3 μV signal to noise operated.
Transmitter	
Power Output	10 W
Modulation	80% positive at 90% negative from 300 Hz to 3500 Hz
Envelope Distortion	10% maximum
Transmit Audio Input	0.3 to 6 V rms maximum
Transmit Audio Input Impedence	150 Ω balanced
Transmitter Sidetone	185 mV at 50% modulation
Tone Modulation	1020 Hz ± 10%
Environmental/Physical	
Operating Temperature Range	-54° C to +71° C
Size — Length	5-3/4 in.
Size — Width	5 in.
Size — Height	9 in.
Weight	9.5 lbs
Electrical	
Input Voltage	+27.5 V dc (30 max.)
Input Current (receive mode)	1.1 A
Input Current (transmit mode)	3.3 A
Antenna Impedence	52 Ω, nominal

Table B2. KTR-908 VHF/FM Transceiver Performance Specifications

General			
Frequency		118.000 to 151.975 MHz	
Available Channels		1359	
Channel Spacing		25 KHz	
Receiver			
Sensitivity		2 μV (30% modulation at 1 KHz) for 6 dB signal plus noise to noise	
IF Bandwidth		20.6 KHz (6 dB), 39.2 KHz (60 dB)	
Audio Output		≧ 100 mW into 500 Ω ≦ 6 dB response from 350 to 2500 Hz	
AGC		5 μV to 200 mV for audio level change < 3 dB	
Squelch		Automatic (internally adjustable) with manual disable	
Transmitter			
Power Output		20 W	
Modulation		≧ 85%, ≦ 98%	
Audio Output		≧ 100 mW into 500 Ω	
Sidetone Output		Adjustable up to 100 mW into 500 Ω	
Frequency Stability		± 0.0015% (-55° C to +70° C)	
Microphone Input		120 mV rms minimum into 500 Ω	
Harmonic Content		> 60 dB down from carrier level	
Spurious Outputs		> 60 dB down from carrier level	
Environmental/Physical			
Operating Temperature Range	(KTR-908)	-55 to +70° C	
	(KFS-598)	-20 to +55° C	
Size		KTR-908	KFS-598
	Width (in.)	1.75	2.193
	Height (in.)	5.00	2.35
	Depth (in.)	1.77	5.5
Weight	4.0 lbs total		
Electrical			
Input Voltage		+27.5 Vdc	
Input Current (receive mode)		0.4 A	
(transmit mode)		7.0 A	
Antenna Impedance		50 Ω, nominal	

Table B3. KHF-950 HF/SSB Transceiver Performance Specifications

General		
Frequency Range		2.000 to 26.999 MHz
Available Channels		250,000
Channel Spacing		100 Hz
Preset Channels		99
Receiver		
Input Impedance		50 Ω, nominal
Frequency Stability		± 20 Hz
Clarifier Range		Up to 250 Hz
Selectivity	(AM)	5.5 KHz < 6 dB. 20 KHz ≥ 60 dB.
	(SSB)	< 6 dB from carrier frequency +360 Hz to carrier frequency +2500 Hz. > 60 dB from carrier frequency -2150 Hz to carrier frequency +5000 Hz.
Sensitivity	(AM)	< 3 μV for 6 dB signal plus noise to noise.
	(SSB)	≤ 1 μV for 10 dB signal plus noise to noise.
AGC		≤ 6 dB change for inputs from 10 to 500,000 μV
Audio Output		100 mW into 500 Ω
Audio Response		< 6 dB from 350 to 2500 Hz
Audio Distortion	(AM)	≤ 12% harmonic
	(SSB)	Third order 25 dB below desired at 100,000 μV
Spurious Response		> 60 dB down from 0.19 to 150 MHz.
Exciter		
Output Impedance		50 Ω, nominal
Frequency Stability		± 20 Hz
Spectrum Control	(Audio Response)	< 6 dB from carrier frequency +350 Hz to carrier frequency +2500 Hz.
	(Spectrum)	≥ 38 dB from carrier frequency -3100 Hz to carrier frequency +5900 Hz. ≥ 43 dB from carrier frequency -6100 Hz to carrier frequency +6900 Hz.
Carrier Suppression		26 dB

Table B3. KHF-950 HF/SSB Transceiver Performance Specifications (Contd)

Transmitter				
Power Output (SSB)		100 W PEP into 50 Ω (non-reactive).		
(AM)		25 W carrier, 100 W PEP into 50 Ω (non-reactive).		
Spurious Emissions (USB)		43 dB +8 KHz, -6 KHz from carrier frequency.		
VSWR		< 1.5:1 typical		
Antenna Tuning Time		3 sec, nominal		
Environmental/Physical				
Operating Temperature Range		-20° C to +55° C		
Size		KCU-951	KAC-952	KTR-953
	Length (in.)	7.70	14.25	11.15
	Width (in.)	5.00	5.40	3.00
	Height (in.)	2.00	7.24	5.25
Weight	(lbs)	1.00	11.60	6.60
Electrical				
Input Voltage		+27.5 Vdc		
Input Current (receive mode)		1 A		
(transmit mode)		15 A		
Antenna Impedance		50 Ω, nominal		

Table B4. L-Tronics VHF/DF Receiver Performance Specifications

DF Sensitivity		± 5° full-scale left-right for input signals ≧ 2 μV
Minimum Useable Signal		0.1 μV
Accuracy		± 3°
Operating Frequency		121.5, 121.6, 242.0, 243.0 MHz (crystal controlled)
IF Bandwidth		15 KHz
Image Rejection		40 dB
Spurious Input Rejection		75 dB
Audio Output		0.5 W into 8 Ω
Input Voltage		+10 to +35 Vdc
Input Current		150 mA
Size	Length	6-5/32 in.
	Height	1-3/16 in.
	Depth	5-3/4 in.
Weight		31 ounces