TW100F FLY-AWAY
HF SSB TRANSCEIVER
TECHNICAL MANUAL

Datron World Communications Inc.
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a. Model, serial number, and date of installation
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b. Include a letter with the following information:

1. Part number
2. Serial number and model of equipment
3. Date of installation

Parts returned without this information will not be replaced. In the event of a dispute over the age of the replacement part, components date-coded over 24 months previously will be considered out of warranty.

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Safety Considerations

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Caution: Before applying ac power, be sure that the equipment has been properly configured for the available line voltage. Attempted operation at the wrong voltage can result in damage and voids the warranty. See the manual's section on Installation.

Earth Ground: All Datron products are supplied with a standard, 3-wire, grounded ac plug. DO NOT attempt to disable the ground terminal by using 2-wire adapters of any type. Any disconnection of the equipment ground causes a potential shock hazard that could result in personal injury. DO NOT operate any equipment until a suitable ground has been established. Consult the manual section on grounding.

Servicing: Only trained personnel should perform servicing. To avoid electric shock, DO NOT open the case unless qualified to do so.

Various measurements and adjustments described in this manual are performed with ac power applied and the protective covers removed. Capacitors (particularly the large power-supply electrolytics) can remain charged for a considerable time after the unit has been shut off. Use particular care when working around them, as a short circuit can release sufficient energy to cause damage to the equipment and possible injury.

To protect against fire hazard, always replace line fuses with ones of the same current rating and type (normal delay, slow-blow, etc.). DO NOT use higher-value replacements in an attempt to prevent fuse failure. If fuses are failing repeatedly, this indicates a probable defect in the equipment that needs attention.

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FIGURES (Continued)

FIGURES (Continued)

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TABLES (Continued)

TABLES (Continued)

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TW100F Flyaway Transceiver.

SECTION 1
GENERAL INFORMATION

1.1 GENERAL DESCRIPTION

The TRANSWORLD TW100F is a high-performance single-sideband transceiver designed for operation on any of the frequencies in the range 1.6 to 30 MHz. The portable transceiver is completely self-contained in a rugged, aluminum-skin, attache-type case. The TW100F is small enough to meet IATA underseat requirements and includes all of the accessories necessary to quickly establish long-distance HF communications from temporary field locations.

1.2 SINGLE SIDEBAND

The transceiver provides voice communications in the single-sideband mode. This mode is almost universally used for voice communications in the HF spectrum and provides a major advantage over the AM mode. The single-sideband (SSB) transmitter uses special circuitry to suppress the carrier and one of the sidebands of an AM signal. This gives a great increase in efficiency, as only 1/6th of the total power in an AM signal is in each sideband. The carrier carries no information, and one of the sidebands is redundant, which means that the SSB signal puts all of the power into an information-carrying sideband—a six-hundred-percent increase in efficiency. Apart from the improved power efficiency, the SSB signal occupies less than half the channel space of an AM signal and permits increased utilization of the crowded HF spectrum. The SSB signal is more intelligible at poor signal levels and is much less effected by selective fading and interference, which gives an overall advantage much greater than the increase in effective power. It is necessary to use a special receiver for SSB, as the transmission is unintelligible without the reinsertion of the carrier. The transceiver does have a compatible AM mode so that the transceiver can communicate with an AM station.

1.3 HF COMMUNICATIONS

The high-frequency (HF) communications spectrum is primarily used for long-distance communications, while the VHF and UHF spectrum is favored for local communications. If the correct frequencies and antenna systems are used, the HF spectrum will provide effective communications over almost any distance including intercontinental ranges. There are two main modes of propagation of HF signals: ground wave and sky wave. The ground wave follows the surface of the earth and provides reliable signals over short ranges. The signals are attenuated very rapidly as they pass over the surface of the earth, so high powers and good antennas are essential for good ground-wave coverage. The ground-wave attenuation increases as a function of frequency, and the lower frequencies below 3 MHz are favored for ground-wave operation. This mode may be the only effective method for local coverage in areas too mountainous for VHF and UHF operation.

Most HF communication is by sky wave where the signals bounce off the reflecting layers of the ionosphere. Long distances can be covered with little signal attenuation provided the correct frequency is chosen. The ionosphere does not stay constant; it varies with the time of day, time of year, the sunspot cycle and the activity of the sun. Solar flares can cause complete radio blackouts with little warning. HF communications are affected by static caused by lighting; sometimes from storms many hundreds or thousands of kilometers away. A clear channel can never be assured, as long-distance propagation may cause strong interfering signals on the frequency from great distances. It must always be understood that although long-distance communications are possible with low powers and simple antennas, high reliability and freedom from interference is not possible. In spite of the problems, a surprisingly good standard of communications can be achieved, provided that care is taken to select the correct frequency and to use good equipment with an efficient antenna system.

The correct choice of frequency is beyond the scope of this manual and may be limited by the frequencies made available by the licensing authorities. If a choice of frequencies is available, the following information may give a starting point in making the choice. Remember the final guide should be an actual test, as often only a small change in frequency may make a big difference in signal strength.

The low frequencies, below 3 MHz, will normally be restricted to short ranges during the day. At night, longer ranges (300-400 kilometers) are possible, but interference and static may be major problems. Good antennas and high power are essential for anything but the shortest distances.

The medium frequencies from 3-5 MHz may be a good choice for moderate distances (300-400 kilometers) during the day. At night, considerable distances are possible, although static will be a frequent problem during summer months. The physical length of a good antenna is still quite long, and it is difficult to achieve good efficiences with mobile antennas in this range.

The medium frequencies from 5-11 MHz are the most popular for communications up to 1000 kilometers. Good ranges are possible during the day, with the higher frequencies being favored for the longer distances. Communications may become more difficult at night with interfering signals from all over the world.

The higher end of the spectrum, above 12 MHz, is favored for long-distance communications. The propagation will be severely effected by the ionosphere, and expert advice is essential in choosing the correct frequencies for long-distance operation. For example, frequencies as high as 30

MHz may be used for worldwide communications during the peak of the sunspot cycle. However, during periods of low sunspot activity, this HF frequency range will be completely dead. It is important to remember that at the higher frequencies there can be skip zones, and a strong signal may be received from 2000 kilometers away, while closer stations cannot be heard.

1.4 MODES OF OPERATION

1.4.1 SINGLE SIDEBAND

Single sideband or SSB will be used for all regular voice communications. Most commercial operation is on the upper sideband (USB), and lower sideband (LSB) is usually used to avoid interference. There are some countries that specify LSB operation. LSB is also used by amateur radio operators in the 3.5-MHz and 7-MHz bands. In some countries LSB operation is not permitted. When this restriction is specified, the LSB filter will not be installed.

1.4.2 AM

AM has now almost disappeared from the HF bands for communications, since AM mode is now used almost exclusively for broadcasting. An AM mode is provided in the transceiver to permit reception by simple radio equipment. It should be noted that reception is in the compatible AM mode which uses the SSB receiver tuned to the carrier frequency of the AM station. Accurate tuning is essential for undistorted AM reception.

1.4.3 CW

There is still some CW (Morse code) operation in the HF bands, and the transceiver does have provision for CW communications. Under poor conditions, good operators will be able to communicate on CW when voice operation would not be possible. The transceiver operates in the CW mode on either USB or LSB by plugging in the Morse key.

1.4.4 RADIO TELETYPE (FSK)

Radioteletype is used for the transmission of data. The transceiver may be used for RTTY or other FSK transmission in the low-power mode. It will be necessary to use a self-contained message terminal such as the TW5500 or a teletype machine with a separate modem. It should be noted that the internal power supply and antenna tuner are not suitable for continuous RTTY operation in the high power mode. Data-burst transmission not exceeding two minutes may be made in the high-power mode using the tuner.

1.5 THE FLYAWAY TRANSCEIVER

The Flyaway HF transceiver makes the concept of a compact, self-contained, long-distance radio telephone a reality. A specially designed, lightweight, 125-W, 1.6- to 30-MHz transceiver is packaged on shock mounts inside of a rugged metal suitcase small enough to be carried under an aircraft seat.

The transceiver contains a universal ac power supply for operation anywhere in the world and also has a separate cable for direct operation from a 12-V vehicle battery. A built-in antenna tuner permits operation from a variety of whip and wire antennas as well as dipoles and other 50-ohm antennas. The case contains a microphone, headset, connecting leads, and wire antennas. It is usually practical to have the transceiver in operation within minutes of arrival at the operating site.

1.6 TRANSCEIVER DESCRIPTON

The transceiver is a solid-state, high-frequency, single-sideband transceiver operating in the frequency range from 1.6-30 MHz. The range is covered in 100-Hz steps, and there are no gaps or disallowed frequencies in the coverage. The transceiver will operate on any frequency and will store 100 different frequencies in permanent memory. Scanning is available on ten channels.

The transmitter uses a special gain-controlled amplifier to give constant output with different voice levels. A front-panel meter is used to measure received signal strength and transmitter power output. The meter is also used as a tuning indicator for the antenna tuner.

The transceiver has a power output of 125 W PEP (100 W AVG) and a switch-selected low-power setting of 10 W. The power output is controlled by automatic circuitry which also protects against mismatched antennas. In order to minimize weight, the transceiver uses a small heat sink that is cooled by a small muffin-type fan. The fan is thermostatically controlled and will only operate on prolonged transmissions. In the event of overheating the transmitter automatically switches to the low-power mode.

The transceiver contains a universal ac power supply which will operate from 105-125 V and 210-245 V. The power supply frequency may range from 50 to 400 Hz. The correct voltage taps on the transformer are selected by means of a three-position switch on the side of the transceiver. The transceiver also has a separate connector for direct operation from a 12-V battery.

A built-in antenna tuner will match the transceiver to a wide variety of whip and wire antennas up to 25 m in length. A low-power tune position is provided, and the front-panel meter is tuned for maxiumum power. A 50-ohm antenna connection is provided for coaxial feed, and the antenna tuner may be used to provide correct matching with VSWR's up to 3:1.

The transceiver is contructed in a lightweight aluminum case with all of the operating controls on the top panel. Most of the circuitry is contained in six diecast boxes with SMA connectors, and the microprocessor and filter modules are mounted under the chassis. All modules use connectors and are simple to replace by unskilled personnel. The transceiver is mounted on four shock mounts inside the high-quality "Zero" aluminum carrying case. The transceiver is normally operated inside the case, but can be quickly removed by loosening the four wingnuts on the shock mounts.

The transceiver uses an up-conversion system with the first IF at 75 MHz and the main selectivity at 1650 kHz. With this system, the main spurious products do not fall within the operating range, which ensures exceptional freedom from spurious response in both the transmitter and the receiver. The front end of the receiver uses a passive double-balanced mixer with a high intercept point giving freedom from intermodulation and overload. The antenna is coupled to the transceiver through six 7-pole, elliptic-function filters that provide a high degree of harmonic attenuation and rejection of out-of-band signals. The receiver is equipped with a special noise immune squelch system designed for SSB operation. This is a great operator convenience as it eliminates background noise, yet opens reliably, even on weak SSB signals. The squelch circuit is preset and is controlled by an ON/OFF switch.

1.7 FREQUENCY SELECTION

The transceiver uses a microprocessor to control the frequency selection. The microprocessor operates in three different modes to suit the particular class of operation desired. The operational mode may be selected by an internal switch or may be permanently set by the use of a special coding circuit.

In Mode 1 the transceiver channel frequencies can be programmed by the operator. Channel 00 is designated as the free tuning channel, and the frequencies may be quickly changed from the keypad and may be programmed for simplex or duplex operation.

In Mode 2 the operator can also display the channel frequency on any of the preprogrammed frequencies. If the channel is programmed for semi-duplex operation the transmit frequency may be displayed. Channel 00 may be programmed by the operator but will only operate in the receive mode.

In Mode 3 the operator may select any one of the preprogrammed channel frequencies by entering the channel number on the keypad. The channel number is shown on the display.

No crystals are required, for all frequency control is derived from a single temperature-controlled, precision crystal oscillator. No tuning or adjustment is required for any frequency change. The channel frequencies are permanently retained in memory using a lithium battery with a life in excess of 10 years.

1.8 SYNTHESIZER DESCRIPTION

The use of integrated circuits has resulted in an extremely efficient and simple synthesizer design. Two separate loops are used. The 10-kHz loop is used for the first conversion stage and covers the full frequency range in 10-kHz steps. The 100-Hz loop is used for the second conversion stage and covers a 10-kHz range in 100-Hz steps. Both loops are direct, which ensures freedom from spurious responses. The frequency control is derived from a single temperature-controlled 5120-kHz crystal oscillator.

The synthesizers are controlled by the microprocessor through the keypad. The use of a synthesizer is a special advantage in a multichannel transceiver. Apart from savings in cost and preventing delays in getting channel crystals, all frequencies are directly synthesized from a highly stable master oscillator. Provided this oscillator is on frequency (a single adjustment), all channels are on frequency. Usually a channel is programmed to a standard frequency station such as WWV, so that the calibration can be checked. Older synthesizer designs suffered, not only from great complexity, but also internal spurs. These spurs caused whistles in the tuning range of the receiver, which made the transceiver unusable on many frequencies. The transceiver has no spurs exceeding 0.5 μV and has no unusable frequencies from 1.6-30 MHz.

1.9 AUDIO INPUTS

The transceiver uses a standard military audio connector and is supplied with a military handset. The transceiver may also be used with other audio accessories, including encryption equipment designed for SSB service. The accessory connector is wired with 0-dBm transmit and receive audio inputs and outputs. The transmit audio level is self-adjusting and will compensate for a wide range of input levels.

SECTION 2
TRANSCEIVER SPECIFICATIONS

2.1 GENERAL INFORMATION

Section 2 contains technical specifications in Table 2-1, semiconductors in Table 2-2, the block diagram (Figure 2-1), and the module location diagrams (Figures 2-2 and 2-3).

TABLE 2-1. Technical Specifications.

GENERAL	
FREQUENCY RANGE:	1.6-30 MHz in 100-Hz synthesized steps.
FREQUENCY ENTRY:	Keypad-controlled microprocessor.
CHANNELS:	100 Simplex and half-duplex.
CHANNEL PROGRAMMING:	Mode 1 Front panel. Mode 2/3 Internal.
CONTINUOUS ENTRY:	Channel 00 by keypad entry. Mode 1: Transmit & Receive. Mode 2: Receive only. Mode 3: Disabled.
FREQUENCY DISPLAY:	6 digit by keystroke (locked out in Mode 3).
PROTECTION AGAINST UN-AUTHORIZED FREQUENCY CHANGE:	Coding device may be removed to lock transceiver in Mode 2 or Mode 3.
TUNING:	Up & down pushbutton switches (receive only), 100-Hz steps.
SCANNING:	Automatic on up to 98 channels.
ANTENNA IMPEDANCE:	50 ohms.
TEMPERATURE RANGE:	-30° to $+60^{\circ}$ C.
FREQUENCY CONTROL:	Temperature-controlled master oscillator ± 0.0001 %, ±20 Hz maximum.
MODES:	Simplex and half-duplex.
OPERATION MODES:	A3J, (USB/LSB), A3H (compatible AM), A1 (CW), F1 teletypes (optional).
TRANSCEIVER:	
SIZE (W x H x D):	43.2 cm x 14 cm x 28.7 cm.
WEIGHT:	10 kg.
INSTALLED IN CARRYING CASE WITH ACCESSORIES:	
SIZE (W x H x D):	53 cm x 18 cm x 33 cm.
WEIGHT:	14 kg.
POWER SUPPLY	
13.6 Vdc:	Receive 600 mA, transmit 12 A average SSB.
	Internal ac power supply 105-125 V/210-245 V, 50/60/400 Hz for SSB operation.
TRANSMITTER	
POWER OUTPUT:	125 W PEP, 100 W average, ±1 dB at ambient.

TABLE 2-1. Technical Specifications, Continued.

ANTENNA MISMATCH:	Protected against mismatch including open and shorted antennas.
CARRIER SUPPRESSION:	Greater than -50 dB.
UNWANTED SIDEBAND:	-60 dB at 1 kHz, typical.
SPURIOUS SUPPRESSION:	Greater than -63 dB, typical.
AUDIO INPUT:	150 ohms, VOGAD for constant audio level. 600 ohms, 0 dBm.
AUDIO BANDWIDTH:	2.4 kHz.
INTERMODULATION DISTORTION:	Greater than -32 dB, typical.
ALC:	Less than 1 dB increase for 20 dB increase in audio input.
METERING:	Relative RF output, tune power.
RECEIVER	
SENSITIVITY:	0.35 μV for 10 dB S + N/N.
SELECTIVITY:	300 to 2700 Hz -6 dB, -60 dB at 5 kHz typical.
IMAGE REJECTION:	Greater than 80 dB.
IF REJECTION:	Greater than 80 dB.
CONDUCTED RADIATION:	-70 dBm.
AGC CHARACTERISTICS:	Less than 6 dB audio increase from 3 μV to 300,000 mV.
INTERCEPT POINT:	+11 dBm.
INTERMODULATION:	-85 dB.
CLARIFIER:	±125 Hz.
SQUELCH:	Audio derived, noise immune.
AUDIO OUTPUT:	4 W into 3 ohms, internal loudspeaker. 600 ohms 0 dBm.
METERING:	RX signal strength.
ANTENNA TUNER	
IMPEDANCE:	6, 12, 50, 120 ohms.
SERIES INDUCTANCE:	0-23 microhenrys.
SHUNT CAPACITANCE:	10-100 pF.

Specifications subject to change without notice.

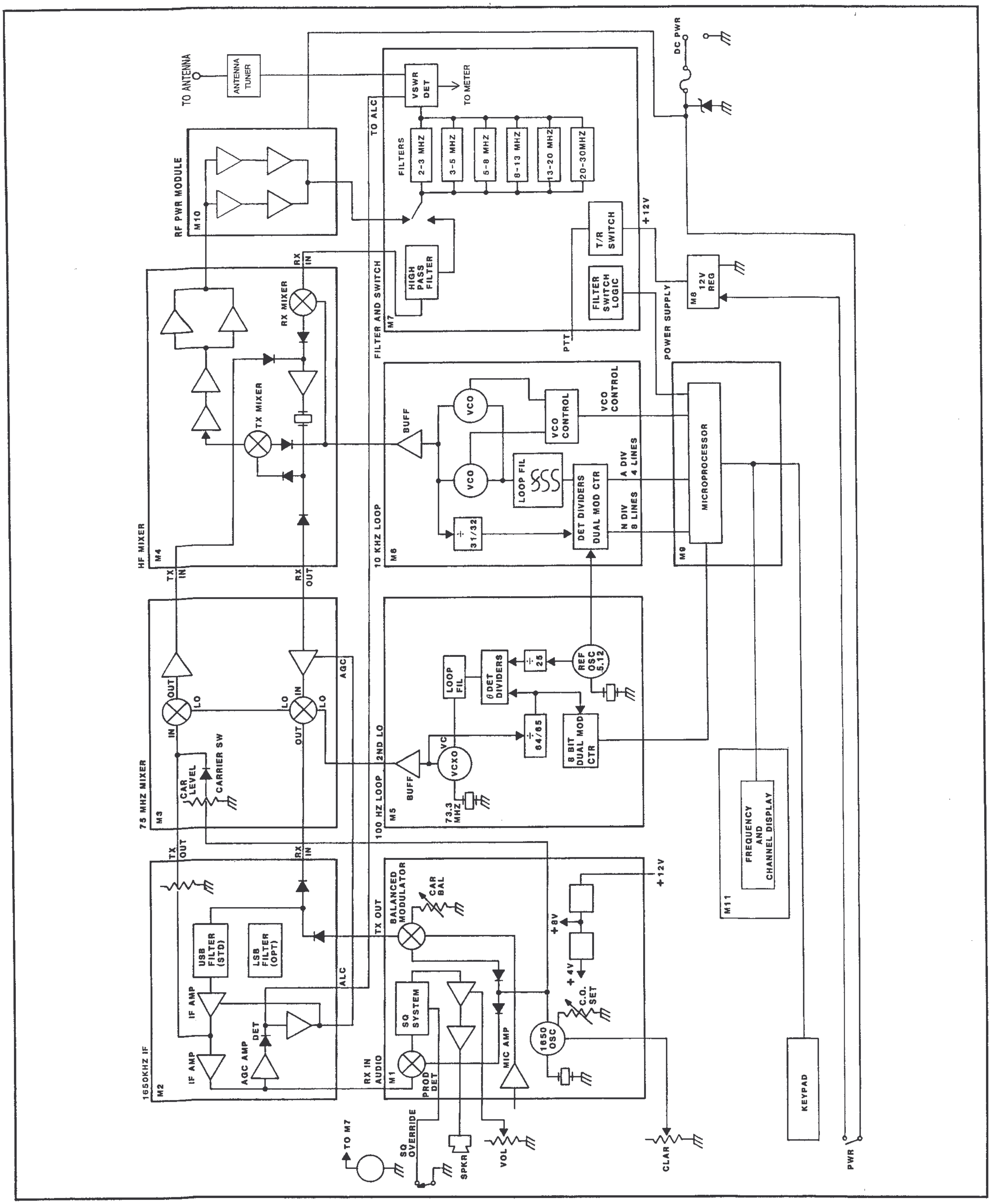


FIGURE 2-1.
Block Diagram.

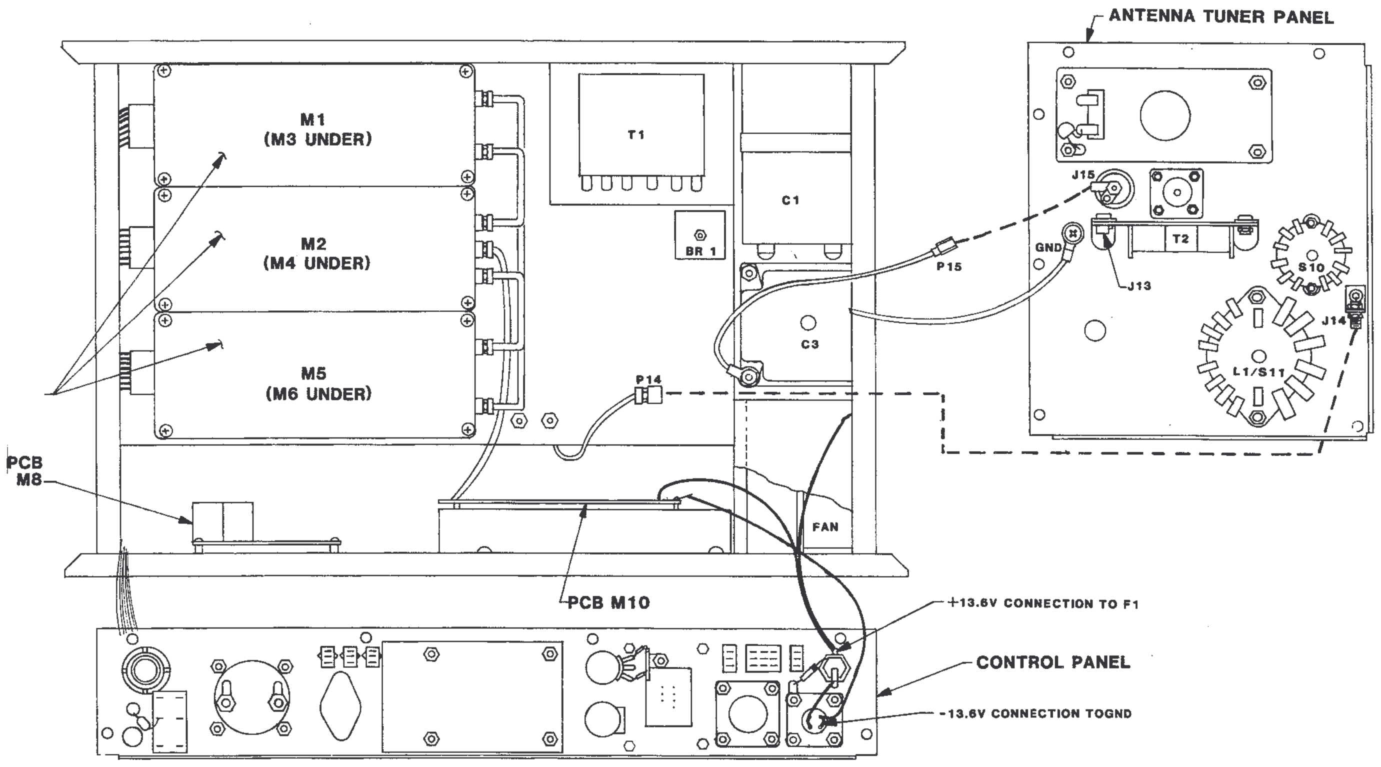


FIGURE 2-2.
Module Location Diagram - Top.

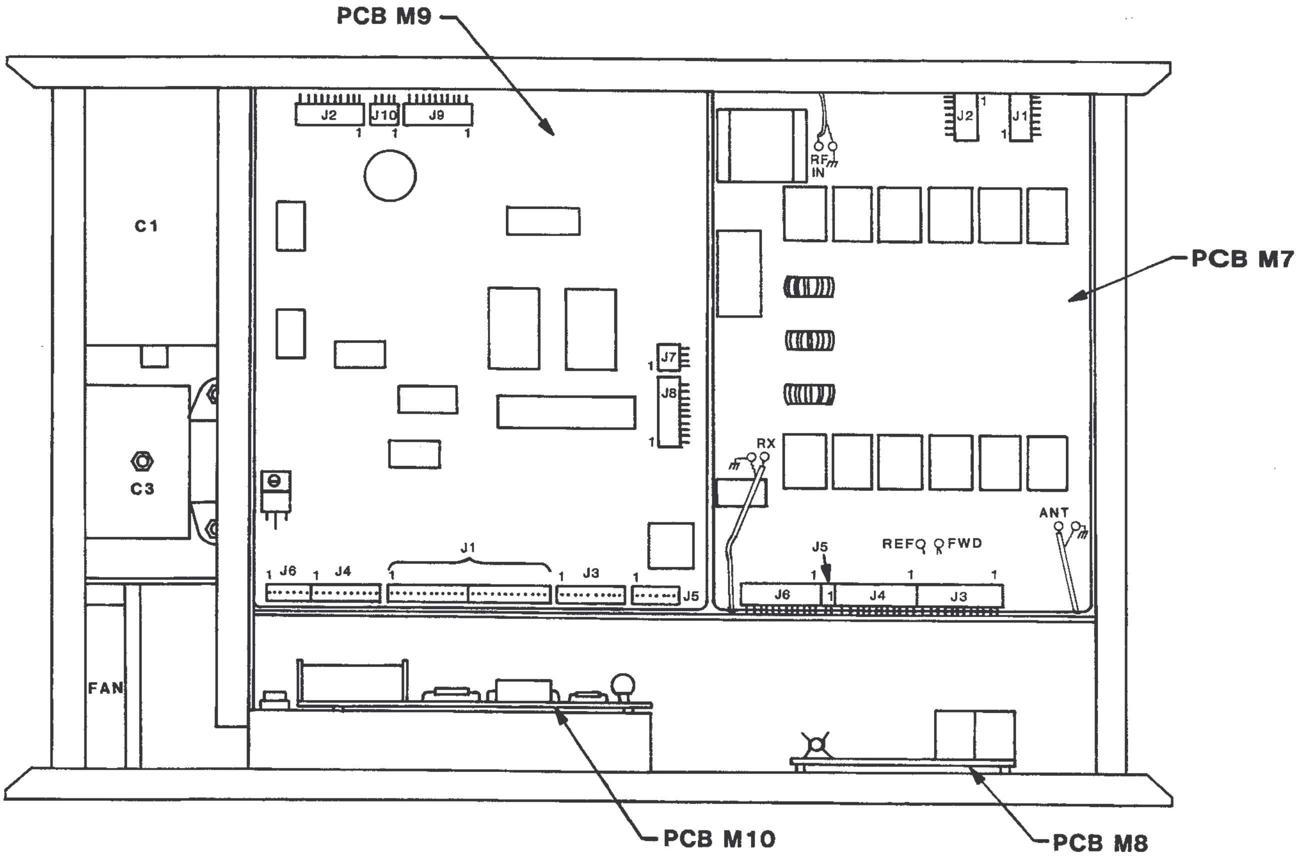


FIGURE 2-3.
Module Location Diagram - Bottom.

SECTION 3
OPERATION

3.1 INTRODUCTION

The Flyaway transceiver is designed for operation in almost any place at any time. Before starting on a mission, ensure that all of the accessories are packed with the transceiver. Read through the instructions carefully. You do not have to be a technician to operate the equipment, but you must understand the functions of the controls and know how to set up the equipment correctly.

NOTE

The numbers in parentheses following the section subheadings refer to the location of front-panel controls indicated in Figure 3-2.

3.2 CHOOSING THE LOCATION

It is important to choose the best location, and this choice will be determined by the antenna. The success or failure of the communications will be largely dependent on the antenna system. Since the antenna system is so important, Chapter 4 is devoted entirely to this subject. A power source is also essential for operation of the transceiver, although using an extension power cable will not affect the performance of the transceiver. However, using a poorly located antenna may prevent completely satisfactory operations.

3.3 POWER SOURCE

3.3.1 AC OPERATION

Determine the voltage of the power source. A three-position switch is located on the right-hand side of the transceiver near the ac supply-cord receptacle. Switch positions corresponding to three different supply voltages are designated by arrows imprinted below the speaker grill. Set the switch to the proper voltage before connecting the ac supply cord to the transceiver.

CAUTION!

Never operate the transceiver on voltages in the 200-V range when the switch is in the 115-V position. ***Serious damage may result.***

If there is any doubt about the voltage of the supply, select the 240-V switch position. The transceiver will operate at voltages down to 200 V with only a small drop in output power. If the transceiver does not operate, make a definite determination of supply voltage before switching to the 115-V position.

Always try to use the ground pin on the cable connector. If an adapter for foreign type outlets is used, make sure that a ground connection is provided.

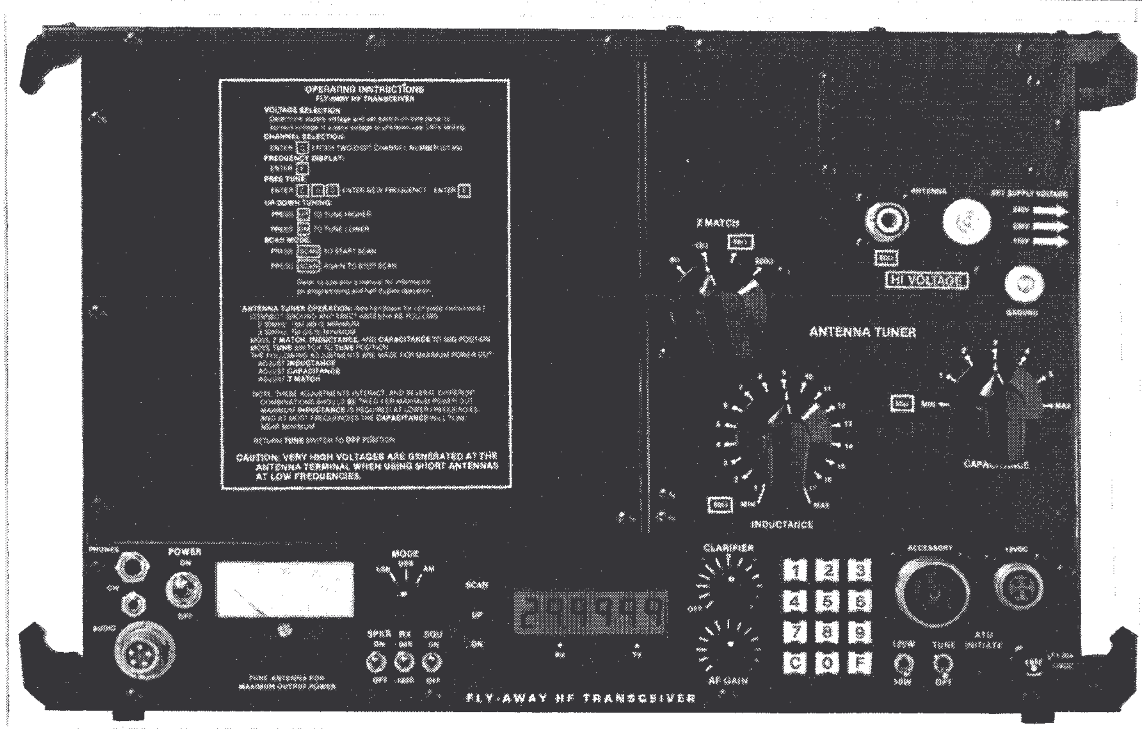


FIGURE 3-1.
Front Panel.

3.3.2 12 -VDC OPERATION

The transceiver will operate from a 12-V supply source with a maximum current capability of 20 A peak. The most convenient source will be a heavy duty 12-V automobile or truck battery. Make sure that the battery is fully charged. For full transmitter power output, the supply voltage should be 13.6 V and should never be lower than 11 V.

The transceiver is supplied with a 12-V cable fitted with a connector and two battery clips. Plug the cable into the connector marked 12 Vdc, then connect the RED clip to the positive terminal (+) of the battery and the BLACK clip to the negative (-) terminal. Be very careful not to reverse the polarity, as the dc supply fuse will blow immediately.

If it is necessary to use longer battery leads, use very heavy gauge wire (8 AWG) to prevent excessive voltage drop.

NOTE

Do not connect the transceiver to the battery when the ac power cable is installed. This could cause damage to both the battery and the transceiver.

3.4 ANTENNAS & GROUND

Refer to Section 4 for full information on the ground, antenna systems and operation of the antenna tuner.

3.5 POWER ON/OFF SWITCH (1)

This switch controls the power to the transceiver with both ac and dc power sources. The frequency display lights when the power is switched on.

3.6 FREQUENCY SELECTION

The transceiver may be supplied in one of three operating modes. The choice of operating mode will usually be determined by the licensing authority for the equipment. Check the operating mode of the equipment as some features are not available in Modes 2 and 3.

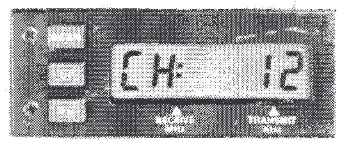
Mode 1: All facilities are available in this mode, including the programming of transmitting frequencies. This mode is normally only available to trained operators.

Mode 2: In this mode the operator has no control over the transmitting frequency and must operate in the pre-programmed channel frequencies. Channel 00 is available as a free-tuning receiver.

Mode 3: In this mode the transceiver operates as a channelized transceiver with permanently programmed channels. The tuneable receiver is not available and channel frequencies cannot be displayed.

3.7 CHANNEL SELECTION - KEYPAD (2)

Enter **C** followed by a 2-digit channel number.



If CH: 00 is entered, the channel frequency is automatically displayed. In Mode 3 the frequency display is suppressed.

NOTE

All channel numbers have 2 digits (01 to 99). ***Channel selection is the only function available in Mode 3.***

3.8 FREQUENCY DISPLAY

Press **F** and the channel frequency is displayed. The position of the decimal point will indicate if the receive or transmit frequency is displayed.

Press **F** twice to display and monitor the transmit frequency. The receiver will automatically return to the receive frequency after the transmit switch is pushed.

NOTE

The transmit and receive frequencies are the same on simplex channels.

3.9 FREE-TUNE CHANNEL 00

Channel 00 is available for free tuning the transceiver. In Mode 2 this channel is only available in the receive mode. The last entered frequency will be retained in memory until changed.

ENTER **C 00**. The transceiver is now in the free-tune mode. The frequency may be changed by entering the new channel frequency, then **F** . Remember **F** must be entered after every frequency change. Frequencies are displayed during and after transmitting on channel 00.

Half-Duplex

When one frequency is entered, the transceiver automatically assumes that it is a simplex frequency. For half-duplex operation, enter the receive frequency first, then press **F** twice and enter the transmit frequency and press **F** . Check that the pointer indicates "transmit frequency".

3.10 UP/DOWN TUNING

The **UP** and **DN** keys permit tuning the transceiver frequency up or down from the original frequency displayed. A single push steps the transceiver 100 Hz. If the key is held down the transceiver steps at a rate of 40 steps per second.

Only the receiver frequency can be changed in this way. Any offset thus entered is retained until the channel is changed. On the free-tune channel (00) it is possible to change the frequency in memory permanently by pressing the **F** key after stepping.

3.11 AF GAIN (3)
Turn the squelch off and adjust the audio frequency gain control to a comfortable level.

3.12 SPEAKER ON/OFF (4)
This control turns off the loudspeaker. The LS OFF position is used to turn off the loudspeaker when headphones are used.

3.13 ATTENUATOR SWITCH - RX (5)
The attenuator switch reduces the gain of the transceiver by 12 dB (equivalent to a power reduction of 16 times). The receiver is very sensitive, and most of the time the background noise level will prevent the reception of very weak signals. Under these conditions, switch in the attenuator (-12-dB position) to reduce the background noise level. The attenuator should also be used to prevent receiver overload when exceptionally strong signals are present. (With the attenuator in the circuit, the input intercept point is +23 dBm, while the sensitivity is still better than 1.2 microvolts.)

3.14 SQUELCH ON/OFF (6)
The squelch circuit is used to eliminate background noise when there are no signals on the channel. The squelch circuit is automatic in operation and is preset to open on weak voice signals.

3.15 CLARIFIER (7)
In the OFF position (fully counter clockwise) the clarifier is disconnected and the receiver operates on the same frequency as the transmitter. The clarifier permits a small change of the receiver frequency and is used to correct pitch of the voice, or tune an FSK signal.

3.16 MODE SWITCH (8)
This switch has the following markings:

USB: Upper-sideband operation. This mode is used for most normal SSB communications.

LSB: Lower-sideband operation. LSB is usually used if there is interference on the other sideband. Both transceivers must be operating in the LSB mode or communication is not possible. In many countries (including the USA) this mode is illegal and will not be fitted to the transceiver.

AM: Compatible AM. This mode is used to provide a signal that is intelligible on an AM signal. It is unlikely to be required for normal communications.

3.17 METER (9)
Receive: The meter indicates the relative signal strength of the received signal. The midscale position is calibrated for a signal strength of 100 microvolts.

Transmit: The meter reads average power output and should read approximately full scale at 100-W output. The meter will indicate between 3 and 4 on a normal voice transmission and should deflect to almost full scale on a whistle in the CW mode. A low meter reading usually indicates a mismatched antenna.

Tune: The meter reads approximately 9 on the tune position when the antenna is correctly tuned.

3.18 ATU (10)
The ATU switch is fitted when the automatic antenna tuner is used. Press the switch when the transceiver is first switched on and when the frequency is changed. The tuning sequence is automatic and a tone is present in the loudspeaker while the tuning cycle is in progress.

3.19 PROGRAMMING CHANNEL FREQUENCIES
The channel frequencies can only be changed in Mode 1.

Enter the channel number **C ? ?** . Press the **F** key and hold it down, then press the **C** key. It is important to follow this sequence by ensuring that the **F** key is pressed before the **C** key and not released until after the **C** key is depressed. Enter the channel frequency and press **F** .

Half-Duplex
Enter the receive frequency as described above.

Enter **F** then repeat the double keystroke action **F C** and check to ensure that the pointer has moved to "transmit frequency". Enter the transmit frequency and press **F** .

The channel frequencies are entered into permanent memory and retained by a lithium battery with a nominal shelf life of 10 years. It is recommended that the battery be changed at five year intervals.

3.20 SCAN MODE
It is possible to scan between 2 and 98 channels in the scan mode. Program the desired frequencies starting at channel 01. Go to the channel which is one more than the highest channel to be scanned. Press the **F** key and hold it down, then press the **C** key, as if programming the frequency as above. Now press **SCAN**. The scan limit will now be set as desired and the channels below this limit will be scanned 3 per second.

Inititate Scan
Press the **SCAN** key.

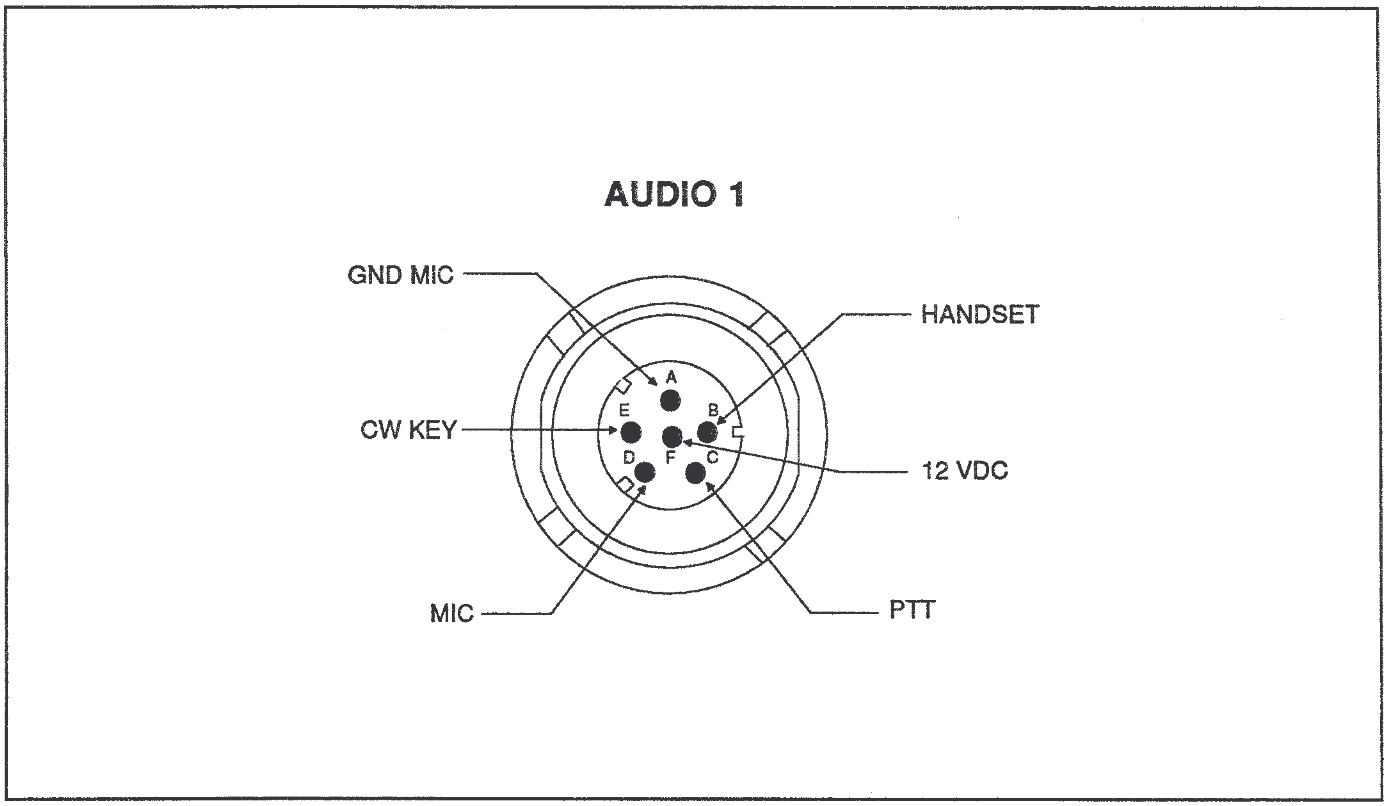


FIGURE 3-2.
Audio Connector - Internal Connections.

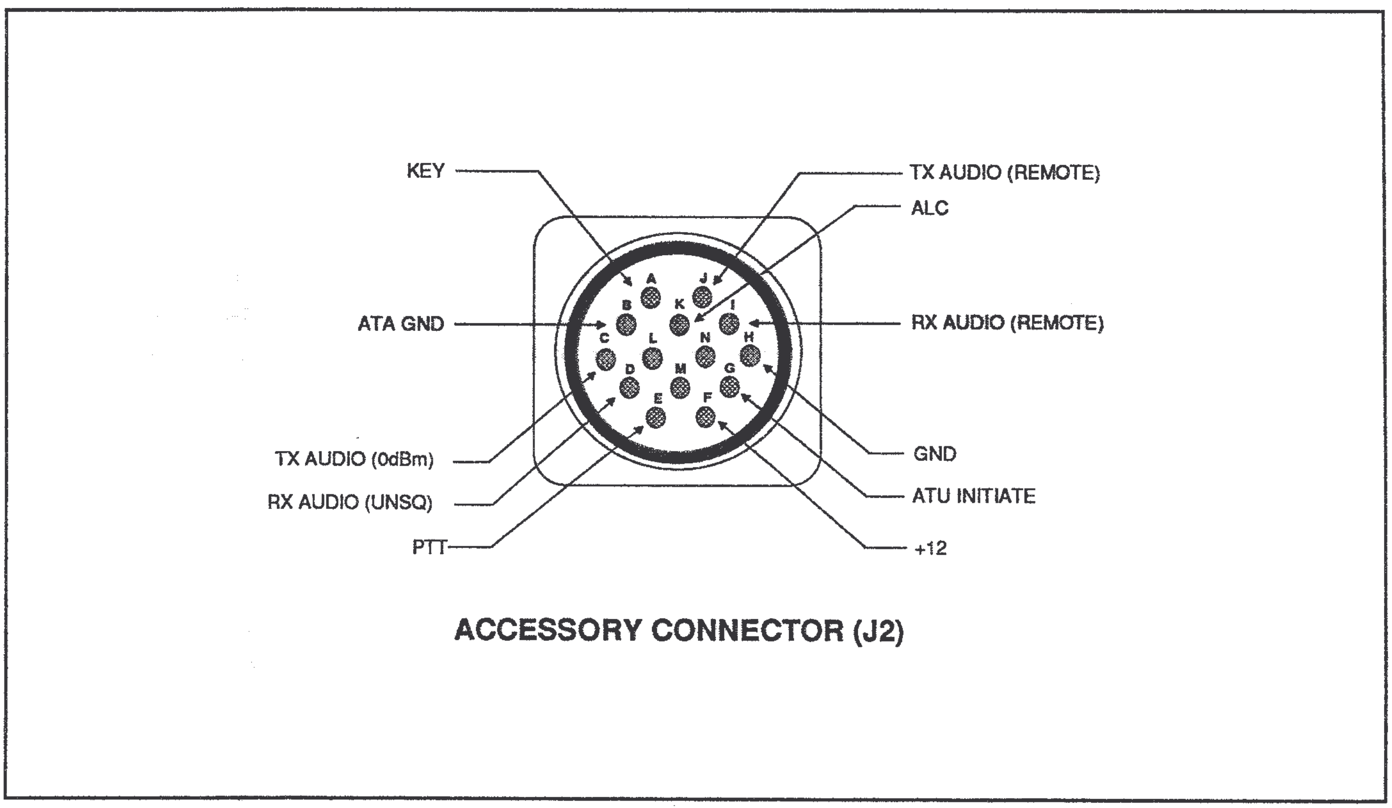
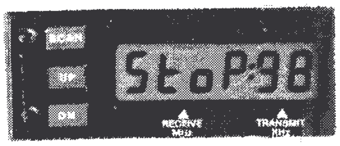


FIGURE 3-3.
Accessory Connector - Internal Connections.

Stop Scan
Press the **SCAN** key again.



NOTE

It is necessary to stop the scan to enter new keypad functions.

3.21 125/10-W SWITCH (11)

This switch selects the power output of the transceiver. If signals are strong, the low-power position may be used to reduce the chance of interception and to prevent interference with other stations.

3.22 TUNE SWITCH (12)

The tune switch is used when adjusting the antenna tuner. Refer to Section 4 for information on the tuning procedure.

3.23 HANDSET (13)

The handset is connected to the connector marked AUDIO. Figure 3-3 shows the internal connections for the audio connector. The connector is the standard U.S. military audio connector and may be used with standard military audio accessories such as handsets and SSB encryption equipment. The transceiver uses a gain-adjusting microphone amplifer and will provide the correct level with a wide range of audio levels.

3.24 HEADPHONES (14)

The larger of the two jacks is used for headphone operation. The speaker switch (4) may be turned off for headphone operation.

3.25 FUSES (15)

There are three fuses in the transceiver.

1) The ac fuse (F2, rated 3A) is mounted on the right side of the transceiver near the ac receptacle.
2) The main 12-Vdc supply fuse (F1, rated 20 A) is located on the control panel.
3) The 12-Vdc regulator fuse (F3, rated 5A) is located on M8 and protects only that portion of the transceiver supplied with ***regulated*** 12 Vdc.

NOTE

Never use a larger fuse than specified. This could cause serious damage to the transceiver.

3.26 CW TELEGRAPHY (16)

To operate on CW (Morse) plug the key into the small jack and use either USB or LSB. The transmitter automatically switches on when the key is pressed. Make a short pause in the keying and the transceiver will return to the receive mode.

3.27 ACCESSORY CONNECTOR (17)

The connections to the accessory connector are shown in Figure 3-4. This connector is normally used for operation with external audio accessories such as a modem or a message terminal for RTTY operation. The connector will also be used with operational wiring if the automatic antenna tuner is used.

NOTE

Other wiring options may be used for other accessory equipment.

3.28 RTTY OR DATA COMMUNICATIONS

The transceiver power supply and antenna tuner are not rated for radio-teletype operation or other data communications at full power. Unless the transceiver is used with an optional power supply rated for 13.6 V at 20 A, RTTY or data communications should be made in the low-power mode. The transceiver may be used for burst transmissions not exceeding two minutes in the high-power mode.

3.29 COOLING

The transceiver uses a small cooling fan mounted on the right side of the transceiver to cool the final amplifier heat sink. The air enters through the bottom cover and exhausts at the right side of the transceiver. It is very important to see that the air inlet and outlet are not obstructed. Make sure that the accessory bags are removed while the tranceiver is in operation. The cooling fan does not run continuously. It is switched on only when the heat sink temperature reaches 60^{o} C. A second thermostat on the heat sink will switch the transceiver to the low-power mode if the temperature reaches 75^{o} C. This is unlikely to happen during voice transmissions, but may occur on radio-teletype operation at elevated temperatures or on extended transmissions.

NOTE

High-power radio-teletype operation is only permitted when using an external heavy-duty power supply.

3.30 OPERATION—SELCALL

The selective calling system is an optional feature. Check that it is fitted to the transceiver before using this function. Each transceiver is assigned a selective-call code (001 to 255). This code is internally programmed in the Selcall module.

To operate Selcall press the "S.C." key and enter the three-digit code for the desired station. Press the "CALL" button, this will switch the transmitter on and will then send the selective-call code. The station called will stop scanning and send back a transpond signal. The Selcall module at the station called displays "CALL" on the LCD display, and sounds the call alarm tone at both stations. When a call is received, press the "SCAN" key to stop the scan. After the call is completed, press any key on the keypad to cancel the "CALL" display. If the scan mode is in use, press the "SCAN" key again to initiate scan.

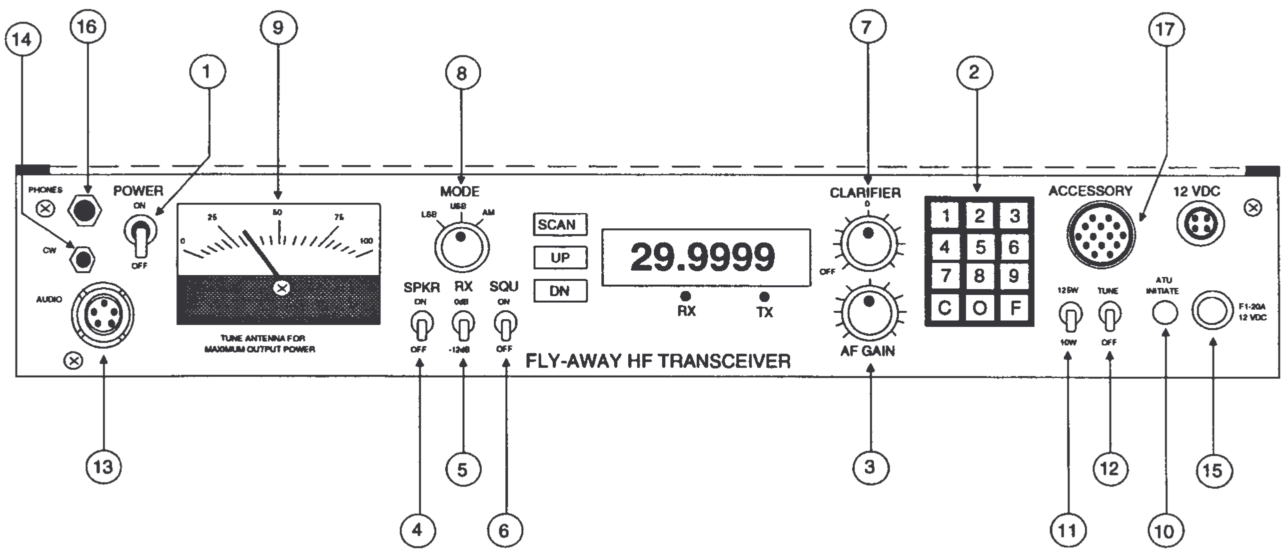


FIGURE 3-4.
Front-Panel Controls.

SECTION 4
ANTENNAS

WARNING - ELECTROCUTION HAZARD

Extreme care should be taken in the erection of antennas, particularly improvised antennas, to make sure that all parts of the antenna system are clear of wires, electrical machinery, or any potential source of electrical shock.

DO NOT TAKE RISKS!

4.1 INTRODUCTION

The performance of a modern HF SSB transceiver is completely dependent upon the antenna and the ground system. With a good antenna system and the correct choice of frequency, the TW100F will communicate over ranges of many thousands of kilometers. With poor antennas communications may be impossible, even over short distances. The transceiver is designed for portable and emergency situations and it will not often be possible to use a properly designed antenna located in a good position. This makes this section of the manual extremely important and we recommend that it be read very carefully.

4.2 ANTENNA TYPES

The transceiver is designed to operate into a 50-ohm antenna system or, with the use of the antenna tuner, can be used with wire or whip antennas of random length. The 50-ohm antenna is usually a resonant dipole or a wideband antenna designed to provide a good match at the operating frequencies. The antenna is fed using a 50-ohm coaxial cable and is not dependent on the ground system for good results. This type of antenna will give superior results compared to the wire or whip antennas, and should be used whenever practical. Further information is given on two types of 50-ohm antenna in paragraphs 4.3 and 4.4.

Unfortunately, it is not always practical to operate with a coaxial-fed 50-ohm antenna, so an end-fed antenna must be used. The transceiver does contain a built-in antenna tuner, and is capable of matching to a wide variety of antennas. The end-fed antenna operates with the ground as an image antenna. This means that a good ground is essential for this type of antenna.

4.3 DIPOLE ANTENNAS

The half-wavelength dipole is the best all-around antenna for HF operation. The antenna is one half wavelength long and is center fed with a 50-ohm coaxial cable. The antenna may be erected between two supports or in the form of an inverted "V" with a single support at the center and the ends sloping towards the ground. The optimum height for long-distance communications is one half wavelength above ground. At 2 MHz, this height is 75 meters and is 13 meters at 12 MHz. On the lower frequencies, often it is not possible to erect the antenna at the optimum height, and the antenna is simply erected as high as possible. Good results are usually obtained with the antenna center at heights of 10 meters or more.

The antenna has maximum radiation at broadside to the antenna and is minimum off the ends. The directivity is reduced if the dipole is erected in the inverted-"V" configuration. If possible, choose a site so that the antenna is clear of obstructions such as buildings and trees. Keep the antenna away from power lines and other sources of noise. The coaxial feed line will not pick up any noise and the location of the transceiver is relatively unimportant.

Figures 4-1 and 4-2 show the construction of the standard half-wavelength dipole in both the horizontal and inverted-"V" configurations. The top section of the antenna should be cut to length according to the following formula.

Total length in feet = 468/F MHz.
(Meters = 146.5/F MHz)

A special portable version of the dipole antenna uses two calibrated steel tapes on reels. The dipole is unreeled to the correct frequency and locked in place. This is a simple and effective antenna for portable operation.

4.4 BROADBAND ANTENNAS

There are many manufacturers of broadband dipole antennas for the HF range. Some antennas, such as log periodics, are directional and must be oriented correctly. The ABB1 antenna is a broadband folded dipole covering the frequency range 3.5 MHz to 30 MHz with a typical VSWR not exceeding 2:1. While this antenna is not as efficient as the single frequency dipole, the performance is much better than most end-fed antennas and the directivity is similar to the resonant dipole antenna.

4.5 TUNING DIPOLE ANTENNA

The resonant dipole antenna provides a satisfactory match at only one frequency, and the broadband dipole may exhibit a poor match at some operating frequencies. The antenna tuning unit in the transceiver may be used to compensate for an unsatisfactory match and will extend the bandwidth of the dipole antenna considerably. The antenna tuner may be used to match the transceiver to the antenna. If the VSWR to the antenna is less than 3:1, the losses in the coaxial cable will be small. Refer to the normal tuning procedure for the antenna tuner.

4.6 END-FED ANTENNAS

Although it is desirable to use a balanced antenna system, such as a center-fed dipole, there will be many installations where it is only practical to use an end-fed antenna. This type of antenna is only efficient when the radiating portion of the antenna is in the clear and there is an excellent ground system. These conditions are usually difficult to achieve at a portable location. The end-fed antenna is usually a length of wire or a whip. The following points should be carefully noted.

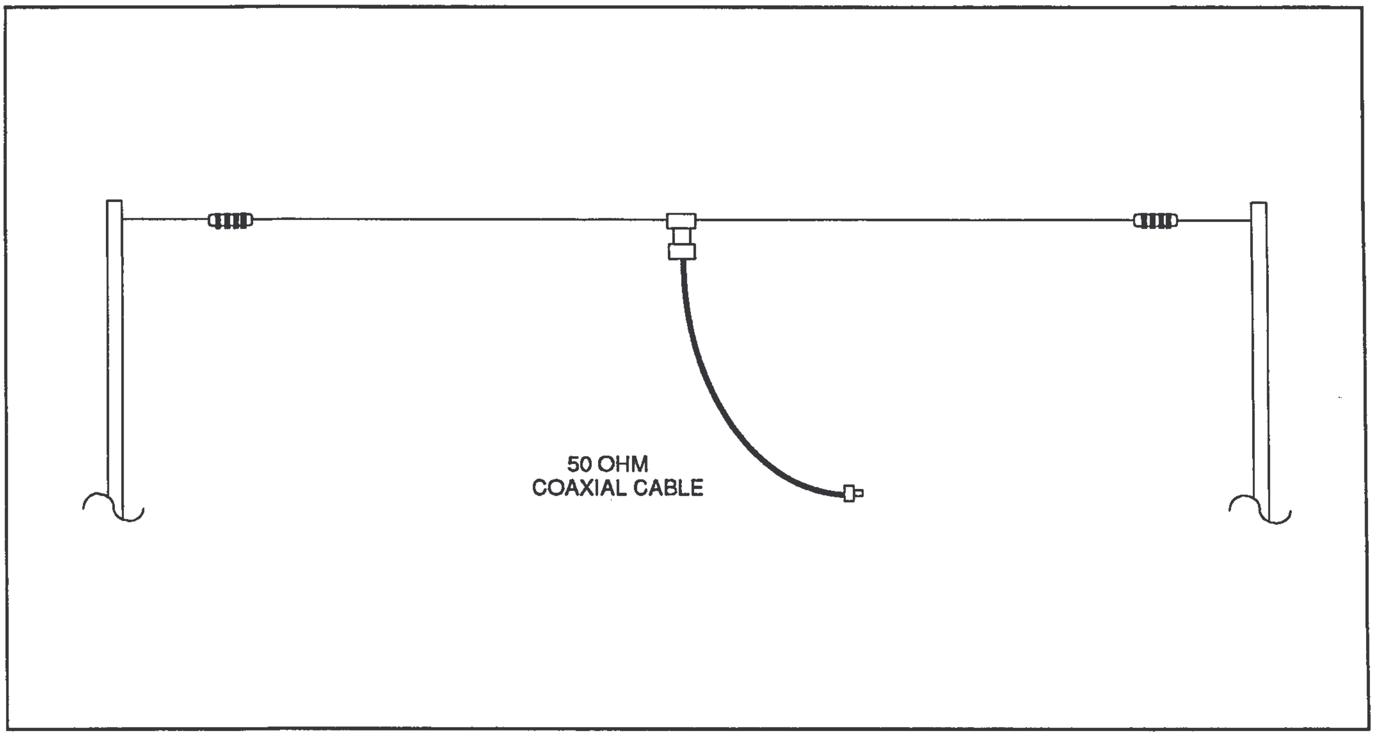


FIGURE 4-1.
Half-Wavelength Dipole.

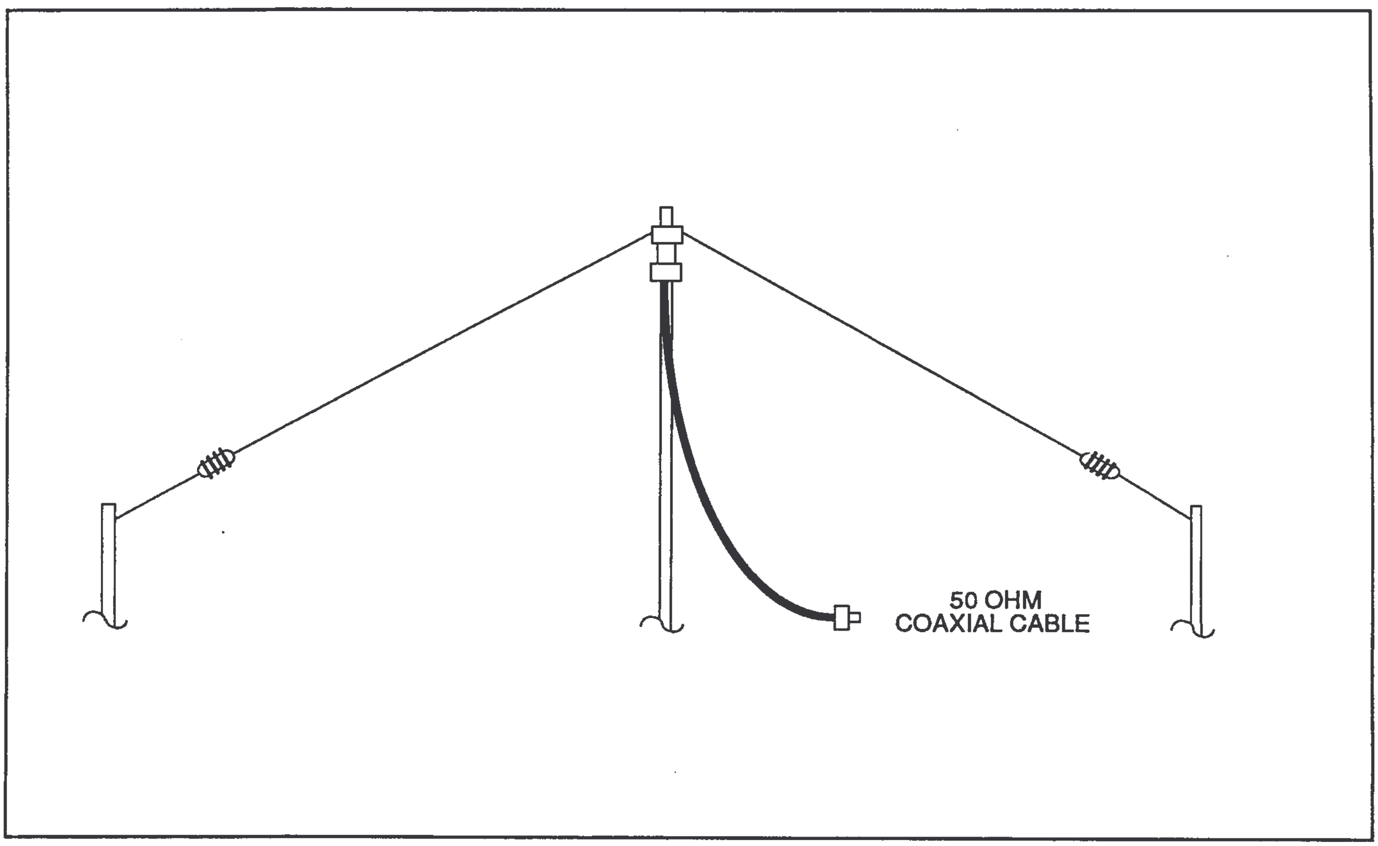


FIGURE 4-2.
Inverted-"V" Antenna.

a) **Length**—maximum efficiency is achieved with resonant antennas. The antenna will be resonant at one quarter wavelength and multiples of this. It is best to avoid the even multiples, as the antenna impedance will be very high at these points and it will be difficult to match the antenna to the transceiver. A quarter wavelength can be calculated by dividing 234 by the frequency in MHz to give the length in feet. (Divide 72.3 by MHz to give length in meters.) If the antenna is substantially less than one quarter wavelength, the efficiency will be reduced.

b) **Location**—Since the entire antenna radiates, it is important to keep it clear of all obstructions and as high as possible. Remember, the antenna radiates beginning at the connection on the transceiver. If the first part of the antenna is close to obstructions, much of the radiated energy will be absorbed. In a hotel room or building, the transceiver should be located right at the window, as a ferro-concrete building will provide almost complete shielding. See the transceiver installation example, Figure 4-3. It is also important to keep the antenna as far away as possible from noise sources, such as power lines.

c) **Construction**—This will often depend on the operator's ingenuity. The antenna may be a vertical one, a horizontal one, an inverted L, or any combination of twists and bends that get the maximum length of wire up in the clear. If a whip antenna is used, make sure that the transceiver is located as close to the bottom of the whip as possible. A typical installation in a house might have the transceiver in a room close to a window, with the antenna wire going up to the eaves of the house and then across to a tree. In a hotel room or building, the antenna may run up to the roof. If the room is on an upper floor, the antenna can be hung down outside the window, with a weight on the end. If this is done, the antenna must be kept clear of the walls. A broom handle might form a convenient prop.

d) **Radiation Pattern**—Maximum radiation is broadside to the antenna and minimum off the ends. A vertical antenna will have an omnidirectional pattern and will radiate equally well in all directions. If the antenna is in the form of an "inverted L," maximum radiation will be from the longest part of the antenna. Always try to erect a horizontal antenna broadside to the desired direction of communications.

e) **Height**—The lowest angle of radiation occurs with the antenna approximately one half wavelength above ground. Low-angle radiation is desirable for long-distance communications. Higher angles are used for shorter distances. At the lower frequencies it will seldom be possible to erect the antenna at the optimum height, but effective communications at distances of several hundred kilometers may often be obtained with quite low antennas. It is better to have an antenna of reasonable length only a few meters above the ground than to try to operate with a very short whip or wire antenna.

f) **Insulation**—The antenna must be carefully insulated from the supports and other surfaces. The voltages on the antenna can be as high as 2000 V, so good insulation is essential. Never run the antenna close to conducting surfaces without an airgap of several centimeters. Also ensure that a metal window frame is never closed on the antenna wire.

g) **Indoor Antennas**—Indoor antennas will sometimes work with reasonable efficiency in wooden buildings. The antenna may be in the attic or pinned along the curtain rail. It may be necessary to go around three sides of the room to get sufficient length. Do try to keep the antenna as far as possible from the electrical wiring.

h) **Invisible Antennas**—The thickness of the wire will have little effect on the efficiency of the antenna. This makes it practical to use a length of very light gauge enameled wire for temporary antenna installations. If nylon fishing line is used for the supports, the antenna will be very difficult to see, and the nylon will provide excellent insulation.

4.7 GROUNDS

The ground system is extremely important when using the end-fed antenna. Without a good ground system the antenna will be difficult to tune and will not radiate efficiently. The case of the transceiver may become hot to RF, which causes malfunctions and operator burns. The transceiver is provided with a ground strap 2.5 meters long. This is the maximum recommended length for the ground. If possible, shorten the ground strap by forming a loop in the surplus strap and twisting the strap together. It is best to relocate the transceiver rather than extend the ground connection, even if this means that some part of the antenna must come inside the building. The best ground systems use multiple radials buried under the antenna or some form of ground mesh. If the soil has good conductivity, several ground rods may be strapped together with low-impedance cables.

Unfortunately, good grounds are seldom available for temporary installations. A metal rod driven at least one meter into moist soil will usually give satisfactory results. Alternatively, a connection to a metal cold-water pipe, just before it enters the ground, will usually be satisfactory. Frequently the transceiver will be located in an upstairs room and a satisfactory ground cannot be obtained. A counterpoise ground must then be used in place of the real ground. This counterpoise could consist of one or more quarter-wavelength wires laid under the antenna. Connection to a hot-water radiator or the plumbing system may be effective. Metal window frames may be connected to the building framework to form a good counterpoise. As a last resort, the electrical wiring ground should be used. In outdoor installations, the body of a car or truck forms a fairly effective counterpoise.

4.8 ANTENNA TUNER

4.8.1 GENERAL

The transceiver uses an efficient internal antenna tuner to match a variety of antennas to the transceiver. The tuner is coupled to both the 50-ohm coaxial cable connector and the antenna insulator for operation with both end-fed and balanced antenna systems. The tuner uses a high-voltage variable capacitor shunted from the antenna terminal to ground, a series 22-microhenry inductor with 17 tap positions, and a matching transformer with 6-, 12-, and 200-ohm taps.

4.8.2 BALANCED ANTENNAS

The tuner may be used with balanced antennas using coaxial cable feed. These usually provide a good match at the resonant frequency, and the tuner will be switched out of circuit by tuning the three controls to 50-ohm positions. The tuner will extend the operating range of the resonant antenna by compensating for a mismatch on the line. If a heavy-duty cable is used, the line losses will not become excessive up to VSWR's of more than 3:1. This means that the antenna may be operated over a bandwidth of approximately 10 %. It is also possible to match the antenna at the three-quarter-wavelength point (3 times the normal frequency). The tuner may also be used to provide an exact match for broadband antenna systems.

4.8.3 ANTENNA LENGTHS - END-FED ANTENNAS

The antenna tuner is extremely compact, which places some limitations on the matching range and the operating voltage. The following table shows the frequency range for different lengths of antennas.

Length		
Feet	Meters	Frequency Range
10	3.0	4.2-30 MHz
25	7.5	3.0-30 MHz
50	15.0	2.0-30 MHz
75	22.5	2.0-30 MHz*

*Series Capacitor 50 pF may be required at higher frequencies.

4.8.4 LONG ANTENNAS

The antenna tuner will not match antennas exceeding 50 feet (15 meters) at all frequencies in the tuning range. As an example, the table above indicates that a series capacitor (50 pF) is required for the 75-foot antenna at higher frequencies. This capacitor is mounted on the antenna terminal and the antenna is connected to the other end of the capacitor (See Figure 4-4). The series capacitor should be tried if a long antenna cannot be matched. This is usually only necessary at higher operating frequencies.

4.9 TUNER ADJUSTMENT

4.9.1 INTRODUCTION

Matching the antenna to the transceiver is much more difficult to describe than it is to do. There are three different controls which give a very large number of possible tuning combinations, but only one such combination is likely to give the correct match. Fortunately, the human brain has little difficulty in detecting the tuning trend and rapidly reaches the correct combination. It is recommended that the operator practice tuning the transceiver on a number of different frequencies to get familiar with the operation of the tuner. (See Table 4-1.)

4.9.2 METERING

In the TUNE position the meter displays the transceiver power output in the lower power mode. The meter is calibrated to read approximately 90 % of full scale at 10-W output. A special circuit detects the degree of antenna mismatch and reduces the power output in relationship to the severity of the mismatch. Full power output is only available when the match is very close to correct. The system is very effective because a maximum reading on the meter not only ensures maximum power to the load, but also ensures the amplifier is seeing the correct match for minimum distortion and correct operation in the high-power position. It is very important to tune for the maximum meter indication, as the transceiver is capable of putting substantial power into mismatched loads.

4.9.3 PROBLEMS

If the transceiver does not tune, check that the ground is satisfactory; the majority of problems in tuning can be traced to poor grounds. Not only will the antenna not match correctly, but the chassis of the transceiver will be part of the antenna system. This means that the transceiver may malfunction, and the operator will get small RF burns from the metal parts of the transceiver. It is also possible that the antenna tuner does not have sufficient tuning range to match the antenna.

Check the table in Section 4.8.3 to see that the antenna is at least the minimum length for the frequency of operation. If a long antenna is used, it may be necessary to place the series capacitor (50 pF) in series with the antenna lead. If none of these measures are successful, try changing the antenna length. It is possible that a particular antenna and ground system cannot be matched with the tuner. Changing the antenna length will probably change the matching so that it falls within the tuner range.

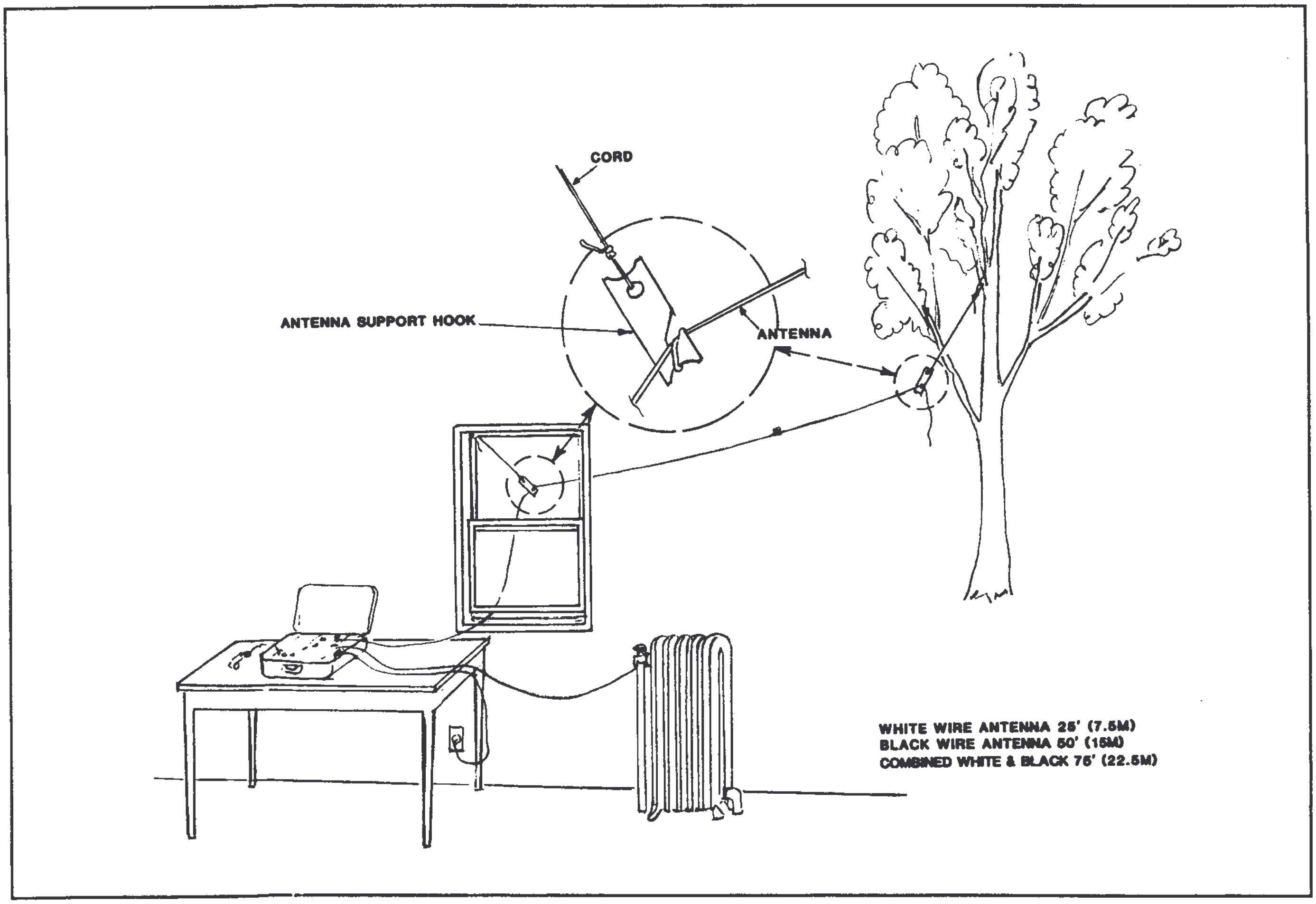


FIGURE 4-3.
Example of Transceiver Installation.

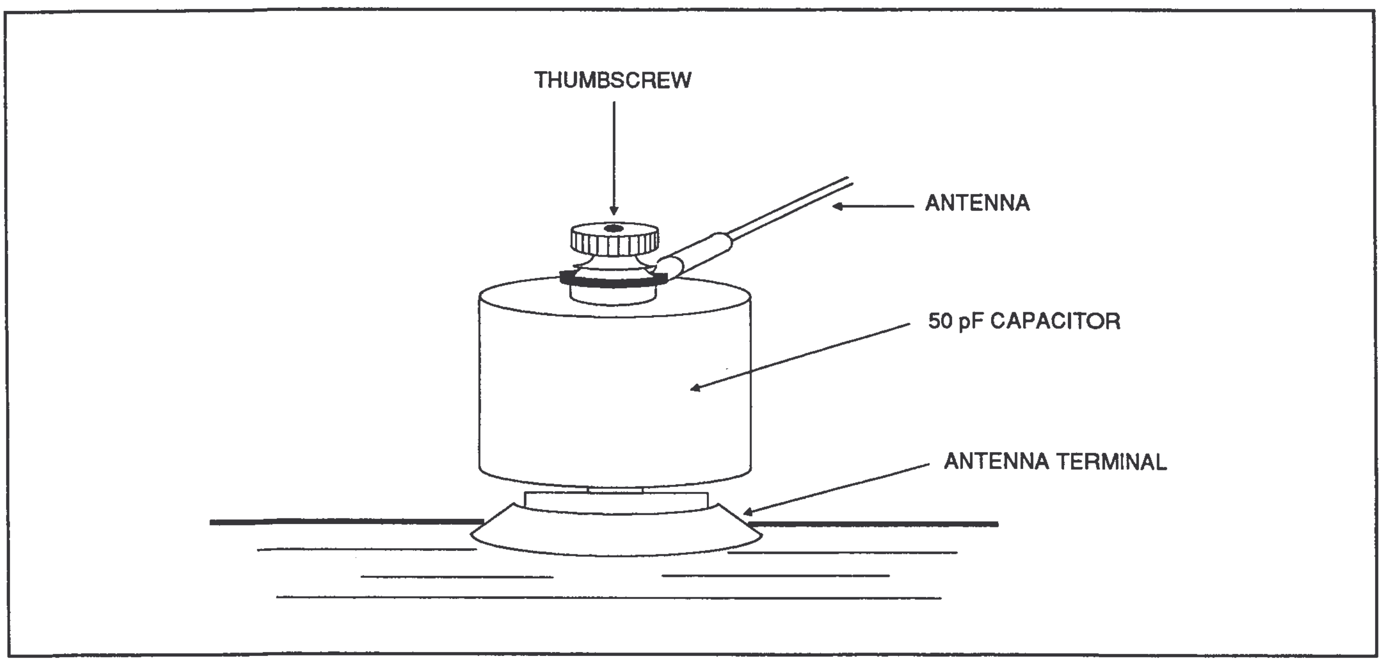


FIGURE 4-4.
Installation of 50-pF Capacitor in Series With Long-Wire Antenna.

TABLE 4-1.
Tuning Procedure.

1. Set the three antenna-tuner controls to the 50-ohm position.
2. Turn the TUNE switch to the TUNE position.
3. The meter will show only a small reading when the antenna is mismatched.
4. Always tune for maximum power. It is important to tune accurately. Even power increases of 2 or 3 percent indicate improvements in the matching.
5. The meter will indicate at least 90 when the antenna is correctly matched.
6. Turn the INDUCTANCE switch, stopping at the position of maximum output.
7. Turn the CAPACITANCE control for maximum output.
8. Repeat procedure, trying higher and lower inductance steps until the combination of inductance and capacitance giving the maximum output is found.
9. Repeat these procedures using the 12-ohm and 200-ohm taps. If the 12-ohm tap shows improved output, try the 6-ohm tap.
10. Select the Z match and the combination of inductance and capacitance that gives the maximum output power.
11. Return TUNE switch to OFF position.

NOTES:

a. The tuning will be very critical with short antennas and good ground systems.

b. With some antennas, it may not be possible to detect the optimum inductance tap with the Z match in the 50-ohm position. In this case, try again using the 12-ohm or 200-ohm taps.

c. The initial search is made with the capacitor in the minimum CAPACITANCE position. This is the correct procedure on most frequencies. If the tuning is unsatisfactory, repeat the tuning procedure with the CAPACITANCE set to maximum.

SECTION 5
ACCESSORIES

5.1 GENERAL INFORMATION

The TW100F transceiver is supplied with the following accessories:

1) 1 each, MHS handset (microphone/earphone).
2) 1 each, antenna assembly, 7.5 m long, black, wound on stowage blade.
3) 1 each, antenna assembly, 15 m long, white, wound on stowage blade.
4) 2 each, hook, antenna support, with cord.
5) 1 each, capacitor assembly, 50 pF.
6) 1 each, power cable, dc.
7) 1 each, ground cable.
8) 1 each, power cable, ac.
9) 1 set, adapters for foreign ac outlets (4 pieces).
10) 7 each, fuse, 5 A; 5 each, fuse, 20 A; 5 each, fuse, 3 A (all contained in box).
11) 2 each, stowage pouch.
12) Operator's manual.

Items 1 through 11 are stowed in 2 pouches (item 11), and the pouches are placed within the suitcase at the left- and right-hand sides of the transceiver.

5.2 OPTIONAL ACCESSORIES

Many optional accessories are available with the TW100F. These accessories include:

1. Headphones, Morse key, heavy-duty hand microphone.
2. ATD adjustable tape dipole antenna.
3. AT100 and RAT100 automatic antenna tuners.
4. TW5201 and RT5201 remote-control consoles.
5. TW9000 and RT9000 DATACOM message terminals.
6. TW5800 telephone coupler.
7. TW100PP portable power source.

Figure 5-1 is a detailed block diagram showing the TW100F and its family of optional accessory equipment. Connections are made via three connectors on the front panel of the transceiver. As can be seen from the figure, there are more audio accessories than there are available transceiver connectors. Therefore, if it is desired to attach more than one audio accessory to the rear panel, special cabling must be made up. Either Y-cables or junction boxes are generally used, with each installation being given special consideration.

5.2.1 ACCESSORY CONNECTIONS

J2 is the accessory connector used to provide control information to companion accessory equipment. The audio levels are 0 dBm and 600 ohms. Table 5-1 shows the pinouts for J2.

5.2.2 DC INPUT POWER CONNECTIONS

J4 is the accessory connector used to provide primary dc power to the TW100F from external power supplies, such as the TW100PP portable power source. Table 5-2 shows the pinouts for J4. Refer to Section 5.3 for more detailed information on the TW100PP.

5.2.3 RF OUTPUT CONNECTIONS

J12 is used for either a 50-ohm antenna or for an external antenna tuner such as the AT100 or RAT100. The following RF cables are used with Transworld antenna tuners:

1.	TW100F to AT100 RF cable	C991535
2.	TW100F to RAT100 RF cable	C991526

The antenna (ANT) connector can hook directly to an external long-wire antenna. In this case, the internal TW100F antenna tuner is used to match the antenna.

5.3 TW100PP PORTABLE POWER SOURCE

5.3.1 GENERAL

The TW100PP is a self-contained portable power source for use with the TW100 and RT100/MP series of transceivers. It is packaged in a rugged aluminum attache-type case matching the TW100F "flyaway" radio. The TW100PP contains a built-in battery charger which is switch selectable for 115 V/230-V 50- to 60-Hz operation. The charger is a constant-current type which uses a fast charge of 2.5 A, which results in a complete charge cycle of ten hours. A built-in timer automatically switches to a float charge of 50 mA at the completion of the charge cycle. A separate panel connector is provided for optional solar charging. The battery voltage is monitored by the panel voltmeter when the power switch is on.

5.3.2 OPERATIONAL CHARACTERISTICS

The TW100PP has been designed to operate any of the TW100 or RT100/MP range of transceivers. The battery life, for voice operation on a 1:9 transmit-receive duty cycle is 16 hours. Other accessories may be operated from the TW100PP with the appropriate reduction in battery life. The TW100PP will operate over an extended temperature range, and capacity is reduced to only 90 % at 0° C and 50 % at -30° C. The cells are vented for 50 PSI and may be safely operated at any altitude.

The TW100PP uses seven 25-Ah Gates energy cells as the power source. The U.S.-manufactured Gates energy cells overcome the limitations of normal lead-acid cells, yet retain the reliability, ruggedness, and long life of the lead-acid system. The cell is truly sealed—no acid, acid vapor or water loss—and incorporates recombination of gases within a starved electrolyte system. The cell is maintenance free and the special internal construction results in low impedance, low corrosion and long life. The overall system weight is comparable to nickel-cadmium batteries without the problems of "memory" effects or cell reversal.

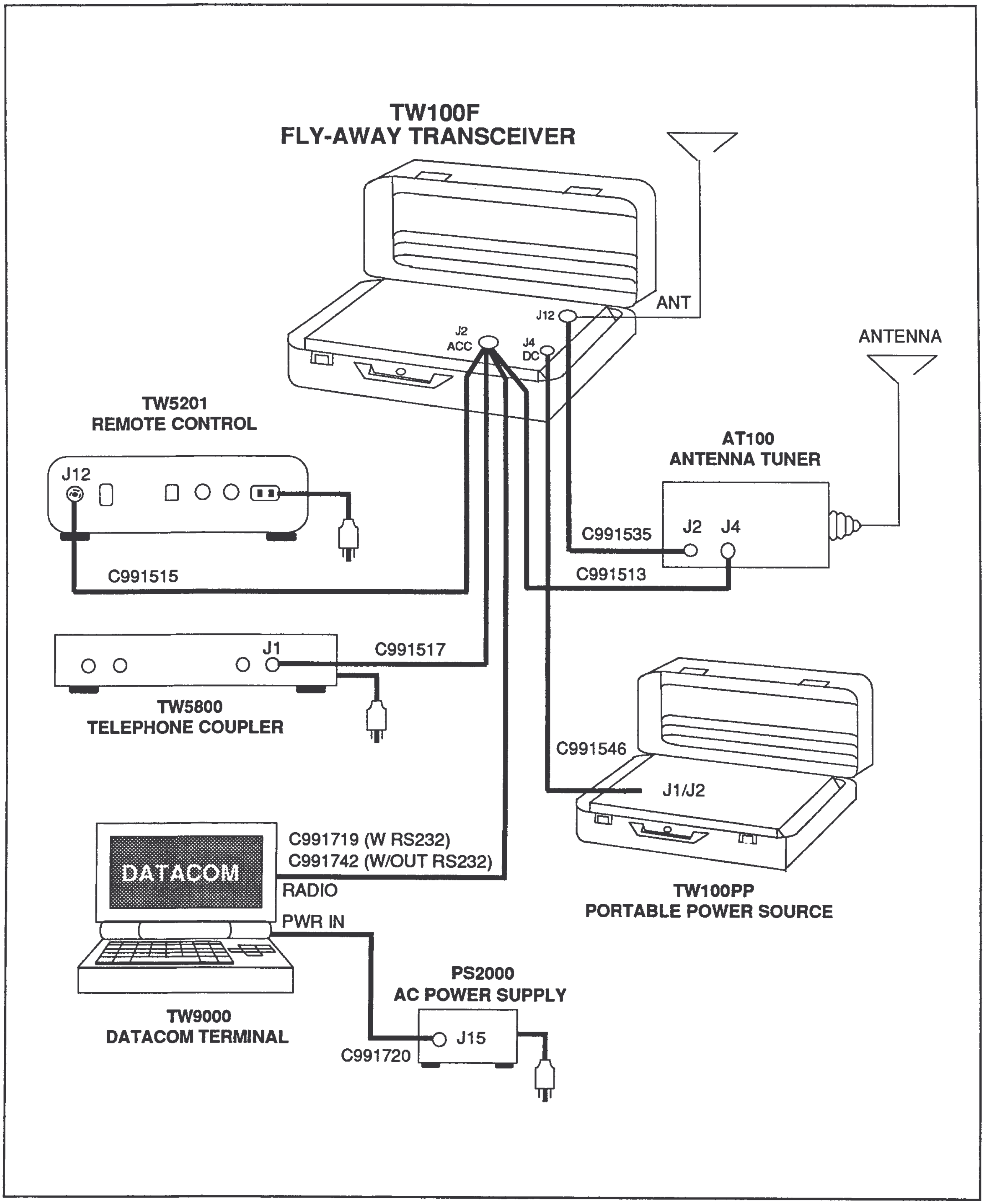


FIGURE 5-1.
TW100F Transceiver and Optional Accessories.

TABLE 5-1.
TW100F (J2) Connector Pin-outs and Accessory Equipment Connections.

Pins on TW100F (J2)	Description	Pins on AT100	Pins on RT/TW9000	Pins on TW5201	Pins on TW5800
A	Key	2	—	—	—
B	Ground	—	6	—	
C	TX Audio (0dBm)	—	7	—	3
D	RX Audio (Unsq)	—	10	—	2
E	PTT	—	9	—	4
F	+12 Vdc	4	—	—	5
G	ATU Initiate	3	—	—	—
H	Ground	1	8,11	1	1
I	RX Audio (remote)	—	3*	2	—
J	TX Audio (remote)	—	1*	3	—
K	ALC	—	—	—	—

* with RS-232

TABLE 5-2.
TW100F (J4) Connector Pin-outs and Accessory Equipment Connections.

Pins on TW100F (J4)	Description	Pins on TW100PP (J1/J2)
A	+14 Vdc	A
B	+14 Vdc	A
C	Ground	B
D	Ground	B

The cell also has excellent shock and vibration characteristics due to the packaging design which limits plate movement in any direction. Storage characteristics are also excellent as the cell may be stored for three years at room temperature and then recharged with no loss in cell reliability or performance capabilities.

Another feature of the TW100PP is that the cell discharge characteristic is relatively flat, which ensures that the overall supply voltage will not fall below 13.6 V until the battery is almost completely discharged. The transceivers are able to operate at full power output during the entire discharge cycle. Figure 5-2 is a plot of the supply voltage versus time for a discharge rate of C/20 (1.25 A average) which approximates typical transceiver operation.

5.3.3 OPERATION OF THE TW100PP

1. **Power-Supply Operation.** The transceiver to be powered should be connected to the TW100PP using the appropriate accessory power cable. The power cables necessary to connect the TW100PP to the TW100F, TW100, or RT100/MP transceivers, are as follows:

1.	TW100PP to TW100F	C991546
2.	TW100PP to TW100	C991545
3.	TW100PP to RT100/MP	C991543

Table 5-3 shows the pinouts for the dc output connectors J1 and J2.

The TW100PP has two monitors of terminal voltage—the front-panel meter, which is a direct indication of terminal voltage, and the "undervoltage" light, which will remain off as long as the battery cells are in the safe operating region. This light is set to go "on" when 100 % capacity has been removed from the cells. ***Discharging the cells after the light has come on will impair the ability of the cells to accept a charge.*** This voltage threshold is approximately 9.5 V. At this point the load should be disconnected from the TW100PP.

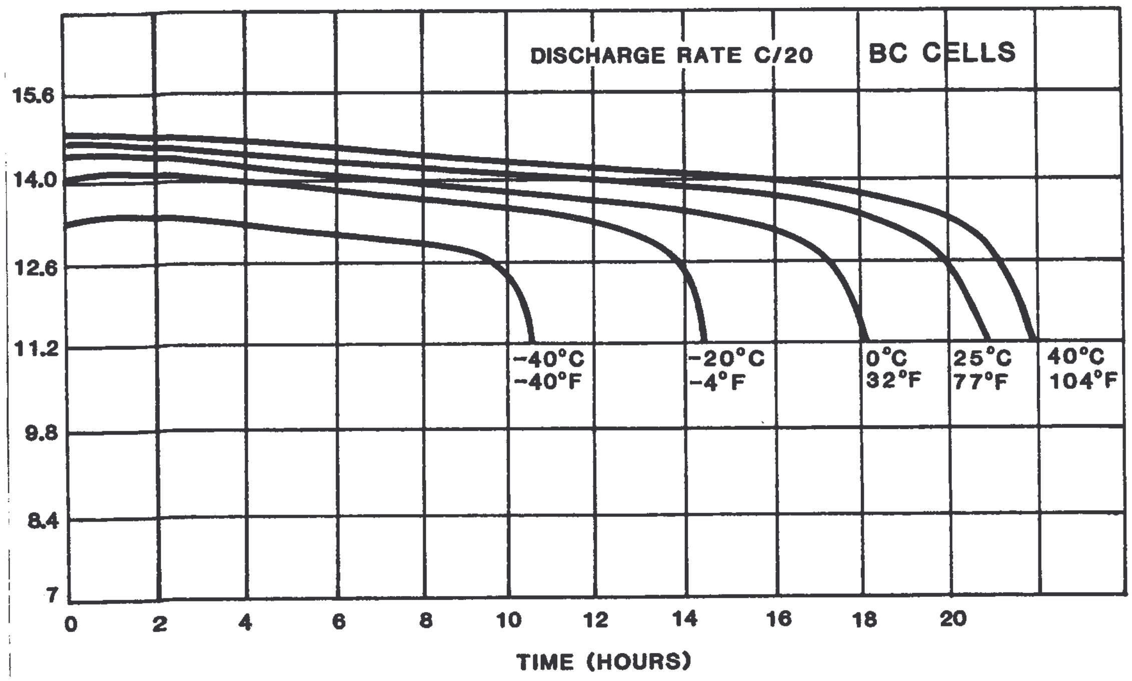


FIGURE 5-2.
Supply Voltage Versus Time.

An alternate procedure to follow if the voltage has dropped to 9.5 V and continued receiver operation is desired, is to plug in the charger part of the power source while keeping the radio connected. The charger has sufficient capability to both charge the battery cells and operate the receiver part of the radio for an indefinite period of time (or at least until the battery is fully charged again).

2. **Battery Charger Operation.** To operate the battery charger in the TW100PP, first select the proper ac voltage by the front-panel selector switch. Then plug the ac power cord into the mains and turn the front-panel switch to the "on" position. When the charger is operating in the "fast-charge," mode the charger light will be "on".

This mode is automatically activated whenever the charger is connected and the terminal battery voltage falls below 15.0 V. The "fast-charge" state will continue until the battery voltage reaches 19.5 V. At this point the charge will cycle between "high" rate and trickle until the batteries do not sag below 15 V. When the charge light goes out and stays out the batteries are fully recharged.

Figure 5-3 is a family of curves of cell voltage versus percent of previous discharge capacity returned for different charge rates. Note that a fast charge rate of 2.5 A corresponds to C/10; at this rate 19.5 V corresponds to 90-95 % of capacity returned.

The TW100PP uses a constant-current charger. Constant-current charging of a cell or battery is accomplished by the application of a nonvarying constant-current source. This charge method is especially effective when several cells are charged in series, since it tends to eliminate any charge imbalance in a battery. Constant-current charging charges all cells equally because it is independent of the charging voltage of each cell in the battery.

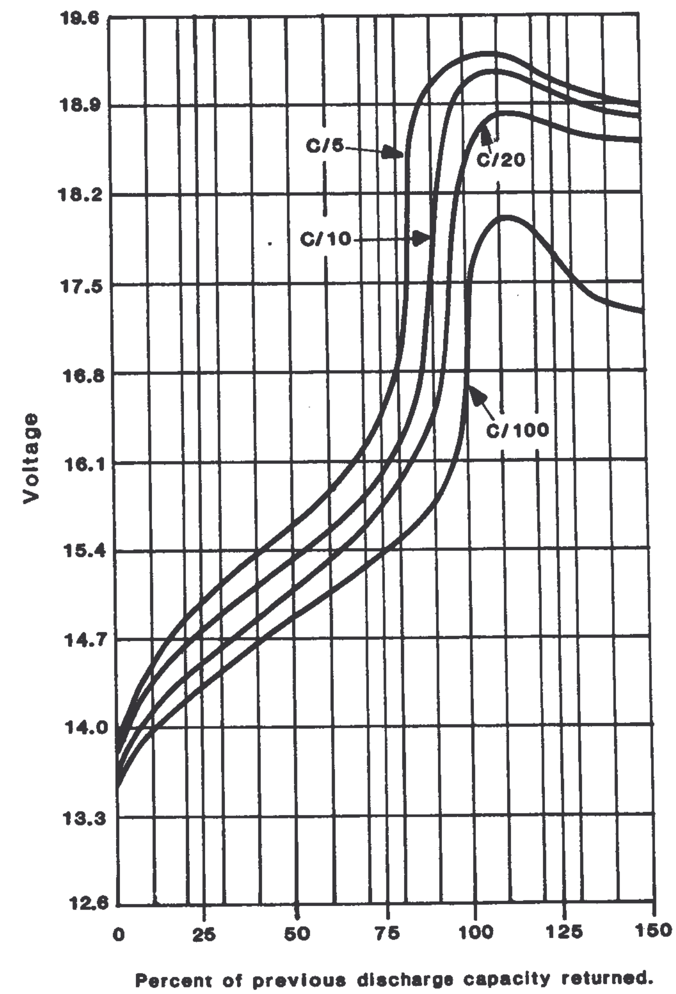
As shown by the curves at different charge rates, the voltage of the cell increases sharply as the full charge state is approached. This increase in voltage is caused by the plates going into overcharge when the majority of the active material on the plates has been converted from lead sulfate to lead on the negative plate and lead dioxide on the positive plate. The voltage increase will occur at lower states of charge when the cell is being charged at higher rates. This is because at the higher constant-current rates the charging efficiency is reduced.

While constant-current charging is an efficient method of charging, continued application at rates above C/500, after the cell is fully charged, can be detrimental to the life of the cell. At overnight charge rates (C/10 to C/20), the large

TABLE 5-3.
TW100PP (J1,J2) Connector Pin-outs and Transceiver Connections.

Pins on TW100PP (J1/J2)	Description	Pins on TW100F (J4)	Pins on TW100 (J6)	Pins on RT100/MP (J4)
A	+14 Vdc	A,B	A	A
B	Ground	C,D	B	B

increase in voltage at the nearly fully charged state is a useful indicator for terminating or reducing the rates for a constant-current charger. If the rate is reduced to C/500, the cell can be left connected continuously and give 8 to 10 years' life at 25° C. The trickle charge rate of the power source at 50 mA represents a C/500 rate. Refer to the TW100PP manual for a technical description of the portable power source.



Voltage curves for cells charged at various constant (current) rates at room temperature.

FIGURE 5-3.
Cell Voltage Versus Percent of Previous Discharge Capacity Returned.

SECTION 6
MODE SELECTION

6.1 INTRODUCTION

A microprocessor is used to control the overall frequency selection of the transceiver. The processor operates in any one of three different modes, which depend on the class of operation desired. The operational mode may be selected by an internal switch or may be permanently set by use of a special coding circuit.

Mode 1: All facilities, including the programming of transmit frequencies, are available in this mode. The operator may select any one of the preprogrammed channel frequencies by entering the channel number on the keypad; this number is shown on the display in receive. In transmit, the display switches and shows the frequency being used in transmit mode. Channel 00 is available for free tuning the transceiver; either simplex frequencies or duplex (separate receive and transmit) frequencies may be programmed.

In order to select Mode 1, insert the appropriate 8-position DIP switch in the M9 board at reference designation U17. Turn positions 2 and 3 ON and all other positions OFF on the DIP switch.

Mode 2: Channel frequencies cannot be changed in Mode 2. All pre-programmed channels may be selected as in Mode 1, and the display operates in the same manner. Channel 00 is only available for free tuning the receiver and will not operate in transmit.

To select Mode 2, first make sure the 8-position DIP switch is inserted in M9-U17. Then turn position 2 ON and all others OFF on the DIP switch. An alternate method of selecting Mode 2 is to insert the special coding device (included in shipment) into the M9-U17 socket in place of the DIP switch.

Mode 3: In this mode the transceiver operates as a channelized transceiver with permanently programmed channels. Only the channel number can be displayed. Channel 00 is not available for either receive or transmit operation.

To select Mode 3, first make sure the DIP switch is inserted in M9-U17. Then turn all switch positions OFF. An alternate method is to remove the DIP switch and leave the M9-U17 socket empty.

SECTION 7
FREQUENCY CALIBRATION & ALIGNMENT

7.1 INTRODUCTION

The transceiver uses broadband circuitry, and no routine tuning or alignment is required. If the transceiver is programmed for new channel frequencies, it is only necessary to reprogram the memory as described in Section 3. Normally the only adjustment required will be the frequency calibration, which will gradually change as the crystal in the master oscillator ages.

7.2 FREQUENCY CALIBRATION

The transceiver uses one temperature-controlled master oscillator to control both synthesizers. This means that only one adjustment is required for all channel frequencies. The adjustment procedure requires the use of an accurate frequency counter.

1. Connect the frequency counter to the output of the transceiver through an attenuator.
2. Turn on the transceiver to the highest channel frequency and wait for 10 minutes so that thermal stability is reached.
3. Turn the mode switch to AM and press the PTT switch.
4. Adjust the piston trimmer C21 (accessible through the hole in the top cover of Module 5), until the counter reads the exact channel frequency.
5. This completes the calibration procedure.

In an emergency, it is possible to calibrate the transceiver by programming one of the channels to receive a frequency standard, such as WWV. If there is any beat note present, the transceiver requires calibration. Turn the clarifier to "OFF." Turn up the volume and adjust C21 on module 5 to zero beat. It will be difficult to hear the low-frequency beat because the carrier frequency is suppressed by the IF filter. It is possible to hear the beat against the reference tone and as a roughness on the voice modulation. With careful adjustment, it is possible to calibrate the transceiver within at least 10 Hz.

7.3 ALIGNMENT POINTS

Refer to Table 7-1.

TABLE 7-1. Alignment Points.

ADJUSTMENT		FUNCTION	COMMENT
Module #1	R59	Frequency adjust 1650 kHz.	Refer to Section carrier oscillator 7.2.
	R18	Squelch sensitivity.	Adjust for reliable squelch opening on weak signals (Section 10.1.6.3).
	R44	Transmit carrier balance.	Adjust for carrier balance (Section 10.1.6.2).
Module #2	L3	IF tuning.*	Adjust for maximum receive output.
	L4	IF tuning.*	Adjust for maximum receive output.
	L1,L2	Crystal-filter tuning USB.*	Fixed - refer to Section 10.2.
	L5,L6	Crystal-filter tuning LSB.*	Fixed - refer to Section 10.2.
	R2	Transmit gain.	Adjust level until ALC is operating. Place meter (5 V scale) on pin 10 and increase gain until ALC drops 1 V on voice peaks.
Module #3	R1	Carrier level.	Adjust in AM for 25-W output.
	R8	Transmit mixer balance.*	Refer to Section 10.3.
	L3	Transmit 75-MHz tuning.	Adjust for maximum transmit output.
	L4	Receive 75-MHz input tuning.*	Adjust for maximum receive output.
	L6	Receive 75-MHz mixer tuning.*	Adjust for maximum receive output.
	L7	Receive 1650-kHz output.	Adjusted for 50-ohm match to M2 filters.
Module #4	L2	75 MHz filter matching.*	Fixed - refer to Section 10.4.
	L3	75 MHz filter matching.*	Fixed - refer to Section 10.4.
Module #5	C21	Frequency calibrate.	Refer to Section 7.2.
	L1	VCXO tuning range.*	Fixed - refer to Section 10.5.
Module #7	R16	ALC threshold - sets power output.	Adjust to prevent peak flattening - refer to Section 10.7.
	R31	Adjusts S-meter sensitivity.	Adjust so that meter reads midscale for 100-µV input signal.
***Adjustment not normally required during service life of transceiver.**			

SECTION 8
SERVICE & MAINTENANCE

8.1 SCOPE
This section contains information on the routine maintenance of the transceiver, the methods for replacing modules and components, methods for locating defective modules and a description of the recommended test equipment. For in-depth information on the individual modules, reference should be made to Section 10 of this manual.

8.2 GENERAL
The transceiver is a complex design using advanced techniques to ensure high-performance, trouble-free service. It is essential to recognize that the transceiver must be serviced by skilled personnel using the correct test equipment and with a full understanding of the operation of the transceiver. Two separate levels of service are recommended—field service and depot service. The transceiver has been constructed so that the complex circuitry is contained on individual modules that may be easily replaced in the field. This section of the manual gives instructions on how to locate the defective module. The modules are designed so that no adjustments will be required after replacement. Defective modules can be returned to the service depot or factory for repair.

8.3 TEST EQUIPMENT
Specific models of test equipment have been recommended for servicing the transceiver. A description of the key characteristics relevant to the transceiver is given for each instrument. It is important that substitute test equipment provide equivalent functions. Attempts to use obsolete test equipment will make satisfactory service very difficult.

The test equipment is required to have the following minimum characteristics:

Signal Generator—The frequencies required are 1.6-30 MHz and 75-105 MHz.

Frequency Calibration—1 kHz with high stability.

Output—0.1 μ V to 1 V with accurate attenuator.

AM modulation is desirable and FM modulation ±15 kHz from external source is required for crystal-filter alignment.

RF Millivoltmeter—Frequency coverage 1.6-200 MHz, low-capacitance probe, 50-ohm adaptor, 10-mV to 3-V peak-reading RMS calibration.

Electronic Multimeter—Any general purpose instrument with 11-megohm minimum input impedance.

Oscilloscope—Any general-purpose oscilloscope with frequency response to 75 MHz; must have external sawtooth output for sweep tests. (Most oscilloscopes can be simply modified to provide this output.)

Attenuator—This attenuator is used as a dummy load and must have an adequate power rating. The attenuator should

TABLE 8-1.
Test Equipment.

DESCRIPTION	MODEL RECOMMENDED
Synthesized Signal Generator	Wavetek 3001
RF Millivoltmeter	Boonton 92C
50-ohm adaptor	Boonton 91-8B
Electronic Multimeter	B & K Model 290
Oscilloscope	Tektronix Model 2213
100-W 30-dB 50-Ω Attenuator	Bird Model 8323
Frequency Counter	Hewlett-Packard Model 5382A
Audio Signal Generator	B & K Model 3010
Thruline Wattmeter	Bird Model 43
Element 50 W	Bird Model 50H
Element 250 W	Bird Model 250H
Power Supply	TRANSWORLD UPS100-12
Return Loss Bridge	Eagle Model RLB 5011
Optional—Spectrum Analyzer	Hewlett-Packard Model 8557A/182T

be accurately calibrated with a correction chart. (An error of 1 dB = +26 W relative to 100 W.)

Frequency Counter—Any general-purpose counter 1.6-105 MHz minimum calibrated accuracy 1 ppm.

Audio Signal Generator—This is not a critical instrument. Any audio generator covering 300-3000 Hz at relatively low distortion (±1 %) will meet this requirement.

Thruline Wattmeter—Used for VSWR checks and as a backup for transmit power measurements. Most instruments will be suitable unless extreme accuracy of power measurements is essential.

Power Supply—Any 13.7- to 14.0-V 20-A power supply will be suitable.

Return-Loss Bridge—This instrument is used with the signal generator to measure the RF-output-filter return loss and is unlikely to be required during routine servicing. The bridge is recommended as a very useful instrument, as accurate measurements of antennas and adjustment of antenna tuners can be accomplished using low power levels or the signal generator. A return loss of 30 dB from 1.6-30 MHz is adequate.

Spectrum Analyzer—This is a useful optional instrument and will be required for measurements of spectral purity. Almost any spectrum analyzer covering the range 1-100 MHz will be useful. The suggested HP8557A is a simple-to-use, versatile instrument that will be of value for both SSB and VHF equipment service.

8.4 MEASUREMENT TECHNIQUES

The following information will be helpful to technicians and engineers who have not had previous experience in testing modern synthesized SSB equipment. Some of the techniques have been developed to simplify measurements and adjustments. Frequently the use of specialized test equipment can be avoided.

8.4.1 POWER MEASUREMENT

Measuring the power output of an SSB transceiver creates more difficulty than the measurement of almost any other performance parameter. A typical problem occurs when an inexperienced technician connects an average-reading power meter such as the Bird Model 43 and talks into the microphone. The power meter kicks up to perhaps 30 W on peaks, and the immediate assumption is that there is a defect in the equipment.

The transceiver is rated at 125-W PEP or 100-W average power output and is capable of 150-W PEP output over much of the range. This means that on a continuous carrier or a sustained audio tone, the power output will be 100 W and will indicate 100 W on an average-reading wattmeter. This can be verified with a steady whistle into the microphone. The SSB voice waveform is an RF waveform changing frequency and amplitude at an audio rate, although the waveform is not a replica of the audio input. If the transceiver is correctly adjusted, the peaks in the RF waveform will reach the same amplitude as the 100-W steady carrier. This is called peak envelope power (PEP). The average-reading wattmeter will show a low reading. The exact reading will depend on the characteristics of the instrument used. The usual method of measuring an SSB signal is to use a two-tone test signal. The two equal amplitude tones produce an RF carrier with an envelope at the difference frequency between the tones. Two equal 31.25-W signals have a PEP of 125 W and will indicate 62.5 W on an average-reading power meter such as the Hewlett-Packard Model 432A. The more frequently used diode-type instruments such as the Bird Model 43 will indicate 50.6 W for a 125-W PEP (two tone).

One of the easiest methods of measuring PEP is to use an oscilloscope which is a peak-reading instrument. To measure 125-W PEP, use any accurate wattmeter to set the transceiver output at 125-W average using a steady carrier or single tone. Use this signal to calibrate the oscilloscope. 125-W PEP will now be indicated by the oscilloscope on any signal—voice—two tone—pulse etc., whenever the peak amplitude is the same as the single tone signal.

The power output of an SSB transceiver can change quite widely without any perceptible change in performance. It is normally necessary to change the power output by a factor of 2:1 to make even the smallest noticeable change in signal strength. Far too much emphasis is put on getting the last few watts out of the transmitter. It is much more important to ensure that the final amplifier is not over driven, which causes distortion and interference on adjacent channels. We recommend use of the oscilloscope as the main power-measuring instrument. Check at all times that there is no peak flattening or compression on voice peaks or the two-tone test signal. If a power meter such as the Bird 43C is used, check the power output while whistling into the microphone. If the meter is accurate, you will see 100 W indicated. More accurate measurement will require the use of a laboratory-type power meter such as the HP 432A and a calibrated attenuator. Figure 8-1 illustrates the power measurements equipment setups.

To simplifiy adjustments, the ALC characteristics have been adjusted in the transceiver so that all adjustments of power output have been made on a single tone signal. If the power output is set at 100 W AVG on a single tone, the two-tone PEP output will be very close to 125 W.

8.4.2 TWO-TONE TEST

The standard method of measuring the performance of an SSB transmitter is to use a two-tone audio test signal. A special two-tone test generator may be used, or two standard audio signal generators may be combined. The tones may be anywhere within the audio passband. Suggested frequencies are 800 Hz and 1800 Hz. The RF envelope of the two-tone test signal is shown in the diagram, Figure 8-3.

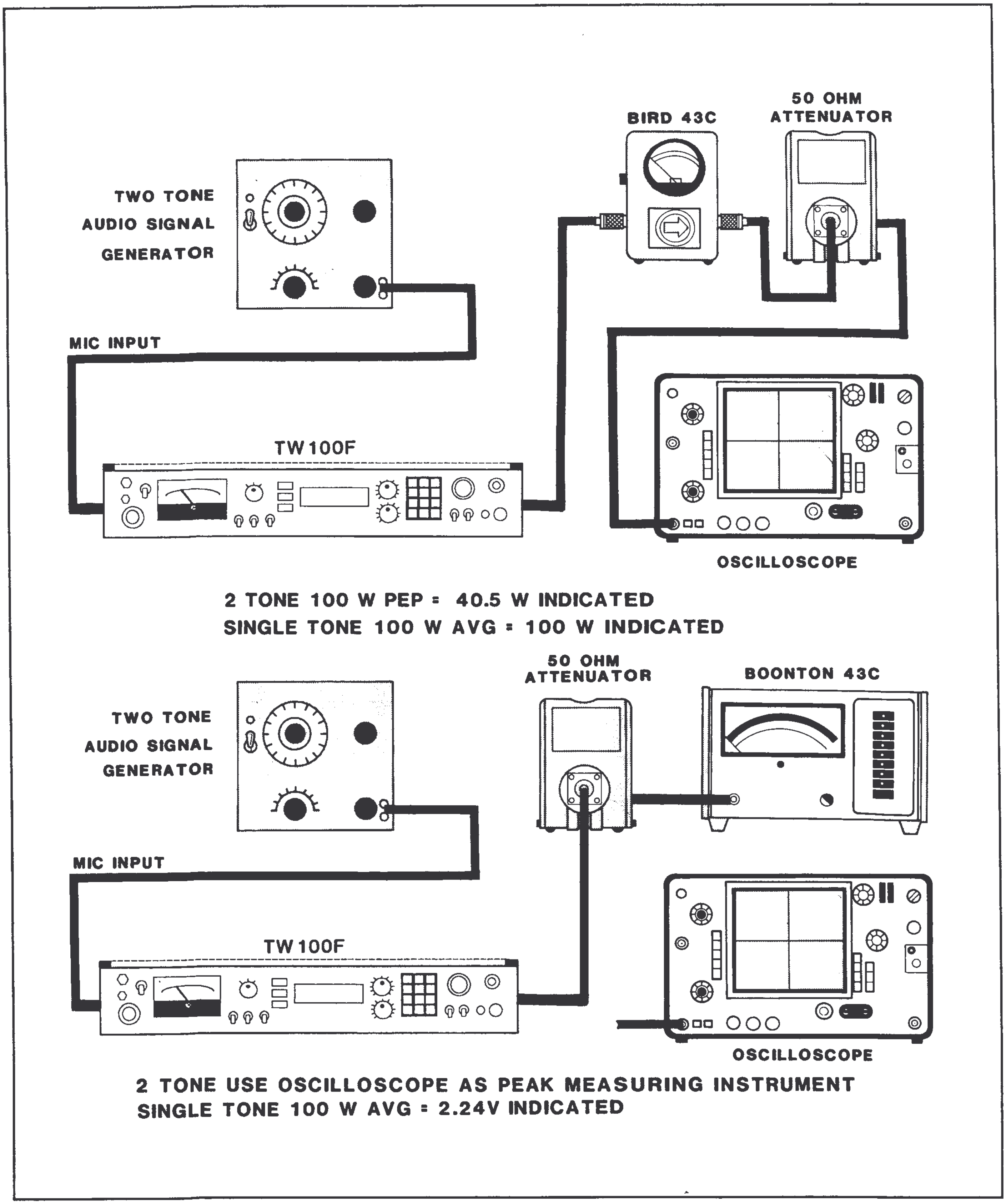


FIGURE 8-1.
Power Measurements.

If only one audio oscillator is available, it is possible to use the carrier oscillator to provide one of the frequencies. The transceiver mode switch is turned to the AM/tune position. A single audio tone (1000 Hz) is injected at the microphone input. Adjust the tone levels until the two signals are balanced, which results in a two-tone RF envelope. If the carrier level is set at 25 W, the resultant two-tone RF signal will be 100-W PEP.

A third method of generating a two-tone test signal is to use two RF tones. This method is particularly useful when measuring distortion with a spectrum analyzer. The two tones can be separated by several kilohertz and the two-tone test pattern examined at comparatively low resolution and high sweep speed. A simple two-tone RF generator can be made using a double-balanced mixer as shown in Figure 8-4.

Two-tone test signals are usually used to measure distortion. It is necessary to have a modulated RF envelope to observe crossover distortion or peak flattening on the signal when examined on an oscilloscope. It is possible to substitute a three-tone test signal for many tests, as distortion can be easily recognized on the three-tone signal displayed on the oscilloscope. The signal generator provides a convenient three-tone test source when operated with 100-% AM modulation. For most routine servicing, the AM-modulated signal generator and the oscilloscope will be far more convenient to use as a test signal source than a two-tone test signal.

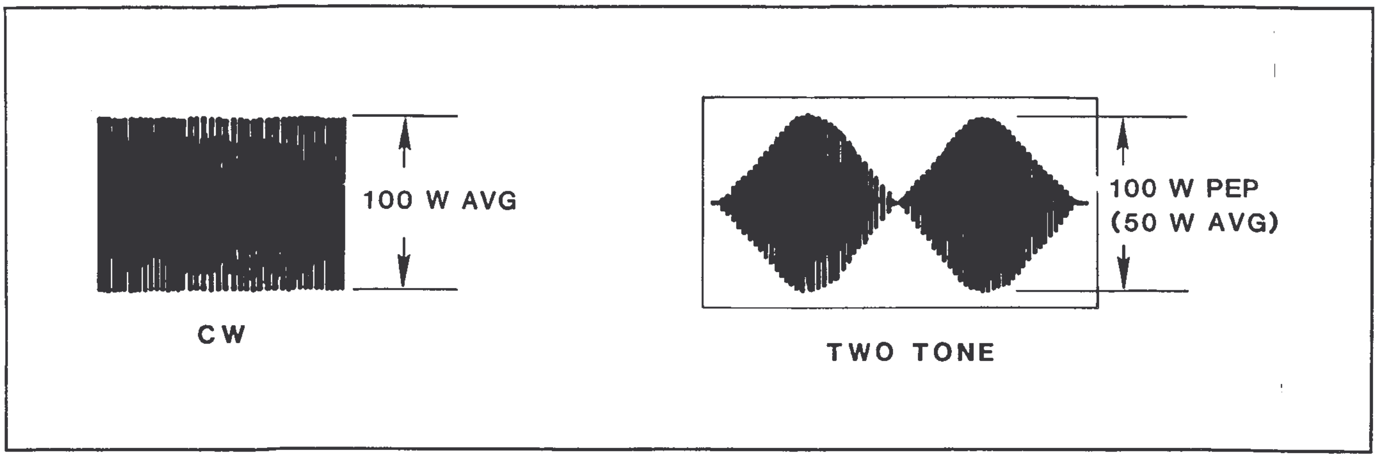


FIGURE 8-2.
Power Measurement Waveforms.

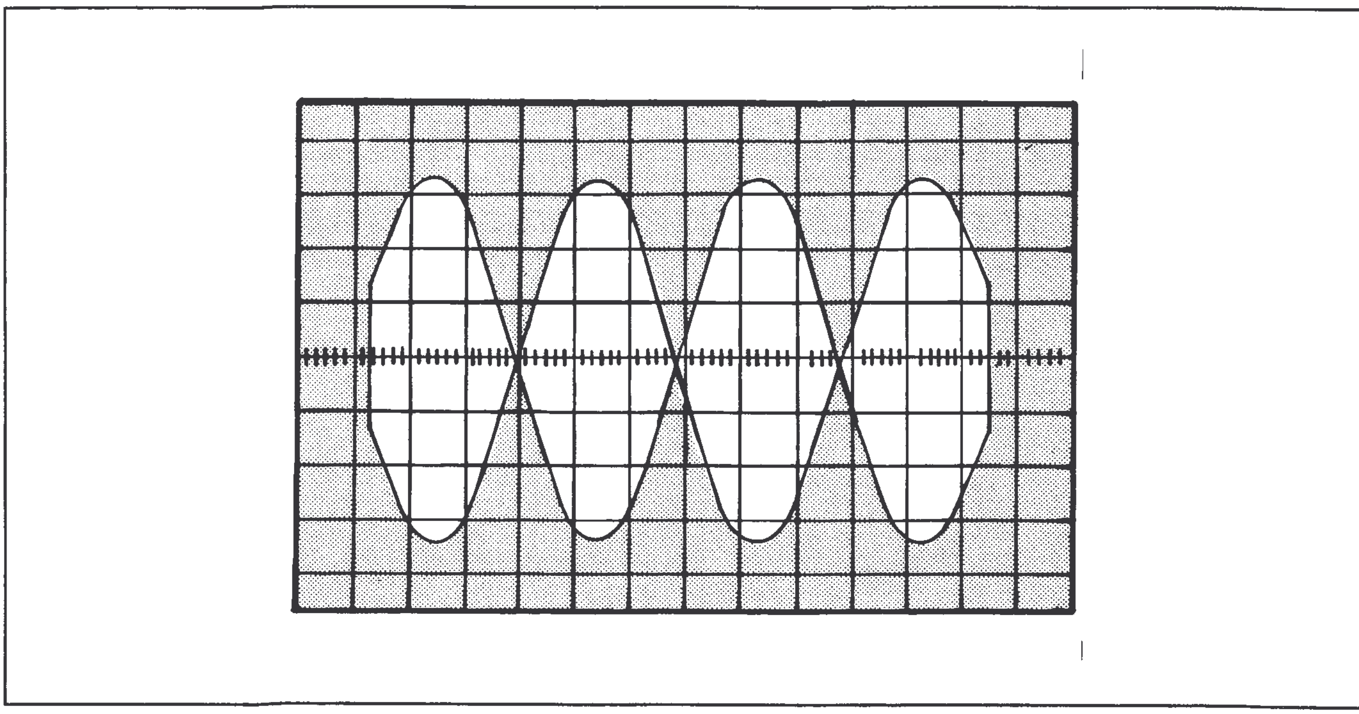


FIGURE 8-3.
Two-Tone Test Signal.

8.4.3 RETURN-LOSS BRIDGE

The return-loss bridge will seldom be required for servicing the transceiver. It is necessary for aligning the RF filters in the transceiver, but this adjustment is only required if damage occurs in the filter module. The use of the return-loss bridge for filter alignment is described in Section 10.7.7. The return-loss bridge is an extremely useful instrument for adjusting antennas and tuners. It is possible to make all adjustments at very low power levels with complete freedom from spurious responses, interference and high voltages in the antenna tuner. The signal generator substitutes for the transmitter, and the return-loss bridge and RF millivoltmeter substitute for the VSWR indicator. The instruments are connected as shown in Figure 8-5.

The test procedure is to adjust the signal generator to the desired frequency. Remove the load and adjust the millivoltmeter sensitivity and signal generator output for a full-scale deflection. Reconnect the load and adjust to the antenna or tuner for minimum reflected signal. The reflected power should be read in dB relative to the full scale reading.

-10 dB = SWR is less than 2:1
-14 dB = SWR is less than 1.5:1
-18 dB = SWR is less than 1.3:1
-27 dB = SWR is less than 1.1:1

The antenna or tuner should always be adjusted for a minimum return loss of 10 dB and preferably 14-20 dB. There is no significant advantage in striving for better than -20 dB return loss.

8.4.4 SPECTRUM ANALYZER

Although a spectrum analyzer is not an essential test instrument for servicing the transceiver, it is a useful instrument for testing SSB equipment. The spectrum analyzer operates in the frequency domain and permits simultaneous examination of both frequency and amplitude. This characteristic is very useful for examining the various RF signals for spectral purity and spurious products. For example, the output from either of the two phase-locked loops in the transceiver can be examined to ensure that the loops are locking correctly, the phase noise is satisfactory and there are no spurious outputs. The spectrum analyzer may be connected, through the high-power attenuator, to the transceiver output and will display harmonics and unwanted spurious outputs. If a two-tone test signal is used, the transmitter intermodulation distortion may be measured. It is very important not to overload the spectrum analyzer when making harmonic measurements. If the input level is too high, the mixer in the spectrum analyzer will generate harmonics internally. Over most of the range, the transceiver's harmonic suppression is more than 70 dB. To make accurate measurements, it is necessary to use a notch filter to reduce the amplitude of the fundamental by at least 20 dB. Remember that almost all errors made during harmonic measurements will result in the harmonic levels appearing to increase.

When the transmitter intermodulation distortion is measured, using two audio tones applied to the microphone input, it is necessary to use a high-resolution spectrum analyzer operated at a very slow scan rate. The HP8557A does not have sufficient resolution for this test. It is suggested that two RF tones, separated by approximately 20 kHz, be used for distortion measurements. The test arrangement, using the double-balanced mixer described in the previous section, may be used. When modulated with a 10-kHz tone, a low-distortion test signal will be generated with a tone separation of 20 kHz. This can easily be examined on the HP8557A and other analyzers with approximately 1-kHz resolution. It is possible to use a comparatively fast sweep rate which gives a continuous display instead of waiting several seconds for

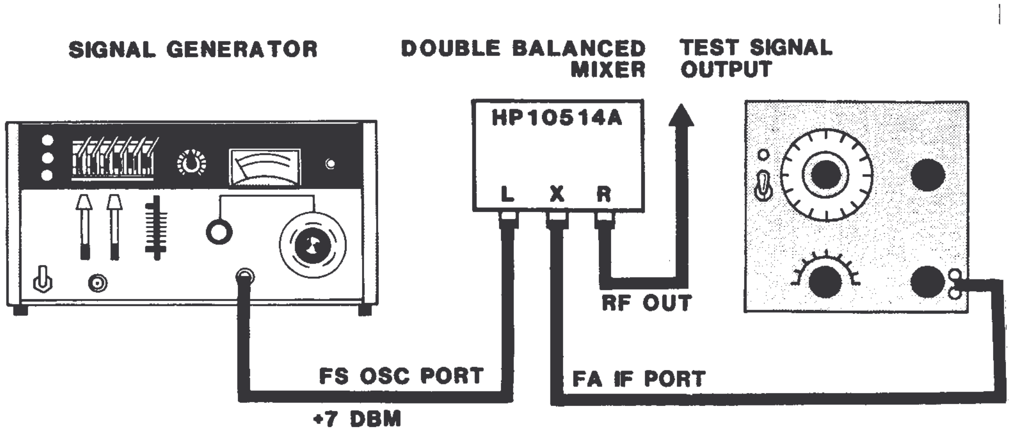


FIGURE 8-4.
Two-Tone RF Generator.

each sweep. Our tests have shown exact correlation between the wideband intermodulation test and those made with limited tone separation.

8.4.5 SIGNAL GENERATOR

The signal generator is primarily considered as an instrument for testing the receiver. It is also a most convenient instrument for injecting controlled signals of known frequency and amplitude into different parts of the transceiver. For example, the signal generator may be used as a temporary substitute for either of the synthesizer loops. The generator may be used at low level to substitute for the output from the audio module at 1650 kHz, or at high level, it is capable of directly driving the high-power RF amplifier. Use the modulated output of the generator so that the linearity can be examined on the oscilloscope. Remember that the signal generator can substitute for the signal outputs from the six main modules in the transceiver and provides a powerful tool in locating faulty modules.

8.4.6 SWEEP MEASUREMENTS

The only practical method of aligning the high-performance 1650-kHz crystal filters is to use a sweep generator. Most commercial sweep generators do not operate satisfactorily at the very narrow deviation required for crystal filter alignment. A signal generator with FM capability and an external modulation input makes an excellent narrowband sweep generator. The sawtooth output from the oscilloscope is connected to the external FM modulation input, and the amplitude is adjusted until the correct sweep width is achieved. The signal generator is connected to the input, of the module and the oscilloscope to the output. When the sweep rate is correctly adjusted (a very slow sweep is essential to prevent ringing and passband distortion) the filter passband will be displayed on the oscilloscope. In the event that the oscilloscope does not have an external otuput, it is usually possible to install a high-resistance voltage divider across one of the X deflection plates to provide a sawtooth voltage of the correct amplitude for the signal generator audio input.

8.4.7 FREQUENCY COUNTER

Apart from the important function of frequency calibration, the frequency counter is a useful tool for servicing the synthesizer. By connecting the counter to different points in the circuitry, it is possible to check that the correct divide ratios are occurring in the synthesizer.

8.4.8 HIGH-POWER ATTENUATOR

A high-power attenuator such as the Bird 8323 is a dummy load capable of dissipating the full power output of the transmitter and at the same time attenuating the signal by 30 dB. This means a 100-W signal is reduced to 100 mW, a level low enough to provide direct connection to most test instruments. High-power RF signals frequently cause disturbances and inaccurate measurements with instruments such as spectrum analyzers, frequency counters and oscilloscopes. The ability to make a 50-ohm direct connection will be found invaluable for many tests.

8.5 ROUTINE MAINTENANCE

The transceiver normally requires no periodic maintenance except to check the calibration of the master oscillator. This procedure is described in Section 7.2. It is often convenient to program an unused channel to a known frequency standard such as WWV. This will enable the operator to make regular checks of the frequency calibration.

The exterior of the transceiver should be kept clean by wiping with a damp cloth and polishing with a soft dry cloth. Make sure that all of the knobs are secure and the

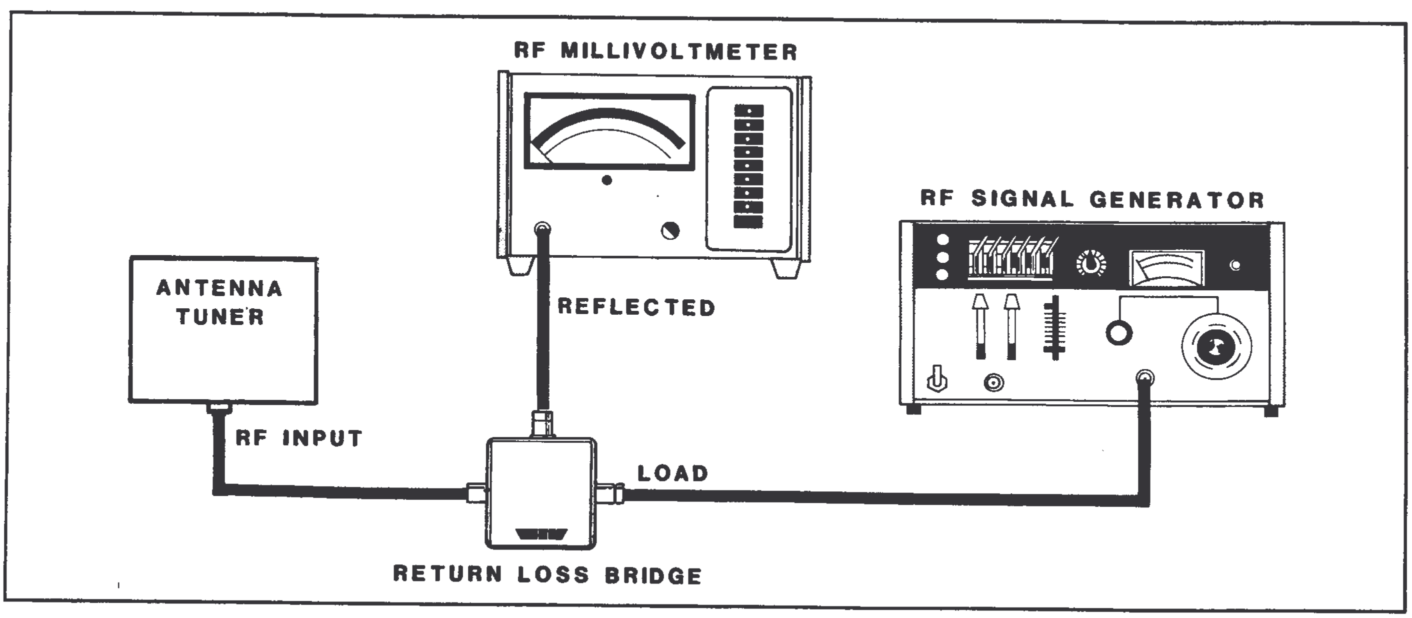


FIGURE 8-5.
Return-Loss-Bridge Set Up.

connectors are firmly in place. When the transceiver is opened, make sure that the coaxial connectors are tight and the module connectors are firmly in place. If the small pin connectors are removed, it is advisable to tighten the spring contacts by squeezing with a pair of pliers before replacement. Remove any dirt or dust using compressed air.

8.6 ACCESS AND MODULE REPLACEMENT

8.6.1 GENERAL INFORMATION

Modules 1 through 6, antenna-tuner components, and control-panel components are accessible while the transceiver is installed in the suitcase. However, service access to the transceiver is generally facilitated by the removal of the transceiver from the suitcase. This is accomplished by loosening the four wingnuts which secure the transceiver to the shock mounts in the corners of the suitcase, and lifting the transceiver out of the suitcase.

Modules M7, M8, M9 and M10 are accessible after the removal of the bottom panel, which is secured by 14 screws.

Power-supply components are accessible after removal of the antenna-tuner panel.

CAUTION!

If the transceiver is fitted with an ac power supply, the full main supply voltage is present at the transformer primary, input connector, input voltage selector switch, fuse holder, and front-panel power switch. It is recommended that an external dc power supply be used when servicing the transceiver. When the transmitter is operating, high RF voltages are present on the modules M7 and M10. Use caution as these RF voltages can cause burns.

8.6.2 MODULE REPLACEMENT M1-M6

Remove the upper left panel which displays the operating instructions (retained by seven screws). Modules M1-M6 are housed in die-cast boxes and are arranged in two layers with modules M1, M2 and M5 on the top layer. Adjustments to these may be made without removing the modules from the transceiver.

The bottom layer consists of modules M3, M4 and M6 (See Figure 8-6). Access to the bottom layer and the removal of any of the modules M1 through M6 require that the cluster of six modules be lifted clear of the transceiver frame. This is accomplished by removing the six retaining screws located at the extreme corners of the three boxes in the upper layer. These are long round-head screws and are not to be confused with the flat-head screws which retain the module covers. The cluster of six modules may now be raised clear of the frame, constrained only by the wiring harness and flexible coax connectors.

The removal of the two flexible coax cables from M4 and the separation of harness plugs from the modules permit the entire cluster of modules to be moved to a work bench for module replacement.

Those semi-rigid coax links which connect to the module to be replaced are loosened by unscrewing the connectors with a 5/16-in. or 8-mm wrench.

NOTE

Special care is needed in removing and replacing the miniature coaxial connectors on the semirigid coaxial cable used in the transceiver. To safely remove any of the coaxial connectors, do the following:

1. Remove the lid of the particular module that the connector is attached to.

2. Two wrenches are necessary to properly unscrew the connector without stressing the bulkhead-mounted female: a 1/4" wrench should be held in place on the bulkhead-mounted female part inside the module can, while a 5/16-in wrench is used to turn the screw-on sleeve of the male cable connector.

3. Unscrew the male cable connector and pull free.

Attaching the cable connector also requires considerable care to insure that the center pin of the male cable connector mates properly with the bulkhead connector attached to the module box. It is possible to blindly push the connectors together and screw them tight with the center pin misaligned; it is easily bent and can be pushed off-center into the teflon insulating material, which causes either no contact or an intermittent contact. Therefore, whenever a connector is attached, ***make absolutely certain that the pin mates properly and is not bent off-center.***

During module replacement, it is important that the semi-rigid coax connectors be sufficiently tight, but care must be taken not to tighten them to the degree that the mating fitting in the module box is rotated, which could damage the internal connection. If the coax fitting in the box is loose, it should be tightened by removing the cover and tightening the fitting on the inside with a 1/4-in. wrench.

8.6.3 MODULE REPLACEMENT, M7

This module is removed by disconnecting all of the connectors. Remove the five mounting screws from the circuit board.

8.6.4 MODULE REPLACEMENT, M8

M8 is mounted on a bracket which is secured to the inside of the front of the frame by four screws. Removing these screws and disconnecting the four push-on leads permits the bracket and module to be removed through the bottom of the transceiver.

To remove the PC board and transistors from the bracket, unscrew the four mounting screws in each corner of the module. Remove the mounting hardware from the two

TAB-PACK transistors and take care not to lose the special shoulder washer and the insulator. When the module is replaced, take care to use thermal compound on the transistor flange. The insulator must be in place and the shoulder washer mounted so that there is no possibility of a short to the chassis. Tighten the transistor mounting screws securely so that there is a good thermal contact to the chassis.

8.6.5 MODULE REPLACEMENT, M9

This module is removed by disconnecting all of the connectors. Unscrew the five retaining screws.

8.6.6 MODULE REPLACEMENT, M10

The M10 RF power amplifier is mounted on a heat sink which is fastened to the front frame member. To facilitate removal of attaching wires and coax cables, the control panel is loosened by the removal of its six attaching screws, and the front frame member is released to pivot outward after removal of the six screws which retain this member to the side rails and fan housing cover.

Care should be taken in removing power connections and coaxial cables, with particular attention being given to soldered connections (see Section 8.6.7). Tag all wires to assure proper replacement.

After removing all of the connections, including those to the two thermostats which are located on the heat sink, the entire heat-sink/amplifier assembly may be withdrawn by removing the four screws which fasten the heat sink to the front frame member.

To replace the amplifier module, remove the eight screws retaining the power-output transistors (two each), the driver transistor (two), and the two bias regulator transistors (one each). Remove the mounting screws at the right corner of the board and one in the center. The entire module can then be removed from the heat sink.

When the replacement module is installed, make sure that a liberal coating of thermal compound is applied to the transistor mounting flanges. The old thermal compound should be cleaned from the heat sink using a solvent, such as isopropyl alcohol. Take special care to see that the insulators are in place under the bias transistors and that the shoulder washers are under the mounting screws. Make sure that the spacers are in place under the board at the five mounting screw positions. Do not tighten any of the screws until they are all installed and the transistors are checked to ensure that there is no strain on the mounting flanges. The board mounting screws should be tightened first, and then the bias transistor screws, and finally the power-transistor mounting screws. It is very important to ensure that there is no strain on the power-transistor mounting screws and that they are very tight. This ensures an excellent thermal contact to the heat sink. If these transistors are not making good thermal contact, they will fail almost immediately when drive is applied.

CAUTION!

If there is any strain on the power transistors when the mounting screws are tightened, the insulating header will crack, which destroys the transistor. This voids the warranty.

8.6.7 PIN CONNECTORS

Small pin contacts are used for connecting wires at various points throughout the transceiver. These pins have an excellent locking action and will require a firm pull for removal. Always grasp the body of the pin with a pair of pliers and pull directly vertical when removing the connectors. If the contact is moved from side to side to aid removal, it will weaken the spring tension in the contact. If this happens, squeeze the end of the contact back together using a pair of pliers. It is very important to ensure that the pins snap firmly in place when the contacts are reinstalled.

8.6.8.1 CONTROL-PANEL COMPONENT ACCESS

The control panel may be hinged outward on its harness after the removal of its six retaining screws: Additional movement may be provided by unsoldering the +13.6-V (red) leads at the connection to F1, and by unsoldering the -13.6-V (black) ground lead at the dc power connector.

8.6.8.2 ANTENNA-TUNER COMPONENT ACCESS

After removing the CAPACITANCE knob (5/64 hex key) and after removing the six attaching screws, the left side of the antenna-tuner panel is raised slightly to permit the separation of the coax connector located near the Z-MATCH switch. The right side of the panel is then raised sufficiently to permit separation of the two-pin speaker connector, which is mounted on the RF transformer backing board, and the separation of the RF slip connector from the variable-capacitor stator. The panel and components can then be removed from the transceiver.

8.7 COMPONENT REPLACEMENT

8.7.1 CIRCUIT BOARDS

The printed-circuit boards are heavy epoxy fiberglass with 2-oz. tinned copper foil meeting the applicable military specifications. Faults in the board are never likely to occur unless faulty repair work is done when replacing components. If the correct procedures are followed, it is possible to remove components many times without damage to the board. All integrated circuits are installed in sockets, which makes replacement very simple.

The correct tools must be used when replacing components. The soldering iron must have a small instrument-type tip about the same size as the pads on the circuit boards. Do not make the mistake of using a very small, low-temperature, instrument-type iron. The iron must have sufficient heat capacity to melt the solder quickly. Do not use an iron that must be held in place for several seconds to melt the solder.

The iron is used to melt the solder at the connection. The solder is removed with a desoldering tool. These tools

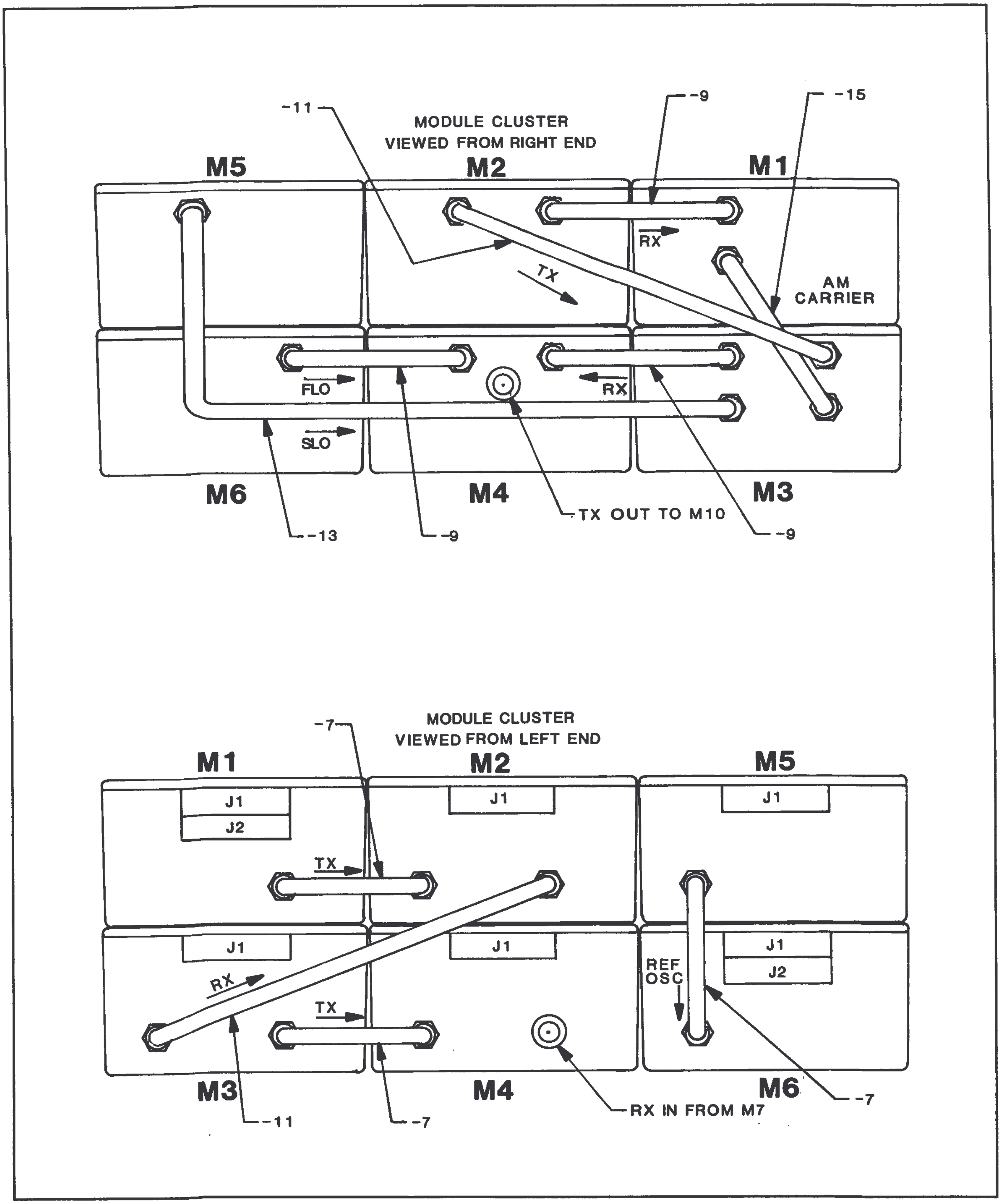


FIGURE 8-6.
Physical Arrangement of Modules M1 Through M6.

come in many forms, but even the simple type consisting of a suction pump with a teflon tip to remove the solder from the joint will be satisfactory. When the solder is molten, the tip of the tool is placed against the point and the suction draws the solder inside the tool. The component can then be removed by giving it a gentle tug after all the solder is removed from the leads.

Take special care not to exert any strain on the foil while removing the component. Nearly all damage to the printed-circuit boards occurs because strain is placed on the foil while the connection is hot. This is because the adhesive used between the fiberglass and copper foil forms an extremely strong bond when the foil is cold, but can be damaged fairly easily when the foil is at soldering temperature.

It is important to clear the holes of solder before installing the new component. This can be done by melting the solder and using a desoldering tool. A frequent cause of foil damage results from pushing the component through the hole and melting the solder at the same time. If the lead catches, it will frequently lift the foil from the board.

8.7.2 FINAL-AMPLIFIER TRANSISTORS

The transistors are secured by two #4 screws in the flange mount. Remove the screws and unsolder the leads to the transistors. If an assistant with an additional soldering iron can be found, it will be much easier to unsolder the leads from the circuit board. The replacement transistor leads should be trimmed to fit the board. The flange in the transistor must be coated with thermal compound to ensure good thermal contact to the heatsink. Do not let the transistor overheat when soldering the leads back in place. Use a large, hot soldering iron and heat the connection as quickly as possible. A small, low-temperature iron held in contact with the lead for several seconds would allow time for the heat to be conducted through the leads and damage the transistor. Damage caused by overheating will void transistor warranties.

NOTE

The transistors should always be operated in matched pairs. The dc beta is usually indicated by a color code on the case. If one transistor is replaced, use the same color code or replace with a matched set.

8.8 SEMICONDUCTOR SERVICING

8.8.1 GENERAL

There are two distinct classes of semiconductors used in the transceiver—the discrete devices such as the transistors and diodes, and the monolithic integrated circuits. Considerable information can be found about the operation of the transistors and diodes by measuring the voltage on the various electrodes. With integrated circuits, there is no external access to much of the circuitry, and it is necessary to use a "black-box" approach to servicing.

8.8.2 SIGNAL & SWITCHING DIODES

All of the diodes may be checked with an ohmmeter. They should show a low forward resistance and a very high back resistance. It is necessary to check the circuit before making any measurements, as the diode will frequently be shunted by other components, and one lead must be lifted before the measurement can be made. Many of the diodes used in the transceiver are used as switches or gates. If the diode is operating correctly, there will be a potential drop of approximately 0.7 V across the diode junction in the ON condition. The measurement of this voltage drop provides a good check on the diode operation.

8.8.3 VARICAP DIODES

The varicap diode is designed so that the capacitance across the reverse-biased junction varies as the voltage is changed. All diodes exhibit the varicap effect, and the BB809 varicap can also be checked in the same way as a signal diode.

8.8.4 DUAL-GATE MOSFET

The field-effect transistor has a closer analogy to a vacuum tube than bipolar transistors. The FET has high input and output impedances in the special case of the dual-gate FET. It can be considered similar to a cascode-tube circuit.

8.8.5 BIPOLAR TRANSISTORS

The simplest method of checking bipolar transistors is to consider the base-emitter and the base-collector junctions as two separate diodes. The ohmmeter is connected with one lead to the base and the other to the collector and then to the emitter. The ohmmeter leads are then reversed and the test repeated. The meter should indicate high resistance in one direction and a low resistance in the other. This check provides a positive indication of a faulty device. Only in rare instances will a transistor passing this test prove to be faulty in other ways. A transistor checker is not required for servicing the transceiver. A simple circuit check can be made with a VTVM. The potential across the base-emitter junction should be about 0.7 V. If the voltage gradient across the junction is substantially different from 0.7 V, there is a fault in the transistor or the circuit.

8.8.6 RF POWER TRANSISTORS

The RF power transistors may be checked with an ohmmeter measuring the base-emitter and base-collector junctions. Do not check the RF power transistors in a standard transistor tester. Low-frequency, low-current beta measurements are usually meaningless as indications of RF performance. Also, leakage measurements may be much higher than normal transistors.

8.8.7 INTEGRATED CIRCUITS

The complex internal circuitry in the IC makes it difficult to do any analytical fault finding in the device itself. The best approach to servicing IC's is to isolate the fault to a particular stage. The voltages should then be checked against the typical voltages shown in the charts. If there are any substantial voltage variations, check all of the circuit components. Finally, the IC may be checked by substitution.

8.9 GENERAL FAULT LOCATION - TABLE 8.2

It is possible for nontechnical personnel to deduce the reason for quite a number of faults without even opening the transceiver case. The general fault-location chart lists many of the faults that can be identified by the nature of the problem or the operation of the controls and indicators.

8.10 BASIC MODULE FAULT LOCATION - TABLE 8.3

This information will assist in locating faulty modules without the use of test equipment. This table provides only a basic guide, and some fault conditions cannot be recognized without test equipment. Use this procedure to try and determine the fault area. If this approach is not successful, the modules should be replaced systematically until the faulty module is located. Remember that some of the preliminary tests can indicate which modules are operational. For example, the two synthesizer modules M5 and M6 are used in both the receive and transmit modes. This means that they are not faulty if either the transmitter or receiver is operational.

Before replacing any modules, check all cables and connections carefully. A broken wire or a loose connector may prevent the module from operating. When modules (except M9) are replaced, it is not normally necessary to make any adjustments or to realign the transceiver. M9 is the program module and does not normally require replacement. If M9 is replaced, it is necessary to reprogram the channel frequencies.

With the exception of the RF power module, M10, all modules may be replaced using a wrench and a screwdriver. The correct procedure for replacing the modules is described in Section 8.6.

8.11 MODULE FAULT LOCATION - DETAILED PROCEDURE

8.11.1 INTRODUCTION

Section 8.10 covers fault location by deduction and simple procedures using no test equipment. This section gives more specific information on the methods for measuring the performance of each module. The procedure described does not require expert technical knowledge but is necessary to understand the operation of the test equipment. It is recommended that Section 8.11 be followed to locate the fault area and then to confirm the nature of the fault using the methods described. Reference should be made to Section 10 for information on the servicing and repair of the module.

The recommended procedure is to determine if the synthesizer is operating correctly, then to follow the path of the signal through the transceiver in either the transmit or receive mode.

8.11.2 POWER SUPPLIES & SWITCHING M7 AND M8

Before starting any service work, check that the power supply is operating correctly. The dc input voltage should be approximately 14 V. The output voltage from the regulator M8 should be 12 V. If the fuse on the regulator board has blown, check for short circuits. Remember that this regulator supplies external accessories and an external fault could be the reason for the fuse blowing. Measure that the voltage is 12 V on the R+ line in the receive mode. This will be indicated on the front panel. When the PTT line is closed, the voltage on the T+ line should rise to 12 V. If these conditions are not met, do not proceed further until M7 or M8 have been replaced or repaired.

8.11.3 SYNTHESIZER M5 AND M6

The synthesizer is used in the transmit and receive mode. If the transceiver is inoperational in both modes, check that the synthesizer is operating correctly. Amplitude and frequency data for both M5 and M6 are shown in Table 8-2.

NOTES:

1. The frequency should be stable (if the counter jumps more than 2 or 3 Hz between counts, there is a problem).

2. The master oscillator is contained in M5. If this fails, M6 will not operate. Check master oscillator at "Ref Out" M5. Counter should read 5120 kHz exactly.

TABLE 8-2.
M5, M6 Amplitude/Frequency Measurement.

	Method	Test Result
M5		
	Connect counter to "OSC OUT."	Frequency = 73.34-73.35 MHz.
	Connect millivoltmeter to "OSC OUT."	Output +3 dBm (0.3 V).
M6		
	Connect counter to "OSC OUT."	Frequency = signal frequency to nearest 10-kHz step.
	Connect millivoltmeter to "OSC OUT."	Output +10 dBm (0.7 V).

3. M6 contains 2 VCO's. If the synthesizer operates from 1.6-15 MHz, VCO #1 (Q1) is operational. VCO #2 (Q2) covers 15-30 MHz.

4. If the output frequency is stable but on the wrong frequency, the frequency module M9 is at fault or one of the control lines is not making contact.

5. The signal frequency is calculated as follows:

$F_{out(M6)} - F_{out(M5)} - 1.650 \text{ MHz} = F_{chan}$

NOTE

The approximate output frequency of M6 should be the channel frequency +75 MHz.

8.11.4 RECEIVER TEST

Initial procedure: Connect the signal generator to the antenna terminal. Adjust the frequency to the channel frequency +1 kHz for USB or -1 kHz for LSB. The procedure will trace signal through the receiver by measuring the output from each module in turn. The faulty module will have a lower output than specified. Use the millivoltmeter terminated with the 50-ohm load to make the measurements.

CAUTION!

Disconnect the microphone. If the transmitter is activated with the signal generator connected, severe damage could occur in the signal generator attenuator.

M7

This module has no active circuitry in the signal path, and the input signal should be attenuated by approximately 1 dB. Greater attenuation indicates defective coaxial connections from antenna input, defective antenna relay, incorrect filter selection or relay malfunction. Since the "RX-ANT" output connectors are pin contacts, it will be easier to make the measurements using the unterminated millivoltmeter probe. This will probably result in the output voltage reading high compared with the voltage at a correct termination.

M4

Input at antenna terminal
-25 dBm (130 mV)
Measure output at "RX OUT"
-20 dBm (22 mV) 75 MHz

M3

Input at antenna terminal
-35 dBm (4 mV)
Measure output at "RX OUT"
-10 dBm (70 mV) 1651 kHz

If this module shows no output, check that the AGC voltage at pin 10 is approximately 4 V. The AGC voltage is derived from M2 and a fault will make M3 appear defective.

M2

Input at antenna terminal
-85 dBm (130 μV)
Measure Output at "RX OUT"
-25 dBm (12 mV) 1651 kHz

M1

If there is 1651-kHz output from M2 and no audio output—M1, the loudspeaker or audio gain control are defective.

8.11.5 TRANSMITTER TEST

Initial procedure: Connect an audio signal generator to the microphone socket pin 3 and ground. Set the frequency to 1000 Hz and the level to 5 mV. Note the audio level is not particularly critical as the VOGAD (Voice Operated Gain Adjusting Device) will automatically set the microphone amplifier gain to the correct level. The antenna output of the transceiver is terminated in the 50-ohm load and wattmeter. Connect a ground to pin 4 of the microphone socket to operate the transmitter. The front-panel meter should indicate approximately full scale and the wattmeter indicate 100 W average (subject to measurement inaccuracies). If the power output is normal during this test and has not been satisfactory with the microphone, replace the microphone. Do remember the wattmeter will read approximately 30-40 W on voice peaks (125-W PEP). Use the millivoltmeter with the 50-ohm termination to measure the output of modules M1 through M4.

M1

Measure output at "TX OUT"
-25 dBm (12 mV) 1650 kHz (DSB)

M2

Measure output at "TX OUT"
-27 dBm to -13 dBm (-15 dBm, 40 mV nominal)
1651 kHz

If the output is not normal, check the AGC voltage. If it is not approximately 4 V, the ALC may be incorrectly set, which reduces the gain of M2. This could also be a defect in M8. Temporarily disconnect M2 ALC pin 9 and check if the gain and AGC voltage return to normal.

M3

Measure output at "TX OUT"
-14 dBm (45 mV) 75 MHz

M4

Measure output at "TX OUT"
Channel Freq + 1 kHz
+2 dBm (0.28 V) - 2 MHz; +8 dBm
(.55 V) - 15 MHz;
+16 dBm (1.4 V) - 30 MHz

M7

This module has no active circuitry in the signal path. A loss through M7 indicates wrong filter selection, incorrect operation of the T/R or filter-select relays, or a defective component in a filter.

M10

Measure the output of M10 using the wattmeter and 100-W load. It is normal for the output to be somewhat higher when measured before the filters. Do note that the ALC will be inoperational during this check and a low ALC setting or fault might make the operation of M10 appear abnormal.

NOTE

Before replacing the RF power module M10, verify that the fault is in this module. Disconnect the "TX-OUT" cable from M4 and then drive the module direct from the signal generator. The RF output should be within 2 dB of the specified figure. Do make sure that the correct RF filter is selected for this test. The ALC will not be operational.

RF INPUT LEVEL (CW):	0.3 V RMS 0.9 V RMS 2.0 V RMS
FREQUENCY OUTPUT:	2 MHz 15 MHz 30 MHz
POWER OUT (Average):	100 W 100 W 100 W

TABLE 8-3. Fault-Location Chart.

(This chart gives fault symptoms that can be isolated by observation of the transceiver operation).

SYMPTOM	POSSIBLE FAULT	ACTION
Display does not light.	Faulty power source.	Measure power source voltage under load.
	Blown fuse(s).	Replace fuse.
NOTE *If the fuse blows again, check the "Transorb," D1, mounted on the 20-A fuse holder on the control panel. The "Transorb" may fail in the shorted mode if subjected to sustained overload or a transient exceeding 5 kW. If the "Transorb" has blown, it is important to determine the cause, which is certain to be external to the transceiver. Repeated replacement of fuses and "Transorb" may cause severe damage to the transceiver.*		
No audio output (squelch off).	Defect in M1, loudspeaker or squelch switch.	Turn squelch off and turn audio gain up. If the speaker is completely dead, the fault is probably in the module or speaker. Repair or replace.
Transceiver does not operate on one frequency or group of frequencies.	Defect in M7 RF filter module.	Check relays and filter components for nonoperating frequency(ies).
Transceiver does not operate on frequencies above/below 15 MHz.	Defect in VCO Q1 (2-15 MHz) or Q2 (15-30 MHz).	Replace module M7 or repair.
Transmitter has no output except for carrier in AM mode.	Defective microphone. Defective audio module M1.	Replace or repair. Replace or repair.
Transmitter has low output on one channel.	Antenna or tuner mismatch.	Measure VSWR and adjust antenna or tuner as required.
Speech sounds garbled and/or fine tune consistently tunes at extremes of range.	Master oscillator out of calibration.	Recalibrate, refer to Section 7.2.
Transmitter does not operate when PTT switch is activated.	Defective microphone. Defective T/R switching.	Check by shorting pin C in microphone socket to ground.

TABLE 8-4. Module Fault-Location Chart.

PRELIMINARY Check power switching. Press PTT switch. Relay should click and receiver should mute.	
M1 AUDIO MODULE	
Transceiver operates in either TX or RX mode.	• 1650-kHz carrier oscillator is operational.
Audio completely dead, not even slight hiss, squelch off, and maximum audio gain.	• Module or loudspeaker defective.
No output from microphone. Carrier present in AM mode.	• M1 or M2 defective, also check microphone.
M2 1650-kHz IF MODULE	
Receiver operational.	• Module will also be operating in transmit mode.
Disconnect "RX-out" coax connector.	• If noise level does not decrease, module is defective.
M3 75-MHz MIXERS MODULE	
Carrier output in AM mode.	• M3, M4, M5, M6, M10 operational in transmit mode.
Disconnect "RX-out" coax connector.	• If noise level does not decrease, module is defective.
M4 HF MIXERS & DRIVER MODULE	
Carrier output in AM mode.	• M3, M4, M5, M6, M10 operational in transmit mode.
Disconnect "RX-out" coaxial connector.	• If noise level does not decrease, module is defective.
M5 SYNTHESIZER - 100-Hz LOOP	
Transceiver operates in either transmit or receive mode.	• Module is operational.
Disconnect "OSC-out" coax connector.	• If noise level does not decrease, module may be defective.
M6 SYNTHESIZER - 10-kHz LOOP	
Transceiver operates in either transmit or receive mode.	• Module is operational.
Channel frequencies do not operate below 15 MHz.	• Defective 1.6 to 15-MHz VCO in module.
Channel frequencies do not operate above 15 MHz.	• Defective 15 to 30-MHz VCO in module.

NOTE

A failure in the master reference oscillator in the module M5 will stop M6 from operating.

TABLE 8-4. Module Fault-Location Chart, Continued.

M7 RF FILTER MODULE Refer to "Preliminary" at beginning of chart for T/R power switching.	
Relay K1.	• Check relay clicks when PTT operated.
Signal path through filters from antenna.	• Disconnect "RX-ANT" coaxial connector from M4. Temporarily connect antenna to "RX-ANT" connector. If receiver operates, defect in M7, filter selection or connections to antenna connector.
M8 POWER-SUPPLY REGULATOR Check input voltage to module at input terminal.	• Should be above 12 V in dc operation. • Should be approximately 18 V in ac operation.
No output from M8 in both transmit and receive mode.	• Module defective.
M9 MICROPROCESSOR MODULE Faults in this module are indicated by incorrect channel selection.	• Check wires and connections.
Failure to retain channel frequencies when transceiver is switched off.	• Replace lithium battery (nominal life 10 years).
M10 RF POWER AMPLIFIER No simple check without instruments.	• Voltages and connections should be carefully checked before replacement.
M11 LCD-DISPLAY MODULE Transceiver appears to be operating correctly but display is not operating.	• Check connections.
MICROPHONE Transmitter does not operate.	• Check by replacement of microphone. • Ground pin C of connector and touch pin D with hand. If transmitter shows RF output, microphone is faulty.

SECTION 9
THEORY OF OPERATION

9.1 INTRODUCTION

This is a general description of the transceiver. Section 10 gives a detailed circuit description of each module as well as technical specifications and servicing data. Table 9-1 provides a functional description of the module.

9.2 FREQUENCY CONVERSION PLAN

The transceiver uses an up conversion plan with the first IF at 75 MHz. This system is used so that the major spurious products fall above the 1.6- to 30-MHz range where they can be easily removed by simple low-pass filters. With a 75-MHz IF, the image responses will fall between 151.6 and 180 MHz. Transmitter spurious responses from a correctly-designed double-balanced mixer will be below -70 dB across the entire operating range. The double-balanced mixers have a level response well into the VHF range, and both the receiver and the transmitter exciter have a level response from 1.6-30 MHz. This broadband response is achieved without any tuning adjustments.

A special VHF crystal filter provides selectivity at 75 MHz. The 3-dB bandwidth is 30 kHz and the stopband is -70 dB. This filter provides sufficient selectivity at the first IF to prevent overload of the second mixer by powerful out-of-band signals. It is necessary to provide a high degree of selectivity to eliminate interference from adjacent in-band signals, and to generate a clean SSB signal. The transceiver uses a second IF of 1650 kHz. At this frequency, it is easy to provide stable high-selectivity crystal filters. The transceiver uses separate high-performance, 6-pole crystal filters for USB and LSB.

To produce the first IF output at 75 MHz, the first loop in the synthesizer must generate an oscillator signal between 76.6 and 105 MHz. The synthesizer generates this frequency range in 10-kHz steps.

The second conversion from 75 MHz to 1650 kHz requires an oscillator injection frequency of 73.35 MHz. As the first synthesizer moves in 10-kHz steps, it is necessary to change the second oscillator frequency over a 10-kHz range to provide complete frequency coverage. The second loop in the synthesizer operates from 73.340-73.350 MHz in 100-Hz steps. Refer to Figure 9-1 for the frequency-conversion plan.

9.3 SYNTHESIZER

The synthesizer uses separate loops controlling the first and second conversion oscillators. Both loops use a stable temperature-controlled 5120-kHz oscillator as a reference standard. The use of direct synthesis with no mixing or other special techniques makes the synthesizers simple and easy to understand. Since modern LSI circuits are used, the synthesizers contain very few parts. Another advantage of the system is the almost complete freedom from spurious responses.

The first loop of the synthesizer covers the range 76.6-105 MHz in 10-kHz increments. Operating in 10-kHz steps simplifies the loop design, which gives a high slew speed and good spectral purity. The 5120-kHz oscillator is divided down to provide the 10-kHz reference frequency. The synthesizer uses a programmed divider to give a variable division ratio of 7,660-10,500 controlled by 12 binary-coded input lines. The divided down output from the VCO is compared with the 10-kHz reference in the phase comparator, and an error voltage is generated that shifts the VCO frequency until lock is achieved. Two separate VCO's are used to cover the frequency range.

The second loop of the synthesizer must cover 73.340-73.350 MHz in 100-Hz increments. It is very difficult to design a VCO operating at this frequency in a 100-Hz loop. This problem was solved by using a VCXO (Variable Crystal-Controlled Oscillator). A special 5th-overtone oscillator circuit was designed with the capability of more than 10-kHz tuning range at 73.35 MHz.

The synthesizer output is almost indistinguishable from a good crystal oscillator—a very important factor in simplifying the synthesizer design. The 5120-kHz reference is divided down to provide the 100-Hz reference frequency. The programmed divider gives a variable division ratio of 733,400 - 733,500 controlled by 8 binary-coded input lines. Using the same reference oscillator for both loops gives a special advantage. Any frequency drift will cancel in the loops and the overall stability of the system is not affected by the high-conversion frequencies. A single frequency adjustment sets all channel frequencies.

9.4 PROGRAMMING CHANNEL FREQUENCIES

The synthesizer in the transceiver is controlled by 21 binary-coded input lines. The desired frequency information is programmed directly into the synthesizer by the microprocessor. The algorithm for determining the frequency coding is given in Section 10.

9.5 RECEIVER

The input signal from the antenna passes through one of six 7-pole, elliptic-function filters, then through a 1650-kHz high-pass filter to prevent overload from MF broadcast stations, and finally through a 30-MHz low-pass filter to prevent VHF responses. The signal is applied to a high-level, double-balanced mixer; and the 75-MHz output is amplified by a high-dynamic-range amplifier before passing through the 4-pole, monolithic 75-MHz filter. The +11-dBm intercept point is maintained through to the output of the 75-MHz filter. The output from the 75-MHz filter is amplified by an AGC-controlled dual-gate MOSFET amplifier and is then down-converted to 1650 kHz in

TABLE 9-1.
Functional Description of Modules.

M1	**AUDIO MODULE** Microphone amplifier (VOGAD) - balanced modulator - product detector - squelch system - audio attenuator - audio power amplifier - audio amplifiers 600 Ω. Carrier oscillator 1650-kHz clarifier. Transmit: Input - microphone, output - 1650-kHz DSB. Receive: Input - 1650-kHz SSB, output - Audio 4 W.
M2	**1650-kHz IF MODULE** 6-pole crystal filters - USB and LSB (optional) - AGC/ALC controlled T & R amplifier - receiver IF Amplifier - AGC amplifier AGC/ALC control amplifier. Transmit: Input - 1650-kHz DSB, output - 1650-kHz SSB. Receive: Input - 1650-kHz SSB, output - 1650-kHz SSB (2.4-kHz bandwidth).
M3	**75-MHz MIXERS MODULE** AGC-controlled 75-MHz RX amplifier, 75-MHz to 1650-kHz RX mixer, 1650-kHz to 75-mHz TX mixer, 75-MHz TX amplifier - carrier injection switch (1650 kHz). Transmit: Input - 1650-kHz SSB, output - 75-MHz SSB. Receive: Input - 75 MHz 30-kHz B/W, output - 1650-kHz RF.
M4	**HF MIXERS AND DRIVER MODULE** 30-MHz low-pass filter, double-balanced RX mixer, 75-MHz amplifier TX & RX, 75-MHz crystal filter TX & RX, double-balanced TX mixer - 3 stage 2 to 30-MHz TX amplifier, 30-MHz low-pass filter. Transmit: Input - 75-MHz SSB, output - 1.6 to 30-MHz SSB (100 mW). Receive: Input - 1.6 to 30-MHz from antenna, output - 75 MHz (30-kHz B/W).
M5	**SYNTHESIZER 100-Hz LOOP MODULE** Output - 73.340-73.350 MHz, 100-Hz increments +7 dBm - temperature-controlled 5120-kHz reference oscillator (for both loops).
M6	**SYNTHESIZER 10-kHz LOOP MODULE** Output 76.6-105 MHz, 10-kHz increments +10 dBm.
M7	**RF FILTER AND SWITCHING MODULE** 7-pole TX & RX elliptical function filters - 2-3 MHz, 3-5 MHz, 5-8 MHz, 8-13 MHz, 13-20 MHz, 20-30 MHz, RX 7-pole, 1.6-MHz high-pass filter, VSWR bridge, ALC control, Filter-switching circuitry, TX/RX switching, S-meter circuit, CW oscillator.
M8	**12-V REGULATOR MODULE** Provides regulated 12 Vdc for all functions except final amplifier collectors.
M9	**FREQUENCY-CONTROL MODULE** Microprocessor control of frequency selection, channel selection, scanning and tuning. 100-channel memory. Operates display and selects correct filters.
M10	**RF POWER MODULE** Two-stage broadband 1.6 to 30-MHz linear amplifier (100 W).
M11	**LCD DISPLAY MODULE** Displays frequency or channel number.
M12	**ANTENNA TUNER** Matches output to antenna.

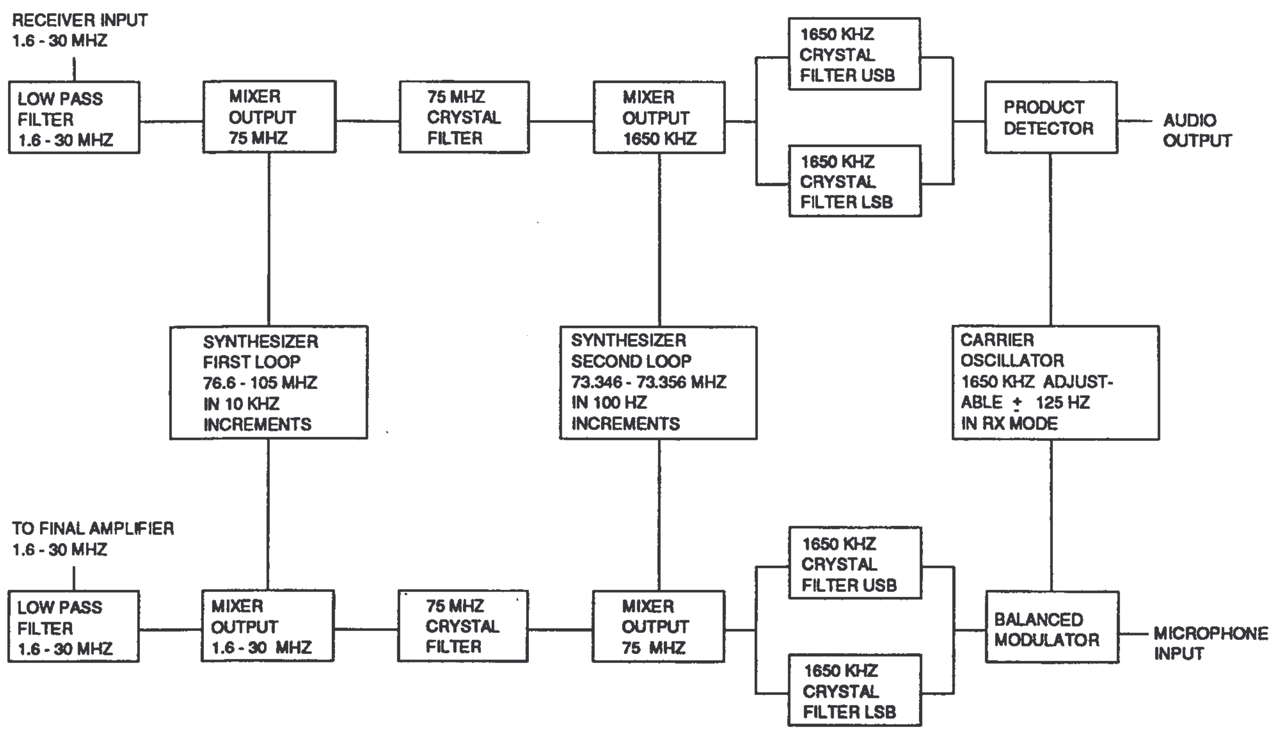


FIGURE 9-1.
Frequency-Conversion Plan.

a junction FET mixer. The signal then passes through either of the 6-pole USB or LSB crystal filters and is then amplified by an AGC-controlled dual-gate MOSFET amplifier. The final IF amplification is provided by a fixed-gain bipolar amplifier. A two-stage AGC amplifier provides excellent fast-attack, slow-release characteristics. This AGC system is so effective that no separate RF gain control is required. The carrier oscillator is provided with a vernier frequency adjustment of ±125 Hz (not operative in transmit mode). This vernier tuning or clarifier permits exact tuning of the received signal. The audio signal passes through the squelch circuit. The audio is processed and applied to a pulse counter which detects the low-frequency FM component in human speech. The output controls an audio gate which opens in the presence of speech and not background noise. A dc attenuator is used to control the audio level to the audio power amplifier. This monolithic integrated circuit provides high gain and a low-distortion audio output of 4 W.

9.6 TRANSMITTER EXCITER

The microphone amplifier is a VOGAD which automatically adjusts the gain to provide constant audio output. A balanced modulator with a 1650-kHz carrier-injection frequency produces 1650-kHz, double-sideband suppressed carrier output.

The 1650-kHz DSB signal passes through either the USB or LSB crystal filter and the 1650-kHz dual-gate MOSFET amplifier. The filters and amplifier are also used in the receive mode. The IF amplifier has ALC applied that is derived from the forward arm of the VSWR bridge at the transmitter output. A control voltage from the reverse arm of the VSWR bridge is also applied to the ALC input. If the VSWR is low, there will be little output on the reverse arm of the bridge, but as the VSWR rises, the gain will be reduced, which protects the high-power final amplifier from antenna mismatch.

The 1650-kHz SSB signal is applied to a balanced mixer where it is up-converted to 75 MHz. A PIN diode switch is used to apply a 1650-kHz signal direct from the carrier oscillator to the mixer input. This carrier is used for the compatible AM mode. It should be noted that the carrier is not controlled by the ALC amplifier. Therefore, the setting is important to prevent carrier reduction on voice peaks in the compatible AM mode.

The 75-MHz SSB signal passes through two stages of amplification to the 75-MHz crystal filter. The second amplifier stage and the crystal filter are also used in the receive mode. The 75-MHz signal is then down-converted to the operating frequency in a double-balanced mixer. A three-stage, broadband, 1.6- to 30-MHz amplifier increases the exciter output to approximately 100 mW. A low-pass filter at the output removes the image frequencies.

9.7 FINAL AMPLIFIER AND FILTERS

The high-power final amplifier consists of a push-pull driver stage and a push-pull final output stage. Special broadband transformers are used for interstage and output coupling. The first amplifier operates class AB and the final stage in class B using a stabilized bias supply. The final amplifier has low spurious output except for the harmonics. Six separate high-performance, elliptical-function filters are used to cover the operating range and provide effective attenuation of the harmonic spectrum. The selection of the filters is controlled by the channelizing module.

9.8 SHIELDING

One of the major problems in designing a synthesized transceiver is preventing spurious responses. The transceiver uses a frequency-conversion plan and a synthesizer design that are essentially free of these responses. Signal leakage from one part of the transceiver to another would create new spurious responses and special construction techniques have been used to prevent this problem. The receiver and transmitter exciter are constructed in RF tight boxes with filtered output leads. All RF connections are made through coaxial cables.

9.9 TRANSMIT-RECEIVE SWITCHING

The transmit-receive switching is achieved by using three +12-V lines; +12 V common, +12 V transmit and +12 V receive. Circuitry common to both the transmit and receive modes operates from the common +12-V line. The receive circuitry operates from the +12-V receive line and the transmit circuitry from the +12-V transmit line. Relay switching is used to switch the transmit and receive lines. Extensive use is made of diode gates to switch the signal paths in parts of the circuitry common to the transmitter and receiver. The antenna is switched by an SPDT relay.

9.10 POWER SUPPLY

The transceiver operates directly from a 13.6-V supply source. A special input regulator with a low-input voltage differential supplies regulated 12 V to the receiver, exciter, final amplifier driver and bias regulator. If the input voltage drops below 12 V, the regulator switches hard on and the full available voltage is used. Numerous individual regulators are used throughout the transceiver so that stability and other important factors are not dependent on the main regulator. The final amplifier output stage is operated directly from this unregulated supply. These transistors have a "never-exceed" voltage rating of 36 V and do not require a regulated supply source. A 20-V "Transorb" is used to prevent excessive voltages or transients from damaging the final amplifier.

SECTION 10
TECHNICAL DESCRIPTION & SERVICE DATA

10.0 INTRODUCTION

This section of the manual contains detailed information on each of the transceiver modules. It is important that this section is carefully studied when servicing or adjusting the transceiver. This section contains the following information:

1. Technical Circuit Description
2. Adjustment Procedure
3. Specifications & Test Data
4. Servicing Information
5. Schematic Diagram
6. Alignment Point & Parts Layout
7. Parts Lists

While studying the technical information on each module, it is important to understand the relationship of the module to the rest of the transceiver. Section 2 provides general overall information including complete technical specifications, a transceiver block diagram (Figure 2-1), and illustrations showing the physical locations of each module. Section 11 contains detailed technical information on the transceiver mainframe including an overall wiring diagram, connector configurations showing all pin locations and module-location drawings showing all adjustment pionts. Both of these sections should be referred to as necessary.

Information in this section is broken down as follows:

SECTION	CIRCUITRY	DESIGNATION
10.1	Audio Module	M1
10.2	1650 kHz IF Module	M2
10.3	75 MHz Mixer Module	M3
10.4	HF Mixer & Pre-Driver Module	M4
10.5	100-Hz Synthesizer Module	M5
10.6	10-kHz Synthesizer Module	M6
10.7	RF Filter & Switching Module	M7
10.8	+12-V Regulator Module	M8
10.9	Frequency Control Module	M9
10.10	RF Power Module	M10
10.11	LCD Display Module	M11
10.12	Antenna Tuner	M12

10.1 AUDIO MODULE, M1

The M1 module contains the receive and transmit audio-processing circuitry and the 1.650-MHz carrier oscillator. It is all contained on printed circuit board 735107 and mounted in a die-cast box located on the far left side of the transceiver.

10.1.1 TECHNICAL CIRCUIT DESCRIPTION

10.1.1.1 MODULE INTERCONNECTIONS

The M1 module has the following interconnects with the transceiver:

RF Connections

a) Transmit Output. DSB 1650-kHz output to the M2 module at approximately 10 mV, RMS. PCB connection is at right front of board; SMA module connector is at right front of box.

b) Receive Input. SSB 1650-kHz input to M1 at approximately 6 mV, RMS. PCB connection is at right rear of board: SMA module connection is at right upper rear of box.

c) Carrier Output. 1650-kHz output to the M3 module at approximately 200 mV, RMS. Used only in AM transmit mode. PCB location is at right center of board. SMA module connector is at right lower rear of box.

Dc/Audio Connections (pairs numbered left to right, top to bottom—when more than one 10-pin connector used).

Pin 1. Ground.
Pin 2. Microphone ground. Connected to audio input connector, pin 1.
Pin 3. Microphone Input. From audio input connector, pin 3.
Pin 4. Regulated +12-V dc.
Pin 5. R+; regulated +12-V dc only in receive mode.
Pin 6. Squelch control. Connected to the front panel LS/squelch switch. A ground on this line enables the syllabic squelch.
Pin 7. Receive audio output to the transceiver loudspeaker.
Pin 8. Dc control input from front panel audio gain control.
Pin 9. Clarifier A. Switches R+ to clarifier circuit.
Pin 10. Clarifier B. Receive control voltage from front panel clarifier potentiometer.
Pin 11. Ground.
Pin 12. Unsquelched receive audio output of product detector at 0 dBm.
Pin 13. 600-ohm transmit audio inputs; requires 0 dBm to drive transceiver to full output.
Pin 14. Jumpered to pin 13.
Pin 15. Sidetone audio inputs; used with CW and automatic antenna tuner tune oscillators.
Pin 16. Jumpered to pin 15.
Pin17. Mute line from M9MP PCB. Mutes receive audio during frequency changes.
Pin 18. CW audio input from the CW oscillator on the M7 PCB.
Pin 19. Tune unbalance line; a ground on this line unbalances the transmit balanced modulator to provide a carrier for automatic antenna tuner tuning.
Pin 20. Squelched receive audio output of product detector at 0 dBm.

10.1.1.2 CIRCUIT DESCRIPTION - RECEIVE

The input to this module is an amplified and filtered 1650-kHz IF signal from M2. This signal is coupled into one part of the integrated-circuit product detector U1. The 1650-kHz carrier oscillator is injected into pin 3 of U1. This device is a double-balanced modulator driven by differential dual current sources. Internal resistors provide biasing and loads, which minimizes the external component count. The output from pin 5 is the sum and difference signals from the two input signals. The high-frequency component is suppressed by C5; and the difference frequency, in the audio baseband, is applied to the audio gate Q1 and to the input of the squelch system. U7 is a dual-operational amplifier used to supply amplified product detector outputs (unsquelched and squelched) for use with accessory equipment.

The squelch operates by detecting the presence of the syllabic rate of change found in all human voices. This means that constant signals such as static noise, repetitive impulse noise or carriers will not open the squelch. Voices and CW will open the squelch, which allows communication to take place.

A front panel switch is provided to disable the squelch and open the received channel. The squelch is preset internally and requires no operator adjustment.

NOTE

It is helpful to refer to the schematic diagram, Figure 10.1-4, while studying this section. References to designators are the ones found on the schematic diagram.

Beginning at U1-5, an audio output from the product detector is fed into Q1 and U2A. Q1 is an audio gate which is turned off when the gate is pulled low. When the squelch is opened, the gate is allowed to float, which lowers the channel resistance which allows the signal to appear at C20, which is connected to the output audio amplifiers. Since no current is sourced or sunk by gate, the annoying "pop" or "click" is eliminated. The gate of Q1 can be pulled low either by enabling the squelch circuit (grounding input pin 6) from the front panel switch, or by grounding input pin 17 (a "MUTE" line from M9MP).

The signal applied to U2A and U2B is amplified and squared or clipped; the gain of these amplifiers is high enough so that the input noise will clip, providing enough amplitude to continuously trigger the one shot U3A and U3B.

The one shot then outputs pulses to high-pass filter C12, C13, R9, R10. The output of the filter is rectified and then smoothed (integrated) by the low-pass filter R11, R12, C14, C19. At this point a dc level proportional to the input frequency of the one shot is present.

This level will shift as the frequency shifts, which provides an ac level shift representing the change in frequency of the voice. This level is fed into U2-13, the differentiation amplifier, which responds to frequencies between 0.5 and 2.5 kHz. The output of this amplifier is fed into U2-9,10, which will pull down D2 if any signal appears to D3/D4 in a positive or negative direction with an amplitude of 0.9 V or more. This unipolar converter will allow the squelch to detect the first syllabic change occuring at the input.

D4 is then connected to U3C and D which form a timer with C15 and R7 to hold the audio gate open for approximately 2 seconds after the last syllabic change is detected.

The output from the audio gate Q1 is applied to the input of U4, an electronic attenuator. The gain of this device is controlled by the dc voltage on pin 2. This gain-control system is used so that there is no low-level audio signal external to the module, which makes it practical to control the gain at a remote location.

The audio output stage is a monolithic integrated circuit U5. This device provides high-level audio output to the loudspeaker with low distortion. The gain of the stage is set by the feedback network R31/R30/C47. The high-frequency response is set by the feedback network C24/R29. Parasitic high-frequency oscillations are suppressed by the damping network R32/C26.

10.1.1.3 CIRCUIT DESCRIPTION - TRANSMIT

The microphone input is applied to U9, an integrated circuit VOGAD (Voice Operated Gain Adjusting Device). This circuit is an audio amplifier with an automatic gain-control circuit. R41 and C30 control the decay time of the gain-control circuit and are adjusted to prevent "pumping" of the audio signal. R40 sets the maximum gain level of the amplifier. The network C56/L3/C57 filters any RF picked up by the microphone lead. The VOGAD circuit is very effective in providing constant level audio output over a wide range of input levels.

Accessory equipment audio inputs are also applied to U9, but in this case they are applied to a 600-ohm input port provided by R64 and isolating resistor R46. The internal CW signal from the M7 module is applied to U9 through isolating resistor R45.

The leveled audio output is applied to one input of the balanced modulator U6. R42 sets the audio level. The 1650-kHz carrier oscillator is applied to the other input of the stage, which is a quad amplifier driven by differential current sources. Internal resistors provide the biasing and loads, which minimizes the external component count. R44 is used to adjust the offset current provided to U6-7. This permits balancing of the modulator, which ensures maximum carrier suppression. The output from U6 is a 1650-kHz, double-sideband, suppressed-carrier signal.

Input pin 19 is grounded during a "tune cycle" when the transceiver is used with an automatic antenna tuner. This unbalances U6 sufficiently to provide a carrier output for tuning.

10.1.1.4 CIRCUIT DESCRIPTION - CARRIER OSCILLATOR

The carrier oscillator is a stable crystal controlled circuit. A modified Colpitts circuit is used. The large-value feedback capacitors C46 and C47 completely swamp out the base capacitance of Q3 and ensure isolation of the crystal Y1 from circuit temperature changes. Two parallel varicap diodes, D12 and D13, are connected between Y1 and ground. Varicap diodes provide a variable capacitance proportional to reverse bias across the diode junction. In the transmit mode, and in the receive mode when the clarifier is switched off, the bias is applied to D12 and D13 through R58 and D8. This bias may be preset by the potentiometer R59 which is used to set the oscillator frequency to exactly 1650 kHz.

When the clarifier is switched on in the receive mode, a variable voltage is applied from the clarifier (connected as a potentiometer) to input B. This variable voltage is used to vary the bias on D12/D13 and shifts the carrier oscillator frequency approximately ±125 Hz giving the operator a limited tuning range in the receive mode.

10.1.1.5 CIRCUIT DESCRIPTION - VOLTAGE REGULATOR

One integrated circuit voltage regulator (U8) is used in the module. This three-terminal device uses no external components and provides a stable regulated and filtered 8-V for the required module circuitry.

10.1.1.6 CIRCUIT DESCRIPTION - TRANSMIT/RECEIVE SWITCHING

The diode gates D9 and D10 switch the carrier oscillator from the product detector U1 to the balanced modulator U9. D9 is forward biased in the transmit mode and D10 is forward biased in the receive mode. The bias switching is controlled by the timer U10. This circuit introduces a small switching delay going from receive to transmit and back again from transmit to receive. This short delay permits the circuitry to stabilize and prevents audible switching transients in the transmitter and receiver.

10.1.2 ADJUSTMENT PROCEDURE

10.1.2.1 CARRIER OSCILLATOR

Turn the clarifier to the "off" position. Connect the frequency counter to the carrier oscillator output terminal. Adjust R59 until the frequency is exactly 1650.000 kHz. (Refer to Figure 10.1-1).

10.1.2.2 CARRIER BALANCE

Connect the transceiver to a 100-W load/30-dB attenuator and the oscilloscope to the attenuator output. Remove U9 from the socket (this ensures there will be no stray background noise from the microphone input). Key the transmitter and adjust the gain of the oscilloscope until the carrier is displayed. Adjust R44 for minimum output. Replace U9 and be careful not to reverse the IC in the socket.

10.1.2.3 SQUELCH SENSITIVITY

A threshold adjustment is provided in order to compensate for minor circuit variations from radio to radio. This adjustment is not critical and is easily set. To adjust, turn the transceiver on and then disconnect the antenna and select a programmed channel. Turn R18 in the CCW direction until the squelch opens, then back off 1/8 turn past the squelch closing point.

NOTE

If unexplained squelch openings are common and the desired received signals are strong, then the adjustment can be turned down slightly further.

10.1.3 SPECIFICATIONS

Table 10.1-1 lists the specifications for the audio module, M1.

10.1.4 VOLTAGE CHART

Table 10.1-2 defines the relevant voltages for the audio module, M1.

10.1.5 SERVICING

If the module is not working in both the transmit and receive modes, the carrier oscillator is probably not operating. Check the frequency and output level at the "carrier oscillator out" terminal. Check the voltages on Q3 and that the voltage on the cathodes of D12 and D13 varies from 0 to 12 V as the clarifier control is rotated. If the voltages are normal, the crystal Y1 is probably defective.

If the module is not operating in the receive mode, check that the squelch is "OFF" (the voltage at the cathode of D1 should be 8 V), the gain control is turned up (the voltage at pin 2 of U4 should be 0.8 V), the carrier injection level at the product detector (pin 3, U6 0.1 V RMS), and the loudspeaker is connected (measure with an ohmmeter at "SPKR OUT" to ground. The resistance should be 3 ohms and the loudspeaker will click as the ohmmeter is connected). If these checks are normal, connect the signal generator to the "receiver input" (1651 kHz at 1.0 mV RMS). The faulty stage can be determined by measuring the audio voltage at the output of each stage.

U1	Pin 5	15.0 mV RMS
Q1	Drain	13.0 mV RMS
U4	Pin 7	32.0 mV RMS
U5	Pin 4	1.0 V RMS

The integrated circuits are best checked by substitution. Faulty components are usually indicated by incorrect voltages.

If the squelch is not opening, connect the override pin to ground. If the squelch does not open, then the fault is in Q1 or U3C. To test the receiver, connect the source and drain of Q1 together. If the receiver works, then the squelch is at fault.

If the squelch opens when the override pin is grounded, then the problem is elsewhere in the squelch system. Check pin 7 of U2. There should be a clipped wave of approximately 6 V peak-to-peak. If not, then check amplifier U2A and U2B. If the clipped wave is present, apply a carrier to the radio to produce a 1000-Hz tone; the wave should be a clipped constant 1000 Hz. If not, then the signal is not getting from the product detector amplifier input. If so, then the problem is further down the string.

Next, test pin 4 of U3B; 1000-Hz pulses should be present or the problem is around U3A or U3B.

Next, test the junction of R12, C19 using a voltmeter. A constant voltage should be present between 3 Vdc and 6 Vdc. Changing the demodulated frequency should cause the voltage to shift and establish a new level. If no voltage is present, then D5 or the filter system is open.

Next, test pin 8 of U2 using a voltmeter; the voltage should be 7 to 8 V. Shift the frequency at a rate of 1 sweep per second. The voltage should drop to below 2 V each time a shift is made. If not, then U2 or D3 and D4 should be examined.

U3C and U3D are the timing circuit and should be checked if the squelch does not stay open for approximately 2 seconds after the actuating signal stops.

NOTE

The squelch is completely immune to amplitude or impulse-type noise but will open on interference, which produces similar characteristics to the human voice. A steady heterodyne will not operate the squelch, but any variation in frequency will cause a squelch opening. There are a number of swept spectrum signals in the HF bands, and it is our experience that these signals are responsible for most unexplained squelch openings. The signal has already swept across the channel by the time the squelch opens and is not heard. The squelch cannot discriminate between SSB signals that are on frequency and signals slightly off the frequency. Squelch openings must be expected when voice interference is present on the channel.

The module is checked in the transmit mode by injecting a 1000-Hz audio tone at the microphone input. Monitor the output at pin 8 of U9 using an oscilloscope. The output should be an undistorted sinewave. The output should limit at 250 mV peak-to-peak with an input of 5-mV RMS. Check that the VOGAD is operating correctly by increasing the input level to 500 mV RMS. The output level should remain constant.

NOTE

Disconnect the TX lead before making the following measurement. The signal at the "Transmit Output" terminal should approximate a 1650-kHz, two-tone test pattern (40-mV peak-to-peak). The apparent distortion at this

TABLE 10.1-1.
Specifications, Audio Module M1.

TRANSMIT	
Current:	110 mA.
Input:	Microphone or 1000 Hz 5 mV.
Output:	1650 kHz, double sideband, 10-mV RMS, -27 dBm.
Oscillator Injection Level:	120-mV RMS, pin 3, U6.
RECEIVE	
Current:	90 mA.
Input:	1650 kHz, -32 dBm, 6-mV RMS.
Output:	1000 Hz ,3.5-V RMS (4 W 3.2) +36 dBm.
System Gain:	68 dB.
Oscillator Injection Level:	100mV RMS pin 3 U1.

TABLE 10.1-2.
Voltage Chart, Audio Module M1.

	RX	(Clarifier On)	TX
D9			
Anode	7.5 V		3.5 V
Cathode	6.8 V		9.0 V
D10			
Anode	1.2 V		4.2 V
Cathode	7.5 V		3.5 V
Q1			
Source:	3.7 V		3.7 V
Drain:	3.7 V		3.7 V
Gate:	0.0 V		0.0 V
Q2		(Clarifier On)	
Emitter:	7.2 V	(0 V)	7.2 V
Base:	7.9 V	(0 V)	7.9 V
Collector:	8.0 V	(8 V)	8.0 V
Q3			
Emitter:	1.2 V		1.2 V
Base:	2.0 V		2.0 V
Collector:	5.0 V		4.0 V
Q4		(Clarifier On)	
Emitter:	0.0 V	(0 V)	0.0 V
Base:	0.0 V	(.7 V)	0.0 V
Collector:	8.0 V	(0 V)	8.0 V

	RX	TX
U1		
Pin 1	NC	NC
Pin 2	3.6 V	3.6 V
Pin 3	3.6 V	3.6 V
Pin 4	8.0 V	8.0 V
Pin 5	7.0 V	7.0 V
Pin 6	6.5 V	6.5 V
Pin 7	3.6 V	3.6 V
Pin 8	0.0 V	0.0 V
U2		
Pin 1	4.2 V	4.2 V
Pin 2	0.5 V	0.5 V
Pin 3	4.2 V	4.2 V
Pin 4	8.0 V	8.0 V
Pin 5	1.6 V	1.6 V
Pin 6	4.2 V	4.2 V
Pin 7	3.5 V	6.8 V
Pin 8	6.0 V	6.8 V
Pin 9	3.8 V	3.8 V
Pin 10	3.8 V	3.8 V
Pin 11	0.0 V	0.0 V
Pin 12	1.8 V	1.8 V
Pin 13	0.5 V	0.5 V
Pin 14	4.2 V	4.2 V

TABLE 10.1-2.
Voltage Chart, Audio Module M1, Continued.

	RX	TX
U3		
Pin 1	3.5 V	6.8 V
Pin 2	2.2 V	0.0 V
Pin 3	3.8 V	0.0 V
Pin 4	2.2 V	0.0 V
Pin 5	5.0 V	6.5 V
Pin 6	5.0 V	6.5 V
Pin 7	0.0 V	0.0 V
Pin 8	8.0 V	8.0 V
Pin 9	8.0 V	8.0 V
Pin 10	0.0 V	0.0 V
Pin 11	8.0 V	8.0 V
Pin 12	0.0 V	0.0 V
Pin 13	0.0 V	0.0 V
Pin 14	8.0 V	8.0 V
U4		
Pin 1	1.2 V	1.2 V
Pin 2	2.8 V	2.8 V
Pin 3	0.0 V	0.0 V
Pin 4	0.0 V	0.0 V
Pin 5	0.0 V	0.0 V
Pin 6	4.8 V	4.8 V
Pin 7	4.4 V	4.4 V
Pin 8	8.0 V	8.0 V
U5		
Pin 1	12.0 V	12.0 V
Pin 2	6.0 V	6.0 V
Pin 3	0.0 V	0.0 V
Pin 4	1.0 V	1.0 V
Pin 5	0.7 V	0.7 V
U6		
Pin 1	0.0 V	0.0 V
Pin 2	3.6 V	3.6 V
Pin 3	3.6 V	3.6 V
Pin 4	8.0 V	8.0 V
Pin 5	7.0 V	7.0 V
Pin 6	6.5 V	6.6 V
Pin 7	3.8 V	3.8 V
Pin 8	0.0 V	0.0 V

	RX	TX
U7		
Pin 1	4.0 V	4.0 V
Pin 2	4.0 V	4.0 V
Pin 3	4.0 V	4.0 V
Pin 4	0.0 V	0.0 V
Pin 5	4.0 V	4.0 V
Pin 6	4.0 V	4.0 V
Pin 7	4.0 V	4.0 V
Pin 8	8.0 V	8.0 V
U8		
Pin 1	8.0 V*	
Pin 2	0.0 V*	
Pin 3	12.0 V*	
*12 V IN, 8 V OUT		
U9		
Pin 1	0.0 V	0.0 V
Pin 2	4.6 V	4.6 V
Pin 3	8.0 V	8.0 V
Pin 4	1.8 V	1.8 V
Pin 5	1.8 V	1.8 V
Pin 6	0.0 V	0.0 V
Pin 7	1.2 V	1.2 V
Pin 8	1.2 V	1.2 V
U10		
Pin 1	0.0 V	0.0 V
Pin 2	2.0 V	0.0 V
Pin 3	0.0 V	10.0 V
Pin 4	12.0 V	11.4 V
Pin 5	7.8 V	7.8 V
Pin 6	2.0 V	0.0 V
Pin 7	0.0 V	0.0 V
Pin 8	12.0 V	11.8 V

minal should approximate a 1650-kHz, two-tone test pattern (40-mV peak-to-peak). The apparent distortion at this point is caused by the presence of the 1000-Hz audio tone. U6 and U7 are best checked by substitution. Make sure that the oscillator injection level is correct at pin 3 of U6.