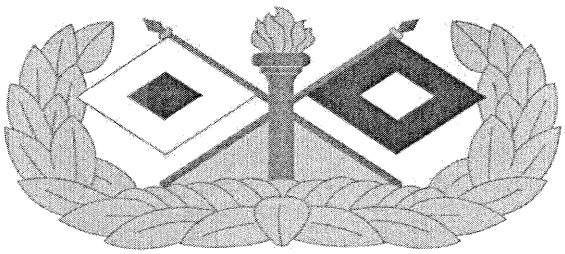
Virginia Defense Force

Communicators Operators Badge

Radio Technology

HF & VHF Systems

Training Material



SUBJECT: Radio Technology

Purpose:

To provide the fundamental knowledge of High Frequency (HF) and Very High Frequency (VHF) radio systems. This class will teach the basic theory of each system, the reasons for using each, and how to place the radio into operation.

TIME Requirements: 6 Hours

Academic.....3 Hours
Hands-on.....2 Hours
Testing.....1 Hour

Score Requirements for Passing: 70%

Modules:

. Radio
    a. HF
        i. Know what a HF System is.
        ii. Know the characteristics, frequencies, and capabilities of the system.
        iii. What type of broadcast area could be anticipated?
        iv. Know how to assemble radio, power supply, signal strength meter, grounding, microphone etc into operation
        v. Know the different type of antennas.
            1. Dipole
            2. Whip
            3. Know how to calculate antenna wave length to the antenna.
            4. Know how to place antenna(s) into operation.
        vi. Erection of antenna mask
            1. What are several methods of placing a HF antenna into operation
            2. Place both whip and dipole antenna into operation.
        vii. Cable
            1. Know the different types of cables.
            2. Sizes, characteristics, types
            3. Connector, Type and how to install.
        viii. Place entire system into operation.
        ix. Troubleshoot equipment, line, antenna components.
        x. Send and receive a message

b. VHF

i. Know what a VHF System is.
ii. Know the characteristics, frequencies, and capabilities of the system.
iii. What type of broadcast area could be anticipated?
iv. Know how to assemble radio, power supply, signal strength meter, grounding, microphone etc into operation
v. Know the different type of antennas.
    1. Whip
    2. Directional
    3. Know how to calculate antenna wave length to the antenna.
    4. Know how to place antenna(s) into operation.
vi. Erection of antenna mask
    1. What are several methods of placing a VHF antenna into operation
    2. Place both whip and directional antenna into operation.

vii. Cable
    1. Know the different types of cables.
    2. Sizes, characteristics, types
    3. Connector, Type and how to install.
viii. Place entire system into operation.
ix. Troubleshoot equipment, line, antenna components.
x. Send and receive a message.

Test (Open Book)

TASK: To aid personnel in using high-frequency (HF) and very high-frequency (VHF) radio systems to achieve successful communications.

CONDITION: The individual is provided with classroom training, documentation, and equipment.

STANDARD: Standard is met when personnel can successfully identify the components of each type of system, put the components into operation, and make a communications check. Personnel must also demonstrate the ability to construct a field expedient antenna.

RISK ASSESSMENT: MODERATE

SAFETY CONSIDERATIONS: Do not permit antennas or their supporting components to come into contact with high-power lines or other sources of electricity. **It can cause injury or death.** DO NOT install antennas or operate radio equipment during thunderstorms or high winds. When installing antennas, remember to keep them at least twice the distance of the tallest component of your antenna system away form any overhead electrical wires. Example: If the tallest part of your supporting structure is 20 feet and there are overhead electrical wires nearby, place your antenna system a minimum of 40 feet away form the electrical wires, more if possible.

In the VaDF we use 4 basic means of communications. Radio to include VHF (very high frequency) and HF (high frequency), Land Line (telephone), and cell phones. If you are lucky enough and are deployed with another agency like the Army Corp of Engineers, you could be using Satellite Phones.

How do we know which system to use?

You must first determine what type of communications is needed. Are you trying to communicate with other troops that are within your immediate area (2-5 mile radius), or do you need to pass traffic to another armory or CP on the other side of the state?

The VaDF uses radio frequencies that are primarily in the high frequency and very high frequency bands. Ultra high frequency or UHF is used to a limited degree with FRS radios. Since FRS radios are extremely limited by their make up (you cannot change their configuration) they will not be covered in this class.

Some frequencies work better during the day, and some frequencies work better at night. Some frequencies are good for long-distance communications (HF), while others provide reliable short-range communications (VHF).

Each frequency range has unique characteristics. The chart shown below is for normal operating conditions. Ranges will change according to operating conditions and propagation.

Frequency Range Characteristics

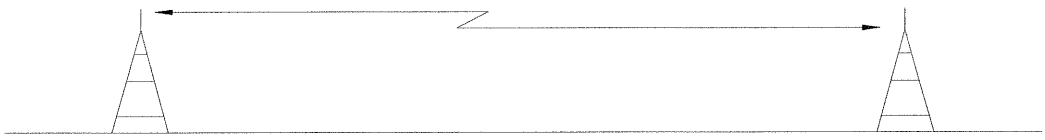
Band	**Ground Wave Range**	**Sky Wave Range**
HF	0-50 miles	100-8000 miles
VHF	0-30 miles	50-150 miles

In the VaDF we use two primary modes or emissions depending on which band we are operating. For VHF we use FM or frequency modulation. On the HF bands we use USB at all times unless directed differently by the net control station. VHF FM is the only type of emission that the radios we use have. With most HF radios, USB must be selected, especially on our 8Mhz. frequency.

NOTE: Equipment used on frequencies that the VaDF is allocated; (VHF or HF) must be NTIA compliant. For more information contact Division Signal Platoon.

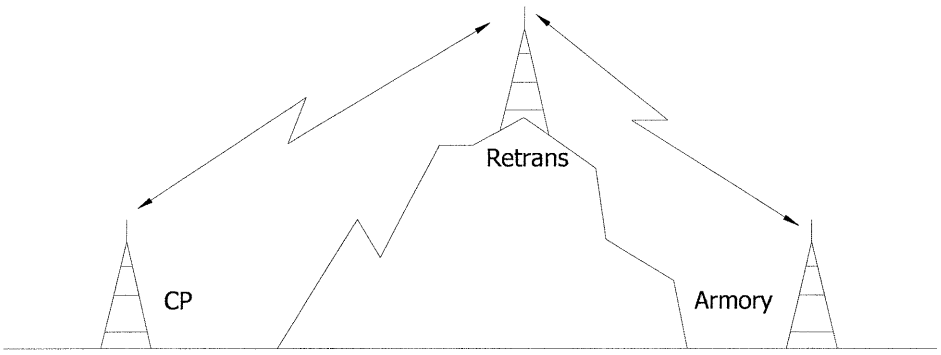
VHF COMMUNICATIONS

VHF radios (handhelds or mobiles) are used for local line of site (LOS) communications. VHF is very limited by terrain (foliage, buildings, and mountains). To use VHF it is necessary to be able to visualize a direct line of site between the transmitter and the antenna. Line of site occurs when radio signals travel in a straight line from one station to the other. VHF is the best choice to use when



LOS Communications

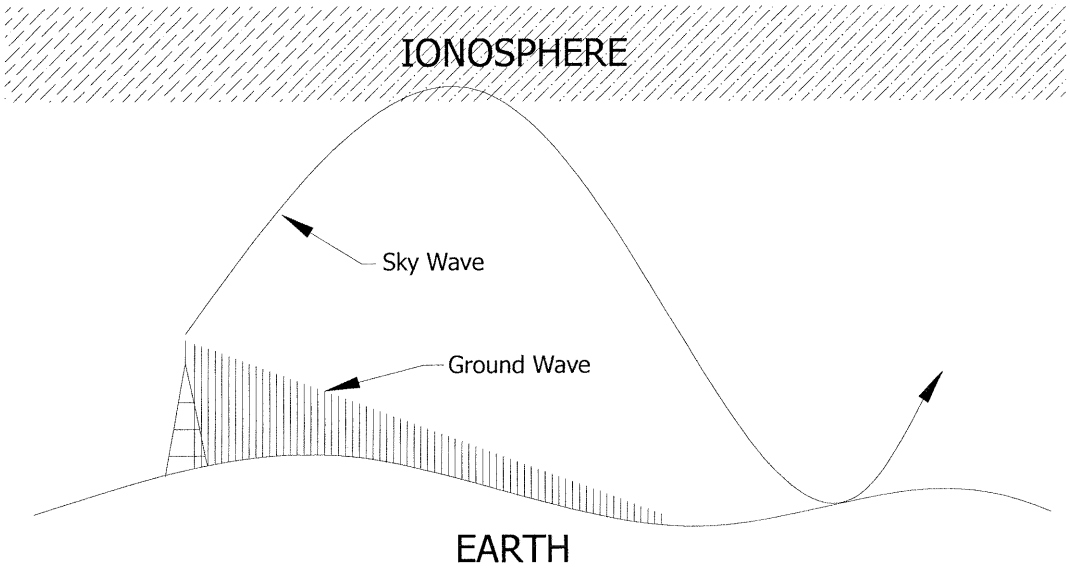
communications are needed to tie all personnel together in a localized area, for example around a command post, armory, etc.
With the type of equipment that we typically use the range can be anywhere from a few hundred feet to several miles for handheld type radios. With mobile VHF radios, which generally have a higher output power, this range can be extended out to a much greater distance. The range of a VHF system can be dramatically improved with the use of a retrans or repeater system. At the annual Apple Blossom in Winchester, a repeater is used for the Commanders net and for the medical people.
(See illustration next page)



RETRANS or Repeater System

The type of antenna and the terrain are two of the biggest factors that will influence VHF communications. The use of a simple ground plane type of antenna can dramatically improve your reception and your transmitted signal. When possible, always locate your CP or your antenna on the highest ground. If this is not possible try to mount your antenna up as high as is safely possible or practical. Remember line of site, the higher up the antenna is, the more it can "see".
VHF radio will work day in and day out all year long with very little concern for weather, time of day, and time of year. This is one reason that VHF has been the preferred system to use by police, rescue, and fire departments for years.

When we need to communicate greater distances, beyond line of site, to someone at the other end of the state or in the next county, HF radio must be used.
HF is used primarily for long-range BLOS (beyond line of site communications). While VHF signals travel primarily in a straight line, there are two principle paths by which HF signals can travel from a transmitter to a receiver. One is by groundwaves and the other is by skywaves. Skywaves can travel up to the ionosphere and are bent downward or refracted back to earth.
(See illustration next page)

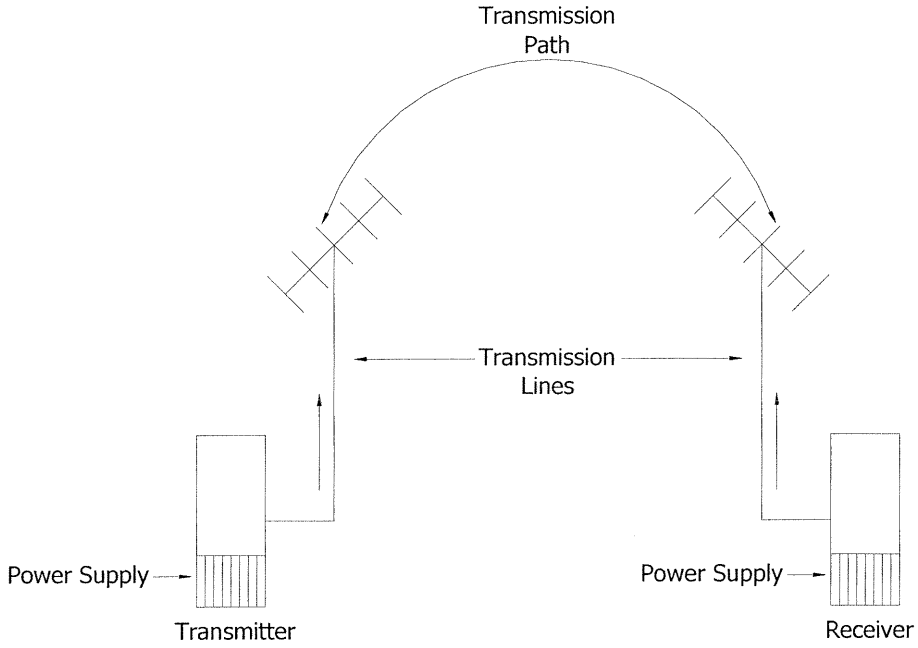


Sky waves can be used to communicate over great distances. Ground waves can be used for short distance HF work 0-50 miles.

HF systems are simple and easy to operate, but even with the best designed system the operator must continually adjust that system to compensate for an ever changing ionosphere and an ever-changing terrestrial environment (interference from other stations, atmospheric interference, manmade noise, etc.)
Despite the additional human effort required to make them work, HF radio systems are still vitally necessary to do some of the jobs that other systems cannot do, or at least cannot do economically. It is almost impossible to match the combination of simplicity, economy, transportability, and versatility of HF systems. HF can be used over almost any distance, and installed and dismantled quickly. Under ideal conditions 15 watts of transmitter power may be used to successfully communicate over thousands of miles.

Radio Communication Circuit:
With both VHF and HF radio systems the equipment for communicating between two stations including the path the radio signal follows through the air, is a radio link. A radio link consists of seven components: transmitter, power supply (or battery), transmission lines (coax), transmitting antenna, propagation path, receiving antenna, and receiver.
Some systems may also require the use of an antenna tuner to match the output characteristics of the radio to the characteristics of the antenna.

The transmitter generates a radio signal. The power supply provides power for the radio. The power supply can be a 115 volt unit, or a battery. The transmission line (coax) delivers the signal from the transmitter to the antenna. The antenna sends the radio signal into space towards the other station. The path in space that the radio signal follows as it goes to the other station is the propagation or transmission path. The antenna at the other station receives the signal and sends it through a transmission line (coax) to the radio. The radio than processes the signal so it can be heard.



Choosing the right antenna and matching its characteristics to the best transmission path are the two most important factors in setting up a communications circuit. The weakest link in the communications circuit is the wrong transmission path. The best transmitter, antenna, and receiver are of little use if the frequency is wrong or the transmission path is improper.

Antennas:

All radios, whether transmitting or receiving, require some sort of antenna. The antenna accepts power form the transmitter and launches it into space as a radio wave. At the receiving end of the circuit, a similar antenna collects energy from the passing radio wave and converts it into a signal that the receiving radio can detect. How well antennas send and receive radio signals directly influences communications reliability and quality.

When selecting the correct antenna there are certain things that must be taken into consideration. Antennas used for VHF do not work well for HF and vice versa.

VHF Antennas:

Vhf antennas are generally small and come in many variations. If your communications area is small, within 1-2 miles a simple mag-mount antenna (tuned for the frequency you are operating), mounted on a vehicle will work well. For communicating greater distances, a simple ¼ wave ground plane type antenna mounted up as high as practical will greatly increase communication range.

HF Antennas:

As stated before, HF can be used for local or long distance communications. If communications are going to be in an area of 0-30 miles, a vertical antenna can be used to take advantage of ground wave. Beyond this distance, the angle that the signal leaves a vertical antenna extends to the horizon to far and will "skip" over an area that communications needs to be established. For greater distances a standard dipole antenna cut to frequency or used with a tuner should be used. This is the antenna that will primarily be used for HF communications in the VaDF.

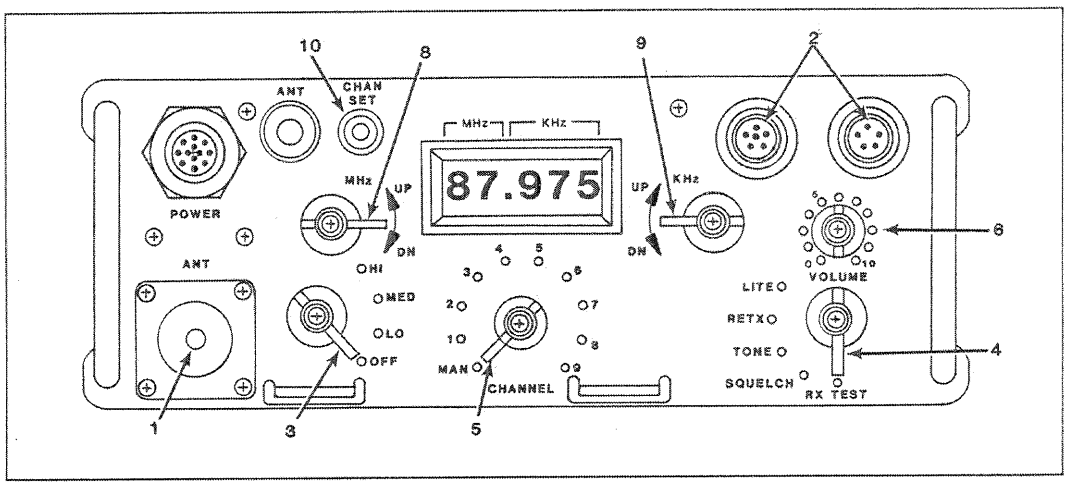
HF NVIS Communications:

For the type of HF communications that the VaDF does within the state, NVIS (Near Vertical Incidence Sky wave) techniques should be used. To communicate over the horizon to a station 100-300 miles away, operators should use NVIS. Using NVIS techniques, the signal will leave the antenna at a very high angle. To simplify how this works, imagine taking the nozzle on a garden hose and shooting the water at a 45 degree angle. The water lands quite a distance away form where it originated. Now take that same nozzle and shoot the water straight up in the air. When the water comes back down, it "rains" down in a circular pattern all around the point of origin. This is basically how NVIS communications work. The standard dipole antenna is mounted about 15' feet off the ground. This causes the signal to be reflected almost straight up and our signal "rains" down in the "skip" zone. NVIS communications is extremely reliable for use where HF communications will be in about a 300-500 mile radius. The nearly vertical angle of radiation also means that lower frequencies must be used. NVIS communications uses frequencies up to about 8 MHz. When using NVIS techniques the frequency selection is very critical and must be below the Maximum Usable Frequency (MUF). MUF is the highest frequency that can be used before a signal will not reflect off the ionosphere.

Field Expedient Antennas:

There are two primary types of radios that will be used in the VaDF. For VHF communications the PRC1077 will be used for base and limited mobile. For squad level communications the Motorola HT750 (handheld) will be used. For HF communications the PRC1099 and the companion "suite case" will be used.

CONDENSED OPERATING INSTRUCTIONS FOR RADIO SET PRC1077



The numbers on the diagram refer to the steps below.

A. TO OPERATE SET

(1) Install the antenna required for the type of operation in the antenna mount.

(2) Attach the handset to either audio connector.

(3) Turn the power switch to the power level for the type of operation. (HI gives maximum range.)

(4) Turn the function switch to RX TEST.

(5) Select the desired channel number.

(6) Turn the VOLUME control to 5.

(7) Press the handset push-to-talk switch and talk into the handset. Release the switch to listen.

(6) Adjust VOLUME control (6) for desired sound level.

(4) To stop the rushing noise when no signal is being received, turn the FUNCTION switch (4) to either SQUELCH or TONE according to the type of operation. TONE should always be selected for operation with PRC77's or other tone-operated radio receivers.

B. TO CHANGE CHANNEL FREQUENCIES

(5) Set the control (5) to MAN.

(8) Turn the MHz switch (8) UP or DOWN to select the Megahertz. (First two digits of the frequency.)

(9) Turn the kHz switch (9) UP or DOWN to select the Kilohertz. (Last three digits of the frequency.)

(10) To change the frequencies of channels 1-9, set the control (5) to the desired channel number. Repeat the previous two steps while depressing the CHAN SET button (10).

C. TO TURN SET OFF

(3) Turn the power switch (3) to off.

D. MEMORY DUMP FEATURE

1. Turn the radio off.
2. Hold the CHAN SET (10) button in, hold the MHZ (8) switch up, switch the radio on.
3. This will erase all memory channel frequencies.

NOTE - MAGNESIUM BATTERIES

1. The magnesium battery BA-4386/U does not deliver full power immediately. If the receiver does not operate immediately, wait for 30-60 seconds for the battery to produce sufficient output voltage. In the transmit mode, the battery output may fall below the operating level when the push-to-talk switch is depressed. Wait at least 10 seconds before speaking to ensure the battery has recovered. Full output power may not be reached for 30-60 seconds.
2. Remove the battery from battery box CY-2562 when the PRC1077 is not in use.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1-1. Scope

a. This manual describes radio set PRC1077 and covers its installation, operation, and operator's organizational maintenance.

b. Items comprising an operable equipment (Para. 1-6).

c. Information on the technical service and maintenance of the PRC1077 is contained in the technical manual TW-PRC1077-MS1.

Section II. DESCRIPTION & DATA

1-2. Purpose and Use (Figure 1-1)

a. Radio set PRC1077 is a short-range, manpack-portable, frequency-modulated (FM) transceiver used to provide two-way, radiotelephone, voice communication.

b. The radio set PRC1077 may also be used as part of radio sets VRC-64 and GRC-160.

c. The radio set PRC1077 can communicate with most military FM radios operating within the 30- to 88-MHz range.

d. The PRC1077 can be used in conjuction with the other equipment—(1) through (8) below.

(1) Antenna equipment RC-292 can be used in place of the whip antennas to extend the communication range.

(2) The PRC1077 can be used for radio relay use in conjunction with another PRC1077 by means of the Retransmission Cable Kit MK-456/GRC.

(3) The PRC1077 may be used in conjuction with a repeater, or two PRC1077's may be used as a repeater, for extended range operation. The PRC1077 is operated in the semi-duplex mode for operation through a repeater.

(4) Remote control of the PRC1077 can be provided by radio set control groups GRA-39 or GRA-6.

(5) Radio/wire integration (RWI) operation with the PRC1077 and remote telephone facilities can be provided by radio set control GSA-7 with oscillator O-574/GRA or the GRA-39 and GRA-6.

(6) The PRC1077 can be used with antenna, homing loop AT-784/PRC for detection and location of homing beacons or other FM radios.

(7) The PRC1077 can be used with antenna AT-984A/G, a long-wire, multiple-wavelength antenna, to extend the transmission and reception ranges.

(8) Loudspeaker, electromagnetic LS-549/PRC can be used with the PRC1077 to monitor radio reception.

(9) The PRC1077 can be used with many types of secure voice equipment.

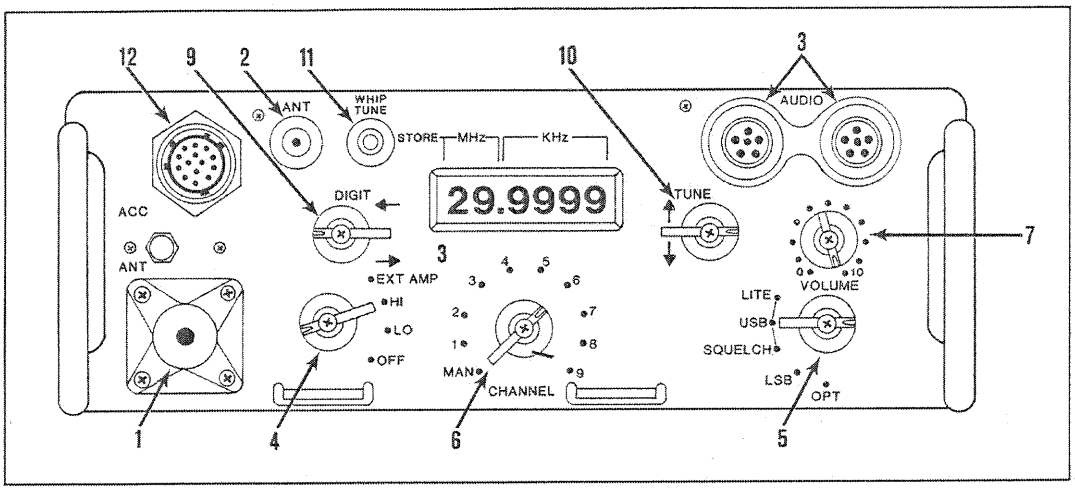
(10) The PRC1077 can be used for digital data transmission and reception.

1-3 Technical Characteristics

Frequency Range:	30-87.975 MHz.
Number of Channels:	2,320.
Memory Channels:	10.
Channel Spacing:	25 kHz.
Types of Transmission and Reception:	
Transmission - Voice (300-3,500 Hz) and 150-Hz squelch tone (selectable is optional).	
Reception: - Voice - no squelch, noise squelch or 150-Hz tone squelch (selectable).	
Security or Digital Data Equipment:	Wideband 200-20,000 Hz.
Transmission and Reception Power Requirements:	
Transmission-10-15 Vdc	
High Power	1.6 A.
Medium Power	1.1 A.
Low Power	800 mA.
Reception	10-15 Vdc 60 mA.
Type of Modulation:	Frequency.
Transmitter Power Output:	Selectable: 0.3 W, 2 W, 5 W.
Type of Squelch:	Tone operated by 150-Hz signal or noise operated.
Distance Range:	5 miles (8 kilometers) (varies with conditions).
Types of Antennas:	
Short Antenna:	Antenna AT-892/U, 3-ft. long, semirigid steel tape.
Long Antenna:	Antenna AT-271A/U, 10-ft. long, multisection whip.
Power Source:	Battery, dry BA-4386/U or BA-398/U; or Sealed lead-acid, or NiCad.
Battery Life:	High Power 60 hours (9:1 receive-transmit ratio) (BA4386/U).

For further information, refer to TW-PRC1077-MS1 Technical Manual.

CONDENSED OPERATING INSTRUCTIONS FOR RADIO SET PRC1099



1. TO OPERATE SET

A. Install the whip antenna in the antenna socket (1) OR attach 50-ohm antenna feedline to BNC antenna connector (2).
B. Attach the handset to either audio connector (3). NOTE: Remote handset attaches to the right audio connector only.
C. Turn the power switch (4) to the power level for the type of operation desired. (HI gives maximum range.)
D. Turn the function switch (5) to USB.
E. Select the desired channel number (6). NOTE: Front-panel CHANNEL switch must be in "MAN" to use remote channel switch.
F. Turn the VOLUME control (7) to 5.
G. Press the handset push-to-talk switch and talk into handset. Release to listen.
H. Adjust volume control (7) for desired sound level.

2. TO RETUNE ANTENNA

A. Depress the WHIP TUNE (11) button (Do not hold down). The antenna-tuning information is updated and stored in memory.

3. TO CHANGE CHANNEL FREQUENCIES

A. Set CHANNEL switch (6) to "MAN".
B. Turn the DIGIT switch (9) UP or DOWN to select the desired digit. The selected digit will flash.
C. Turn the TUNE switch (10) UP or DOWN to select the correct number.
D. To change the frequencies in channels 1-8, set the control (6) to the desired channel number, press and hold the store button and repeat steps 3A-3C.

4. MEMORY DUMP FEATURE

A. Turn the radio off.
B. Hold the WHIP TUNE (11) button in, hold DIGIT Switch (9) up, switch the radio on.
C. This will erase all memory and channel frequencies.

5. SCAN CHANNEL FEATURE

A. To enable Scan, hold the DIGIT switch (9) up until a two-digit number is displayed, enter the number of channels you want to scan by using the TUNE switch (10).

6. TRANSADAPT OPTION OPERATION

A. To install Selcall Code, hold the DIGIT switch (9) down until a three-digit number is displayed, enter the code using the TUNE switch (10).
B. To enter TRANSADAPT Mode 1, hold DIGIT switch (9) down and press WHIP TUNE (11).
C. To enter TRANSADAPT Mode 2, select channel 9, hold DIGIT switch (9) and press WHIP TUNE (11).

NOTES

1. LOW BATTERY - Display flashes.
2. ACCESSORY CONNECTOR (12) - Cap must be connected whenever accessory connector is not in use.
3. RF OUTPUT NORMAL - Transmit sidetone is heard.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1-1. Scope

a. This manual describes Radio Set PRC1099 and covers its installation, operation, and operator's organizational maintenance.

b. Items comprising an operable equipment (Para. 1-6).

c. Information on technical service and the maintenance of the PRC1099 is contained in the technical manual TW-PRC1099-MS1.

Section II. DESCRIPTION & DATA

1-2 Purpose and Use (Figure 1-1)

a. Radio Set PRC1099 is a high-frequency, manpack-portable, single-sideband (SSB) transceiver used to provide long-range, two-way, voice, CW, and data communication.

b. The Radio Set PRC1099 may also be used as part of the Transworld RA100, RA400/5 or RA1000/5 high power fixed, portable and mobile stations.

c. The Radio Set PRC1099 can communicate with most HF SSB radios operating within the 1.6- to 30-MHz range.

d. The PRC1099 can be used in conjunction with the other equipment (1) through (8) below.

(1) Long-wire antennas can be used in place of the whip antennas, using the internal tuner to extend the communication range.

(2) Coaxial-fed 50-ohm antennas such as resonant dipoles, broadband antennas and directional antennas can be used in place of the whip antenna for extended range, or where directional transmission/reception is desired.

(3) The antenna tuner RAT100 can be used with the PRC1099 in mobile installations and other applications where the antenna must be located away from the transceiver.

(4) The PRC1099 can be operated from the ac power supply PRC-PS in place of the internal battery.

(5) The PRC1099 can be used with high power amplifiers RA100 (100 W), RA400/5 (400 W), or RA1000/5 (1000 W) and can provide automatic control of these amplifiers.

(6) Remote control of the PRC1099 can be provided by radio set control groups GRA-39.

(7) Loudspeaker, electromagnetic LS-549/PRC can be used with the PRC1099 to monitor radio reception.

(8) The PRC1099 can be used with the morse key KY562 for telegraphy.

(9) The PRC1099 can be used with secure voice equipment designed for HF SSB operation.

(10) The PRC1099 can be used for digital data (burst or RTTY) transmission and reception.

1-3. Technical Characteristics

Frequency Range: 1.6-30 MHz.

Number of Channels: 284,000.

Memory Channels: 10.

Channel Spacing: 100 Hz.

Types of Transmission and Reception:

Transmission -	Voice - (300-2700 Hz) SSB, USB/LSB.
	CW - semi break-in.
	Data - with external modem.
Reception -	Voice - (no squelch, noise immune squelch).
	CW
	Data - with external modem.

Security Equipment: Equipment must be designed for HF/SSB.

Transmission and Reception Power Requirements:

Transmission -	12.0 - 15 Vdc.
	High Power - Avg. voice 1.5 A.
	Low Power - Avg. voice 1.0 A.
Reception -	12.0 - 15 Vdc.
	Squelched 100 mA typical.
	Unsquelched 130 mA typical.

Type of Modulation: Single Sideband - USB/LSB.

Transmitter Power Output: Selectable - 5 W, 20 W.

Type of Squelch: Noise immune.

Types of Antennas:

Whip Antenna -	Antenna AT-271A, 10-ft long, multisection whip with AB591 Flexible Support.
Long Wire -	25-ft, 50-ft, 100-ft or random length long wire.
50-Ω Antenna -	50-Ω coaxial fed antennas with VSWR 3:1 or less.

Power Source:

Lithium battery, sealed lead-calcium battery (rechargeable), or PRC-PS ac power supply.

Battery Life:

High power 50 hours (9:1 receive-transmit ratio) with BA6598/U.

1-4. Items Used with PRC1099 (Figure 1-2)

The following components are normally used with the PRC1099 in the manpack configuration. Dimensions and

Safety:

Be aware of all overhead wires at all times. Never install antennas where they will come into contact with any overhead electrical service. **THEY WILL KILL YOU.** When installing antennas, remember to keep them at least twice the distance of the tallest component of your antenna system away form any overhead electrical wires. Example: If the tallest part of your supporting structure is 20 feet and there are overhead electrical wires nearby, place your antenna system a minimum of 40 feet away form the electrical wires, more if possible.