SECTION 3 OPERATION

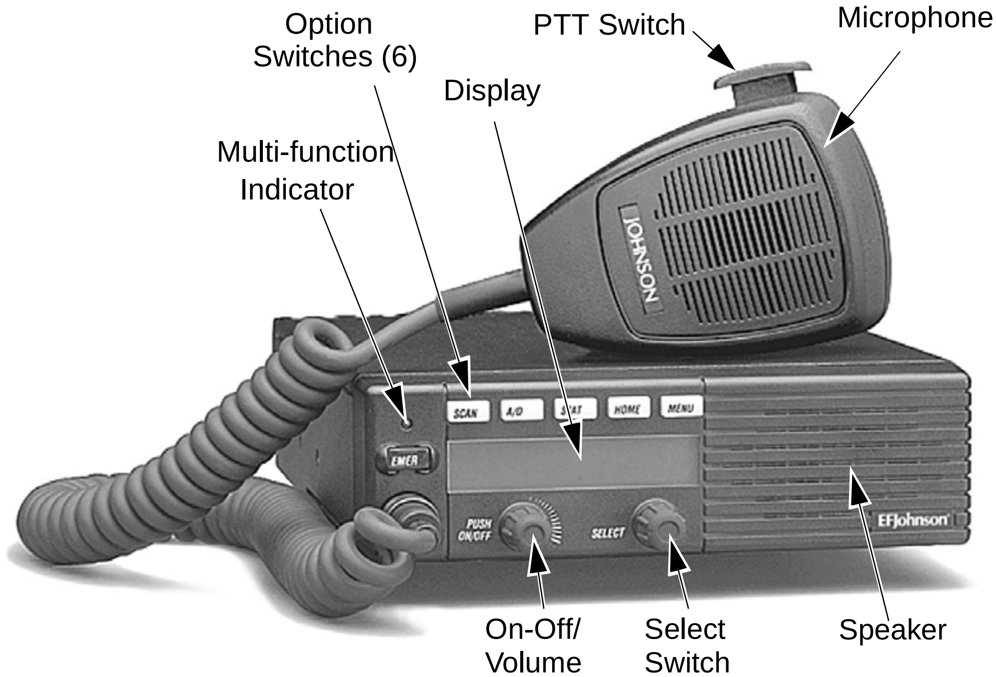


Figure 3-1 Front Panel Controls

3.1 FEATURES

3.1.1 GENERAL FEATURES

- Each channel is programmable for one of the following operating modes:
  – Conventional analog or Project 25 (digital)
  – SMARTNET™/SmartZone® trunked analog or Project 25 (digital)
- Up to 16 zones with up to 16 channels each programmable (256 channels total)
- Large liquid crystal display (LCD) with backlight
- Six option switches that can be programmed with a different function for each operating mode (conventional and SMARTNET)
- User selectable high and low power output
- Standard scan mode
- Operation on both narrow and wideband channels
- Time-out timer

3.1.2 CONVENTIONAL FEATURES

- Each channel selects a different radio channel and squelch coding
- Repeater talk-around
- Normal/Selective squelch selected by microphone hanger or option switch
- Carrier, tone (CTCSS), or digital (DCS) controlled Call Guard® squelch on analog channels. NAC and group IDs on Project 25 channels
- Penalty and conversation timers
- Priority channel sampling when scanning
- Busy channel lockout (transmit disable on busy)
- ANI (Automatic Number Identification)
- SecureNet™ secure communication available on analog channels or SecureNet DES-OFB on Project 25 channels
- Individual ID calls on Project 25 channels
- Emergency switch

3.1.3 SMARTNET/SMARTZONE FEATURES

- Channels select talk groups
- Private and telephone* calls
- Emergency alarms to alert dispatcher of emergency conditions
- Emergency calling for high priority system access
- Failsoft* operation on a predefined conventional channel if trunked system fails

Available with future release. *Contact your EFJohnson account manager for more information.*

- Priority group calls detected while listening to other group calls
- Call alert (send and receive pages)
- Predefined messages (up to 16) can be sent to a dispatcher
- Predefined status conditions (up to 8) can be sent to a dispatcher
- Dynamic regrouping* (dispatcher can automatically gather users on a channel to receive a message)
- Roaming (SmartZone only)
- SecureNet™ secure communication available on analog channels, SecureNet DES-OFB available on Project 25 channels

NOTE: The availability of many of the preceding features is controlled by transceiver programming (see Section 4) and the capabilities of the radio system being accessed.

3.2 CONTROLS AND DISPLAY

NOTE: The controls and indicators described in the following information are shown in Figure 3-1.

3.2.1 FRONT PANEL CONTROLS

On-Off/Volume - Pressing this control turns power on and off, and rotating it sets the volume level.

Select Switch - Selects zones/channels and is also used for other functions such as selecting names from a call list. When selecting zones/channels, a bar above the zone or channel display indicates which is currently being changed (see Figure 3-3). To switch this bar between displays, press this switch, and to select zones or channels, rotate it (see Section 3.3.6).

Multi-function Indicator - This is a two-color LED that indicates the following:

Red (constant) - Transmitter keyed (PTT switch pressed).
Green (constant) - Busy condition (carrier detected in receive mode).

Option Switches - Each of the six options switches on the front panel (including the one located to the left of the display) can be programmed to control a function. Different functions can be programmed for each operating mode (conventional and SMARTNET). Therefore, up to 12 different functions can be programmed. Refer to Section 3.4.1 for more information.

Speaker - An internal 16-ohm, 5-watt speaker is located behind the grille. An optional 4-ohm, 12-watt external speaker may be used if desired. The internal speaker is disabled when an external speaker is used.

PTT Switch - This push-button switch on the microphone is pressed to talk (key the transmitter) and released to listen.

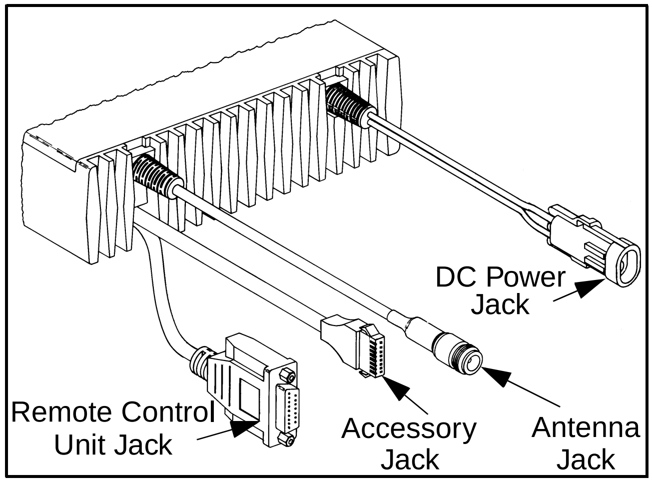


Figure 3-2 Rear Panel Jacks

3.2.2 REAR PANEL JACKS

DC Power Jack - Connection point for a nominal 12-volt, negative ground power source (see Figure 3-2).

Antenna Jack - Type N jack for connecting the 50-ohm antenna.

Accessory Jack - Black connector for connecting optional accessories such as an external speaker and ignition sense line (see Section 2.4).

Remote Control Unit Jack - Connection point for a remote control unit or handheld control unit (if used). This cable is optional with front-mount models.

Siren Control Jack (Not Shown) - Yellow/orange connector similar to accessory jack for connecting siren controller (if used).

**** Available with future release.*** *Contact your EFJohnson account manager for more information.*

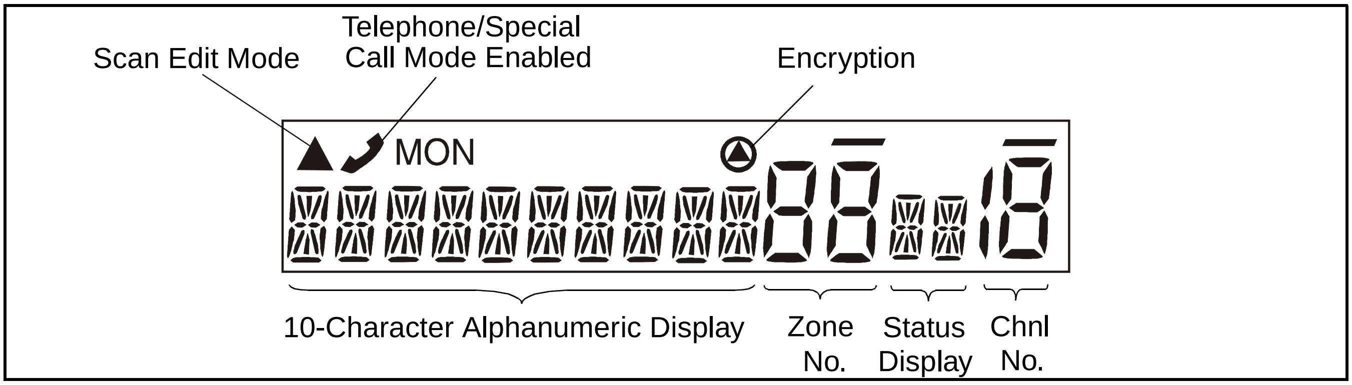


Figure 3-3 Front Panel Display

3.2.3 DISPLAY

Zone Number - Indicates the currently selected zone from 1 up to 16 (see Figure 3-3). A zone is a collection of channels that can be any combination of the conventional and SMARTNET/SmartZone types (see Section 1.2.4).

Channel Number - Indicates the currently selected radio channel (conventional) or talk group (SMARTNET/SmartZone).

Alphanumeric Display - This 10-character area of the display indicates the alias (alpha tag) for the selected channel. It may also display other information such as the channel frequency (conventional) if certain option switches are programmed. It also displays various status and error messages.

Status Display - These two characters indicate the following status information:

- This symbol in the left position indicates that the displayed channel is in the scan list (scanned normally).

- A "P" in the left position indicates that the selected conventional channel is a priority channel.

- This rotating clock-like symbol in the right position indicates that scanning is enabled.

- Indicates that the scan list edit mode is selected (see Section 3.5.11).

- Indicates that a SMARTNET/SmartZone telephone call* has been initiated. It is non-functional in the conventional mode.

- Indicates that voice encryption is enabled.

MON - Indicates that the conventional monitor mode is enabled by taking the microphone off-hook or pressing the MON switch (if available). This mode disables squelch control features so that all messages are heard on the channel (see Section 3.5.3).

- The line above the zone and channel displays indicate which display is changed if the Select switch is turned. To switch this line between displays, press the Select switch (see Section 3.3.6).

3.3 GENERAL OPERATION

3.3.1 TURNING POWER ON

Turn power by pressing the On-Off/Volume knob. The multi-function indicator then flashes green, a series of beeps sound, and an initial greeting is indicated by the alphanumeric display. The zone and channel displays then indicate the currently selected zone and channel. Programming determines if the last selected or home zone is selected at power up.

3.3.2 POWER-UP PASSWORD

The power-up password feature prevents unauthorized use of the transceiver. When it is enabled by system operator programming, an eight-digit password must be entered each time transceiver power is turned on. In addition, since the logic resets each time programming data is read or written, it must be entered after performing those functions.

If this feature is enabled, “LOCKED” is displayed when power is turned on. The eight-digit numeric password is then entered by rotating and pressing the Select switch.

With this transceiver, this password can be changed only by the PCConfigure programmer (see Section 4). It cannot be changed by the user. If it is forgotten, all programming must be erased to make the transceiver operational again. This is done using the “EEPROM Erase” function of the PCTune program (see Section 6.3.3).

3.3.3 BACKLIGHT

The backlight for the display and option keys can be programmed to automatically turn on at high or medium brightness levels with transceiver power or it can be disabled. If the Backlight option switch is programmed, the user can manually select “High”, “Med”, or “Off”.

If the display is difficult to read, the viewing angle can be adjusted as follows: While pressing and holding the last option switch above the display, press the first option switch above the display and then release both switches. Turn the Select switch for best contrast. This function times out in 3-5 seconds.

NOTE: If the display appears blank or if all icons are always displayed, this adjustment may be at the end of its adjustment range.

3.3.4 SETTING VOLUME LEVEL

The relative volume setting can be determined by noting the index on the On-Off/Volume knob. Otherwise, a reference tone can be enabled as follows:

- If the key press tones are enabled (see Section 3.4.6), a short tone sounds when an option switch is pressed or the Select switch is pressed or rotated.

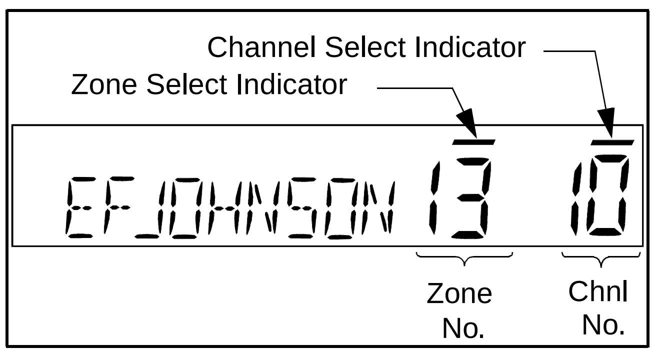
- If a conventional channel is selected, take the microphone off-hook and if someone is talking, voice is heard. If the Monitor option switch is programmed (see Section 3.5.3), pressing it unsquelches the transceiver and either voice or background noise is heard. If a SMARTNET/ SmartZone channel is selected, the transceiver cannot be manually unsquelched.

3.3.5 ZONE/CHANNEL DISPLAY

The selected zone and channel are displayed by the zone and channel displays shown in Figure 3-3. In addition, the unique alphanumeric identification (alias) programmed for the channel is displayed in the alphanumeric display area. With conventional operation, the channel frequency may be displayed (see Section 3.5.9). Refer to Section 1.2.4 for more information on zones and channels.

3.3.6 ZONE/CHANNEL SELECT

The front panel Select switch is used to change the zone and channel. Pressing this switch toggles between the zone and channel select modes, and rotating it changes the zone or channel.



Select Mode Indicators

The current select mode is indicated by the bar over the zone or channel display (see above). For example, when the bar is over the zone display, rotating the Select switch changes the zone number. Rotating this switch clockwise increases the zone or channel and rotating it counterclockwise decreases the zone or channel. After the highest zone or channel is displayed, wrap-around to the lowest zone or channel occurs and vice versa.

The transceiver can be programmed so that the bar defaults to either the zone or channel display when power is turned on and after a change is made. The delay that occurs before it returns is programmable for

1-15 seconds or infinite (“infinite” causes it to remain in the last selected mode).

When an unprogrammed (inactive) channel is selected, “UNPROGRAMD” is displayed and a tone sounds. The transceiver can be programmed so that only active channels are displayed. This indication then does not occur.

3.3.7 SETTING SQUELCH

This transceiver does not have a squelch control, and the squelch level is preset during alignment. The level set for each channel can be changed by keypad programming if desired (see Section 3.8).

3.3.8 TRANSCEIVER OPERATING MODES

Each selectable channel can be programmed for any of the following modes. For example, Zone 1/ Channel 1 could be a conventional channel, Zone 1/ Channel 2 a SMARTNET channel, and so on. Refer to Section 1.2.4 for more information on systems, channels, and zones.

Conventional - This is a non-trunked operating protocol which accesses independent radio channels (there is no automatic access to several channels). Selecting a conventional channel selects a transmit and receive frequency and other channel parameters such as squelch control coding.

Conventional channels can be either standard (analog) or Project 25 (digital). With digital operation, the DSP (Digital Signal Processor) converts the audio signal to digital data which is sent over the air as complex tones. Another difference is that analog channels use Call Guard (CTCSS/DCS) squelch control and Project 25 channels use a NAC (Network Access Code) and talk group ID codes. With NAC, a number similar to an ID code is transmitted, and for communication to occur, it must match one programmed in the base equipment and the mobile(s) being called. In addition, to receive standard group calls, the receiving mobile(s) must be programmed to detect the transmitted ID code.

With conventional operation, a busy channel condition is detected automatically if the busy channel lockout (transmit disable on busy) feature is programmed. Otherwise, it must be detected manually. An out-of-range condition is not indicated by special tones or messages as with SMARTNET operation because there is no initial data exchange with the repeater that allows this condition to be detected. Operating features unique to conventional channels are described in Section 3.5.

SMARTNET/SmartZone - This is a Motorola trunked protocol. Talk group ID codes are used to select what mobiles are being called and what calls are received. Monitoring is also performed automatically and special messages and tones indicate busy and out-of-range conditions.

SMARTNET and SmartZone operation and programming is very similar. Basically, SMARTNET operation is limited to a single repeater site and SmartZone operation allows automatic roaming between sites.

Enhanced features available with this protocol include telephone*, private, and emergency calls, call alert, messaging, and emergency calls. Either analog or digital (Project 25) signaling may be selected for each talk group. SecureNet™ secure communication is available with analog channels, and DES-OFB is available with digital channels. Operating features unique to SMARTNET/SmartZone channels are described in Section 3.6.

3.4 RADIO-WIDE FEATURES

3.4.1 OPTION SWITCHES

The six option switches on the front panel (including the one to the left of the display) can be programmed to control different functions for each operating mode. Therefore, up to 12 different functions can be controlled by these switches (six each for conventional and SMARTNET/SmartZone channels) The functions controlled in each mode and the section in which the function is described are shown in Table 3-1.

3.4.2 TIME-OUT TIMER

The time-out timer disables the transmitter if it is keyed for longer than the programmed time. It can be programmed for 15 seconds to 3 minutes, 45 seconds or it can be disabled. If the transmitter is keyed for longer than the programmed time, the transmitter is

Table 3-1 Programmable Option Switch Functions

Suggested Key Label	Function	Available in Mode:				See Descript. in Section:
		Conv.	Proj 25 Trk	SMARTNET	SmartZone	
TONES	Alert tones On-Off	X		X	X	3.4.6
BKLHT	Backlight On-Off	X		X	X	3.3.3
ALERT	Call Alert Select			X	X	3.6.7
RESP	Call Response Select			X	X	3.6.5
C/S	Clear/Secure Select	X		X	X	3.4.8
DISP	Displayed Information Select	X				3.5.9
EMER	Emergency Select	X		X	X	3.5.10, 3.6.10
HOME	Home Zone Select	X		X	X	3.4.3
	Key Select	X				3.4.8
PROG	Keypad Programming Select	X				3.8
MSG	Messaging			X	X	3.6.8
MON	Monitor Mode Select	X				3.5.3
SEL SQ	Normal/Selective Select	X				3.5.5
PHONE	Phone Call Select*			X	X	3.6.6
CALL	Private Call Select			X	X	3.6.5
	Remote Access (Pyramid Reptr)	-	-	-	-	-
RWS	Radio Wide Scan Select*	X		X	X	3.4.7
RTA	Repeater Talk-Around Select	X				3.5.8
SCAN	Scan Select	X		X	X	3.4.7
SCN ED	Scan Edit Select	X		X	X	3.4.7
	Scan List Select		X	X	X	3.4.7
SEL SQ	Selective Squelch Code Select	X				3.5.5
LOCK	Site Lock Select				X	3.6.14
SEARCH	Site Search Select				X	3.6.14
STATUS	Status Select			X	X	3.6.9
TG SEL	Talk Group Select	X				3.5.15
TX PWR	Transmit Power Select	X		X	X	3.4.5
CALL	Unit Call Select	X				3.5.15
-	Unprogrammed (not used)	X	X	X	X	-

disabled, a continuous tone sounds, and “TX TIMEOUT” is displayed. Five seconds before time-out occurs, a warning beep sounds to indicate that time-out is approaching. The timer and tone are reset by releasing the PTT switch. A different time can be programmed for each system, and the timer can be enabled or disabled on each channel.

3.4.3 HOME ZONE SELECT

If the Home Zone option switch is programmed, it can be used to quickly select the preprogrammed home zone. The transceiver also can be programmed so that when power is turned on, either the home or last selected zone is automatically selected.

3.4.4 POWER TURN-OFF DELAY

The transceiver can be installed so that the vehicle ignition switch as well as the front-panel power switch controls transceiver power. This is done by connecting the accessory ignition switch wire to a power source switched by the ignition switch (see Section 2.4.3). Power off delays of 0-254 minutes or Forever can then be programmed. This delay can be overridden at any time by turning power off using the front-panel power switch or turning the ignition switch back on.

A turn-off delay allows the radio to remain active for the programmed delay time after the ignition switch is turned off. At the same time, advantages of ignition switch control can be utilized such as preventing battery discharge that may occur if the transceiver is accidentally left on for an extended period.

3.4.5 POWER OUTPUT SELECT

Each conventional channel and SMARTNET/ SmartZone system can be programmed for high, low, or switchable power. If the High/Low Power option switch is programmed and selectable power is programmed on the current channel or system, high and low transmitter power can be selected. All models support high/low power.

Pressing this switch toggles the power setting. The new level is flashed in the display when this switch is pressed as either “HIGH POWER” or “LOW POWER”. If selectable power is not permitted on the current channel, the programmed power level is flashed and no power change occurs. The selected power level for a channel is permanent until it is manually changed again.

3.4.6 TONE SELECT

The various alert tones that sound are described in Section 3.7. To toggle all these tones on and off, press the Alert Tones option switch. When all tones are off, “TONE OFF” is momentarily displayed, and when all tones are on, “TONE ON” is momentarily displayed. If this switch is not programmed, tones are fixed in the on or off mode by programming.

3.4.7 SCANNING

Introduction

Scanning monitors the channels in the scan list for messages that the transceiver is programmed to receive. When a message is detected, scanning stops and the message is received. Shortly after the message is complete, scanning resumes (unless it has been disabled).

If the microphone off-hook condition is detected (Hangup Box Monitor is selected by programming), scanning stops, and selective squelch (such as CTCSS or NAC/group ID detect) is disabled on conventional channels. If the off-hook condition is not detected, taking the microphone off-hook has no affect on transceiver operation.

NOTE: With early versions of the software, taking microphone off-hook does not halt scanning even if Hangup Box Monitor is enabled.

There are two basic scan modes available: Standard and Radio Wide*. The operation of the standard type is unique to the type of channel selected, and the operation of Radio Wide type is the same regardless of the type of channel selected. Only one type can be enabled at a time. For example, if standard scanning is enabled and radio wide scanning is selected, standard scanning is automatically disabled and vice versa. More information on these types of scanning follows.

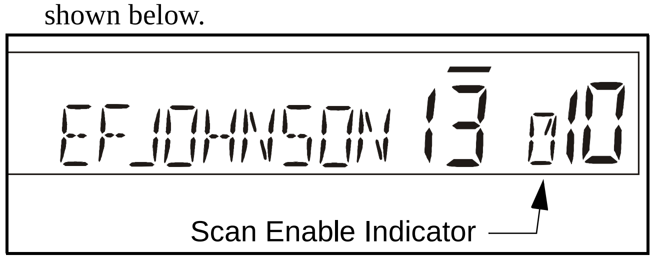
Standard Scanning

Standard scanning monitors only channels that are the same type as that currently selected. Therefore, if a conventional channel is selected, only conventional channels are scanned, and if a SMARTNET channel is selected, only SMARTNET channels are scanned. More information on how standard scanning operates in these modes is located in the following sections:

Conventional Mode Scanning - Section 3.5.11
SMARTNET Mode Scanning - Section 3.6.12

Standard scanning is turned on and off by the Scan option switch as follows. If this switch is not programmed, standard scanning is not available.

- Press the Scan option switch. Scanning is enabled when “SCAN ON” is briefly displayed and a rotating is indicated in the right status display as shown below.



- To turn scanning off, press the Scan option switch again. On conventional channels, this may also select another scan list, so several presses may be required (see Section 3.5.11). Scanning is disabled when "SCAN OFF" is briefly displayed and is no longer indicated in the status display.

- If the zone or channel is changed while scanning is selected, scanning continues on the same or a different scan list (see "Standard Mode Scan List" which follows).

<u>Radio Wide Scanning*</u>

NOTE: The radio wide scan feature is not fully implemented in this radio and therefore should not be used.

NOTE: Use radio wide scanning only if conventional and SMARTNET/SmartZone channels need to be scanned at the same time. Otherwise, use the more efficient standard scanning because there is less chance of missed calls.

Radio wide scanning monitors the channels in the radio-wide scan list. This scan list can include up to 16 channels of any type and assigned to any zone (see "Scan Lists" which follows). Radio wide scanning is turned on and off by the Radio Wide Scan option switch as follows. If this switch is not programmed, radio wide scanning is not available.

- To turn radio wide scanning on, press the Radio Wide Scan option switch and "RSCN ON" is briefly displayed. In addition, is displayed the same as with standard scanning.

- To turn radio wide scanning off, press the Radio Wide Scan option switch again and "RSCN OFF" is briefly displayed and is no longer displayed.

- If the zone or channel is changed while radio wide scanning, scanning continues normally.

<u>Scan Resume Delay</u>

When a message is received or transmitted while scanning, there is a delay before scanning resumes. The delay after receiving a call prevents another message from being received before a response can be made. The delay after transmitting a call ensures that a response is heard instead of another message occurring on some other channel.

Separate delay times are programmable for radio wide and standard scanning. With radio wide and conventional standard scanning, delays of 0-7.5 seconds are programmable in 0.5-second steps. With SMARTNET/SmartZone standard scanning, if active talk back scan is programmed, a delay of 2-10 seconds can be programmed in 0.5-second steps.

<u>Transmitting in the Scan Mode</u>

If the transmitter is keyed while scanning is enabled, transmissions occur on various channels as follows.

Conventional Operation - Transmissions can occur on the priority, selected, or receive channel. Refer to Section 3.5.11 for more information.

SMARTNET/SmartZone Operation - If scanning is halted to receive a message, programming determines if transmissions occur on the selected or receive channel. Transmissions at other times occur on the selected channel.

<u>Standard Mode Scan Lists</u>

NOTE: The selected channel is always scanned.

With both conventional and SMARTNET/SmartZone operation, each scan list can be programmed with up to 256 channels/talk groups. As many scan lists can be programmed as can be stored in the available memory.

Other conventional operation is as follows:

- Scan lists are selected by the Scan option switch as described in Section 3.5.11. Selecting another channel does not change the selected scan list.

- The scan lists are user programmable if the Scan Edit option switch is programmed (see description which follows).

With SMARTNET/SmartZone operation, each scan list is programmed with up to 256 talk groups from the current system. As many scan lists can be programmed as can be stored in the available memory. Other operation is as follows:

- Each channel is programmed to automatically select one of the scan lists and also enable scanning if desired (Auto Scan). Each channel can also be programmed so that scanning is disabled (No List).

- Scan lists are user programmable if the Scan Edit option switch is programmed (see description which follows).

- Scan lists are user selectable if the Scan List Select option switch is programmed. This switch can be used to temporarily change the scan list for all talk and announcement groups in the current system. Refer to Section 3.6.12 for more information.

Radio Wide Mode Scan List

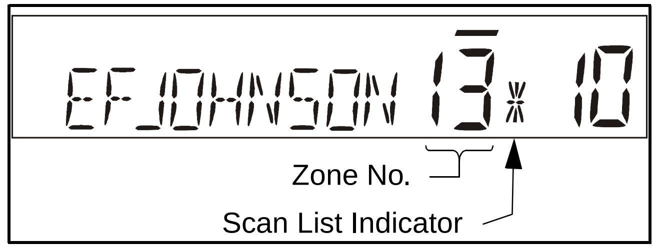
With radio wide scanning*, there is only one scan list available regardless of the type of channel selected. This scan list can contain up to 16 channels of any type. For example, it could include six conventional channels and ten SMARTNET/SmartZone channels.

Determining Which Channels are in Scan List

The channels in the radio-wide and conventional scan lists are indicated as follows. Channels in the SMARTNET/SmartZone lists are indicated only when editing a scan list.

1. To view the conventional scan list, enable standard scanning by pressing the Scan switch. Likewise, to view the radio wide scan list, enable radio wide scanning by pressing the Radio Wide Scan switch. With conventional scanning which can have several lists, also select the scan list if applicable (see Section 3.5.11).

2. Select the desired zone and then scroll through the channels by rotating the Select switch. When the displayed channel is in the scan list (scanned normally), the symbol is displayed next to the zone number as follows.



Nuisance Channel Add/Delete

With standard scanning, both conventional and SMARTNET/SmartZone channels can be temporarily deleted from the scan list, for example, if messages become annoying. This feature is not available with radio wide scanning. Channels can also be permanently added or deleted by editing the scan list (see “Programming a Scan List” which follows). Proceed as follows to temporarily delete a channel:

NOTE: The selected channel and also conventional priority channels cannot be deleted from the scan list.

1. While receiving a message on the channel to be deleted, press and hold the Scan option switch until a tone sounds (about 2 seconds).

2. The channel is then deleted and scanning of the remaining channels in the scan list resumes.

3. Deleted channels are added back into the scan list if any of the following occur:

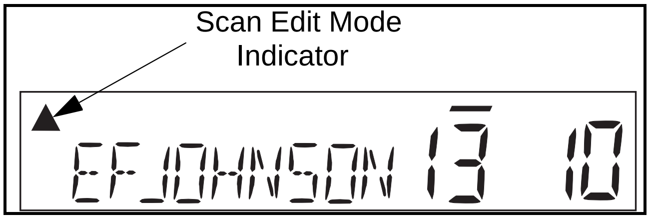
   - Scanning is turned off and then on again using the Scan option switch.
   - Transceiver power is turned off and then on again.
   - The selected channel is changed.

Programming a Scan List

If the Scan Edit option switch is programmed, conventional and SMARTNET/SmartZone standard scan lists can be user programmed as follows. Changes are permanent (cycling power does not reselect a default condition).

1. Make sure that both standard and radio wide scanning are off (the rotating icon is not displayed in the right status display). Then select a conventional or SMARTNET/SmartZone channel corresponding to the scan list being programmed.

2. Press the Scan Edit option switch and the scan edit mode is indicated by a triangle in the upper left part of the display (see following illustration).



3. With conventional channels, if applicable, select the list to be edited by rotating and then pressing the Select switch. The selected list is indicated as "SCAN LIST x", where "x" is the list number. If user programming is disabled on a list, "NO LIST" is momentarily displayed and it cannot be edited.

4. Select the channel you want to add or delete by rotating the Select switch. After the last conventional channel in the current zone is displayed, the first valid channel in the next zone is displayed and vice versa. Lists are limited to 256 channels.

5. If the selected channel is in the scan list (scanned), the symbol is displayed next to the zone number. To change the status of the displayed channel, press the Select switch.

   NOTE: The priority channel cannot be deleted (see "Priority Channel Sampling" description which follows).

6. With conventional channels only, if the scan list is set for one of the priority modes (see Section 3.5.12), the next press of the Select switch makes the current channel the priority channel. A "**P**" is indicated in the left status display to indicate that the selected channel is now the priority channel.

7. Additional presses of the Select switch change the scan list status of the channel as described in step 4. To exit this mode and save the changes, press the Scan Edit option switch again.

3.4.8 SECURE COMMUNICATION

Introduction

This transceiver may be equipped to provide secure communication on some or all channels. This feature encrypts the voice so that it can be understood only by someone using a transceiver equipped with a similar encryption device and encryption codes.

When a secure call is received or transmitted, is indicated in the display. If equipped with the Clear/Secure option switch and the current channel is programmed to allow switch selection, secure communication can be manually enabled and disabled by that switch. Otherwise, channels are strapped to Clear or Coded operation. Secure communication can be programmed on a per channel basis to operate in various ways. Refer to the following for more information:

Conventional Channels

On conventional analog channels, the protocol that can be used to provide secure communication is SecureNet™ DES or DES-XL scrambling.

On conventional digital (Project 25) channels, the SecureNet DES-OFB protocol is used. In the receive mode, clear and secure messages are always automatically detected.

SMARTNET/SmartZone Channels

On SMARTNET/SmartZone analog channels, SecureNet DES or DES-XL protocol can be selected. On SMARTNET/SmartZone digital channels, only the DES-OFB protocol is available. Talk groups can be strapped to Clear, Coded, or Switch selectable, and clear and secure messages are always autodetected.

The following SMARTNET/SmartZone calls require their own encryption key selection: emergency, failsoft, patch, telephone, private, and system-wide.

SecureNet

SecureNet is a proprietary Motorola protocol that digitizes the voice and then encrypts it using the DES or DVP algorithm. The SecureNet protocols include the following:

- DVP (Digital Voice Privacy) is an earlier encryption method that is self synchronizing using cipher feedback. It was originally designed to be used by anyone needing protection from unauthorized eavesdropping.

- DES (Data Encryption Standard) provides the highest level of security, and also uses cipher feedback. It was originally designed to be used only by the Federal government.

- DVP-XL/DES-XL - A disadvantage of the DVP and DES encryption types is reduced communication range when compared to clear voice. The DES-XL and DVP-XL methods were designed to provide better range but at the cost of lower voice quality. They use a different type of feedback called counter addressing.

- DES-OFB - A form of DES encryption for digital channels that uses output feedback. This protocol does not result in the degraded range that occurs with analog channels.

The transmission mode (DES/DES-XL) is selected by the programming software for each SecureNet analog channel. If a channel is programmed for DES-XL, it will also receive DES, but transmissions always occur in DES-XL.

Each SecureNet channel is assigned a hardware key from 0-15. This is the hardware location of the encryption key to be used. The keys in these locations are loaded into the radio using the Motorola key loader. This is a radio-like device that converts an input of approximately 20 characters into the “key” that is loaded into the radio. There is a maximum of 16 keys that can be loaded into the radio at one time.

NOTE: There is a security feature that automatically erases the encryption keys when the bottom cover is removed. This function is performed by a push button switch S1 on the logic board.

The transceiver must be connected to an unswitched power source to preserve the encryption keys in memory. However, there is a storage capacitor (C173, 0.22 µF) which maintains the 5-volt supply (and the encryption keys) for a minimum of approximately 8 hours if power is temporarily lost.

Transmissions on an analog channel are in the clear mode if the channel has been strapped to the clear mode by programming, and in the SecureNet mode if it has been strapped to SecureNet. If the channel has been strapped to “switched”, the mode is selected by the Clear/Secure option switch. When a message is received or transmitted in the secure mode, is displayed.

If the channel has been strapped “Clear” and the option button selects the “Secure” mode on power up and a transmission is attempted, “Clear Only” is displayed and transmitting is disabled. Conversely, if the channel is strapped “Secure” and the option button selects the “Clear” mode on power up and a transmission is attempted, “Secure Only” is displayed and the transmitter is disabled.

If an attempt is made to transmit a secure message without loading the corresponding key, “KEYFAIL” is displayed. The message must then be transmitted in the clear mode (this is possible only if the channel is strapped to “switchable”) or the key must be loaded.

<u>SecureNet Key Selection</u>

NOTE: This feature is available on conventional channels only.

When multiple hardware keys are programmed (see preceding information), the Hardware Key Select option switch can be programmed to allow selection of another key for the channel. This feature permanently selects another key for the channel (cycling power or selecting a different channel does not reselect the original key). Therefore, to switch back to the original key, it must be manually reselected. Proceed as follows to select a key:

1. Press the Hardware Key Select switch and HWKEY x is displayed. The “x” indicates the current key selection from 0-15.

2. Rotate the Select switch to display the desired key and then press the Select switch to select it. Press the Hardware Key Select switch again to return the display to normal operation.

<u>460 Scrambling</u>

The 460 Scrambling protocol is a proprietary Transcrypt protocol that is compatible with the standalone scrambling option from Transcrypt. The 460 type of scrambling is no longer available with 5300 transceivers.

Transmit Mode Options

The following transmit options are available when SecureNet encryption is selected:

Clear - All calls are in the clear mode unless responding to a secure call. If the response is then made within the delay time (see Section 3.4.7), it occurs in the secure mode.

Coded - All calls are made in the selected secure mode.

Switched - The mode is selected by the Clear/Secure switch. When the clear mode is selected by this switch, “CLEAR” is flashed, and when the secure mode is selected, “SECURE” is flashed.

Receive Mode Options

With the SecureNet protocol, the following receive options can be programmed:

No Autodetect - Only signals coded like the transmit signals are received.

Secure Autodetect - Both clear and SecureNet signals are automatically detected. This mode is automatically selected if the transmit mode is switch selectable.

Proper Key Autodetect - An incoming SecureNet call is compared against all of the available keys programmed into the radio. If a match is found, the call is decrypted using matched key.

3.5 CONVENTIONAL MODE FEATURES

3.5.1 INTRODUCTION

An overview of the conventional and SMARTNET/SmartZone operating modes is located in Section 3.3.8. The following information describes the features unique to conventional operation (both analog and digital (Project 25). Refer to the preceding section (3.4) for information on features common to all operating modes.

3.5.2 MONITORING BEFORE TRANSMITTING

With conventional operation, the channel may need to be manually monitored before transmitting to make sure that it is not being used by someone else. With SMARTNET/SmartZone operation, monitoring is always performed automatically. Monitor conventional channels automatically or manually as follows:

Automatic Channel Monitoring

If the selected channel is programmed with the Busy Channel Lockout (Transmit Disable On Busy) feature, monitoring is performed automatically. Refer to Section 3.5.4 for more information on this feature.

Manual Channel Monitoring

The automatic monitoring just described may occasionally disable the transmitter when the channel is not in use, such as if the repeater has extended hang time. In this case, you may not want to use it and the channel must then be monitored manually as follows:

Busy Indicator - With scanning disabled, note if the multi-function indicator on the front panel is steady green (see Figure 3-1). If it is not, the channel is not being used and a call can be transmitted. It it is green, a carrier is being detected, so the channel may be busy.

Monitor Mode - There may be times when a busy condition is indicated even though no one is using the channel. Monitoring should then be performed by disabling Call Guard squelch (or group ID detect on Project 25 channels). This is usually done by taking the microphone off-hook or selecting the Monitor mode as described next. The Normal/Selective option switch described in Section 3.5.5 can also be used.

3.5.3 MONITOR MODE

The monitor mode unsquelches the receiver even if no carrier is detected. Call Guard squelch is disabled on analog channels and NAC and group ID detect are disabled on P25 channels. In addition, it overrides the Busy Channel Lockout feature (see next section) and temporarily disables scanning.

To select the monitor mode, briefly press the Monitor option switch (if available). The display then briefly indicates “MON” and the receiver unsquelches. To disable the monitor mode and return to normal operation, press the Monitor option switch again.

If off-hook detection is enabled by programming, taking the microphone off-hook has the same affect except the receiver unsquelches only if a signal is present. Pressing the Normal/Selective switch (see Section 3.5.5) disables Call Guard squelch/P25 group ID detect but not scanning and P25 NAC detect. In the scan mode, pressing and holding the Monitor option switch monitors the scanned channel instead of the selected channel (if it is different).

3.5.4 BUSY CHANNEL LOCKOUT

The Busy Channel Lockout (also called Transmit Disable on Busy) feature automatically disables the transmitter if the channel is busy when the PTT switch is pressed. When the transmitter is disabled by this feature, “BUSY” is displayed, a busy tone sounds, and the transmitter is disabled.

The Busy Channel Lockout feature can be programmed to operate as follows. Each conventional channel can be programmed differently.

Off - Busy channel lockout is disabled and the transmitter keys even if the channel is busy.

Noise - If a carrier is detected on the channel, the transmitter is disabled when the PTT switch is pressed.

Tone (NAC) - If an incorrect Call Guard (CTCSS/ DCS) or NAC code (see Section 3.5.15) is detected, the transmitter is disabled when the PTT switch is pressed. An incorrect code is any code other than the one programmed for the current channel.

If Busy Channel Override is permitted by programming, it is possible to transmit even when the transmitter is disabled by this feature. Simply release the PTT switch and then quickly press it again.

3.5.5 CALL GUARD SQUELCH

Introduction

Tone or digital Call Guard squelch (also called CTCSS/DCS signaling) can be programmed on each conventional analog transmit and receive channel in any order desired. The reverse burst and turn-off code are always transmitted and also detected on channels programmed with Call Guard squelch.

The Call Guard squelch feature eliminates distracting messages intended for others using the channel. This is done by using a subaudible tone or digital code to control the squelch. This tone or code is unique to a user or a group on that channel. This tone or code is transmitted with the voice signal but is not heard because it is in the subaudible range and is attenuated by a filter. Call Guard squelch must be used in both the transmitting and receiving transceiver to be functional.

Call Guard Squelch Enable/Disable

The Normal/Selective option switch (if programmed) can be used to disable receive Call Guard squelch on analog channels or group ID code detect on P25 channels. When selective squelch is disabled, “NORMAL” is flashed in the display, and when it is enabled, “SELECTIVE” is flashed.

When “Normal” is selected, the receiver unsquelches only if a carrier is detected, and scanning and P25 NAC detection are not disabled. The selected mode remains in effect until it is manually changed. Selecting another channel or cycling power does not reselect a default condition.

Tone Call Guard Squelch

Tone-type Call Guard squelch utilizes subaudible CTCSS tones from 67-254.1 Hz. Although there are 42 tones assigned, those above 33 (210.7 Hz) are normally not used because of their close proximity to the voice band which starts at 300 Hz. In addition, tones 11 (97.4 Hz), 39 (69.3 Hz), 40 (206.5 Hz), 41 229.1 Hz), and 42 (254.1 Hz) are normally not used because they may cause interference with adjacent tones.

A reverse burst is transmitted when the push-to-talk switch is released and also detected when calls are received. It is a 180-degree phase reversal for a period of time determined by the tone frequency, and it eliminates the squelch tail (noise burst) in the receiving transceiver. Both the transmitting and receiving transceiver must be equipped with this feature for it to be utilized.

Digital Call Guard Squelch

Digital Call Guard squelch (CDCSS) uses digital data instead of subaudible tones to control the squelch.

This data consists of continuous repetitions of 23-bit words. No bit or word synchronization information is used. When the push-to-talk switch is released, a turn-off code is transmitted which eliminates the squelch tail similar to the reverse burst.

Although there are thousands of possible code combinations with 23 bits, only 83 are unique with the data scheme used. The number specified when the code is programmed is actually a seed for a special algorithm used to generate the 23-bit data word. The data is transmitted at a rate of 134.4 bits per second. Therefore, approximately six words are transmitted each second. When the data is decoded, 23-bit samples are taken and then the bits are rotated to determine if a valid code was received.

Selectable Call Guard Code (CTCSS/DCS/NAC)

NOTE: Call Guard codes can be permanently reprogrammed by keypad programming (see Section 3.8).

A different CTCSS/DCS/NAC squelch code can be temporarily selected if the Selective Squelch option switch and a CTCSS/NAC code list have been programmed. This feature allows the normal transmit and receive Call Guard programming to be temporarily overridden with a code selected from this list.

The CTCSS/DCS/NAC list is programmed with up to sixteen tone (CTCSS) or digital (DCS) Call Guard codes. In addition, for operation on Project 25 channels, each position can be programmed with an NAC code.

When the Call Guard code is changed using this feature, it remains selected even if other channels are selected. When scanning, the selected code also applies to all scanned channels. If both analog and digital (Project 25) channels can be selected or scanned, the CTCSS/DCS code for the selected position is used for analog channels and the NAC code for the selected position is used for P25 channels. If a channel is programmed for mixed mode operation, the selective squelch type (analog or digital) programmed for the transmit mode determines the selective squelch type used.

Proceed as follows to select a preprogrammed Call Guard code:

1. Press the Selective Squelch option switch and then rotate the Select switch to select the desired position. The display indicates “SEL SQ xx” where, “xx” is the selected code from 1-16.

2. To select the displayed code and return to the normal display, press the Selective Squelch switch again.

3. To check which code is selected, press the Selective Squelch switch once to display the current selection and then again to return to normal operation.

4. To return to the normal selective squelch codes, select “DEFAULT” in this mode. The normal codes are also automatically reselected whenever transceiver power is cycled or a talk-around channel is selected.

3.5.6 PENALTY TIMER

A penalty timer may be programmed on conventional systems to prevent transmissions for the programmed time after the time-out timer disables the transmitter (see Section 3.4.2). The penalty timer can be programmed for the same times as the time-out timer, and timing starts when the PTT switch is released. If the PTT switch is pressed during the penalty time, the time-out indication occurs again. When the penalty timer expires, a beep sounds and the transmitter can be keyed.

3.5.7 CONVERSATION TIMER

A conversation timer can be programmed on conventional systems in addition to the time-out timer (see Section 3.4.2). This timer limits that total length of a conversation rather than just the length of each transmission as with the time-out timer. The following is more information on this timer.

- It can be programmed for times up to 7.5 minutes.
- It is reset when the time between transmissions exceeds the time programmed for the penalty timer.
- A warning beep sounds 5 seconds before this timer disables the transmitter.
- When this timer disables the transmitter, a continuous tone sounds and the red transmit indicator turns off. The PTT switch must then be released until the penalty timer expires (indicated by a beep).

3.5.8 REPEATER TALK-AROUND

Normally, all transmissions go through a repeater which usually increases range. However, there may be times when a mobile is out of range of the repeater and therefore unable to talk to anyone even though the mobile being called is only a short distance away. To allow communication in this situation, repeater talk-around can be selected. Transmissions then occur on the receive frequency which permits direct mobile-to-mobile communication.

Repeater talk-around can be selected if the RTA option switch is programmed. When talk-around is enabled by this switch, "RTA ON" is flashed in the display, and when it is disabled, "RTA OFF" is flashed. This feature remains enabled during scanning, and changing channels or turning power off does not change the selected condition. Talk-around is available on conventional channels only.

3.5.9 DISPLAYING TX/RX FREQUENCY

If the Displayed Information option switch is programmed (see Section 3.4.1), it can be used to display the channel frequency in megahertz. Pressing this switch toggles between displaying the standard channel alias and the channel frequency. The receive frequency is displayed when receiving and the transmit frequency is displayed when transmitting. This feature is available on conventional channels only.

3.5.10 EMERGENCY MODE

An Emergency option switch may be programmed on conventional channels to alert a dispatcher or someone else of an emergency condition.

When this switch is pressed with a Project 25 (digital) channel selected, all transmissions have the emergency flag set. Scanning is disabled and the transceiver remains in the emergency mode until power is cycled.

Emergency conditions are not transmitted when an analog channel is selected. However, if it is pressed on an analog channel and a Project 25 channel is selected before power is turned off, the emergency condition is transmitted on the Project 25 channel as just described.

3.5.11 CONVENTIONAL MODE SCANNING

General

Channel scanning features common to all operating modes are described in Section 3.4.7. The following information describes features unique to conventional operation.

Selecting a Scan List

Conventional mode scan lists are selected by repeatedly pressing the Scan option switch. For example, if three scan lists are programmed, the first press of the Scan switch activates scanning and scan list 1, the second press activates scan list 2, the third press activates scan list 3, and the fourth press disables scanning and then the cycle repeats. The currently selected scan list is flashed in the display as "SCAN LIST x", where "x" is the scan list number. Scanning is disabled when the scanning indicator turns off.

Transmitting in Scan Mode

Each conventional scan list can be programmed for one of the following modes. These modes determine if priority sampling occurs and also the channel on which transmissions occur while scanning. Refer to the next section for more information.

No Priority - No priority channel sampling occurs when the list is selected. The radio transmits on the selected channel.

Priority/Tx Priority - Priority sampling occurs and the priority channel is the one programmed in the selected scan list. The radio transmits on the priority channel.

Priority/Tx Selected - Priority sampling occurs and the priority channel is the one programmed in the selected scan list. The radio transmits on the selected channel.

Priority on Selected - The priority channel is always the selected channel. The radio transmits on the selected channel.

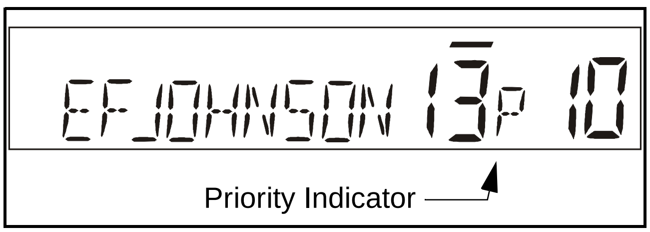
Talkback - No priority sampling occurs. The radio transmits on the channel of a call while scanning is halted. Then once scanning resumes, it transmits on the selected channel.

3.5.12 PRIORITY CHANNEL SAMPLING

General

The priority channel sampling feature ensures that when standard scanning, messages on the priority channel are not missed while listening to a message on some other channel. The transceiver can be programmed as just described so that the priority channel is a fixed channel programmed in the current scan list, the currently selected channel, or not used.

When the selected channel is a priority channel, "**P**" is indicated in the left status display next to the zone number as follows:



Priority channel sampling occurs only with standard conventional scanning. It does not occur with radio-wide scanning, when listening to any type of SMARTNET/SmartZone call, or when transmitting. A series of "ticks" may be heard when the priority channel is sampled while listening to a message on some other conventional channel.

The priority sampling times are programmed by the following parameters:

Lookback Time A - This time determines how often the priority channel is checked for activity. Times of 0.25-4.00 seconds in 0.25-second steps can be programmed.

Lookback Time B - This time determines how often the priority channel is checked once an incorrect Call Guard (CTCSS/DCS) or NAC code is detected. Since it takes much longer to detect an incorrect Call Guard signal than a carrier, this time should be relatively long to prevent the interruptions from making a message difficult to understand. Times of 0.5-8.0 seconds can be programmed in 0.5-second steps.

Changing the Priority Channel

If the priority channel is associated with the current scan list, it can be changed if the Scan Edit option switch is programmed. In the scan edit mode, the second press of the Select switch makes the current channel the priority channel. Refer to "Programming a Scan List" on page 3-9 for more information.

3.5.13 PLACING AND RECEIVING CONVENTIONAL CALLS

NOTE: A DTMF microphone is required to place conventional mode telephone calls.

Placing a Standard Conventional Call

1. Turn power on and set the volume as described in Sections 3.3.1 and 3.3.4. Select the channel programmed for the mobile you want to call as described in Section 3.3.6.

2. Monitor the channel automatically or manually as described in Section 3.5.2.

3. Press the PTT switch and the call proceeds as follows:

    - If the Busy Channel Lockout feature is programmed on the channel (see Section 3.5.4), the transmitter is automatically disabled if the channel is busy.

    - Otherwise, busy and out-of-range conditions are not indicated and speaking can begin after monitoring the channel.

4. Press (and hold) the PTT switch to talk and release it to listen. When the call is finished, place the microphone back on-hook.

Receiving a Standard Conventional Call

1. Select or scan the channel programmed for the call you want to receive (refer to Sections 3.4.7 and 3.5.11 for more scanning information).

2. When the call is received, take the microphone off-hook and press the PTT switch to talk and release it to listen. If scanning, responses may occur on the

priority, selected, or receive channel as described in Section 3.5.11.

3. When the call is finished, place the microphone back on-hook.

3.5.14 DTMF/ANI SIGNALING

DTMF (Dual Tone Multi-Frequency) tones can be generated automatically for ANI (Automatic Number Identification) and other purposes. The following options may be enabled by system operator programming for each conventional channel:

Pre-Tx ANI - A preprogrammed ANI sequence is automatically sent when you press the PTT switch.

Post-TX ANI - A preprogrammed ANI sequence is automatically sent each time you release the PTT switch.

Disabled - All DTMF signaling is disabled.

3.5.15 PROJECT 25 MODE FEATURES

<u>Individual, Group, and NAC Codes</u>

Individual ID - Each transceiver that operates on Project 25 (digital) channels is programmed with an 8-digit individual ID. This ID is unique for each transceiver and can be any number from 1-16,777,216. When power is turned on with a Project 25 channel selected, this ID is briefly displayed.

Group ID - Each Project 25 channel is programmed with a group ID that determines which group of mobiles will receive the call. A call is received on a channel if a selected or scanned channel is programmed with that group ID and the correct NAC is detected (see following). Group IDs can be any number from 0-65,535. Group ID detect can be disabled by the Normal/Selective squelch function described in Section 3.5.5.

NAC - Project 25 conventional channels also use a NAC (Network Access Code) to control which calls are received on a channel. The NAC can be 0-4095, and each transmit and receive channel can be programmed for a different code. Other operation, such as monitoring before transmitting, is similar to that of standard analog channels. NAC (and group ID) detect can be disabled by the monitor mode described in Section 3.5.3.

<u>Changing Talk Group Assigned To A Channel</u>

Group calls are placed by simply selecting the channel programmed for the desired group, monitoring the channel if required, and transmitting. If the Digital Talk Group Select option switch is programmed, the talk group assigned to a channel can be permanently changed by the user. Therefore, the new talk group continues to be assigned to the channel even after radio power is cycled or another channel is selected. To change a channel talk group, proceed as follows:

1. Select the channel to be changed and then press the (Digital) Talk Group Select option switch.

2. Rotate the Select switch until the alias (alphatag) of the desired talk group is displayed.

3. To select that talk group and return to normal operation, press the Talk Group Select option switch again or press the Select switch. If talk group selection has been disabled on the channel by programming, “NO LIST” is displayed and a tone sounds.

<u>Unit Calls</u>

Unit calls (also called Individual Calls) can be placed to a specific radio on Project 25 channels if the Unit Call option switch is programmed. Only the individual ID of the target radio is sent (a talk group ID is not sent). The mobiles that can be called are preprogrammed in the unit call list.

To receive a unit call, the RF channel of the call must be selected or scanned and the correct NAC and unit ID must be detected. The ID of the calling radio is then transmitted back. To respond to the call, the transceiver must be programmed with the unit ID option switch, and have a Unit Call programmed with the ID of the calling mobile.

Place and receive a unit call as follows:

1. Press the Individual ID Call option switch and the alias (tag) of the last unit call is displayed.

2. If required, rotate the Select switch to display the desired call. The alias (alphatag) and ID of the calls that have been programmed are alternately displayed.

3. Press and then release the PTT switch. Ringing is then heard and “WAIT” displayed to indicate that the mobile is being rung. To disable this ringing but not the call, briefly press the PTT switch again. Ringing occurs for 20 seconds or until the call is answered, whichever occurs first.

4. When a Unit call is received, two beeps sound (if tones are enabled) and “Call Rcvd” and the alias or frequency of the currently selected talk group are alternately displayed.

   In addition, the transceiver can be programmed to display the alias of the talk group on which the call is being received (if it is not the same as the selected talk group) and/or the ID of the mobile placing the call.

5. To respond, select the Unit Call mode by pressing the Unit Call option switch. The following operation then occurs:

- If a unit call has been programmed with the ID of the calling mobile, it is automatically selected. A response can then be made without changing the selected channel.

- If no Unit Call has been programmed with the ID of the calling mobile, a response cannot be made in this mode.

- If the call timer times out (set by programming) or the channel is changed before a response is made, the unit call mode is exited.

3.6 SMARTNET/SMARTZONE FEATURES

3.6.1 INTRODUCTION

An overview of the SMARTNET/SmartZone operating mode is located in Section 3.3.8. The following information describes the features unique to the SMARTNET and SmartZone modes of operation. Refer to Section 3.4 for information on features common to all operating modes.

3.6.2 ANALOG AND DIGITAL OPERATION

Either analog or digital operation can be selected for communication on SMARTNET traffic channels. Each talk group can be programmed for either type of operation.

3.6.3 VIEWING UNIT ID

When power is turned on with a SMARTNET/SmartZone channel selected, the five-digit Unit ID is briefly displayed as IDxxxxx.

3.6.4 STANDARD GROUP CALLS

Standard calls are between you and another mobile, group of mobiles, or a control station (a radio in a fixed location). Most calls are probably this type. Proceed as follows to place and receive these calls.

A SMARTNET/SmartZone channel may be programmed with a Talk Group and/or Announcement Group ID plus an Emergency ID. When a call is received on a channel programmed with both Talk and Announcement groups, only the Talk and Announcement group IDs are detected. Other IDs in the Announcement group are detected only if no talk group is programmed. The emergency ID is used for the emergency alarm and call (see Section 3.6.10). Proceed as follows to place and receive group calls:

<u>Placing a Standard Group Call</u>

1. Turn power on and set the volume as described in Sections 3.3.1 and 3.3.4. Select the channel programmed for the talk group you want to call (see Section 3.3.6). A regular or announcement talk group can be selected.

2. If the talk group is programmed for encryption and is not strapped to Clear or Coded, select the desired mode by pressing the Clear/Secure option switch. The status of that switch is ignored if the talk group is strapped to Clear or Coded. Refer to Section 3.4.8 for more information.

3. Press the PTT switch and begin talking. A talk permit tone may sound to indicate when talking can begin. Events that may occur are as follows:

- If in the secure mode and your transceiver is not programmed with the proper encryption key, "KEYFAIL" is displayed and the call must be made in the clear mode or the proper key must be programmed.

- If the busy tone sounds and "BUSY" is displayed, the system is busy. Release the PTT switch and wait for the call back tone to sound. Then press the PTT switch within 3 seconds.

- If a continuous tone sounds and "NO SYS" is displayed, you may be out-of-range. Drive closer or away from shielding objects and try again.

- If your unit ID is invalid, the call is being made to an invalid group ID, group calls are not enabled, or the selected talk group is not programmed for the selected secure mode, "DISABLED ID" is displayed and an alert tone sounds.

- If an attempt is made to change an analog call from the clear to secure mode and there is no available secure channel, "NO SEC" is flashed and the call continues in the clear mode.

- If an attempt is made to change an analog channel from the secure to clear mode, "SEC ONLY" is displayed and the call continues in the secure mode. (Calls on digital channels can be changed if not strapped.)

- If the secure mode is selected by the Secure/Clear option switch and an attempt is made to transmit on a channel strapped as clear, "Clear Only" is displayed and the transmitter is disabled. Conversely, if the clear mode is selected and the channel is strapped as secure, "Secure Only" is displayed and the transmitter is disabled.

<u>Receiving a Standard Group Call</u>

When a SMARTNET/SmartZone group call is received, the transceiver can be programmed to display the Individual ID of the calling mobile and/or the received talk group alias. The Individual ID is briefly displayed when the call is received and the talk group and channel alias are then alternately displayed (if applicable).

3.6.5 PRIVATE (UNIT-TO-UNIT) CALLS

Private calls allow calls to be placed to a specific mobile unit. Either the Enhanced Private Conversation™ or standard Private Conversation modes may be programmed depending on the capabilities of the radio system.

The Private Call option switch is required to place these calls, and either that switch or the Call Response option switch is required to receive them. Operation in each mode is as follows:

<u>Placing an Enhanced Private Conversation Call</u>

1. Momentarily press the Private Call option switch and the alias of the last called mobile is displayed.

2. If required, select another mobile by rotating the Select switch until the alias of the desired mobile is displayed.

3. Press the PTT switch to initiate the call. Events that may occur are as follows:

   - If the mobile being called is on the air, "WAIT" is displayed and ringing is heard until the called party answers or for 20 seconds, whichever occurs first. Pressing the PTT switch or an option key stops the ringing but not the call. When the call is answered, the voice of the called party is heard.

   - If the called mobile does not answer within 20 seconds, a continuous tone sounds and "NO ANS" is displayed.

   - If the called mobile is not on the air, a continuous tone sounds instead of the ringing tone and "NO ACK" is displayed.

   - If the busy tone sounds and "BUSY" is displayed, the called mobile has answered the call but the system is busy. When the system is no longer busy, the call back tone sounds.

   - If your transceiver or the called transceiver is inhibited or not programmed to make this type of call or for the requested secure mode, "REJECT" is displayed and an alert tone sounds.

- If your transceiver does not have the proper encryption key, “KEYFAIL” is displayed and the call must be made in the clear mode by pressing the Clear/Secure option switch (if strapped to switchable). Otherwise, load the correct key.

4. When the call is finished or is not answered, end it by pressing the Private Call option switch and placing the microphone back on-hook.

Placing a Standard Private Conversation Call

1. Momentarily press the Private Call option switch and the alias of the last called mobile is displayed.

2. If required, select another mobile by rotating the Select switch until the alias of the desired mobile is displayed.

3. Press the PTT switch. Events that may occur are as follows:

   - The called party answers the call.
   - The called party does not answer. Press the Private Call option switch to end the call.
   - If the selected mobile ID is not valid, “INVALID ID” is displayed and an alert tone sounds.
   - If the radio system is busy, four low tones sound and “BUSY” is displayed. When the system is no longer busy, the call back tone (four beeps) is heard and the channel is automatically acquired. Press the PTT switch to continue the call.
   - If the call is in the secure mode and the transceiver does not have the proper encryption key, “KEYFAIL” is displayed and the call must be made in the clear mode by pressing the Clear/Secure option switch (if strapped to switchable). Otherwise, load the correct key.

4. When the call is finished or if it is not answered, end it by pressing the Private Call option switch and placing the microphone on-hook.

Receiving a Private Call (All Types)

1. When a private call is received, “CALL” is displayed and a recurring call tone sounds.

2. To answer the call, press the Private Call option switch and then the PTT switch and begin speaking. The unit ID of the calling mobile is displayed. More information follows:

   - If the PTT switch is pressed before the Private Call option switch, the call is transmitted as a group call.
   - If private calls are not permitted (the Private Call option switch is not programmed), press the Call Response option switch to answer the call.
   - The call must be answered within 20 seconds or it is automatically terminated.
   - If the system is busy when a response is made, “BUSY” is displayed and the busy tone sounds.

3.6.6 TELEPHONE CALLS

The telephone call* feature allows telephone calls to be placed and received over the public telephone system using your transceiver. The type of call (secure/clear) is determined by the mode selected by the Clear/Secure option switch. Telephone calling is programmed to operate in one of the following modes:

- Disabled
- Answer-only capability
- Telephone numbers can be recalled from memory only (direct entry using a keypad is not available)

Placing a Telephone Call

1. With a SMARTNET/SmartZone channel selected, momentarily press the Phone option switch. The alias of the last called telephone number is displayed.

2. If required, rotate the Select switch to display the desired number. The alias of each number is displayed.

3. Press and release the PTT switch and “DIALING” is displayed. Events that may occur are as follows:

   - If the access is successful, a dial tone sounds and the dialed number is displayed and sent. Either ringing or a busy signal is then heard as with a standard telephone call. When the called party

*** Available with a future release.** *Contact your EFJohnson account manager for more information.*

answers, press the PTT switch to talk and release it to listen (since the transceiver is half-duplex, it is not possible to talk and listen at the same time). Each time the PTT switch is released, a go-ahead tone is sent to the landside party to indicate when they can respond. To dial a number after the connection is made, press the PTT switch and dial the number using the microphone keypad.

- If the selected telephone number is not valid, “INVALID” is displayed and an alert tone sounds. Select a valid number.

- If the system is busy, “BUSY” is displayed and the busy tone sounds. The call will automatically proceed when the system becomes available.

- If you are out-of-range or the radio cannot be accessed for some reason, “NO PHONE” is displayed and an alert tone sounds.

- If the interconnect call you are making or the selected secure mode is not authorized, “REJECT” is displayed and an alert tone sounds.

- If your transceiver does not have the proper encryption key, “KEYFAIL” is displayed and the call must be made in the clear mode (press the Clear/Secure option switch).

4. When the telephone call is finished or if it could not be completed for some reason, end it by pressing the Phone option switch and placing the microphone back on-hook.

Answering a Telephone Call

1. When a telephone call is received, “ringing” similar to a standard telephone is heard and “PHONE” is displayed.

2. To answer the call, press the Phone option switch and press the PTT switch to talk and release it to listen (since the transceiver operates half duplex, it is not possible to talk and listen at the same time).

3. When the call is finished, end it by pressing the PHONE option switch and placing the microphone back on-hook.

3.6.7 CALL ALERT

The call alert feature allows pages to be sent and received. Your transceiver may be programmed to answer pages in the Enhanced Private Conversation or Private Conversation II modes. The operation differences are noted in the procedure which follows.

Answering a Page

1. When a page is received, four beeps sound and “PAGE” is displayed. The ID of the mobile paging you is stored as the last ID received.

2. To clear or ignore the page, press any option switch. If the PTT switch is pressed, a group call is placed on the selected channel.

3. To answer the page as a private call (see Section 3.6.5), press the Private Call option switch and the alias of the mobile paging you is displayed. Press the PTT switch and respond. One of the conditions that follow may also occur:

   Enhanced Private Conversation Mode

   - If the mobile being called is on the air, ringing is heard until the called party answers or for 20 seconds, whichever occurs first. If no answer occurs within 20 seconds, “NO ANS” is displayed.

   - If the mobile being called is not on the air, no ringing is heard and “NO ACK” is displayed.

   Standard Private Conversation Mode

   - If the mobile being called is not on the air or does not answer, you will simply not hear a response.

4. When the call is finished or it could not be completed for some reason, end it by pressing the Private Call option switch and placing the microphone back on-hook.

Initiating a Page

1. With a SMARTNET/SmartZone channel selected, momentarily press the Call Alert option switch. The alias of the last ID called is displayed.

2. If required, rotate the Select switch to display the desired mobile. The alias of each number is displayed.

3. Press the PTT switch and one of the following occur:

   - If five beeps sound, the system received the page and the paged mobile is on the air and received it. The page mode is automatically exited.

   - If the system received the page but the called mobile is not on the air, a single beep sounds and “NO ACK” is displayed 6 seconds after the PTT switch is pressed. Auto exit then occurs.

3.6.8 MESSAGING

The messaging feature allows preprogrammed messages to be sent to a dispatcher. Up to 16 messages can be preprogrammed, and they are identified by an alias. If a Message option switch is programmed, messages are sent as follows:

1. Momentarily press the Message option switch. The alias of the last message sent is displayed.

2. If required, rotate the Select switch to display the desired message. Then send the message by momentarily pressing the PTT switch. One of the following events then occurs:

   - If five beeps sound and “ACK RCVD” is displayed, the message was received and automatically acknowledged by the system.

   - If after five tries the message is not acknowledged, a tone sounds, “NO ACK” is displayed, and the messaging mode is automatically exited.

3.6.9 SENDING STATUS CONDITIONS

The status feature allows you to manually or automatically send your current status to your dispatcher. Up to eight status conditions can be preprogrammed, and they are identified by an alias. If the Status option switch is programmed, status conditions are sent as follows:

1. Momentarily press the Status option switch. The alias of the current status condition is displayed.

2. To change the current status, rotate the Select switch until the desired status is displayed. Then to send the status, momentarily press the PTT switch. One of the following events then occurs:

   - If five beeps sound, the status was received and acknowledged by the system.

   - If after five tries the message is not acknowledged, a tone sounds, “NO ACK” is displayed, and this mode is automatically exited.

3.6.10 EMERGENCY ALARM AND CALL

<u>Introduction</u>

Emergency Alarms and Calls are separate functions that can be individually enabled or disabled on each SMARTNET/SmartZone system. The Emergency option switch is also required for these functions. Emergency Alarms are transmitted on the last selected talk group, and Emergency Calls are transmitted on the emergency talk group programmed on the selected system.

<u>Emergency Alarms</u>

An emergency alarm is a special data transmission on the selected talk group that alerts a dispatcher of an emergency situation. Proceed as follows to activate an emergency alarm:

1. Select a SMARTNET/SmartZone channel that has this feature enabled and then press the Emergency option switch. The radio then begins automatically transmitting an emergency alarm data message and “EMERGNCY” is indicated in the display for 3 seconds.

2. When the emergency alarm is acknowledged by the system, ACK RCVD” is briefly displayed and the emergency acknowledge tone (two beeps) sounds. Silent operation may also be programmed in which case no tone sounds and there is no indication that an acknowledgment occurred.

3. The radio continues to transmit this message until an acknowledgment is received or the programmed number of attempts have been made. To exit this mode, power must be turned off and then on again.

Emergency Calls

An emergency call urgently requests access to a voice channel. To place this call, proceed as follows:

1. Select a SMARTNET/SmartZone channel that has this feature enabled and press the Emergency option switch. The emergency mode is indicated when “EMERGNCY” is indicated in the display for 3 seconds.

2. To place the emergency call, manually press the PTT switch and begin speaking as with a standard call. All group calls which follow are then emergency calls (private, telephone*, and call alert calls are not allowed). If the channel is changed, the call is made on the emergency talk group programmed for the new channel.

3. To exit this mode, power must be turned off and then on again.

3.6.11 FAILSOFT OPERATION

If a failure occurs in the SMARTNET/SmartZone system so that it cannot be used, the transceiver automatically enters the failsoft mode*. When in this mode, “FAILSOFT” and the alias of the selected channel are alternately displayed.

When in the failsoft mode, operation is in the conventional mode on the preprogrammed failsoft channel (a different failsoft channel can be programmed on each talk group). If a transmission is attempted before a failsoft channel is located, a continuous tones sounds until the PTT switch is released. When the radio system returns to normal operation, this is automatically detected and normal operation resumes.

3.6.12 SMARTNET/SMARTZONE SCANNING

General

Scanning on a SMARTNET/Smartzone system is called Priority Monitor Scan, and is similar to the standard scanning described in Section 3.4.7. Each SMARTNET/SmartZone system can be programmed with up to as many scan lists as can be stored in memory, and each list can include up to 256 talk groups from the same SMARTNET/SmartZone system, one of which can be a priority talk group. The priority talk group can also be the selected talk group.

Scanning is enabled and disabled by the Scan option switch. Also, channels can be programmed so that scanning is automatically disabled (No List) or automatically starts whenever the channel is selected (Auto Scan). If scanning is enabled and the selected channel does not permit scanning, it automatically resumes when a channel is selected that permits scanning.

In addition to calls on channels in the scan list, pages, private calls, and telephone* calls are received while scanning. Messages on the priority channel are received while listening to lower priority messages. However, private and telephone* calls are not interrupted by priority messages.

When responding to calls in the scan mode, the Talk Back Scan programming parameter determines if the response always occurs on the talk group of the call (Active Group) or the Selected Group if they are different. Transmissions at other times always occur on the selected talk group.

Scan List Editing and Selection

Scan lists are user programmable if the Scan Edit option switch is programmed. The procedure is described in “Programming a Scan List” on page 3-9. In addition, nuisance channels can be temporarily deleted as described in Section 3.4.7.

SMARTNET/SmartZone scan lists are user selectable if the Scan (List) Select option switch is programmed. This switch can be used to temporarily select another scan list for all talk and announcement groups in the current system. Press this switch and then rotate the Select switch to select the desired list (“No List” can also be selected if desired). Selecting “Programmed” or cycling power returns to the default scan list programmed for each group.

3.6.13 DYNAMIC REGROUPING

The dynamic regrouping* feature allows a dispatcher to switch mobiles to a predefined regrouping channel to receive an important message. Dynamic regrouping operates as follows:

1. When this command is received, alternating tones sound for 5 seconds and the transceiver automatically changes to the regrouping channel and the display indicates the alias of the channel.

2. Manually select the channel corresponding to that alias. If this is not done, transmission still occurs on the new channel, but the alternating tones sound each time the PTT switch is pressed.

3. Talk and listen as usual. The dispatcher cancels dynamic regrouping which is indicated by a short tone. If a standard channel is not selected after this occurs, an error tone periodically sounds.

3.6.14 SMARTZONE FEATURES

Introduction

As described in Section 3.3.8, the SmartZone mode provides wide area coverage by allowing roaming between SMARTNET and conventional sites. SmartZone operation is the same as SMARTNET with the following additional features:

Busy Override

The busy override feature is enabled at the system level by the system manager and is not a programmable radio feature. It allows a call to be placed even if not all sites you are calling have a free traffic channel. The only sites guaranteed to be included are the Critical Sites and the sites where a Critical User is located. This feature operates as follows:

1. Assume that you have attempted to place a call and the system was busy ("BUSY" displayed and busy tone sounded).

2. Release the PTT switch and then press it for 5 seconds or more. If a chirp tone sounds with the PTT switch pressed, busy override is occurring.

   NOTE: Remember that not all members of the talk group are receiving your message. Missing members will start receiving your message as channels become available.

Site Trunking

Site trunking occurs when a site can no longer participate in wide area trunking. When site trunking is occurring, the radio searches for other sites that may provide wide area coverage. Site trunking ends when a wide area coverage site is located, the current site is operating again as a wide area coverage site, an out-of-range condition occurs, or the failsoft mode is entered.

Determining Current Site and Searching For New Site

To display the RSSI level of the current site, press the Site Search option switch (if programmed). The display then indicates the current site number as "SITE xx" and the RSSI level as "RSSI xx". This mode is then automatically exited.

To scroll through the other programmed sites, rotate the Select switch while "SITE xx" or "RSSI xx" is displayed. To select the displayed site, press the Site Search option switch. If site lock is on when site search is entered (see following), the radio will be locked on the new site when this function is exited.

Locking/Unlocking a Site

It is sometimes desirable to stay on a site. To prevent the transceiver from searching for a new site, lock it on the current site by pressing the Site Lock option switch. The display then momentarily indicates "LOCK x" to indicate that the current site is locked ("x" is the current site number). To unlock the site, press the Site Lock switch again and "UNLOCK" is momentarily displayed.

3.7 SUPERVISORY TONES

Single Beep (Alert Tone)

- Power was turned on and a successful power-up sequence occurred (Section 3.3.1).
- The time-out timer is about to expire or the penalty timer has expired (Section 3.4.2).
- The conversation timer is about to expire (Section 3.5.7).
- The system received your page but the paged mobile is not on the air (Section 3.6.7).
- Telephone interconnect is not operational (Section 3.6.6).

Continuous Tone (Invalid Condition)

- A transmission is being attempted on a conventional channel programmed as receive-only.
- The transmitter is disabled by the busy channel lockout feature (Section 3.5.4).
- The transmitter has been disabled by the time-out timer feature (Section 3.4.2).
- The transmitter has been disabled by the conversation timer (Section 3.5.7).
- An out-of-range condition exists (SMARTNET/ SmartZone only).
- A transmission is being attempted before the penalty timer has expired (Section 3.5.6).
- Dynamic regrouping has been exited but the dynamic regrouping channel is still selected (Section 3.6.13).

Single Short Medium-Pitch Tone

- A valid key has been pressed.

Single Short Low-Pitch Tone

- An invalid key has been pressed.

Medium Tone (No Acknowledge)

- The paged mobile did not acknowledge the page (Section 3.6.7).
- The message that was sent has not been acknowledged (Section 3.6.8).
- The status condition that was sent has not been acknowledged (Section 3.6.9).

Five Beeps (Recurring)

- The page was received (Section 3.6.7).

Two Short Tones

- A private call was received (Section 3.6.5).

Five Beeps

- The paged mobile received the page and acknowledged it (Section 3.6.7).
- The message that was sent has been received and acknowledged (Section 3.6.8).
- The status condition that was sent has been received and acknowledged (Section 3.6.9).

Four Beeps

- The emergency alarm condition was acknowledged (Section 3.6.10).

- Four low beeps indicated the call back mode (the system is no longer busy).

Alternating Tone

- Dynamic regrouping has occurred (Section 3.6.13).
- Dynamic regrouping has occurred but the regrouping channel is not selected (Section 3.6.13).

Busy Signal

- The radio system is busy or a busy condition exists when making a telephone call.

Three Medium Pitch Tones

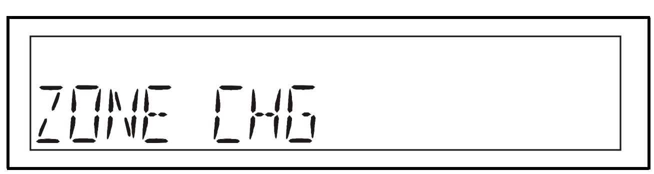
- A channel is available after a busy condition occurred (SMARTNET/SmartZone only).

3.8 KEYPAD PROGRAMMING

NOTE: Keypad programming is a feature available only in Federal Government models of this transceiver. It cannot be enabled in other models because keypad programming is not allowed by any user regulated by the Federal Communications Commission.

3.8.1 INTRODUCTION

Keypad programming can be enabled only if it has been hard coded in the control logic at the factory. As described in the preceding note, this feature is allowed only in transceivers sold to the Federal Government. Keypad programming is then available if a conventional mode option switch is programmed for the “Keypad Programming” function. It is selected by simply pressing that switch (password entry is not required). The keypad programming mode is indicated by “ZONE CHG” and blanked Zone and Channel displays as follows:



Keypad programming allows conventional channel parameters such as the transmit and receive frequency and Call Guard squelch code to be changed. In addition, several conventional mode timers can be changed. It cannot be used to reprogram disabled channels or any SMARTNET/SmartZone information.

3.8.2 MENU DESCRIPTION

A menu system is used to select parameters to be changed in the keypad programming mode. When the keypad programming mode is selected by pressing the Keypad Programming option button, the first menu parameter “ZONE CHG” is displayed as just described. Rotate and press the Select switch to scroll through and select the available parameters which are as listed below. Additional information on this parameters is located in the following sections.

- **ZONE CHG**
- **CHAN CHG**
- **SYS PRM**
- **CHAN PRM**

Key Identification For Keypad Programming

Press the Select switch or F6 key (see preceding illustration) to select the displayed parameter. Press the F5 key from one of the main menus to exit keypad programming. Pressing it in the other menus returns to the previous menu. A flowchart showing the keypad programming mode menu structure is located in Figure 3-4 on the next page.

3.8.3 ZONE PASSWORD

NOTE: *Make sure that the zone password(s) are not lost because they cannot be overridden in the field. New passwords must be programmed or the data uploaded and displayed to recover lost passwords.*

Each zone can be programmed with a password by the PCConfigure software. The correct password must then be entered before system or channel parameters in that zone can be changed by keypad programming. This prevents unauthorized reprogramming of zones. The zone password is programmed in the Zones > Edit Zone screen. (see Section 4). A different password can be programmed for each zone.

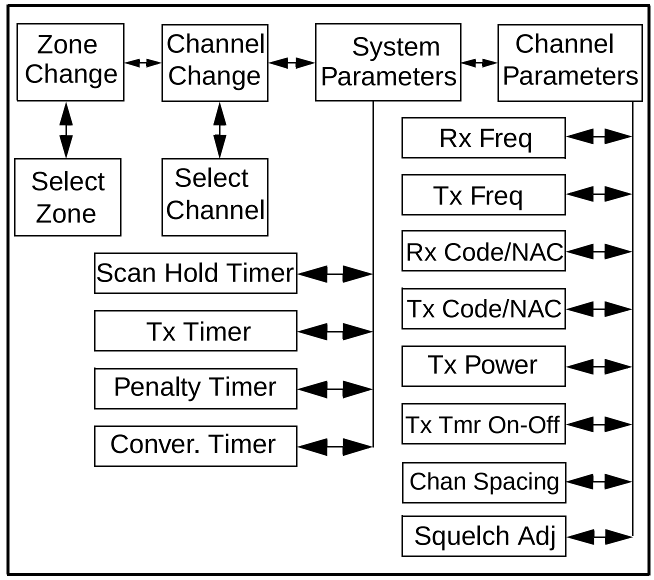


Figure 3-4 Keypad Programming Menu Flowchart

When a password protected zone is selected, “PASSWORD” is flashed the first time an attempt is made to select a system or channel parameter in that zone. Each digit of the password is then entered by rotating and then pressing the Select switch. The password is always eight digits long, and after the eighth digit is entered, system and channel parameters for that zone can be reprogrammed normally.

3.8.4 ZONE CHANGE PARAMETER

General

The “ZONE CHG” menu parameter selects the zone containing the conventional channel to be reprogrammed. It does not change the zone selected for normal operation.

Press the Select switch to select the “ZONE CHG” parameter and then scroll through the programmed zones by rotating that switch. When the desired zone is displayed, select it by pressing the Select switch.

3.8.5 CHANNEL CHANGE PARAMETER

The “CHAN CHG” menu parameter selects the conventional channel to be reprogrammed. Disabled or SMARTNET/SmartZone channels cannot be selected. This does not change the channel selected for normal operation.

Press the Select switch to select the “CHAN CHG” parameter and then scroll through the programmed channels by rotating that switch. When the desired channel is displayed, select it by pressing the Select switch.

3.8.6 SYSTEM PARAMETERS

NOTE: If “PASSWORD” is briefly displayed when attempting to select a parameter, see Section 3.8.3.

The “SYS PRM” menu parameter selects the conventional mode timer to be reprogrammed (see following). Press the Select switch to select the “SYS CHG” parameter and then rotate that switch to display the desired parameter. Then press the Select switch again to select it.

SCAN TMR - Selects the Scan Hold timer. Rotate the Select switch to decrement/increment the timer in 0.5-second steps, and press the F2 key (see illustration on the preceding page) to disable the timer (set it to 0 seconds). When the desired value is displayed, store it by pressing the Select switch.

TX TMR - Selects the transmit time-out timer. Rotate the Select switch to decrement/increment the timer in 15-second steps, and press the F2 key to disable the timer (set it to 0 seconds). When the desired value is displayed, store it by pressing the Select switch.

PEN TMR - Selects the penalty timer. Rotate the Select switch to decrement/increment the timer in 15-second steps, and press the F2 key to disable the timer (set it to 0 seconds). When the desired value is displayed, store it by pressing the Select switch.

CONV TMR - Selects the conversation timer. Rotate the Select switch to decrement/increment the timer in 30-second steps, and press the F2 key to disable the timer (set it to 0 seconds). When the desired value is displayed, store it by pressing the Select switch.

3.8.7 CHANNEL PARAMETERS

NOTE: If “PASSWORD” is briefly displayed when attempting to select a parameter, see Section 3.8.3.

The “CHAN PRM” menu parameter selects the following conventional channel parameters that can be reprogrammed. Press Select switch to select the “CHAN PRM” parameter and then rotate that switch to display the desired parameter. Then press the Select switch again to select it. The squelch control parameters are unique to the type of conventional channel selected (analog or Project 25).

RX FREQ - Selects the receive channel frequency. To select the digit to change, move the cursor right by pressing the Select switch or F4 key (see illustration on preceding page) and move it left by pressing the F3 key. Then to display the desired digit, rotate the Select switch. When the desired frequency is displayed, store it by pressing the F6 key. If an invalid frequency is entered, a beep sounds, “INVALID” is briefly displayed, and the frequency editing mode continues to be selected.

TX FREQ - Selects the transmit frequency the same as RX FREQ above.

Squelch Control (Analog Channel)

RX CODE - Selects the receive Call Guard (CTCSS/DCS) code. Rotate the Select switch to scroll through the available codes. Press the F2 key (see illustration on preceding page) once to display the first available code, and press it again to toggle between types (CTCSS and DCS). When the desired code is displayed, store it by pressing the Select switch.

TX CODE - Selects the transmit codes the same as RX CODE above.

Squelch Control (Project 25 Channel)

RX NAC - Selects the Network Access Code (NAC) which can be any number from 0-4095. Select the code using the Select switch and F3 and F2 keys the same as when setting the receive frequency as described above. Press the F2 key (see illustration on preceding page) to reset the NAC to 0. When the desired code is displayed, store it by pressing the F6 key. If an invalid code is entered, a beep sounds, “INVALID” is briefly displayed, and the NAC editing mode continues to be selected.

TX NAC - Selects the transmit NAC the same as RX NAC above.

TX POWER - Selects the desired power output level. Rotate the Select switch to scroll through the following choices. When the desired setting is displayed, store it by pressing the Select switch.

- POWER HI - High transmit power
- POWER LO - Low transmit power
- POWER SW - Switchable power selectable by the High/Low power switch. This choice is not available if that switch is not programmed.

TX TMR - Enables or disables the time-out timer on the current channel. Rotate the Select switch to toggle between the on and off mode, and when the desired setting is displayed, store it by pressing the Select switch.

CHAN SPC - Selects either wide or narrow band channel spacing on analog channels only. Rotate the Select switch to toggle between “WIDE” and “NARROW”, and when the desired setting is displayed, store it by pressing the Select switch.

SQ ADJ - Changes the preset squelch setting on that channel. The default setting is “0” and values of –7 to +7 can be selected. Increasing this setting toward +7 causes the squelch to open sooner so that weaker signals can be received, and decreasing it toward –7 causes the opposite to occur.

Figure 3-5 Handheld Control Unit Controls

3.9 HANDHELD CONTROL UNIT OPERATION

3.9.1 FRONT PANEL CONTROLS

Power On-Off - Turns power on and off.

PTT (Push-To-Talk) Switch - This button is pressed to talk (enable the transmitter) and released to listen.

Microphone - The microphone is located behind this grille.

Telephone (DTMF) Keypad - These keys are used to dial numbers when placing telephone calls (if applicable).

Volume Up/Down - Pressing VOL ▲ increases the speaker volume level and pressing VOL ▼ decreases the speaker volume level. Holding the button down causes the function to repeat.

Up/Down Select - Selects zones in the zone select mode, or channels in the channel select mode. Pressing ▲ increases the selected number and pressing ▼ decreases the selected number. It is also used for other functions such as selecting names from a call list. The zone and channel select modes are selected by the following Mode Select button.

Mode Select - Pressing this button switches between the Zone and Channel select modes. The current mode is indicated by the bar above either the Zone or Channel display (see Figure 3-3). Refer to Section 3.3.6 for more information on selecting zones and channels. This button is also used in other modes to select various functions.

Option Keys - These keys can be system operator programmed to control radio functions. Each key can be programmed to control one function in the conventional mode and another in the SMARTNET/SmartZone mode. Refer to Section 3.4.1 for more information on option key functions.

Multi-function Indicator - This is a two-color LED that indicates the following:

Red (constant) - Transmitter keyed (PTT switch pressed).
Green (constant) - Busy condition (carrier detected in receive mode).

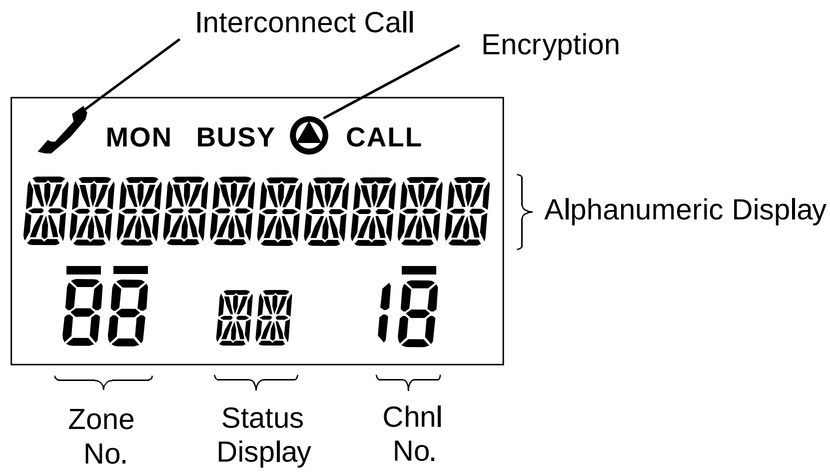


Figure 3-6 Handheld Control Unit Display

NOTE: This indicator is non-functional when the display and keypad backlight is turned off by the Backlight option switch or programming (see Section 3.3.3).

3.9.2 DISPLAY

 - With SMARTNET/SmartZone operation, indicates that an interconnect call has been initiated. It is non-functional in the conventional mode.

MON - Indicates that the monitoring is enabled by the Monitor option key (conventional operation only). This key unsquelches the receiver so that all messages are heard on the channel. Refer to Section 3.5.3 for more information.

 - Indicates that voice encryption is enabled.

Alphanumeric Display - This 10-character area of the display indicates the alias (unique identification) for the selected channel. In other modes, it may also indicate such things as the channel frequency, system/group number, and status and error messages.

Zone Number - Indicates the currently selected zone from 1 up to 16. A zone is a collection of channels that can be any combination of the conventional and SMARTNET/SmartZone types.

Channel Number - Indicates the currently selected channel.

▬ - The lines above the zone and channel displays indicate which display is changed if the Up/Down select button is pressed. To switch between displays, press the Mode button (see Section 3.3.6).

Status Display - These two characters indicate the following status information:

 - This symbol in the left position indicates that the displayed channel is in the scan list (scanned normally).

 - A "P" in the left position indicates that the selected conventional channel is a priority channel.

 - This rotating clock-like symbol in the right position indicates that scanning is enabled.

3.9.3 OPERATION DIFFERENCES

Handheld control unit operation is very similar to the operation of the standard front 5300 control unit. Some minor differences are as follows:

- The Up/Down button performs the same function as rotating the Select switch, and pressing the MODE button performs the same function as pressing the Select switch.

- The display has basically the same icons. An exception is the triangle icon used to indicate the scan edit mode described on page 3-9. This mode is not indicated with the handheld control unit.

- The Emergency and Clear/Secure buttons on the top panel have fixed functions. The programmable option switches are F1-F5 on the front panel.

- To change the viewing angle of the display, press and hold the MODE key and then press the F2 key. Then release both keys and adjust the viewing angle using the Up/Down key (see Section 3.3.3).

SECTION 4 TRANSCEIVER PROGRAMMING

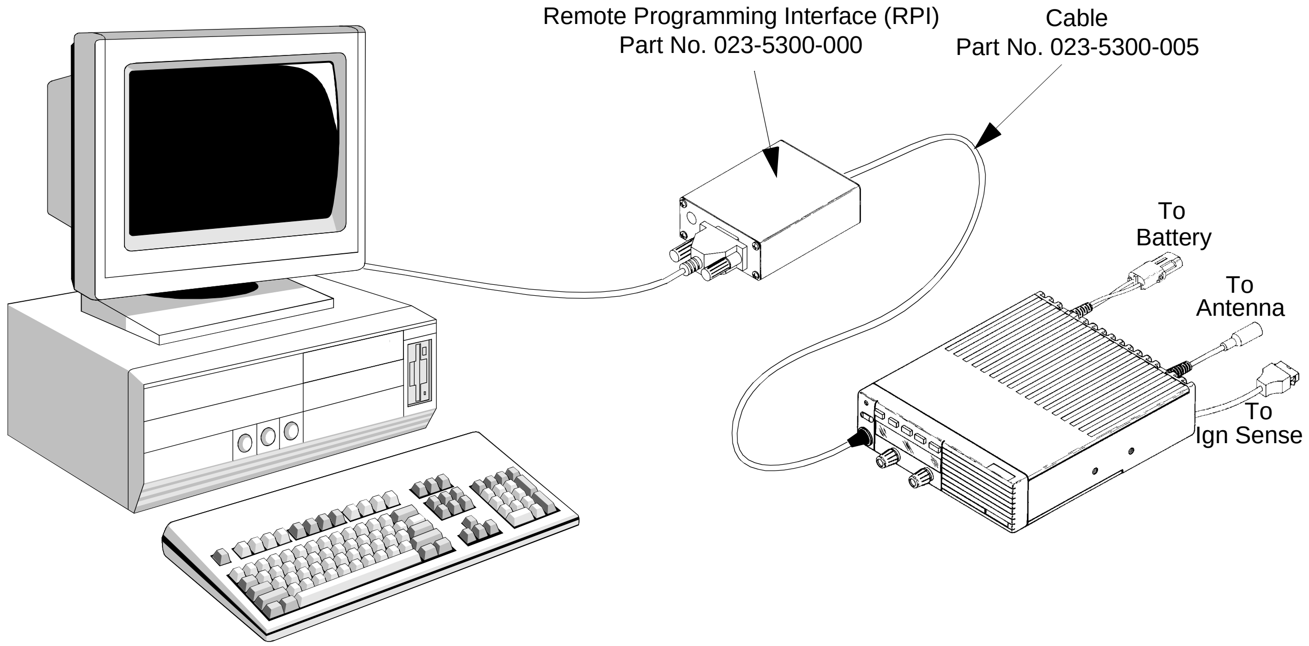


Figure 4-1 Programming Setup (Standard Front/Remote Models)

4.1 GENERAL

4.1.1 PROGRAMMING SETUP

The following items are required to program the transceiver. The part numbers of this equipment are shown in Table 1-1 in Section 1. The programming setup is shown above.

- A Windows®-based computer (see next section)
- Remote Programming Interface (RPI), Part No. 023-5300-000
- Programming cable from RPI to transceiver (see Section 4.1.3 for more information).
- EFJohnson PCConfigure programming software, Part No. 023-9998-488.

NOTE: The -005 cable, the -488 software, and a CD manual are included in the 5300 Series Programming Kit, Part No. 250-5000-004.

4.1.2 COMPUTER DESCRIPTION

The computer used to program this transceiver should meet the following minimum requirements:

- Windows 95/98/NT/2000 (3.1 cannot be used)
- Pentium® processor or equivalent
- 16 MB of RAM
- A hard disk drive with at least 5 MB of free space
- A CD-ROM drive
- An available serial port

4.1.3 CONNECTING COMPUTER TO TRANSCEIVER

NOTE: Only RPI, Part No. 023-5300-000, can be used to program the 5300-series transceiver. Other RPIs such as 023-9800-000 and 023-9750-000 are not compatible with this transceiver.

<u>Connecting RPI To Computer</u>

The Radio Programming Interface (RPI) provides the required logic interface between the computer and transceiver. The cable from the RPI to computer is not included with the RPI. The RPI has a female DB9 connector, and most computer serial ports have a male DB9 or DB25 connector. Therefore, a male DB9 to female DB9 or DB25 is usually required. This is a standard cable available at most computer supply stores or order 6 ft. DB9M to DB9F cable, Part No. 597-5900-002.

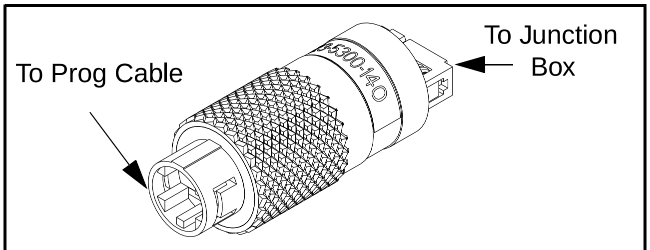
Connecting RPI To Transceiver

The programming setup for a front mount transceiver is shown in Figure 4-1. With transceivers that use the standard front or remote control unit, the cable from the RPI plugs into the microphone jack of the transceiver or control unit. This cable is Part No. 023-5300-005, and it is not included with the RPI. Connecting the programming setup to the handheld controller is described in the next section.

4.1.4 HANDHELD CONTROLLER PROGRAMMING SETUP

When the Handheld Control Unit is used (see Section 3.9), the same computer, RPI, and programming cable are used as with the standard front and remote models. In addition, the following components are required:

- The junction box (Part No. 023-5300-130) is required to provide a connection point for the RPI since the control unit does not have a programming jack. This box may not be included with some handheld control units.
- Adapter Plug, Part No. 023-5300-140, is required to plug the 5300 programming cable into the rectangular 10-pin programming connector on the junction box (see following illustration).



Programming Adapter Plug

Only one transceiver programming parameter must be changed when the Handheld Control Unit is used. Set the “Controller Type” parameter on the Global screen of the PCConfigure programming software for “Handheld” instead of “Normal”.

4.1.5 SIREN PROGRAMMING

When the optional siren feature is installed (see Section 2.10), one transceiver programming parameter may need to be changed for proper operation of the siren controller backlight. On the Global screen of the PCConfigure programming software, set the “Auxiliary B Toggle” parameter for “Backlight”. The Siren Control Head backlight then turns on and off with the transceiver control unit backlight.

4.2 USING THE PCCONFIGURE SOFTWARE

The PCConfigure software is described in a separate CD-based manual included on the CD-ROM with this service manual and also the programming software. To open the manual included with this service manual, click the following link or go to the PCConfigure directory on the CD and open the file “Manual.pdf”.

(Click here to open PCConfigure manual)

Tone (CTCSS) and digital (DCS) Call Guard tones and 800 MHz channel frequencies are shown on the following pages.

Table 4-1 Call Guard (CTCSS/DCS) Codes and Tones

Recommended Tone Call Guard Codes									
Code	Freq	Code	Freq	Code	Freq	Code	Freq	Code	Freq
		09	91.5	18	123.0	27	167.9	36*	233.6
01	67.0	10	94.8	19	127.3	28	173.8	37*	241.8
02	71.9	11**	97.4	20	131.8	29	179.9	38*	250.3
03	74.4	12	100.0	21	136.5	30	186.2	39**	69.3
04	77.0	13	103.5	22	141.3	31	192.8	40**	206.5
05	79.7	14	107.2	23	146.2	32	203.5	41**	229.1
06	82.5	15	110.9	24	151.4	33	210.7	42**	254.1
07	85.4	16	114.8	25	156.7	34*	218.1		
08	88.5	17	118.8	26	162.2	35*	225.7		
* These tones normally are not used because of their close proximity to the voice frequencies ** This tone is normally not used because it may cause interference with adjacent tones.									
Recommended Digital Call Guard Codes									
023	065	131	172	261	346	431	532	654	743
025	071	132	174	263	351	432	546	662	754
026	072	134	205	265	364	445	565	664	
031	073	143	223	271	365	464	606	703	
032	074	152	226	306	371	465	612	712	
043	114	155	243	311	411	466	624	723	
047	115	156	244	315	412	503	627	731	
051	116	162	245	331	413	506	631	732	
054	125	165	251	343	423	516	632	734	

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq	Mobile Tx Freq
1	851.0125	806.0125	51	852.2625	807.2625	101	853.5125	808.5125
2	851.0375	806.0375	52	852.2875	807.2875	102	853.5375	808.5375
3	851.0625	806.0625	53	852.3125	807.3125	103	853.5625	808.5625
4	851.0875	806.0875	54	852.3375	807.3375	104	853.5875	808.5875
5	851.1125	806.1125	55	852.3625	807.3625	105	853.6125	808.6125
6	851.1375	806.1375	56	852.3875	807.3875	106	853.6375	808.6375
7	851.1625	806.1625	57	852.4125	807.4125	107	853.6625	808.6625
8	851.1875	806.1875	58	852.4375	807.4375	108	853.6875	808.6875
9	851.2125	806.2125	59	852.4625	807.4625	109	853.7125	808.7125
10	851.2375	806.2375	60	852.4875	807.4875	110	853.7375	808.7375
11	851.2625	806.2625	61	852.5125	807.5125	111	853.7625	808.7625
12	851.2875	806.2875	62	852.5375	807.5375	112	853.7875	808.7875
13	851.3125	806.3125	63	852.5625	807.5625	113	853.8125	808.8125
14	851.3375	806.3375	64	852.5875	807.5875	114	853.8375	808.8375
15	851.3625	806.3625	65	852.6125	807.6125	115	853.8625	808.8625
16	851.3875	806.3875	66	852.6375	807.6375	116	853.8875	808.8875
17	851.4125	806.4125	67	852.6625	807.6625	117	853.9125	808.9125
18	851.4375	806.4375	68	852.6875	807.6875	118	853.9375	808.9375
19	851.4625	806.4625	69	852.7125	807.7125	119	853.9625	808.9625
20	851.4875	806.4875	70	852.7375	807.7375	120	853.9875	808.9875
21	851.5125	806.5125	71	852.7625	807.7625	121	854.0125	809.0125
22	851.5375	806.5375	72	852.7875	807.7875	122	854.0375	809.0375
23	851.5625	806.5625	73	852.8125	807.8125	123	854.0625	809.0625
24	851.5875	806.5875	74	852.8375	807.8375	124	854.0875	809.0875
25	851.6125	806.6125	75	852.8625	807.8625	125	854.1125	809.1125
26	851.6375	806.6375	76	852.8875	807.8875	126	854.1375	809.1375
27	851.6625	806.6625	77	852.9125	807.9125	127	854.1625	809.1625
28	851.6875	806.6875	78	852.9375	807.9375	128	854.1875	809.1875
29	851.7125	806.7125	79	852.9625	807.9625	129	854.2125	809.2125
30	851.7375	806.7375	80	852.9875	807.9875	130	854.2375	809.2375
31	851.7625	806.7625	81	853.0125	808.0125	131	854.2625	809.2625
32	851.7875	806.7875	82	853.0375	808.0375	132	854.2875	809.2875
33	851.8125	806.8125	83	853.0625	808.0625	133	854.3125	809.3125
34	851.8375	806.8375	84	853.0875	808.0875	134	854.3375	809.3375
35	851.8625	806.8625	85	853.1125	808.1125	135	854.3625	809.3625
36	851.8875	806.8875	86	853.1375	808.1375	136	854.3875	809.3875
37	851.9125	806.9125	87	853.1625	808.1625	137	854.4125	809.4125
38	851.9375	806.9375	88	853.1875	808.1875	138	854.4375	809.4375
39	851.9625	806.9625	89	853.2125	808.2125	139	854.4625	809.4625
40	851.9875	806.9875	90	853.2375	808.2375	140	854.4875	809.4875
41	852.0125	807.0125	91	853.2625	808.2625	141	854.5125	809.5125
42	852.0375	807.0375	92	853.2875	808.2875	142	854.5375	809.5375
43	852.0625	807.0625	93	853.3125	808.3125	143	854.5625	809.5625
44	852.0875	807.0875	94	853.3375	808.3375	144	854.5875	809.5875
45	852.1125	807.1125	95	853.3625	808.3625	145	854.6125	809.6125
46	852.1375	807.1375	96	853.3875	808.3875	146	854.6375	809.6375
47	852.1625	807.1625	97	853.4125	808.4125	147	854.6625	809.6625
48	852.1875	807.1875	98	853.4375	808.4375	148	854.6875	809.6875
49	852.2125	807.2125	99	853.4625	808.4625	149	854.7125	809.7125
50	852.2375	807.2375	100	853.4875	808.4875	150	854.7375	809.7375

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq
151	854.7625	809.7625
152	854.7875	809.7875
153	854.8125	809.8125
154	854.8375	809.8375
155	854.8625	809.8625
156	854.8875	809.8875
157	854.9125	809.9125
158	854.9375	809.9375
159	854.9625	809.9625
160	854.9875	809.9875
161	855.0125	810.0125
162	855.0375	810.0375
163	855.0625	810.0625
164	855.0875	810.0875
165	855.1125	810.1125
166	855.1375	810.1375
167	855.1625	810.1625
168	855.1875	810.1875
169	855.2125	810.2125
170	855.2375	810.2375
171	855.2625	810.2625
172	855.2875	810.2875
173	855.3125	810.3125
174	855.3375	810.3375
175	855.3625	810.3625
176	855.3875	810.3875
177	855.4125	810.4125
178	855.4375	810.4375
179	855.4625	810.4625
180	855.4875	810.4875
181	855.5125	810.5125
182	855.5375	810.5375
183	855.5625	810.5625
184	855.5875	810.5875
185	855.6125	810.6125
186	855.6375	810.6375
187	855.6625	810.6625
188	855.6875	810.6875
189	855.7125	810.7125
190	855.7375	810.7375
191	855.7625	810.7625
192	855.7875	810.7875
193	855.8125	810.8125
194	855.8375	810.8375
195	855.8625	810.8625
196	855.8875	810.8875
197	855.9125	810.9125
198	855.9375	810.9375
199	855.9625	810.9625
200	855.9875	810.9875

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq
201	856.0125	811.0125
202	856.0375	811.0375
203	856.0625	811.0625
204	856.0875	811.0875
205	856.1125	811.1125
206	856.1375	811.1375
207	856.1625	811.1625
208	856.1875	811.1875
209	856.2125	811.2125
210	856.2375	811.2375
211	856.2625	811.2625
212	856.2875	811.2875
213	856.3125	811.3125
214	856.3375	811.3375
215	856.3625	811.3625
216	856.3875	811.3875
217	856.4125	811.4125
218	856.4375	811.4375
219	856.4625	811.4625
220	856.4875	811.4875
221	856.5125	811.5125
222	856.5375	811.5375
223	856.5625	811.5625
224	856.5875	811.5875
225	856.6125	811.6125
226	856.6375	811.6375
227	856.6625	811.6625
228	856.6875	811.6875
229	856.7125	811.7125
230	856.7375	811.7375
231	856.7625	811.7625
232	856.7875	811.7875
233	856.8125	811.8125
234	856.8375	811.8375
235	856.8625	811.8625
236	856.8875	811.8875
237	856.9125	811.9125
238	856.9375	811.9375
239	856.9625	811.9625
240	856.9875	811.9875
241	857.0125	812.0125
242	857.0375	812.0375
243	857.0625	812.0625
244	857.0875	812.0875
245	857.1125	812.1125
246	857.1375	812.1375
247	857.1625	812.1625
248	857.1875	812.1875
249	857.2125	812.2125
250	857.2375	812.2375

FCC Chan. No.	Mobile Rx Freq	Mobile Tx Freq
251	857.2625	812.2625
252	857.2875	812.2875
253	857.3125	812.3125
254	857.3375	812.3375
255	857.3625	812.3625
256	857.3875	812.3875
257	857.4125	812.4125
258	857.4375	812.4375
259	857.4625	812.4625
260	857.4875	812.4875
261	857.5125	812.5125
262	857.5375	812.5375
263	857.5625	812.5625
264	857.5875	812.5875
265	857.6125	812.6125
266	857.6375	812.6375
267	857.6625	812.6625
268	857.6875	812.6875
269	857.7125	812.7125
270	857.7375	812.7375
271	857.7625	812.7625
272	857.7875	812.7875
273	857.8125	812.8125
274	857.8375	812.8375
275	857.8625	812.8625
276	857.8875	812.8875
277	857.9125	812.9125
278	857.9375	812.9375
279	857.9625	812.9625
280	857.9875	812.9875
281	858.0125	813.0125
282	858.0375	813.0375
283	858.0625	813.0625
284	858.0875	813.0875
285	858.1125	813.1125
286	858.1375	813.1375
287	858.1625	813.1625
288	858.1875	813.1875
289	858.2125	813.2125
290	858.2375	813.2375
291	858.2625	813.2625
292	858.2875	813.2875
293	858.3125	813.3125
294	858.3375	813.3375
295	858.3625	813.3625
296	858.3875	813.3875
297	858.4125	813.4125
298	858.4375	813.4375
299	858.4625	813.4625
300	858.4875	813.4875

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq	Mobile Tx Freq
301	858.5125	813.5125	351	859.7625	814.7625	401	861.0125	816.0125
302	858.5375	813.5375	352	859.7875	814.7875	402	861.0375	816.0375
303	858.5625	813.5625	353	859.8125	814.8125	403	861.0625	816.0625
304	858.5875	813.5875	354	859.8375	814.8375	404	861.0875	816.0875
305	858.6125	813.6125	355	859.8625	814.8625	405	861.1125	816.1125
306	858.6375	813.6375	356	859.8875	814.8875	406	861.1375	816.1375
307	858.6625	813.6625	357	859.9125	814.9125	407	861.1625	816.1625
308	858.6875	813.6875	358	859.9375	814.9375	408	861.1875	816.1875
309	858.7125	813.7125	359	859.9625	814.9625	409	861.2125	816.2125
310	858.7375	813.7375	360	859.9875	814.9875	410	861.2375	816.2375
311	858.7625	813.7625	361	860.0125	815.0125	411	861.2625	816.2625
312	858.7875	813.7875	362	860.0375	815.0375	412	861.2875	816.2875
313	858.8125	813.8125	363	860.0625	815.0625	413	861.3125	816.3125
314	858.8375	813.8375	364	860.0875	815.0875	414	861.3375	816.3375
315	858.8625	813.8625	365	860.1125	815.1125	415	861.3625	816.3625
316	858.8875	813.8875	366	860.1375	815.1375	416	861.3875	816.3875
317	858.9125	813.9125	367	860.1625	815.1625	417	861.4125	816.4125
318	858.9375	813.9375	368	860.1875	815.1875	418	861.4375	816.4375
319	858.9625	813.9625	369	860.2125	815.2125	419	861.4625	816.4625
320	858.9875	813.9875	370	860.2375	815.2375	420	861.4875	816.4875
321	859.0125	814.0125	371	860.2625	815.2625	421	861.5125	816.5125
322	859.0375	814.0375	372	860.2875	815.2875	422	861.5375	816.5375
323	859.0625	814.0625	373	860.3125	815.3125	423	861.5625	816.5625
324	859.0875	814.0875	374	860.3375	815.3375	424	861.5875	816.5875
325	859.1125	814.1125	375	860.3625	815.3625	425	861.6125	816.6125
326	859.1375	814.1375	376	860.3875	815.3875	426	861.6375	816.6375
327	859.1625	814.1625	377	860.4125	815.4125	427	861.6625	816.6625
328	859.1875	814.1875	378	860.4375	815.4375	428	861.6875	816.6875
329	859.2125	814.2125	379	860.4625	815.4625	429	861.7125	816.7125
330	859.2375	814.2375	380	860.4875	815.4875	430	861.7375	816.7375
331	859.2625	814.2625	381	860.5125	815.5125	431	861.7625	816.7625
332	859.2875	814.2875	382	860.5375	815.5375	432	861.7875	816.7875
333	859.3125	814.3125	383	860.5625	815.5625	433	861.8125	816.8125
334	859.3375	814.3375	384	860.5875	815.5875	434	861.8375	816.8375
335	859.3625	814.3625	385	860.6125	815.6125	435	861.8625	816.8625
336	859.3875	814.3875	386	860.6375	815.6375	436	861.8875	816.8875
337	859.4125	814.4125	387	860.6625	815.6625	437	861.9125	816.9125
338	859.4375	814.4375	388	860.6875	815.6875	438	861.9375	816.9375
339	859.4625	814.4625	389	860.7125	815.7125	439	861.9625	816.9625
340	859.4875	814.4875	390	860.7375	815.7375	440	861.9875	816.9875
341	859.5125	814.5125	391	860.7625	815.7625	441	862.0125	817.0125
342	859.5375	814.5375	392	860.7875	815.7875	442	862.0375	817.0375
343	859.5625	814.5625	393	860.8125	815.8125	443	862.0625	817.0625
344	859.5875	814.5875	394	860.8375	815.8375	444	862.0875	817.0875
345	859.6125	814.6125	395	860.8625	815.8625	445	862.1125	817.1125
346	859.6375	814.6375	396	860.8875	815.8875	446	862.1375	817.1375
347	859.6625	814.6625	397	860.9125	815.9125	447	862.1625	817.1625
348	859.6875	814.6875	398	860.9375	815.9375	448	862.1875	817.1875
349	859.7125	814.7125	399	860.9625	815.9625	449	862.2125	817.2125
350	859.7375	814.7375	400	860.9875	815.9875	450	862.2375	817.2375

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq	Mobile Tx Freq
451	862.2625	817.2625	501	863.5125	818.5125	551	864.7625	819.7625
452	862.2875	817.2875	502	863.5375	818.5375	552	864.7875	819.7875
453	862.3125	817.3125	503	863.5625	818.5625	553	864.8125	819.8125
454	862.3375	817.3375	504	863.5875	818.5875	554	864.8375	819.8375
455	862.3625	817.3625	505	863.6125	818.6125	555	864.8625	819.8625
456	862.3875	817.3875	506	863.6375	818.6375	556	864.8875	819.8875
457	862.4125	817.4125	507	863.6625	818.6625	557	864.9125	819.9125
458	862.4375	817.4375	508	863.6875	818.6875	558	864.9375	819.9375
459	862.4625	817.4625	509	863.7125	818.7125	559	864.9625	819.9625
460	862.4875	817.4875	510	863.7375	818.7375	560	864.9875	819.9875
461	862.5125	817.5125	511	863.7625	818.7625	561	865.0125	820.0125
462	862.5375	817.5375	512	863.7875	818.7875	562	865.0375	820.0375
463	862.5625	817.5625	513	863.8125	818.8125	563	865.0625	820.0625
464	862.5875	817.5875	514	863.8375	818.8375	564	865.0875	820.0875
465	862.6125	817.6125	515	863.8625	818.8625	565	865.1125	820.1125
466	862.6375	817.6375	516	863.8875	818.8875	566	865.1375	820.1375
467	862.6625	817.6625	517	863.9125	818.9125	567	865.1625	820.1625
468	862.6875	817.6875	518	863.9375	818.9375	568	865.1875	820.1875
469	862.7125	817.7125	519	863.9625	818.9625	569	865.2125	820.2125
470	862.7375	817.7375	520	863.9875	818.9875	570	865.2375	820.2375
471	862.7625	817.7625	521	864.0125	819.0125	571	865.2625	820.2625
472	862.7875	817.7875	522	864.0375	819.0375	572	865.2875	820.2875
473	862.8125	817.8125	523	864.0625	819.0625	573	865.3125	820.3125
474	862.8375	817.8375	524	864.0875	819.0875	574	865.3375	820.3375
475	862.8625	817.8625	525	864.1125	819.1125	575	865.3625	820.3625
476	862.8875	817.8875	526	864.1375	819.1375	576	865.3875	820.3875
477	862.9125	817.9125	527	864.1625	819.1625	577	865.4125	820.4125
478	862.9375	817.9375	528	864.1875	819.1875	578	865.4375	820.4375
479	862.9625	817.9625	529	864.2125	819.2125	579	865.4625	820.4625
480	862.9875	817.9875	530	864.2375	819.2375	580	865.4875	820.4875
481	863.0125	818.0125	531	864.2625	819.2625	581	865.5125	820.5125
482	863.0375	818.0375	532	864.2875	819.2875	582	865.5375	820.5375
483	863.0625	818.0625	533	864.3125	819.3125	583	865.5625	820.5625
484	863.0875	818.0875	534	864.3375	819.3375	584	865.5875	820.5875
485	863.1125	818.1125	535	864.3625	819.3625	585	865.6125	820.6125
486	863.1375	818.1375	536	864.3875	819.3875	586	865.6375	820.6375
487	863.1625	818.1625	537	864.4125	819.4125	587	865.6625	820.6625
488	863.1875	818.1875	538	864.4375	819.4375	588	865.6875	820.6875
489	863.2125	818.2125	539	864.4625	819.4625	589	865.7125	820.7125
490	863.2375	818.2375	540	864.4875	819.4875	590	865.7375	820.7375
491	863.2625	818.2625	541	864.5125	819.5125	591	865.7625	820.7625
492	863.2875	818.2875	542	864.5375	819.5375	592	865.7875	820.7875
493	863.3125	818.3125	543	864.5625	819.5625	593	865.8125	820.8125
494	863.3375	818.3375	544	864.5875	819.5875	594	865.8375	820.8375
495	863.3625	818.3625	545	864.6125	819.6125	595	865.8625	820.8625
496	863.3875	818.3875	546	864.6375	819.6375	596	865.8875	820.8875
497	863.4125	818.4125	547	864.6625	819.6625	597	865.9125	820.9125
498	863.4375	818.4375	548	864.6875	819.6875	598	865.9375	820.9375
499	863.4625	818.4625	549	864.7125	819.7125	599	865.9625	820.9625
500	863.4875	818.4875	550	864.7375	819.7375	600	865.9875	820.9875

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq	Mobile Tx Freq
-	866.0000	821.0000	645	866.6000	821.6000	691	867.2000	822.2000
601	866.0125	821.0125	646	866.6125	821.6125	692	867.2125	822.2125
-	866.0250	821.0250	647	866.6250	821.6250	693	867.2250	822.2250
602	866.0375	821.0375	648	866.6375	821.6375	694	867.2375	822.2375
603	866.0500	821.0500	649	866.6500	821.6500	695	867.2500	822.2500
604	866.0625	821.0625	650	866.6625	821.6625	696	867.2625	822.2625
605	866.0750	821.0750	651	866.6750	821.6750	697	867.2750	822.2750
606	866.0875	821.0875	652	866.6875	821.6875	698	867.2875	822.2875
607	866.1000	821.1000	653	866.7000	821.7000	699	867.3000	822.3000
608	866.1125	821.1125	654	866.7125	821.7125	700	867.3125	822.3125
609	866.1250	821.1250	655	866.7250	821.7250	701	867.3250	822.3250
610	866.1375	821.1375	656	866.7375	821.7375	702	867.3375	822.3375
611	866.1500	821.1500	657	866.7500	821.7500	703	867.3500	822.3500
612	866.1625	821.1625	658	866.7625	821.7625	704	867.3625	822.3625
613	866.1750	821.1750	659	866.7750	821.7750	705	867.3750	822.3750
614	866.1875	821.1875	660	866.7875	821.7875	706	867.3875	822.3875
615	866.2000	821.2000	661	866.8000	821.8000	707	867.4000	822.4000
616	866.2125	821.2125	662	866.8125	821.8125	708	867.4125	822.4125
617	866.2250	821.2250	663	866.8250	821.8250	709	867.4250	822.4250
618	866.2375	821.2375	664	866.8375	821.8375	710	867.4375	822.4375
619	866.2500	821.2500	665	866.8500	821.8500	711	867.4500	822.4500
620	866.2625	821.2625	666	866.8625	821.8625	712	867.4625	822.4625
621	866.2750	821.2750	667	866.8750	821.8750	713	867.4750	822.4750
622	866.2875	821.2875	668	866.8875	821.8875	714	867.4875	822.4875
623	866.3000	821.3000	669	866.9000	821.9000	-	867.5000	822.5000
624	866.3125	821.3125	670	866.9125	821.9125	715	867.5125	822.5125
625	866.3250	821.3250	671	866.9250	821.9250	-	867.5250	822.5250
626	866.3375	821.3375	672	866.9375	821.9375	716	867.5375	822.5375
627	866.3500	821.3500	673	866.9500	821.9500	717	867.5500	822.5500
628	866.3625	821.3625	674	866.9625	821.9625	718	867.5625	822.5625
629	866.3750	821.3750	675	866.9750	821.9750	719	867.5750	822.5750
630	866.3875	821.3875	676	866.9875	821.9875	720	867.5875	822.5875
631	866.4000	821.4000	-	867.0000	822.0000	721	867.6000	822.6000
632	866.4125	821.4125	677	867.0125	822.0125	722	867.6125	822.6125
633	866.4250	821.4250	-	867.0250	822.0250	723	867.6250	822.6250
634	866.4375	821.4375	678	867.0375	822.0375	724	867.6375	822.6375
635	866.4500	821.4500	679	867.0500	822.0500	725	867.6500	822.6500
636	866.4625	821.4625	680	867.0625	822.0625	726	867.6625	822.6625
637	866.4750	821.4750	681	867.0750	822.0750	727	867.6750	822.6750
638	866.4875	821.4875	682	867.0875	822.0875	728	867.6875	822.6875
-	866.5000	821.5000	683	867.1000	822.1000	729	867.7000	822.7000
639	866.5125	821.5125	684	867.1125	822.1125	730	867.7125	822.7125
-	866.5250	821.5250	685	867.1250	822.1250	731	867.7250	822.7250
640	866.5375	821.5375	686	867.1375	822.1375	732	867.7375	822.7375
641	866.5500	821.5500	687	867.1500	822.1500	733	867.7500	822.7500
642	866.5625	821.5625	688	867.1625	822.1625	734	867.7625	822.7625
643	866.5750	821.5750	689	867.1750	822.1750	735	867.7750	822.7750
644	866.5875	821.5875	690	867.1875	822.1875	736	867.7875	822.7875

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq	FCC Chan. No.	Mobile Rx Freq	Mobile Tx Freq
737	867.8000	822.8000	783	868.4000	823.4000	-	869.0000	824.0000
738	867.8125	822.8125	784	868.4125	823.4125	-	869.0125	824.0125
739	867.8250	822.8250	785	868.4250	823.4250	-	869.0250	824.0250
740	867.8375	822.8375	786	868.4375	823.4375	-	869.0375	824.0375
741	867.8500	822.8500	787	868.4500	823.4500	-	869.0500	824.0500
742	867.8625	822.8625	788	868.4625	823.4625	-	869.0625	824.0625
743	867.8750	822.8750	789	868.4750	823.4750	-	869.0750	824.0750
744	867.8875	822.8875	790	868.4875	823.4875	-	869.0875	824.0875
745	867.9000	822.9000	791	868.5000	823.5000	-	869.1000	824.1000
746	867.9125	822.9125	792	868.5125	823.5125	-	869.1125	824.1125
747	867.9250	822.9250	793	868.5250	823.5250	-	869.1250	824.1250
748	867.9375	822.9375	794	868.5375	823.5375	-	869.1375	824.1375
749	867.9500	822.9500	795	868.5500	823.5500	-	869.1500	824.1500
750	867.9625	822.9625	796	868.5625	823.5625	-	869.1625	824.1625
751	867.9750	822.9750	797	868.5750	823.5750	-	869.1750	824.1750
752	867.9875	822.9875	798	868.5875	823.5875	-	869.1875	824.1875
-	868.0000	823.0000	799	868.6000	823.6000	-	869.2000	824.2000
753	868.0125	823.0125	800	868.6125	823.6125	-	869.2125	824.2125
-	868.0250	823.0250	801	868.6250	823.6250	-	869.2250	824.2250
754	868.0375	823.0375	802	868.6375	823.6375	-	869.2375	824.2375
755	868.0500	823.0500	803	868.6500	823.6500	-	869.2500	824.2500
756	868.0625	823.0625	804	868.6625	823.6625	-	869.2625	824.2625
757	868.0750	823.0750	805	868.6750	823.6750	-	869.2750	824.2750
758	868.0875	823.0875	806	868.6875	823.6875	-	869.2875	824.2875
759	868.1000	823.1000	807	868.7000	823.7000	-	869.3000	824.3000
760	868.1125	823.1125	808	868.7125	823.7125	-	869.3125	824.3125
761	868.1250	823.1250	809	868.7250	823.7250	-	869.3250	824.3250
762	868.1375	823.1375	810	868.7375	823.7375	-	869.3375	824.3375
763	868.1500	823.1500	811	868.7500	823.7500	-	869.3500	824.3500
764	868.1625	823.1625	812	868.7625	823.7625	-	869.3625	824.3625
765	868.1750	823.1750	813	868.7750	823.7750	-	869.3750	824.3750
766	868.1875	823.1875	814	868.7875	823.7875	-	869.3875	824.3875
767	868.2000	823.2000	815	868.8000	823.8000	-	869.4000	824.4000
768	868.2125	823.2125	816	868.8125	823.8125	-	869.4125	824.4125
769	868.2250	823.2250	817	868.8250	823.8250	-	869.4250	824.4250
770	868.2375	823.2375	818	868.8375	823.8375	-	869.4375	824.4375
771	868.2500	823.2500	819	868.8500	823.8500	-	869.4500	824.4500
772	868.2625	823.2625	820	868.8625	823.8625	-	869.4625	824.4625
773	868.2750	823.2750	821	868.8750	823.8750	-	869.4750	824.4750
774	868.2875	823.2875	822	868.8875	823.8875	-	869.4875	824.4875
775	868.3000	823.3000	823	868.9000	823.9000	-	869.5000	824.5000
776	868.3125	823.3125	824	868.9125	823.9125	-	869.5125	824.5125
777	868.3250	823.3250	825	868.9250	823.9250	-	869.5250	824.5250
778	868.3375	823.3375	826	868.9375	823.9375	-	869.5375	824.5375
779	868.3500	823.3500	827	868.9500	823.9500	-	869.5500	824.5500
780	868.3625	823.3625	828	868.9625	823.9625	-	869.5625	824.5625
781	868.3750	823.3750	829	868.9750	823.9750	-	869.5750	824.5750
782	868.3875	823.3875	830	868.9875	823.9875	-	869.5875	824.5875

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq
-	869.6000	824.6000
-	869.6125	824.6125
-	869.6250	824.6250
-	869.6375	824.6375
-	869.6500	824.6500
-	869.6625	824.6625
-	869.6750	824.6750
-	869.6875	824.6875
-	869.7000	824.7000
-	869.7125	824.7125
-	869.7250	824.7250

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq
-	869.7375	824.7375
-	869.7500	824.7500
-	869.7625	824.7625
-	869.7750	824.7750
-	869.7875	824.7875
-	869.8000	824.8000
-	869.8125	824.8125
-	869.8250	824.8250
-	869.8375	824.8375
-	869.8500	824.8500
-	869.8625	824.8625

FCC Chan. No.	Mobile Rx Freq	Mobile Tx Freq
-	869.8750	824.8750
-	869.8875	824.8875
-	869.9000	824.9000
-	869.9125	824.9125
-	869.9250	824.9250
-	869.9375	824.9375
-	869.9500	824.9500
-	869.9625	824.9625
-	869.9750	824.9750
-	869.9875	824.9875

SECTION 5 CIRCUIT DESCRIPTION

5.1 GENERAL TRANSCEIVER DESCRIPTION

5.1.1 INTRODUCTION

The E.F. Johnson 5300 is a microcontroller-based radio that uses a Digital Signal Processor (DSP) to provide the following modes of operation:

Narrowband Analog - FM modulation with a maximum deviation of 2.5 kHz. This mode is usually used in systems where the channel spacing is 12.5 kHz. Call Guard (CTCSS or DCS) subaudible squelch signaling can be used in this mode.

Wideband Analog - FM modulation with a maximum deviation of 5 kHz. This mode is usually used in systems where the channel spacing is 25 kHz or 30 kHz. Call Guard (CTCSS or DCS) subaudible squelch signaling can be used in this mode.

Project 25 Digital - The voice is digitized, error corrected, optionally encrypted and transmitted using C4FM modulation according to the Project 25 standard. This mode can be used in channel spacings of 12.5 kHz.

DES/DES-XL Encryption - This mode is compatible with the Motorola DES and DES-XL protocols. Voice is digitized, encrypted, and transmitted using FSK modulation. This mode can be used in channel spacings of 25 kHz. The DSP processes the received signals and generates the appropriate output signals. The microcontroller controls the hardware and provides an interface between hardware and DSP.

5.1.2 PC BOARDS

The 5300-series mobile contains the following PC board assemblies:

RF Board - Contains the receiver, synthesizer, and exciter sections.

PA Board - Contains the transmitter power amplifier, power control, and main DC power switching sections.

Logic Board - Contains the digital signal processing (DSP), control logic, and audio processing sections.

Interface Board - A small board that provides the electrical connections between the logic and RF/PA boards. It also contains the audio amplifier and volume control circuits for internal and external speakers.

Display Controller - Contains a microcontroller which provides an interface between the controller on the logic board and the front panel display and switches.

Display Board - Contains the liquid crystal display, option switch keypad, and display drivers. In addition, it contains the backlight for the display and keypad.

5.1.3 CIRCUIT PROTECTION (FUSES)

Circuit protection is provided as follows:

- A 15-ampere fuse in the power cable provides overall transceiver protection.
- A 2-ampere fuse on the RF board protects circuits on that board.
- F700 (2-ampere) on the display controller board protects the Sw B+ output of the microphone connector.
- F1 on the logic board protects the Sw B+ output of universal interface connector J5.
- The various voltage regulators provide circuit protection by automatically limiting current.

5.1.4 ANALOG MODE DESCRIPTION

<u>Receive Mode</u>

The RF signal is routed from the antenna connector to the RF Board where it is filtered, amplified, and mixed with the first local oscillator frequency generated by the synthesizer. The resulting IF signal is also filtered and amplified and sent to the ABACUS chip.

The signal is then mixed with the second local oscillator frequency to create a second IF signal of 450 kHz. The second IF signal is then sampled at 14.4 Msps and downconverted to baseband. The baseband signal is then decimated to a lower sample rate that is selectable at 20 kHz. This signal is then routed via a serial interface using a differential current output to the ADSIC U3 on the logic board.

On the logic board ADSIC U3 digitally filters the input signal, performs frequency discrimination to obtain the message signal, and then routes the message signal to DSP (Digital Signal Processor) U12. The DSP first performs a carrier-detection squelch function on the radio. If a signal is determined to be present, the audio portion of the signal is resampled to an 8 kHz rate and then filtered appropriately. The filtered signal is then routed back to a D/A in the ADSIC to produce an analog signal for output to the audio power amplifier (PA) and then the speaker. Any detected signaling information is decoded and the resulting information is sent to the microcontroller.

Transmit Mode

The signal from the microphone is amplified by the audio PA and is then routed to ADSIC U3 where it is first digitized at a 16 ksps rate and then sent to DSP U12. The DSP performs the required filtering, adds the desired signaling, converts the sample rate to 48 ksps and then sends the resulting signal back to a D/A in the ADSIC to produce the analog modulation signal for the VCO. The modulated VCO signal is then sent to the RF PA for amplification.

5.1.5 PROJECT 25 DIGITAL MODE

Introduction

In Project 25 Digital Mode, the carrier is modulated with four discrete deviation levels of ± 600 Hz and ± 1800 Hz. Digitized voice is created using an IMBE™ vocoder.

Receive Mode

The signal is processed in the same way as an analog mode transmission until after the squelch function is performed. If a signal is detected to be present, DSP U12 resamples the signal from 20 kHz to 24 kHz. This is done so that the sample rate is an integer multiple (5x) of the data rate of the digital modulation which is 4800 symbols/sec (9600 bits/sec).

The resampled signal is then processed by a demodulator routine to extract the digital information. The resulting bit stream (9600 bps) is sent to a routine that performs unframing, error-correction, and voice decoding. The result of these operations is a reconstructed voice signal sampled at 8 kHz. The sampled voice signal is sent to a D/A in ADSIC U3 to produce an analog signal for output to the audio power amplifier and speaker.

Transmit Mode

The microphone signal is processed as in the analog mode until it reaches DSP U12. At this point the audio signal is processed by a voice encoding routine to digitize the information. The resulting samples are then converted to a bit stream that is placed into the proper framing structure and error protected. The resulting bit stream has a bit rate of 9600 Hz.

This bit stream is then encoded, two bits at a time, into a digital level corresponding to one of the four allowable frequency deviations. This produces 16-bit symbols with a rate of 4800 Hz. The symbols are resampled to a rate of 48 kHz and filtered to comply with channel bandwidth requirements. The filtered signal is then sent to a D/A in ADSIC U3 to produce the analog modulation signal for the VCO. The modulated VCO signal is then mixed up to the final transmit frequency and then sent to the RF board power amplifier section.

5.1.6 RF BOARD OVERVIEW

The receiver front end consists of a preselector, an RF amplifier, a second preselector, and a mixer (see Figure 5-1). Both preselectors on the VHF and UHF boards are varactor-tuned, two-pole filters controlled by the control logic. The 800 MHz board uses stripline technology for the preselector. The RF amplifier is a dual-gate, gallium-arsenide based IC. The mixer is a double-balanced, active mixer coupled by transformers. Injection is provided by the VCO through an injection filter. Refer to Table 5-1 for local oscillator (LO) and first IF information.

The frequency generation function is performed by three ICs and associated circuitry. The reference oscillator provides a frequency standard to the synthesizer/prescaler IC which controls the VCO IC. The

IMBE™ voice coding technology embodied in this product is protected by intellectual property rights including patent rights of Digital Voice Systems, Inc.

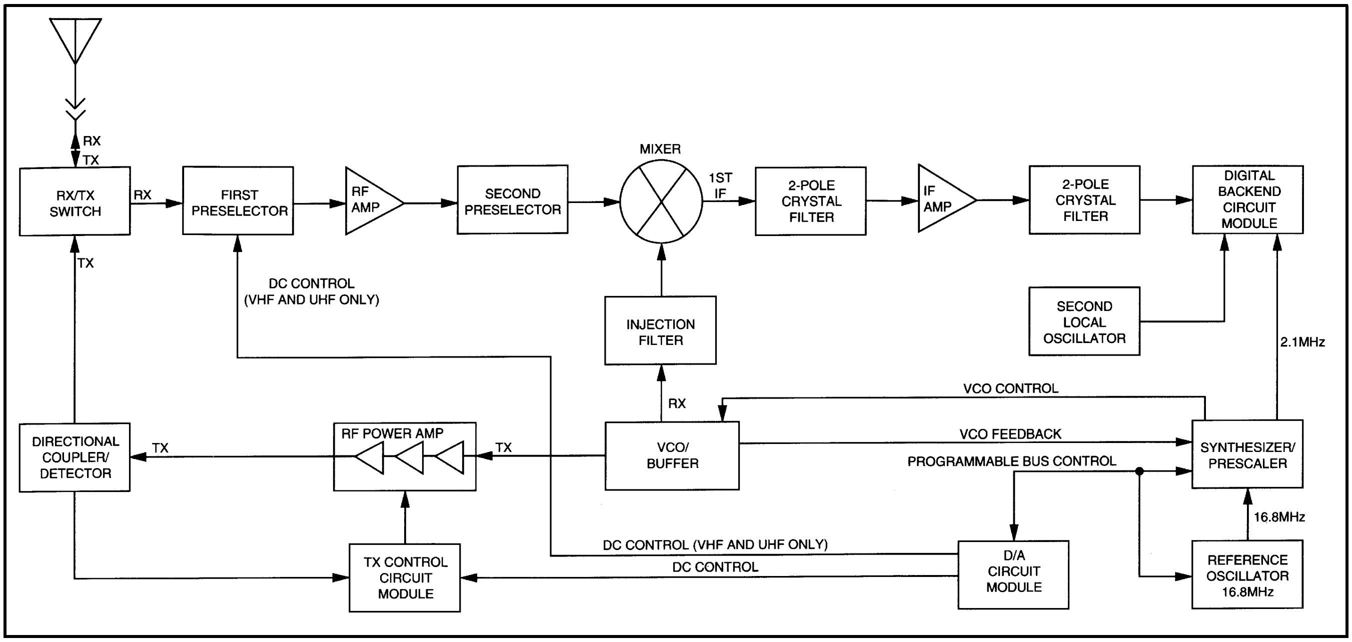


Figure 5-1 RF Board Block Diagram

VCO IC actually generates the first LO and transmit-injection signals and buffers them to the required power level. The synthesizer/prescaler circuit module incorporates frequency-division and comparison circuitry to keep the VCO signals stable. The synthesizer/prescaler IC is controlled by the control logic through a serial bus. Most of the synthesizer circuitry is enclosed in rigid metal cavities to reduce microphonic effects.

Table 5-1 LO and First IF Frequencies

	VHF	UHF	800 MHz
LO Frequency range	181.15 - 219.15 MHz	329.65 - 446.65 MHz	776.65 - 796.65 MHz
First IF Frequency	45.15 MHz	73.35 MHz	73.35 MHz

The receiver back end consists of a two-pole crystal filter, an IF amplifier, a second two-pole crystal filter, and the digital back-end IC (ABACUS). The two-pole filters are wide enough to accommodate 5 kHz modulation. Final IF filtering is done digitally in the ADSIC.

The digital back-end IC (ABACUS) consists of an amplifier, the second mixer, an IF analog-to-digital converter, a baseband down-converter, and a 2.4 MHz synthesis circuit. The second LO is generated by discrete components external to the IC. The output of the ABACUS IC is a digital bit stream that is current driven on a differential pair for a reduction in noise generation.

The transmitter consists of an RF power amplifier IC that gets an injection signal from the VCO. Transmit power is controlled by two custom ICs that monitor the output of a directional coupler and adjust PA control voltages correspondingly. The signal passes through a Rx/Tx switch that uses PIN diodes to automatically provide an appropriate interface to transmit or receive signals.

5.2 VHF/UHF RF BOARD

NOTE: The RF Board is not field serviceable. It must be replaced as a unit if it is defective.

This description applies to the revised VHF and UHF RF boards (the unrevised boards are similar). Refer to Section 5.3 for information on the 800 MHz RF board. The revised VHF RF board is used in standard power transceivers that have a revision letter of “H” or higher or 100W models that have a revision letter of “C” or higher (see page 1-8). The revised UHF board will be phased in at a future date.

VHF/UHF RF BOARD

5.2.1 FREQUENCY GENERATION UNIT (FGU)

The frequency generation unit (FGU) consists of three major sections: the high stability reference oscillator (U203), the fractional-N synthesizer (U204,) and the VCO buffer (U201). A 5V regulator (U202), supplies power to the FGU. The synthesizer receives the 5V REG at U204, and applies it to a filtering circuit within the module and capacitor C253. The well-filtered 5-volt output at U204, pin 19 is distributed to the Tx and Rx VCOs and the VCO buffer IC.

The mixer's LO injection signal and transmit frequency are generated by the Rx VCO and Tx VCO, respectively. The Rx VCO uses an external active device (Q202), whereas the VHF Tx VCO's active device is a transistor inside the VCO buffer. The UHF Tx VCO uses two active devices, one external (Q203) and the other internal to the VCO buffer. The base and emitter connections of this internal transistor are pins 11 and 12 of U201.

The Rx VCO is a Colpitts-type oscillator, with capacitors C235 and C236 providing feedback. The Rx VCO transistor (Q202) is turned on when pin 38 of U204 switches from high to low. The Rx VCO signal is received by the VCO buffer at U201, pin 9, where it is amplified by a buffer inside the IC. The amplified signal at pin 2 is routed through a low-pass filter (L201 and associated capacitors) and injected as the first LO signal into the mixer (U2, pin 8). In the VCO buffer, the Rx VCO signal (or the Tx VCO signal during transmit) is also routed to an internal prescaler buffer. The buffered output at U201, pin 16 is applied to a low-pass filter (L205 and associated capacitors). After filtering, the signal is routed to a prescaler divider in the synthesizer at U204, pin 21.

The divide ratios for the prescaler circuits are determined from information stored in memory during programming. The microcontroller extracts data for the division ratio as determined by the selected channel and sends that information to a comparator in the synthesizer via a bus. A 16.8 MHz reference oscillator, U203, applies the 16.8 MHz signal to the synthesizer at U204 pin 14. The oscillator signal is divided into one of three pre-determined frequencies. A time-based algorithm is used to generate the fractional-N ratio.

If the two frequencies in the synthesizer's comparator differ, a control (error) voltage is produced. The phase detector error voltage (V control) at pins 31 and 33 of U204 is applied to the loop filter consisting of resistors R211, R212, and R213, and capacitors C244, C246, C247, and C248. The filtered voltage alters the VCO frequency until the correct frequency is synthesized. The phase detector gain is set by components connected to U204, pins 28 and 29.

In the Tx mode, U204, pin 38 goes high and U201, pin 14 goes low, which turns off transistor Q202 and turns on the internal Tx VCO transistor in U204 and the external Tx VCO buffer Q203 on the UHF circuit. The Tx VCO feedback capacitors are C219 and C220. Varactor diode CR203/CR207 sets the Tx frequency while varactor CR202 is the Tx modulation varactor.

The modulation of the carrier is achieved by using a two-port modulation technique. The modulation of low frequency tones is achieved by injecting the tones into the A/D section of the fractional-N synthesizer. The digitized signal is modulated by the fractional-N divider, generating the required deviation. Modulation of the high-frequency audio signals is achieved by modulating the varactor (CR203) through a frequency compensation network. Resistors R207 and R208 form a potential divider for the higher-frequency audio signals.

In order to cover the very wide bandwidths, positive and negative V-control voltages are used. High control voltages are achieved using positive and negative multipliers. The positive voltage multiplier circuit consists of components CR204, C256, C257, and reservoir capacitor C258. The negative multiplier circuit consists of components CR205, CR206, C266, C267, and reservoir capacitor C254.

Out-of-phase clocks for the positive multiplier appear at U204, pins 9 and 10. Out-of-phase clocks for the negative multiplier appear at U204, pins 7 and 8, and only when the negative V-control is required (that is, when the VCO frequency exceeds the crossover frequency). When the negative V-control is not required, transistor Q201 is turned on, and capacitor C259 discharges. The 13V supply generated by the positive multiplier is used to power-up the phase detector circuitry. The negative V-control is applied to the anodes of the VCO varactors.

VHF/UHF RF BOARD (Cont'd)

The Tx VCO signal is amplified by an internal buffer in U201, routed through a low pass filter and routed to the Tx PA module, U105, pin 1. The Tx and Rx VCOs and buffers are activated via a control signal from U204, pin 38.

The reference oscillator supplies a 16.8 MHz clock to the synthesizer where it is divided down to a 2.1 MHz clock. This divided-down clock is fed to the ABACUS IC (U401), where it is further processed for internal use.

5.2.2 ANTENNA SWITCH

The antenna switch is a current device consisting of a pair of diodes (CR108/ CR109) that electronically steer RF between the receiver and the transmitter. In the transmit mode, RF is routed through transmit switching diode CR108, and sent to the antenna. In the receive mode, RF is received from the antenna, routed through receive switching diode CR109, and applied to the RF amplifier Q1 (VHF) or U1 (UHF). In transmit, bias current, sourced from U101, pin 21, is routed through L105, U104, CR108, and L122 (VHF) and L105, CR108, and L122 (UHF). Sinking of the bias current is through the transmit ALC module, U101, pin 19. In the receive mode, bias current, sourced from switched B+, is routed through Q107 (pin 3 to pin 2), L123 (UHF), L121, CR109, and L122. Sinking of the bias current is through the 5-volt regulator, U106, pin 8.

5.2.3 RECEIVER FRONT END

The RF signal is received by the antenna and coupled through the external RF switch. The UHF board applies the RF signal to a low-pass filter consisting of L126, L127, L128, C149, C150, and C151. The VHF board bypasses the low-pass filter. The filtered RF signal is passed through the antenna switch (CR109) and applied to a bandpass filter consisting of (VHF) L11 - L14, CR1 - CR9, C4, C2, and C3 or (UHF) L30, L31, L32, L34, L35, CR6 - CR9, C1, C2, and C3. The bandpass filter is tuned by applying a control voltage to the varactor diodes in the filter (CR1 - CR9 VHF and CR6 - CR9 UHF).

The bandpass filter is electronically tuned by the D/A IC (U102), which is controlled by the microcomputer.The D/A output range is extended through the use of a current mirror consisting of Q108 and R115 and R116. When Q108 is turned on via R115, the D/A output is reduced due to the voltage drop across R116. Depending on the carrier frequency, the microcomputer will turn Q108 on or off. Wideband operation of the filter is achieved by retuning the bandpass filter across the band.

The output of the bandpass filter is applied to wideband GaAs RF amplifier IC U1 (UHF) or active device Q1 (VHF). The RF signal is then further filtered by a second broadband, fixed-tuned, bandpass filter consisting of C6, C7, C8, C80, C86, C87, C88, C97, C99, L3, L4, L5, and L30 (VHF) or C4 -C7, C88 - C94, C99, and L11 - L15 (UHF) to improve the spurious rejection.

The filtered RF signal is routed through a broadband 50-ohm transformer (T1) to the input of a broadband mixer/buffer (U2). Mixer U2 uses GaAs FETs in a double-balanced, Gilbert Cell configuration.

The RF signal is applied to the mixer at U2 pins 1 and 15. An injection signal (1st LO) of about –10 dBm supplied by the FGU is applied to U2, pin 8. Mixing of the RF and the 1st LO results in an output signal that is the first IF frequency. The first IF frequency is 45.15 MHz for the VHF band and 73.35 for the UHF band. High side injection is used for VHF and low side for UHF. The first IF signal output at U2, pins 4 and 6 is routed through transformer T2 and impedance matching components, and applied to a two-pole crystal filter (FL1), which is the final stage of the receiver front end. The two-pole crystal filter removes unwanted mixer products. Impedance matching between the output of the transformer (T2) and the input of the filter (FL1) is accomplished by C605 and L605 (VHF) or C611, C614, and L605 (UHF).

5.2.4 RECEIVER BACK END

The output of crystal filter FL1 is matched to the input of IF buffer amplifier transistor Q601 by C610 and L604 (VHF) and C609, C610, and L600 (UHF). Transistor Q601 is biased by the 5V regulator (U202). The IF frequency on the collector of Q601 is applied to a second crystal filter through a matching circuit. The second crystal filter (FL2) input is matched by C604, C603, and L601 (VHF) and C604, L601, and L602 (UHF). The filter supplies further attenuation at

VHF/UHF RF BOARD (Cont'd)

the IF sidebands to increase the radios selectivity. The output of FL2 routed to pin 32 of U401 through a matching circuit which consists of L603, L606, and C608 (VHF) and L603, C606, and C605 (UHF).

In the ABACUS IC (U401), the first IF frequency is amplified and then down-converted to the second IF frequency of 450 kHz. At this point, the analog signal is converted into two digital bit streams by a sigma-delta A/D converter. The bit streams are then digitally filtered, mixed down to baseband, and filtered again. The differential output data stream is then sent to the logic board where it is decoded to produce the recovered audio.

The ABACUS IC (U401) is electronically programmable. The amount of filtering, which is dependent on the radio channel spacing and signal type, is controlled by the microcontroller. Additional filtering, which used to be provided externally by a conventional ceramic filter, is replaced by internal digital filters in the ABACUS IC. The ABACUS IC contains a feedback AGC circuit to expand the dynamic range of the sigma-delta converter. The differential output data contains the quadrature (I and Q) information in 16-bit words, the AGC information in a 9-bit word, imbedded word sync information, and fill bits dependent on sampling speed. A fractional N synthesizer is also incorporated on the ABACUS IC for 2nd LO generation.

The 2nd LO/VCO is a Colpitts oscillator built around transistor Q401 (VHF) or Q1 (UHF). The VCO has a varactor diode, VR401 (VHF) or CR5 (UHF) to adjust the VCO frequency. The control signal for the varactor is derived from a loop filter consisting of C426, C428, and R413.

5.2.5 TRANSMITTER

The transmitter consists of three major sections:

- Harmonic Filter
- RF Power Amplifier Module
- ALC Circuits

<u>Harmonic Filter</u>

With VHF versions, RF from PA module U105 is routed through coupler U104 and passed through the harmonic filtering network to antenna switch CR108. With UHF versions, RF from the PA module U105 is routed through coupler U104 and passed through transmit antenna switch CR108 and applied to a harmonic filtering network. The harmonic filtering circuit is composed of (VHF) L126, L127, L128, C149, C150, and C151 or (UHF) L126, L127, L128, C129, C130, C149, C150, and C151. Resistor R117 (VHF) or R117 (UHF) provides a current-limited 5V to J2.

<u>RF Power Amplifier Module</u>

RF power amplifier module U105 is a wide-band, three-stage (VHF) or four-stage (UHF) amplifier. Nominal input and output impedance of U105 is 50 ohms. The DC bias for U105 is on pins 2, 4, 5. In the transmit mode, the voltage on U105, pins 2 and 4 (close to the B+ level) is obtained via switching transistor Q101. Transistor Q101 receives its control base signal as follows:

- The microcomputer keys the D/A IC to produce a ready signal at U 102 pin 3,
- the ready signal at U102 pin 3 is applied to the Tx ALC IC at U101 pin 14 (5V), and
- the synthesizer sends a LOC signal to the Tx ALC IC (U204 pin 40 to U101 pin 16).

When the LOC signal and the ready signal are both received, the Tx ALC IC (pin 13) sends a control signal to turn on transistor Q101.

<u>ALC Circuits</u>

Coupler module U104 samples the forward and reverse power of the PA output voltage. Reverse power is present when there is other than 50 ohms impedance at the antenna port. Sampling is achieved by coupling some of the forward and/or reverse power, and applying it to CR102 (VHF) or CR101 (UHF) and CR103 for rectification and summing. The resultant DC signal is then applied to the Tx ALC IC (U101, pin 2) as RFDET to be used as an RF strength indicator.

The transmit ALC circuit, built around U101, is the heart of the power control loop. Circuits in the Tx ALC module compare the signals at U101, pins 2 and 7. The resultant signal, C BIAS, at U101, pin 4 is applied to the base of transistor Q110. In response to the base drive, transistor Q110 varies the DC control voltages applied to the RF PA at U105, pin 3, thus controlling the RF power of module (U105).

Thermistor RT101 senses the temperature of the Tx ALC IC. If an abnormal operating condition exists that causes the PA temperature to rise to an unacceptable level, the thermistor forces the ALC to reduce the set power.

5.3 800 MHz RF BOARD

NOTE: The RF Board is not field serviceable. It must be replaced as a unit if it is defective. This description applies to the revised 800 MHz RF board.

5.3.1 FREQUENCY SYNTHESIS

The complete synthesizer subsystem consists of the reference oscillator (U304), the voltage-controlled oscillator (VCO U307), a buffer IC (U303), and the synthesizer (U302).

The reference oscillator contains a temperature-compensated 16.8 MHz crystal. This oscillator is digitally tuned and contains a temperature-referenced, five-bit, analog-to-digital (A/D) converter. The output of the oscillator (pin 10 on U304) is applied to pin 14 (XTAL1) on U302 through capacitor C309 and resistor R306.

Voltage-controlled oscillator module U307 is varactor tuned. Therefore, as the voltage being applied to pins 1 and 7 of the VCO varies (2-11V), so does the varactor's capacitance which changes the VCO output frequency. The 800 MHz VCO is a dual-range oscillator that covers the 806-825 MHz and the 851-870 MHz frequency bands.

The low-band VCO (777-825 MHz) provides the first LO injection frequencies (777-797 MHz) that are 73.35 MHz below the carrier frequency. In addition, in the transmit mode when the radio is operated through a repeater, the low-band VCO generates the transmit frequencies (806-825 MHz) that are 45 MHz below the receiver frequencies. The low band VCO is selected by pulling pin 3 high and pin 8 low on U307. When radio-to-radio or talk-around operation is necessary, the high band VCO (851-870 MHz) is selected. This is accomplished by pulling pin 3 low and pin 8 high on U307.

The buffer IC (U303) includes a Tx, Rx, and prescaler buffer which maintain a constant output level and provides isolation. The Tx buffer is selected by setting pin 7 of U303 high, and the Rx buffer is selected by setting pin 7 of U303 low. The prescaler buffer is always on. In order to select the proper combination of VCO and buffer, the following conditions must be true at pin 6 of U303 (or pin 38 of U302) and pin 7 of U303 (or pin 39 of U302):

- For first LO injection frequencies 777-797 MHz, pins 6 and 7 must both be low.
- For Tx repeater frequencies 806-825 MHz, pins 6 and 7 must both be high.
- For talk-around Tx frequencies 851-870 MHz, pin 6 must be low and pin 7 must be high.

The synthesizer IC (U302) consists of a prescaler, a programmable loop divider, a divider control logic, a phase detector, a charge pump, an A/D converter for low-frequency digital modulation, a balance attenuator to balance the high-frequency analog modulation to the low-frequency digital modulation, a 13V positive-voltage multiplier, a serial interface for control, and finally, a filter for the regulated 5-volt supply. This filtered five volts is present at pin 19 of U302, pin 9 of U307, and pins 2, 3, 4, and 15 of U303. It is also applied directly to resistors R309, R315, and R311. Additionally, the 13V supply generated by the positive voltage multiplier circuitry should be present at pin 35 of U302. The serial interface (SRL) is connected to the microprocessor via the data line (pin 2 of U302), clock line (pin 3 of U302), and chip-enable line (pin 4 of U302).

The complete synthesizer subsystem operates as follows:

- The output of the VCO, pin 4 on U307, is fed into the RF input port (pin 9) of U303. In the Tx mode, the RF signal is present at pin 4 of U303; in the RX mode, the RF signal is present at pin 3 of U303.
- The output of the prescaler buffer, pin 15 of U303, is applied to the PREIN port (pin 21) of U302. The

800 MHz RF BOARD (Cont'd)

prescaler in U302 is a dual modulus type with selectable divider ratios. This divider ratio is controlled by the loop divider, which in turn receives its inputs from the SRL. The loop divider adds or subtracts phase to the prescaler divider by changing the divide ratio via the modulus control line.

- The output of the prescaler is then applied to the loop divider.

- The output of the loop divider is then applied to the phase detector. The phase detector compares the loop divider's output signal with the signal from U304 (that is divided down after it is applied to pin 14 of U302). The result of the signal comparison is a pulsed DC signal which is applied to the charge pump.

- The charge pump outputs a current that is present at pin 32 of U302. The loop filter (which consists of capacitors C322, C317, C318, C329, C324, and C315, and resistors R307, R305, and R314) transforms this current into a voltage that is applied to pins 1 and 7 of U307 to alter the VCO's output frequency.

In order to modulate the PLL, the two-port modulation method is utilized. The analog modulating signal is applied to the A/D converter as well as the balance attenuator, via U302, pin 5. The A/D converter converts the low-frequency analog modulating signal into a digital code that is applied to the loop divider, thereby causing the carrier to deviate. The balance attenuator is used to adjust the VCO's deviation sensitivity to high-frequency modulating signals.

5.3.2 ANTENNA SWITCH

An electronic PIN diode switch steers RF between the receiver and transmitter. The common node of the switch is at capacitor C101. In the transmit mode, RF is routed to the anode of diode CR104. In receive mode, RF is routed to pin 1 of U201. In the transmit mode, bias current sourced from U504, pin 21, is routed through PIN diodes CR104 and CR102 which biases them to a low-impedance state. Bias current returns to ground through U504, pin 20. In receive, U504, pin 21, is pulled down to ground and pin 20 is pulled up to B+ which reverse-biases diodes CR104 and CR102 to a high impedance.

5.3.3 RECEIVER FRONT END

The 800 MHz receiver front end converts the received RF signal to the first IF frequency of 73.35 MHz and also provides spurious immunity and adjacent channel selectivity. The received RF signal is passed through antenna switch input matching components C101, L105, and C114, through tank components C106 and L103 (which are anti-resonant at the radios transmitter frequencies), and through output matching components C103 and L104. Both pin diodes CR102 and CR104 must be back-biased to properly route the received signal.

The stage following the antenna switch is a 50-ohm, inter-digitated, three-pole, stripline preselector (U201). The preselector is positioned after the antenna switch to provide the receiver preamp with some protection against strong, out-of-band signals.

After the preselector (U201), the received signal is processed through receiver preamp U202. The preamp is a dual-gate, GaAs MESFET transistor which has been internally biased for optimum IM, NF, and gain performance. Components L201 and L202 match the input (gate 1) of the amp to the first preselector, while at the same time connecting gate 1 to ground potential. The output (drain) of the amp is pin 7, and is matched to the subsequent receiver stage by L204 and C222.

A supply voltage of 5V DC is provided to pin 3 through RF choke L203 and bypass capacitor C204. The 5-volt supply is also present at pin 4, which connects to a voltage divider network that biases gate 2 (pin 5) to a predefined quiescent voltage of 1.2V DC. Resistor R202 and capacitor C203 are connected to pin 5 to provide amp stability. The FET source (pin 3) is internally biased at 0.55 to 0.7VDC for proper operation with bypass capacitors C201 and C202, connected to the same node.

The output of the amp is matched to a second three-pole preselector (U203) of the type previously discussed. The next stage in the receiver chain is first mixer U205 which uses low-side injection to convert

800 MHz RF BOARD (Cont'd)

the RF carrier to an intermediate frequency (IF) of 73.35 MHz.

Since low-side injection is used, the LO frequency is offset below the RF carrier by 73.35 MHz, or fLO = fRF - 73.35 MHz. The mixer utilizes GaAs FETs in a double-balanced, Gilbert Cell configuration. The LO port (pin 8) incorporates an internal buffer and a phase shift network to eliminate the need for a LO transformer. The LO buffer bypass capacitors (C208, C221, and C216) are connected to pin 10 of U205, and should exhibit a nominal DC voltage of 1.2 to 1.4V DC. Pin 11 of U205 is LO buffer Vdd (5V DC), with associated bypass capacitors C226 and C209 connected to the same node. An internal voltage divider network within the LO buffer is bypassed to virtual ground at pin 12 of U205 through bypass capacitor C213. The mixer's LO port is matched to the radio's PLL by a capacitive tap, C207 and C206.

A balun transformer (T202) is used to couple the RF signal into the mixer. The primary winding of T202 is matched to the preceding stage by capacitor C223, with C227 providing a DC block to ground. The secondary winding of T202 provides a differential output, with a 180° phase differential being achieved by setting the secondary center tap to virtual ground using bypass capacitors C210, C211, and C212. The secondary of transformer T202 is connected to pins 1 and 15 of the mixer IC, which drives the source leg of dual FETs used to toggle the paralleled differential amplifier configuration within the Gilbert Cell.

The final stage in the receiver front end is a two-pole crystal filter (FL1). The crystal filter provides some of the receiver's adjacent channel selectivity. The input to the crystal filter is matched to the first mixer using L605, C600, and C614. The output of the crystal filter is matched to the input of IF buffer amplifier transistor Q601 by L600, C609, and C610.

5.3.4 RECEIVER BACK END

The IF frequency on the collector of Q601 is applied to a second crystal filter (FL2) through a matching circuit consisting of L601, L602, C604, and C612. The filter supplies further attenuation at the IF sidebands to increase the radio's selectivity. The output of FL2 is routed to pin 32 of U401 through a matching circuit consisting of L603, C603, and C606, and DC blocking capacitor C613.

In the ABACUS IC (U401), the first IF frequency is amplified and then down-converted to the second IF of 450 kHz. The analog signal is then converted into two digital bit streams by a sigma-delta A/D converter. The bit streams are then digitally filtered, mixed down to baseband, and filtered again. The differential output data stream is then sent to the ADSIC on the logic board, where it is decoded to produce the recovered audio.

The ABACUS IC (U401) is electronically programmable. The amount of filtering is dependent on the radio channel spacing and signal type, and is controlled by the microcomputer. Additional filtering, which used to be provided externally by a conventional ceramic filter, is replaced by internal digital filters in the ABACUS IC. The ABACUS IC contains a feedback AGC circuit to expand the dynamic range of the sigma-delta converter. The differential output data contains the quadrature (I and Q) information in 16-bit words, the AGC information in a 9-bit word, imbedded word sync information, and fill bits which are dependent on sampling speed. A fractional N synthesizer is also incorporated on the ABACUS IC for 2nd LO generation.

The second LO/VCO is a Colpitts oscillator built around transistor Ql. The VCO has a varactor diode (VR401), which is used to adjust the VCO frequency. The control signal for the varactor is derived from a loop filter consisting of C426, C428, and R413.

5.3.5 TRANSMITTER

The 800 MHz RF power amplifier (PA) is a five-stage amplifier (U502). The RF power amplifier has a nominal input and output impedance of 50 ohms.

An RF input drive level of approximately +3 dBm, supplied from the VCO buffer IC (U303), is applied to pin 1 of U502. The DC bias for the internal stages of U502 is applied to pins 3 and 4 of the module. Pin 3 is switched through Q502 and pin 4 is unswitched B+ to the final amplifier stage. Power control is achieved by varying of the DC bias to pin 2, the third and fourth amplifier stages of the module. The amplified RF signal leaves the PA module at pin 5 and is applied to the directional coupler (U501).

The purpose of U501 is to sample both the forward power and the reverse power. Reverse power is present when a load other than 50 ohms exists at the antenna port. The sampling is achieved by coupling some of the reflected power, forward and/or reverse, to a coupled leg on the coupler. The sampled RF signals are applied to diode CR501 for rectification and summing. The resultant DC signal is applied to the ALC IC (U504, pin 2) as RFDET, to be used as an indicator of the strength of the RF signal being passed through the directional coupler (U501).

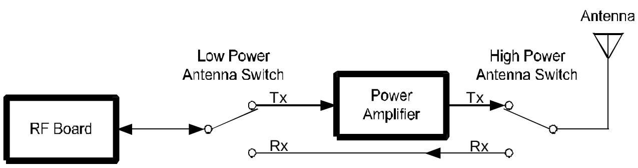
The transmit ALC IC (U504) is the main part of the power control loop. The REF V line (U504 pin 7), a DC signal supplied from the D/A IC (U503), and the RF DET signal described earlier, are compared internally in the ALC IC to determine the amount of C BIAS, pin 4, to be applied to the base of transistor Q501. Transistor Q501 responds to the base drive level by varying the DC control voltages applied to pin 2 of the RF PA which controls the RIF power level of module U502. The ALC IC also controls the base switching to transistor Q502 via pin 12, BIAS.

The D/A IC (U503) controls the DC switching of the transceiver board. Its outputs, SC1 and SC3 (pins 12 and 14, respectively), control transistor Q503 which then supplies Tx 5V and Rx 5V to the transceiver board. The D/A also supplies DC bias to the detector diode (CR501) via pin 7, and the REF V signal to the ALC IC (U504).

5.4 VHF 50W PA BOARD

5.4.1 ANTENNA SWITCHES

The RF signal from the RF board is fed by a coaxial cable to the PA board. Since both the receive and transmit signals are present on the input of the PA board, special antenna switching is required on the PA board to route the receive signal around the amplifier section to the antenna. Both a high power and a low power antenna switch are used as shown below.



The low power switch consists of pin diodes* CR512 and CR513 and other components. The Q7 output of shift register U501 is high in the transmit mode and low in the receive mode. Therefore, in the transmit mode, Q507 and Q514 are on and Q508 and Q513 are off. This forward biases CR513 and reverse biases CR512. The transmit signal from the RF board then has a low impedance path through C533 and CR513 to driver Q509, and the high impedance provided by CR512 blocks it from the receive path.

In the receive mode, the opposite occurs, so CR513 is reverse biased and CR512 forward biased. The receive signal from the high power antenna switch (see following) then has a low impedance path through C544, CR512, and C534 to the RF board, and is blocked from the power amplifier by CR513.

The high power antenna switch consists of pin diodes* CR501, CR502, and CR503. This switch effectively switches the antenna between the power amplifier and the receive bypass path to the RF board (see preceding illustration).

Transistor Q501 is on in the transmit mode and off in the receive mode. Therefore, in the transmit mode, all three diodes are forward biased (CR501 and CR502 are biased by voltage applied from the collector of Q510). The transmit signal then has a low impedance path through CR502 to the low-pass filter and is blocked from the bypass path by L504/C511 and L505/C515 which present a high impedance at the transmit frequency. In the receive mode, all three diodes are reverse biased. Therefore, the receive signal from the antenna is blocked from the power amplifier by CR502 and has a low impedance path through L504 and L505 to the RF board.

5.4.2 AMPLIFIERS (Q509, Q510)

Impedance matching between the low power antenna switch and Q509 is provided by L511 and several capacitors and sections of microstrip. Class C biasing is provided by L510 and ferrite bead EP503, and negative feedback for stabilization is provided by R557 and R543. Supply voltage to Q509 is controlled by the power control circuit to regulate the power output of the transmitter. Conditioning and isolation of the DC supply to Q509 is provided by L509, L514, EP501, and C540-C542.

* A reverse biased pin diode presents a high impedance to RF signals. Conversely, and a forward biased pin diode presents a variable low impedance that changes inversely to current.

VHF 50W PA BOARD (CONT'D)

Impedance matching between Q509 and final amplifier Q510 is provided by several capacitors and sections of microstrip. Class C biasing of Q510 is provided by L515, EP502, R559, and R560. The current for this stage flows through L516, R561, and L517. The voltage drop across R561 is sensed by the power control circuit to detect an over-current condition.

From Q510 the transmit signal is fed through another impedance matching network to a directional coupler, to the high power antenna switch (see preceding section), and then to the low-pass filter. This filter attenuates harmonics occurring above the transmit frequency band to prevent adjacent channel interference. The directional coupler detects the forward component of the output power for use by the power control circuit.

5.4.3 POWER CONTROL

Introduction

The power control circuit maintains a constant power output as changes occur in temperature and voltage. It does this by sensing forward power and then varying the drive to Q510 to maintain a constant output power. The drive to Q510 is controlled by varying the supply voltage to driver Q509. The current to final amplifier Q510 is also sensed, but power output is affected by this input only if current becomes excessive. Power output is then cut back to approximately 25% of full power.

The power output level is set in 127 steps by D/A converter U501 which is controlled by the microcontroller. This allows power to be adjusted using the PCTune software and computer and also different power levels to be programmed. In addition, it allows the microcontroller to cut back power if the power amplifier temperature is excessive. Temperature is sensed via thermistor RT501.

U502A, Q500/Q502 Operation

The forward power signal from the directional coupler is applied to pin 2 of amplifier U502A. This is a DC signal that increases proportionally to forward power. The other input to U502A is a DC reference voltage from a D/A converter formed by shift register U501 and several resistors. The voltage from this D/A converter sets the voltage on pin 3 which sets the power output of the transmitter.

U502A is a difference amplifier which amplifies the difference between the reference voltage on pin 3 and the forward power signal on pin 2. The turn-on time of U502A is controlled by the time constant of C528 and R534, and negative AC feedback to prevent oscillation is also provided by C528. This circuit operates as follows: Assume the output power attempts to increase. The DC voltage applied to U502A, pin 2 then increases which causes the output voltage on pin 1 to decrease. Transistors Q505 and Q506 then turn off slightly which decreases the supply voltage to driver Q509. The output power then decreases to maintain a constant power output. R541 and R542 limit the voltage gain of Q505 and Q506 to approximately two.

Delayed PTT

Transistor Q504 is used to delay power output for a short time after the transmitter is keyed. This allows the synthesizer and exciter to stabilize so that the transmitter does not transmit off-frequency. The signal which controls Q504 is from microcontroller U9 on the logic board. In the receive mode this output is low, so Q504 is off. Pin 2 of U502A is then pulled high by the 7.2-volt supply applied through R537 and CR506. This causes the output on pin 1 of U502A to go low which shuts off power to Q509. Then when the transmitter is keyed, the Q504 control signal goes high after a short delay. Q504 then turns on and diode CR506 is reverse biased. Only the forward power signal is then applied to pin 2 of U502A.

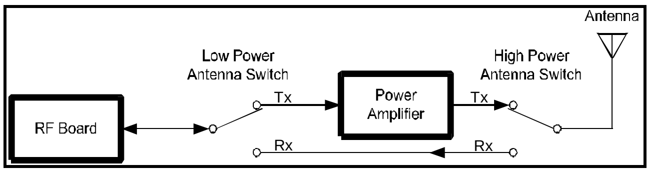
Over-Current Shutdown

Current to final amplifier Q510 is monitored by sensing the voltage drop across R561. Pins 3 and 6 of U506 are connected across this resistor. As current increases, the output voltage on U506, pin 8 decreases. This causes the output voltage of voltage follower U507A to decrease. This signal is applied to Schmitt trigger U502B. When the voltage on pin 6 rises above the reference on pin 5, the output on pin 7 goes low. This lowers the power control voltage applied to U502A, pin 3 which lowers the power output to approximately 25% of full power.

5.5 UHF 15W PA BOARD

5.5.1 ANTENNA SWITCHES

The RF signal from the RF board is fed by a coaxial cable to the PA board. Since both the receive and transmit signals are present on the input of the PA board, special antenna switching is required on the PA board to route the receive signal around the amplifier section to the antenna. Both a high power and a low power antenna switch are used as shown below.



The low power switch consists of pin diodes* CR507 and CR508 and other components. The Q7 output of shift register U501 is high in the transmit mode and low in the receive mode. Therefore, in the transmit mode, Q504 and Q510 are on and Q505 and Q506 are off. This forward biases CR508 and reverse biases CR507. The transmit signal from the RF board then has a low impedance path through C574 and CR508 to driver Q509, and the high impedance provided by CR507 blocks it from the receive path.

In the receive mode, the opposite occurs, so CR508 is reverse biased and CR507 is forward biased. The receive signal from the high power antenna switch (see following) then has a low impedance path through C519, C555, CR507, and C569 to the RF board, and is blocked from the power amplifier by CR508.

The high power antenna switch consists of pin diodes* CR501, CR505, and CR503. This switch effectively switches the antenna between the power amplifier and the receive bypass path to the RF board (see preceding illustration).

Transistor Q503 is on in the transmit mode and off in the receive mode. Therefore, in the transmit mode, all three diodes are forward biased (CR501 and CR505 are biased by voltage applied from the collector of Q507). The transmit signal then has a low impedance path through CR505 to the low-pass filter and is blocked from the bypass path by L501/C528 and L500/C523 which present a high impedance at the transmit frequency. In the receive mode, all three diodes are reverse biased. Therefore, the receive signal from the antenna is blocked from the power amplifier by CR505 and has a low impedance path through L501 and L500 to the RF board.

5.5.2 AMPLIFIERS (Q509, Q508)

Impedance matching between the low power antenna switch and Q509 is provided by 3 dB pad R568/R562/R569 and several capacitors and two sections of microstrip. Class C biasing is provided by L510, ferrite bead EP6, and R556. Supply voltage to Q509 is controlled by the power control circuit to regulate the power output of the transmitter. Conditioning and isolation of the DC supply to Q509 is provided by L508, L510, EP1, and several capacitors.

Impedance matching between Q509 and driver Q508 is provided by two sections of microstrip and several capacitors. Class C biasing of Q508 is provided by L513, EP4, and R563. The supply voltage to this stage is the unswitched battery supply.

Impedance matching and biasing on the input of final amplifier Q507 is similar to Q508. The current for this stage flows through L511, R554, and L505. The voltage drop across R554 is sensed by the power control circuit to detect an over-current condition.

From Q507 the transmit signal is fed through another impedance matching network to a directional coupler, to the high power antenna switch (see preceding section), and then to the low-pass filter. This filter attenuates harmonics occurring above the transmit frequency band to prevent adjacent channel interference. The directional coupler detects the forward component of the output power for use by the power control circuit.

5.5.3 POWER CONTROL

Introduction

The power control circuit maintains a constant power output as changes occur in temperature and voltage. It does this by sensing forward power and then varying the drive to Q508 to maintain a constant output power. The drive to Q508 is controlled by varying the supply voltage to pre-driver Q509. The current to final amplifier Q507 is also sensed, but power output is affected by this input only if current

* A reverse biased pin diode presents a high impedance to RF signals. Conversely, and a forward biased pin diode presents a variable low impedance that changes inversely to current.

becomes excessive. Power output is then cut back to approximately 25% of full power.

The power output level is set in 127 steps by D/A converter U501 which is controlled by the microcontroller. This allows power to be adjusted using the PCTune software and computer and also different power levels to be programmed. In addition, it allows the microcontroller to cut back power if the power amplifier temperature is excessive. Temperature is sensed via thermistor R574.

U502A, Q500/Q502 Operation

The forward power signal from the directional coupler is applied to pin 2 of amplifier U502A. This is a DC signal that increases proportionally to forward power. The other input to U502A is a DC reference voltage from a D/A converter formed by shift register U501 and several resistors. The voltage from this D/A converter sets the voltage on pin 3 which sets the power output of the transmitter.

U502A is a difference amplifier which amplifies the difference between the reference voltage on pin 3 and the forward power signal on pin 2. The turn-on time of U502A is controlled by the time constant of C504 and R514, and negative AC feedback to prevent oscillation is also provided by C504. This circuit operates as follows: Assume the output power attempts to increase. The DC voltage applied to U502A, pin 2 then increases which causes the output voltage on pin 1 to decrease. Transistors Q501 and Q500 then turn off slightly which decreases the supply voltage to predriver Q509. The output power then decreases to maintain a constant power output. R516 and R521 limit the voltage gain of Q501 and Q500 to approximately two.

Delayed PTT

Transistor Q502 is used to delay power output for a short time after the transmitter is keyed. This allows the synthesizer and exciter to stabilize so that the transmitter does not transmit off-frequency. The signal which controls Q502 is from microcontroller U9 on the logic board. In the receive mode this output is low, so Q502 is off. Pin 2 of U502A is then pulled high by the 7.2-volt supply applied through R511 and CR500. This causes the output on pin 1 of U502A to go low which shuts off power to Q509. Then when the transmitter is keyed, the Q502 control signal goes high after a short delay. Q502 then turns on and diode CR500 is reverse biased. Only the forward power signal is then applied to pin 2 of U502A.

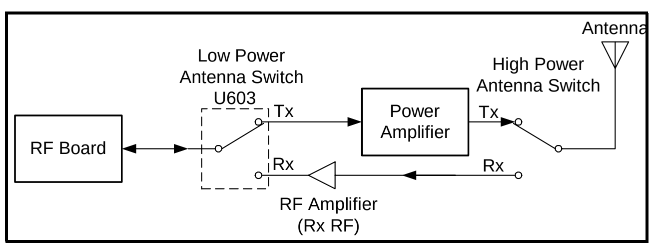
Over-Current Shutdown

Current to final amplifier Q507 is monitored by sensing the voltage drop across R554. Pins 3 and 6 of U505 are connected across this resistor. As current increases, the output voltage on U505, pin 8 decreases. This causes the output voltage of voltage follower U507A to decrease. This signal is applied to Schmitt trigger U502B. When the voltage on pin 6 rises above the reference on pin 5, the output on pin 7 goes low. This lowers the power control voltage applied to U502A, pin 3 which lowers the power output to approximately 25% of full power.

5.6 800 MHz 35W PA BOARD

5.6.1 LOW POWER ANTENNA SWITCH

The RF signal from the RF board is fed by a coaxial cable to the PA board. Since both the receive and transmit signals are present on the input of the PA board, special antenna switching is required on the PA board to route the receive signal around the power amplifier section to the antenna. Both high power and a low power antenna switches are used as shown below.



Low power antenna switching is provided by electronic antenna switch U603. Pin 5 is effectively connected to pin 1 when pin 6 is high (and pin 4 is low). Conversely, pin 5 is connected to pin 3 when pin 4 is high and pin 6 is low. These control signals are provided by the Q7 output of shift register U501 and inverters Q516/Q517. In the transmit mode, the signal from the RF board is then routed through C532 to the PA module, and blocked from RF amplifier Q503. In

800 MHz 35W PA BOARD (Cont'd)

the receive mode, the opposite occurs. Refer to Section 5.6.4 for a description of the high power antenna switch.

5.6.2 POWER DETECTOR AND ATTENUATOR

The transmit RF output signal of pin 3 of antenna switch U603 is coupled by C595 to a power detector circuit formed by CR521, R591, and other components. When RF power is detected, the voltage on pin 13 of op amp U502 increases. When it rises above the reference on pin 12, the output on pin 14 goes low and turns off Q507. The base of Q505 is then no longer grounded which allows it to be controlled by the power control circuit. This provides maximum attenuation in the receive mode to minimize the amplification of any low level receive signal that may be present (see following).

A 3-dB pad formed by R541, R542, and R543 provides attenuation of the RF signal and also a 50-ohm impedance. Matching between U603 and this pad is provided by C532 and L514. This pad is then matched by a section of microstrip and L503 to a limiter and variable 50-ohm attenuator formed by pin diodes* C516-C518 and other components. This attenuator provides approximately 0-20 dB attention of the RF signal input to PA module. This controls the power output of the transceiver.

The limiter section formed by CR516, CR517, C535 and biasing resistors R580/R581 attenuates high level input signals that could cause improper operation of the attenuator. The attenuator circuit is formed by CR518 and CR519 and controlled by Q505 and the rest of the power control circuit (see Section 5.6.6). Biasing of these diodes is provided by CR520, R597, R584, R582, R586, and R538 connected to the emitter of Q505. When Q505 is turned off, CR518 is reverse biased by the voltage applied through R537. It then provides maximum attenuation of the RF signal.

A shunt path is provided around CR518 by R583, C537, and R585. Pin diode CR519 is at its maximum forward biased condition when Q505 is off, and connects R583 to AC ground through C538. This maintains a constant 50-ohm impedance. Then as Q505 turns on, CR518 becomes forward biased and provides less attenuation. Likewise, CR519 becomes less forward biased which increases the impedance of the path to ground. From the attenuator the signal is coupled by C542 to a 1 dB, 50-ohm pad formed by R544-R546 and then applied to PA module U504.

5.6.3 POWER AMPLIFIER MODULE (U504), FINAL (Q509)

Power amplifier module U504 provides approximately 19 dB of gain. Pins 2, 3, and 4 are the supply voltage inputs to three separate gain stages. The supply voltage on pin 2 (VS1) is switched by Q508 and limited to 12 volts by CR508 and R549. Switch Q508 is controlled by the same signal used to control the high power antenna switch (see Section 5.6.4).

The supply voltage applied to pins 3 and 4 (VS2/VS3) is the unswitched battery from the power jack. Therefore, power is applied to these pins even when transceiver power is turned off.

The output signal on U504, pin 5 is then applied to final amplifier Q509 which provides about 5 dB of gain. Current to this stage flows through R550, and transmitter current is monitored by sensing the voltage drop across this resistor (see Section 5.6.6). The output impedance on U504, pin 5 is 50 ohms, and it is matched to Q509 by a section of microstrip, C556, C557, and C558. Class C biasing of Q509 is provided by L507. The unswitched battery supply applied to Q509 is isolated from RF by ferrite bead EP503, inductor L508, and several capacitors. Impedance matching is provided on the output by C559, C561, C562, C566, and a section of microstrip.

5.6.4 HIGH POWER ANTENNA SWITCH

The high power antenna switch consists of pin diodes* CR501, CR502, CR503, and other components. This switch effectively switches the antenna to the power amplifier in the transmit mode, and the receive RF amplifier path in the receive mode (see preceding illustration).

Transistors Q506 and Q501 controlled by the Q7 output of shift register U501 after it is double inverted by Q516 and Q517. This signal is high in the transmit mode and low in the receive mode. Therefore, Q506 and Q501 are on in the transmit mode which forward biases CR501, CR502, and CR503. One current path is through Q501, R503, R504, CR501, L508, CR502,

800 MHz 35W PA BOARD (Cont'd)

and L508, and the other is through Q506, R559, CR503, and R560.

Since a forward biased pin diode has a low impedance, the RF signal passes through CR502 to the low-pass filter. The signal is blocked from the RF amplifier by two discrete grounded quarter-wave lines. One line is formed by L508/C507 and the other by L502/C514. Diode CR501 is effectively AC grounded by C507, and CR503 is AC grounded by C514. When one end of a quarter-wave line is grounded, the other end presents a high impedance to the quarter-wave frequency.

In the receive mode, all three diodes are reverse biased. Therefore, the receive signal from the antenna is blocked from the power amplifier by CR502 and has a low impedance path through the quarter-wave lines which are no longer grounded. Resistors R505 and R506 improve the isolation provided by CR501 and CR502 when they are reverse biased in the receive mode.

5.6.5 DIRECTIONAL COUPLER, LOW-PASS FILTER, TEMP SENSE

A directional coupler is formed by adjacent sections of microstrip near C566. The forward component of output power is rectified by CR509 and developed across R557 and then fed to the power control circuit. Reverse power is not detected in this transceiver.

From the directional coupler the transmit RF signal is coupled by C511 to a low-pass harmonic filter formed by C501-C505 and several sections of microstrip. This filter attenuates harmonic frequencies occurring above the transmit band. Resistor R501 dissipates static buildup on the antenna.

The ambient power amplifier temperature is sensed by thermistor RT501. The resistance of a thermistor decreases as temperature increases. The thermistor forms a voltage divider with R147 on the audio/logic board, and the voltage across this divider is monitored by A/D converter U21. If the PA temperature increases above limits set in software, the power is first cut back. Then if it continues to rise, the transmitter is turned off.

5.6.6 POWER CONTROL

Introduction

The power control circuit maintains a constant power output as changes occur in temperature and voltage. It does this by sensing the forward power and then varying the output of Q505 to maintain a constant output power (see Section 5.6.2). Although current to final amplifier Q509 is also sensed, power output is affected by this input only if current becomes excessive. Power output is then cut back to approximately 25% of full power.

The power output level is set in 127 steps by D/A converter U501 which is controlled by the microcontroller. This allows power to be adjusted using the PCTune software and computer and also different power levels to be programmed. In addition, it allows the microcontroller to cut back power if the power amplifier temperature is excessive. Temperature is sensed via thermistor RT501 (see Section 5.6.5).

U502A Operation

The forward power signal from the directional coupler is applied to pin 2 of amplifier U502A. This is a DC signal that increases proportionally to forward power. The other input to U502A is a DC reference voltage from a D/A converter formed by shift register U501 and several resistors. The voltage from this D/A converter sets the voltage on pin 3 which sets the power output of the transmitter.

U502A is a difference amplifier which amplifies the difference between the reference voltage on pin 3 and the forward power signal on pin 2. The turn-on time of U502A is controlled by the time constant of C525 and R527. This circuit operates as follows: Assume the output power attempts to increase. The DC voltage applied to U502A, pin 2 then increases which causes the output voltage on pin 1 to decrease. Transistor Q505 then turns off slightly which increases the attenuation provided by the attenuation circuit (see Section 5.6.2). The output power then decreases to maintain a constant power output.

Delayed PTT

Transistor Q504 is used to delay power output for a short time after the transmitter is keyed. This allows the synthesizer and exciter to stabilize so that the transmitter does not transmit off-frequency. The signal which controls Q504 is from pin 14 of microcontroller U9 on the logic board. In the receive mode this output is low, so Q504 is off. Pin 2 of U500A is then pulled high by the 7.2-volt supply applied through R530 and CR505. This causes the output on pin 1 of U502A to go low which shuts off Q505 and produces maximum attenuation. Then when the transmitter is keyed, the Q504 control signal goes high after a short delay. Q504 then turns on and diode CR505 is reverse biased. Only the forward power signal is then applied to pin 2 of U502A.

Over-Current Shutdown

Current to final amplifier Q509 is monitored by sensing the voltage drop across R550. Pins 3 and 6 of U505 are connected across this resistor. As current increases, the output voltage on U505, pin 8 decreases. This signal is applied to Schmitt trigger U502B. When the voltage on pin 6 rises above the reference on pin 5, the output on pin 7 goes low. This lowers the power control voltage applied to U505 which lowers the power output to approximately 25% of full power.

5.6.7 RF AMPLIFIER (Q503)

The receive signal from the antenna switch is applied to bandpass filter Z501. This is a three-pole filter with a center frequency of 860 MHz and a bandwidth of 18 MHz. This filter attenuates frequencies outside the receive band such as the first injection, image, and half IF frequencies.

The signal is then applied to RF amplifier Q503 which improves and stabilizes receiver sensitivity and also recovers filter losses. A section of microstrip and C515 provide impedance matching on the input. CR504 protects the base-emitter junction of Q503 from damage caused by high level input signals.

The bias current of Q503 is fixed at a constant level by Q502. The collector current of Q503 flows through R511, and the voltage drop across that resistor (and therefore the current) is set by R508 and R509.

For example, if current through R2511 attempts to increase, the emitter voltage of Q502 decreases. Q502 then conducts less and turns Q503 off slightly to maintain a constant bias current. This provides a stable bias over changes in temperature. The output signal of Q503 is applied to a 3 dB, 50-ohm pad formed by R587-R589, and then coupled by C531 to antenna switch U603. From U603 it is applied to the RF board.

5.7 DC POWER DISTRIBUTION

5.7.1 POWER ON OPERATION

When the On-Off/Volume knob is pressed to turn power on (this is a push on/push off switch), the following sequence of events occurs:

1. The power switch closes and grounds the emitter of Q8 on the logic board.

2. If ignition switch sense is used, the 13V signal from the ignition switch is applied to the base of Q8 and pin A7 of microcontroller U6 (or pin 48 of microcontroller U9 with the Rev 3 logic board). If ignition sense is not used, pull-up resistor R145 can be installed to make the transceiver functional.

3. Q8 then turns on which grounds the base of Q512 on the PA board and turns it on. This turns on main power switching transistor Q511 and applies power to the switched portions of the transceiver.

5.7.2 POWER OFF OPERATION

When power is turned off, the following sequence of events occur:

1. If the power switch is pressed, it opens and the base of Q8 is no longer grounded. This also applies a high signal to the microcontroller which then detects the power-off condition.

2. If ignition switch control of power is used, turning the ignition switch off causes the signal applied to the base of Q8 to go low. This signal is also inverted by Q5 and applied the microcontroller.

3. Q8 then turns off. However, when the controller detects the power-down request, it holds Q2 on to delay power turn-off until all the required save operations are complete.

REV 3 LOGIC BOARD DESCRIPTION

4. The controller then turns off Q2 and both Q511 and Q512 on the PA board turn off which turns off transceiver power.

5.8 LOGIC BOARD (REV. 3 VERSION)

NOTE: The following description applies to the Revision 3 Logic Board shown on page A-8.

5.8.1 LOGIC BOARD OVERVIEW

The Logic Board contains ADSIC U3, Digital Signal Processor U12 (TMS320C50), static RAM U5/ U6, FLASH memory U2, and a programmable logic IC U1. In addition, it contains microcontroller U9, audio circuits, and a 5V power supply. The logic board connects with the interface board via J9 and the display controller board via J1.

The ADSIC performs the frequency discrimination and receiver filtering functions. It also performs analog-to-digital (A/D) and digital-to-analog (D/A) conversion. Functions previously performed in hardware like filtering and limiting are performed by software running in the DSP chip. The DSP performs demodulation and modulation, voice encoding and decoding, audio filtering, and squelch signaling. The software for the radio is stored in FLASH memory that is loaded in to static RAM at turn-on. The programmable logic IC controls which device (Flash, SRAM, or UART) is connected to the DSP address and data bus.

5.8.2 DIGITAL SIGNAL PROCESSING OVERVIEW

The DSP section consists of a DSP chip (U12), the ADSIC (U3), two 128K x 8-bit Static RAM chips (U5, U6), one 512K x 16-bit FLASH ROM memory chip (U2), a UART chip (U20), a programmable logic IC (U1), and a glue-logic chip (U4). The FLASH ROM contains the program code executed by the DSP. Depending on the operational mode selected for the radio, different sections of the program code in the FLASH ROM are copied into SRAM for faster execution.

The ADSIC is a support chip for the DSP. It provides the interface between the DSP and the analog signal paths, and between the DSP and the ABACUS chip on the RF Board. Configuration of the ADSIC is handled primarily by the microcontroller. The DSP has access to a few memory-mapped registers on the ADSIC.

In receive mode, the ADSIC interfaces the DSP with the ABACUS IC on the RF board. The ADSIC collects the I and Q samples from the ABACUS and performs channel filtering and frequency discrimination on the signals. The resulting demodulated signal is routed to the DSP via the serial port for further processing. After the DSP processing, the signal is sent to the ADSIC Speaker D/A by writing to a memory-mapped register. The ADSIC then converts the processed signal from the DSP to an analog signal and then outputs this signal to the speaker power amplifier on the interface board.

In transmit mode the ADSIC Microphone A/D digitizes the analog signal from the microphone. The DSP reads these values from a memory-mapped register in the ADSIC. After processing, the DSP sends the modulation signal to the ADSIC via the serial port. In the ADSIC, the VCO D/A converts the sampled modulation signal into an analog signal and then routes this signal to the VCO on the RF board.

5.8.3 RECEIVE SIGNAL PATH

The ABACUS IC on the RF board provides a digital back end for the receiver section. It provides a digital output of I (in phase) and Q (quadrature) samples which represent the IF signal at the receiver back end. These samples are routed to the ADSIC where the signal is filtered and frequency discriminated to recover the modulating signal.

The recovered signal is sent to the DSP chip for processing. The ADSIC interface to the ABACUS is comprised of four signals SBI, DIN, DIN*, and ODC. The ODC signal is a clock the ABACUS provides to the ADSIC. Most internal ADSIC functions are clocked by this ODC signal at a rate of 2.4 MHz and are available as soon as the power is supplied to the circuitry. This signal initially may be 2.4 or 4.8 MHz after power-up. It is programmed by the ADSIC through the SBI signal to 2.4 MHz when the ADSIC is initialized by the microcontroller through the SPI bus. For any functionality of the ADSIC to exist, including initial programming, the reference clock must be present.

REV 3 LOGIC BOARD DESCRIPTION (Cont'd)

SBI is a programming data line for the ABACUS. This line is used to configure the operation of the ABACUS and is driven by the ADSIC. The microcontroller programs many of the ADSIC operational features through the SPI interface. There are 36 configuration registers in the ADSIC of which 4 contain configuration data for the ABACUS. When these particular registers are programmed by the microcontroller, the ADSIC in turn sends this data to the ABACUS through the SBI.

DIN and DIN* are the data lines in which the I and Q data words are transferred from the ABACUS. These signals make up a differentially encoded current loop. Instead of sending TTL-type voltage signals, the data is transferred by flowing current one way or the other through the loop. This helps reduce internally generated spurious emissions on the RF board. The ADSIC contains an internal current loop decoder which translates these signals back to TTL logic and stores the data in internal registers.

The ADSIC performs digital IF filtering and frequency discrimination on the signal, sending the baseband demodulated signal to the DSP. The internal digital IF filter is programmable with up to 24 taps. These taps are programmed by the microcontroller through the SPI interface.

The DSP processes this data through the SSI serial port. This is a six-port synchronous serial bus. The ADSIC transfers the data to the DSP on the TxD line at a rate of 2.4 MHz. This is clocked synchronously by the ADSIC which provides a 2.4 MHz clock on SCKT. In addition, a 20 kHz interrupt is provided on TFS to signal the arrival of a data packet. This means a new I and Q sample data packet is available to the DSP at a 20 kHz rate which represents the sampling rate of the received data. The DSP then processes this data to extract audio, signaling, and other information based on the 20 kHz interrupt.

In addition to the SPI programming bus, the ADSIC also contains a parallel configuration bus. This bus is used to access registers mapped into the DSP memory. Some of these registers are used for additional ADSIC configuration controlled directly by the DSP. Some of the registers are data registers for the speaker D/A. Analog speaker audio is processed through this parallel bus where the DSP outputs the speaker audio digital data words to this speaker D/A. In addition, an analog waveform is generated which is output to SDO (Speaker Data Out).

In conjunction with speaker D/A, ADSIC contains a programmable attenuator to set the rough signal attenuation. However, the fine levels and differences between signal types are adjusted through the DSP software algorithms. The speaker D/A attenuator setting is programmed by the microcontroller through the SPI bus.

The ADSIC provides an 8 kHz interrupt to the DSP on IRQB for processing the speaker data samples. This 8 kHz signal must be enabled through the SPI programming bus by the microcontroller and is necessary for any audio processing to occur.

5.8.4 TRANSMIT SIGNAL PATH

The ADSIC contains an analog-to-digital (ADC) converter for the microphone. The microphone path in the ADSIC also includes an attenuator that is programmed by the microcontroller through the SPI bus. The microphone input in the ADSIC is on pin MAI (U3-19). The microphone ADC converts the analog signal to a series of data words and stores them in internal registers. The DSP accesses this data through the parallel data bus. As with the speaker data samples, the DSP reads the microphone samples from registers mapped into its memory space. The ADSIC provides an 8 kHz interrupt to the DSP on IRQB for processing the microphone data samples.

The DSP processes these microphone samples and generates and mixes the appropriate signaling and filters the resultant data. This data is then transferred to the ADSIC on the DSP SSI port. The ADSIC generates a 48 kHz interrupt so that a new sample data packet is transferred at a 48 kHz rate and sets the transmit data sampling rate at 48 ksps. These samples are then input to a transmit D/A which converts the data to an analog waveform. This waveform is the modulation signal from the ADSIC and is connected to the VCO on the RF Board.

5.8.5 DSP CHIP (U12)

DSP chip U12 has a 16-bit data bus and a 16-bit address bus. It has 10K words of internal SRAM from

REV 3 LOGIC BOARD DESCRIPTION (Cont'd)

which 0.5K are used only to store data and 9.5K are used either for data or for program storage. The DSP bus can access through its buses the following external devices:

SRAM U5 and U6 - These two chips are 128K x 8 chips. U5 stores the lower byte of the word while U6 stores the higher byte. Those chips are selected by asserting CE2 high and CE1* low. The programmable logic IC is responsible for controlling the select lines of these ICs.

FLASH ROM U2 - This chip is 512K x 16 words in size. It is selected by asserting CE* low. The programmable logic IC is responsible for controlling the select line of this IC.

ADSIC U3 - The ADSIC contains several registers which can be read from or written to by the DSP. The ADSIC IC has an output which drives a data/address bus enable signal for the programmable logic IC.

UART U7 - This chip converts data from the DSP into serial data. It is used to interface with the optional encryption board.

Programmable Logic U1 - This IC arbitrates access to the DSP's address/data bus between the flash (U2), SRAMs (U5,U6), and UART (U7). The DSP can modify the memory configuration by writing to a series of registers in the programmable logic IC. In order to reduce power consumption, the programmable logic IC can be 'disconnected' from the DSP's address/data bus using the bus enable input on the programmable logic IC (pin 44).

The DSP uses memory as data space, program space, and I/O space as follows. Refer to Figure 5-2 for more information.

Program Space - Internal SRAM, external SRAM, and FLASH memory.
Data Space - Internal SRAM and external SRAM.
I/O Space - Programmable logic IC, ADSIC, and the UART.

The DSP accesses the difference spaces by setting the corresponding lines PS*, DS*, IS* low. Only one of these three signals can be low at a given time. When the DSP accesses internal SRAM, none of these lines is activated.

The programmable logic IC (PLD) acts as the primary arbitrator of the DSP's memory map. The FLASH ROM and the SRAM are both mapped in the program space and cannot both be active at the same time. The DSP may control which type of memory is mapped in program space by enabling the programmable logic IC (PLD), then manipulating a register in the PLD. In addition, the DSP can manipulate other registers to control paging of both the Flash and the SRAM. Paging refers to the swapping of 64K word blocks of Flash or SRAM into or out of the DSP's memory map.

FLASH ROM U2 is used to permanently store the program to be executed in the DSP. However, it is slow to access, so to fully utilize the speed of the DSP, the program stored in the FLASH ROM must be copied into the SRAM. As the size of the SRAM is half the size of the FLASH ROM, only the code required for the current mode of operation is copied in the SRAM. As previously mentioned, the FLASH ROM and the SRAM cannot be active at the same time. Therefore, the internal data memory is used as a temporary buffer to transfer the program from the FLASH ROM to the SRAM.

The following hardware interrupts are used on the DSP:

Interrupt	Description
INT1*	8 kHz interrupt for speaker DAC and microphone ADC from ADSIC
INT2*	125 kHz signal from ADSIC
INT3*	2 kHz timer interrupt from the Controller on the Keypad Board.
INT4*	Interrupt from the UART
NMI*	Not used

Connector J3 allows connection to an emulator for debugging purposes. The emulator connects to some dedicated pins on the DSP.

5.8.6 UART (U20)

UART U20 performs parallel to serial and serial to parallel conversion. The serial format used is a 9-bit format with start and stop bits. The serial transmission speed is 19200 bps. The UART appears as eight registers visible in the I/O space of the DSP starting at every multiple of 0008h from 0000h to 07FFh. U1 performs the address decoding by selecting the UART

REV 3 LOGIC BOARD DESCRIPTION (Cont'd)

(pin 39) when both IS* and A15 are low. Crystal Y2 along with the internal oscillator of the UART provides the clock required to generate the correct bit rate on the serial output of the UART.

When the UART receives a new serial word or is ready to accept a new word to send from the DSP, it generates an interrupt on INTRN. This pin is connected to one of the hardware interrupt lines on the DSP. The DSP responds by reading the status register in the UART and by answering accordingly.

5.8.7 ADSIC

The ADSIC is a complex custom IC which performs many analog-to-digital, digital-to-analog, and purely digital functions as previously described. The ADSIC has four internal registers accessible by the DSP. They are selected through the use of address lines A15, A14, A13, A2, A1, A0, IS* (IS* needs to be inverted with U4 to be compatible with the logic level required by the ADSIC), RD*, and WR*. Two of these registers are read-only while the two others are write-only. Therefore, they can be accessed as two locations in the I/O spaces. Due to the decoding performed, those locations appear at the following addresses: Fxx0h, Fxx1h, Fxx8h, Fxx9h, Exx0h, Exx1h, Exx8h, and Exx9h.

Crystal Y1 along with the internal oscillator in the ADSIC provide a 20 MHz clock. This clock signal is used internally by the ADSIC and is also multiplied by two to provide a 40 MHz clock to the DSP. The frequency of the clock can be electronically shifted a small amount by controlling varicap D1 through the OSCW pin (U3-97). This removes interference created on some channels by the clock.

The ADSIC and DSP exchange the sampled receive data and the sampled VCO modulation signal through a serial port. This serial port consists of pins SCKR*, RFS, RxD, TxD, SCKT, and TFS on the ADSIC. U21 and U1 modify the relative phase of TxD and TFS to be compatible with the timing required on the serial port of the DSP.

SDO is the output of the internal speaker DAC. MAI is the input of the internal microphone attenuator and is followed by the microphone ADC.

The ADSIC is configured partially by the DSP through its data and address bus (see preceding). However, most of the configuring is provided through an SPI compatible serial bus. This SPI serial bus consists of pins SEL*, SPD, and SCLK. The other side of this bus is connected to microcontroller U9.

5.8.8 MICROCONTROLLER U9 OVERVIEW

The microcontroller provides an interface between the hardware and DSP U12. When the user presses or rotates a control such as the Select switch, an option button, or the PTT switch, the microcontroller signals the change to the DSP. Conversely, when the DSP needs to change the display or an LED, it signals the microcontroller which then performs the action. The microcontroller also controls peripheral ICs such as the synthesizer, reference oscillator, display processor, and ADSIC.

The microcontroller uses a serial bus to communicate with the DSP and another RS-485 bus to communicate with the front panel/remote control unit. The RS-485 bus is used for external communication with a computer running the programming or tuning software. Finally, the microcontroller maintains certain operating parameters in the associated EEPROM which is controlled via a two-wire serial bus.

5.8.9 MICROCONTROLLER DESCRIPTION

Microcontroller U9 is a Motorola 68HC08XL36 chip. It includes 28K bytes of internal ROM memory and 1K byte of internal SRAM. It does not have an external bus and therefore cannot access any external program memory.

The clock to the microcontroller is provided by Y3 and an internal oscillator. The frequency of the clock can be slightly offset by polarizing the base of Q1 through software control. This prevents RF interference on some channels caused by the clock.

The microcontroller contains an SPI-compatible synchronous serial bus. This bus consists of pins MISO (U1-53), MOSI (U1-52), SPSCK (U1-50), and a chip enable for each device with which it communicates. The devices which communicate with the microcontroller through this bus are as follows:

REV 3 LOGIC BOARD DESCRIPTION (Cont'd)

- PA temperature sense ADC U21
- ADSIC chip U3
- Reference Oscillator (RF Board)
- Front-End DAC (RF Board)
- Synthesizer chip (RF Board)
- Shift register U801 (PA board)
- Optional DES board

The microcontroller communicates with the DSP chip through a custom serial bus. This serial port includes pins PTA3 (U9-8), PTA4 (U9-9), PTA5 (U9-10), PTA6 (U9-11), and PTA7 (U9-12).

The microcontroller SCI asynchronous serial bus is converted to an RS-485 bus by U14. The RS-485 bus is then used for communication with the front panel/remote control unit controller and the external computer running the programming or tuning software. The SCI bus consists of RxD (U9-42) and TxD (U9-43). The RS-485 driver (U14) converts U9 signals at a logic level of 0 and 5 V to three-state RS-485 logic levels.

Serial EEPROM U10 is used to store some important radio parameters. The EEPROM is read to or written from using I/O lines PTC6 and PTC7 of the microcontroller. PTC6 is the data line, and PTC7 is the clock line.

5.8.10 RECEIVE AUDIO CIRCUIT

In receive mode, the analog receive waveform created by the ADSIC is fed to summing amplifier U19A. This amplifier sums this signal with the audio tones generated by the microcontroller on pin 46. The output of the summing amplifier is then fed to buffer amplifiers U19B and U18B, and to U17A/U17B which provide a differential output.

The output signal from U19B is fed to volume control IC U4 on the interface board and then to audio amplifier U1. The output signal from U18B provides the External PA output to the accessory cable, and the output signal from U17A/U17B is fed to the display controller board. It is then converted back to a single-ended signal and fed to the Rx Audio pin of the front panel microphone jack. If a remote control unit is used, the U17A/U17B output signal is also routed to the audio amplifier in the remote control unit.

5.8.11 TRANSMIT AUDIO CIRCUIT

In transmit mode, the audio for transmission can be selected from the microphone connected to the front panel microphone jack or the microphone connected to a remote control unit. U15A and U15B convert a differential input to a single-ended output, and analog switch U18A selects the desired microphone signal.

The microphone signal is then buffered by U15C and fed to analog switch U18B and to the microphone output pin of the universal interface connector. U18B which selects either the microphone or universal interface microphone input signal. Additional buffering is provided by U15D and the signal is then fed to the A/D input of the ADSIC.

5.8.12 VOLTAGE REGULATION

The 5-volt supply is produced by switching DC-DC converter U11. This device is powered by the switched 7.2V supply, and the switching frequency is approximately 160 kHz. A switching regulator provides improved efficiency compared to a standard linear regulator. The 5-volt supply power provides a large percentage of the total power consumed by the radio. The peak-to-peak residual ripple on the 5-volt supply is approximately 50 mV.

The DC-DC converter has a soft-start feature (R27, C141) to prevent chattering of the output regulated voltage due to “bouncing” of the on/off switch. The converter has current limiting that limits output current to 1.5 A. The under voltage protection turns the converter off if the input (switched B+) voltage drops below 5.45 V.

REV 3 LOGIC BOARD DESCRIPTION (Cont'd)

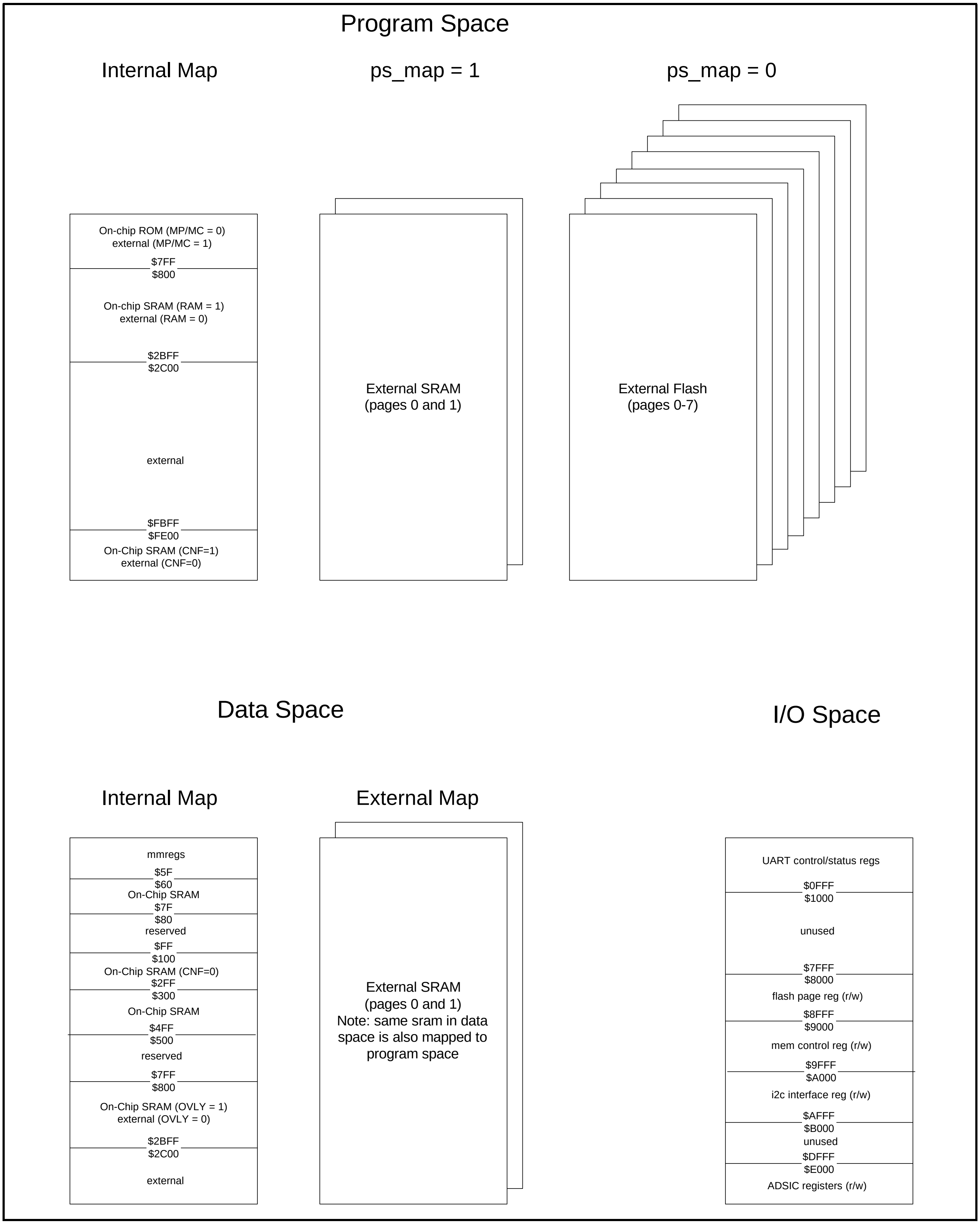


Figure 5-2 Memory Utilization