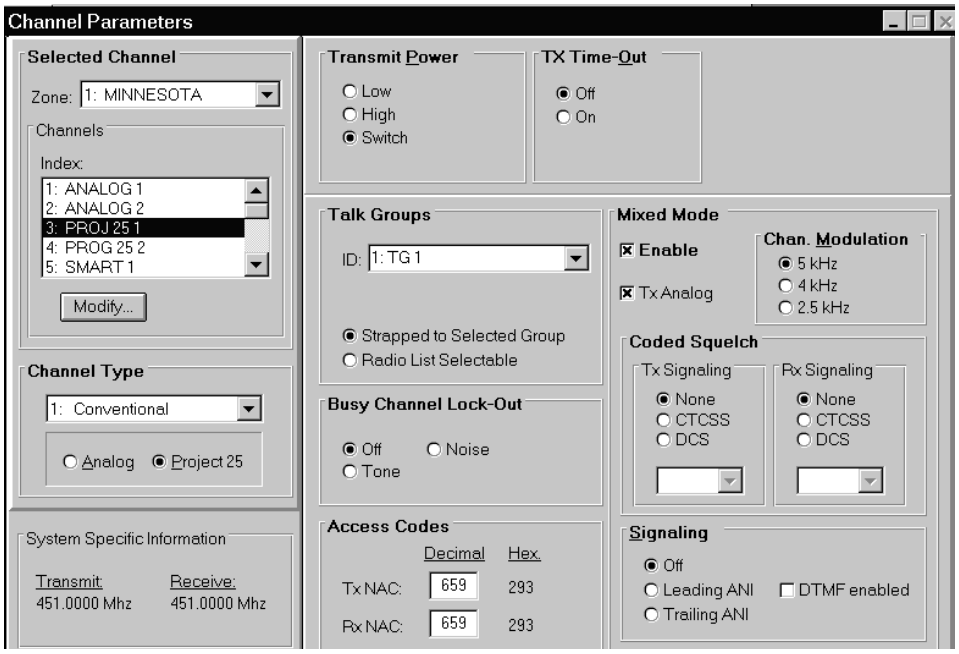


Figure 3-4 Conventional Project 25 Digital Channel Screen

3.5.7 CONVENTIONAL PROJECT 25 (DIGITAL) CHANNEL SCREEN PARAMETERS

The following parameters are programmed in the conventional Project 25 digital channel screen shown in Figure 3-4. Refer to Section 2.6.16 for more information on Project 25 operation.

The Selected Channel, Channel Type, Transmit Power, and Transmit Time-Out Parameters are programmed the same as with analog channels described in preceding section.

Talk Groups

This selects the Project 25 talk group that is assigned to the channel. The talk group programs the talk group ID, strapping mode, and encryption key address. Talk groups for Project 25 channels are programmed in the Conventional System Talk Group screen described in Section 3.5.4.

Strapped to Selected Group - If this parameter is selected, the talk group on that channel is always the selected talk group and cannot be changed.

Radio List Selectable - If this parameter is selected, the talk group may be changed by the radio operator using the (Digital) Talk Group Select option switch.

Busy Channel Lockout

Off = disabled, Noise = transmit disallowed if carrier is detected, NAC = transmit allowed only if correct NAC is detected (Section 2.6.5).

Access Codes

Programs the transmit and receive NAC (Network Access Code). These codes can be 0-4095. Refer to Section 2.6.16 for more information.

Mixed Mode

A mixed mode that allows both analog and Project 25 operation to be programmed on a channel can be enabled on the Project 25 channel screen (see Figure 3-4). This mode is programmed as follows:

Enable - Checking this box selects mixed analog/Project 25 operation on the channel.

Tx Analog - Checking this box selects Transmit = analog/Receive = Project 25. If it is not checked, the opposite is selected.

When the mixed mode is selected, the channel modulation, coded squelch, and ANI signaling parameters for the analog channel must then be programmed.

These parameters are programmed the same as described in Section 3.5.6.

3.6 PROGRAMMING SMARTNET/SMARTZONE SYSTEMS AND CHANNELS

3.6.1 INTRODUCTION

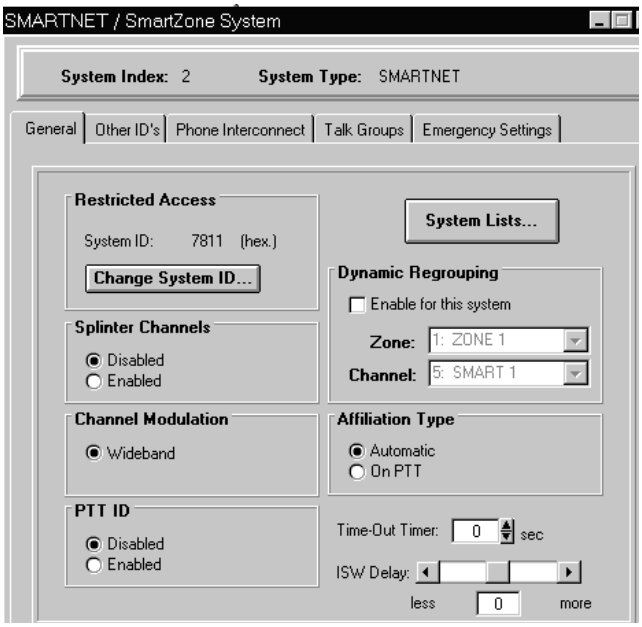
To program SMARTNET and SmartZone systems and channels, proceed as follows:

1. Program the SMARTNET/SmartZone radio-wide information as described in Section 3.4.

2. To create a new SMARTNET/SmartZone system, select the Systems > Add Systems in the menu bar (see Section 3.1.11). Up to sixteen systems of any type can be programmed as described in Section 1.2.5.

3. Program the SMARTNET/SmartZone system information as described starting in the next section. Make sure the desired SMARTNET or SmartZone system is displayed by clicking it in the left pane or selecting it in the Window menu in the menu bar (see Section 3.1.9). Then program the channels as described starting in Section 3.6.8.

3.6.2 SMARTNET/SMARTZONE SYSTEM GENERAL SCREEN



The preceding SMARTNET/SmartZone System General screen programs the following parameters:

Restricted Access

Change System ID Button - Displays the Change System ID screen which is used to enter the system ID of the system. This ID is entered as a hexadecimal number from 0-9 and A-F. Valid numbers are from 0001-FFFF. The system ID corresponding to the desired ID must also be located in the "key" subdirectory of the program file.

System ID - Read-only field which shows the ID of the system currently being edited.

Splinter Channels

When splinter channels are enabled, the receive and transmit frequencies are 12.5 kHz lower than the normal frequencies. Splinter channels are used only as required in the Mexico and Canada border areas for frequencies between 806 and 820.975 MHz.

Channel Modulation

When "Wideband" is enabled, the radio operates with a 4 kHz maximum deviation between 821.000 and 824.975 MHz and 5 kHz maximum deviation for all other frequencies. When it is disabled, deviation is 5 kHz with all frequencies.

System Lists Button

This button displays the screens used to program the various per system lists. Refer to Section 3.6.7 for more information on these lists.

Dynamic Regrouping

Enable For This System - When this box is checked, a dynamic regrouping channel is enabled. This is a SMARTNET channel which has the corresponding talk group dynamically set by the dispatcher.

Zone - The physical zone containing the dynamic regrouping channel. The value is selected on the Channel Parameters screen.

Channel - The physical channel used for dynamic regrouping. The value is selected on the Channel Parameters screen.

Affiliation Type

Automatic - The radio immediately affiliates with the central controller as soon as it is turned on and automatically re-affiliates each time the talk group is changed.

On PTT - The radio affiliates with the central controller only when the PTT switch is pressed.

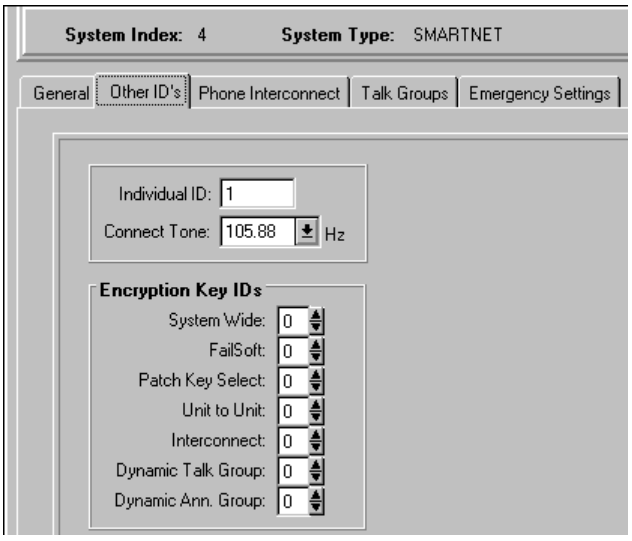
Time-Out Timer

This programs the time-out timer setting for the system. It can be programmed for 0 min, 15 sec up to 3 min, 45 sec or it can be disabled (see Section 2.4.10).

ISW Delay

Increasing or decreasing this value changes the transmission timing of ISWs relative to the reception of OSWs.

3.6.3 SMARTNET/SMARTZONE SYSTEM OTHER ID'S SCREEN



The SMARTNET/SmartZone Other ID's screen is shown above, and it programs the following parameters.

Individual ID - Uniquely identifies the radio on a particular system. Each radio must have a different Unit ID. Valid Unit IDs are from 1-63535.

Connect Tone - The tone expected by the controller on the traffic channel to verify that a subscriber transmission is occurring. This tone should be set the same as it is in the controller.

Encryption Key IDs

Programs SecureNet Encryption ID selection that is used in all except group calls.

System Wide - Key used for system-wide calls (typically originated by the dispatcher).

Failsoft - Key used in failsoft conditions (see Section 2.7.11).

Patch Key Select - Key used in patch calls.

Unit To Unit - Key used for unit-to-unit (private) calls.

Interconnect - Key used for telephone interconnect calls.

Dynamic Talk Group - Key used for the dynamic regrouping talk group when it is a standard talk group.

Dynamic Ann. Group - Key used for the dynamic regrouping talk group when it is an announcement group.

3.6.4 SMARTNET/SMARTZONE SYSTEM PHONE INTERCONNECT SCREEN

The SMARTNET/SmartZone Phone Interconnect screen follows on the next page, and it programs the following parameters.

Phone Interconnect

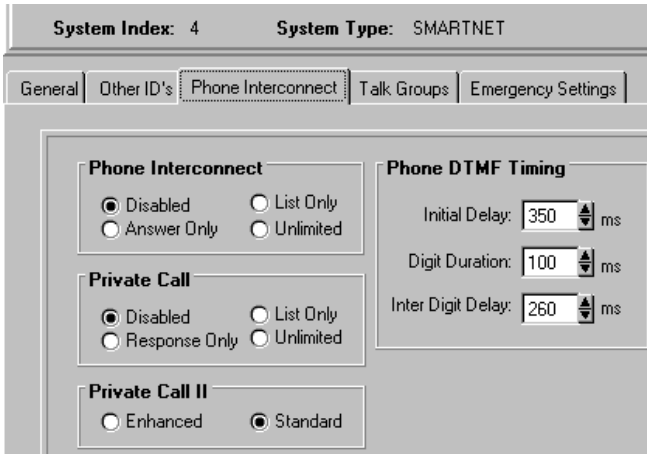
Refer to Section 2.7.6 for more information on telephone calls.

Disabled - Telephone calls cannot be placed or received.

Answer Only - Telephone calls can be received but not placed.

List Only - Telephone calls can be placed and received, and numbers can be recalled from memory only.

Unlimited - Telephone calls can be placed and received, and numbers can be recalled from memory or dialed using a microphone keypad.



SMARTNET/SmartZone Phone Interconnect Screen

Private Call

This is the same as above, except for private (unit-to-unit) calls. Refer to Section 2.7.4 for more information.

Private Call II

This programs either standard or enhanced private calls as follows:

Standard - The user does not receive any feedback when the called radio is not active in the system. Only a "No Answer" is received if the called radio does not answer.

Enhanced - When a call is placed, the system tells the user if the called radio is currently active in the system and within range. The calling radio displays "No Ack" if the called radio is not active in the system and "No Answer" if it is active but does not answer.

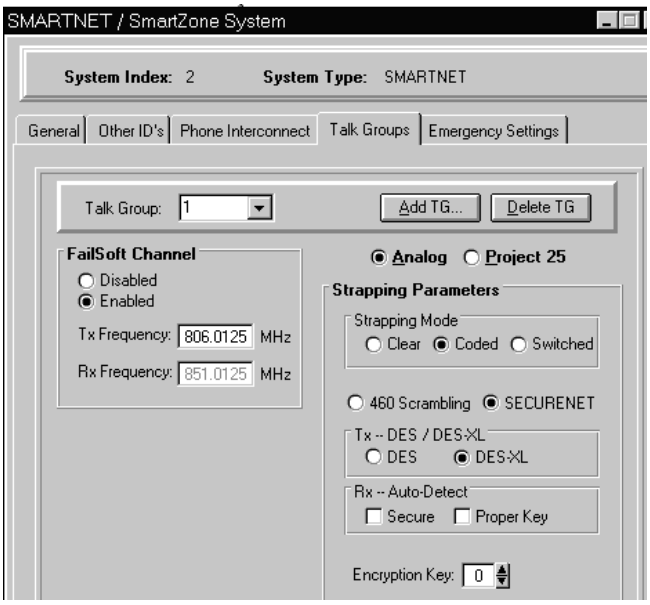
Phone DTMF Timing

Initial Delay - Delay from 50-500 milliseconds from when a traffic channel is granted for phone interconnect to the start of the dialing out of the phone number.

Digit Duration - Duration from 50-500 milliseconds of each phone number digit.

Inter-Digit Delay - Delay from 50-500 milliseconds between each digit of a phone number. start here

3.6.5 SMARTNET/SMARTZONE SYSTEM TALK GROUPS SCREEN



The SMARTNET/SmartZone Talk Groups screen shown above is used to set up SMARTNET/ SmartZone talk groups and program unique talk group information. The parameters programmed in this screen are as follows:

Talk Group - Selects the talk group to program. This is the actual ID of the talk group. Talk groups are added or deleted by clicking the Add TG or Delete TG button (see following). Talk groups are assigned to channels on the channel screen (see Section 3.6.9).

Add TG... - Clicking this button displays a dialog box that adds a new talk group. The alias (alpha tag) of up to ten characters is entered, and the new group is then added after the others that are already set up.

Each SMARTNET/SmartZone system can be programmed with up to 256 talk groups.

Delete TG - Clicking this button deletes the currently selected talk group (the one displayed in the "Talk Group" box).

Failsoft Channel

Enable - Enables a failsoft channel on the talk group if a controller failure occurs (see Section 2.7.11).

Disable - The failsoft mode is not entered if the controller fails.

Tx/Rx Frequency - Programs the failsoft channel frequency if "Enabled" is checked.

Analog/Project 25

This selects the type of SMARTNET/SmartZone channel as analog or Project 25 (digital).

Strapping Parameters

The Strapping Parameters program the channel type (analog or Project 25 digital) and encryption on the talk group as follows:

Clear Mode - All transmissions on the talk group occur in the clear (unscrambled) mode.

Coded Mode - All transmissions on the talk group occur in the secure (scrambled) mode selected as follows.

Switched Mode - The clear or secure status of the talk group is selected by the Clear/Secure option switch.

NOTE: Refer to Section 2.7.15 for more SMARTNET/SmartZone encryption information.

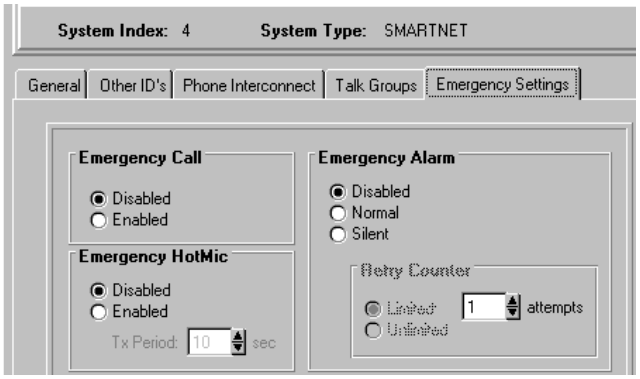
460 Scrambling/SecureNet Mode - These options select either the Transcrypt 460 or DES type of secure communication when either the coded or switched strapping mode is selected.

Tx DES/DES-XL - Selects either DES or DES-XL encryption protocol.

Rx Secure Autodetect - With the SecureNet protocol, selecting "Secure" enables automatic detection of encrypted receive signals. This may increase the response time of the radio to an incoming signal. Selecting "Proper Key" causes the radio to search the available SecureNet keys until it finds a match for the current transmission.

Encryption Key - Selects the encryption key used on the talk group. This is a number from 0-15 that refers to a hardware location in the radio that contains the real key.

3.6.6 SMARTNET/SMARTZONE SYSTEM EMERGENCY SETTINGS SCREEN



The SMARTNET/SmartZone Emergency Settings screen and the parameters programmed in this screen are as follows:

Emergency Call

Enable - When the Emergency option switch and then the PTT switch are pressed, an emergency group call is transmitted.

Disable - An emergency group call is not authorized.

Emergency Hot Mic

Enable - When an emergency alarm is generated and the emergency alarm acknowledgment received, the emergency mode is automatically entered and transmitting begins for the time specified by the Tx Period parameter (see following).

Disable - Automatic transmissions do not occur.

Tx Period - Defines the period during which transmissions occur with the microphone audio unmuted (without user intervention). Times of 10-120 seconds in 10-second steps can be selected.

Emergency Alarm

Disabled - No emergency signal is sent when the user presses the Emergency option switch.

Normal - When the user presses the Emergency option switch, an emergency signal is sent to the dispatcher. Audio and visual feedback is provided by the radio.

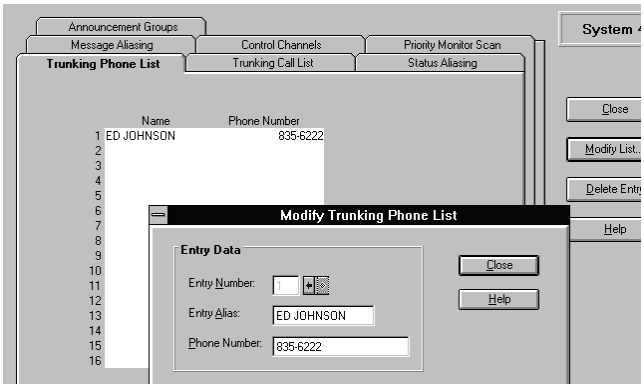
Silent - Same as "Normal" except no audio or visual feedback is provided.

Retry Counter - When "Unlimited" is selected, an emergency call is repeated until acknowledged or canceled. When "Limited" is checked, calls are attempted only the specified number of times.

3.6.7 SMARTNET/SMARTZONE SYSTEM LISTS SCREENS

Clicking System Lists in the left pane under SMARNET > General or the System Lists... button in the General screen described in Section 3.6.2 displays the screens used to program the various lists that are unique for each SMARTNET/SmartZone system. These screens are as follows:

Trunking Phone List Screen



This screen programs the phone number list if used (see Section 2.7.6). To edit this list, click the Trunking Phone List tab and then the "Modify List" button on the right side of the screen. The following information is then programmed in the dialog box that is displayed:

Entry Number - This box selects the entry to be edited. The scroll bars to the right of this box select the desired entry. A phone list can contain up to 16 entries. Selecting a new entry number automatically validates and stores the current entry. If the current entry contains an invalid field (for example, too many digits in the phone number), the entry number does not change and the invalid field is highlighted.

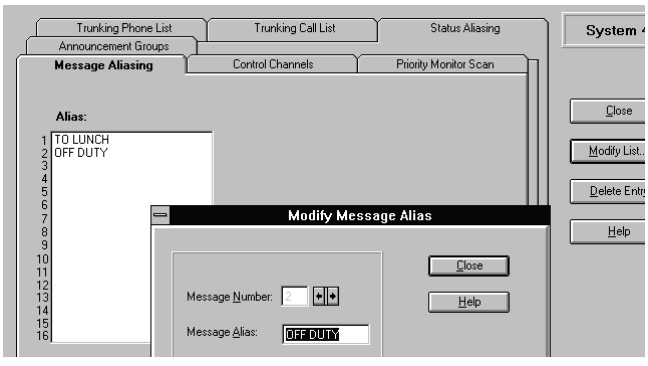
Entry Alias - Up to ten characters can be entered to identify the phone number. This identification is displayed when phone numbers are selected by the user from the list. Only uppercase letters can be entered, so lowercase letters are automatically converted to uppercase by the program.

Phone Number - This is the number dialed when the location is selected. Characters that can be entered include 0-9, #, (,), and P (a "P" programs a pause). The maximum number of digits excluding (,) and spaces is 16, and the maximum including (,) and spaces is 24.

Close - Clicking this button verifies the current entry, stores it, and then closes the dialog box. If the current entry contains an invalid field, the dialog box does not close and the invalid field is highlighted.

Help - Accesses the Help screen. Help can also be selected at any time by pressing the F1 key.

Message Aliasing Screen



This screen associates an alias (name) with each message number (see Section 2.7.8). To edit this list,

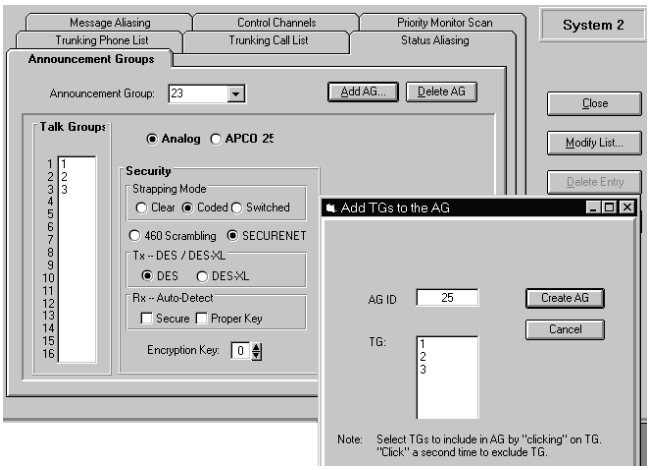
click the Message Aliasing tab and then the “Modify List” button on the right side. The following information is then programmed in the dialog box that is displayed:

Message Number - This box selects the message to be edited. The scroll bars to the right of this box select the desired message number.

Message Alias - Programs the alias which can be up to any ten alphanumeric characters.

Close Button - Validates the entry and closes the dialog box. The entry is also validated when another message number is selected.

Announcement Groups Screen



This screen programs the announcement groups that are used to communicate with several talk groups simultaneously. There can be up to 3 announcement groups per system, and each announcement group can have up to 15 talk groups.

To create an announcement group, click the “Add AG” button and the “Add TGs to the AG” screen also shown above is displayed. Enter the announcement group ID, click the talk groups to select/deselect those that are to be included, and then create the announcement group by clicking the “Create AG” button. To delete the current announcement group, click the “Delete AG” button.

To edit an announcement group, click the “Modify List” button and select the announcement group to be edited from the “AG” pull-down menu. Then click the talk groups to select/de-select them and then click the “Update List” button to make the changes.

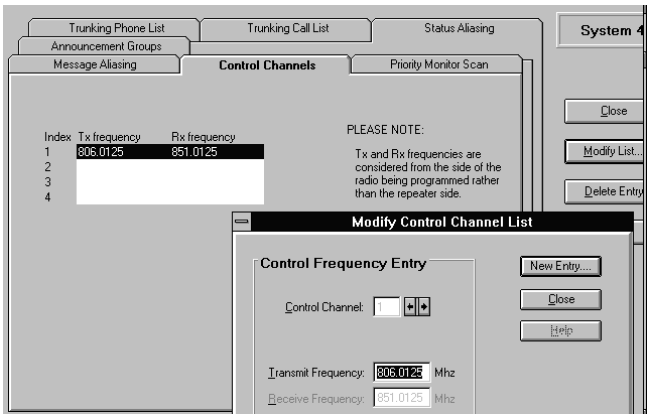
Main Screen Parameters

Talk Groups - This is a read-only list of all talk groups currently in the announcement group.

Analog/Project 25 - Programs the type of communication associated with the announcement group. Either analog or digital (Project 25) communication can be selected.

Security - Defines the type of secure communication used, if any, for the announcement group. These parameters are programmed similar to those on the Talk Group screen described in Section 3.6.5.

Control Channels Screen



This screen allows the system manager to view and edit the control channels. Each SMARTNET system can have up to four control channels, and each SmartZone system can have up to 32 control channels. Only one control channel is active at a time.

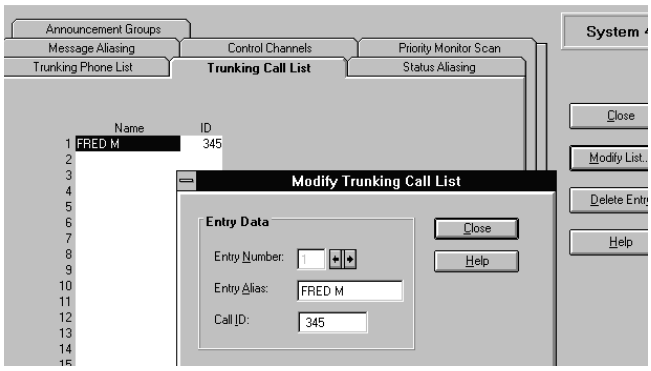
To edit this list, click the Control Channels tab and then the “Modify List” button on the right side. The following information is then programmed in the dialog box that is displayed:

Control Channel - Selects the control channel to be edited. To add a new channel, click the “New Entry” button.

Frequency - The transmit and receive frequency of the control channel. These are the mobile frequencies, not the repeater frequencies. Only multiples of 5 kHz and 6.25 kHz are valid. With 800 MHz frequencies, a receive frequency 45 MHz above the transmit frequency is automatically entered.

New Entry Button - Click this button to display the dialog box used to add another control channel.

Trunking Call List Screen



This screen is shown above, and it allows the list of IDs used for private calls to be programmed. A maximum of 16 IDs can be programmed (see Section 2.7.4).

To edit this list, click the Trunking Call List tab and then the "Modify List" button on the right side. This following information is then programmed in the dialog box that is displayed:

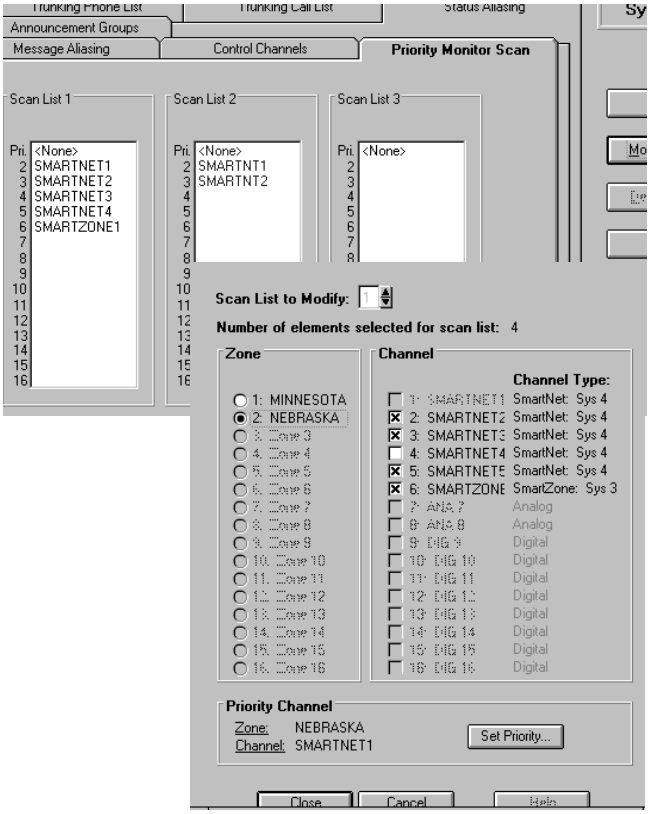
Entry Number - This box selects the entry to be edited. The scroll bars to the right of this box select the desired entry. A phone list can contain up to 16 entries. Selecting a new entry number automatically validates and stores the current entry. If the current entry contains an invalid field, the entry number does not change and the invalid field is highlighted.

Entry Alias - Up to ten characters can be entered to identify the user being called. This identification is displayed when the mobile to be called is selected by the user from the list. Only uppercase letters can be entered, so lowercase letters are automatically converted to uppercase by the program.

Call ID - This is the ID of the radio being called. Valid entries are 1-49152. A "0" is detected as no entry.

Close Button - Verifies the current entry, stores it, and then closes the dialog box. If the current entry contains an invalid field, the dialog box does not close and the invalid field is highlighted.

Priority Monitor Scan Screen



This screen is shown above, and it programs up to three Priority Monitor scan lists that are allowed. Each scan list can contain up to 15 channels plus a priority channel (see Section 2.7.12). These channels must be from the same SMARTNET/SmartZone system. Channels set up for other systems are not allowed.

To edit a list, click the Priority Monitor Scan tab and then click the "Modify List" button on the right side. A screen similar to the top screen shown above is then displayed to select the channels to be included in that scan list. Select channels as follows:

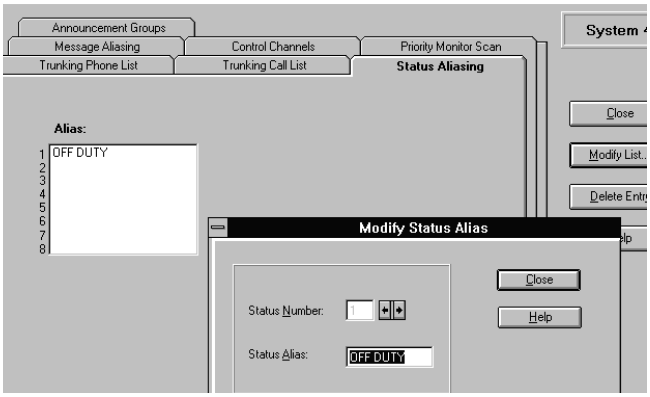
1. Select the scan list to be edited using the scroll bars next to the "Scan List To Modify" box.

2. Select the first zone with channels to be included and select the desired channels. Repeat for the other zones.

3. To select the priority channel, click the Set Priority button. Then select the desired Zone/Channel or "None" if no priority channel is to be scanned.

4. Repeat the preceding steps for the other scan lists if applicable.

Status Aliasing Screen



This screen is shown above, and it programs the alias for each of up to eight status conditions that can be sent. The meaning of each status number is defined by the system manager. Refer to Section 2.7.9 for more information.

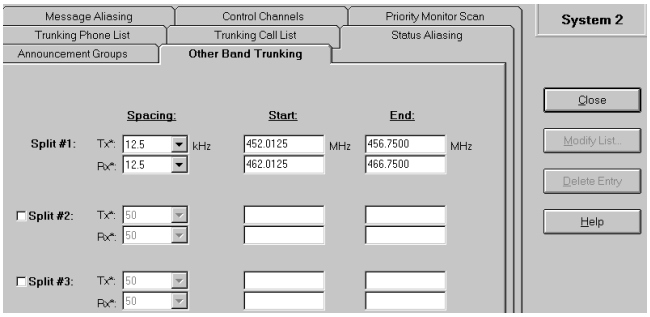
To edit this list, click the Status Aliasing tab and then the "Modify List" button on the right side. The following information is then programmed in the dialog box that is displayed:

Status Number - The scroll bars to the right of this box select the status number that is to be edited.

Status Alias - Programs up to 10 characters that identify the status. This identification is displayed when the user selects a status condition.

Other Band Trunking Screen

The Other Band Trunking screen follows, and it is displayed only when programming channels in the VHF and UHF frequency bands. It is used to define the relationship between the transmit and receive channel frequencies in these bands. With 800 MHz systems, this is not required because the difference between the transmit and receive frequency is always 45 MHz.



Other Band Trunking Screen

This screen organizes the available frequency band into three sub-bands, called splits. Each split is defined by a start frequency, stop frequency, and channel spacing as follows. Frequencies outside the defined split cannot be accessed by the radio. These frequency splits must be defined the same way they are defined for the trunking controller.

Tx and Rx Spacing - Spacing in kHz between each potential transmit and receive frequency.

Tx and Rx Start Frequency - Start in MHz of the band split for transmit and receive frequencies.

Tx and Rx Stop Frequency - Stop in MHz of the band split for transmit and receive frequencies.

3.6.8 SETTING UP SMARTNET/SMARTZONE CHANNELS

The SMARTNET/SmartZone Channel screen shown in Figure 3-5 is displayed when the SMARTNET or SmartZone channel type is selected. The channel screen programs unique channel parameters and also assigns channels to the selectable zones displayed by the transceiver.

The general procedure for setting up a SMARTNET/SmartZone channel is as follows. Refer to the descriptions which follow this procedure for information on SMARTNET/SmartZone Channel screen parameters.

1. Make sure that the desired zone is selected in the Zone box.

2. Select the channel number in the Channels Index box which is to be programmed with the channel. This will be the number displayed when the channel is selected.

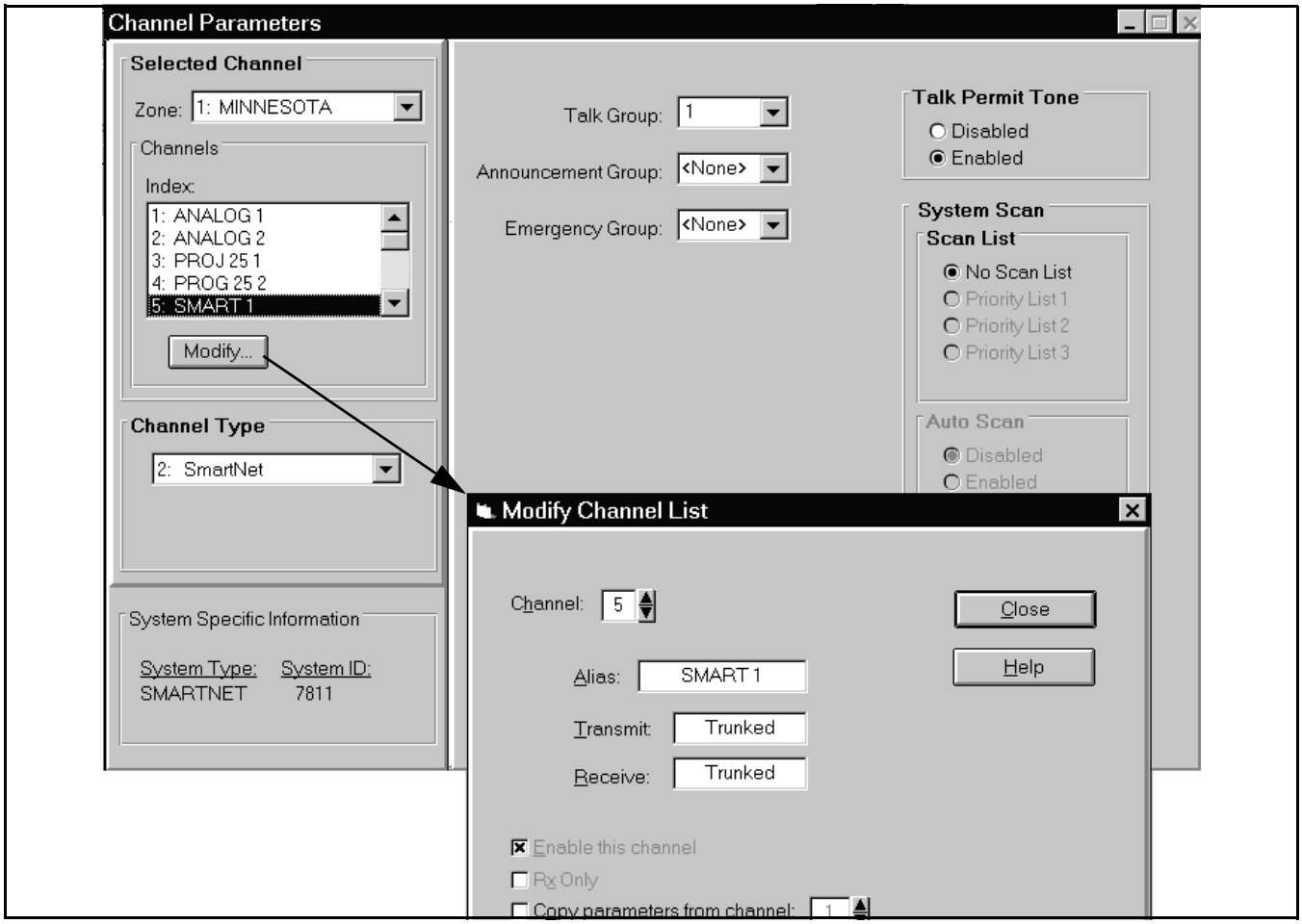


Figure 3-5 SMARTNET/SmartZone Channel Screen

3. To set up a SMARTNET channel, select "SMARTNET" as the channel type, and to set up a SmartZone channel, select "SmartZone".

4. Click the Modify button to display the dialog box shown in the lower part of Figure 3-5. This box programs the alias (tag) that is displayed when it is selected.

5. Program the other parameters in the main part of the screen (see information which follows).

3.6.9 SMARTNET/SMARTZONE CHANNEL SCREEN PARAMETERS

The following parameters are programmed in the SMARTNET/SmartZone channel screen shown in Figure 3-5.

Selected Channel

Zone Box - Clicking the arrow to the right of this box displays the available zones. Click on a zone to select it. Zones and zone aliases are set up on the Radio-Wide General screen described in Section 3.4.2.

Channel Index Box - Displays the channels in the selected zone. The channel type is selected by the Channel Type box below it.

Modify... - Displays the screen shown in the lower part of Figure 3-5. The parameters programmed in this screen are as follows:

Channel - Selects the channel to be edited.
Alias - Programs the identification that is displayed when the channel is selected. Up to 10 characters can be programmed.

Transmit - Not programmable because the transmit frequency is dynamically assigned over the air ("Trunked" is always displayed).

Receive - Dynamically assigned like the preceding transmit frequency.

Enable This Channel - Not used because SMARTNET/SmartZone channels are always enabled if set up. To disable a channel so that it is not selectable, choose the conventional type and do not check this box.

Copy Parameters From Channel - If another channel is selected in the box, the parameters from that channel are copied to the new channel.

Channel Type

Channel Type Box - Selects the specific system from which the channel is selected. All programmed systems are displayed by number and type (conventional, SMARTNET, SmartZone). When a different channel type is selected, the screen for that type of channel is automatically displayed.

Other Screen Parameters

System Specific Information - With SMARTNET/SmartZone systems, indicates the system ID programmed on the system General screen (see Section 3.6.2).

Talk Group - Selects the talk group selected by that channel. Talk groups are programmed in the Talk Group screen described in Section 3.6.5.

Announcement Group - Selects one of up to three announcement groups selected by the channel. Refer to "Announcement Group Screen" in Section 3.6.7 for more information.

Emergency Group - Selects the talk group used for emergency calls.

Talk Permit Tone - When enabled, a short tone sounds after a request for a group call has been approved by the main controller. This indicates that speaking can begin. When disabled, no audio feedback is used to indicate when speaking can begin.

System Scan - Selects the Priority Monitor Scan list selected by the channel (see "Priority Monitor Scan Screen" description in Section 3.6.7). If "No Scan List" is programmed, scanning is not selectable on that channel.

Auto Scan - When enabled and a channel is selected, the radio automatically begins scanning the scan list associated with that channel. When disabled, scanning can only be started manually by the Scan option switch.

3.7 PASSWORD OPERATION

3.7.1 GENERAL

The 50xx portable radio can be programmed with a Power-Up and Programming password. If the Power-Up password is enabled, it must be entered each time power is turned on to make the radio operational. This prevents unauthorized use. The Programming password must be entered to access the keypad programming feature of the radio. This prevents unauthorized reprogramming of the transceiver. Currently, the 50xx portable is the only transceiver that is programmed with the PCTrunk software that utilizes password access. More information on these two passwords follows.

3.7.2 POWER-UP PASSWORD

The Power-Up password function is enabled on the Radio-Wide General screen described in Section 3.4.2. This password must then be entered each time transceiver power is turned on. In addition, since the radio resets after downloading or uploading data, it must be entered after performing those functions (see Sections 3.3.3 and 3.3.4). When entering the password using the radio keypad, enter the eight password digits and then press the **ENT** key. If an error is made, press the **CLR** key to start over.

To enable the power-up password function on the programmer screen, the Power-Up password must be entered. This prevents the radio from being programmed with an unknown password which would make it inoperable. The password is a series of eight numbers, and it is programmed by clicking the "Change Password" button on the Radio-Wide General screen. The default password is eight zeros (00000000), and it may need to be entered as the "old" password if applicable. The password can also be

changed using the radio keypad when the keypad is locked by entering the old password and then pressing the # key. Refer to Section 2.4.3 for more information.

If the Power-Up password has been enabled in the radio connected to the programmer, the Programming password described in the next section must then be entered before a data can be downloaded or uploaded. This prevents an unauthorized person from reading radio data or changing radio programming.

If the password is forgotten, it can be overridden by pressing the lower button on the side 8 times. This unlocks the radio and reverts to the default password of "00000000". However, it also erases all channel frequencies, trunked group IDs, and encryption information. Therefore, the radio must be reprogrammed after this is done to make it operational again.

3.7.3 PROGRAMMING PASSWORD

The Programming password must be entered to enable the Keypad Programming mode described in Section 2.9. This prevents an unauthorized person from changing the radio programming. As described in the preceding section, the Programming password must also be entered when downloading or uploading data from a radio that has the Power-Up password function enabled.

Table 3-1 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	37*	241.8
01	67.0	10	94.8	19	127.3	28	173.8	38*	250.3
02	71.9	11**	97.4	20	131.8	29	179.9	39**	69.3
03	74.4	12	100.0	21	136.5	30	186.2	40**	206.5
04	77.0	13	103.5	22	141.3	31	192.8	41**	229.1
05	79.7	14	107.2	23	146.2	32	203.5	42**	254.1
06	82.5	15	110.9	24	151.4	33	210.7		
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	49	852.2125	807.2125	97	853.4125	808.4125
2	851.0375	806.0375	50	852.2375	807.2375	98	853.4375	808.4375
3	851.0625	806.0625	51	852.2625	807.2625	99	853.4625	808.4625
4	851.0875	806.0875	52	852.2875	807.2875	100	853.4875	808.4875
5	851.1125	806.1125	53	852.3125	807.3125	101	853.5125	808.5125
6	851.1375	806.1375	54	852.3375	807.3375	102	853.5375	808.5375
7	851.1625	806.1625	55	852.3625	807.3625	103	853.5625	808.5625
8	851.1875	806.1875	56	852.3875	807.3875	104	853.5875	808.5875
9	851.2125	806.2125	57	852.4125	807.4125	105	853.6125	808.6125
10	851.2375	806.2375	58	852.4375	807.4375	106	853.6375	808.6375
11	851.2625	806.2625	59	852.4625	807.4625	107	853.6625	808.6625
12	851.2875	806.2875	60	852.4875	807.4875	108	853.6875	808.6875
13	851.3125	806.3125	61	852.5125	807.5125	109	853.7125	808.7125
14	851.3375	806.3375	62	852.5375	807.5375	110	853.7375	808.7375
15	851.3625	806.3625	63	852.5625	807.5625	111	853.7625	808.7625
16	851.3875	806.3875	64	852.5875	807.5875	112	853.7875	808.7875
17	851.4125	806.4125	65	852.6125	807.6125	113	853.8125	808.8125
18	851.4375	806.4375	66	852.6375	807.6375	114	853.8375	808.8375
19	851.4625	806.4625	67	852.6625	807.6625	115	853.8625	808.8625
20	851.4875	806.4875	68	852.6875	807.6875	116	853.8875	808.8875
21	851.5125	806.5125	69	852.7125	807.7125	117	853.9125	808.9125
22	851.5375	806.5375	70	852.7375	807.7375	118	853.9375	808.9375
23	851.5625	806.5625	71	852.7625	807.7625	119	853.9625	808.9625
24	851.5875	806.5875	72	852.7875	807.7875	120	853.9875	808.9875
25	851.6125	806.6125	73	852.8125	807.8125	121	854.0125	809.0125
26	851.6375	806.6375	74	852.8375	807.8375	122	854.0375	809.0375
27	851.6625	806.6625	75	852.8625	807.8625	123	854.0625	809.0625
28	851.6875	806.6875	76	852.8875	807.8875	124	854.0875	809.0875
29	851.7125	806.7125	77	852.9125	807.9125	125	854.1125	809.1125
30	851.7375	806.7375	78	852.9375	807.9375	126	854.1375	809.1375
31	851.7625	806.7625	79	852.9625	807.9625	127	854.1625	809.1625
32	851.7875	806.7875	80	852.9875	807.9875	128	854.1875	809.1875
33	851.8125	806.8125	81	853.0125	808.0125	129	854.2125	809.2125
34	851.8375	806.8375	82	853.0375	808.0375	130	854.2375	809.2375
35	851.8625	806.8625	83	853.0625	808.0625	131	854.2625	809.2625
36	851.8875	806.8875	84	853.0875	808.0875	132	854.2875	809.2875
37	851.9125	806.9125	85	853.1125	808.1125	133	854.3125	809.3125
38	851.9375	806.9375	86	853.1375	808.1375	134	854.3375	809.3375
39	851.9625	806.9625	87	853.1625	808.1625	135	854.3625	809.3625
40	851.9875	806.9875	88	853.1875	808.1875	136	854.3875	809.3875
41	852.0125	807.0125	89	853.2125	808.2125	137	854.4125	809.4125
42	852.0375	807.0375	90	853.2375	808.2375	138	854.4375	809.4375
43	852.0625	807.0625	91	853.2625	808.2625	139	854.4625	809.4625
44	852.0875	807.0875	92	853.2875	808.2875	140	854.4875	809.4875
45	852.1125	807.1125	93	853.3125	808.3125	141	854.5125	809.5125
46	852.1375	807.1375	94	853.3375	808.3375	142	854.5375	809.5375
47	852.1625	807.1625	95	853.3625	808.3625	143	854.5625	809.5625
48	852.1875	807.1875	96	853.3875	808.3875	144	854.5875	809.5875

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq
145	854.6125	809.6125
146	854.6375	809.6375
147	854.6625	809.6625
148	854.6875	809.6875
149	854.7125	809.7125
150	854.7375	809.7375
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
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
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

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
289	858.2125	813.2125	337	859.4125	814.4125	385	860.6125	815.6125
290	858.2375	813.2375	338	859.4375	814.4375	386	860.6375	815.6375
291	858.2625	813.2625	339	859.4625	814.4625	387	860.6625	815.6625
292	858.2875	813.2875	340	859.4875	814.4875	388	860.6875	815.6875
293	858.3125	813.3125	341	859.5125	814.5125	389	860.7125	815.7125
294	858.3375	813.3375	342	859.5375	814.5375	390	860.7375	815.7375
295	858.3625	813.3625	343	859.5625	814.5625	391	860.7625	815.7625
296	858.3875	813.3875	344	859.5875	814.5875	392	860.7875	815.7875
297	858.4125	813.4125	345	859.6125	814.6125	393	860.8125	815.8125
298	858.4375	813.4375	346	859.6375	814.6375	394	860.8375	815.8375
299	858.4625	813.4625	347	859.6625	814.6625	395	860.8625	815.8625
300	858.4875	813.4875	348	859.6875	814.6875	396	860.8875	815.8875
301	858.5125	813.5125	349	859.7125	814.7125	397	860.9125	815.9125
302	858.5375	813.5375	350	859.7375	814.7375	398	860.9375	815.9375
303	858.5625	813.5625	351	859.7625	814.7625	399	860.9625	815.9625
304	858.5875	813.5875	352	859.7875	814.7875	400	860.9875	815.9875
305	858.6125	813.6125	353	859.8125	814.8125	401	861.0125	816.0125
306	858.6375	813.6375	354	859.8375	814.8375	402	861.0375	816.0375
307	858.6625	813.6625	355	859.8625	814.8625	403	861.0625	816.0625
308	858.6875	813.6875	356	859.8875	814.8875	404	861.0875	816.0875
309	858.7125	813.7125	357	859.9125	814.9125	405	861.1125	816.1125
310	858.7375	813.7375	358	859.9375	814.9375	406	861.1375	816.1375
311	858.7625	813.7625	359	859.9625	814.9625	407	861.1625	816.1625
312	858.7875	813.7875	360	859.9875	814.9875	408	861.1875	816.1875
313	858.8125	813.8125	361	860.0125	815.0125	409	861.2125	816.2125
314	858.8375	813.8375	362	860.0375	815.0375	410	861.2375	816.2375
315	858.8625	813.8625	363	860.0625	815.0625	411	861.2625	816.2625
316	858.8875	813.8875	364	860.0875	815.0875	412	861.2875	816.2875
317	858.9125	813.9125	365	860.1125	815.1125	413	861.3125	816.3125
318	858.9375	813.9375	366	860.1375	815.1375	414	861.3375	816.3375
319	858.9625	813.9625	367	860.1625	815.1625	415	861.3625	816.3625
320	858.9875	813.9875	368	860.1875	815.1875	416	861.3875	816.3875
321	859.0125	814.0125	369	860.2125	815.2125	417	861.4125	816.4125
322	859.0375	814.0375	370	860.2375	815.2375	418	861.4375	816.4375
323	859.0625	814.0625	371	860.2625	815.2625	419	861.4625	816.4625
324	859.0875	814.0875	372	860.2875	815.2875	420	861.4875	816.4875
325	859.1125	814.1125	373	860.3125	815.3125	421	861.5125	816.5125
326	859.1375	814.1375	374	860.3375	815.3375	422	861.5375	816.5375
327	859.1625	814.1625	375	860.3625	815.3625	423	861.5625	816.5625
328	859.1875	814.1875	376	860.3875	815.3875	424	861.5875	816.5875
329	859.2125	814.2125	377	860.4125	815.4125	425	861.6125	816.6125
330	859.2375	814.2375	378	860.4375	815.4375	426	861.6375	816.6375
331	859.2625	814.2625	379	860.4625	815.4625	427	861.6625	816.6625
332	859.2875	814.2875	380	860.4875	815.4875	428	861.6875	816.6875
333	859.3125	814.3125	381	860.5125	815.5125	429	861.7125	816.7125
334	859.3375	814.3375	382	860.5375	815.5375	430	861.7375	816.7375
335	859.3625	814.3625	383	860.5625	815.5625	431	861.7625	816.7625
336	859.3875	814.3875	384	860.5875	815.5875	432	861.7875	816.7875

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq
433	861.8125	816.8125
434	861.8375	816.8375
435	861.8625	816.8625
436	861.8875	816.8875
437	861.9125	816.9125
438	861.9375	816.9375
439	861.9625	816.9625
440	861.9875	816.9875
441	862.0125	817.0125
442	862.0375	817.0375
443	862.0625	817.0625
444	862.0875	817.0875
445	862.1125	817.1125
446	862.1375	817.1375
447	862.1625	817.1625
448	862.1875	817.1875
449	862.2125	817.2125
450	862.2375	817.2375
451	862.2625	817.2625
452	862.2875	817.2875
453	862.3125	817.3125
454	862.3375	817.3375
455	862.3625	817.3625
456	862.3875	817.3875
457	862.4125	817.4125
458	862.4375	817.4375
459	862.4625	817.4625
460	862.4875	817.4875
461	862.5125	817.5125
462	862.5375	817.5375
463	862.5625	817.5625
464	862.5875	817.5875
465	862.6125	817.6125
466	862.6375	817.6375
467	862.6625	817.6625
468	862.6875	817.6875
469	862.7125	817.7125
470	862.7375	817.7375
471	862.7625	817.7625
472	862.7875	817.7875
473	862.8125	817.8125
474	862.8375	817.8375
475	862.8625	817.8625
476	862.8875	817.8875
477	862.9125	817.9125
478	862.9375	817.9375
479	862.9625	817.9625
480	862.9875	817.9875
481	863.0125	818.0125
482	863.0375	818.0375
483	863.0625	818.0625
484	863.0875	818.0875
485	863.1125	818.1125
486	863.1375	818.1375
487	863.1625	818.1625
488	863.1875	818.1875
489	863.2125	818.2125
490	863.2375	818.2375
491	863.2625	818.2625
492	863.2875	818.2875
493	863.3125	818.3125
494	863.3375	818.3375
495	863.3625	818.3625
496	863.3875	818.3875
497	863.4125	818.4125
498	863.4375	818.4375
499	863.4625	818.4625
500	863.4875	818.4875
501	863.5125	818.5125
502	863.5375	818.5375
503	863.5625	818.5625
504	863.5875	818.5875
505	863.6125	818.6125
506	863.6375	818.6375
507	863.6625	818.6625
508	863.6875	818.6875
509	863.7125	818.7125
510	863.7375	818.7375
511	863.7625	818.7625
512	863.7875	818.7875
513	863.8125	818.8125
514	863.8375	818.8375
515	863.8625	818.8625
516	863.8875	818.8875
517	863.9125	818.9125
518	863.9375	818.9375
519	863.9625	818.9625
520	863.9875	818.9875
521	864.0125	819.0125
522	864.0375	819.0375
523	864.0625	819.0625
524	864.0875	819.0875
525	864.1125	819.1125
526	864.1375	819.1375
527	864.1625	819.1625
528	864.1875	819.1875
529	864.2125	819.2125
530	864.2375	819.2375
531	864.2625	819.2625
532	864.2875	819.2875
533	864.3125	819.3125
534	864.3375	819.3375
535	864.3625	819.3625
536	864.3875	819.3875
537	864.4125	819.4125
538	864.4375	819.4375
539	864.4625	819.4625
540	864.4875	819.4875
541	864.5125	819.5125
542	864.5375	819.5375
543	864.5625	819.5625
544	864.5875	819.5875
545	864.6125	819.6125
546	864.6375	819.6375
547	864.6625	819.6625
548	864.6875	819.6875
549	864.7125	819.7125
550	864.7375	819.7375
551	864.7625	819.7625
552	864.7875	819.7875
553	864.8125	819.8125
554	864.8375	819.8375
555	864.8625	819.8625
556	864.8875	819.8875
557	864.9125	819.9125
558	864.9375	819.9375
559	864.9625	819.9625
560	864.9875	819.9875
561	865.0125	820.0125
562	865.0375	820.0375
563	865.0625	820.0625
564	865.0875	820.0875
565	865.1125	820.1125
566	865.1375	820.1375
567	865.1625	820.1625
568	865.1875	820.1875
569	865.2125	820.2125
570	865.2375	820.2375
571	865.2625	820.2625
572	865.2875	820.2875
573	865.3125	820.3125
574	865.3375	820.3375
575	865.3625	820.3625
576	865.3875	820.3875

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
577	865.4125	820.4125	623	866.3000	821.3000	669	866.9000	821.9000
578	865.4375	820.4375	624	866.3125	821.3125	670	866.9125	821.9125
579	865.4625	820.4625	625	866.3250	821.3250	671	866.9250	821.9250
580	865.4875	820.4875	626	866.3375	821.3375	672	866.9375	821.9375
581	865.5125	820.5125	627	866.3500	821.3500	673	866.9500	821.9500
582	865.5375	820.5375	628	866.3625	821.3625	674	866.9625	821.9625
583	865.5625	820.5625	629	866.3750	821.3750	675	866.9750	821.9750
584	865.5875	820.5875	630	866.3875	821.3875	676	866.9875	821.9875
585	865.6125	820.6125	631	866.4000	821.4000	-	867.0000	822.0000
586	865.6375	820.6375	632	866.4125	821.4125	677	867.0125	822.0125
587	865.6625	820.6625	633	866.4250	821.4250	-	867.0250	822.0250
588	865.6875	820.6875	634	866.4375	821.4375	678	867.0375	822.0375
589	865.7125	820.7125	635	866.4500	821.4500	679	867.0500	822.0500
590	865.7375	820.7375	636	866.4625	821.4625	680	867.0625	822.0625
591	865.7625	820.7625	637	866.4750	821.4750	681	867.0750	822.0750
592	865.7875	820.7875	638	866.4875	821.4875	682	867.0875	822.0875
593	865.8125	820.8125	-	866.5000	821.5000	683	867.1000	822.1000
594	865.8375	820.8375	639	866.5125	821.5125	684	867.1125	822.1125
595	865.8625	820.8625	-	866.5250	821.5250	685	867.1250	822.1250
596	865.8875	820.8875	640	866.5375	821.5375	686	867.1375	822.1375
597	865.9125	820.9125	641	866.5500	821.5500	687	867.1500	822.1500
598	865.9375	820.9375	642	866.5625	821.5625	688	867.1625	822.1625
599	865.9625	820.9625	643	866.5750	821.5750	689	867.1750	822.1750
600	865.9875	820.9875	644	866.5875	821.5875	690	867.1875	822.1875
-	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

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq
-	867.5000	822.5000
715	867.5125	822.5125
-	867.5250	822.5250
716	867.5375	822.5375
717	867.5500	822.5500
718	867.5625	822.5625
719	867.5750	822.5750
720	867.5875	822.5875
721	867.6000	822.6000
722	867.6125	822.6125
723	867.6250	822.6250
724	867.6375	822.6375
725	867.6500	822.6500
726	867.6625	822.6625
727	867.6750	822.6750
728	867.6875	822.6875
729	867.7000	822.7000
730	867.7125	822.7125
731	867.7250	822.7250
732	867.7375	822.7375
733	867.7500	822.7500
734	867.7625	822.7625
735	867.7750	822.7750
736	867.7875	822.7875
737	867.8000	822.8000
738	867.8125	822.8125
739	867.8250	822.8250
740	867.8375	822.8375
741	867.8500	822.8500
742	867.8625	822.8625
743	867.8750	822.8750
744	867.8875	822.8875
745	867.9000	822.9000
746	867.9125	822.9125
747	867.9250	822.9250
748	867.9375	822.9375
749	867.9500	822.9500
750	867.9625	822.9625
751	867.9750	822.9750
752	867.9875	822.9875
-	868.0000	823.0000
753	868.0125	823.0125
-	868.0250	823.0250
754	868.0375	823.0375
755	868.0500	823.0500
756	868.0625	823.0625
757	868.0750	823.0750
758	868.0875	823.0875
759	868.1000	823.1000
760	868.1125	823.1125
761	868.1250	823.1250
762	868.1375	823.1375
763	868.1500	823.1500
764	868.1625	823.1625
765	868.1750	823.1750
766	868.1875	823.1875
767	868.2000	823.2000
768	868.2125	823.2125
769	868.2250	823.2250
770	868.2375	823.2375
771	868.2500	823.2500
772	868.2625	823.2625
773	868.2750	823.2750
774	868.2875	823.2875
775	868.3000	823.3000
776	868.3125	823.3125
777	868.3250	823.3250
778	868.3375	823.3375
779	868.3500	823.3500
780	868.3625	823.3625
781	868.3750	823.3750
782	868.3875	823.3875
783	868.4000	823.4000
784	868.4125	823.4125
785	868.4250	823.4250
786	868.4375	823.4375
787	868.4500	823.4500
788	868.4625	823.4625
789	868.4750	823.4750
790	868.4875	823.4875
791	868.5000	823.5000
792	868.5125	823.5125
793	868.5250	823.5250
794	868.5375	823.5375
795	868.5500	823.5500
796	868.5625	823.5625
797	868.5750	823.5750
798	868.5875	823.5875
799	868.6000	823.6000
800	868.6125	823.6125
801	868.6250	823.6250
802	868.6375	823.6375
803	868.6500	823.6500
804	868.6625	823.6625
805	868.6750	823.6750
806	868.6875	823.6875
807	868.7000	823.7000
808	868.7125	823.7125
809	868.7250	823.7250
810	868.7375	823.7375
811	868.7500	823.7500
812	868.7625	823.7625
813	868.7750	823.7750
814	868.7875	823.7875
815	868.8000	823.8000
816	868.8125	823.8125
817	868.8250	823.8250
818	868.8375	823.8375
819	868.8500	823.8500
820	868.8625	823.8625
821	868.8750	823.8750
822	868.8875	823.8875
823	868.9000	823.9000
824	868.9125	823.9125
825	868.9250	823.9250
826	868.9375	823.9375
827	868.9500	823.9500
828	868.9625	823.9625
829	868.9750	823.9750
830	868.9875	823.9875
-	869.0000	824.0000
-	869.0125	824.0125
-	869.0250	824.0250
-	869.0375	824.0375
-	869.0500	824.0500
-	869.0625	824.0625
-	869.0750	824.0750
-	869.0875	824.0875
-	869.1000	824.1000
-	869.1125	824.1125
-	869.1250	824.1250
-	869.1375	824.1375
-	869.1500	824.1500
-	869.1625	824.1625
-	869.1750	824.1750
-	869.1875	824.1875
-	869.2000	824.2000
-	869.2125	824.2125
-	869.2250	824.2250
-	869.2375	824.2375
-	869.2500	824.2500
-	869.2625	824.2625
-	869.2750	824.2750
-	869.2875	824.2875

800 MHz Channels

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq
-	869.3000	824.3000
-	869.3125	824.3125
-	869.3250	824.3250
-	869.3375	824.3375
-	869.3500	824.3500
-	869.3625	824.3625
-	869.3750	824.3750
-	869.3875	824.3875
-	869.4000	824.4000
-	869.4125	824.4125
-	869.4250	824.4250
-	869.4375	824.4375
-	869.4500	824.4500
-	869.4625	824.4625
-	869.4750	824.4750
-	869.4875	824.4875
-	869.5000	824.5000
-	869.5125	824.5125
-	869.5250	824.5250

FCC Chan. No.	Mobile Rx Freq.	Mobile Tx Freq
-	869.5375	824.5375
-	869.5500	824.5500
-	869.5625	824.5625
-	869.5750	824.5750
-	869.5875	824.5875
-	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
-	869.7375	824.7375
-	869.7500	824.7500
-	869.7625	824.7625

FCC Chan. No.	Mobile Rx Freq	Mobile Tx Freq
-	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
-	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 4 CIRCUIT DESCRIPTION

4.1 GENERAL OVERVIEW

4.1.1 INTRODUCTION

The E.F Johnson 5100 series digital portable radio 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.

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.

PC Boards

This radio contains the following PC boards:

- RF Board
- Digital Board
- Keypad Board
- Four flex circuits that provide interconnection and support for the volume, on/off, and LED controls.
- Encryption board (optional)

The Keypad Board provides the input/output interface for the user. It accepts input from the keypad and the various control knobs and sends the appropriate signals to the DSP on the Digital Board and to the RF Board for proper configuration. It provides the dual display information to inform the user of the status of the radio. It also performs all RS-232 communications between the radio and remote computer stations for the purposes of radio programming, tuning, encryption key loading and software downloading.

4.1.2 ANALOG MODE

Receive Mode

The 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 chip on the Digital Board.

On the Digital Board the ADSIC digitally filters the input signal, performs frequency discrimination to obtain the message signal and then routes the message signal to the DSP. 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 the ADSIC chip where it is first digitized at a 16 ksps rate and then sent to the DSP. 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 transmission.

4.1.3 PROJECT 25 DIGITAL MODE

Introduction

In Project 25 Digital Mode, the carrier is modulated with 4 discrete deviation levels. These levels are ± 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, the DSP 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 the ADSIC 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 the DSP. 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 in 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 the ADSIC 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 PA for transmission.

4.1.4 RF BOARD

NOTE: The RF Board is not field serviceable. It must be replaced as a unit with a new board.

The receiver front end consists of a preselector, RF amplifier, second preselector, and mixer. Both preselectors on the VHF and UHF board are varactor-tuned, two-pole filters controlled by the microcontroller unit through the D/A IC. The 800 MHz board uses stripline technology for the preselector. The RF amplifier is a dual-gate gallium-arsenide IC. The mixer is a double-balanced, transformer-coupled active mixer. Injection is provided by the VCO through an injection filter. See Table 4-1 for local oscillator (LO) and first IF information.

Table 4-1 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 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 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 microcontroller through a serial bus. Most of the synthesizer circuitry is enclosed in rigid metal on the RF Board to reduce microphonic effects.

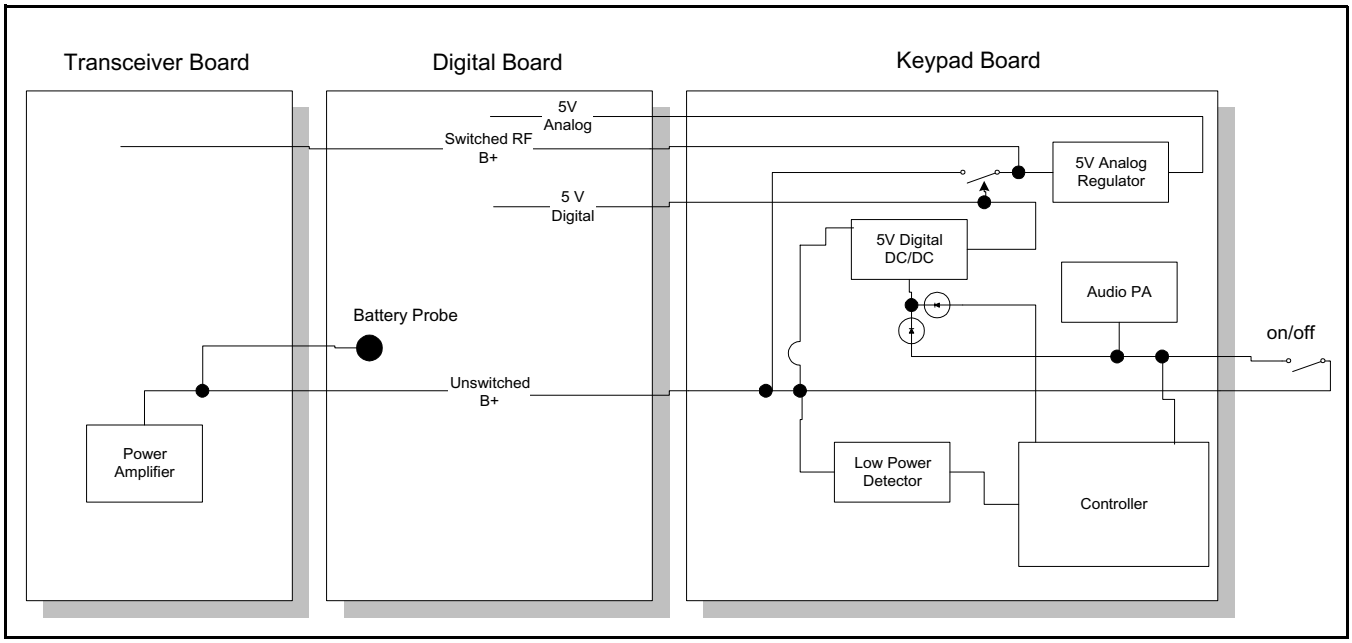


Figure 4-1 Power Supply Diagram

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

The ABACUS digital back-end chip consists of an amplifier, second mixer, IF analog-to-digital converter, a baseband down-converter, and a 2.4 MHz synthesis circuit to provide a clock to the ADSIC on the Digital Board. The second LO is generated by discrete components external to the ABACUS. The output of the ABACUS is a digital bit stream that is current driven on a differential pair to reduce noise generation.

The transmitter consists of an RF power amplifier IC that amplifies an injection signal from the VCO. Transmit power is controlled by two custom ICs that monitor the output of a directional coupler and adjust the power amplifier 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.

4.1.5 DIGITAL BOARD

The Digital Board contains the ADSIC, DSP (TMS320C50), static RAM, FLASH memory, and a programmable logic IC. The RF Board and Keypad/ Display Board are connected to the Digital Board. 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. 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.

4.1.6 KEYPAD/DISPLAY BOARD

The Keypad Board contains the microcontroller (HC08), audio circuits, front LCD display assembly, display driver, and 5V analog and 5V digital regulators. All interfaces to the side connector and the switches are on this board. The microcontroller determines transmit/receive frequencies, power levels, and display content. It communicates with the DSP via a serial interface.

4.2 POWER SUPPLY

4.2.1 GENERAL

The radio is typically powered by a battery which is fastened at the back of the radio. The electrical contact between the battery and the radio occurs on probes located on the Digital board (see Figure 4-1). However the positive battery voltage (UNSWB+) is directly routed through a small flex circuit (Power Flex) to contacts located on the bottom of the RF Board.

The UNSWB+ signal is then routed to the RF power amplifier module and ALC IC on the RF Board. It also passes through a fuse and is then routed to the Digital Board.

The UNSWB+ signal passes through the Digital Board without being used and is transferred to the Keypad Board. On the keypad board, the UNSWB+ signal is routed as follows:

- Input of the 5V digital regulator
- Electronic switch which controls the input of the 5V analog regulator and the "switched RF B+"
- "On/off switch" located on the top of the radio
- Low voltage detector
- Audio amplifier power FET

4.2.2 POWER ON OPERATION

When the user turns the radio on using the top panel "on/off switch", the following sequence of events occur:

1. Power is applied to the shutdown pin of the 5V digital regulator.

2. The 5-volt digital supply is created.

3. The appearance of the 5V digital supply turns on the electronic switch which applies the battery voltage to the "Switched RF B+" line and to the input of the 5V analog regulator.

4. The 5-volt analog supply is created.

5. If the battery voltage is high enough, the low voltage detector output goes high.

6. The controller sets the control line to the shutdown pin of the DC/DC converter to a high level.

7. The controller sets the radio in an operational mode.

4.2.3 POWER OFF OPERATION

When the user turns the radio off using the top panel "on/off switch", the following sequence of events occur:

1. The "on/off switch" opens.

2. Power is removed from the shutdown pin of the 5V DC/DC converter.

3. The controller detects that the power is off through the pin connected to Switched B+.

4. The controller performs all required save operations.

5. The controller resets the control line to the shutdown pin of the DC/DC converter.

6. The 5-volt Digital source disappears.

7. The electronic switch opens.

8. The switched RF B+ and 5V analog sources disappear.

4.2.4 LOW VOLTAGE DETECT

Low battery voltage is detected by a comparator chip. When a low voltage condition is detected (less than 6.3V), the following actions occur:

1. The low voltage detector output goes low which alerts the controller.

2. The controller prevents any action which could have a damaging effect (like writing in flash memory).

3. The controller releases its control of the shutdown pin of the DC/DC converter.

4. The transmitter switches to the low power mode.

RF BOARD

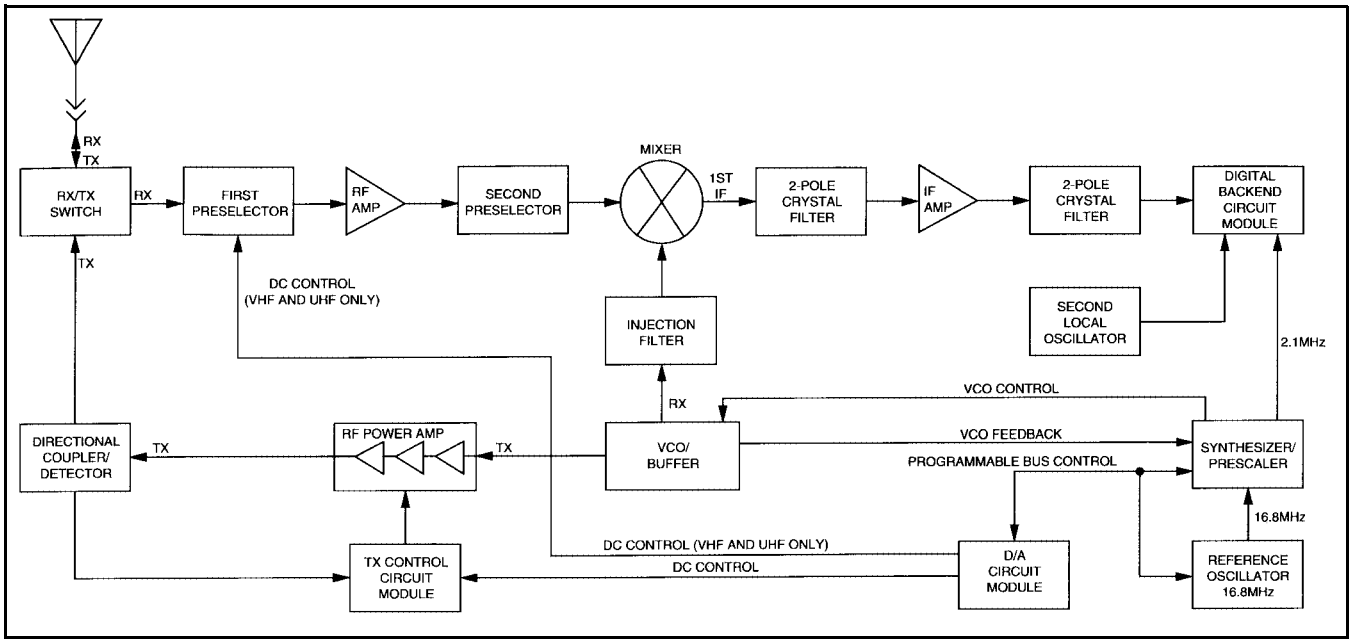


Figure 4-2 RF Board Block Diagram

5. When the voltage gets really low, the 5 volt DC/DC converter automatically shuts down.

6. The 5-volt analog and switched RF B+ sources turn off.

4.3 RF BOARD CIRCUIT DESCRIPTION

4.3.1 FREQUENCY GENERATION UNIT

The Frequency Generation Unit (FGU) consists of these three major sections: (1) high stability reference oscillator, (2) fractional-N synthesizer, and (3) VCO buffer. A 5-volt regulator supplies power to the FGU. The regulator output voltage is filtered and then distributed to the transmit and receive VCOs and the VCO buffer IC. The mixer LO injection signal and transmit frequency are generated by the receive VCO and transmit VCO, respectively. The receive VCO uses an external active device, and the transmit VCO active device is a transistor inside the VCO buffer.

The receive VCO is a Colpitts-type oscillator. The receive VCO signal is received by the VCO buffer where it is amplified by a buffer inside the IC. The amplified signal is routed through a low-pass filter and injected as the first LO signal into the mixer. In the VCO buffer, the receive VCO signal is also routed to an internal prescaler buffer. The buffered output is applied to a low-pass filter. After filtering, the signal is routed to a prescaler divider in the synthesizer.

The divide ratios for the prescaler circuits are determined from information stored in an EEPROM. The microprocessor extracts data for the division ratio as determined by the position of the channel-select switch and routes the signal to a comparator in the synthesizer. A 16.8 MHz reference oscillator applies the 16.8 MHz signal to the synthesizer. 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, an error voltage is produced. The phase detector error voltage is applied to the loop filter. The filtered voltage alters the VCO frequency until the correct frequency is synthesized.

In the transmit mode, the modulation of the carrier is achieved by using a two-port modulation technique. The modulation for low frequency tones, such as CTCSS and DCS, is achieved by injecting the tones into the A/D section of the fractional-N divider, generating the required deviation. Modulation of the high frequency audio signals is achieved by modulating the varactor through a frequency compensation network.

RF BOARD (CONT'D)

The transmit VCO signal is amplified by an internal buffer, routed through a low-pass filter, and then sent to the transmit power amplifier module. 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.

4.3.2 ANTENNA SWITCH

A pair of diodes is used to electronically steer the RF signal between the receiver and transmitter. In the transmit mode, RF is routed through a transmit switching diode and sent to the antenna. In receive mode, RF is received from the antenna, routed through a receive switching diode and applied to the RF amplifier.

4.3.3 RECEIVER FRONT END

The RF signal from the antenna is sent through a bandpass filter. The bandpass filter is electronically tuned by the microcontroller via the D/A IC by applying a control voltage to the varactor diodes in the filter. The D/A output range is extended through the use of a current mirror. Wideband operation of the filter is achieved by retuning the bandpass filter across the band.

The output of the bandpass filter is applied to a wideband amplifier. After being amplified by the RF amplifier, the RF signal is further filtered by a second broadband, fixed tuned, bandpass filter to improve spurious rejection.

The filtered RF signal is routed via a broadband 50 Ω transformer to the input of a broadband mixer/buffer. The mixer uses GaAs FETs in a double-balanced Gilbert Cell configuration. The RF signal is mixed with a first LO signal of about –10 dBm supplied by the FGU. Mixing of the RF and the first LO results in an output signal which is the first IF frequency according to Figure 4-1. The first IF signal output is routed through a transformer and impedance matching components and is then applied to a two-pole crystal filter. The 2-pole crystal filter removes unwanted mixer products.

4.3.4 RECEIVER BACK END

The output of the crystal filter is matched to the input of the IF buffer amplifier transistor. The output of the IF amplifier is applied to a second crystal filter through a matching circuit. This filter supplies further attenuation at the IF sidebands to increase radio selectivity.

In the ABACUS IC the first IF frequency is amplified and then downconverted to 450 KHz, the second IF frequency. At this point, the analog signal is converted into two digital bit streams via a sigma-delta A/D converter. The bit streams are then digitally filtered and mixed down to baseband and filtered again. The differential output data stream is then sent to the ADSIC on the Digital Board where it is processed to produce the recovered audio.

The ABACUS IC is electronically programmable, and 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. The VCO has a varactor diode to adjust the VCO frequency. The control signal for the varactor is derived from a loop filter.

4.3.5 TRANSMITTER

The transmitter consists of three major sections: Harmonic Filter, RF Power Amplifier, and the ALC (Automatic Level Control) circuit.

The RF signal from the PA module is routed through a coupler, then through the harmonic filter, then to the antenna switch. The RF power amplifier module is a wide-band multi-stage amplifier. The nominal input and output impedance of the power amplifier is 50 Ω. The DC bias for the RF power amplifier is controlled by a switching transistor. The microcontroller uses the D/A IC to produce a ready

signal for the transmit ALC IC. The synthesizer sends a LOC signal to the transmit ALC IC. When both the ready signal and LOC signal are available to the transmit ALC IC, the switching transistor for the RF power amplifier is turned on.

A coupler module samples the forward power and the reverse power of the PA output voltage. Reverse power is present when there is other than 50 Ω impedance at the antenna port. Sampling is achieved by coupling some of the forward and/or reverse power for rectification and summing. The resulting DC voltage is then applied to the transmit ALC IC as an RF strength indicator.

The transmit ALC circuit is the core of the power control loop. Circuits in the transmit ALC module compare the RF strength indicator to a reference value and generate a bias signal that is applied to the base of a transistor. This transistor varies the DC control voltage applied to the RF PA controlling the RF power.

4.4 DIGITAL BOARD

4.4.1 INTRODUCTION

The Digital Signal Processing (DSP) functions are performed by the DSP chip (U12) and the ADSIC (U3) with the support of FLASH (U2) and SRAM (U5, U6) memory devices. Functions previously performed in hardware like filtering and limiting are performed by software running in the DSP chip. The digital board connects with the Keypad Board via J4 and with the RF board via J1.

4.4.2 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 (U7), a programmable logic IC (U1), and two glue-logic chips (U4, U9). 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 keypad 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.

4.4.3 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.

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.

4.4.4 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.

DIGITAL BOARD (CONT'D)

4.4.5 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 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 4-3 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. Thus we use the internal data memory 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 J2 allows connection to an emulator for debugging purposes. The emulator connects to some dedicated pins on the DSP.

DIGITAL BOARD (CONT'D)

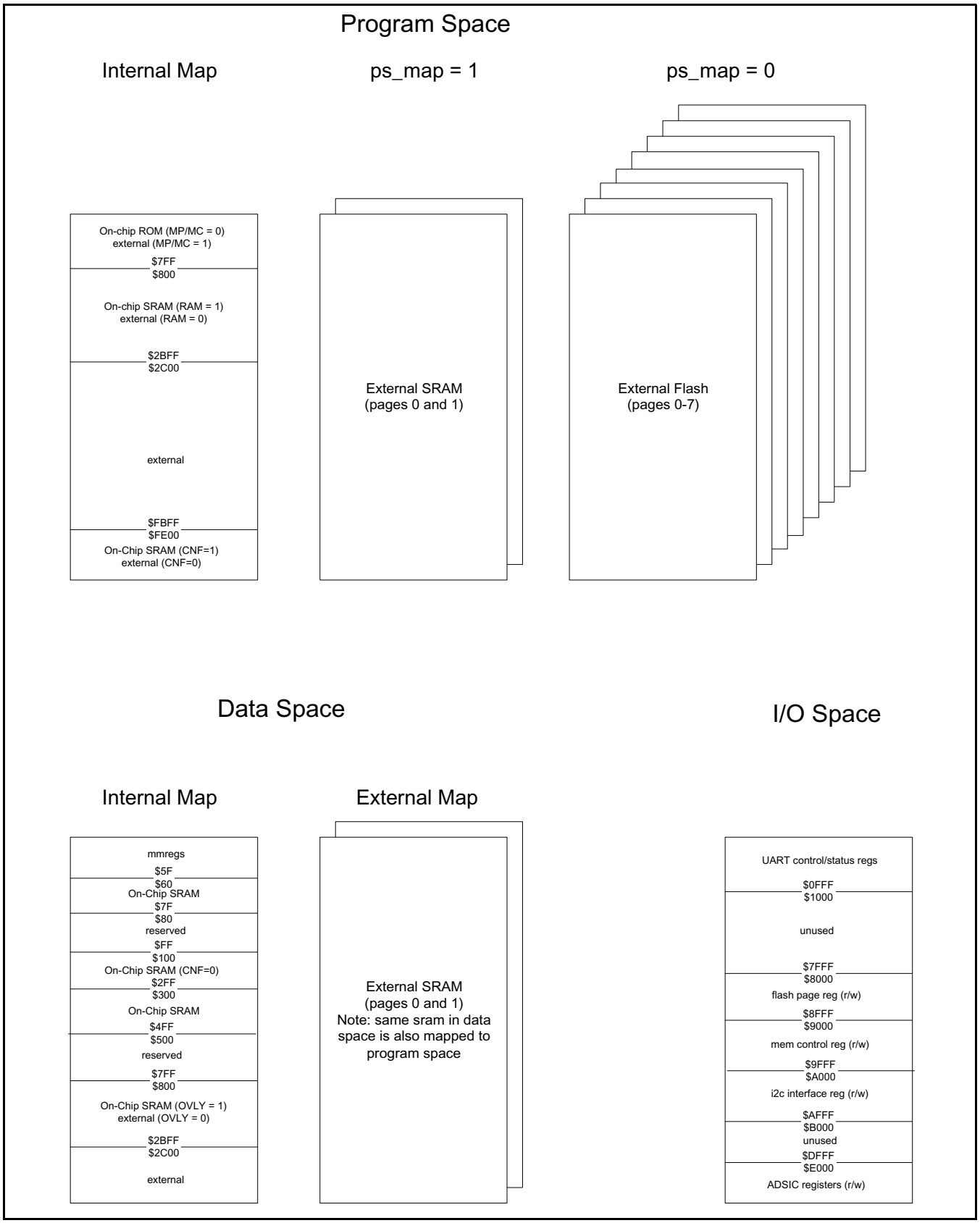


Figure 4-3 Memory Utilization