

# Application Note

## Understanding PassPort® Radio Systems



PassPort radio systems are being widely used in the United States and other countries. Learn about this technology and how to test PassPort with an IFR 2975.

## Introduction

PassPort radio systems are becoming widely accepted in the United States and other countries for radio system operators. Its primary advantage over other trunked radio protocols is its ability to provide an affordable, trunked radio environment that also provides theft protection for system operators by tracking subscriber units through the use of ESNs (Electronic Serial Numbers). As part of a trunked radio network, the mobile subscriber gains access to the network by going through a registration procedure that is used to track the validity of that mobile on the system.

## Understanding Trunked System Operation

Trunked radio systems utilize techniques that allow multiple users on a limited number of voice or traffic channels. These systems incorporate control functions to manage larger volumes of traffic and work off of the principle that not all users will utilize system resources at one time. This, however, means that you have to control what resources are allocated, and the priority of these resources for the various users.

In understanding control functions, we need to remember that control messages are already utilized in some form by many conventional mobile communication systems. The relatively simple use of sub-audible tones and codes (CTCSS and DCS) on a conventional analog two-way channel enables or blocks access to the system. Within more advanced systems, control messages are exchanged as data that control access to the channel and specific functions of the radio communication.

Figure 1.0 shows conventional communication between two radios using simplex operation. Simplex operation means that the radio uses the same frequency to transmit and receive.

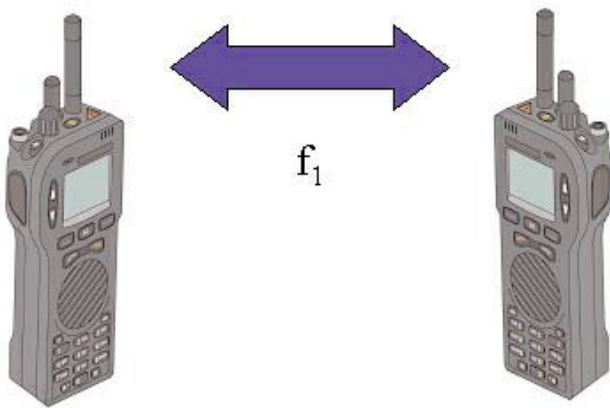


Figure 1: Two-way Radio Communication Using Simplex Operation

As you can see, both units use one frequency ( $f_1$ ) to communicate to each other. This means that only one user can be talking at one time. If both “key up” at the same time, then the users will not be able to understand each other, because neither will be receiving, as they will both be transmitting. Some systems provide control signalling along with the voice transmission that provides a level of intelligence that avoids these kinds of conflicts.

Duplex operation allows users to carry on a conversation much in the same way we use a regular telephone. Separate RF paths ( $f_1$  and  $f_2$ ) are assigned for the transmitter and receiver. This allows both parties to talk and listen simultaneously. (Except in the case of half-duplex). Figure 2 shows a radio in duplex operation.

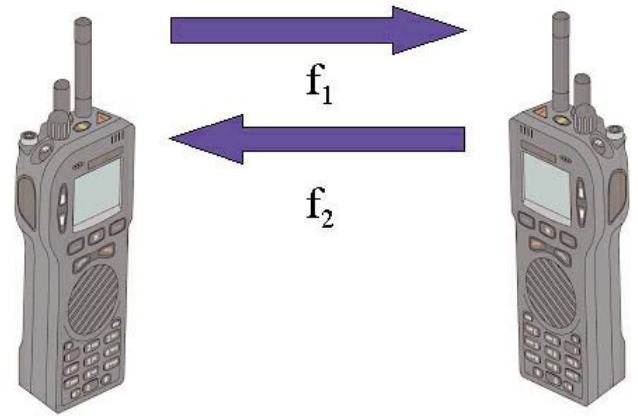


Figure 2: Two-way Radio Communications Using Duplex Operation

## Dedicated Control Channel Operation

Now, let’s compare simplex and duplex operation to trunked radio operation. Trunked radio systems use duplex operation because control data has to be bi-directional to maintain communications. It also allows for simultaneous voice communications and for phone system interconnect. With trunked radio operation, there is a base site or repeater that coordinates the communication between the various mobile units through the use of a control channel. This control channel provides the additional management of the system resources. In effect, it is acting as an “overseer” of the network and controls who can use the system, when they can use it and how they can use it.

In some trunked systems, the control channel is a separate frequency channel that is designated as the dedicated control channel frequency. It is different from the voice channel in that it functions as a resource allocation and digital communication message bearer and handler between the repeater and network and the subscriber unit (radio). Figure 3 shows the concept of a dedicated control channel.

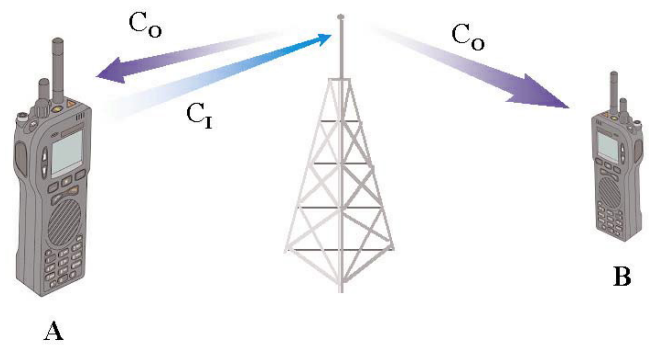


Figure 3: Dedicated Control Channel

As you can see, the control channel outbound ( $C_o$ ) is a dedicated frequency and the control channel inbound ( $C_i$ ) is also a dedicated frequency. The dedicated use of a frequency pair for the control channel does not allow for voice to be carried along with the control information.

## Distributed Control Channel Operation

PassPort, however, uses a type of control channel format called “distributed” control channels. One advantage of the distributed method used in PassPort systems is that control information can be accessed on any channel that is idle. The repeater and network manages which channels are available and transmits this information in a data stream that rides along with analog voice information. Another advantage is that unlike a dedicated control channel, the duplex frequency pair can be used for voice transmission as well as data. Figure 4 shows the concept of a distributed control channel.

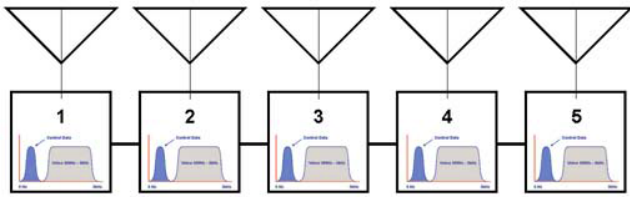


Figure 4: Distributed Control Channel

As you can see, this trunking system has five different repeaters, each with its own channel pair that mobiles can use. With distributed control channels, this channel also includes voice and control data that is riding along “underneath” the 300 Hz lower frequency limit of the voice modulation. This sub-audible control data function sends system originated control messages. In PassPort systems, the outbound control channel sends information in “words” and those words are called Outbound Signaling Messages (OSMs). Figure 5 shows the sub-audible data in a frequency domain.

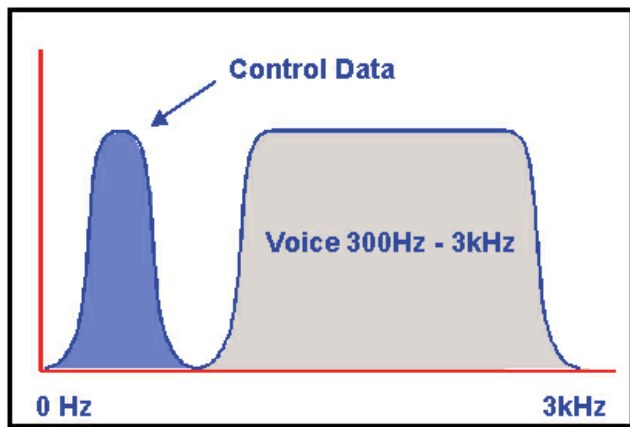


Figure 5: Sub-audible Data Transmission

### Basic Group Call Procedures

To better understand how this works; use this example. Suppose a user wishes to initiate a call to everybody in his talk group. Using Figure 6, assume that mobile A and B have the same group ID and are monitoring channel 3, which is designated as the home frequency on the repeater. The home frequency is feeding control information to the radios in the form of an idle message that is sent every 3-5 seconds when it is not involved with voice traffic. When a mobile is not placing or receiving a call, it is always monitoring its home channel to determine which channels are free and if it is being asked to participate in a group or unit call by the repeater.

Mobile A is monitoring its home frequency (channel 3) for control information. It determines from the control data that the home channel is available and upon key up, it transmits a request to the repeater on an inbound control channel that is matched to the outbound channel (for example, an 800 MHz system would utilize the standard 45 MHz offset for that band).

The request includes the radio's programmed Digital Color Code (DCC) - more on this later - and the GoTo (or available) channel information obtained by monitoring the home channel. The repeater looks at these message elements and verifies that the mobile is on the correct system and channel.

The repeater station processes the request, and then responds with a handshake message on the home channel including the DCC, Affiliate System ID (ASID), GoTo Channel and Group ID. All the mobiles currently used in the network look at this information to determine if the call is for

them and that they are on the same channel. If everything matches, Mobile A begins transmitting and all other radios that are in the same talk group as Mobile A are muted but listen in on that channel. The handshake message is transmitted for the duration of the call so that any mobiles that are “homed” to channel 3 and that come on to the system during the call can participate in the conversation.

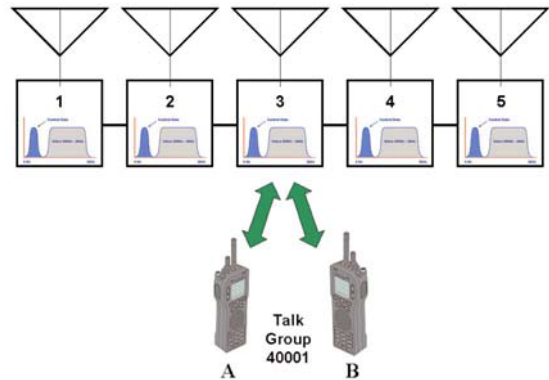


Figure 6: PassPort Group Call and Home Channel Monitoring

### Busy Home Channel/Free Channel Operation

Now in Figure 7, assume that mobile C, whose home channel is 3 and has a different talk group, wants to initiate a group call. Since the home channel is busy on a talk group call with mobiles A and B (using a different Group ID), the repeater will say “I’m busy, but channel 5 is free.”

Mobile C will then switch to channel 5 and try again to place the call. Once the handshake is established with channel 5 and since the mobiles are programmed for home channel 3, the system will tell channel 3 to add a new message that is then interleaved with the handshake message. This new message is called a GoTo message that mobiles with the same Group ID as mobile C will see and know to go to channel 5.

If all channels are busy, the system will send out an “All Trunks Busy” message from the repeater and the initiating mobile will emit a busy tone.

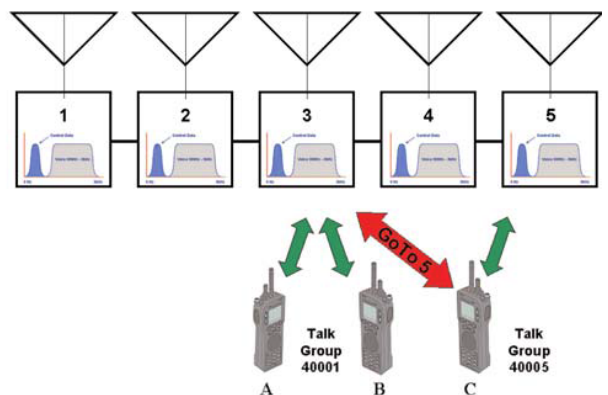


Figure 7: Free Channel Operation

### PassPort Control Channel Specifics

Remember that there are two primary types of control messages used in PassPort systems - those that the repeater sends and those that the radios send. The repeater's messages are called Outbound System Messages (OSMs). The radio's messages are called Inbound System Messages (ISMs).

OSMs contain control information required for the mobile to communicate with the network. These include the GoTo and Free channels mentioned earlier but PassPort also provides more robust systems capabilities by

providing additional information such as DCC, Affiliated System ID (ASID), Call Status information, System Parameters, and Neighbor List.

The DCC allow PassPort networks to perform more robustly in multi-site environments where there are more than one repeater on a given frequency (for example, two cities near each other, each with their own repeater). When the mobile registers with one repeater, it assumes the DCC of that repeater. This allows the mobile to distinguish between the two repeaters since they will have different DCCs.

The ASID allows PassPort operators to provide the system or a member system of a shared environment (like a wide area network) with a unique identifier.

Call Status information provides a variety of functions. It provides information for call processing such as dispatch call in progress and channel re-direct commands. Modes of registration are also controlled through the call status function. Finally, Call Status allows radios to be temporarily or permanently disabled (“stunned” or “killed”) - to disable non-registered or stolen radios.

The System Parameters message provides information about the bandwidth the system is operating in - either wide or narrow band. It also gives information about the home and neighbor system DFA band assignments.

The Neighbor List function provides information about the nearest affiliated system that is adjacent to the system where the mobile radio is currently registered.

### Repeater Control Channel States

The PassPort repeater control channel has four different states of operation. These states are as follows:

1. Normal Idle State. In this state, the repeater channel is not in use and a message is sent that is known as a Normal IDLE message.
2. Forced Idle State. In this state, the repeater channel is occupied, and a message is sent that is known as the Forced IDLE message.
3. Home Busy State. In this state, the repeater home channel is occupied with either a Group or MIN call (unit specific call) but there are other free channels on the system available.
4. All Channels Busy State. In this state, no repeater channels are available to the users.

### Bands of Operation

PassPort radios work in a variety of bands - VHF, UHF, 800 and 900 MHz bands. In addition, PassPort radios work in the specialized 216-225, 221 MHz and 700 MHz bands. The PassPort protocol assigns particular ranges within these bands and designated DFA (Direct Frequency Access) bands. The NTS or PassPort band assignments for PassPort are as follows:

0	800 MHz
1	900 MHz
2	400 to 420 MHz
3	420 to 440 MHz
4	440 to 460 MHz
5	450 to 470 MHz
6	460 to 480 MHz
7	470 to 490 MHz
8	480 to 500 MHz
9	490 to 512 MHz

10	Canada Structure
11	NTIA
12	Reserved
13	216 to 225 MHz, 6.25 kHz
14	Reserved
15	700 MHz band, 3.125 kHz channels
VHF	VHF Band Operation

The reason for the use of DFA bands is to allow the PassPort systems to actively manage up to 1791 different frequencies in a 22 MHz bandwidth using a frequency resolution of 12.5 kHz.

VHF systems use a Direct Frequency Assignment for each TX and RX pair using a special PassPort message for VHF radio systems.

### Voice and Data Modulation Formats

PassPort systems use FM modulation for voice information with the maximum deviation determined by the type of channel bandwidths being utilized. PassPort supports both wide-band and narrow-band operation in the 25 kHz and 12.5 kHz modes. While the actual voice transmission uses analog technology, PassPort uses a robust digital modulation scheme in the sub-audible spectrum (under 300 Hz) to transfer data messages that enable the many specialized features of the PassPort system. This digital data rides under the voice bandwidth range (typically 300 Hz to 3 kHz).

The PassPort control channel utilizes a form of FM modulation to carry the digital information over the air to the mobile unit. This modulation is a form of Frequency Shift Keying. It imparts digital data to the RF carrier by changing frequency states. These states then are recognized as digital “1s” and “0s”. The control channel for PassPort systems operate at a data rate of about 300 baud or 300 bits per second.

### Call Scenarios

The types of calls that can be made in a PassPort system are:

1. Dispatch Group Calls - This allows a set of radios to be called at the same time (for example, all fire units, all ambulance units, all law enforcement units).
2. Unit to Unit (or Selective) Calls - This allows one radio to call one specific radio only (for example, call the Chief!)
3. Public Switched Telephone Network (PSTN) Calls - Allowing the radio to make or receive phone calls.

As part of these calls, each of the PassPort mobiles are required to register with the network.

### Overview of the Stun and Kill

The PassPort protocol provides extra security for the radio system operator by using unique features called Stun and Kill. These features allow the system operator to manage the radios that are allowed on the network. Non-subscribers or stolen radios can be denied access using these features. The Stun functions are based off an invalid MIN received from the radio during the registration process. Stunning a radio causes the radio to be temporarily disabled and not able to access the network until a re-registration request is initiated.

In addition to Stun, radios that have a mismatch on the MIN/ESN association with the billing function will force a kill message to be sent to the radio. Once killed, the radio can only be “revived” by returning the radio to an authorized PassPort dealer or the radio manufacturer.

## Review of Key Terminology

In any wireless mobile communication system, acronyms abound. PassPort is no different and there are certain acronyms and terms used that you need to be familiar with before moving on to using the IFR 2975 for testing PassPort radios and repeaters. The following is a list of PassPort terms you should be familiar with:

**ACK:** Acknowledge message, or a response to a request.

**ASID:** Affiliated System Identifier. A unique identifier for each member system of a wide area network or stand alone network.

**CALL STATUS:** A field in the PassPort message structure that informs the mobile of system status and may request additional information from the mobile.

**COLLECT CHANNEL:** A channel used by roamers for auto-registration of traffic and is designed to eliminate channel access bottlenecks.

**CTCSS:** Continuous Tone Coded Squelch System.

**DCC:** Digital Color Code.

**DCS:** Digital Coded Squelch.

**DE-REGISTRATION:** A process where the mobile ends data communications with a network.

**DFA:** Direct Frequency Access.

**ESN:** Electronic Serial Number.

**FLEET:** A number of groups of MINs associated together.

**FORCED IDLE:** A message sent on the home channel when engaged in an active call.

**FREE CHANNEL:** The channel designated by a channel in use as available.

**GOTO CHANNEL:** The channel designated by the repeater to indicate the channel to go to for a particular group call.

**GROUP:** A collection of users assigned a particular ID number to designate them as a unique category of users.

**HANDSHAKE:** The process used by the mobile and repeater to set up communications.

**HSID:** Home System Identifier.

**INTERCONNECT:** A call made to or from the Public Switched Telephone Network.

**ISM:** Inbound System Message. Occurs from the mobile to the NTS.

**KILL:** The ability of the system to totally disable a mobile.

**LTR:** Logic Trunked Radio.

**MIN:** Mobile Identity Number

**MOBILE:** For this application note, a mobile denotes either a portable or mobile radio.

**NARROW BAND:** 12.5 kHz bandwidth operation.

**NEIGHBOR LIST:** A list of neighbor systems.

**NORMAL IDLE:** A message sent on the home channel when not in use.

**NTS:** Networked Trunking System.

**OPEN CHANNEL:** Free channel.

**OSM:** Outbound System Message. Occurs from the NTS to the mobile.

**PARAMETRICS:** The RF performance of a radio system including RF error, power and modulation accuracy, as well as radio sensitivity.

**PRIMARY GROUP:** The mobiles priority talk group.

**PROTOCOL:** A series of communication processes defined to set up calls and to send various forms of data to and from the mobile.

**PSTN:** Public Switched Telephone Network.

**PTT-ID:** Push to Talk Identifier. The display of a calling parties designator.

**REGISTRATION:** The initial handshake process that allows the radio to communicate.

**RX:** Receive.

**SECONDARY GROUP:** Any PassPort Group ID that is not the Primary Group ID.

**STUN:** The ability to not allow a radio on the network.

**TILE:** This applies to the IFR 2975. A tile is a window view of various functions within the IFR 2975. There are two tiles. One is a 1/4 tile and the other is 1/8 tile. The 1/4 tiles are used for displaying repeater analyzers and oscilloscopes and take up 1/4 of the total screen area. The 1/8 tiles are used for meters and take up 1/8 of the total screen area.

**TX:** Transmit.

**UNIT:** Mobile or portable radio.

**VLR:** Visitor Location Register.

**WIDE AREA:** A group of repeaters configured as one network over a large geographic area.

**WIDE BAND:** 25 kHz bandwidth operation.

## Overview of Test Requirements for PassPort Radios

The IFR 2975 has an extensive test suite designed for testing PassPort radios. It is important to understand exactly what we want to test when looking at PassPort systems. Parametric measurements such as power and frequency are, of course, very important to the performance of trunked systems. However, protocol tests are sometimes equally as important in determining the functionality of the radio system.

Let's look further into the details of the types of tests you will use for determining radio performance.

### Parametrics

When testing radios, we want to be able to look at transmitter and receiver performance. For the transmitter, these include RF frequency error and power. Since PassPort utilizes standard FM for voice transmission, we also want to check for proper FM deviation. However, since PassPort also uses special messaging under the 300 Hz low end of the voice spectrum, we also want to check for proper Sub-Audible Deviation, which of PassPort is 1 kHz peak deviation. The key here is that the proper PassPort signaling is utilized to get the call up and running.

For receiver testing, the proven 12 dB SINAD test would be the most appropriate. Again, the radio needs to be in conversation with the IFR 2975 using the PassPort protocol to make this measurement. These tests will be performed on both the repeater and the mobile radios.

## Protocol

Protocol plays a critical role in the performance of trunked radio networks, and as such, requires some verification testing. We use the word verification because protocol is software and once the software has been developed and implemented into a radio it is effectively locked down and does not “break” in the field.

However, we do want to verify operation of the mobile using different system configurations and to ensure that the radios are programmed correctly. That is where protocol tests prove beneficial, although we are not actually testing the protocol, rather we are verifying protocol operation.

Protocol verification is useful when trying to figure out if a radio failure is hardware related or if there is a programming related issue.

### Setting Up the IFR 2975 for PassPort Testing

Prior to setting up the 2975 for PassPort testing, please read the user manual first. This will give you a good basis on how the unit operates.

To begin PassPort testing, select the Duplex mode <MODE 3>. From there you can access the two primary PassPort support functions for repeater simulation (testing mobile radios) and mobile simulation (testing repeaters) as shown in Figure 8.

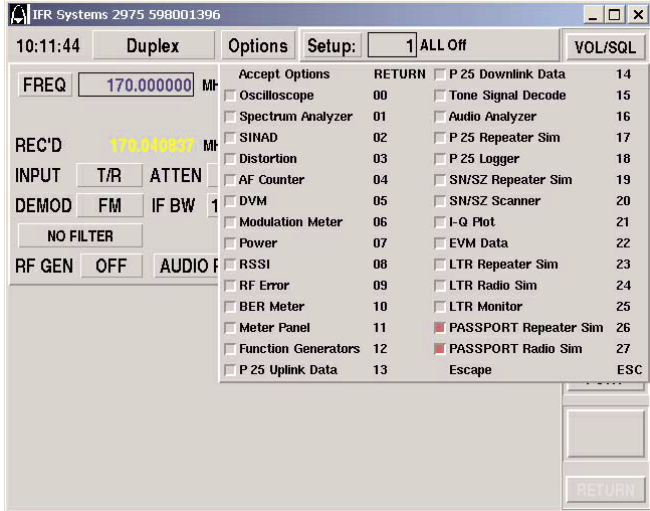


Figure 8: Selecting the Two PassPort Support Functions

### Setting Up to Test PassPort Mobiles (Repeater Simulator)

We will start with the PassPort repeater simulations, which will allow us to test PassPort radios. For initial purposes, we will set up the repeater simulator and the spectrum analyzer. This will allow us to see the spectrum from the radio initially to verify that we have properly set up the test set to test the radios. To do this, select the spectrum analyzer and the PassPort repeater simulator. (Note: Options 00 to 15 are standard options supplied with the 2975. Additional options are purchased and will fill out the remaining slots as they are added.) Figure 9 will show the duplex operation with the spectrum analyzer and repeater simulator enabled.

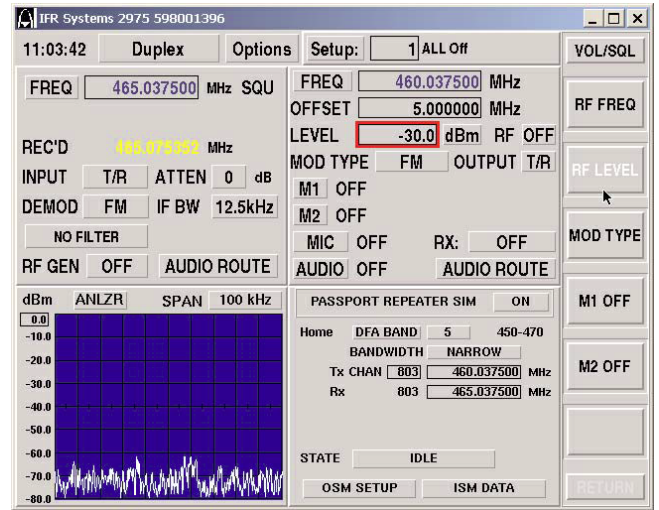


Figure 9: Setting Up the 2975 with Spectrum Analyzer and PassPort Repeater Simulator

As you can see, the basic system parameters and access to various configuration screens are displayed on the PassPort repeater simulator tile. For the home channel information, the DFA band, bandwidth (12.5 kHz and 25 kHz) and Tx DFA (home channel number and associated Tx frequency) can be configured to match that of the radio under test.

Although this is the basic information needed to enable a communication with the radio, we also need to add additional programming to the OSM data to further emulate a PassPort network.

To further define the PassPort control channel information, select the OSM SETUP button. This will pop up a window that will allow you to configure the unit for test. Figure 10 shows the setup screen for the repeater simulator.

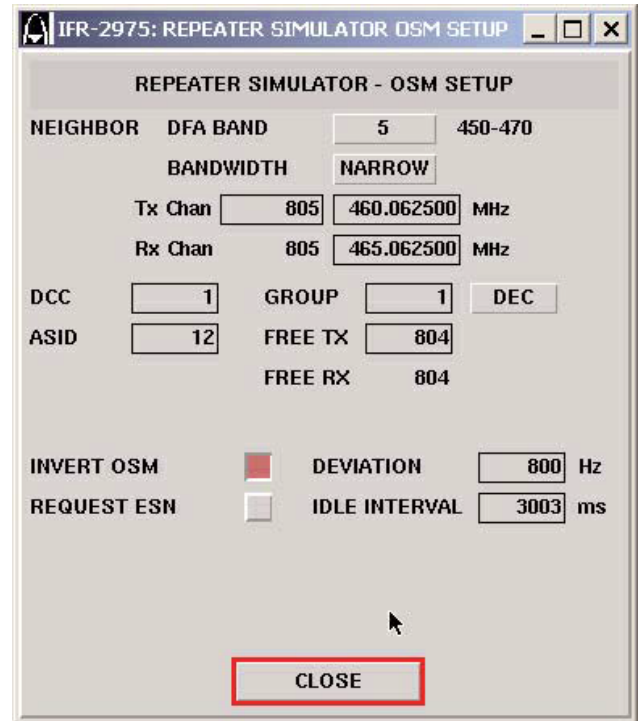


Figure 10: The OSM SETUP Screen

Starting from the top of the screen, we can configure the 2975 to perform the repeater function to test the radio. Remember that this is a test system, so not all repeater functions will be available. Our primary purpose is to establish the proper protocol to enable parametric measurements.

Neighbor: This area at the top configure the neighbor channel. Although we can configure one neighbor channel, and that goes across as control information to the radio, we do not actually set up a neighbor channel since the 2975 is limited to one transmit/receive path. To use this feature more robustly, a second 2975 can be used as the neighbor channel.

When configuring the neighbor information, you can use dummy information or actual information. Remember the radio is going to be configured with a particular neighbor list, so it is best to use actual neighbor channel data for this information. The parameters to be set are as follows:

DFA Band: This can be set to an appropriate frequency band.

Bandwidth: Narrow (12.5 kHz) or Wide (25 kHz) operation.

Tx Channel: The appropriate channel number for the actual neighbor home channel. This also automatically sets the Rx channel except in VHF, where this needs to be set up as well.

DCC: Digital Color Code. This field is used for the actual field used for a repeater and should be a DCC recognized by the radio.

ASID: The affiliated system ID for the system the radio will be used.

GROUP: This is the associated Group ID for radios and designates the Group identifier that will be sent out during a call initiated from the 2975 to the mobile unit. It will also reflect the Group ID from the mobile that is currently operating, if there is a mobile originated call to the 2975, because the system mirrors that mobile's Group ID for other users to use and take part in that call. Make sure that this field matches a group that is programmed into the mobile.

DEC: This button is a toggle button that shows either HEX or DEC, depending on how you want to view the setup data.

FREE: This is the FREE channel that is broadcast from the repeater. The mobile uses this channel information to access the network. It is the same as the Home channel, if the Home channel is available.

If the Home channel is busy on a particular group call, the FREE channel is the channel that a different mobile group would use to access the network.

This feature can be used in conjunction with another 2975 to emulate a repeater and assign calls to a different channel on another 2975 for enhanced protocol testing in the event the HOME channel on the main 2975 is in use by a different mobile group.

Invert OSM: This simply inverts the OSM data. Used to enhance system performance in varying RF conditions.

Request ESN: This function allows the repeater simulator to request the mobile's ESN during the registration process.

Deviation: This is the peak deviation of the OSM data.

Idle Interval: This establishes the amount of time between normal idle messages. Normally sent between three and five seconds.

Once the OSM setup is complete, we can now look at the ISM from the PassPort mobile to verify radio programming and proper response to our repeater simulation. To do this, we simply click on the ISM data button on the PassPort repeater simulation tile. Figure 11 shows the ISM data screen.



Figure 11: The ISM Data Screen

DEC: This button is a toggle button that shows either HEX or DEC, depending on how you want to view the data.

DCC: Digital Color Code. This field is the DCC that is programmed in the radio.

GROUP: This is the associated Group ID for radios and designates the Group identifier that is sent out during a call initiated from the mobile unit.

TGT MIN: Not currently used. Future application.

GOTO: The currently set GoTo channel in the radio. The Home channel.

ESN: The mobile's electronic serial number.

ASID: The affiliated system ID for the system the radio will be used with.

MIN: The Mobile Identity Number of the mobile.

STATUS REPORTING: The most currently viewed message received from the mobile.

STATUS REPORTING: A history log of messages received from the mobile.

CLEAR: Clears the status reporting history.

COPY TO TX: This allows the user to copy the information received from the mobile to the 2975's repeater simulator.

## VHF Mode of Operation

The 2975 also supports PassPort VHF operation. The VHF functions allow the user to set up independent DFA channel assignments for the TX and RX frequencies. This is common in the VHF band where there are not specific TX/RX offsets.

In the VHF mode, PassPort utilizes a special message that sets both the TX and RX frequencies for the radio. In addition, the PassPort radio can learn up to 30 TX/RX combinations or slots.

The 2975 emulates all the proper VHF messaging required to get the radio up and running including the special CHF messages with the independent TX/RX DFA assignments. To set up the 2975 to do VHF testing, DFS band 16 has been assigned by Cobham as the Trident designates VHF as a different mode

of operation in the NTS. Fixed TX/RX offset operation is Mode I (bands 0-15). VHF or non-fixed operation is Mode II. There is no DFA Band 16 in the NTS. Cobham uses DFA Band 16 simply as a convenience to the user. Figure 12 shows how to set up the 2975 for VHF radio testing.

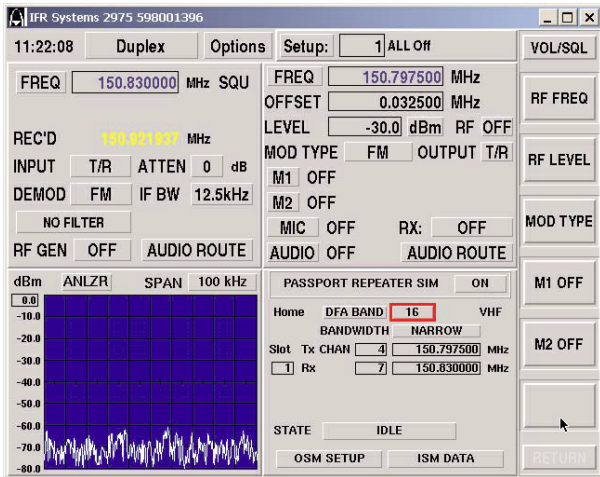


Figure 12: Setting Up the 2975 for VHF Testing

### Advanced DFA Modes of Operation

The 2975 takes the PassPort model a step further by allowing user defined DFA bands. This unique feature allows the user to set up a non-standard frequency/channel correlation to reproduce a unique repeater configuration that is not quite a PassPort standard configuration. This also allows developers to experiment with new channel configurations and provides a degree of protection to 2975 owners in the event that band assignments change (especially in the 800 MHz band).

To configure the user defined mode of operation, see Figure 13.

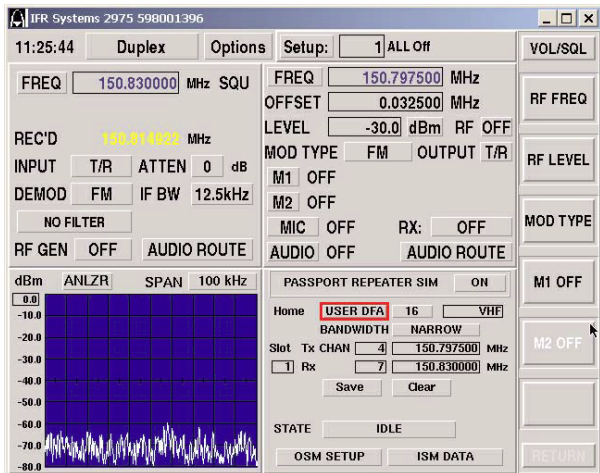


Figure 13: The 2975 User Defined Mode

The user defined mode shown allows the user to correlate channel numbers to unique frequencies (either in the existing DFA band or outside of the existing DFA band) together. The user needs to simply enter a channel number and the corresponding frequency and the 2975 will continue to log the appropriate channel/frequency combination. After establishing the required channel/frequency associations, the user can then save both the user defined channels and the configuration to a setup file for future reference. See the 2975 manual for more information on how to save configurations.

### Setting Up to Test PassPort Repeaters (Mobile Simulator)

The 2975 can also emulate a PassPort radio and use this function to test PassPort repeaters. In the radio simulation mode, the 2975 sets up the proper ISM messages needed to access a PassPort network. In effect, we are using

the 2975 in the opposite mode of the repeater simulator, but are performing the same parametric tests on the repeater without having to take the repeater out of service to perform testing. By emulating a radio or subscriber unit, the 2975 allows the system operator to perform direct connect or over the air (antenna) testing of the repeater.

We will start with the PassPort radio simulation, which will allow us to test PassPort repeaters. For initial purposes, we will set up the radio simulator and the spectrum analyzer. This will allow us to see the spectrum from the repeater initially to verify that we have properly set up the test set to test the repeater. To do this, select the spectrum analyzer and the PassPort radio simulator. Figure 14 shows the duplex operation with the spectrum analyzer and radio simulator enabled.

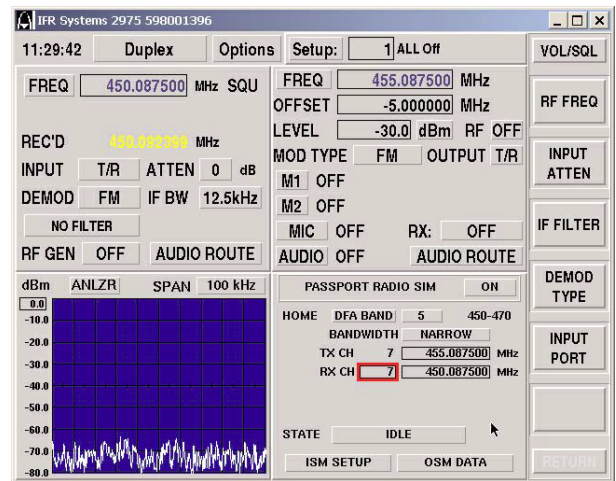


Figure 14: Setting Up the 2975 with Spectrum Analyzer and PassPort Radio Simulator

As you can see, the basic radio parameters and access to various configuration screens are displayed on the PassPort radio simulator tile. The home channel information, DFA band, bandwidth (12.5 kHz and 25 kHz) and RX DFA (home channel number and associated RX frequency) can be configured to match that of the repeater under test.

This is the basic information needed to enable a communication with the radio however we also need to add additional programming to the ISM data to further emulate a PassPort radio.

To further define the PassPort radio information, select the ISM SETUP button. This will pop up a window that will allow you to configure the unit for test. Figure 15 shows the ISM setup screen for the radio simulator.

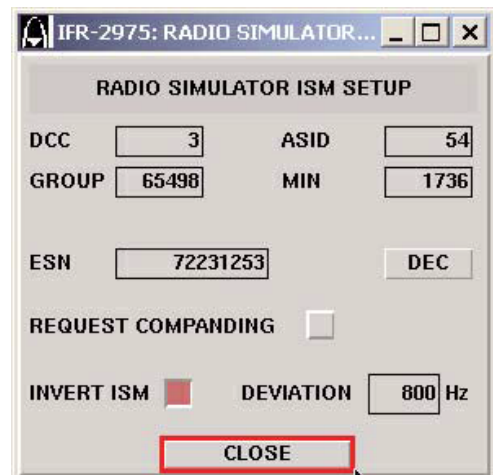


Figure 15: The ISM SETUP Screen



Starting from the top of the screen, we can configure the 2975 to perform the radio function to test the repeater. Remember, our primary purpose is to establish the proper protocol to enable parametric measurements.

**DCC:** Digital Color Code. This field is the same as the repeater's DCC and should be a DCC recognized by the network.

**ASID:** The affiliated system ID for the system the radio will be used.

**GROUP:** This is the associated Group ID for radios and designates the group identifier that will be sent out during a call initiated from the 2975 to the repeater unit. Make sure that this field matches a group that is programmed into the mobile.

**MIN:** This is the Mobile Identity for the 2975 since it is being used as a radio to talk to the repeater. This needs to be a valid MIN that the network will recognize.

**ESN:** The emulated Electronic Serial Number of the 2975 since it is being used as a radio to talk to the repeater. This needs to be a valid ESN that the network will recognize.

**DEC:** This button is a toggle button that shows either HEX or DEC, depending on how you want to view the setup data.

**Invert ISM:** This simply inverts the ISM data. Used to enhance system performance in varying RF conditions. Make sure that this is set up so that it is compatible with the receiver.

**Deviation:** This is the peak deviation of the ISM data. Once the ISM setup is complete, we can now look at the OSM from the PassPort repeater to verify network programming and proper response to our radio simulation. To do this, we simply click on the OSM data button on the PassPort radios simulator tile. Figure 16 shows the OSM data screen.



Figure 16: The OSM Data Screen

**DEC:** This button is a toggle button that shows either HEX or DEC, depending on how you want to view the data.

**DCC:** Digital Color Code. This field is the DCC that is being received by the repeater.

**ASID:** This is the affiliated System ID from the repeater designating the network's system identity.

**GROUP:** This is the associated Group ID coming from the repeater and should designate the same Group Identifier that is sent out during the simulated call if initiated from the 2975 unit.

**MIN:** This is the repeater sending back to the 2975 the pre-programmed MIN that was used to access the network.

**GOTO:** The current GoTo channel from the repeater to the radio. The Home Channel.

**FREE:** The corresponding free channel in the event that the home channel is busy. The 2975 will simply display this information for reference. If you wish to test the free channel operation, another 2975 could be set up with the proper information and perform this test.

**STATUS REPORTING:** The most currently viewed message received from the repeater.

**STATUS REPORTING:** A history log of the messages received from the repeater.

**CLEAR:** Clears the status reporting history.

**COPY TO TX:** This allows the user to copy the information received from the repeater to the 2975's radio simulator.

### Transmitter Performance Testing Using the 2975

It is important now to note that the 2975 instruments (meters, oscilloscope, spectrum analyzer, etc.) are always running. The only thing that changes is the "view" of the various meters and test instruments.

For this test, we are going to use the 2975 to test a mobile radio. Once the protocol is set up and ready to talk to the mobile, we can now configure the unit for testing the various parameters. To do this, we will access the duplex mode <MODE 3> configuration as seen in Figure 12 previously. This allows us to view both the transmit and receive information, as well as the spectrum and the call processing information. We would then enable the repeater simulator by turning it ON. The radio would "see" the repeater and camp on the proper home channel.

From there, we can configure the 2975 receiver mode for testing the transmitter of the mobile. To do this, we would enable the receiver mode by selecting <MODE 2> or the receiver mode. Please refer to the 2975 manual for more information on how the different modes of the instrument operate.

Using the Options menu, we would enable the key parameters that we want to view on this screen. The spectrum analyzer, modulation meter, power and RF frequency meter would be set up to view the performance of the transmitter. In addition, we can enable our function generators to set up and output a 1 kHz tone for deviation measurements based on a fixed audio level input. Figure 17 shows how to access the options menu and select these meters and functions.

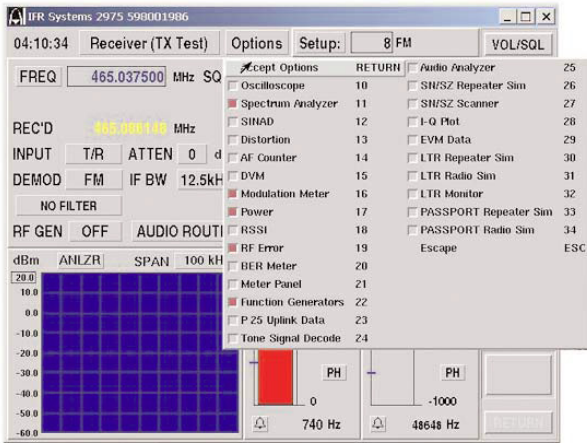


Figure 17: Accessing the Options Menu

Once you have selected these features, you can now start working with the 2975 for testing the transmitter performance. Figure 18 shows how a standard setup for using the 2975 in the receiver mode <MODE 2> for testing mobile transmitter performance would appear.

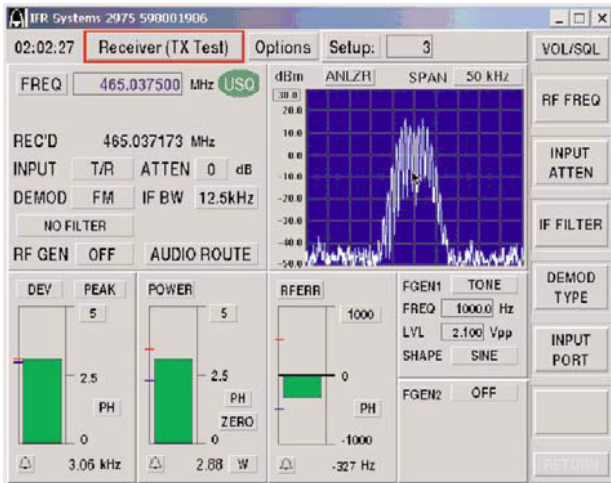


Figure 18: The 2975 Receiver Mode Setup for Testing Mobile Transmitter Parameters

At this point, what we have done is configure two basic modes of operation, duplex and receiver. Each is running independently and can be accessed simply by selecting the mode of the 2975.

In the receiver mode <MODE 2> show in Figure 18, looking at the upper right hand quarter tile of the 2975, we can see that we have the ability to set the following:

Receiver Frequency	(FREQ)
Input	(INPUT)
Attenuation	(ATTEN)
Type of DEMOD	(DEMOD)
IF Bandwidth	(IF BW)
Audio Filters	(Shown as NO FILTER - since no filter is currently selected) Optionally High Pass, Low Pass and Band Pass filters can be selected.
RF Generator Source	(ON/OFF)
Audio Routing	(AUDIO ROUTE)

In addition, we can also read the received frequency (REC'D).

The spectrum analyzer is shown receiving signal from the radio. The span is set to 50 kHz, although this is fully selectable by the user for spans up to 5 MHz in the channel analyzer mode (shown). To view wider spans, utilize the full span analyzer by selecting (<MODE 6>).

The meters selected are the following:

Modulation	(DEV) This will change based on the type of modulation.
Power	(POWER) in Watts or dB
RF Error	(RF ERR) in Hz

As you can see, all the meters are green or "good". This means that the radio is performing within specified limits. The 2975 allows you to color-code pass/fail parameters for particular tests. For example, if we expand the power meter by selecting (POWER), the meter expands to a larger size and shows additional setup information, including pass/fail limits. By enabling these limits, the 2975 will automatically display, in color, the corresponding condition of the radio compared to the pass/fail limits.

Red (high) is displayed if the levels are above the range, green (good) is displayed if the levels fall within the range specified in the setup and blue (low) is displayed if the levels fall below the established range.

Figure 19 shows the expanded power meter and the available selections. Other meters have similar features. See the 2975 operation manual for more details on meter setup and selection.

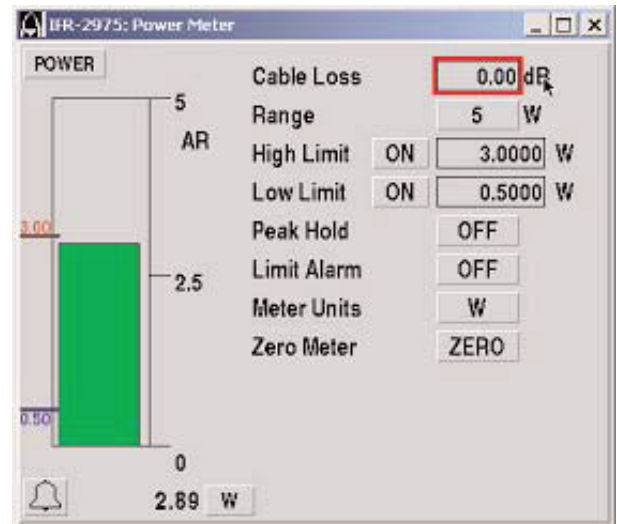


Figure 19: The Expanded Power Meter

In addition to our RF meters, we also have the function generators set up. In this instance, function generator 1 (FGEN 1) is used to generate a 1 kHz tone at a proper level into the radio to get a particular deviation of 3 kHz. Figure 20 shows how the 2975 is connected to the radio using the audio/mic accessory (AC25007) for driving the audio circuits to produce the desired deviation output.

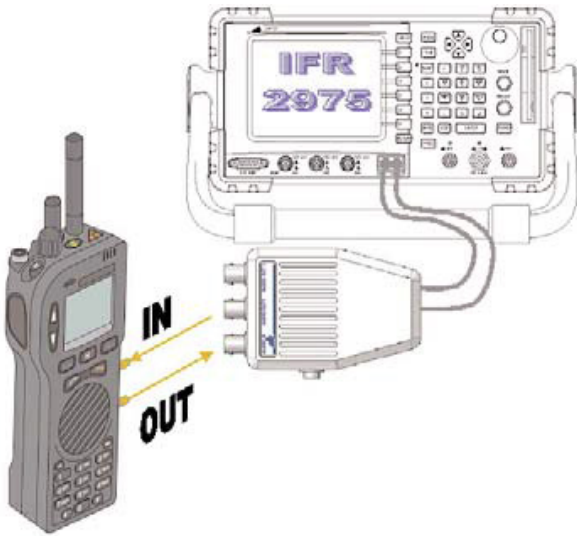


Figure 20: Connecting the Radio to the 2975 for Audio Tests

The 2975 has a very powerful audio routing function. In addition to the proper hardware connections, we need to make sure that the 2975 is set up to properly route the audio from the function generator to the proper audio output. Figure 21 shows the audio route function of the 2975 and how it can be set up to route audio from function generator 1 to audio output 1 on the AC25007 audio/mic accessory.



Figure 21: Routing Audio on the 2975

Now, to test the radio, we simply key the radio and note the results. It is as simple as that. Any parameter out of specification will show up as either red or blue. If the meters are green, you have just finished a complete test, against predetermined pass/fail criteria of the PassPort radio transmitter performance and verified that they are within test parameters.

### Receiver Performance Testing Using the 2975

The primary method for determining receiver sensitivity is to find the radio's 12 dB SINAD point. To do this, we must generate a RF signal into the radio with a 1 kHz tone (typically) modulating the RF. We then recover the demodulated 1 kHz tone and look at the SINAD level as we gradually reduce the RF level to the radio. When we reach the RF level that produces 12 dB of SINAD, we call that the 12 dB SINAD point and that is the receiver's sensitivity.

To perform a radio receiver test, again, the proper audio connections should be utilized. Review Figure 20 for proper audio connections to the 2975.

We need to make sure that the audio is being properly recovered from the radio to perform the SINAD and DISTORTION tests on the 1 kHz audio tone. We need to set the SINAD and DISTORTION meter inputs to monitor the audio input from the AC25007. We simply do this by selecting AUDIO from the input for the meter. Once we have a valid input signal we can perform the receiver sensitivity tests. See Figure 22 for how to perform this test.



Figure 22: Performing a Receiver Sensitivity Test

As you can see, we are in the Duplex mode and have the PassPort repeater simulator running in the group call mode, generating a call to the radio. We also have the SINAD and DISTORTION meters running. We have reduced the level of the RF generator with the 1 kHz tone generated into the radio and are recovering the audio to do the analysis. In this case, the radio receiver performance is approximately -117.7 dBm for a 12 dB SINAD level.

### Conclusion

The 2975 is fully capable of emulating a repeater and radio for testing either radios or repeaters. Depending on how we configure the system, we can perform a variety of measurements. We have seen that we can emulate the various call messages needed to get the radios into conversation and then perform the detailed parametric analysis for both receiver and transmitter tests.