Application Note

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Testing SmartNet™/SmartZone™ Systems

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Understanding the testing of SmartNet™/SmartZone™ Systems

SmartNet™ Overview

SmartNet™ systems are two-way trunked radio systems that are marketed by Motorola under the ASTRO name. SmartZone™ systems are simply a number of SmartNet™ systems tied together that allow a larger system deployment. It is a proprietary technology developed by Motorola and licensed to other radio manufacturers, including E.F. Johnson, for sale to various police, fire, emergency, federal and military customers. The system is marketed as a digital trunked technology, although most of the functionality of the system is tied to analog modulation techniques adapted for trunked messaging. Encrypted SmartNet™ systems are known as SecureNet systems. All of these systems operate either in a conventional 25 kHz channel bandwidth or a 12.5 kHz bandwidth (Narrowband Operation).

Motorola Type I Systems refer to the original Motorola systems that were based on Fleets and Subfleets. Each system had a certain number of Fleets assigned, and then each Fleet had a certain number of Subfleets and radio IDs. Motorola Type I systems are not scalable because they limit the amount of IDs any fleet or subfleet can support.

Motorola Type II systems refer to the second generation Motorola Trunking systems that replaced Fleets and Subfleets with the concept of talkgroups and individual radio IDs. There are no dependencies on Fleetmaps; therefore there are no limitations to how many radio IDs can participate on a talkgroup. This allows for greater flexibility for the user.

Motorola Hybrid systems have "blocks" of the system that are Type I Fleets/Subfleets and Type II talkgroups. All radios may be Type II, or the Type I radios might be used exclusively in subfleets while the Type IIs are used exclusively in talkgroups. Type IIi Hybrid systems have Type I fleets and subfleets, and Type II radios that are able to use those Type I fleet/subfleets. The common reason that an agency sets up a Type IIi Hybrid system is because they have newer Type II radios that they want to interoperate with older Type I radios, without having to create new Type II talkgroups. The following is true of a Type II SmartNet™ system.

- Up to 28 system channels
- Up to 65,535 unique radio IDs
- Up to 4000 talkgroups
- APCO 16 Compliant

SmartZone™

SmartZone™ systems are SmartNet™ Type II systems that are networked together via microwave or land-line to provide multi-site wide area communications. Radios affiliate with a particular site, and affiliate with a talkgroup which allows the radio to talk on that talkgroup to other radios on other sites. Many large public safety and state agencies use SmartZone™ systems for wide area communications. The following are the characteristics of a Motorola SmartZone™ system:

- Up to 28 channels per site
- Up to 65,535 unique radio IDs

- Up to 48 Sites
- Analog and/or Digital voice
- APCO 16 Compliant

OmniLink

SmartZone™ OmniLink provides a broad range of robust system features and utilizes a distributed call processing architecture which links up to four multi-site SmartZone™ systems together into one seamless network, supporting up to 192 sites.

Typical users of SmartZone™ OmniLink systems include organizations who have vast geographic requirements - such as electric and gas companies and extremely large public safety agencies.

ASTRO Name Brand

ASTRO is the trademark name for Motorola's Digital Communications Solution. The original Motorola ASTRO implementation uses the standard SmartZone™ 3600-baud data channel and the digital voice solution is based on the Motorola proprietary VSELP vocoder. Digital voice is accomplished by using a CVSD vocoder at 12 kbps and imparting the information onto a 25 kHz wide channel using FSK (CEFM or Constant Envelope Frequency Modulation) modulation.

ASTRO APCO-25 is Motorola's APCO-25 compatible Digital Trunking Solution. This implementation uses the standard SmartZone™ 3600 baud data channel, and the digital voice solution is based on the APCO-25 IMBE vocoder.

ASTRO-25 is Motorola's implementation of the Project 25 Digital Trunking standard, which uses the TIA 9600 baud control channel.

Understanding Trunked Systems versus Conventional Two-Way Communications

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

In understanding control channel functions, we need to remember that control messages are already utilized in some form by many conventional mobile communication systems. The simple voice statement "over" on a conventional analog two-way channel indicates to another user that the previous user is done talking and the system is available for use by a different user. Within more advanced systems, control messages are exchanged as sub-audible tones that control access to the channel and specific functions of the radio communication. Even digital P25 systems are used in a simplex mode that relies on control messages being shared between users.

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. As we can see in figure 1.0, 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 signaling 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 2.0 shows a radio in duplex operation.

Figure 2.0 Two-way radio communication using duplex operation

Now, let's compare simplex and duplex operation to trunked radio operation. 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 dedicated 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.

Usually, the control channel is a separate frequency channel that is designated as the dedicated control channel frequency and is different from the traffic channel in that it functions as a resource allocation and digital communication message bearer and handler between the RFSS (Radio Frequency Sub System) and the SU (Subscriber Unit). Since the control channel is communicating in digital "words", the modulation has to support digital "1s" and "0s" to accomplish the transfer of data.

Using a dedicated control channel is desirable in that it provides additional control of spectrum in larger systems. It allows for the control of system resources and offers added features not available in conventional radio communications. Additional features include PSTN connect, data and other services.
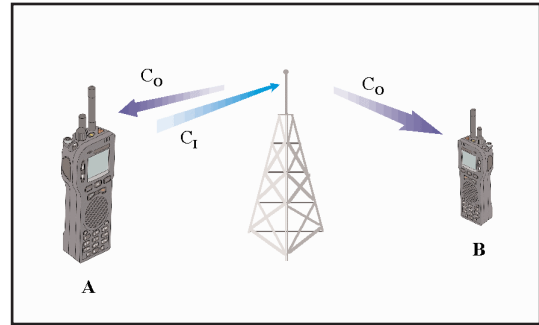

Figure 3.0 shows how a control channel operates.

As you can see, the repeater is putting out an outbound control channel (C_O) that both mobiles are monitoring. In SmartNet™/SmartZone™ systems the outbound control channel sends information in "words" and those "words" are called Outbound Signaling Words or OSWs.

Let's assume that mobile A wants to place a call to another user on the systems. Mobile A transmits a request to the repeater on an inbound control channel (C_I). In SmartNet™/SmartZone™ systems, the inbound control channel sends information words called Inbound Signaling Words or ISWs. The repeater station processes the request, and then sends an alert on the outbound control channel that the designated user, mobile B, recognizes as a call that is part of its group or that is designated specifically for itself.

As you can see in figure 4.0, the calls are then assigned to particular voice channels that operate on separate frequencies (f_1, f_2, f_3, f_4). The transmit and receive frequencies for the mobiles are offset from each other (f_1 and f_2) (f_3 and f_4). This is called duplex offset. In VHF/UHF systems the duplex offset is set up by the system administrator, whereas in the 800 MHz band, the offset is 45 MHz. Control of these resources is accomplished through the control channel that the mobile unit monitors continuously when not engaged in a communication session with another user or with the network.
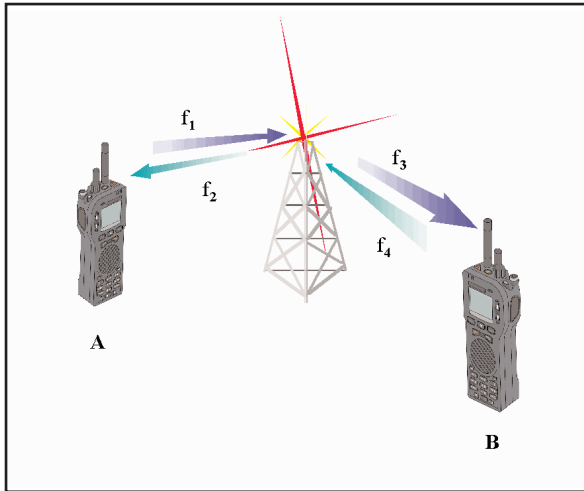
Figure 4.0 Two-way radio communications using trunked operation

SmartNet™/SmartZone™ Control Channel Specifics

The SmartNet™/SmartZone™ control channel utilizes a form of FM modulation to carry the digital information over the air to the mobile unit. This modulation is called FSK, or Frequency Shift Keying. FSK imparts digital data to the RF carrier by changing frequency states. These states are then recognized as digital "1s" and "0s". The control channel for SmartNet™/SmartZone™ systems operates at a data rate of 3600 baud, or 3600 bits per second.

The control channel sends messages outbound to the various "listening" mobiles (subscriber units that are using the network) using or OSWs. These OSWs contain the control information required for the mobile to communicate with the network. These include System Wide ID Announcement, System Status and other pertinent information required to communicate with the network that the mobile is accessing.

Correspondingly, the mobile accesses the network through a series of ISWs. These ISWs contain information about the mobile's identifier, group affiliation and manufacturer ID as well as access messages that enable the mobile to gain access to the network.

SmartNet™/SmartZone™ Operation

SmartNet™ and SmartZone™ systems incorporate a number of feature rich functions that have led this standard to be one of the most deployed systems in the world. Among these features, this technology incorporates typical PMR functions including Group Calls and Emergency Calls but also includes Dynamic Regrouping (dynamic assignment of group calls), System Wide calls, Private Calls and other specialized functions. These features have enabled these systems to be widely accepted at the Local, State and Federal level for wireless communications.

These systems can operate in a wide-band (25 kHz) or narrow-band (12.5 kHz) mode. Voice is transmitted using standard FM in conventional systems. One key feature of newer systems is the ability to work P25 digital traffic channels into the network's channel plan. This capability allows users to slowly migrate existing

SmartNet™/SmartZone™ systems to the more spectrally efficient P25 standard.

The Associated Control Channel or Low Speed Data

SmartNet™/SmartZone™ systems utilize an associated control channel that rides along with the FM voice channel. This Low Speed Data (LSD) is in the sub-audible range and below the 300-3 kHz voice filters. LSD operates at 150 bps and handles control functions (such as individual, group call and call termination messages) during an ongoing conversation with other users. It also includes a synchronizing byte that allows the radio and repeater to synchronize itself with each other. Figure 5.0 shows the use of LSD along with the voice information.
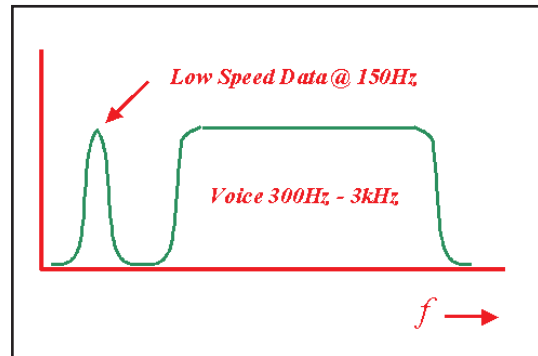

Figure 5.0 Low Speed Data

Security in SmartNet™/SmartZone™ Systems

Conventional SmartNet™/SmartZone™ systems utilize FM modulation that can be easily detected through an FM discriminator. Encrypted systems are called SecureNet and use a vocoder to digitize the voice information and also utilize various types of encryption to "scramble" the voice data. There are many encryption types used on SecureNet and SmartNet™ Systems:

DVP is the Motorola developed Digital Voice Privacy algorithm made in the mid-1970's using 32 bit key length

DES is the Motorola encryption algorithm that meets U.S. Gov't encryption guidelines (56 bit DES key)

DVP-XL is the Motorola proprietary encryption algorithm using 32 bit key encryption. This is a SecureNet encryption mode.

DVI-XL is a variant of DVP-XL for export outside of the U.S. This is a SecureNet encryption mode.

DES-XL is a Motorola variant of the U.S. Gov't DES algorithm. This is a SecureNet encryption mode.

Testing SmartNet™/SmartZone™ Radios

When testing SmartNet™/SmartZone™ radios, you need to know what type of system you are supporting. With ASTRO APCO-25 Systems, there are two types of technology you need to test; conventional analog and P25 digital. Understanding the type of system is important to understanding the tests required to verify performance of a SmartNet™/SmartZone™ radio.

Conventional analog SmartNet™/SmartZone™ systems utilize analog voice channels controlled by a digital control channel. We do not test the control channel for parametrics, however we do test

for some interaction between the control channel and the transition to the voice channel. These tests are called protocol tests, in which we test the radio's ability to respond to commands from the radio test set.

In order to do this, the test system needs to be able to emulate some of the protocol (OSWs) that the repeater sends out. In addition, the system needs to be able to respond to the ISWs the mobile is sending and react appropriately to get the unit onto a voice channel for testing. While on the voice channel the test system needs to be able to keep communication with the mobile through the Low Speed Data link.

Being an analog based system, these systems also require the ability to test and verify parametric performance including frequency error, power, SINAD, deviation and other parameters.

When in the P25 mode, we need to be able to command a mobile that is dual-mode capable to a P25 traffic channel, which means we need to set up a control channel with the proper commands to allow a dual mode radio to go to a P25 mode. In addition, the test set has to support the radio's request for a P25 traffic channel.

Additional features that will prove helpful, especially as new features are being added, include protocol message logging for the control channel and the traffic channel. These features will allow the user to test the messaging between the mobile and repeater.

Using the 2975 with Option 1 to perform SmartNet™/SmartZone™ testing

The 2975 provides powerful test features for SmartNet™/SmartZone™ systems. Among these tests are the following:

1. The ability to emulate a repeater station. With the 2975, you are not locked into a specific test sequence for the radio. You decide what pass and fail means.

2. The ability to "find" and monitor a SmartNet™/SmartZone™ control channel in a given area and then "follow" the channel, the group or the individual unit.

3. The ability to "log" a SmartNet™/SmartZone™ control channel and word. It also provides the ability to log the ISWs and LSD.

4. The ability to perform full analog test functions.

SmartNet™/SmartZone™ Control and Voice Channel Setup for Analog Test

Setting up the control and voice channel is the first thing that needs to be accomplished to begin testing SmartNet™/SmartZone™ systems. This section shows how to enable the Repeater Simulator for testing mobiles. In all test modes for SmartNet™/SmartZone™ mobile systems, the unit should be in the duplex mode. To enable the duplex mode, click on the screen selection button next to the time at the very upper left of the screen or select <MODE>, <3> as shown in figure 6.0. Once established, the user can move outside the duplex mode for more extended tests.
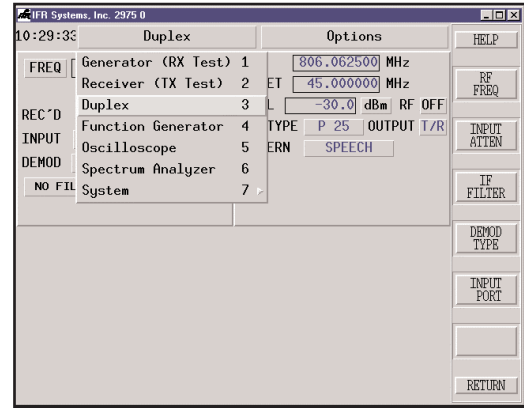

Figure 6.0 Selecting Duplex Mode

From there, we want to enable the Repeater Simulator. To do this, select the "Options" button next to the Duplex display at the top right of the display or select <SHIFT>,<MODE> and then select item 24 "SN/SZ Repeater Sim". See figure 7.0 for this selection.
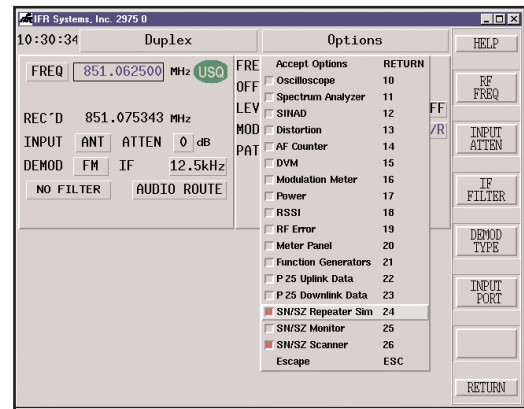

Figure 7.0 Selecting SN/SZ Repeater Simulator

To set up the control channel, enable the SmartNet™/SmartZone™ repeater function as well as the scanner function. Select numbers <24> and <26> on the "Options" menu, or <SHIFT>,<MODE> and then select item 24 and 26. Figure 8.0 will show you the SmartNet™/SmartZone™ repeater simulator mode with the scanner function enabled. This particular setup will allow you to enter in the valid control and voice channel parameters, or, if they are not known, to find the control channel in a particular area by monitoring it off the air and then use the information retrieved off of any system found.
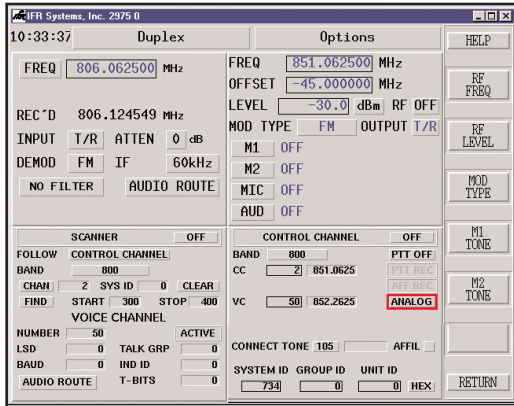
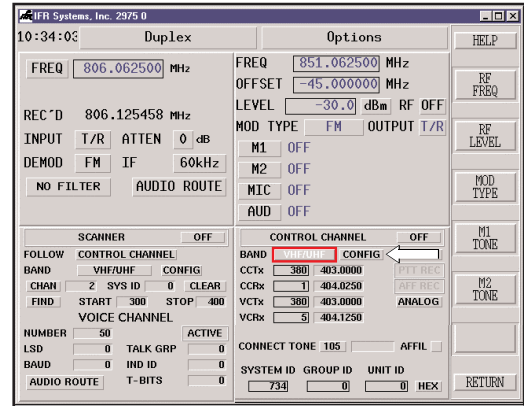*Figure 8.0 SN/SZ Repeater Simulator with Scanner Function (800 MHz band)*

To enable a valid control channel, make sure that the mode selected is analog (for analog test mode). Then set up the proper control and voice channel numbers. This is fairly straight-forward for 800 MHz operation, in that the channels are defined with a set frequency assignment. The duplex offset is also standard at 45 MHz. We simply enter the proper channel number or frequency in the CC and VC data fields.

This is not the case with operations in the VHF and UHF band. With this band, we need to define the Transmit and Receive parameters. This all depends upon the concept of an "open" band. This band can be configured however we want. The only parameter is that the Unit Under Test (UUT) Rx channel always starts at 380 and goes up, based on the spacing of the channels. The corresponding Tx channel starts at 0. The offset is entirely user defined. Figure 9.0 shows the VHF/UHF control channel tile enabled while Figure 10.0 shows the Channel configuration settings for three particular frequency blocks. Selecting the "CONFIG" button on the VHF/UHF Repeater tile when the band selected is VHF/UHF calls up this screen.

With this screen, we can set up our channel start and stop frequencies for the various blocks within a user's allocated spectrum. Not all blocks need to be used. The reason the three blocks are provided is due to the fact that the user may have split bands that he has to deal with. Control and voice channels are designated within the defined frequency ranges. Once we have the configuration set, then we can enter the appropriate control and voice channel information.

Figure 9.0 VHF/UHF Control Channel Repeater Tile with Scanner Function enabled. The arrow indicates the "CONFIG" button where VHF/UHF Channel Plans are entered.
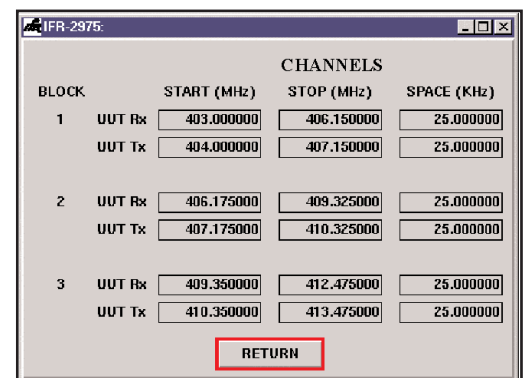
Figure 10.0 VHF/UHF Control Channel Configuration Screen

Once we have the control and voice channel set up, additional parameters need to be entered. For both analog and digital operation, we need to enter a valid system ID and appropriate group ID for the network that the mobile will be accessing. This is the minimum configuration for testing the mobile unit. The 2975 will automatically decode the Group ID from the mobile when the unit affiliates with the box, but we need to know the System ID at least. Additionally, we can add the mobile unit ID, however this is not required. With the 2975, this information can be entered in either hex or decimal.

Before we are ready to start testing mobiles, we need to also select the connect tone for analog operation. The connect tone is a low frequency tone that is broadcast alternately with the LSD, and is a tone the mobile looks for on the voice channel to confirm the proper channel has been located and allows for synchronizing to the network. Once the mobile sees the connect tone and verifies the LSD, the repeater and the mobile can carry on a conversation. Figure 11.0 shows the valid connect tone options.
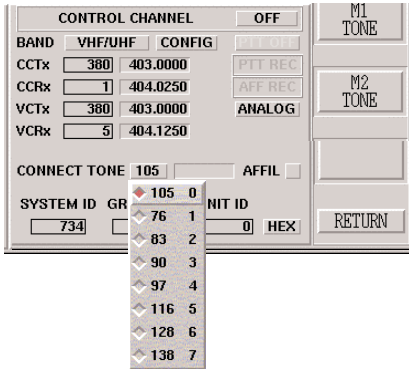
Figure 11.0 Sending the proper connections

Another added feature is the Affiliation enable mode. By enabling the affiliation button (enabled by clicking on the box next to AFFIL, which will then turn green), the mobile is required to affiliate with the 2975. The 2975 sets an affiliation status bit in the control channel information being sent to the mobile and the mobile responds with a two word ISW that includes the individual ID, Talk Group ID and information. The 2975 responds back to the mobile with the exact same information to ensure that the information received is correct, along with connect tone information. Figure 12.0 shows the affiliation button enabled.
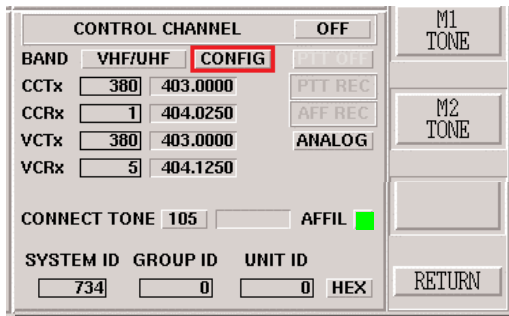
Figure 12.0 Enabling the affiliation function

Once we have the control channel configured, we can then enable the control channel by selecting the On/Off button on the repeater simulator tile. The 2975 is now generating a control channel on the proper channel with the proper System ID and Group ID information and the voice channel is configured with the proper connect tone. Figure 13.0 shows how to turn on the SmartNet™/SmartZone™ control channel.
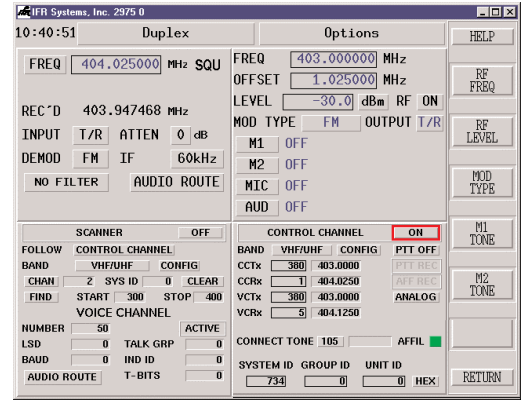
Figure 13.0 Enabling the Control Channel

We can now perform either a mobile originated call or a repeater originated (user or dispatch originated) call. To perform mobile radio transmitter tests, simply key the mobile unit and the 2975 will automatically assign the unit to the proper voice channel for performing parametric tests.

800 MHz Operation

The 2975 SmartNet™/SmartZone™ also allows for 800 MHz-band operation. As with VHF/UHF operation, the proper System ID and Group ID need to be entered before the unit will operate with the 2975. The 800 MHz band is easier to set up, however, since the offset and channels are already assigned. Figure 14.0 shows operation in the 800 MHz band with the control channel enabled and the mobile affiliation received function indicated.
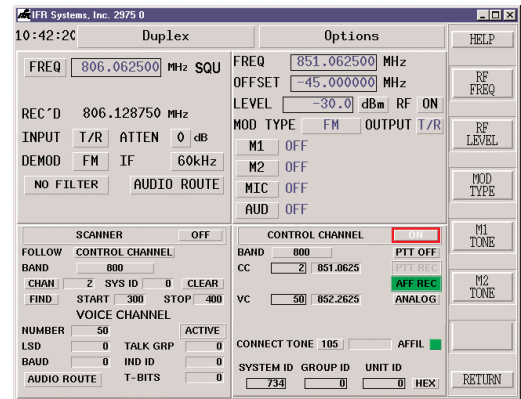

Figure 14.0 800 MHz Band Operation

Once we have the control channel set up and running, and the mobile is talking with the 2975, we can then select any number of options to run in conjunction with the simulator. This includes the O'scope, Spectrum Analyzer, Meter Panel, Power Meter, RSSI Meter, etc…. To enable these functions, select the "Options" button or select <SHIFT>,<MODE> and select the combinations you wish. Remember that not all screens can be displayed at one time and we will be limited to two meter screens or one oscilloscope/spectrum analyzer screen.

The best way to enable multiple displays of various parameters quickly is to select the "Meter Panel", number <20>. See figure 15.0 for a sample of using the meter panel with the

SmartNet™/SmartZone™ repeater tile enabled while figure 16.0 shows the 2975 with the SmartNet™/SmartZone™ repeater panel with the spectrum analyzer enabled <SHIFT><MODE> <11>. Notice that the PTT REC indicator is lit up and the duplex rec./gen. frequencies have changed since the unit is now on the voice channel with 45 MHz duplex offset.
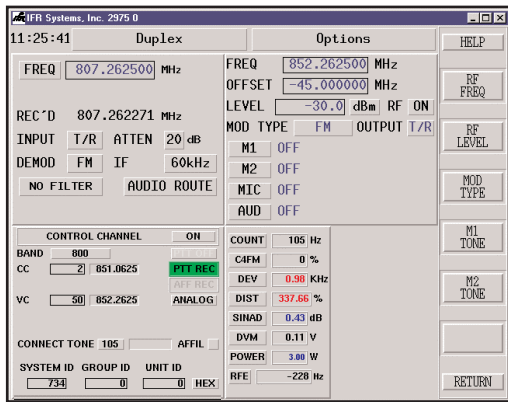

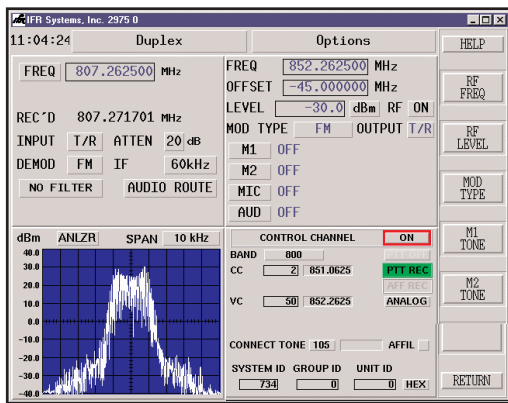*Figure 15.0 Using the SmartNet™/SmartZone™ repeater tile with the meter panel*

Figure 16.0 SmartNet™/SmartZone™ repeater tile with Spectrum Analyzer enabled

To perform mobile receiver measurements, enable the PTT mode by selecting the PTT button directly below the ON/OFF button on the repeater screen. This will cause a repeater originated call request to be sent to the mobile and the mobile will then be assigned to a voice channel in a "listen" (receive) mode.

From this mode, receiver sensitivity can be tested using a SINAD test in the analog mode. See section titled "Analog Receiver Testing" in the 2975 manual for more information on how to perform this test.

P25 Traffic Channel Operation

The 2975 performs unique tests for SmartNet™/SmartZone™ systems that allow P25 Traffic Channel interoperation with conventional FM SmartNet™/SmartZone™ systems. Primarily designed as a high performance P25 test system, the 2975 provides true C4FM EVM measurements, message logging and embedded speech patterns.

As part of the SmartNet™/SmartZone™ option, the 2975 allows users to select the digital mode. Figure 17.0 shows how to enable the P25 digital traffic channel on the SmartNet™/SmartZone™ Repeater tile. Remember that we need to at least enter in a valid System ID.
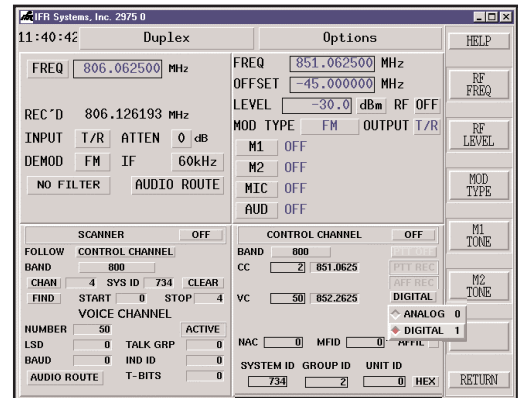
Figure 17.0 Enabling the Digital P25 mode on the SmartNet™/SmartZone™ Repeater Tile

Once the 2975 is set up for Digital mode operation, the rest of the tests are pretty much the same. Transmitter measurements are performed just like in the Analog mode. The major difference, however, is the C4FM EVM meter and the exclusive speech patterns applicable to P25 digital mode. The C4FM meter shows true EVM of the desired C4FM signal, unlike other test systems that only provide deviation measurements. See figure 18.0 on how to use the C4FM meter with the SmartNet™/SmartZone™ repeater simulator.
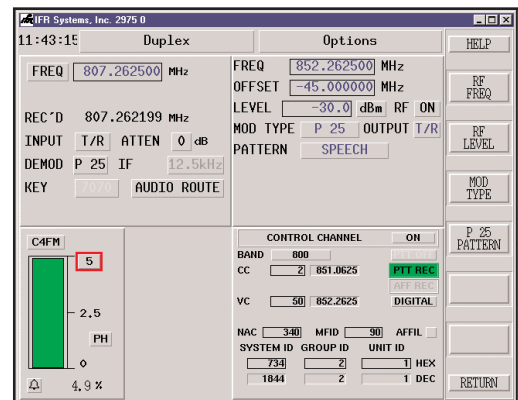

Figure 18.0 SmartNet™/SmartZone™ Repeater Simulator with the C4FM meter enabled

The 2975 makes receiver measurements extremely easy and requires a few additional setup parameters. Since the 2975 is going to be transmitting to the mobile under test, we need to properly set up the P25 downlink functions. The three parameters that need to be defined in order for the mobile to support the call are the NAC or Network Access Code, TGID and the Mobile Manufacturer ID. The TGID parameter is directly taken from the SmartNet™ Group ID field. Figure 19.0 shows the SmartNet™/SmartZone™ Repeater tile with the P25 downlink tile.
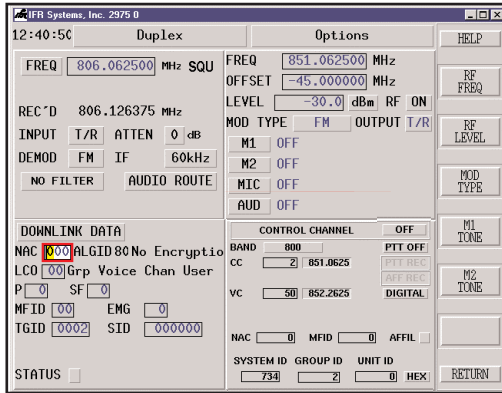
Figure 19.0 Enabling and setting up the P25 Downlink Tile

Also, the mobile needs to receive Link Control messages (LCOs) of type 00 (LC_GRP_V_CH_USR) in order to determine if the values of the NAC, TGID and MFID fields are acceptable to its connect requirements. This is per TSB102.AABD section 7.0, under Traffic Channel Maintenance. Although the 2975 has the downlink tile set to LCO 00, the user can change this, which will not allow the Mobile Initiated connection to be completed.

These fields will be set up using the information from a prior Mobile Initiated Call. However, if we want to do a System Initiated call without first doing a Mobile Initiated call, we will need to set these parameters manually.

If we do not know the NAC, TGID or MFID, then we can use the 2975 to display these parameters easily. Simply key the mobile and the 2975 will decode this information from the mobile. Figure 20.0 shows the captured information on the repeater simulator tile, which we can then use to enter into the Downlink tile - see figure 21.0. This will enable the 2975 to talk with the mobile to make sensitivity tests.
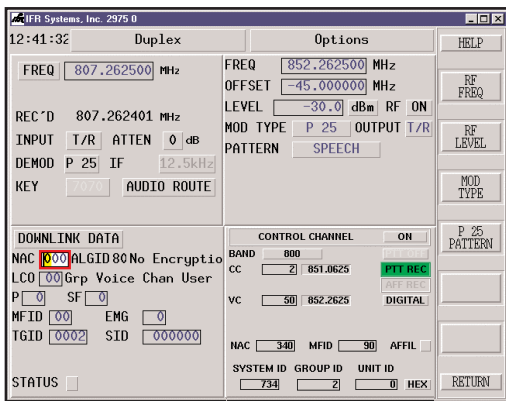
Figure 20.0 Obtaining valid NAC, TGID and MFID information
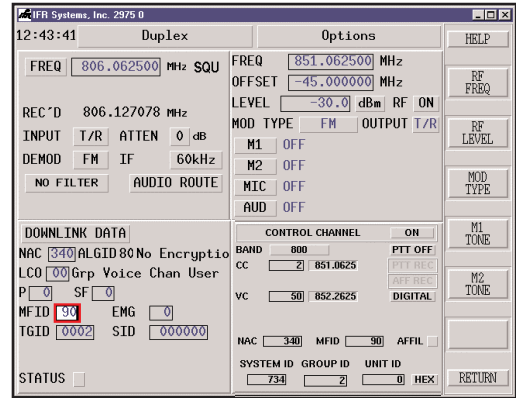
Figure 21.0 Entering in the proper NAC and MFID information

Once the P25 downlink tile is enabled, we can enable a unique sensitivity test called the "Speech" mode. The speech mode is a special voice file that provides pre-recorded voice patterns that allow the test professional to quickly determine the receiver's sensitivity. This is accomplished by listening to the pre-recorded audio voice patterns and then reducing the RF sensitivity until the voice starts to break up or sounds become slurred. This test is unique to the 2975 and is another way that IFR is improving technician productivity. Figure 22.0 shows how to select the speech mode and figure 23.0 shows where to adjust the RF level.
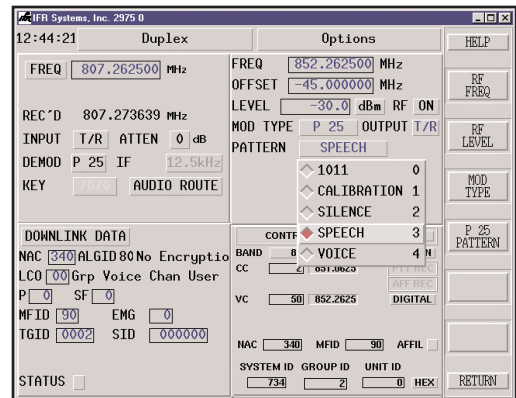

Figure 22.0 Setting the 2975 up for P25 sensitivity testing using the speech mode
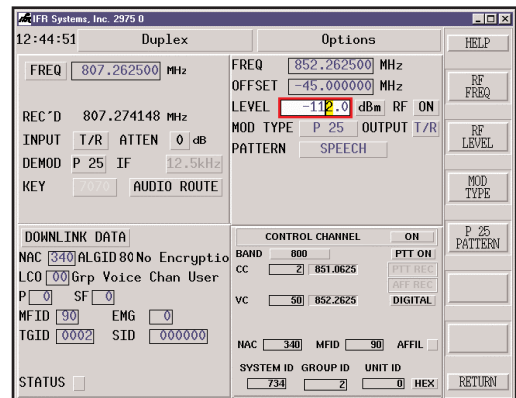

Figure 23.0 Decrease the RF output until speech quality degrades

Finding a SmartNet™/SmartZone™ Control Channel

If the control channel information is not known, the 2975 provides a unique function for tracking and monitoring a SmartNet™/SmartZone™ control channel. With the scanner function, the user can monitor off-the-air control channels and track the channel number and system ID. Once a control channel has been located, the 2975 can lock onto and follow the control channel as it hands off to SmartNet™/SmartZone™ analog voice channels.

To find a control channel, the user simply enters the band and the channel number range in the start and stop channel boxes. Selecting "FIND" will then start the search for a control channel. This function will simply scan for channels and we do not want to enable the scanner function until we have found the control channels. Remember to use the antenna input to ensure best sensitivity. Figure 24.0 shows the 2975 having found two valid control channels, 364 and 374. After we have located control channels, then enable the scanner function by selecting the "ON" button at the upper right hand of the SmartNet™/SmartZone™ scanner tile. Figure 25.0 shows the unit tracking an active voice call on channel 204 with a talk group ID of 3746.

To ensure best operation of the find and scanner functions, make sure that the RF generator is "OFF", the IF Filter bandwidth is set to 12.5 kHz and that you do not have any attenuation or audio filters enabled.
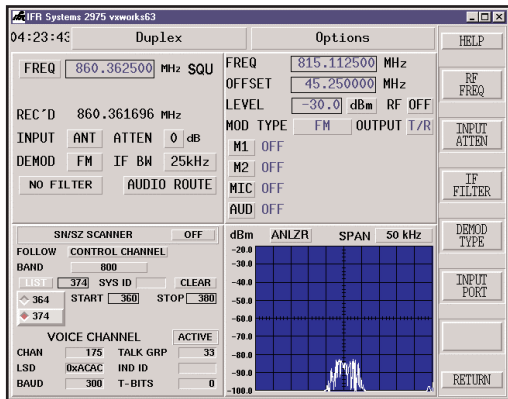
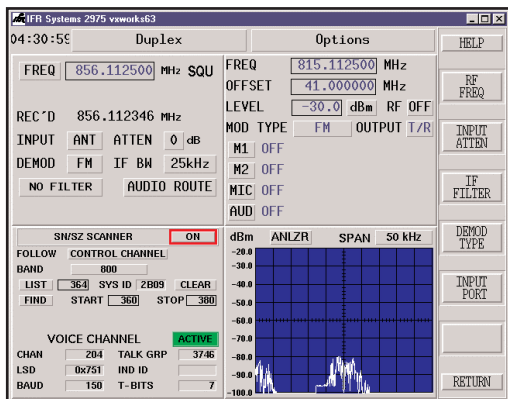*Figure 24.0 Using the 2975 to find a control channel*

Figure 25.0 Scanner function enabled with an Active voice channel

Audio Routing

The 2975 provides excellent audio routing features. These routing features allow for unparalleled testing flexibility. To perform SmartNet™/SmartZone™ testing, we can route demodulated audio to the speaker and for voice tests, and the ability to take Mic or Audio in, and route it to the radio. For more about the audio routing, see the 2975 operation manual. Figure 26.0 shows the audio routing function that appears when the "AUDIO ROUTE" button is selected.

Figure 26.0 The Audio Routing screen

Conclusion

Using the 2975 provides some of the most advanced testing functions ever presented in a communication test set. For testing SmartNet™/SmartZone™ systems, the 2975 truly allows for dynamic testing of both Analog and Digital Enabled SmartNet™ II systems. Through true repeater functionality, unique scanner functions and the use of the world's most comprehensive P25 test facilities, the 2975 provides the test professional with the most advanced wireless test set on the market for PMR systems.

Sources: Trunkedradio.net

Motorola.com

Batlabs.com

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