SyTech Corporation RIOS Technical Evaluation

The Office for Interoperability and Compatibility

Department of Homeland Security

Test Procedures and Results

Homeland Security

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Homeland Security

THE OFFICE FOR INTEROPERABILITY AND COMPATIBILITY

Defining the Problem

Emergency responders—police officers, fire personnel, emergency medical services—need to share vital voice and data information across disciplines and jurisdictions to successfully respond to day-to-day incidents and large-scale emergencies. Unfortunately, for decades, inadequate and unreliable communications have compromised their ability to perform mission-critical duties. Responders often have difficulty communicating when adjacent agencies are assigned to different radio bands, use incompatible proprietary systems and infrastructure, and lack adequate standard operating procedures and effective multi-jurisdictional, multi-disciplinary governance structures.

OIC Background

The Department of Homeland Security (DHS) established the Office for Interoperability and Compatibility (OIC) in 2004 to strengthen and integrate interoperability and compatibility efforts in order to improve local, tribal, state, and Federal emergency response and preparedness. Managed by the Science and Technology Directorate, OIC is assisting in the coordination of interoperability efforts across DHS. OIC programs and initiatives address critical interoperability and compatibility issues. Priority areas include communications, equipment, and training.

OIC Programs

OIC's communications portfolio is currently comprised of the SAFECOM and Disaster Management (DM) programs. SAFECOM is creating the capacity for increased levels of interoperability by developing tools, best practices, and methodologies that emergency response agencies can put into effect, based on feedback from emergency response practitioners. DM is improving incident response and recovery by developing tools and messaging standards that help emergency responders manage incidents and exchange information in real time.

Practitioner-Driven Approach

OIC is committed to working in partnership with local, tribal, state, and Federal officials in order to serve critical emergency response needs. OIC's programs are unique in that they advocate a "bottom-up" approach. The programs' practitioner-driven governance structures gain from the valuable input of the emergency response community and from local, tribal, state, and Federal policy makers and leaders.

Long-Term Goals

- Strengthen and integrate homeland security activities related to research and development, testing and evaluation, standards, technical assistance, training, and grant funding that pertain to interoperability.
- Provide a single resource for information about, and assistance with, interoperability and compatibility issues.
- Reduce unnecessary duplication in emergency response programs and unneeded spending on interoperability issues.
- Identify and promote interoperability and compatibility best practices in the emergency response arena.

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Department of Homeland Security (DHS)

Science and Technology Directorate (S&T)

Office for Interoperability and Compatibility (OIC)

TECHNOLOGY EVALUATION PROJECT

Technical Evaluation of the SR-3001 Radio Inter-Operability System (RIOS)

Manufactured by SyTech Corporation

Test Procedures and Results

Document No. TE-08-0003

January 2008

Prepared by

National Institute of Standards and Technology (NIST) Office of Law Enforcement Standards (OLES) via

National Telecommunications and Information Administration (NTIA)/Institute for Telecommunication Sciences (ITS)

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Homeland Security

Publication Notice

Abstract

This report describes the test procedures and results of the product evaluation for the SR-3001 Radio Inter-Operability System (RIOS). The RIOS is an audio gateway device manufactured by SyTech Corporation. An audio gateway device (also called an audio matrix or a cross-band switch) links disparate radio systems to support communications interoperability between dissimilar wireless systems. Such a device simply passes baseband (audio) signals from the receiver portion of one radio to the transmitter portion of a dissimilar radio system.

Disclaimer

The U.S. Department of Homeland Security's Science and Technology Directorate serves as the primary research and development arm of the Department, using our Nation's scientific and technological resources to provide local, state, and Federal officials with the technology and capabilities to protect the homeland. Managed by the Science and Technology Directorate, the Office for Interoperability and Compatibility (OIC) is assisting in the coordination of interoperability efforts across the Nation.

Certain commercial equipment, materials, and software are sometimes identified to specify technical aspects of the reported procedures and results. In no case does such identification imply recommendations or endorsement by the U.S. Government, its departments, or its agencies; nor does it imply that the equipment, materials, and software identified are the best available for this purpose.

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Table of Contents

List of Figures

List of Tables

Executive Summary

Working on behalf of the National Institute of Standards and Technology (NIST)/Office of Law Enforcement Standards (OLES), the National Telecommunications and Information Administration's Institute for Telecommunication Sciences (ITS) conducted a series of tests to evaluate the functionality of the SR-3001 Radio Inter-Operability System (RIOS). The RIOS is manufactured by SyTech Corporation (http://www.sytechcorp.com). It is part of a collection of bridge, or audio gateway, technology products offered by various manufacturers.

An audio gateway device (also called an audio matrix or a cross-band switch) links disparate radio systems to support communications interoperability between dissimilar wireless systems. Such a device simply passes baseband (audio) signals from the receiver portion of one radio to the transmitter portion of a dissimilar radio system.

The RIOS enables interoperability between wireless and wireline communication systems by multiplexing audio input signals to the audio input ports of several radios. The RIOS serves to connect radios that operate within different radio frequency (RF) bands and that use analog or digital modulation. This is accomplished by fanning out a single audio input source to multiple radio audio inputs.

The RIOS is designed to enable one user to simultaneously broadcast to 16 radios or phone lines, each of which potentially can be programmed into any of eight available talk groups. Note there is a minimum of two radios per talk group.

To exercise the functionality of the RIOS, ITS developed a series of focused test procedures to evaluate:

- Balanced Input Audio Impedance
- Balanced Output Audio Impedance
- Input Audio Level
- Output Audio Level
- Audio Frequency Response
- VOX[1] Input Threshold
- VOX Attack Time and Throughput Delay
- Audio Distortion – Signal + Noise + Distortion to Noise + Distortion (SINAD) and Total Harmonic Distortion plus Noise (THD+N)
- Crosstalk

In general, the RIOS performed as specified, as the test results in this report demonstrate. This report notes areas of small concern. A small potential exists for interference from RF emissions from the RIOS in the very high frequency (VHF) public safety band. If a VHF receiver is near the RIOS, RF emissions can affect it. In addition, the audio monitoring function on the managing computer supplied with the system seemed to suffer from frequent buffer overflow. This was evidenced by a pop from the PC audio speakers at approximately one-second intervals. This did not affect the signal to the radios.

[1] VOX means voice operated transmit.

Document Scope and Intended Audience

This report presents the procedures employed in the technical evaluation testing for the RIOS, and also summarizes the results. The RIOS falls under the category of cross-band technology devices that public safety organizations may use to perform wireless communications interoperability between dissimilar wireless systems. By necessity, this document is quite technical in nature.

1 Introduction

Public safety operations require effective command, control, coordination, communication, and sharing of information with numerous criminal justice and public safety agencies. Thousands of incidents that require mutual aid and coordinated response happen every day. High-profile incidents, such as bombings or plane crashes, test the ability of public safety service organizations to mount well-coordinated responses. In an era where technology can bring news, current events, and entertainment to the farthest reaches of the world, many police officers, firefighters, and emergency medical service (EMS) personnel cannot communicate with each other during major emergencies, as evidenced by September 11, 2001, and Hurricanes Katrina and Rita, or even during routine traffic accidents or fire operations.

1.1 Bridging Communications Gaps

There are more than 18,000 state and local law enforcement agencies in the United States. Approximately 95 percent of these agencies employ fewer than 100 sworn officers. Additionally, more than 32,000 fire and EMS agencies exist across the Nation. Due to the fragmented nature of this community, many public safety communications systems are stovepiped, i.e., individual systems do not communicate with one another or help bring about interoperability. Just as the public safety community is fragmented, so is radio spectrum. Public safety radio frequencies are distributed across isolated frequency bands, from very high frequency (VHF) (25 to 50 megahertz (MHz)) to 800 MHz (806 to 869 MHz), and now 4.9 gigahertz (GHz).

The convergence of information and communication technologies requires a coordinated approach to bridge the gaps in interoperability. By focusing on enabling technologies and open standards for interoperability, the Department of Homeland Security's (DHS) Office for Interoperability and Compatibility (OIC) Technology Evaluation Project provides this needed link.

1.2 The OIC Technology Evaluation Project

The OIC Technology Evaluation Project is focused on assessing the applicability of currently available and evolving products and services to the interoperability requirements of users in public safety agencies. To accomplish this, products and services are evaluated to determine if they are both cost-efficient and effective for users. They also are evaluated consistent with the tenets of the long-term standardization approach developed by OIC for nationwide interoperability.

Evaluation comprises classic techniques, including observation, analysis, demonstration, and testing. In many cases, products or services may be comprehensively evaluated within an independent laboratory or other closed environment. For other products or services, however, a more extensive approach may be necessary to determine the ramifications of placing those products or services in an agency conducting actual job functions. To help with the demonstrations and testing of selected products or services of this type, operational test beds (OTBs) may be established. This aim is to assess the operational impacts of technologies that assist interoperability. In addition, focused “pilot projects” are also used to evaluate solutions to specific operational requirements.

While evaluation processes conducted at independent laboratories may take weeks to complete (for example, 4 to 8 weeks), evaluations within the OTB may take months (for example, 6 to 12 months). This is because such evaluations carefully characterize the impact of the new product or service on existing operations. In addition, they project how future operations may change with a permanent application of the technology.

2 Background

A fundamental interoperability challenge today is wireless voice communications among agencies that have different radio systems operating on various radio frequencies. OIC will ultimately address this issue through promotion of interoperability standards, including standardized methods of bridging between systems operating in different frequency bands.

While interoperability standards are being developed, however, other mechanisms are needed to address interoperability requirements. One such mechanism is the audio gateway device (also called an audio matrix or a cross-band switch) that links disparate radio systems. Not unlike a dispatcher’s patch panel, such a device simply passes base band (audio) signals from the receiver portion of one radio to the transmitter portion of a dissimilar radio system. For example, audio from the receiver function of a very high frequency (VHF) transceiver is passed to the transmitter circuitry of an ultra high frequency (UHF) transceiver.

2.1 Audio Gateway Advantages

An audio gateway has several advantages over the dispatcher’s patch panel. One big advantage is that an audio gateway requires no manual intervention once it is configured. The device automatically routes voice calls from one radio system to another via control signals (e.g., dual-tone multi-frequency (DTMF) signals) that are input by a radio user. Audio gateways also support connections between radios, telephone lines, and cellular phones. In addition, an audio gateway offers mobile versatility over dispatchers’ patch panels. For example, an audio gateway can be configured for use in a van or sport utility vehicle (SUV), and so become part of an incident commander’s command post. This way, the audio gateway becomes a mobile repeater, allowing the disparate radio systems to communicate in a wide geographical radius around the incident.[2]

2.2 Overview of the SyTech RIOS

The SyTech RIOS is an audio gateway device. It is designed to enable interoperability between wireless and wireline communication systems by multiplexing audio input signals to the audio input ports of several radios. The RIOS serves to connect radios that operate within different radio frequency (RF) bands and that use analog or digital modulation. This is accomplished by fanning out a single audio input source (for example, a radio) to multiple radio audio inputs.

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[2] The ability to configure and operate an audio gateway device in the field is a powerful feature. However, proper training is crucial to operating an audio gateway. Field personnel not properly trained in the technical operation of the device or with relevant agency policies, may go on to create connections that cause unforeseen problems. It is incumbent on the operating agency to ensure appropriate policies and procedures for the use of any audio gateway device in its possession.

One user can simultaneously broadcast on several radios using the RIOS. It can connect to a total of 16 land mobile radios (LMRs) or phone lines. Each of these potentially can be programmed into any of eight available talk groups. Note there is a minimum of two radios per talk group.

Figure 1 shows the portable RIOS, and its controlling or managing computer, which include the following features:

- Interconnectivity of 16 devices. A rack-mount version supporting 32 devices is also available.
- Iridium or Nextel phones, or any of a variety of LMRs
- Devices can be assigned to a dispatch group (one-to-many or many-to-one) or a talk group (many-to-many).
- Comes with a laptop computer with control software for managing the RIOS.
- Managing computer connects via Ethernet port.
- Managing computer can listen to voice traffic from any group.

Figure 1: SyTech RIOS and Managing Computer (Provided)

The portable version of the RIOS, which was tested, consists of two metal-cased components combined into a portable plastic case that is rack-mountable. Configuration of the device is primarily conducted through a computer connected via an Ethernet or RS-232 serial line. A managing computer is provided to perform device programming. The managing computer can monitor any audio communications activity that takes place using the RIOS. With additional software, the managing computer can store and back up the audio communications.

For all tests, setup and operation of the unit were conducted according to manufacturer documentation. This report refers to the Revision 2.03.106 16 June 2004 version of the *Rack Mount Radio Inter-Operability System (RIOS) Operations Manual* as “the RIOS user’s manual.” The unit was conformance tested in accord with vendor-supplied product specifications detailed on the SyTech Corporation Web site (http://www.sytechcorp.com).

3 General Evaluation Approach – Laboratory Testing

The first phase of evaluation involves laboratory testing and analysis. The aim is to answer two basic questions:

- Does the product operate and perform "as advertised," and successfully address the interoperability problems that it was designed to confront?
- Did issues arise during the testing that might affect the use of the product for the purposes advertised?

ITS conducted a series of tests to confirm that the device operates in conformance with published specifications. In addition, ancillary tests of significant interest to the users and agencies in general, were performed to provide a means to benchmark or compare this device to others in its class.

The next sections outline the types of tests and analysis performed. Section 4 lists detailed test and analysis procedures for the RIOS.

3.1 Performance Testing

Performance testing quantifies the performance of the RIOS gateway device by evaluating the degradation, if any, it inflicts on end-to-end (radio system-to-radio system) operation. Although not specified by the manufacturer, the following performance parameters were considered important for this evaluation and were assessed:

- Input audio impedance
- Output audio impedance
- Audio distortion
- Audio frequency response
- VOX input threshold
- VOX attack time and throughput delay
- Crosstalk

3.2 Observations

Section 4.3 describes significant observations on:

- RF emissions
- Use of setup and control software on computer
- Manufacturer responsiveness

4 RIOS Evaluation

The sixteen input/output (I/O) channels are designated as ports 1 to 16 throughout this report. The RIOS accepts both audio input and output (I/O) signals at its interface ports. Figure 2 shows how connections to the audio input and output signals at these radio ports were made using audio I/O cables. ITS engineers custom-made the cables that mate with the DB-25C connectors on the RIOS. Each cable provides the connections to the RIOS interface ports using a pigtail with XLR connectors on each end: one for audio input and one for audio output. The manufacturer provided no pin-out information for the DB-25C connectors on the RIOS.

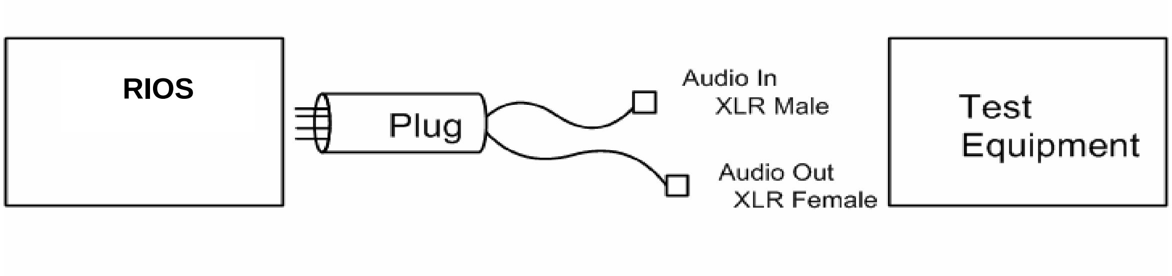

Figure 2: Audio I/O Cable

The following test equipment was used to conduct these tests:

- Tektronix TDS 3012B Digital Phosphor Oscilloscope
- Audio Precision ATS-1 Dual Domain Audio Test System Audio Analyzer
- IET Labs Precision Resistance Substituter (model number RS-201)
- Agilent E4443A PSA Series Spectrum Analyzer

In this report, the Tektronix TDS 3012B Digital Phosphor Oscilloscope is referred to as *DPO*. The Audio Precision ATS-1 Dual Domain Audio Test System Audio Analyzer is referred to as *ATS*.

4.1 Performance Characteristics

The next sections list measurements for performance parameters not specified by the manufacturer, and summarize the results obtained. Each test comprises the following components:

- Test Procedures
- Test Case Results and Summary

4.1.1 Input Audio Impedance

Impedance refers to the amount of resistance to an electrical current. Input impedance provides information on the types of electrical signals that can be input into the device. If this parameter is out of specification, potential effects include increased noise in the audio signal.

Test Procedures

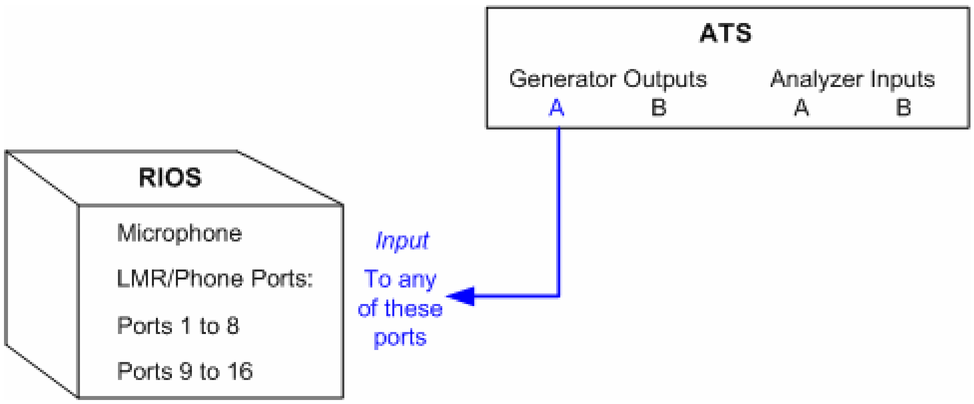

Figure 3: Balanced Input Audio Impedance

1. For each radio port, connect the RIOS audio input to the Generator Output A port of the ATS.
2. Configure a 1 kilohertz (kHz) sine wave as the input signal to the RIOS from the Generator Output A port of the ATS.
3. From the front panel of the ATS, select the Gen Load softkey. This will automatically measure the input impedance of the radio port tested.
4. Record the input impedance measurement from the front panel display of the ATS.

Test Case Results and Summary

Table 1: Input Impedance

Radio Port	Measured Impedance (ohms)
Port 1	794
Port 2	796
Port 3	791
Port 4	795
Port 5	791
Port 6	794
Port 7	789
Port 8	794
Port 9	793
Port 10	795
Port 11	791
Port 12	791
Port 13	797
Port 14	794
Port 15	794
Port 16	793

For typical applications, an input impedance greater than 600 ohms will provide appropriate impedance for a proper connection.

4.1.2 Output Audio Impedance

Output impedance provides information on the electrical signal that can be provided to other devices. When output audio impedance is greater than the specified value, potential effects include increased noise in the audio signal.

Test Procedures

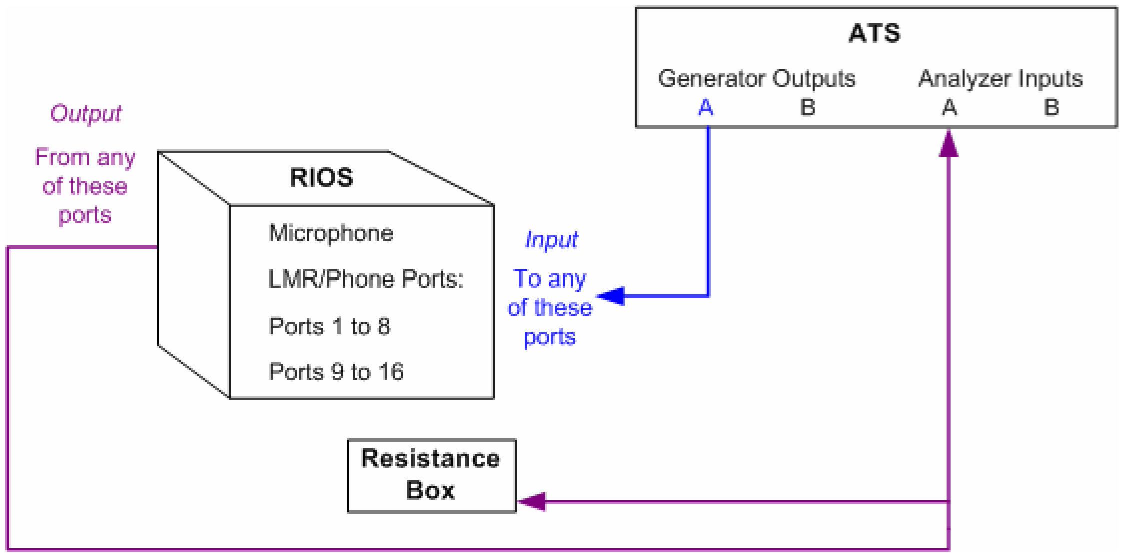

Figure 4: Output Audio Impedance

1. For each radio port, assign the radio port being tested to net 1 (*net* means network).
2. Assign one of the other radio ports to net 1. This will be the input interface. Ensure that no other radio ports are assigned to net 1.
3. Connect the ATS I/O cables to the radio port tested and the input radio port.
4. At the input radio port, connect the audio cable's input pigtail to the Generator Output A port of the ATS.
5. At the radio port tested, connect the audio cable's output pigtail to an adjustable resistance box. Split the signal to connect the Analyzer Input A port of the ATS in parallel with the resistance box.
6. Configure the ATS to provide a 1 kHz sine wave at a value of 287 mVp (peak level in millivolts).
7. Record the non-terminated voltage reading from the ATS. Calculate the value for a 50 percent reduction in voltage.
8. Connect the resistance box on the output radio port. Adjust its load resistance until the 50 percent reduction in voltage is measured at the ATS. The value of the resistance box, when connected in parallel with the output radio port that yields a 50 percent reduction in the output voltage, should equal the output impedance of the radio port.
9. Record the output impedance value.

Test Case Results and Summary

Table 2: Output Impedance

Input Radio Port	Output Radio Port	Open Channel Voltage (mV)	Half V (mV)	Gateway Setting (ohms)
1	2	1.99	0.995	8.768
1	3	1.97	0.958	8.865
1	4	1.98	0.99	8.999
1	5	1.86	0.93	8.388

Input Radio Port	Output Radio Port	Open Channel Voltage (mV)	Half V (mV)	Gateway Setting (ohms)
1	6	2.05	1.025	8.996
1	7	2.04	1.02	9.311
1	8	2	1	9.321
1	9	1.93	0.965	8.822
1	10	1.98	0.99	9.112
1	11	1.9	0.95	8.11
1	12	1.86	0.93	8.119
1	13	2.18	1.09	8.223
1	14	2.14	1.07	8.101
1	15	2.09	1.045	8.221
1	16	2.19	1.095	8.334

Table 5 shows the output impedance of each port of the device. Considering the crudeness of this measurement method, the output impedance in the table is quite reasonable. It should operate satisfactorily with other audio equipment that requires 10,000 ohms input.

4.1.3 Audio Frequency Response

Audio frequency response indicates how accurately the device outputs a speech signal from a given input signal. The frequency band that the telephone industry has used for decades is 300 Hertz (Hz) to 3.5 kHz. It is generally accepted that accurate reproduction across this band will allow for good speaker recognition and for speaker voice characteristic (e.g., emotional state) recognition.

Test Procedures

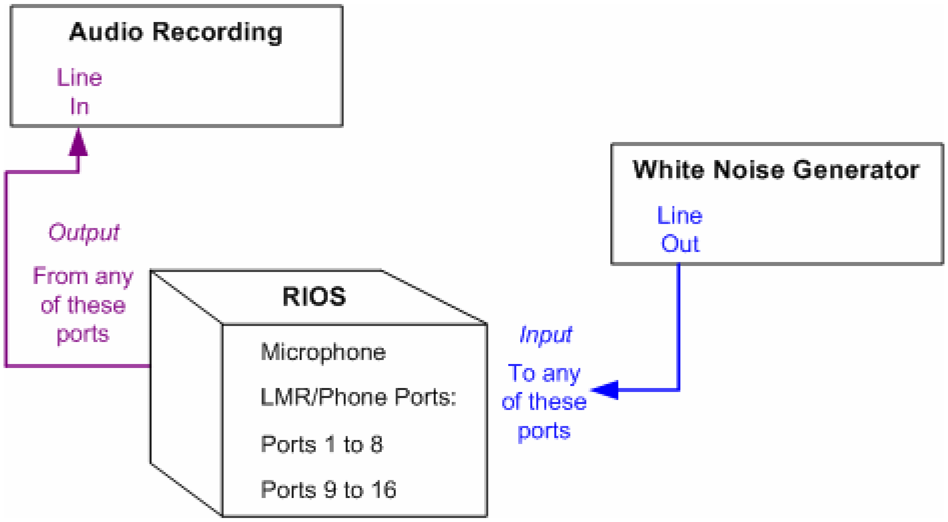

Figure 5: Frequency Response

This test is performed non-invasively by combining the input and output frequency response tests.

1. For each output radio port to be tested, assign a single input by making the appropriate net selection.
2. Inject white noise into the port.
3. Record the audio output.
4. Calculate the Fast Fourier Transform (FFT) of the audio output response.
5. Plot the device frequency response.

Test Case Results and Summary

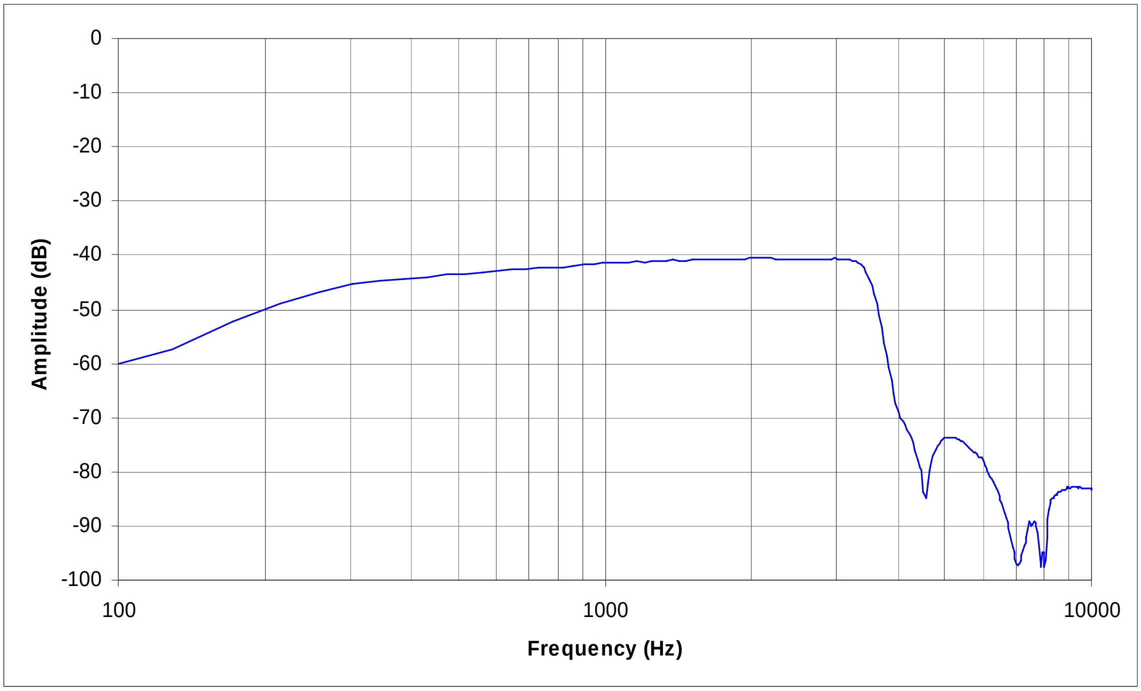

Figure 6: Frequency Response – Input Port to Output Port

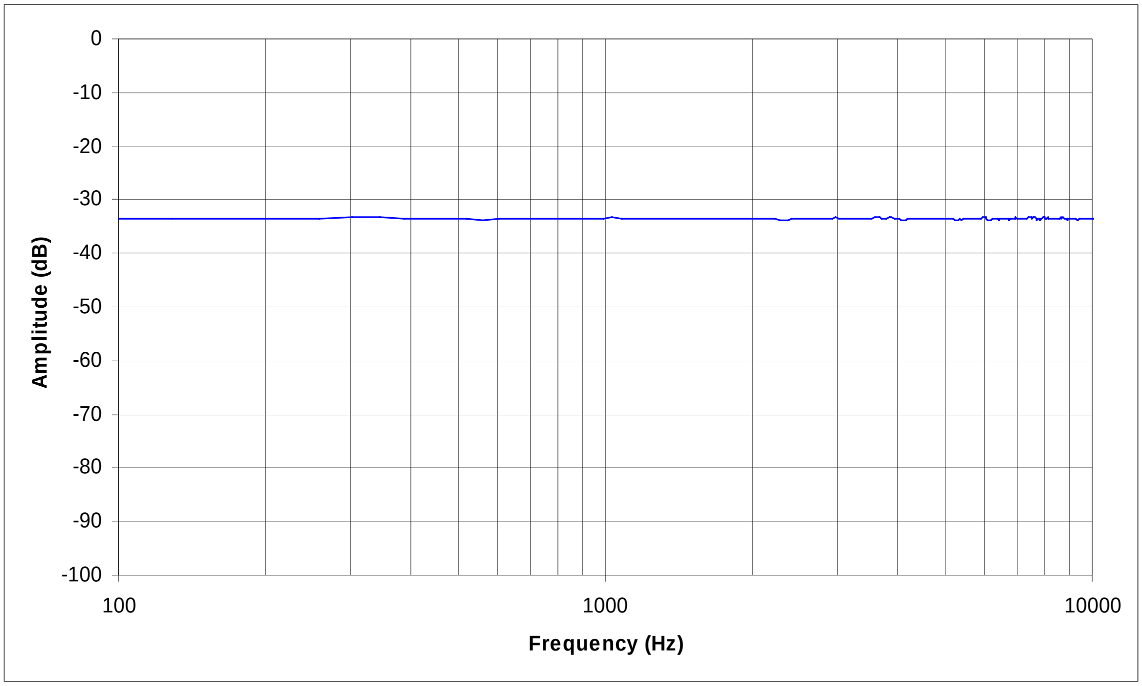

Figure 7: FFT of Input Noise Used To Determine Frequency Response

The -3 dB pass band of the RIOS is approximately 520 Hz to 3450 Hz. While this is generally acceptable at the high end, it is typically preferred if the low end of the -3 dB pass band is at 300 Hz or lower. At 300 Hz, there was approximately 5 dB of attenuation. This may have the effect of making male voices sound thin or tinny.

4.1.4 VOX Input Threshold

The VOX input threshold is the level of signal at which the device switches open the channel to allow a transmission to happen. It is an audio signal equivalent to a radio squelch control, helping the device to distinguish a valid signal from background noise. How the threshold is set may affect how the device reacts to quiet sounds, such as someone whispering over a radio channel or someone who talks very quietly.

Test Procedures

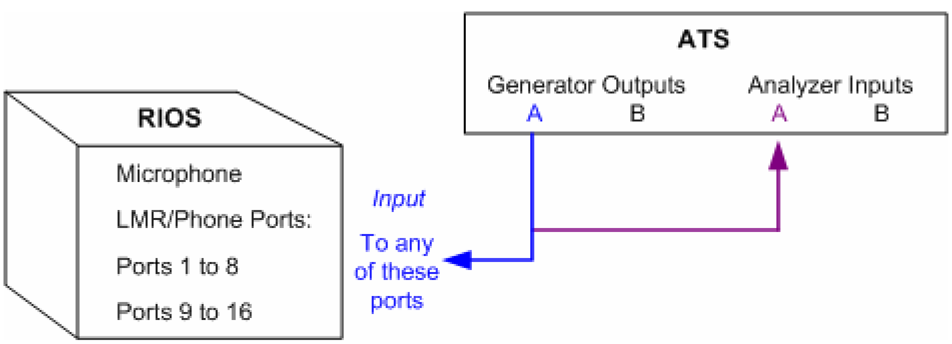

Figure 8: VOX Input Threshold

1. For each radio port, connect the RIOS audio input to the Generator Output A port of the ATS.

2. Configure a 1 kHz sine wave as the input signal to the RIOS from the Generator Output A port of the ATS. Use either the maximum or minimum specified input level.
3. Adjust the radio ports to the desired VOX level.
4. Increase the ATS Generator Output A port level until the VOX circuitry activates.
5. Record the output amplitude from the ATS and the VOX level on the RIOS.

Test Case Results and Summary

Table 3: VOX Input Threshold Meaurement Results

Generator Output (mVp) to Port 1	VOX Setting (dB)	Generator Output (mVp) to Port 1	VOX settings in dB
100	-28	550	-13
125	-26	625	-12
150	-24	675	-11
175	-23	775	-10
200	-22	875	-9
225	-21	975	-8
250	-20	1075	-7
275	-19	1200	-6
300	-18	1350	-5
350	-17	1525	-4
400	-16	1700	-3
425	-15	1925	-2
475	-14	2150	-1

Table 3 shows the measured VOX threshold setting for the entire range settable in the RIOS software. The range of settings accommodate a reasonable range of input levels.

4.1.5 Throughput Delay and Transmit Delay

Throughput delay is the amount of time it takes the device to reproduce an audio signal on the output port that is presented at the input port. It is separate from, but often related to, VOX attack time.

VOX attack time is the time interval between the device's receipt of a valid audio signal, and when the device recognizes that the signal is valid and actually starts allowing the audio signal to be reproduced at the output. Longer attack times can lead to pieces of words getting clipped from the beginning of a message.

The VOX transmit delay is an additional, programmable delay to allow time for transmitters to ramp up before the audio signal starts. This helps to avoid the loss of words or syllables in transmission.

Test Procedures

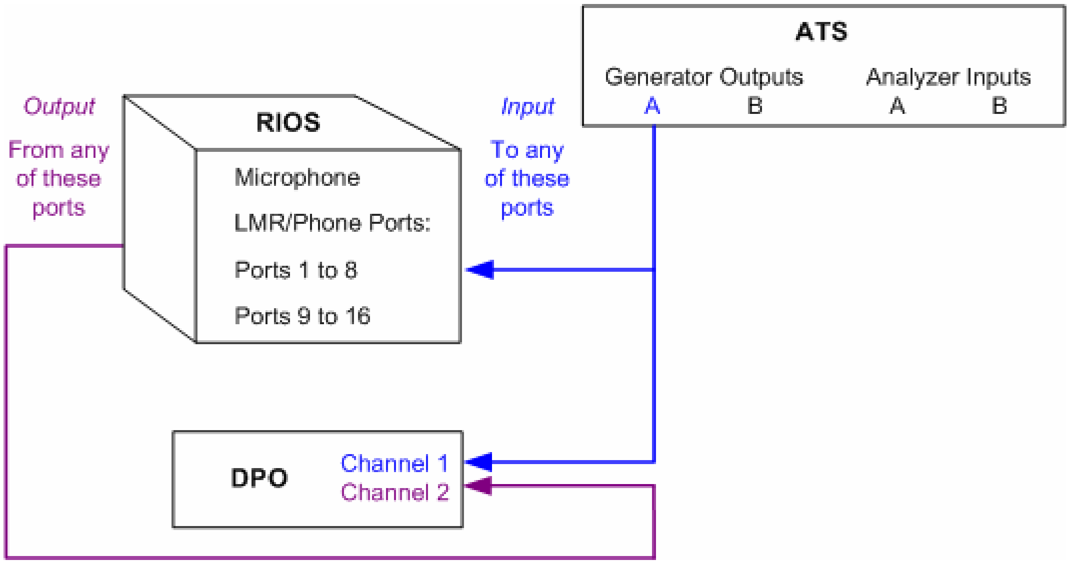

Figure 9: VOX Attack Time and Throughput Delay

1. Connect the output of an input source, such as the ATS, to the TCB-2 input port under test and to the DPO.
2. Configure the ATS to give a 20 millisecond (ms) 1 kHz burst with a 0.8 second duty cycle.
3. Set the DPO to single sweep mode, externally triggered from the ATS.
4. Connect the output radio port to the DPO.
5. Adjust the DPO as appropriate.
6. Each time the signal is initiated, it will simultaneously trigger the DPO and the voice activation feature of the RIOS radio port. Record the time difference from the input signal to the output signal.

Test Case Results and Summary

Table 4: Audio Throughput Delay (Input on Radio Port 11)

Radio Port	Average Measured Delay (ms)
11	235

4.1.6 Audio Distortion – SINAD and THD+N

SINAD is the ratio of Signal + Noise + Distortion to Noise + Distortion. SINAD is a rough, commonly used estimation of audio quality. Radio thresholds are commonly set at the point where SINAD equals 10, 12, or 20 dB. As long as the device does not approach these values (i.e., it has a significantly higher value), this matter is not a source of concern.

Total Harmonic Distortion + Noise (THD+N) is a measurement of how changed the audio signal is as it passes through a device. A THD+N higher than 0.3 percent would generally be considered slightly audible distortion, and a THD+N higher than 3.0 percent is generally considered audible distortion. Exceeding that threshold may cause difficulty in speaker recognition or in the identification of the emotional state of a speaker.

Test Procedures

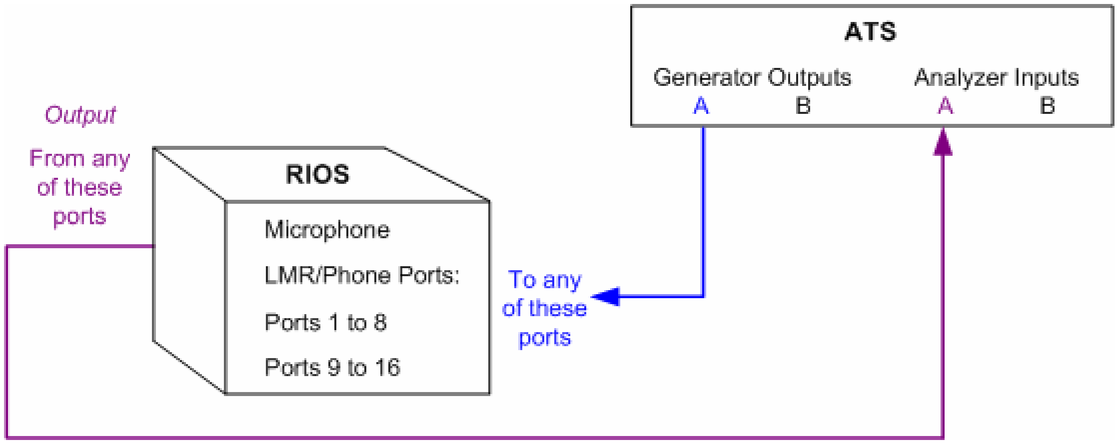

Figure 10: Audio Distortion: THD+N

1. Configure the ATS to measure THD+N using the front panel softkeys.
2. Connect the input radio port to the ATS, and apply a 1 kHz sine wave at an amplitude of 1 Vp.
3. Using the ATS, measure the THD+N and SINAD levels across a bandwidth of 22 Hz to 22 kHz.
4. Repeat the above steps for all output radio ports.

Test Case Results and Summary

Table 5: Summary of Measurement Results

Input Radio Port	Output Radio Port	THD+N (%)	SINAD (dB)
1	2	1.67	35.5
1	3	1.67	35.5
1	4	1.68	35.5
1	5	1.67	35.5
1	6	1.68	35.5
1	7	1.67	35.5
1	8	1.69	35.4
1	9	1.67	35.4
1	10	1.67	35.5
1	11	1.67	35.5
1	12	1.67	35.4
1	13	1.68	35.5
1	14	1.68	35.4
1	15	1.68	35.4
1	16	1.67	35.5

The THD+N and SINAD are consistent over all ports tested.

4.1.7 Crosstalk

Crosstalk occurs where the content of a signal on one path through a system bleeds over into other parts of the system. Being significantly off the specification could cause conversations of different groups to become confused or unintelligible. Further, a conversation from one net could be heard on a net for which it was unintended.

Test Procedures

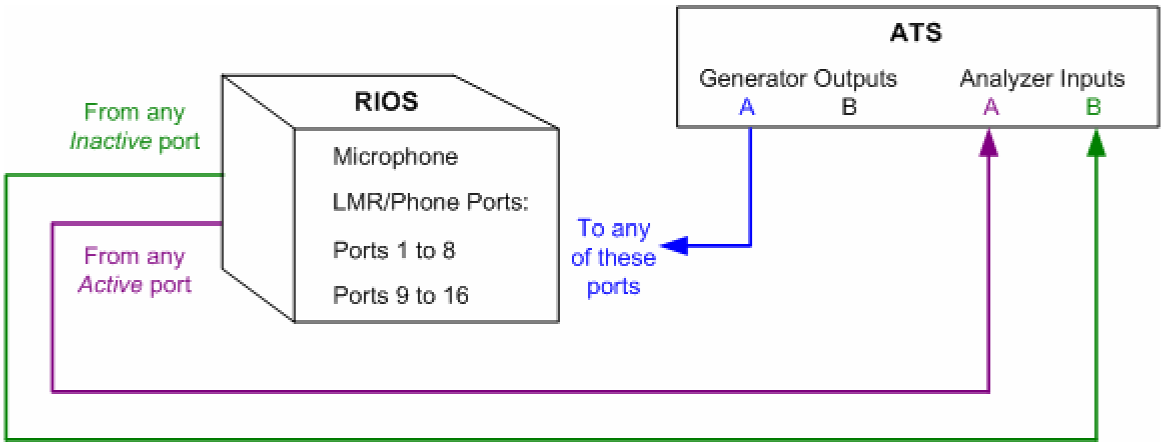

Figure 11: Crosstalk Measurement

1. Configure the ATS to measure crosstalk using the front panel softkeys.
2. Connect the input radio port to the ATS, and apply a 1 kHz sine wave with an amplitude of 2 Vp to trigger the input filter on the ATS.
3. Using the ATS measurement, determine the crosstalk in dBV.[3]
4. Repeat step 3 for all output radio ports.

Test Case Results and Summary

Table 6: Summary of Crosstalk Measurement Results

Measured Radio Port	Driven Radio Port (Input Amplitude)	Crosstalk (dBV)
2	3 (-24.3 dBV)	-122.2
4	3 (-24.3 dBV)	-129.8
5	3 (-24.3 dBV)	-128.8
6	3 (-24.3 dBV)	-130.3
7	3 (-24.3 dBV)	-126.9
8	3 (-24.3 dBV)	-123.2
9	3 (-24.3 dBV)	-121.2
10	3 (-24.3 dBV)	-119.9
11	3 (-24.3 dBV)	-118.6
12	3 (-24.3 dBV)	-115.9
13	3 (-24.3 dBV)	-127.5
14	3 (-24.3 dBV)	-128.2
15	3 (-24.3 dBV)	-129.9
16	3 (-24.3 dBV)	-128.8

[3] dBV refers to decibels relative to 1 volt peak to peak.

The crosstalk is consistent between radio ports on a single module and between radio ports on differing modules.

4.2 Observations

The next sections list observations that may interest public safety organizations, including: RF emissions and use of a computer for setup and monitoring.

4.2.1 RF Emissions

Gateway devices like the RIOS must operate in environments with other RF equipment. Therefore, an informal RF emissions scan was made in the 20 MHz to 500 MHz range on the RIOS, with no transmitters attached or active. This section details those measurement procedures and results.

Test Procedures

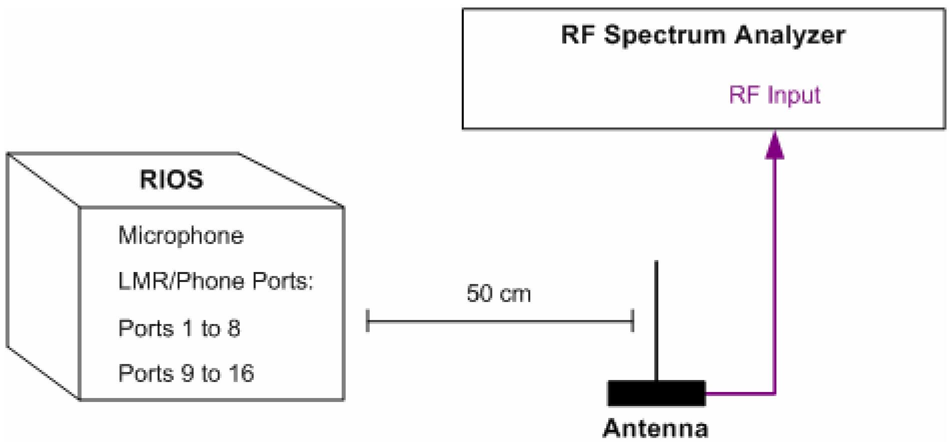

Figure 12: RF Emission Measurement

1. Configure the RF Spectrum Analyzer to measure RF energy from 20 MHz to 500 MHz, which encompasses the VHF band where interference was observed.
2. Position the antenna probe at 50 centimeters (cm) from the device under test.
3. Using the spectrum analyzer, record the RF energy across the frequency band of interest with the device under test powered off.
4. Repeat step 3 with the device under test powered on.

Test Results and Summary

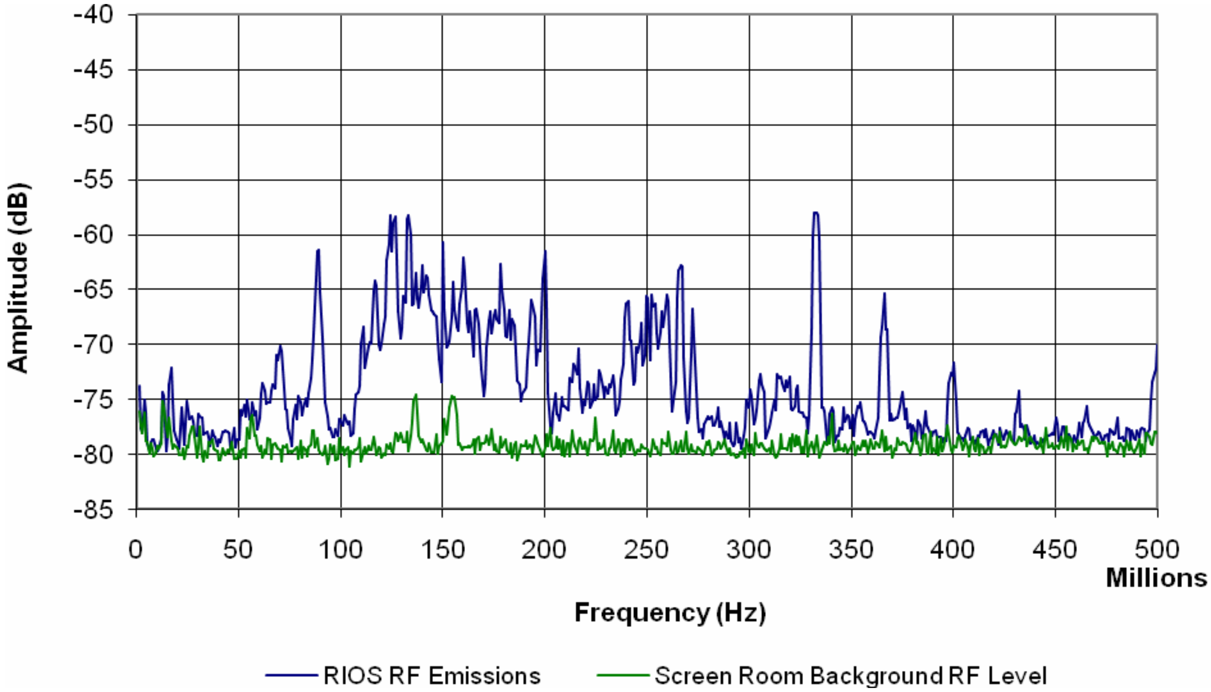

Figure 13: RIOS Horizontally Polarized RF Emissions from 20 MHz to 500 MHz

The RIOS does not appear to introduce significant RF energy into the environment.

4.2.2 Monitoring and Control Computer

A laptop computer with control software is provided with the RIOS for device configuration and monitoring. The computer is connected to the RIOS via the serial port or the Ethernet port.

Appendix: Glossary of Terms and Acronyms

AGC (Automatic Gain Control) – A process or means by which a signal level is adjusted in a specified manner. AGC attempts to keep a consistent output signal level regardless of the level of the input signal.

Crosstalk (Xtalk) – Undesired coupling or bleeding of a signal in one portion of an electronic circuit or channel into another, causing undesired effects if the crosstalk is too great

dBV – Decibels relative to 1 volt peak to peak

DHS – U.S. Department of Homeland Security

DPO – Digital Phosphor Oscilloscope, for the tests in this document, the Tektronix TDS 3012B

DTMF (Dual-tone multi-frequency) – A method of coding the numbers on a telephone touch pad into combinations of frequencies that machines can interpret.

FFT (Fast Fourier Transform) A computationally efficient means of computing the frequency content of a waveform

Hang Time – Indicates the duration that a channel is open following the most recent audio signal to exceed the VOX (voice operated transmit) level setting

I/O – Input/Output

LMR (Land Mobile Radio) – A common descriptor of the type of radio communication system frequently used by public safety practitioners

ms – Milliseconds

OIC – The Office of Interoperability and Compatibility within the DHS Science and Technology (S&T) Directorate

RF (Radio Frequency) – Of, or pertaining to, any frequency within the electromagnetic spectrum normally associated with radio wave propagation

RIOS – An interoperability communications controller manufactured by SyTech Corporation

RX – Received or Receiver

S&T – Science and Technology Directorate of DHS

SINAD – The ratio of Signal + Noise + Distortion to Noise + Distortion

THD+N – The sum of the Total Harmonic Distortion plus Noise. THD is the ratio of the power of all harmonic frequencies introduced by a system to the power of the fundamental frequency to which they are added.

Throughput Delay – The time from when a specific signal is introduced into the system being tested until that signal appears on an output port of the device being tested.

Transmit Delay – A delay intentionally introduced into an audio signal path to enable a transmitter to ramp up to appropriate power levels before the audio signal is presented to the transmitter. This is to avoid temporal clipping (for example, words or syllables being chopped off) at the beginning of a transmission.

TX – Transmitted or Transmitter

UHF (Ultra High Frequency) – Frequencies from 300 MHz to 3,000 MHz

VHF (Very High Frequency) – Frequencies from 30 MHz to 300 MHz

VOX (Voice Operated Transmit) – A device that transmits a signal only when an active audio signal (that is, voice) above the detection of a defined threshold

VOX Attack Time – The amount of time it takes a voice detection circuit to recognize that an audio signal is above the defined threshold and to begin transmitting that audio signal

Vp – Peak voltage

Vpp – Peak-to-peak voltage