Application Note

Mapping BER and Signal Strength of P25 Radio Systems

S412D

LMR Master™

September 9/11 and Hurricane Katrina were two pivotal events in the course of America's recent history. In addition to transforming the way the United States prepares for and responds to threats against the homeland and national disasters, these two events reinforced the need for interoperability between the U.S. military and civilian public safety agencies (e.g., police and fire). Project 25 (P25) is a suite of standards for digital radio communications that is specifically designed to meet this need.

While touting many benefits, the P25 standards pose interesting measurement challenges for installers and network managers of P25-compliant public safety communications systems. One key challenge lies in mapping bit error rate (BER) and signal strength (RSSI) measurements which are essential to diagnosing coverage problems and avoiding critical loss of communications. While general-purpose test equipment is currently available to measure P25 system components, these bench top, fully-featured laboratory design, development and compliance instruments are simply too expensive, not to mention big, bulky and very complicated to operate. Today's P25 radio system installers and network managers demand an alternate solution, one that offers a quick and easy, handheld approach to mapping BER and signal strength.

P25 Technology Overview

P25 standards govern the manufacturing of interoperable, digital two-way wireless communications products that are used by federal, state/province and local public safety agencies to communicate with other agencies and mutual aid response teams in emergencies. It was developed through the joint efforts of the Association of Public Safety Communications Officials International (APCO), the National Association of State Telecommunications Directors (NASTD), selected Federal Agencies, and the National Communications System (NCS). P25 was standardized and continues to be administered by the Telecommunications Industry Association (TIA) as ANSI/TIA-102. While developed primarily for North America, P25 technology and products have also been selected and deployed in other private system applications, worldwide.

P25 standards define the interfaces, operation and capabilities of any P25-compliant radio system. P25-compliant radios can communicate in analog mode with legacy radios and in either digital or analog mode with other P25 radios (Figure 1). Phase 1 radios are designed for 12.5-kHz channel bandwidths and use compatible 4 level FM (C4FM) modulation for digital transmissions. P25 radios must also operate in analog mode on either 25-kHz or 12.5-kHz channels. This backward compatibility allows P25 users to gradually transition to digital while continuing to use analog equipment. An open interface to the RF Sub-System, included in P25 radios, facilitates interlinking of different vendors' systems.

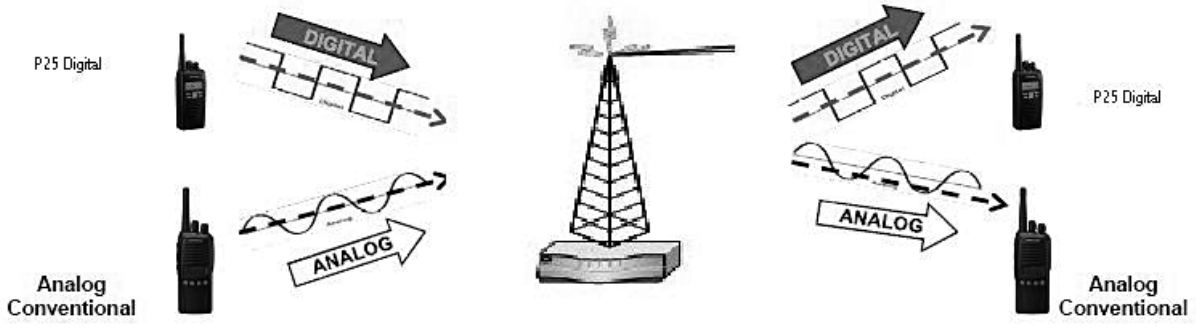

Figure 1. P25 radio systems can communicate in both analog and digital or modes.

When operating in digital mode, P25 radio systems can be either conventional or trunked. Conventional systems employ a relatively simple frequency-based talk-group allocation. Here, talk-groups are controlled by the radio users channel selection. In contrast, the management of a trunked system's operation, including talk-group allocation, is done by a control channel (Figure 2). Essentially, a group of traffic channels are automatically shared among a large group of talk-groups. As users request access, a controller in the infrastructure assigns the calls to specific traffic channels based on a talk-group priority list. Unlike cellular phone systems, the frequencies and control channel allocation are unique to every city and state. Each public safety organization must manage its own unique system.

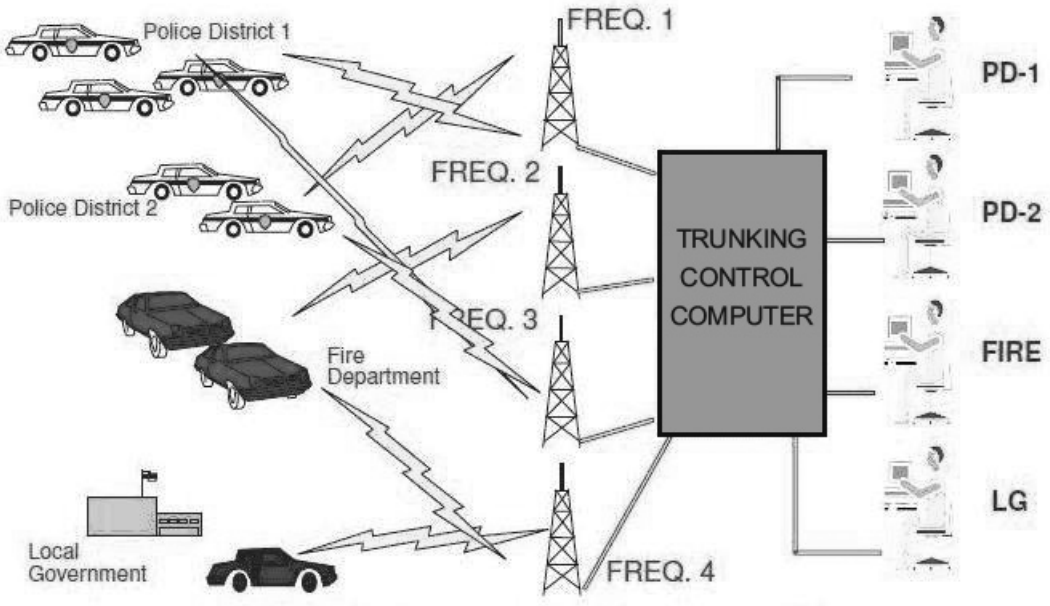

Figure 2. With trunked P25 radio systems, a limited number of channels are shared among a large number of users.

Both conventional and trunked P25 systems use C4FM modulation, operate at a 9600-bps bit rate, and utilize the Common Air Interface (CAI) which specifies the type and content of signals transmitted by P25-compliant radios. Advanced Encryption Standard (AES) and Data Encryption Standard (DES-OFB) algorithms, along with other encryption algorithms are used for secure P25 radio transmissions. P25 standards also support over-the-air rekeying (OTAR) features that allow subscriber encryption key management through a radio network.

A Better Approach

With digital communications systems like P25, multipath and fading can degrade communications, even when the signal strength is adequate. BER is the ultimate test of a digital communication system. At high signal strengths, greater than -90 dBm, there is a tight relationship between the BER and the signal strength. As the signal strength is reduced, it no longer predicts the bit error rate. Because of this, the P25 standard includes BER test patterns to allow mapping coverage of received BER. Handheld test equipment that can produce BER coverage maps are therefore critical as they provide installers and network managers with confidence that communications will be possible, even with local interference.

The Anritsu LMR Master is the industry's first battery-powered Land Mobile Radio (LMR) tester for P25 coverage mapping (Figure 3) plus also offers many of the tools needed to install, maintain and certify LMR systems including: a cable and antenna analyzer, spectrum analyzer, interference analyzer, power meter, channel scanner, P25 transmitter analyzer, transmission analyzer for 2-port devices, and GPS receiver.

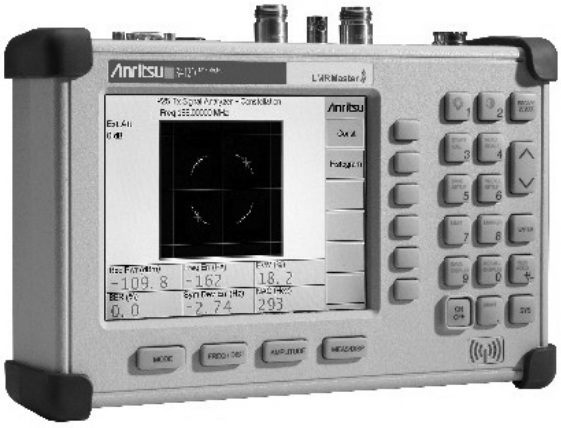

Figure 3. The Anritsu LMR Master is the ideal for LMR and Public Safety System technicians and engineers testing the RF performance of P25 radios in the VHF/UHF, 400 MHz, 700 MHz, and 800 MHz bands.

LMR Master supports P25 talk-out coverage mapping with BER measurements on 1011 Hz and O.153 talk-out-test BER patterns. GPS location and time are tagged for each measurement using the internal GPS receiver. Because these measurements cause signal disruption, LMR Master also provides alternatives for testing without disrupting the signal: BER estimation from voice traffic (e.g., FEC and payload data) and a message error rate (MER) measurement from control channel traffic. Both BER and MER are measured down to realistic -110 dbm signal levels.

When operating in Tx Signal Analyzer mode, LMR Master can display the control-channel messages in a P25 trunked system (Figure 4). Snapshots of up to 17 messages in Hexidecimal format can be displayed directly on the LMR Master display (Figure 5). Specific message headers can be selected as a trigger point. Control channel messages can be streamed out the RS232 port to a PC using Microsoft HyperTerminal or a decode utility PRO96COM.

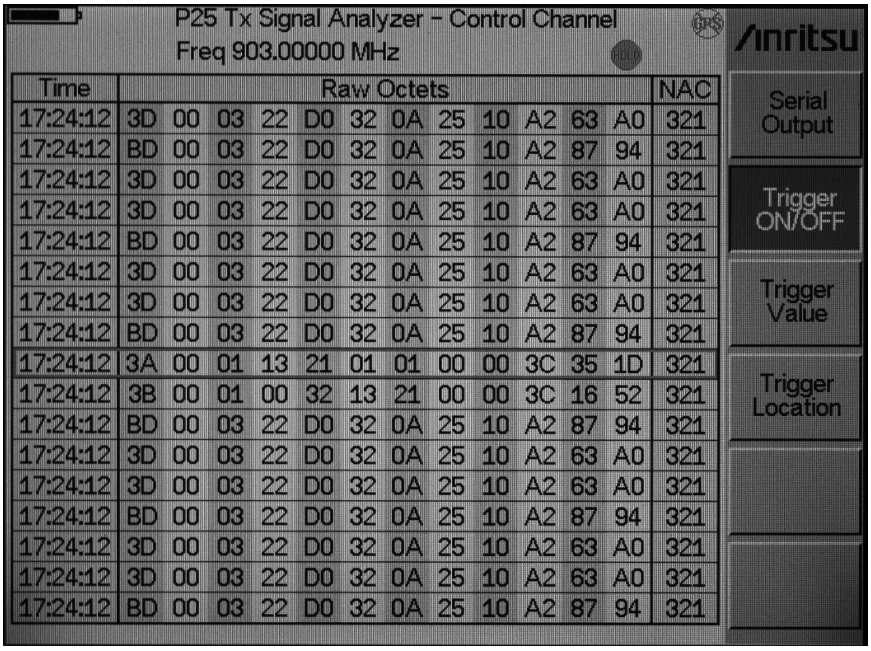

Figure 4. P25 control-channel messages are displayed in Hexidecimal format.

Figure 5. LMR Master can stream control channel traffic, real-time, to an external decode utility PRO96COM

P25 Coverage Mapping

Performing P25 talk-out coverage measurements is a now simple and straightforward process with Anritsu's LMR Master. To make coverage measurements, the installer or network manager simply connects a receive antenna and a GPS antenna to the LMR Master. The instrument automatically stores BER and receiver signal strength readings, along with GPS location, every second. Up to eight hours of continuous testing can be stored internally. The LMR Master can be run for 2 hours from its internal battery, or powered for an unlimited amount of time from a vehicle's cigarette lighter adapter (Figure 6).

Figure 6. LMR Master can be easily set up in the field to perform P25 coverage mapping.

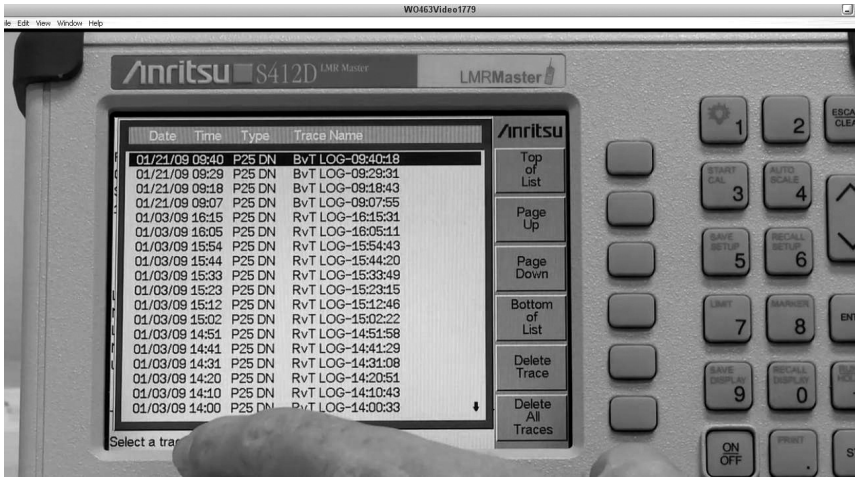

Figure 7. Traces of mapping data are automatically saved and can be later recalled and viewed from the LMR Master's front panel.

Traces of mapping data can be recalled and viewed from the LMR Master's front panel (Figure 7). Mapping traces can also be transferred to a PC using the RS232 interface with Anritsu's Master Software Tools which provide the user with comprehensive data management and post processing tools (Figure 8). Master Software Tools easily convert the stored traces to comma delimited ASCII files containing GPS location/time, RSSI and BER/MER, which can then be used with most third-party mapping software (Figure 9).

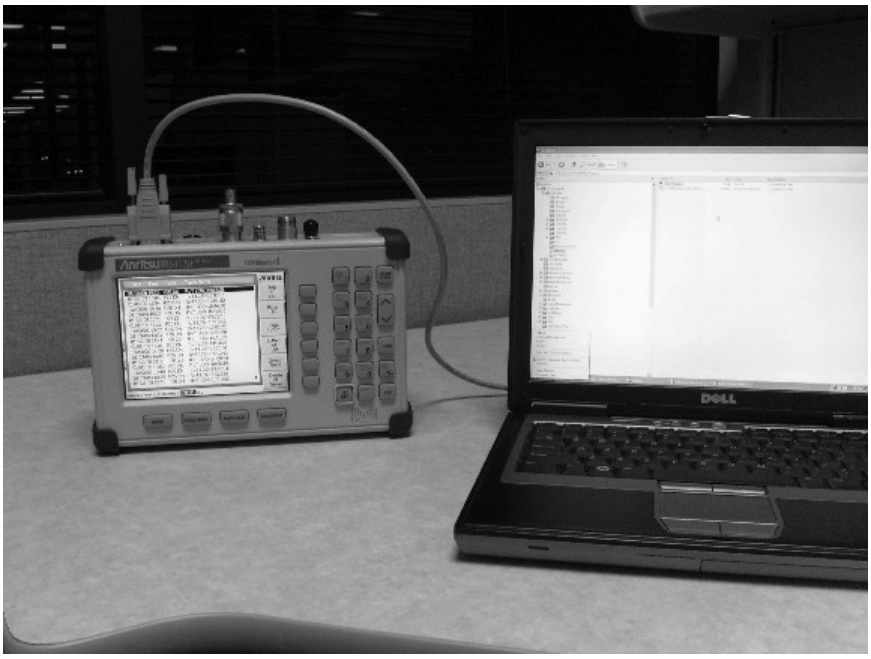

Figure 8. P25 coverage mapping data can be transferred to Anritsu's Master Software Tools via an RS232 interface.

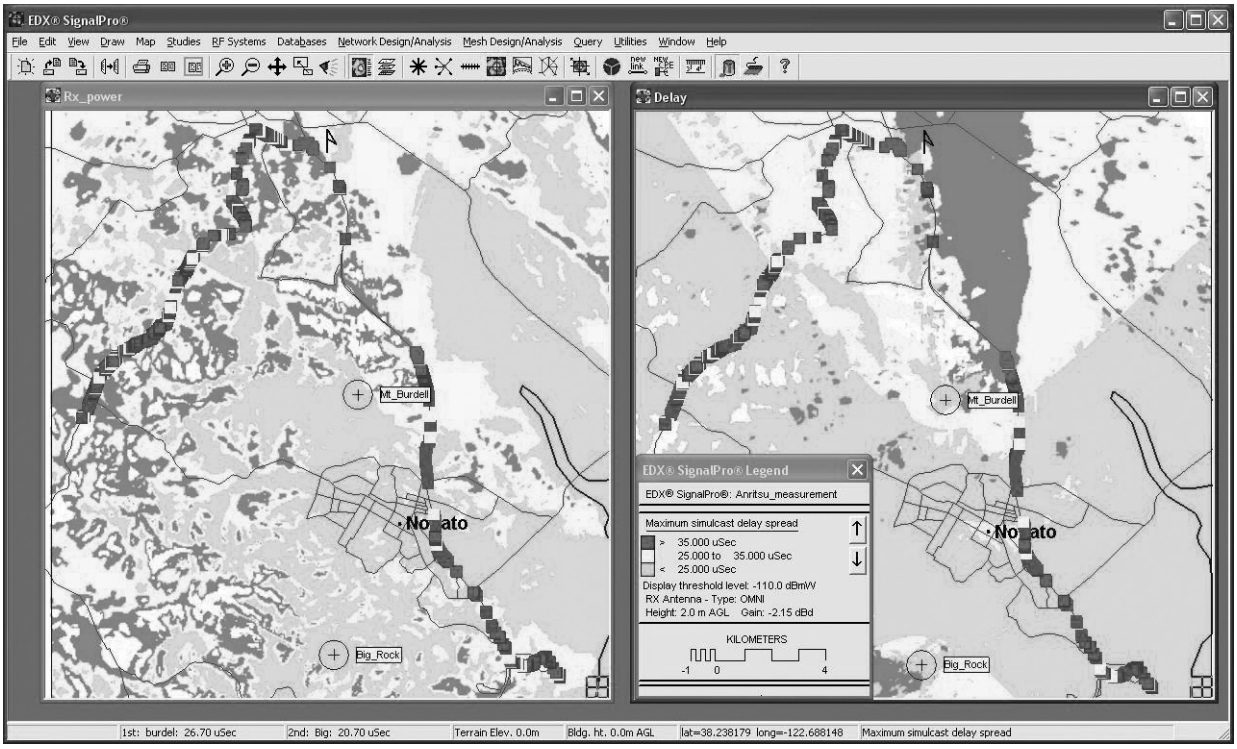

Figure 9. Shown here is an example of mapping data displayed with third-party mapping software from EDX.com.

LMR Master's Master Software Tools can also convert stored traces to a KML file format for use with the Google Earth application. Once the KML file is created, the installer or network manager simply clicks on the file name with Windows Explorer, which in turn activates Google Earth and displays the measurement locations (Figure 10).

Measurement locations are shown by colored push pins. Individual pins can be selected to show the measurements at that location.

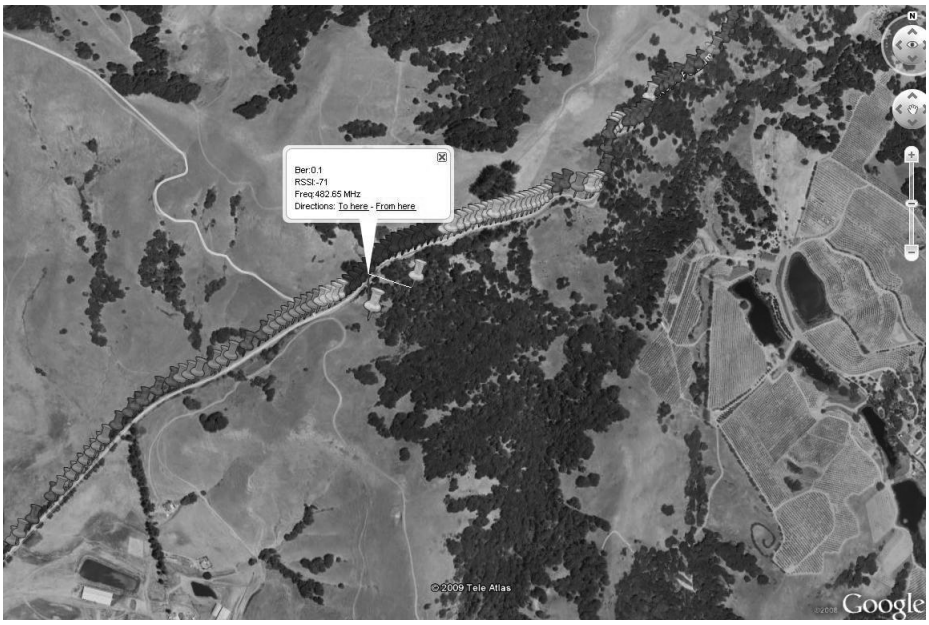

Figure 10. Google Earth can display LMR Master measurement locations.

	RSSI	**BER**
Green	> -80 dBm	0-5%
Yellow	-80 to -90	5-10%
Orange	-90 to -100	10-15%
Red	< -100 dBm	>15%

Table 1. BER and RSSI Measurements can be shown on Google Earth maps with the push pins colored as shown in the above table.

Summary

P25 coverage mapping is a key capability for diagnosing coverage problems in P25 public safety communications systems and ultimately, avoiding a critical loss of communications. An excellent way to map the BER/MER and signal strength of P25 systems is through use of the Anritsu LMR Master. This solution also supports P25 control channel measurements, along with measurements for most of the P25 system's components—all in one easy-to-use, battery-powered instrument. Such capabilities are absolutely critical to assuring robust and reliable communications with today's P25 radio communications systems.

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Application Note No. 11410-00508, Rev. A Printed in United States 2009-05