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PTC Radio Testing

The radio equipment at the heart of a positive train control (PTC) network must be in optimal condition.

By Wayne Black and Ed Mick

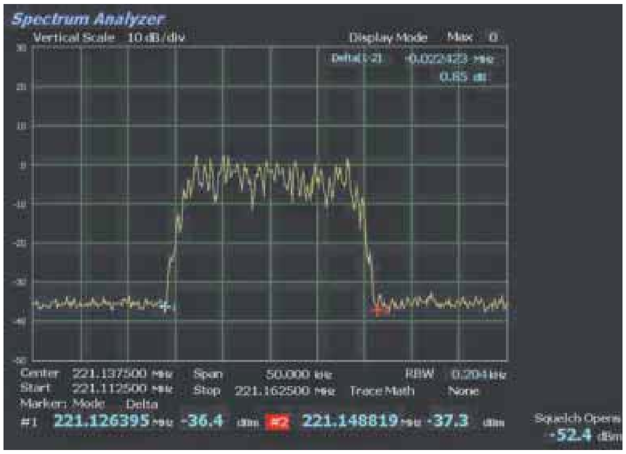
On Sept. 12, 2008, a commuter rail train collided head-on with a long-haul freight train in the Chatsworth district of Los Angeles, killing 25 people and injuring more than 100. The National Transportation Safety Board (NTSB) determined the cause of the crash to be the failure of the train's engineer to stop at a red signal — likely because of distraction resulting from texting.

Shortly thereafter, Congress passed the Rail Safety Improvement Act of 2008. Among its many provisions, the act mandated the implementation of positive train control (PTC) systems for "each Class I railroad carrier and each entity providing regularly scheduled intercity or commuter rail passenger transportation" by December 2015. With much of the industry still working toward compliance, Congress in 2015 passed the Surface Transportation Extension Act, which extended the deadline to Dec. 31, 2018, with the possibility of an extension through 2020 if certain conditions are met.

The Federal Railroad Administration (FRA) defines PTC as "a processor-based/communication-based train control system designed to prevent train accidents." The PTC mandate represents a high-level concept of train safety that can be implemented by whatever means an individual railroad selects. Although the FRA identifies 10 types of PTC systems, the two being widely implemented for federal compliance are the Interoperable Electronic Train Management System (I-ETMS) and the Advanced Civil Speed Enforcement System (ACSES). Most long-distance freight carriers are implementing I-ETMS, whereas commuter lines, particularly in the Northeast Corridor, are implementing ACSES.

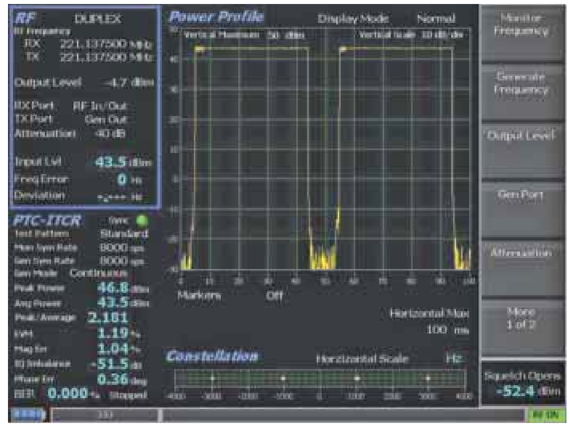
I-ETMS is designed to prevent track authority and speed limit violations, unauthorized entry into work zones and train movements through incorrectly positioned switches. The system monitors and ensures a crew's compliance with all operating instructions and provides a range of operating information to the train crew. As a train moves down a track, the I-ETMS computer continuously calculates warning and braking curves based on all relevant train and track information, including speed, location, movement authority, speed restrictions, work zones and consist restrictions. The system also queries wayside devices for broken rails, proper switch alignments and signal aspects.

DQPSK Waveform Verification



The expected waveform shapes for the full- and half-rate versions of the DQPSK signal are shown.

PTC-ITCR Measurements



The display zone in the center shows the power profile as seen for the same signal, while the PTC-ITCR zone on the bottom left displays the PTC signal quality metrics.

Images courtesy Freedom

Estimates predict that PTC will eventually cover nearly 70,000 miles of railroad tracks and about 25,000 locomotives. The FRA provides quarterly PTC implementation updates, tracking industry progress toward implementation based on several metrics.

As a comprehensive safety system, the PTC model involves many aspects of railroad operation. The FRA type approval defines four segments of an I-ETMS system: office, wayside, communications and locomotive. This article focuses on testing the radios at the heart of the I-ETMS communications segment.

I-ETMS uses a radio network known as Interoperable Train Control Radio (ITCR) that operates from 217.6 – 222 MHz using 25-kilohertz channels. The physical layer consists of a Pi/4 DQPSK waveform providing bit rates of 32 kilobits per second (kbps) at the full rate and 16 kbps at the half rate in a 25-kilohertz channel. The network consists of three types of radios: locomotive radios positioned in the cab of each locomotive, wayside radios positioned along the edge of the railroad tracks and 75-watt base radios.

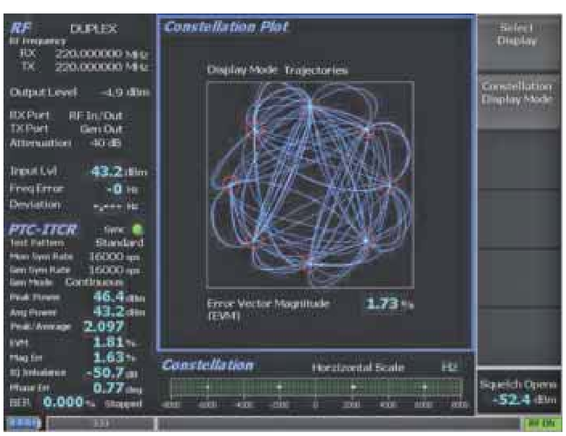
Meteorcomm and CalAmp produce ITCR radios, and testing requirements are identical for radios manufactured by the two firms. Accurate verification of radio operation is required during both initial radio installation and as part of an ongoing maintenance life cycle to meet the requirements of this critical communications system. Products such as the Freedom R8100 or R8000 equipped with the PTC test option provide the needed tools to properly test the physical-layer characteristics of ITC radios.

Key Measurements and Considerations

The following are key measurements and considerations for testing ITC radio transmitters. These descriptions detail some of the most critical testing required to verify proper operation of ITC radios. Technicians should follow instructions provided by the radio manufacturer to set up and configure radios for transmission and testing. A comprehensive list of test limits and procedures will be available to the radio technician in the service manual provided by the radio manufacturer.

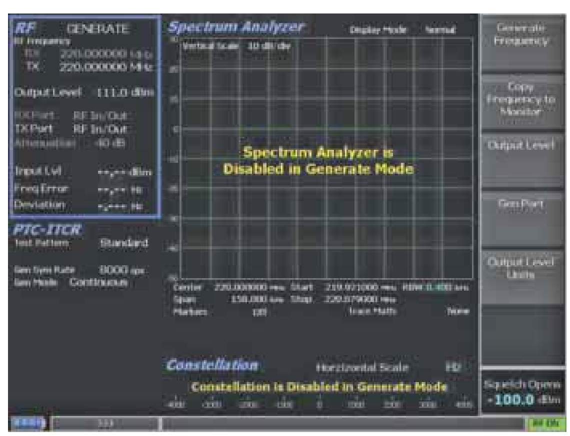
QPSK waveform verification. Using the manufacturer-provided con-

Constellation Plot with EVM



The figure shows frequency errors in the RF zone at the top left, and an EVM percentage reading, along with a constellation plot, in the display zone in the center.

Setup on Generate Mode



The analyzer should be placed in generate mode to output the DQPSK modulation with a specific symbol rate. The RF in/out port provides the signal to the ITC radio with starting amplitude of -100 dBm.

figuration software, the ITC radio can be placed in a test mode to transmit full- or half-rate signals. One basic visual test that can be quickly performed is verifying that waveform shapes are as expected from an ITC transmitter. The half-rate waveform should be virtually identical to the full-rate waveform, except it will have a narrower signal bandwidth.

RF peak and average power. When ITC radios are put in service, it's critical that output power is checked to verify compliance with specific link budget requirements for the installation location and adjusted if necessary. When the communications test analyzer is in sync with the radio transmission, the PTC-ITCR zone provides peak power, average power, peak/average, error vector magnitude (EVM), magnitude error, in-phase and quadrature (IQ) imbalance, and phase error measurements. When making power measurements, power should be fed into the RF in/out port, which can support full power from the ITC radios without an external attenuator.

Transmit center frequency and EVM are additional key PTC measurements. Radio manufacturers specify tolerances for each ITC radio type. A typical tolerance for frequency error is +/- 22 Hz at 220 MHz and is less than 5 percent for EVM.

Receiver sensitivity testing. Testing the ITC radio receiver sensitivity also requires the manufacturer's radio configuration software. To conduct the receiver sensitivity test, the radio must be set up according to the radio manufacturer's instructions. The communications analyzer should then be placed in generate mode to output the DQPSK modulation with a specific symbol rate. The analyzer's RF in/out port provides the signal to the ITC radio with starting amplitude of -100 dBm.

The radio configuration software will calculate and report bit error rate (BER) and power level in real time as the user adjusts the analyzer's output power level. The generated signal level should be taken down in 0.5 db steps while watching the BER measurement on the radio configuration software. When the BER is reporting errors greater than 1E-4, slowly increase the power level until the BER clears. Allow 10 seconds to verify constant BER. Then if the BER is less than 1E-4, the test is complete.

The typical specification for full-rate transmissions is -108 dBm or less and -111 dBm or less for half-rate transmissions. Radios with higher sensitivity levels should be further investigated because they may be unable to detect lower-level signals in some environments, threatening the integrity of the radio communications link.

The railroad industry and the federal government are fully committed to the near-term implementation of PTC. The American Association of Railroads (AAR) estimated that through 2015, the industry had spent about $6 billion on PTC, with another $4 billion to be spent before implementation is complete. When PTC is universally adopted, it is expected that tragedies such as the Chatsworth collision can be significantly reduced, if not eliminated.

To fully realize this potential, the radio communications equipment at the heart of the PTC network must be kept in optimal condition. Even the best network is of little value if not properly maintained and tested. ■

PTC Implementation through Quarter 3 2016

	Freight	Passenger
Radio Towers Installed	78%	45%
Locomotives Equipped	38%	29%
Route Miles in Operation	12%	23%
Track Segments Completed	20%	11%
Training Completed	50%	44%

Source: FRA

Wayne Black is the chief technical officer (CTO) for Freedom Communication Technologies. He previously served as technical director and engineering manager for General Dynamics and as an engineer on the NASA space shuttle program.

Ed Mick is the director of sales and marketing for Freedom Communication Technologies. He has held multiple product and sales management positions for Motorola, General Dynamics and Freedom Communication Technologies. Email feedback to editor@RRMediaGroup.com.