U.S. Department of Transportation

Federal Railroad Administration

RESEARCH RESULTS

FRA OFFICE OF RESEARCH, DEVELOPMENT & TECHNOLOGY

RR 18-10 | **July** 2018

POSITIVE TRAIN CONTROL INTEROPERABILITY TEST SUPPORT: RADIO FREQUENCY DESENSE TESTING

SUMMARY

The Federal Railroad Administration (FRA) sponsored research that was conducted by Transportation Technology Center, Inc. (TTCI) to evaluate the performance of the Advanced Civil Speed Enforcement System (ACSES) 220 MHz data radios and the Interoperable Train Control (ITC)-compliant 220 MHz data radios when they were in close geographical proximity. The radio frequency (RF) evaluation included:

- Developing test plans and procedures based on railroad input and deployment details
- Performing laboratory and field radio desensitization (desense) tests
- Executing tests to demonstrate the effectiveness of one potential mitigation technique
- Analyzing and reporting results

The Positive Train Control (PTC) tests, conducted from March, 2013 to March, 2015 at the Transportation Technology Center (TTC), quantified the potential degradation of communications system performance for dissimilar PTC radios that operate in the same geographical region. **Figure 1** shows a photograph of one of the radio desense field tests conducted as part of this project. The results of these tests led to the establishment of the Northeast Corridor (NEC) Communications team to collaborate and clearly identify the extent of the challenges the NEC railroads face in deploying dissimilar PTC radio networks, and, equally important, to promote the successful deployment of the two dissimilar PTC systems along the NEC.

Figure 1 Field Testing with an ACSES Radio on the Locomotive Desensing an ITC Wayside Radio

BACKGROUND

The NEC serves multiple passenger, commuter, and freight rail agencies. It extends from Washington D.C. to Boston, with several lines branching into nearby states. Two PTC systems are being deployed by NEC railroads: 1.) Advanced Civil Speed Enforcement System (ACSES) and 2.) Interoperable Train Control (ITC) or the Interoperable Electronic Train Management System (I-ETMS®).

Both PTC systems use 220 MHz data radios from different manufacturers and they use different communication protocols. Since the PTC systems use dissimilar radios that operate in the same frequency band, severe communication issues could occur in ACSES and ITC deployments within the NEC. In particular, if ACSES and ITC radios are used concurrently within close proximity of each other, loss of messages for the other type of radio can occur due to receiver desensitization (desense), if the problem is not properly mitigated.

Throughout the NEC, ACSES and ITC will be deployed in close proximity (sometimes on the same track). Additionally, in some locations, freight and passenger trains are to operate on the same track, which will require some trains to transition between ACSES and ITC territory.

OBJECTIVES

A critical component of interoperability between dissimilar PTC systems in revenue service is mitigating potential interference and performance problems among the radio frequency (RF) communications networks, because the ACSES and ITC systems are operating in the same geographic territory. The 220 MHz PTC radio testing conducted at TTC evaluated communication performance with operation of ACSES 220 MHz data radios and ITC-compliant 220 MHz data radios in the same geographical region.

METHODS

The communications performance evaluation focused on desense testing between the dissimilar radios. The test procedure determined the interfering signal level incident upon the radio under test (RUT) receiver, which resulted in a packet error rate (PER) greater than or equal to 5 percent for the RUT receiver. All tests followed a similar set of steps:

- A fixed desired signal level of -85 decibel-milliwatts (dBm) or -95 dBm at the RUT was set using attenuation on the signal emitted from the corresponding transmitter of either the ITC or ACSES system.
- The interfering signal was then introduced from a transmitter of the dissimilar PTC system, and the signal level was incrementally increased until the PER observed at the RUT was approximately 5 percent.

The 5 percent PER was established as the threshold for degraded performance because it is the PER currently used for planning the ITC RF network designs. This threshold was considered a reasonable target by the surveyed NEC commuter and passenger railroads. Many commuter railroads that responded to the survey design their RF networks to achieve a target coverage signal level of -85 dBm. The ITC target minimum signal level is in the range of -92 dBm to -95 dBm.

Two different cases for spectral separation were tested. A 50 kHz spectral separation represented the worst-case scenario with the ACSES and ITC systems operating on two nearly adjacent channels in the 220 MHz to 222 MHz range. A 1.1375 MHz spectral separation represented the worst-case scenario with an ACSES radio operating on a channel very close to 219 MHz, (218.9875 MHz) and an ITC radio operating on a channel near 220 MHz (220.1125 MHz).

RESULTS

The key tests for the ITC radios used a desired signal level of approximately -95 dBm at the RUT, and employed a spectral separation of 1.11375 MHz. At this desired signal level, interfering ACSES signals ranging from -18.1 dBm (for the ITC wayside radio) to -20.2 dBm (for the ITC base and ITC locomotive radios) resulted in the specified 5 percent PER for the RUT.

Applying a bandpass filter to the interfering signal may not be a typical practice in revenue service deployments, but it was used during some tests to improve the quantification of true desense as opposed to in-band interference.

The interfering signal strengths tolerated by the ITC base with a bandpass filter in line were up to 3.2 dB stronger than the interfering signal strengths tolerated by the ITC base without the bandpass filter in line. This may indicate some level of the spectral energy from the interfering ACSES radio may be present up to 1.1375 MHz away from the center frequency and could affect the ITC base receiver.

For a spectral separation of 1.1375MHz, the ITC radios tolerated interfering signal strengths that were 6.4 dB to 12.3 dB stronger than the interfering signal strengths tolerated by the ITC base for a spectral separation of 50 kHz.

The key tests for the ACSES radios used a desired signal level that was approximately -85 dBm at the RUT and a spectral separation of 1.1375 MHz. At this desired signal level, the interfering ITC signals ranging from -23 dBm to –28.3 dBm resulted in the specified 5 percent PER for the RUT.

Similar to ITC radios, the interfering signal strengths tolerated by the ACSES radio with a bandpass filter in line were up to 7.7 dB stronger than the interfering signal strengths tolerated by the ITC base without the bandpass filter in line. This may indicate that some spectral energy from the ITC base and ITC locomotive radios may be present 1.1375 MHz away from the center frequency and the receiving ACSES radio may be affected. **Figure 2** shows the PTC Test Laboratory at TTC that was used to conduct the desense testing.

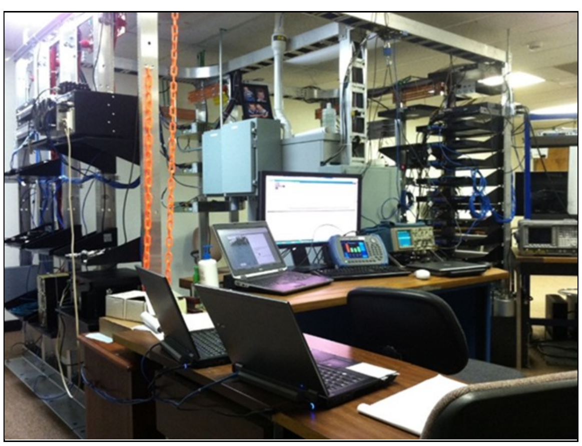

Figure 2 PTC Test Laboratory at TTC

Testing also included demonstration of a duplexer to successfully mitigate desense.

CONCLUSIONS

RF desense testing for the ACSES and ITC radios quantified a dissimilar radio's interfering signal that causes degraded communications performance. For a spectral separation between the ACSES and ITC radios of 1.1375 MHz, the ACSES TD220x had a PER of approximately 5 percent when it was subjected to an interfering ITC radio signal level of -28.3 dBm or stronger. The ITC radios had an approximate PER of 5 percent when subjected to an interfering ACSES signal level of -20.2 dBm or higher. An RF duplexer, capable of providing 80 dB or more of isolation between ACSES and ITC signals, was demonstrated to provide mitigation of interference and desense for ACSES and ITC radios co-located at a given communication tower.

FUTURE ACTION

The results of the RF tests provided information that the industry can use to quantify the effects that dissimilar PTC radios have on one another. As a result, the industry has decided to collaborate on a successful PTC deployment solution of both ACSES and ITC in the same or neighboring geographical locations, such as seen on the NEC. Two FRA-funded projects were awarded near the completion of this project to further investigate the potential of RF filter or active interference cancelling technologies to mitigate the desense issues for a locomotive equipped with both ITC and ACSES.

ACKNOWLEDGEMENTS

FRA would like to acknowledge the radio suppliers, Meteorcomm and General Electric, for loaning equipment and/or giving engineering support during the project. FRA would also like to acknowledge the railroads operating on the NEC for their technical guidance during the project, giving feedback for the test procedure, and sharing information regarding planned deployment details.

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KEYWORDS

PTC, ITC, ACSES, radio frequency, RF desense testing

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