900 MHZ TESTING REPORT

Evaluating the Interference Potential of Proposed LTE Operations in the 900 MHz Band

Abstract

The FCC has proposed adding a broadband LTE frequency allocation in the 900 MHz band currently used by critical infrastructure and others for voice and narrowband data, licensed under Part 27. Test were conducted to determine the interference potential of the proposed LTE operations in this band.
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Summary

Tests were conducted to measure the compatibility of existing LMR receivers with the proposal to permit LTE operations on adjacent spectrum in the existing LMR band. Concerns about potential interference to incumbent narrowband licensed operations in the 900 MHz band were the primary motivator for conducting these tests.

The testing focused on LMR receiver sensitivity and whether LTE base station signal strength in the same band would degrade LMR receiver sensitivity. This testing was designed to mimic the proposed 900 MHz spectrum plan where LMR systems and LTE broadband systems would be assigned immediately adjacent frequency allocations. Representative equipment was used for testing, including an LMR receiver fully compliant with TIA102 (P25) performance requirements and with an FCC equipment authorization. Similarly, a production Band 8 LTE base station was used.

Figure 1 shows LMR receiver sensitivity data as a function of incident LTE signal strength at the LMR receiver. Without the presence of an LTE signal the LMR device had a sensitivity of -121 dBm. The data show measured sensitivity for the lowest channel in the upper LMR sub-band (939.5125 MHz). This channel is centered 12.5 kHz away from the broadband allocation. The data shows sensitivity decreasing as LTE signal strength increases.
Introduction

A series of tests were conducted to evaluate coexistence of a 900 MHz broadband signal that is proposed within the current 900 MHz LMR band. The proposed allocation results in two segments (sub-bands) of LMR with a lower sub-band from 935.0125 – 936.4875 MHz and an upper sub-band from 939.4875 – 939.9875 MHz. In the lower sub-band, the lowest ~10 channels may be allocated to PTC (positive train control.) and therefore may not be available for incumbent LMR use.

The testing was designed to provide information on the compatibility of LMR operations with LTE when spectrum allocations are configured as proposed. This report provides information on how tests were performed and the raw data that resulted from testing.

Team members measured the effects of a spectrally adjacent LTE base station signal on typical LMR device performance. The base station signal was from commercially available equipment that was configured to match the bandwidth and frequency that has been proposed.

The goal of the testing was to collect data that measured LMR receiver sensitivity as a function of LTE signal levels. Testing was performed on an existing commercial LTE base station designed to operate in LTE Band 8. The operating frequency of this LTE base station corresponds with the proposed frequency allocation. Since no allocation for broadband communication equipment at 938 MHz exists in current FCC rules, no equipment authorization exists for this equipment.

Likewise, a representative LMR device was used to evaluate effects on radio sensitivity under varied broadband conditions. P25 C4FM was chosen as the LMR communication protocol. For measurement purposes P25 sensitivity was defined as the minimum signal power required to obtain a bit error rate (BER) of 5%.

Testing was focused on an LTE base station with high loading or channel occupancy.

Test methods and terms are based on TIA102-CAAA (P25 radio performance) methods and equipment definitions. Terms not defined in this document are defined in TIA102-CAAA.
Scenario: LMR Device operations near Broadband Base Stations

This scenario evaluates LMR receiver sensitivity as a function of the incident LTE base station signal strength at the LMR receiver port.

Test Objectives
The objective of these tests was to collect performance data relevant to each sub-scenario. Test results may influence planning for follow-on field testing that may be conducted. Where possible, testing has been designed to directly measure the effect of broadband operations on LMR receiver performance. The scope of this testing has focused on measuring the effects of nearby interference and not necessarily demonstrating through measurement the ability to separate interference mechanisms.

Common Information Applicable to LMR Receiver Tests
The LMR Receiver Tests were designed to understand LMR receiver sensitivity as a function of LTE signal strength at the LMR receiver’s location. This section provides general information applicable to all the receiver tests in this section. For testing, the LTE signal is centered at 938.0 MHz and generates the E-TM3.1 test signal as defined in 3GPP standard 36.141 and also specified for testing LTE rejection by P25 standards (TIA102-CAAA).

The test objective was to measure LMR receiver sensitivity as a function of LTE interference power. Table 1 identifies LMR protocols for testing. This table may be extended with additional protocols as desired, but only includes those performed.

Table 2 lists test frequencies. Test points include: the highest and lowest LMR channels at frequencies above the LTE proposed allocation and high and low channels for the wider lower LMR allocation. Additional test channels may be added to the table as needed.

Table 3 provides a range of LTE signal strengths for testing.

Table 1, Protocols for Testing

<table>
<thead>
<tr>
<th>Priority</th>
<th>Protocol</th>
<th>Performance Measure</th>
<th>Waveform</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P25</td>
<td>Reference Sensitivity</td>
<td>C4FM</td>
<td></td>
</tr>
</tbody>
</table>

Table 2, Test Cases

<table>
<thead>
<tr>
<th>Test</th>
<th>LMR Test Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>935.0125 MHz (Ch 1)</td>
</tr>
<tr>
<td>Test</td>
<td>LTE Signal Strength (dBm)</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>2</td>
<td>936.4875 MHz (CH 119)</td>
</tr>
<tr>
<td>3</td>
<td>939.5125 MHz (Ch 361)</td>
</tr>
<tr>
<td>4</td>
<td>939.9875 MHz (Ch 399)</td>
</tr>
</tbody>
</table>

Table 3, Interference RMS Signal Power

Test 1: LTE Rejection

Definition
This test measures the sensitivity of an LMR device receiver amidst varying levels of LTE base station signal strength.

Testing Considerations

Figure 2 illustrates the test configuration for LTE Rejection Testing. The LMR signal generation used was P25 C4FM as defined for receiver sensitivity testing. An Aeroflex 3920 with built in P25 BER generation was used. The signal level of the 3920 was adjusted to find the receiver 5% BER sensitivity for each test point. The reference LTE base station was configured for a single output at 80 watts operating in test mode E-TM3.1. This test mode was chosen to match the test mode specified in TIA 102-CCAA (P25 standard.) A fixed high power 30 dB attenuator was connected directly to the base station port and that was followed by a step variable attenuator used to adjust the incident LTE signal strength at the LMR radio under test. Following the variable attenuator, the signal was split to provide monitoring of the LTE signal. The Sage 8901 provided LTE power reference and demodulated the LTE signal to verify its proper test configuration. Finally, the LTE signal and P25 signal were combined and the combined signal passed
through a Faraday box to the test radio. BER performance of the radio was continuously monitored via a laptop that was connected to the Radio under test by USB.

![Diagram of test configuration](image)

**Figure 2, Test Configuration LTE Rejection**

**Method of Measurement**

1) Connect equipment as illustrated in *Figure 2*.
2) Configure the Standard LMR source according to *Table 4*.
3) Adjust the LMR signal source power to determine the LMR Standard Sensitivity.
4) Add the standard 3 MHz LTE interference signal centered at 938.0 MHz
5) Adjust the LTE signal starting at -50 dBm watching the BER screen for a change in the BER.
6) Begin taking data at an LTE signal level that noticeably increases the standard BER.
7) Find and record the LMR Standard BER Sensitivity.
8) Repeat testing for each LTE signal strength listed in the current item of *Table 4*.
9) Repeat testing for each item in *Table 4*.

*Table 4, LTE Rejection Test List,*

<table>
<thead>
<tr>
<th>Item</th>
<th>Protocol</th>
<th>LMR Test Frequency</th>
<th>LTE Bandwidth</th>
<th>LTE Signal Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P25 C4FM</td>
<td>935.0125 MHz</td>
<td>3 MHz</td>
<td>-50 to -20 dBm; 2 dB steps or ~ 30 dB desense</td>
</tr>
</tbody>
</table>

1 The starting power level of the interference source should be decreased if the BER sensitivity is reduced by more than 0.5 dB. A goal with this testing is to collect at least one data point before the radio significantly desenses.
### Required Performance
There is no required performance level for this test.

### Required Equipment List

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
<th>Example Part #</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMR Radio</td>
<td>1</td>
<td>Example device</td>
<td></td>
</tr>
<tr>
<td>LTE Base Station</td>
<td>1</td>
<td>Example device</td>
<td></td>
</tr>
<tr>
<td>LMR Signal Generator</td>
<td>1</td>
<td>Aeroflex 3920</td>
<td></td>
</tr>
<tr>
<td>LTE Analyzer</td>
<td>1</td>
<td>Sage 8901</td>
<td></td>
</tr>
<tr>
<td>30 dB Attenuator</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjustable attenuator N-female to N-female</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Splitter</td>
<td>2</td>
<td></td>
<td>This part is used as both a power splitter and power summer.</td>
</tr>
<tr>
<td>Coaxial Cable as required</td>
<td>x</td>
<td></td>
<td>Cable length may be adjusted for convenience</td>
</tr>
<tr>
<td>USB cable radio under test Faraday box</td>
<td>1</td>
<td></td>
<td>Cable length may be adjusted for convenience</td>
</tr>
<tr>
<td>USB extension cable Faraday box to laptop computer</td>
<td>1</td>
<td></td>
<td>Cable length may be adjusted for convenience</td>
</tr>
</tbody>
</table>
3 MHz Test Results

LMR sensitivity data was collected for a 3 MHz LTE interferer at 938 MHz and LMR channels at the lowest defined channel in the NPRM’s proposed low LMR sub-band (LL), the highest frequency channel in the lower sub-band (LH), the lowest frequency channel in the proposed upper sub-band (HL), and the highest frequency channel in the upper sub-band (HH). The results illustrated in Figure 3, demonstrate the effects of LTE signal strength on LMR sensitivity.

Figure 3, LMR Sensitivity vs LTE Power (3MHz)

The LL trace in blue illustrates the performance of the test LMR device when operating in the lowest defined LMR channel. Sensitivity is initially lost gradually followed by a more rapid loss in sensitivity beginning when LTE signal strength is above -30 dBm.

Traces LH and HL in purple and grey have very similar characteristics. They demonstrate desense of the LMR radio for the closest defined LMR channels directly above and below the proposed broadband allocation.

Finally Trace HH in Figure 3 illustrates the sensitivity obtained for the highest LMR channel defined.
1.4 MHz Test Results

LMR sensitivity data was collected for a 1.4 MHz LTE interferer at 938 MHz and LMR channels at the lowest defined channel in the low LMR sub-band (LL) and the highest frequency channel in the lower sub-band (LH). The results illustrated in Figure 4, demonstrate the effects of LTE signal strength on LMR sensitivity.

Figure 4, LMR Sensitivity vs LTE Power (3MHz)

The LL1p4 trace in blue illustrates the performance of the test LMR device when operating in the lowest defined LMR channel.

Trace LH1p4 in red demonstrates desense of the LMR radio for the closest defined LMR channel directly below the proposed broadband allocation.