Keysight Technologies
A Flexible Testbed to Evaluate Potential Co-Existence Issues Between Radar and Wireless

Application Note

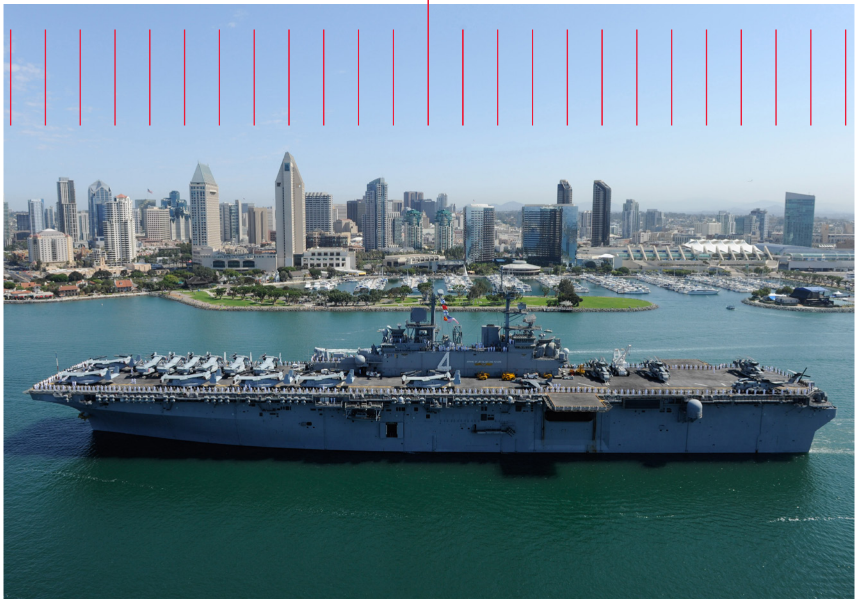

Photo courtesy US Department of Defense

Problem: Radar and wireless may interfere with each other

Today's radar and electronic warfare (EW) equipment operate in increasingly cluttered RF and microwave spectral environments, with many potential interference issues. Spectral environments may consist of many different types of emitters including radar, wireless communications, wireless networking, and other potential interference sources. Co-existence between radar and wireless systems has the potential to be a significant issue.

Investigating potential interference issues between complex wireless signals such as LTE (Long Term Evolution), WLAN (Wireless Local Area Network), WCDMA (Wide-band Code Division Multiplexing Access), and radar can be useful to ensure successful deployment. Testing these systems for co-existence prior to deployment may provide discernible benefits in terms of helping to identify potential co-existence issues earlier to reduce field testing time and potential re-work time. Finding and addressing problems in a lab environment is typically much less costly than trying to correct issues after deployment to the field.

Solution: A flexible R&D testbed combining design simulation with a precision arbitrary waveform generator

Recent advances in integrating the Keysight Technologies, Inc. SystemVue electronic-system-level (ESL) design simulation with its M8190A precision wideband arbitrary waveform generator (AWG) has made possible a new approach to creating and analyzing multi-emitter test signals using a commercial-off-the-shelf (COTS) approach. For example, design simulation arbitrary resampling techniques enable signals with different sampling rates (e.g., multiple radar, wireless communications, and wireless networking signals) to be combined into a single waveform which is downloaded to a high precision Keysight M8190A COTS AWG to create the multi-emitter test signal (Figure 1).

As will be shown with three different case studies, it is possible to combine Keysight's SystemVue design simulation with wideband COTS test equipment to create and analyze wideband multi-emitter test signals.

In the first case study, radar signals will be combined with LTE GSM (Global System for Mobile communications), EDGE (Enhanced Data rates for GSM Evolution), and WCDMA cellular signals, along with WLAN signals, to create several multi-emitter test signals. This case study will examine how radar and WCDMA signals can coexist.

The second case study will examine how radar and emerging 802.11ac wireless networking signals can co-exist, and what happens when radar signals interfere with 802.11ac WLAN signals.

The last case study will examine how radar and LTE signals can co-exist, and what happens when radar signals interfere with LTE signals.

The flexibility and adaptability of this R&D test solution allows multiple combinations of emitters to be tested for co-existence and evaluated for performance degradation. One set of test hardware can be used to test many combinations of potential interference scenarios, reducing and quantifying system integration risks for new hardware deployment.

Evaluating the level of interference being imposed by one system on another can be determined using metrics such as Error Vector Magnitude (EVM) and Bit Error Rate (BER) measurements. An RF signal analyzer is used to measure the spectrum and EVM performance to evaluate potential degradation due to interference. BER and throughput can be key metrics for receiver sensitivity, both with and without interferers present.

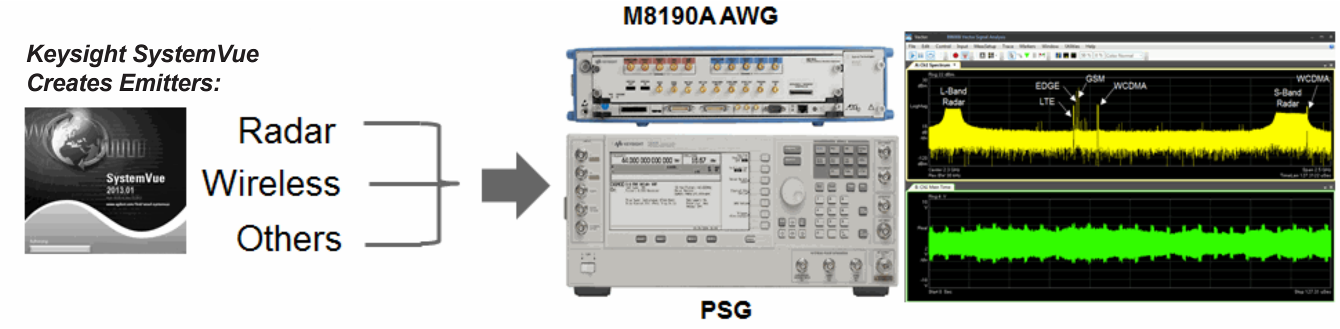

Figure 1. Creating multi-emitter signals.

Results, part 1: Coexistence of S-band radar and WCDMA

The first case study involves creating a multi-emitter test signal comprised of radar signals, LTE, EDGE, GSM, and WCDMA signals. The signals will be created in simulation, and then downloaded to the M8190A precision AWG to create the multi-emitter test signal on the test bench. Wideband signal analysis will then be performed with an ultra-wideband real-time oscilloscope with vector signal analysis (VSA) software. Modulation-domain analysis, by means of EVM analysis, will be performed with an RF signal analyzer with VSA software.

Figure 2 shows in schematic form some of the different wireless and radar signals that can co-exist and that would need to be combined to create a realistic interference signal for testing. Each signal type—radar, GSM and EDGE, LTE, and WCDMA—has its own unique center frequency, bandwidth, and sample rate appearing at the input to the Signal Combiner model prior to being resampled, combined, and downloaded to the M8190A AWG for generation of interference signals.

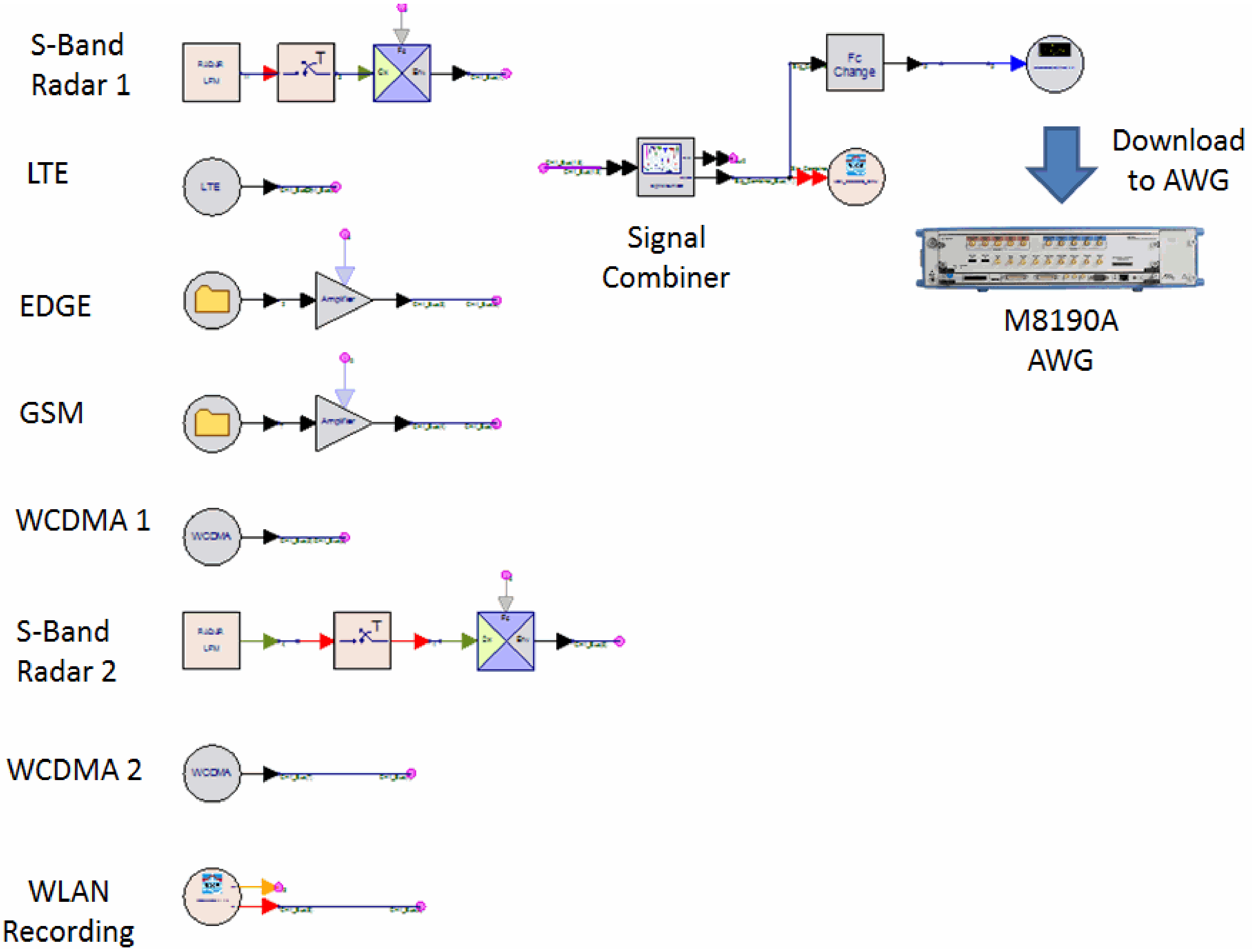

Figure 2. Multi-emitter simulation for radar and WCDMA co-existence case study.

Figure 3 shows the COTS test setup used to create and analyze multi-emitter test-signal environments. The SystemVue design simulation software (upper left) is installed in the AXIe embedded controller. The M8190A AWG output is analyzed by an Keysight Infiniium 62-GHz high-performance real-time oscilloscope with Keysight 89600 VSA software (upper right) and an N9030 PXA RF signal analyzer with VSA software (lower right). Wideband radar and multi-emitter spectral analysis is performed with the Infiniium oscilloscope, while demodulation (EVM) of the wireless emitters is accomplished by the PXA RF signal analyzer and the 89600 VSA software (lower right).

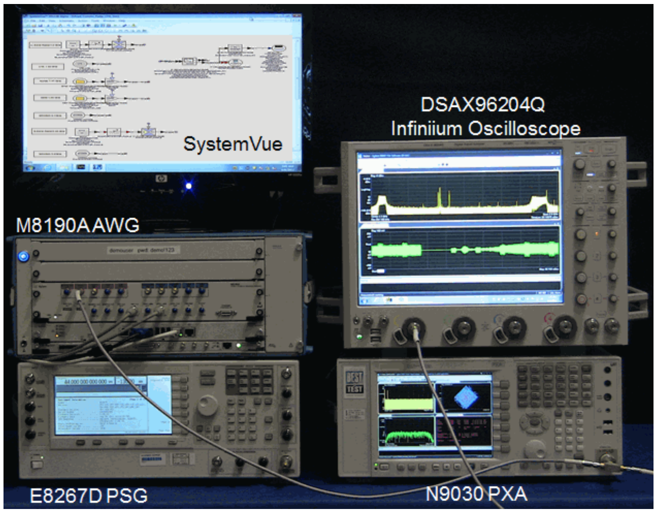

Figure 3. COTS test setup to create and analyzer multi-emitter test signals.

Figure 4's upper display shows the multi-emitter test signals as measured by the oscilloscope and VSA software. The L-band radar emitter is on the left, followed by the LTE, EDGE, GSM, and WCDMA emitters. The S-band radar emitter is on the right, with a WCDMA emitter sitting within the S-band radar's bandwidth.

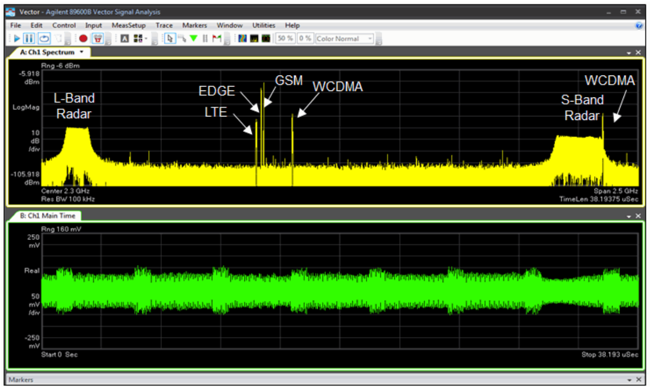

Figure 4. Multi-emitter test signal.

The PXA RF signal analyzer is used to effectively zoom into each of the wireless emitters and demodulate them with the 89600 VSA software. Figure 5 shows the GSM, EDGE, LTE, and WCDMA emitters being demodulated with the PXA RF signal analyzer and 89600 VSA software. The low residual EVMs demonstrate the signal fidelity of the precision AWG.

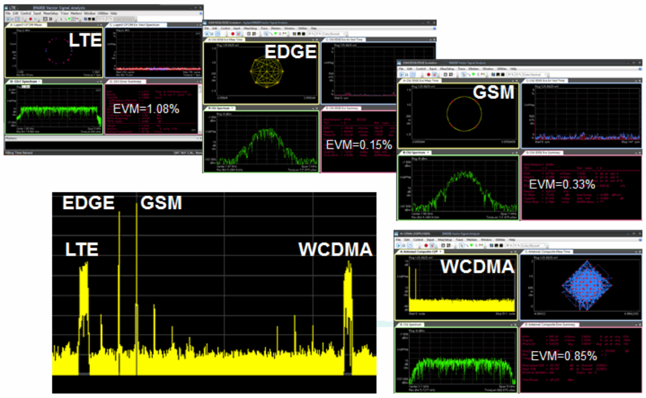

Figure 5. Demodulation of wireless signals unencumbered by radar interferer.

The multiple-emitter environment shown in figure 4 contains two WCDMA signals: one at 2.1 GHz (which is unencumbered by interferers within its 5-MHz channel bandwidth), and one at 3.4 GHz (which is sitting within the S-band radar's bandwidth).

Figure 5 shows a measured EVM of approximately 0.85% for the WCDMA signal at 2.1 GHz. However, Figure 6 shows that demodulating the WCDMA signal within the bandwidth of the S-band radar significantly impacts the WCDMA EVM performance. EVM has degraded to approximately 10%, while the radar signal is also impacted by the presence of the WCDMA emitter.

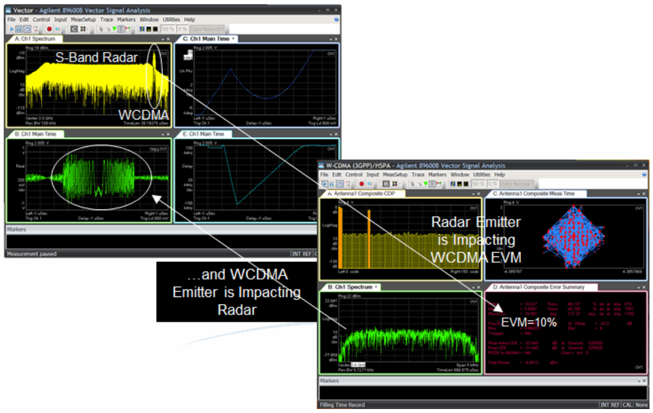

Figure 6. Demodulation of WCDMA signal in the presence of the radar interferer.

Results, part 2: Coexistence of C-band radar and 802.11ac VHT wireless LAN

The second case study uses the same COTS test setup to study potential coexistence issues between radar systems and emerging wireless networking signals. The test setup is reconfigured to examine the interaction between a C-band radar emitter and an 802.11ac Very High Throughput (VHT) WLAN emitter to help determine potential co-existence issues.

To examine this, a design simulation schematic was created to combine an 802.11ac WLAN 5.8-GHz emitter with a C-band radar signal (Figure 7). The 802.11ac simulation signal source is configured for a 160-MHz bandwidth, while the radar signal source is configured for a 200-MHz LFM chirp bandwidth.

The same COTS test setup used in the previous case study was also used to create and analyze this test signal; however, in this case the M8190A AWG was used to generate differential I/Q outputs which were then fed to the wideband I/Q inputs ports of the E8267D vector PSG signal generator. This configuration is used because the 5.8 GHz carrier frequency for the 802.11ac WLAN signal exceeds the maximum RF bandwidth of the AWG, so the PSG is used to modulate the M8190A AWG I/Q outputs on a 5.8 GHz carrier frequency. The PSG can be used for carrier frequencies to 44 GHz, however the external wideband I/Q inputs of the vector PSG are limited to a 2 GHz modulation bandwidth.

The C-band radar signal was set to several different frequencies to effectively “walk-through” the WLAN OFDMA (Orthogonal Frequency-Division Multiple Access) emitter (centered at 5.8 GHz) so that co-existence effects could be analyzed at different frequencies. Figure 8 shows one scenario where the radar emitter’s center frequency was set to 5.6 GHz, where it only slightly overlaps with the 5.8 GHz 802.11ac emitter. The EVM of the WLAN was measured at 3.1% for this case.

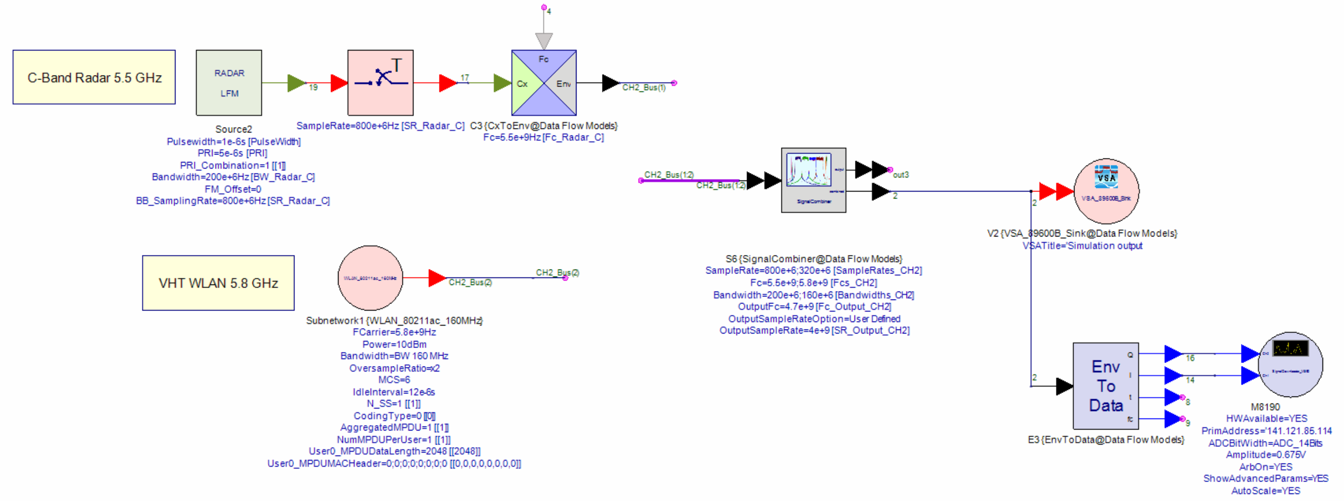

Figure 7. Multi-emitter simulation for C-band radar and 802.11ac WLAN co-existence case study

Figure 8. Slight overlap between 802.11ac WLAN and C-band radar signal.

Figure 9 shows a more severe case for the offending radar emitter, where its center frequency is set to 5.7 GHz, resulting in significant overlap between the radar and the 802.11ac WLAN OFDMA emitter. In this case, the radar emitter destructively impacts the 802.11ac WLAN emitter's EVM. Because the 89600 VSA software cannot achieve synchronization with the WLAN emitter due to the radar interferer, it is unable to demodulate the waveform.

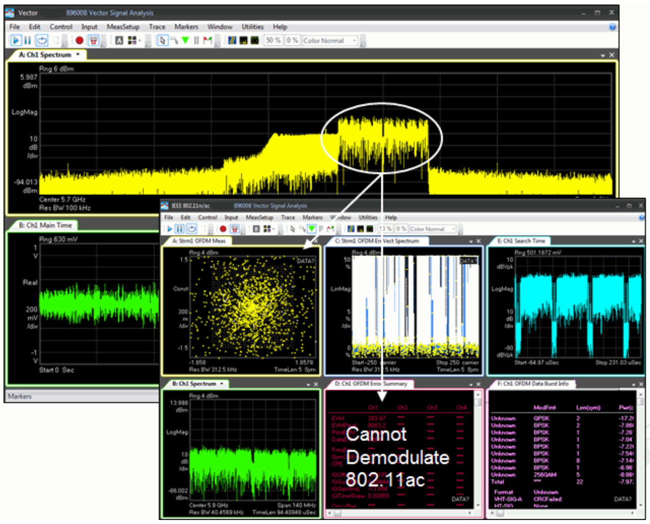

Figure 9. Significant overlap between 802.11ac WLAN and C-band radar signal.

Results, part 3: Coexistence of S-band radar and LTE

This final scenario focuses on an LTE downlink signal in the S frequency band and an S-band radar signal. The S-band radar simulation signal source is generated along with the LTE downlink, EDGE, GSM, WCDMA signal source. An additional S-band radar signal source and WCDMA signal source are also included.

A COTS test setup similar to the one shown in figure 2 is used to generate the multi-emitter test spectrum shown in figure 10, which was measured with the RF signal analyzer.

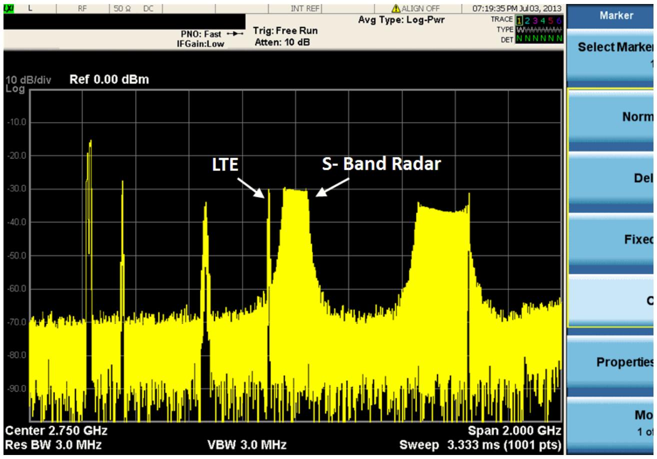

Figure 10. Multi-emitter spectrum with LTE and S-band radar signals.

The multi-emitter spectrum includes GSM, EDGE, and LTE emitters, two S-band radar emitters, and two WCDMA emitters. The LTE emitter and S-Band radar emitter are shown near the center of the measured frequency spectrum.

The PXA RF signal analyzer is used to zoom into the portion of the multi-emitter spectral environment which contains the LTE and radar emitters, as shown in Figure 11. The 89600 VSA demodulation measurement with the PXA RF signal analyzer shows the constellation (upper left), spectrum (lower left), EVM vs. subcarrier (upper right), and EVM error summary (lower right).

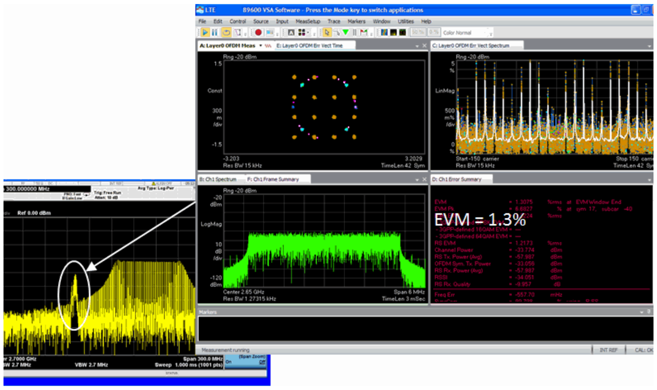

Figure 11. Scenario 1: LTE demodulation in the presence of S-band radar with slight overlap.

The EVM is approximately 1.3% in the presence of the radar interferer, and the EVM vs. subcarrier measurement shows performance degradation resulting from the radar interferer.

To further illustrate the impact of the interference, the radar signal was moved closer to the LTE signal as shown in figure 12. The multi-emitter simulation was re-run to generate the new test signal scenario.

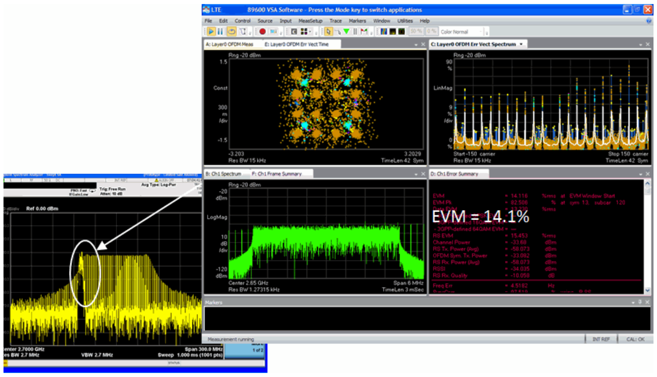

Figure 12. Scenario 2: LTE demodulation in the presence of S-band radar with significant overlap.

The EVM demodulation results in figure 12 show that the radar signal clearly has a more significant impact on the LTE signal in this scenario, relative to the first scenario. The EVM has degraded to approximately 14.1%, as a result of more spectral overlap with the radar spectrum. The EVM versus subcarrier measurement also shows additional performance degradation resulting from the radar interferer, relative to the first scenario.

A third scenario evaluates the BER degradation of an interference signal. Figure 13 shows the simulation schematic used to evaluate the impact of an S-Band radar interferer on a simulated LTE downlink coded BER as the interferer's center frequency is swept.

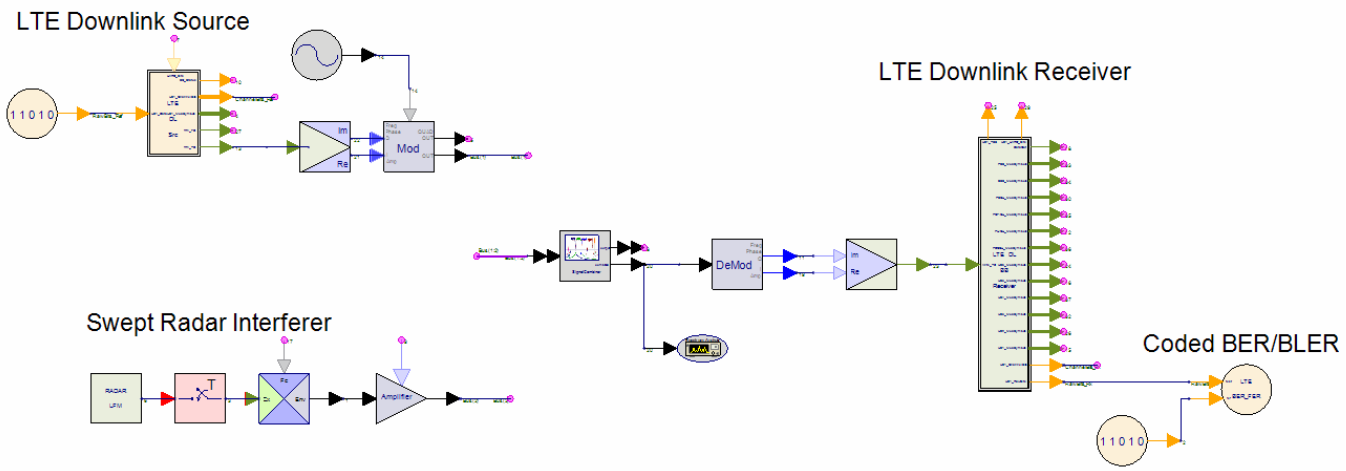

Figure 13. Simulation schematic to evaluate S-band radar interferer on coded BER.

The schematic consists of an LTE downlink signal source on the upper left. Below the LTE downlink signal source is an LFM radar signal source. The center frequency of the LFM radar signal source will be swept for the LTE BER simulation. The LTE signal and radar signal are combined by a Signal Combiner element to re-sample and combine the two signals. The combined signal is then fed into the LTE receiver for the coded BER simulation measurement. The LTE receiver performs the physical layer decoding recover the data bits so that coded BER and data throughput can be measured in simulation.

Figure 14 shows the LTE coded BER results as a function of the radar interferer's center frequency, which was swept in the simulation. The LTE coded BER performance is significantly impacted as the radar interferer's center frequency is swept across the LTE downlink frequency, increasing from 0% BER to approximately 24% BER. The LTE configuration, radar interferer configuration, and power levels can be varied to evaluate potential co-existence issues. An RF transmitter design and a receiver design with modeled design impairments could have also been evaluated as part of this simulation.

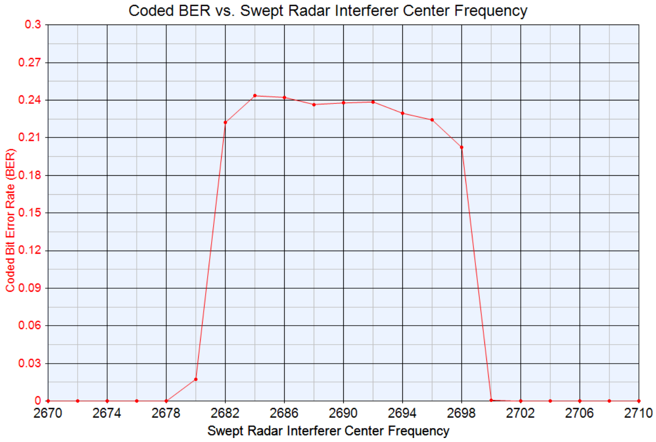

Figure 14. Simulation results for coded BER versus swept radar interferer frequency.

Conclusion

Systems being designed to operate in today's crowded and complex spectral environments may require additional testing in the R&D lab environment to evaluate potential interference scenarios. Signal generation flexibility is required to address the many types of signals which may need to be considered, including radar, wireless networking, and wireless communication signals.

Having the ability to perform pre-deployment co-existence R&D testing can save schedule and rework costs by allowing issues to be addressed in the lab environment instead of in the field.

Keysight provides a flexible R&D testbed solution allowing quantitative performance evaluations of complex spectrum interference scenarios. Although this is not real-time capability, this cost effective and flexible approach to generating test spectrums using COTS hardware and software can allow development teams the ability to explore and investigate what-if scenarios in the R&D lab environment long before potential co-existence issues may develop in the operational environment.

myKeysight

www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

Three-Year Warranty

www.keysight.com/find/ThreeYearWarranty
Keysight's commitment to superior product quality and lower total cost of ownership. The only test and measurement company with three-year warranty standard on all instruments, worldwide.

Keysight Assurance Plans

www.keysight.com/find/AssurancePlans
Up to five years of protection and no budgetary surprises to ensure your instruments are operating to specification so you can rely on accurate measurements.

www.keysight.com/quality
Keysight Electronic Measurement Group
DEKRA Certified ISO 9001:2008
Quality Management System

Keysight Channel Partners

www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

Cover photo courtesy US Department of Defense.
(U.S. Navy photo Mass Communication Specialist Seaman Veronica Mammina)

www.keysight.com/find/ad

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

Europe & Middle East

Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	0800 000154
Sweden	0200 882255
Switzerland	0800 805353
	Opt. 1 (DE)
	Opt. 2 (FR)
	Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:
www.keysight.com/find/contactus
(BP-05-29-14)

This information is subject to change without notice.

Published in USA, August 4, 2014
5991-3809EN
www.keysight.com