

Automotive RF Immunity Testing using Peak Power Meters

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Abstract

The Boonton model 55006 USB Peak Power Sensor and 4542 benchtop Power meter used with model 57006 Peak Power sensor or model 51011 EMC power sensors are the instruments of choice for capturing, displaying and analyzing RF power for automotive EMC and RF immunity testing. This application paper focuses on discussing the usage of peak power meters in RF immunity testing for EMC purposes.



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Introduction

A relatively well known case of RF interference that involves automobiles especially for those drivers who live near Naval bases as well as near airports, is the garage doors opening and closing on their own. Operating in the same (military) frequency band as the garage openers, the Naval communication systems typically overpower the garage opener signal therefore opening and closing the garage doors seemingly on their own. This is one of the rare instances where RF interference significantly impacts the owner of a vehicle and the auto industry would like to make sure there are not any others.

Automotive EMC and RF immunity

The subject of RF immunity (RI) and Electromagnetic Compatibility (EMC) has been a concern for the automotive industry for decades, especially since the control and operation of the modern day automobile is increasingly relying on advanced electronic systems. These systems happen to be both the source and victim of EMI and RF interference. Furthermore the increasing number of RF transmitting devices such as smart phones, tablets and laptops transmitting high speed wideband 4G, Wi-Fi and Bluetooth signals have introduced additional sources of RF interference as well. The purpose of immunity testing is to emulate the effect of real world RF interference upon tested electronic device or system. One example in the automotive world would be the automotive CAN bus system used for wired, digital communication between electronic subsystems in a motor vehicle. These systems are often used to monitor and control important performance and safety parameters of the vehicle including engine operation, braking, and the steering/stability systems. Their ability to operate correctly under all electrical interference conditions is crucial to passenger safety. Robust RF immunity has become a mandatory part of the automotive design process where any sort of malfunction could result in injury or damage to people or property. As a result, over the decades international standards organizations such as CISPR, ISO and SAE have introduced a set of requirements to deal with the RI for the automotive electronic systems. In addition, the automakers themselves have developed their own testing and qualification procedures to make sure their subsystem suppliers meet the international standards as well as their own internal requirements.

RF Immunity standards and specifications

In this application note we are going to explore RI section of a specification document called EMC Specification for Electrical/Electronic Components and Subsystems¹ by a major automaker. RI specification requirements applies to all electronic circuits used in the vehicle including:

- Electronically controlled electric motors.
- Electronic modules containing analogue op amp circuits, microprocessor based controllers and displays, and switching power supplies.
- Sensor circuitry which provides an input to a controller.
- Modules containing or connected to external magnetically sensitive elements or magnetically controlled relays.
- Modules containing or controlling an inductive device.
- Remote keyless vehicle entry systems.
- Remote keyless ignition systems.

The RI section has two sets of tests that are of interest to us, namely RI 114 covering 400 –3100 MHz divided into four sub-bands (bands 4-7) and RI 115 covering 360–2700 MHz divided into six sub-bands (bands 8-13)(see *Table 1*). The purpose of RI 115 is to test for immunity from radiation of hand portable devices placed within the vehicle; therefore it covers most communication technologies, including Tetra, TDMA, GSM, CDMA, WCDMA, and LTE. The test signals used are mainly pulsed RF signals with varying pulse repletion rates (PRR), duty cycles, modulation parameters, signal levels and are test frequency dependent. Table 1 shows signal levels and modulation schemes for each band. The frequency step size is 10 MHz between 400 – 1000 MHz and 20 MHz for above 1000 MHz.

Test Set-up

Immunity testing is performed in a large anechoic chamber for isolation from external RF interference while testing the DUT (Device under Test). One important requirement for the test is the application of a simulated interference signal with accurately known amplitude. Block diagram in *Figure 1* shows the general test set-up.

Mobile Systems	Band	Frequency Range	Test Signal Level		Modulation
			Level 1 (V/m)	Level 2 (V/m)	
	4	400-800	50	100	400-470 MHz, Pulsed PRR=18 Hz, PD = 28 msec, DC = 12.5% 470-800 MHz, CW, AM 80%
GSM	5	800-2000	50	70	CW, Pulsed PRR = 217 Hz, PD=0.57 msec
Radar	6	1200-1400	n/a	300/600	Pulses PRR = 300 Hz, PD = 3 usec / 6 usec with only 50 pulses every 1 second
Radar	7	2700-3100	n/a	300/600	
TETRA	8	360-480	4.5 W	9.0 W	Pulsed, PRR = 18 Hz, DC = 50%
GSM / CDMA	9	800-1000	7.0 W	14.0 W	Pulsed, PRR = 217 Hz, DC = 12.5%
GSM / WCDMA	10	1600-1950	1.5 W	3.0 W	Pulsed, PRR = 217 Hz, DC = 12.5%
PCS / UMTS	11	1950-2200	.75 W	1.5 W	Pulsed, PRR = 217 Hz, DC = 12.5%
Wi-Fi	12	2400-2500	.1 W	0.2 W	Pulsed, PRR = 1600 Hz, DC = 12.5%
WiMAX / LTE	13	2500-2700	.25 W	0.5 W	Pulsed, PRR = 217 Hz, DC = 12.5%

Table 1. RI 114 & RI 115 Frequency bands and test signal levels and modulation characteristics

The baseband pulse generator and the CW and pulse modulator transmit the specified signal to the power amplifier (PA). The generator output needs to have good spectral purity so that spurious signals are not fed into the PA. The PA itself should be linear and broadband. Biconical antennas known for their broadband characteristics are ideal for swept measurements for emissions and immunity testing but because of their poor VSWR performance large portions of the transmitted signal will inevitably be reflected back to the PA. The net power radiated to the DUT is the difference between the PA output power and the reflected power from the

antenna. In order to establish the precise amount of net power radiated to the DUT, both delivered power from the PA and the reflected power from the antenna must be measured. A dual channel power meter and a 4-port directional coupler provide the best method of measuring the reflected power and the amplifier output power simultaneously. While performing the test the signal generator output power is adjusted at each of the specified frequency steps across the test band to achieve the desired RF field strength in the anechoic chamber.

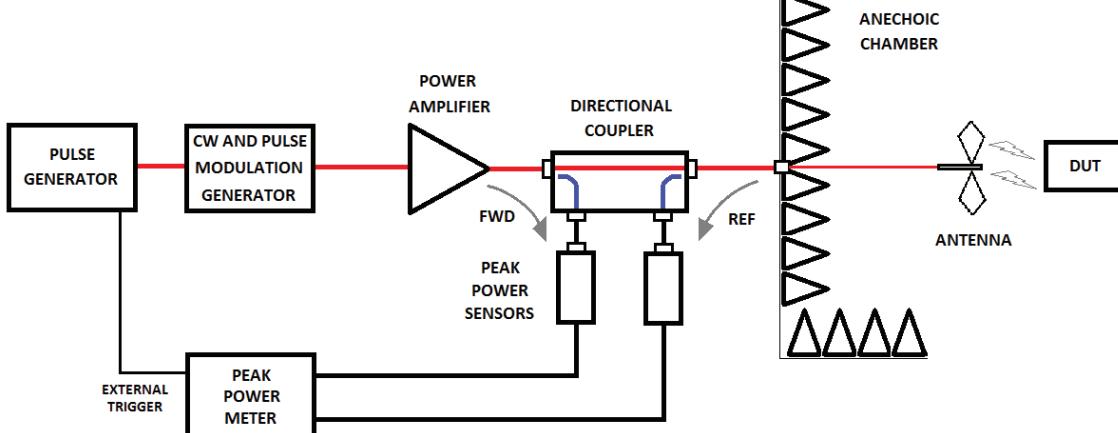


Figure 1. RF Immunity Calibration / Test set-up

Measuring Pulsed RF Power

The power measurement device ideal for pulsed RF signals should be capable of making broadband measurements as well as measuring peak power in order to carry out an analysis at instantaneous points on a waveform. Standards documents ISO 11451 & ISO 11452 require a power meter both during calibration and testing in their set-up diagrams⁴. Power meters are ideal for these type of measurements and specifically a calibrated peak power sensor rather than an average CW one. The average CW sensor does not accurately measure the field strength of a modulated RF signal, so correction factors must be applied to the probe readings to account for the signal's dynamic behavior. Although a CW signal can be used to estimate the power being delivered, an additional correction factor must be applied to account for the modulation applied during the actual testing³. This correction is adequate for simple AM modulation, but is often insufficient for the narrow duty cycles required by RI test standards (see *Figure 2*). Using a peak power sensor eliminates the need for peak calculations and modulation correction factors associated with the average CW sensors. The peak sensor can follow a signal's power envelope and yield the true average and peak power, provided the envelope bandwidth remains within the maximum video bandwidth rating of the sensor and power meter. Knowing the peak power value will help ascertain whether the DUT is being subjected to the necessary amount of interference to operate correctly in any environment. A good peak power sensor has temperature compensation and is linearized to increase its dynamic range.

Among test signals defined in *Table 1*, the pulsed radar signal specified in frequency bands 6 & 7 is the most challenging one to make measurements on since it is narrow duty cycle and has long periods of inactivity (See *Figure 2*). For signals with duty cycles narrower than about 1%, the dynamic range of the average-responding power sensor is eroded by the need to maintain both the peak power and the average power within the sensor's operating and measurable range. In our example the duty cycle is 0.1% and only 50 pulses in a 1 second period which means there is no RF activity for 0.8 seconds, sending the average power even lower. A peak power sensor that is able to track and measure the delivered peak power is often a better solution for measuring this type of signal³.

Furthermore EMC specifications document¹ does mention a spectrum analyzer as a possible substitute but calls the Peak Envelope Power Meter as the preferred measurement equipment especially when the signal is pulse modulated. A spectrum analyzer (SA) is a frequency tuned measuring instrument containing components that provide frequency selective functionality. The additional components such as attenuators, oscillators, mixers, filters and amplifiers, all contribute to measurement uncertainty and adds to testing time since the SA needs to be tuned to a new frequency each time a measurement has to be made at a new test frequency point. The fractional cost of peak power meters compared to spectrum analyzers is also an added benefit.

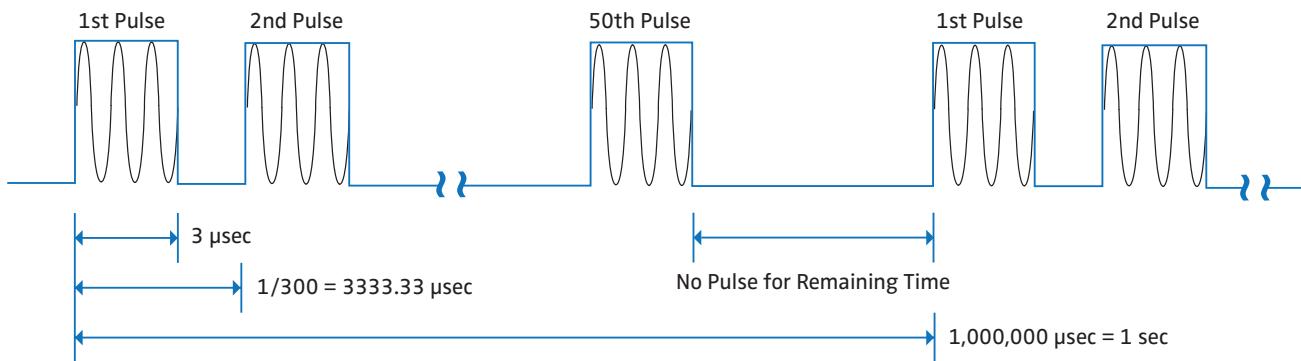


Figure 2 – 300 Hz PRR signal with 3 microsecond pulsewidth (Bands 6 & 7)

Conclusion

In conclusion, a Peak Power Meter or a Peak Envelope Power (PEP) meter is the instrument of choice for the measurement of RI of electrical and electronic components and subsystems especially with pulsed RF signals. Boonton offers two solutions that can accomplish the task of performing Automotive RI testing. The first is the bench-top two channel 4542 Peak Power Meter used with 57006 peak power sensors, as well as 51011 EMC sensors. The second is the new 55006 USB Peak Power Sensor which eliminates the need for an instrument box. The USB connection of this new sensor turns a PC, laptop or tablet into a state-of-the-art peak power meter. Both models are high performance and low cost solutions for performing RI Measurements.

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ISO 11452 - Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy



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