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Federal Communications Commission
Office of Engineering and Technology
Laboratory Division Public Draft Review

Draft Laboratory Division Publications Report

Title: Measurement Procedure for Level Probing Radars

Short Title: Meas Level Probing Radars

Reason: Establish measurement procedure for Level Probing Radar based on new rules.

Note: This draft is only for review. The procedures will only apply after the final version is published and the new rules become effective.

Publication: 890966

Keyword: Level Probing Radar, LPR, Tank Level Probing Radar, TLPR, 15.256

First Category: Radio Service Rules
Second Category: Part 15 General

Question: What is the measurement procedure for level probing radars?

Answer: The attachment, 890966 D01 Level Probing Radar v01, provides guidance on making measurements for devices operating under section 15.256.

Attachment List:
890966 D01 Meas level Probing Radars v01

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Measurement Procedure for Level Probing Radars

A. Introduction

In January 2014, the FCC released a Report and Order (FCC-14-2, docket no. 10-23) that establishes new rules for the operation and approval of level probing radars (LPR). The new LPR rules are codified in § 15.256.[1] This KDB publication provides guidance for an acceptable measurement procedure. [*see* § 15.256(l)(7)].

B. General considerations

Compliance measurements for § 15.256 should normally be performed using radiated emissions test set-ups. In some cases it may be necessary or desirable to perform the measurements using conducted emissions test set-ups. Care must be taken to assure that peak emission levels do not exceed the safe input levels or cause amplitude compression for the measurement instruments such as spectrum analyzers, downconverters, oscilloscopes and diode detectors. Attenuators may be required when making conducted measurements, while low noise amplifiers may be required for radiated emission measurements. When downconversion is required because of limited frequency range of measurement equipment, the downconverter bandwidth must be at least as wide as the fundamental emission bandwidth. Be aware that when using harmonic mixers in conjunction with a spectrum analyzer, image interference with the fundamental emission will occur when the bandwidth of the fundamental is greater than twice the I.F. frequency, which prevents accurate measurements.

All emissions at and below 960 MHz are based on measurements employing a CISPR quasi-peak detector. All power averaging (RMS) emission levels are to be measured utilizing a 1 MHz resolution bandwidth with a one millisecond dwell time over each 1 MHz segment. The frequency span of the analyzer should equal the number of sampling bins times 1 MHz and the sweep rate of the analyzer should equal the number of sampling bins times one millisecond. The video bandwidth of the measurement instrument shall not be less than the resolution bandwidth and trace averaging shall not be employed. The RMS average emission measurement is to be repeated over multiple sweeps with the analyzer set for maximum hold until the amplitude stabilizes. The peak emission measurement is to be repeated over multiple sweeps with the analyzer set for maximum hold until the amplitude stabilizes.

For LPRs that employ frequency-modulated continuous wave (FMCW), frequency hopping or stepped frequency modulation, the fundamental emission bandwidth, the maximum average power level in 1 MHz, the peak power level in 50 MHz and the level of unwanted emissions shall be made with the FMCW, frequency hopping or step function active.

[1] As an alternative to the provisions of paragraphs (a) – (l) of Section 15.256 [*cf.* § 15.31(q)], an LPR may be certified under Part 15 for use solely in a metal or concrete tank by showing compliance with the provisions of Section 15.209 as measured outside the tank with the LPR installed inside the tank according to measurement procedure ANSI C63.10 in lieu of the following measurement procedure.

C. Frequency bands of operation

5.925-7.250 GHz

24.05-29.00 GHz

75-85 GHz

D. Fundamental emission bandwidth

1. Observe fundamental emission on the spectrum analyzer with a peak detector, 1 MHz RBW and at least 3 MHz VBW. If necessary, downconvert the signal to within the frequency range of the spectrum analyzer.
2. Activate any frequency sweep, step or hop function of the EUT and select "Max Hold" function on the spectrum analyzer.
3. Perform multiple sweeps until the amplitude stabilizes.
4. Determine the 10 dB emission bandwidth.
5. Verify that the fundamental emission is within the operating frequency band at the highest and lowest operating frequencies. (See Frequency stability section.)

E. Fundamental emission

1. For radiated emission measurements, locate the receive test antenna at a far field distance boresighted on the LPR transmit antenna. Adjust the LPR and the test antenna for maximum main beam coupling.
2. For conducted measurements, connect the output of the LPR transmitter through an appropriate attenuator to the downconverter or spectrum analyzer.
3. Set the spectrum analyzer for power averaging (RMS) detector and 1 MHz RBW.
4. Record the maximum level and frequency of the signal within the fundamental emission bandwidth which must be contained entirely within the authorized frequency band.
5. Centered on the frequency of the maximum signal recorded in step 4, select peak detector, 50 MHz RBW and at least 50 MHz VBW.
    a. If 50 MHz RBW is not available on the spectrum analyzer, determine the maximum of the spectrum trace in a narrower RBW which is greater than or less than the PRF by a factor of 3, but not less than 1 MHz, and calculate the maximum signal level in 50 MHz by adding the appropriate correction factor shown below to the maximum measured signal level.
        i. For pulsed LPRs
        20 Log (50/RBW) dB, if PRF < RBW/3
        20 Log (50/PRF) dB, if PRF > 3*RBW
        ii. For FMCW, step or hopping LPRs
        20 Log (50/RBW) dB
    b. It may be necessary to offset the measurement frequency in order to ensure that the measurement is made within the fundamental emission bandwidth because the 3 dB bandwidth of the RBW is not entirely within the fundamental emission bandwidth. The measurement shall be made at the nearest frequency to the frequency identified in step 4 when the 3 dB point of the RBW closest to the fundamental emission band edge is at the frequency of the band edge.
    c. If the measurement must be performed with a RBW greater than 3 MHz because the PRF is between 1 MHz and 3 MHz or for any other reason, the test report must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation used.
6. Calculate the EIRP.
The EIRP of the fundamental emission is obtained from the preceding power measurements

by calculating the actual conducted power output of the EUT or the field strength (F.S.) produced by the EUT at the measurement distance taking into account all attenuators, amplifier gains, antenna factor, measurement distance extrapolation, conversion loss, cable losses, etc., and applying the appropriate equation as follows:

a. For conducted measurements
EIRP (dBm) = conducted power (dBm) + antenna gain (dBi)

b. For radiated emission measurements
EIRP (dBm) = F.S. (dBµV/m) – 104.8 + 20 Log D
where:
D is the measurement distance

F. Unwanted emissions

Because unwanted emissions below 1000 MHz are measured with a CISPR quasi-peak detector and emissions above 1000 MHz are measured in a 1 MHz bandwidth, a spectrum analyzer with a RBW of 1 MHz is adequate to permit the measurement of the unwanted emissions within the frequency range of the spectrum analyzer. When using harmonic mixers for measurements above the maximum frequency of the spectrum analyzer, the I.F. frequency of the analyzer must be at least one-half the bandwidth of the emission. Unless otherwise provided, unwanted emissions are to be measured according to the procedures in ANSI C63.10.

1. Pre-scan measurements

For the required frequency range, scan the EUT on all three axes for signals which, considering the sensitivity of the measurement setup at each frequency, may exceed the limit. It may be necessary to measure at close distances to achieve the sensitivity necessary to detect signals at the limit level.

2. Final measurements

a. Using the appropriate test antenna, amplifiers and harmonic mixers, measure the level of the signals identified in the pre-scan test with the spectrum analyzer settings at the required RBW and detector for the frequency range being measured.

b. Calculate the Field Strength

c. Using the antenna factor, amplifier gains, conversion loss, measurement distance extrapolation, cable losses, etc., calculate the field strength at 3 m.

G. Frequency stability

As specified in Section 15.215(c), the bandwidth of the fundamental emission must be contained within the frequency band over the temperature range -20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage. Frequency stability is to be measured according to Section 2.1055 at the highest and lowest frequency of operation and with the modulation that produces the widest emission bandwidth.