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Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

Public Draft for Review and Comment

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

Note: This draft 890966 D01 Meas level Probing Radars v01 DR03-41866 replaces the draft 890966 D01 Meas level Probing Radars v01 DR02-41831 posted on 07/11/2014 to make correction to section F (below).

890966 D01 Meas Level Probing Radars v01r01

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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 the frequency of the signal to be measured is greater than the maximum frequency range of the spectrum analyzer, a downconverter or external harmonic mixer is required. The downconverter bandwidth must be at least as wide as the fundamental emission bandwidth and 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. This problem can be eliminated if an image suppression function is available.

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.
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 for Pulsed Transmitters

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 external harmonic mixer, if necessary, to the 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. For pulsed LPRs

      20 Log (50/RBW) dB, if PRF < RBW/3

      20 Log (50/PRF) dB, if PRF > 3*RBW

      where:

      RBW is the resolution bandwidth in MHz

      PFR is the pulse repetition frequency in MHz

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. Determine the conducted power output of the EUT or the field strength produced by the EUT at a given distance from the measurements in steps 1 to 5 by calculation taking into account all attenuators, amplifier gains, antenna factor, measurement distance extrapolation, conversion loss, cable losses, etc. as applicable or the signal substitution method.

7. The EIRP is then calculated by applying the appropriate equation as follows:

   a. For conducted measurements
   EIRP (dBm) = conducted power (dBm) + antenna gain (dBi)
   where the conducted power is the conducted power output of the EUT and antenna gain is the gain of the EUT antenna.

   b. For radiated emission measurements
   EIRP (dBm) = E (dBμV/m) – 104.8 + 20 Log D
   where E is the field strength at the far field distance D.

F. Fundamental Emissions for FMCW transmitters

When making the following measurements, it is important to recognize that there is a sweep frequency time and sweep frequency span for both the LPR signal and the spectrum analyzer which are independent of each other.

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 external harmonic mixer, if necessary, to the spectrum analyzer.

3. Set the spectrum analyzer frequency span to enable viewing the entire sweep frequency span of the LPR signal.

4. Calculate the dwell time, T_D, of the sweep frequency signal per MHz of the sweep frequency span

$$T_D = T_S/\Delta F$$

where:

T_S is the signal sweep frequency time in seconds

ΔF is the signal sweep frequency span in MHz

5. Set the detector to peak mode.
6. Set the RBW to 1 MHz.
7. Perform sufficient multiple scans on the spectrum analyzer in maximum hold with a sweep time suitable for displaying the variation in the signal level over the frequency span.
8. Record the maximum signal level. This is the peak value of the LPR signal.
9. Calculate the average factor

   Average factor = (T_D) / cycle time

   where:

   cycle time is the total time for a complete cycle of the signal including retrace and any other latency times.
10. Determine the average by multiplying the maximum signal level obtained in Step 8 by the average factor.
11. Determine the conducted power output of the EUT or the field strength produced by the EUT at a given distance from the measurements in steps 1 to 10 by calculation taking into account all attenuators, amplifier gains, antenna factor, measurement distance extrapolation, conversion loss, cable losses, etc. as applicable or the signal substitution method.
12. The EIRP is then calculated by applying the appropriate equation as follows:

    a. For conducted measurements
       EIRP (dBm) = conducted power (dBm) + antenna gain (dBi)
       where the conducted power is the conducted power output of the EUT and antenna gain is the gain of the EUT antenna.

    b. For radiated emission measurements
       EIRP (dBm) = E (dBµV/m) – 104.8 + 20 Log D
       where E is the field strength at the far field distance D.

G. 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 if image suppression is not available. Unless otherwise provided, unwanted emissions are to be measured according to the procedures in ANSI C63.10-2009.

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.

H. 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.