RECOMMENDATION ITU-R M.1177-3*

Techniques for measurement of unwanted emissions of radar systems

(Question ITU-R 202/8)

(1995-1997-2000-2003)

Summary

This Recommendation provides two techniques for the measurement of radiated radar unwanted emissions. It should be used to measure the spurious emission limits in Appendix 3 (Section II) of the Radio Regulations (RR), or to measure the level of unwanted emissions falling within the out-of-band domain.

The ITU Radiocommunication Assembly,

considering

a) that both fixed and mobile radar stations in the radiodetermination service are widely implemented in bands adjacent to and in harmonic relationship with other services;

b) that stations in other services are vulnerable to interference from radar stations with unwanted emissions with high peak power levels;

c) that many services have adopted or are planning to adopt digital modulation systems which are more susceptible to interference from radar unwanted emissions;

d) that under the conditions stated in *considering* a) through c), interference to stations in other services may be caused by a radar station with unwanted emissions with high peak power levels;

e) that Recommendation ITU-R SM.329 specifies the maximum values of unwanted emissions in the spurious emission domain from radio transmitters;

f) that Recommendation ITU-R SM.1541 specifies the generic limits for unwanted emissions in the out-of-band domain,

recommends

1 that measurement techniques as described in Annex 1 be used to provide guidance in quantifying radiated unwanted emission levels from radar stations operating above 400 MHz;

2 that measurement techniques as described in either Annex 1 or Annex 2 are used, as appropriate based upon radar design, to provide guidance in measuring radiated unwanted emission levels for radar stations operating between 50 MHz and 400 MHz;

---

* This Recommendation should be brought to the attention of the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO), the International Maritime Radio Association (CIRM), the World Meteorological Organization (WMO) and Radiocommunication Study Groups 1, 4 and 9.

3 that measurement techniques described in Annex 2 be used to provide guidance in quantifying radiated unwanted emission levels from radar stations operating below 50 MHz;

4 that results of such usage of this Recommendation be reported to ITU-R, in order to determine any limitations in the techniques, e.g. tolerances of measurements and repeatability over the required frequency ranges, so that confidence can be established in the measurement methods.

Annex 1

Measurement of unwanted emissions of radar systems as detailed in *recommends* 1 and 2

1 Introduction

Techniques have been developed in response to § 1 of Question ITU-R 202/8. Two techniques known as the direct and indirect methods are described.

The direct measurement method is recommended and measures unwanted emissions from all radars including those that preclude measurements at intermediate points within the radar transmitters. Examples include those which use distributed-transmitter arrays built into (or comprising) the antenna structure.

The indirect method separately measures the components of the radar and then combines the results. The recommended split of the radar is to separate the system after the Rotating Joint (Ro-Jo) and thus to measure the transmitter output spectrum at the output port of the Ro-Jo and to combine it with the measured antenna gain characteristics.

2 Reference bandwidth

For radar systems, the reference bandwidth, B_{ref}, used to define unwanted emission limits (Recommendations ITU-R SM.329 and ITU-R SM.1541, and RR Appendix 3) should be calculated for each particular radar system. For the four general types of radar pulse modulation utilized for radionavigation, radiolocation, acquisition, tracking and other radiodetermination functions, the reference bandwidth values are determined using the following formulas:

– for fixed-frequency, non-pulse-coded radar, one divided by the radar pulse length (e.g. if the radar pulse length is 1 μs, then the reference bandwidth is 1/1 μs = 1 MHz);

– for fixed-frequency, phase-coded pulsed radar, one divided by the phase chip length (e.g. if the phase coded chip is 2 μs long, then the reference bandwidth is 1/2 μs = 500 kHz);

– for FM or chirped radar, the square root of the quantity obtained by dividing the chirp bandwidth (MHz) by the pulse length (μs) (e.g. if the FM is from 1 250 MHz to 1 280 MHz or 30 MHz during the pulse of 10 μs, then the reference bandwidth is $(30 \text{ MHz}/10 \text{ μs})^{1/2} = 1.73$ MHz);

– for radars operating with multiple waveforms the reference bandwidth is determined empirically from observations of the radar emission. The empirical observation is performed as follows: the measurement system receiver is tuned to one of the fundamental frequencies of the radar, or is tuned to the centre frequency within the chirp range of the radar. The measurement system bandwidth is set to the widest available value, and the received power level from the radar in this bandwidth is recorded. The measurement bandwidth is then progressively narrowed, and the received power level is recorded as a function of the bandwidth. The end result is a graph or table showing measured power as a function of measurement system bandwidth. The required bandwidth is the smallest bandwidth in which the full power level is still observed and the reference bandwidth can be calculated from a knowledge of the impulse response of the measurement receiver using the factor, measurement bandwidth ratio (MBR), as described below. If a reduction in power level is observed immediately, then the widest available bandwidth should be used.

In all cases, where the bandwidths above are greater than 1 MHz, then a reference bandwidth, B_{ref}, of 1 MHz should be used.

3 Measurement bandwidth and detector parameters

The measurement bandwidth, B_m, is defined as the impulse bandwidth of the receiver and is greater than the IF bandwidth, B_{if}, (sometimes referred to as resolution bandwidth for spectrum analysers). The measurement bandwidth, B_m, may be derived from the following equation:

$$B_m = B_{if} \times MBR$$

The MBR needs to be determined for the measurement receiver being used. MBR is approximately 3/2 for a –3 dB IF bandwidth Gaussian filter as typically used in many commercial spectrum analyser receivers (in some instruments the IF bandwidth is defined at the –6 dB point).

An appropriate receiver IF bandwidth should be selected to give one of the following recommended measurement bandwidths.

Measurement bandwidth B_m[1]

≤ $(1/T)$ for fixed-frequency, non-pulse-coded radars, where T is the pulse length (e.g. if the radar pulse length is 1 μs, then the measurement bandwidth should be = ≤ 1/(1 μs) = 1 MHz).

≤ $(1/t)$ for fixed-frequency, phase-coded pulsed radars, where t is the phase-chip length (e.g. if the radar transmits 26 μs pulses, each pulse consisting of 13 phase coded chips that are 2 μs in length, then the measurement bandwidth should be ≤ 1/(2 μs) = 500 kHz).

[1] In all cases, if the above derived measurement bandwidth is greater than 1 MHz then a measurement bandwidth, B_m, close to 1 MHz should be used.