Radar Correspondence Group/August 2002

FRANCE

Example of unwanted emissions of radars measured using Recommendation ITU-R M 1177 (direct method)

1. Introduction

The purpose of this paper is to show an example of application of the direct method of Recommendation ITU-R M.1177 to measure the out of band emissions of an ATC radar in L band (TRAC 2000).

2. Reference documents

- Recommendation ITU-R SM329-8 : spurious emissions
- Recommendation ITU-R SM.1541 : unwanted emission in the out of band domain
- Recommendation ITU-R SM.1539 : Boundaries between out of band and spurious emissions
- Recommendation ITU-R M.1177 : Techniques for measurement of unwanted emissions of Radar Systems
- Appendix 3 on Maximum Permitted Spurious Emission Power Levels.

3. Measurements

3.1 Definition of the emission mask:

* spurious emissions : 43 +10log (P) or 60dB (the less constraining value, P= peak power), **60dBc.** The « necessary » bandwidth is calculated by :

- un-modulated pulses : $B_n = \frac{1.79}{\sqrt{t \otimes t.r}}$ ou $\frac{6.36}{t}$ (the lesser)
- modulated pulses : $B_n = \frac{1.79}{\sqrt{t \otimes t.r}} + 2\ B_c$,

with t: pulse length, tr: rise time, B_c = total frequency shift during the pulse duration

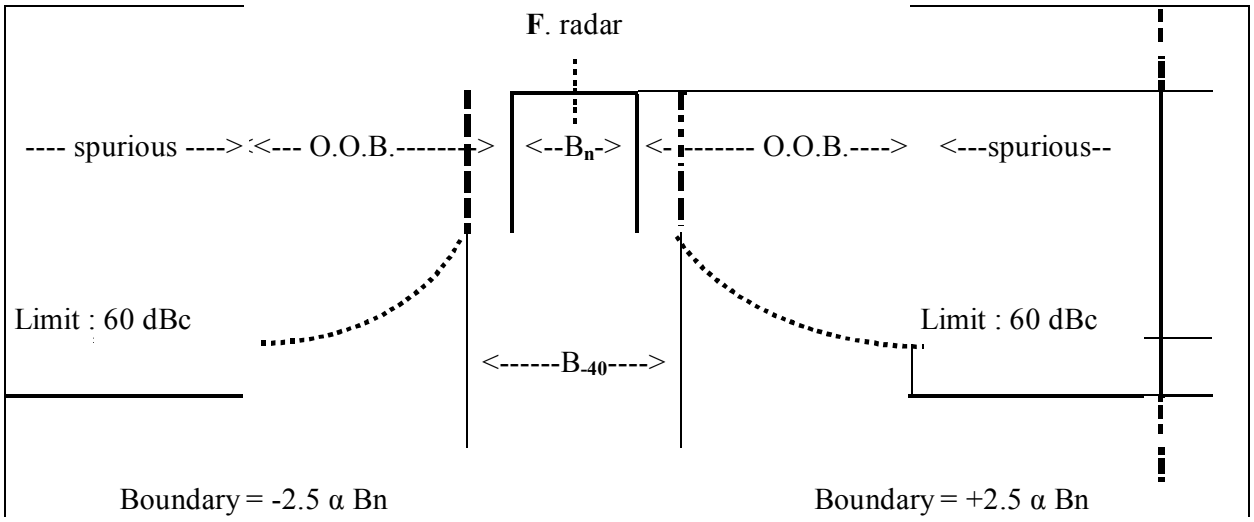
* out of band emissions : the emission mask is calculated from the 40 dB bandwidth, which is given by :

- un-modulated pulses: $B_{-40} = \frac{K}{\sqrt{t \otimes t.r}}$ ou $\frac{64}{t}$ (the lesser).
- modulated pulse : $B_{-40} = \frac{K}{\sqrt{t \otimes t.r}} + 2\ (B_c + \frac{A}{tr})$

with t: pulse length, tr: rise time, K=7.6, B_c :frequency shift., A=0,105

* boundary : the emission mask applies from the 40 dB boundary to the spurious emission limit, in 2.5 α B_n, which gives a slope of 20dB/decade when **α** is equal to $2.B_{-40}/ B_n$.

* illustration :



3.2 Emission masks

With the previous formulas of , we have the followings emission masks :

For pulses of 1µs (tr#150ns),

The band of measurement must be : <= à 1/t , here 1MHz
The necessary bandwidth (B_n) is the lesser of 4.6MHz or 6.36MHz →**B_n= 4.6MHz**
The 40 dB bandwidth B_{-40} is the lesser of 19.6MHz or 64MHz →**B_{-40}= 19.6MHz**

Which gives $\alpha = 2.B_{-40}/ B_n = 8.5$

The boundary between out of band emissions and spurious emissions is at ±(2.5 α B_n = **97.7MHz**) from the reference frequency.

For pulses of 100µs (tr#150ns),

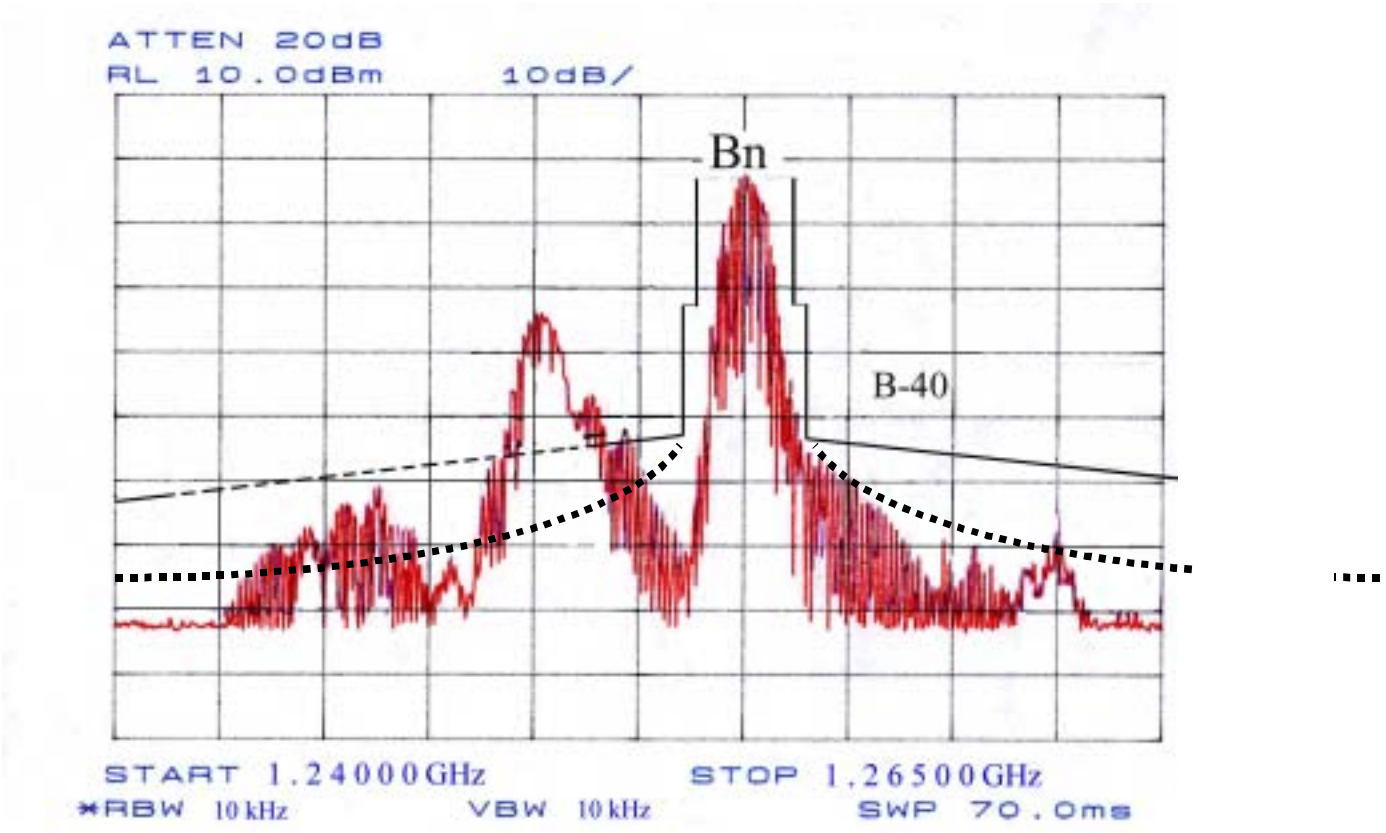
The band of measurement must be <= 1/t, here 10kHz
The necessary bandwidth is Bn= 0.46+2 MHz → **B_n= 2.46MHz**
The 40 dB bandwidth B-40= $0.46+(2+\frac{0.065}{150.ns})$→ **$B_{-40}$= 2.89MHz**

Which gives $\alpha = 2.B_{-40} / B_n = 2.35$

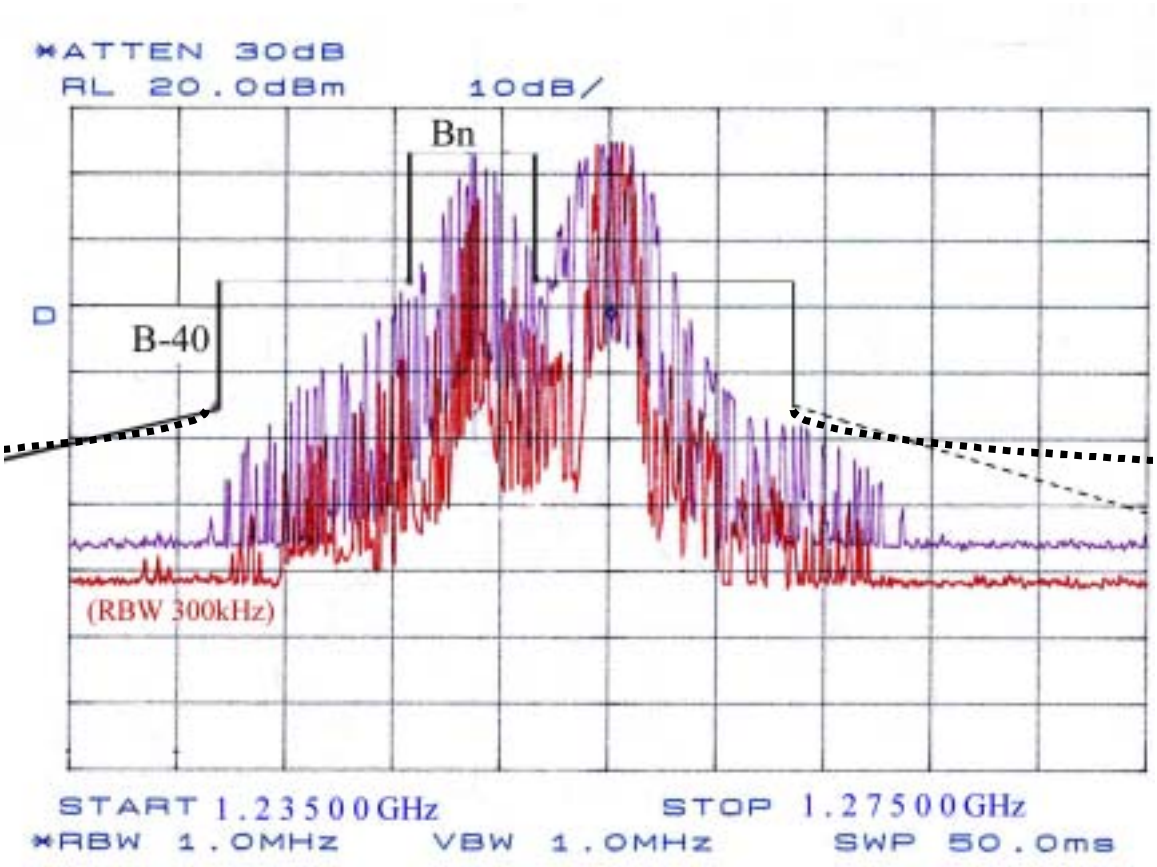
The boundary between out of band emissions and spurious emissions is at $\pm(2.5\ \alpha\ B_n =$ **14.45 MHz**) from the reference frequency.

3.3 Use of the emission masks

3.3.1 : on the modulated part



3.3.2 : on the un-modulated part



ANNEX

OBJECTIVES FOR BOUNDARIES AND LIMITS FOR PRIMARY RADAR

CEPT recommends the following boundaries for spurious emissions:

SPURIOUS DOMAIN LIMITS FOR RADAR SYSTEMS IN THE RADIODETERMINATION SERVICE[1]	
Type of Radars for radiodetermination	**Limits** Absolute levels (dBm) or Attenuation (dB) below the power supplied to the antenna port
Fixed stations[2] (wind profiler, multi-frequency, and active array radars are excluded)	PEP in the reference bandwidth : -30 dBm or 100 dB , whichever is less stringent
All other types of radar for radiodetermination	(43 + 10 logPEP), or 60 dB, whichever is less stringent these limits may be expressed in absolute PEP level in the reference bandwidth as : -13 dBm where PEP ≤ 50 W (10logPEP - 30) dBm where PEP > 50 W
Radar systems operating in standby mode	- 57 dBm 9 kHz ≤ *f* ≤ 1 GHz - 47 dBm 1 GHz < *f* (see recommend 3) No limit Within ±250% of the necessary bandwidth
PEP = peak envelope power in Watts at the antenna port in accordance with RR S1.157.	

This Annex defines the limits recommended for unwanted emissions in the out-of-band domain for the fixed radar stations for which ERC Rec. 74-01 applies the more stringent Category B Limits of Recommendation SM.329.

The limits of the unwanted emissions in the out-of-band domain for any other radar systems are given in Annex 8 of ITU-R SM.1541.

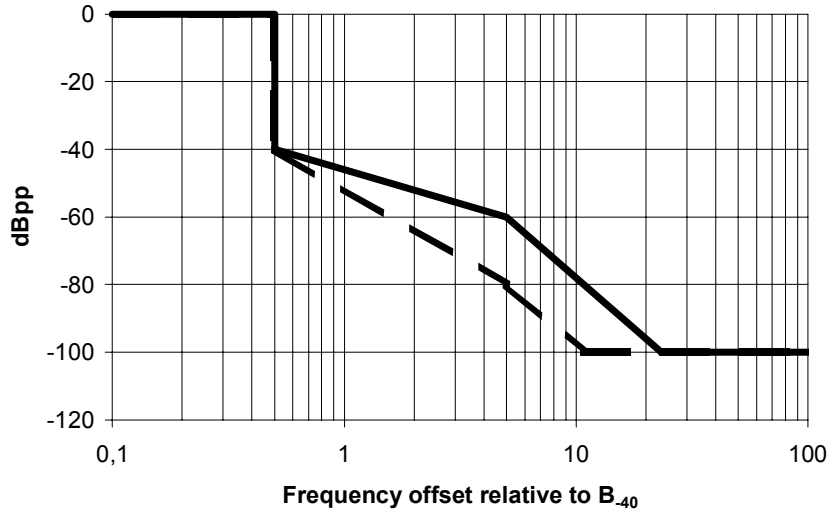
Two spectrum masks are given, the first one based on the roll-off of 20 dB/decade and the second one based on the design objective both taken from the Rec. ITU-R SM.1541. The mask based on an initial 20 dB roll off is applicable to all Radars which fall under this Annex. New radar design should aim to meet the design objectives as soon as possible. In the future it is intended to apply a more stringent mask based upon the design objective.

The two masks are as shown in Figure 1 below.

2 On a site by site basis, administrations may permit the use of maritime mobile radar equipment in fixed installations (e.g. Vessel Traffic Services radar), using the appropriate limits for mobile radars.

Figure 1: Emission Mask for Radars

The solid line is the current limit for unwanted emissions in the out of band domain. The dashed line represents the proposed design objective.



For the Category B limit, the mask rolls off at 20dB per decade from the calculated 40 dB Bandwidth (B_{-40}) to a level of –60 dB_{pp}. The limit continues to roll off at 60 dB per decade to the -100 dB level. For the design aim the mask rolls off at 40dB per decade from the calculated 40dB Bandwidth to a level of –80 dB_{pp}. The limit continues to roll off at 60 dB per decade to the -100 dB level. The equations for determining the 40 dB bandwidth are given in Annex 8 of ITU-R SM.1541.

The limit will result in the out of band emission domain of 46.4 times B_{-40}. The design objective will reduce the out of band emission domain to 21.5 times B_{-40}.

These two masks have the characteristics listed in the following Tables. The limits are given as a multiple of the frequency of the 40 dB bandwidth excursion.

Table 1: Limit of unwanted emission.

Offset Frequency x B_{-40}	Limit dB	Slope dB/decade
0 to 0.5	0	0
0.5	40	∞
0.5 to 5	40 to 60	20
5 to 23.2	60 to 100	60
23.2 to ∞	100	0

Table 2: Design Objective

Offset Frequency x B_{-40}	Limit dB	Slope dB/decade
0 to 0.5	0	0
0.5	40	∞
0.5 to 5	40 to 80	40
5 to 10.75	80 to 100	60
10.75 to ∞	100	0