



Technique to Suppress Unwanted Emission for the Marine Radar

1. ITU regulation status

Recommendation ITU-R SM.1541 has been updated in 2011. The OoB emission limits of primary radars are defined by some OoB masks, which depend on waveforms. As for marine radars using non-FM pulse, the mask rolls off at 30dB per decade is applied. In addition, the mask rolls off at 40 dB per decade is still described as the design objective.

New Japan Radio Company recommends the radar designers to choose the adaptable design to the mask rolls off at 30dB per decade and 40dB per decade, since the design objective says that “Radars should be designed to meet the requirement of the design objective mask. Where possible, radar design should avoid the use of technologies that are not capable of meeting the design objective”.

Extract from ITU Recommendation ITU-R SM.1541-4 (09/2011)

Formulas for the 40 dB bandwidth of non-FM pulse radars, -----, the bandwidth is the lesser of:

$$B_{-40} = \frac{K}{\sqrt{t \cdot t_r}} \text{ or } \frac{64}{t}$$

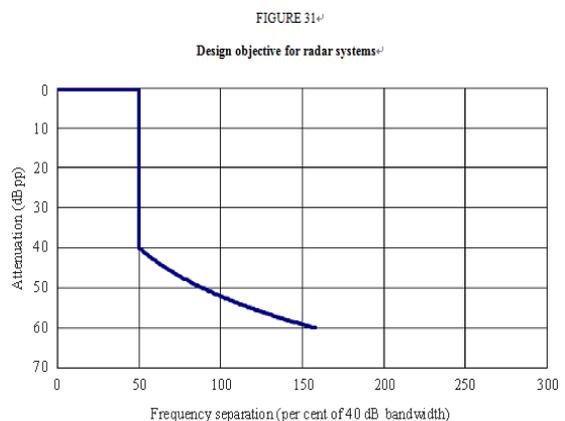
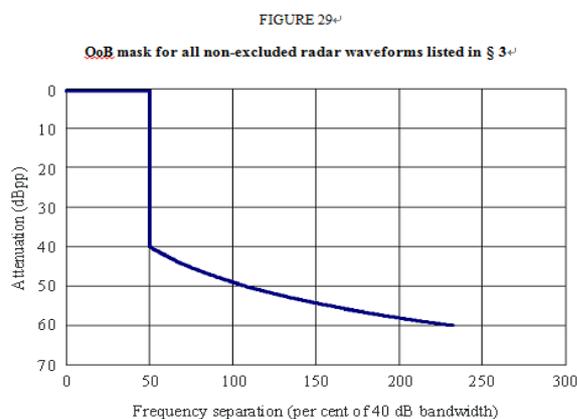
where coefficient K is 7.6 for lower-power radars and radars operating in the radionavigation service in the 2 900-3 100 MHz and 9 200-9 500 MHz bands.

Design objective

Radars should be designed to meet the requirement of the design objective mask. Where possible, radar design should avoid the use of technologies that are not capable of meeting the design objective.

◆ The mask rolls off at 30dB per decade

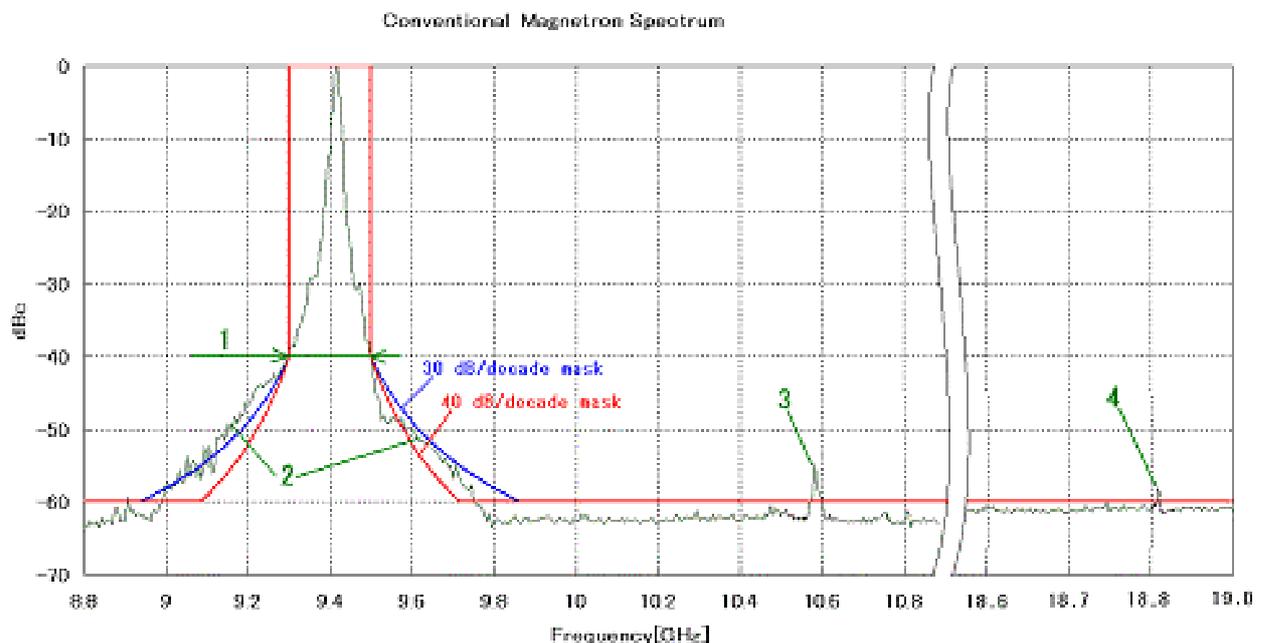
◆ The design objective mask rolls off at 40dB per decade



2. Critical points of suppressing unwanted emissions

There are 4 critical points to suppress unwanted emission level for adaptation to the mask.

1. B-40 Bandwidth
2. Side lobe emission
3. pi-1 mode emission
4. Second harmonics emission



3. Recommended solution

1. Install the V9 Technology magnetrons into the radar.



The V9 Technology magnetron is designed with advanced spectrum control technology.

This technology has been published in the IEEE transaction on Electron Devices

December 2009 Volume 56 Number 12 pp. 3191-3195. "Frequency Bandwidth Narrowing technology for Pulsed Magnetrons"

[http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=5299051&contentType=](http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=5299051&contentType=Journals+%26+Magazines&queryText%3DFrequency+Bandwidth+Narrowing+Technology)

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- ✓ 1. Narrower B-40 bandwidth
- ✓ 2. Better symmetry of spectrum
- ✓ 3. Shorter rise time [8nsec-17nsec]
- ✓ 4. Lower -1 mode emission



2. Adjust the modulator waveform

Recommendation ITU-R M.1177 says that “For radars with multiple pulse width settings, that can be selected individually, the setting which results in the widest calculated B40 dB bandwidth should be used. Emission measurements only need to be carried out for this pulse width setting.”. Therefore, it’s very important for the narrowing spectrum bandwidth to adjust the waveform of the shortest pulse.

The caring points for the modulator design are the anode voltage and the current waveform over 70 % area of the peak. The transient impedance matching between the magnetron and modulator output without overshoot is required. The slow or quick rising voltage also creates some problem, so that it’s necessary to adjust the appropriate rising voltage. In the end, the unwanted emission should be measured at the official site for the type approval.

3. Install the filter into the radar transmission line

The use of filter devices helps reduce unwanted emissions effectively.

Filter line-up is as follows,

Waveguide	Suppressible unwanted emission			
	pi-1 mode	second harmonics	pi-1 second harmonics	pi-1 mode second harmonics
WRJ-3 WR284	NJC9333	NJC9335	NJC9334	-
WRJ-9 WR-112	NJC9935	NJC9939	NJC9938	-
WRJ-10 WR90	NJC9936	NJC9941	NJC9937	NJC9952

It is important to adjust the phase between each device including the rotary joint in case the isolator isn’t installed between the magnetron and other devices.

4. Remarks

Many radar manufacturers have already successfully gotten approval with the above solution. It’s the choice of each radar manufacturer to adapt the “30dB per decade design” or the “40dB per decade design.”. In any case, New Japan Radio Company hopes this technical information is useful and effective for each radar manufacturer.