NTIA Technical Memorandum TM-05-430

Comparison of Radar Spectra on Varying Azimuths Relative to the Base of the Antenna Rotary Joint

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August 2005

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CONTENTS

COMPARISON OF RADAR SPECTRA ON VARYING AZIMUTHS RELATIVE TO THE BASE OF THE ANTENNA ROTARY JOINT

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This technical memorandum describes the results of radiated measurements of the emission spectrum of a maritime radar at varying azimuths relative to the base of the radar transmitter antenna rotary joint. The measurements were performed to address the question of whether the emission spectrum of such a radar might vary as a function of the pointing azimuth of the radar antenna as it rotates due to variation in the joint's voltage standing wave ratio (VSWR) with azimuth. If such variation were to occur, then the radiated spectrum would need to be characterized as a function of azimuth. The measurement results indicate that the emission spectrum of this radar does not vary as a function of transmitter antenna azimuth. It is concluded that this issue is probably not a concern for radar emission measurements in general, and that the radiated spectrum measurement procedures described in NTIA Report TR-05-420 are adequate.

Key words: radar emission measurement techniques; radar rotary joint voltage standing wave ratio (VSWR); radar spectrum engineering criteria

1 INTRODUCTION

According to published procedures for the measurement of radiated emissions from radar transmitters [1-2], the measurement system should stay at a fixed azimuth relative to the radar transmitter unit for the duration of a spectrum measurement. For radar transmitters that utilize mechanically rotated antennas, this means that such a spectrum measurement would be performed at a single azimuth relative to the base of the radar transmitter antenna rotary joint. The question has arisen as to whether the electrical characteristics of radar rotary joints might be expected to vary sufficiently as a function of azimuth as to cause the emission spectra of such radars to vary significantly as a function of azimuth from the radar transmitters.

To address this question, the authors have performed measurements of emission spectra of a maritime radiolocation radar transmitter, operating in the band 8,500-10,500 MHz, at four separate azimuths with respect to the base of the rotary joint of the radar antenna. The four spectra obtained have been compared to determine the amount of variation between those emission spectra. This document describes those measurements and the results that were obtained.

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2 APPROACH

A maritime surface search radar, operating in the 8,500-10,500 MHz band, was set up in a normal operating mode at the Table Mountain Radio Quiet Zone facility north of Boulder, CO, USA. Pertinent radar transmitter characteristics are given in Table 1. The radar transmitter antenna was located at a height of approximately 4 m above the ground.

Table 1. Characteristics of the Maritime Radar Used in the Rotary Joint Study

Pulse width (ns)	Output device	Transmitter peak power (kW)	Antenna type, length, and gain	Radiated EIRP (MW)
80	magnetron	12	end fed slotted array 1.8 m, 30 dBi	12

The measurement antenna was a 0.5-m diameter parabolic unit mounted about 4 m above the ground. Measurement system calibration (with a noise diode and a standard Y-factor computation) and data collection were performed in conformance with published procedures of NTIA and the International Telecommunication Union Radiocommunication Sector (ITU-R) [1-2]. The measurement system block diagram is shown in Figure 1. The 3-dB measurement bandwidth was 8 MHz and the frequency step size was 8 MHz between data points. The data were collected at a distance of 126 m from the radar.

The radar antenna rotated normally during all measurements. After the first radar emission spectrum was completed with the base of the radar in its initial position, the radar was temporarily turned off and the base of the radar was rotated 90 degrees clockwise (as seen from above) on the mounting tower; the measurement system position was not changed. Then the radar was reactivated and the spectrum measurement was repeated, again with the radar antenna rotating normally throughout. Then the procedure of rotating the base of the radar transmitter and measuring the spectrum was repeated twice more, with the base of the radar oriented at angles of 180 degrees and 270 degrees relative to the initial orientation.

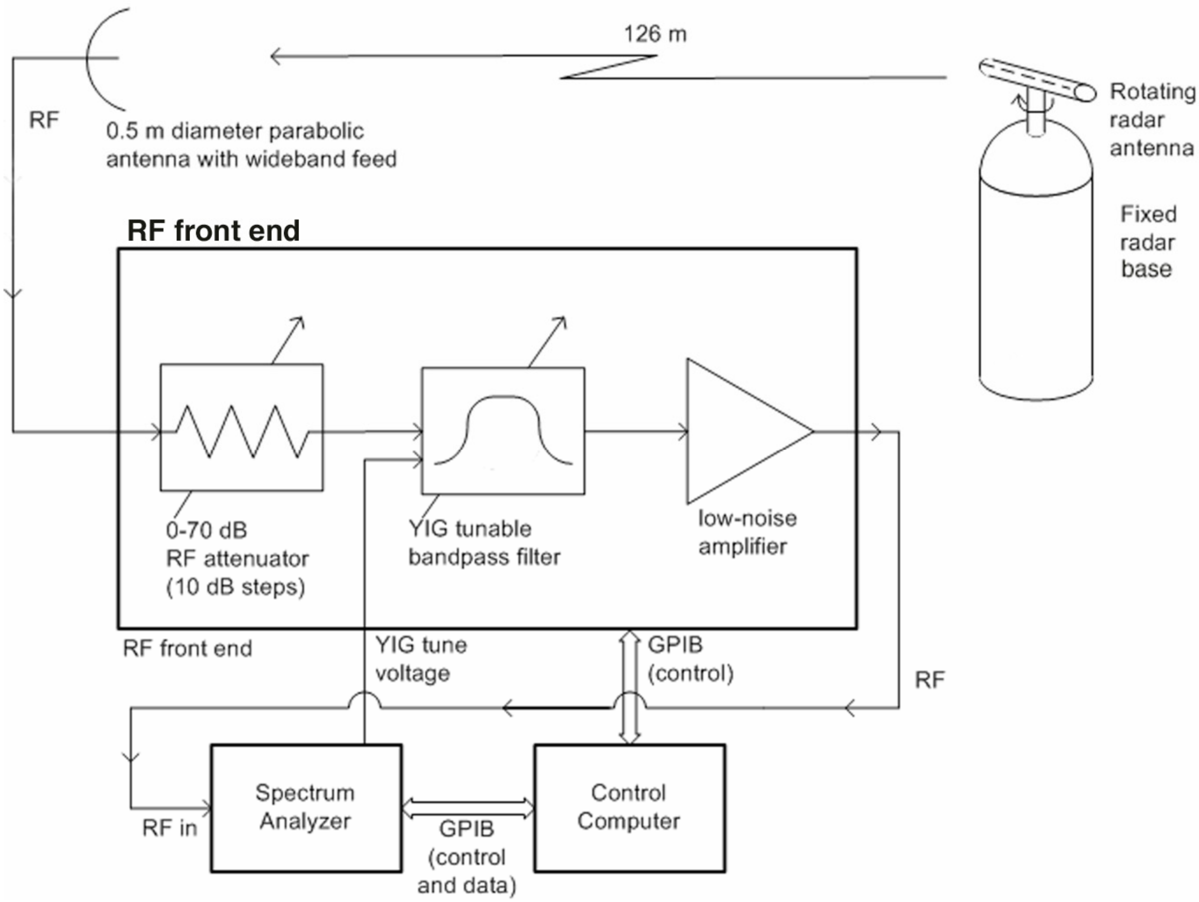

Figure 1. Block diagram of the radar spectrum measurement system. The spectrum analyzer was an Agilent E-4440A. The RF front end was designed and built by NTIA/ITS.

3 RESULTS AND ANALYSIS

The result of these measurements was a set of four radar emission spectra made at four azimuths relative to the base of the radar antenna rotary joint and separated one from the next by an angle of 90 degrees.

The spectrum measurement results are shown in Figures 2 and 3. The figures show the four radiated spectra observed from the four rotary joint base angles. In Figure 2, the radar emission spectra are shown, the only corrections being drawn from the noise diode Y-factor calibration that had been run on the measurement system before the data were collected. In Figure 3, the spectra are normalized to the same power level at the radar fundamental frequency. In both cases, the variation between the spectra, about 1 dB, is less than the resolution of the measurement system [3].

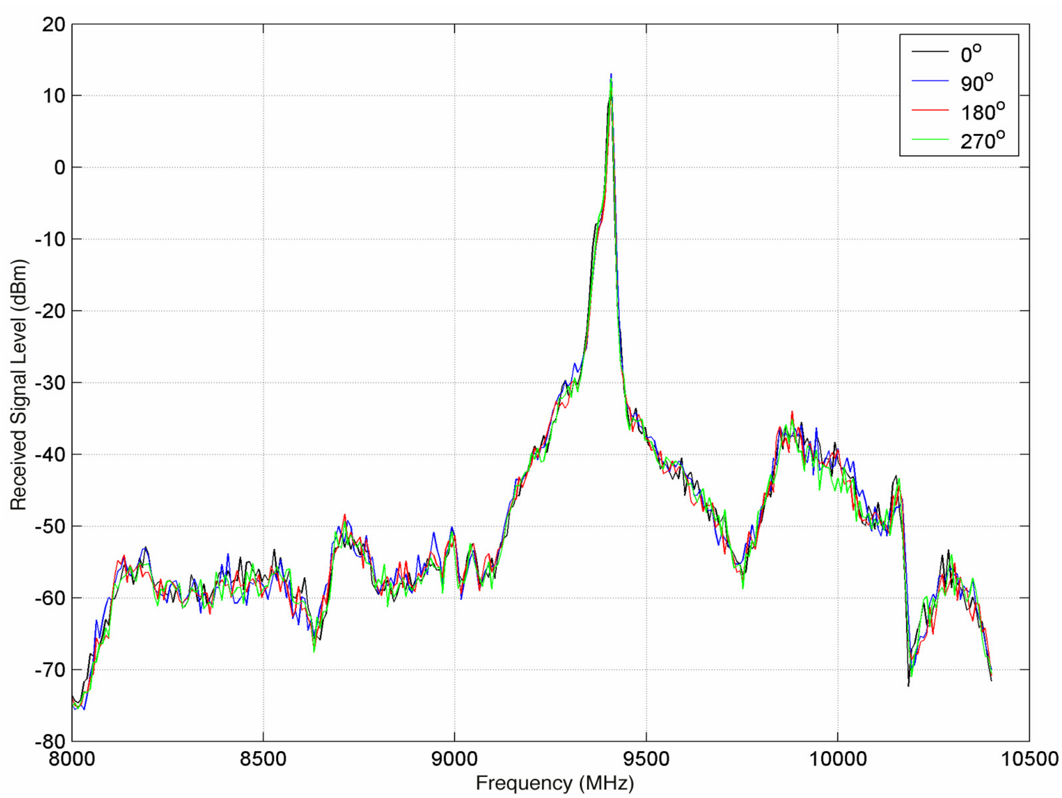

Figure 2. Non-normalized radar emission spectra measured at four azimuths relative to the base of the radar transmitter antenna rotary joint.

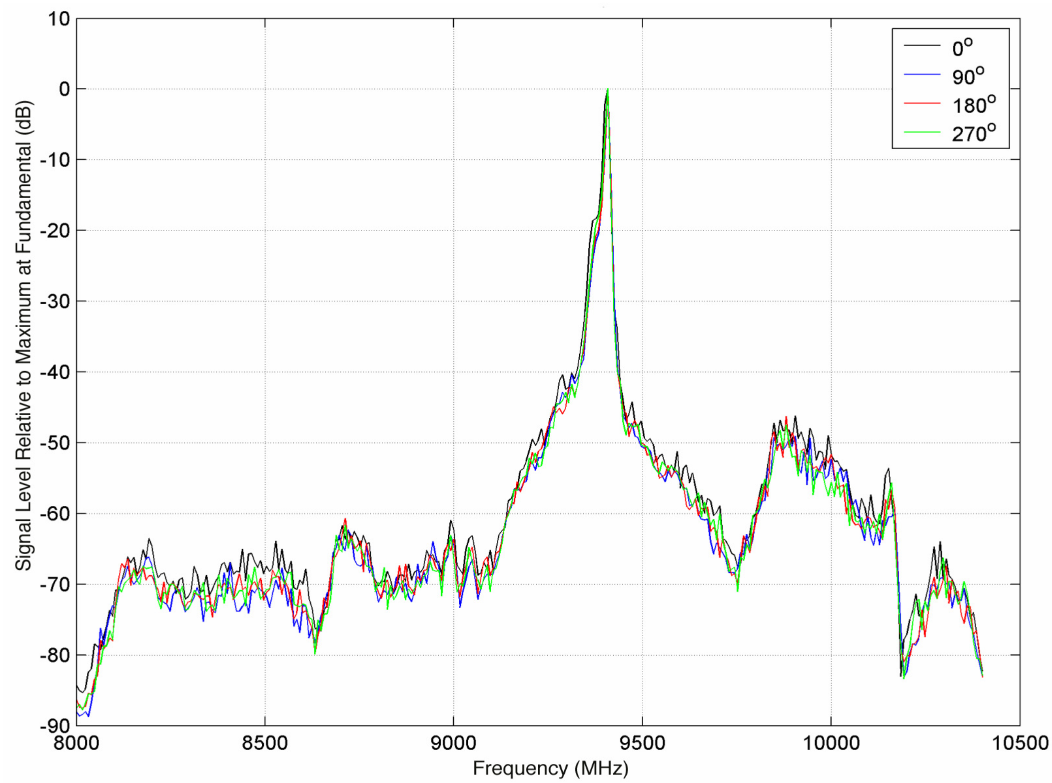

Figure 3. Radar emission spectra on four azimuths relative to the base of the rotary joint, normalized to 0 dB maximum power at the fundamental frequency.

4 CONCLUSION

No difference was observed between emission spectra at four azimuths separated by 90 degrees relative to the base of the rotary joint of this radar. The small variations that are observed are accounted for by the inherent error of the measurement system.

While it could be hazardous to generalize this conclusion (as it is based upon a sample set of one), it should be noted that the radar transmitter used for these measurements was a relatively inexpensive unit that had been handled somewhat roughly at some times in its operational history. In particular, the radar antenna was mechanically stressed on one occasion, resulting in a slight vertical oriented bend near the center of the antenna, directly above the rotary joint. Thus, if there were any radar antenna rotary joint that should have shown significant variation in its electrical characteristics as a function of azimuth, this one was it.

Since this radar does not show significant variations in its emission spectrum as a function of rotary joint azimuth, it is concluded that the issue may not be very important for radar rotary joints in general. Published procedures for measurements of radiated emission spectra from radar transmitters [1-2], which currently specify measurements of such emissions from a single azimuth, are therefore presumed to be adequate.

5 REFERENCES

[1] F.H. Sanders, R.L. Hinkle, and B.J. Ramsey, “Measurement procedures for the radar spectrum engineering criteria,” NTIA Report TR-05-420, Mar. 2005.

[2] ITU-R Recommendation M.1177, “Techniques for measurement of unwanted emissions of radar systems,” International Telecommunication Union, Radiocommunication Sector, 2003.

[3] J.W. Allen, “Gain characterization of the RF measurement path,” NTIA Report TR-04-410, Feb. 2004.