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Estimation of Minimum Power Signal for Target Detection using the Comparative Study of Radar Bands

Anuj Gupta*, Shashank Jain*, Sonali Srivastava*, Sudhir Kumar Chaturvedi*, and Pavan Kumar Nanduri*
*(Department of Aerospace, University of Petroleum and Energy Studies, Dehradun-248007)
(Email: sudhir.chaturvedi@ddn.upes.ac.in)

ABSTRACT
Radar is an object detection system which uses radio waves to determine the range, altitude, direction, or speed of objects. The radar dish or antenna transmits pulses of radio waves or microwaves which bounce off any object in their path. The object returns a tiny part of the wave's energy to a dish or antenna which is usually located at the same site as the transmitter. The purpose of this paper is to estimate the minimum power required to detect the target using various radar bands. The power for each band will be determined using RADAR Range equation in terms of various parameters such as aperture, wavelength, and noise factor. The result output from this work is used for the detection of minimum observable target power for the target detection under higher level of accuracy in a short period of time.
Keywords: Aperture area, Bands, Minimum power detections, RADAR

I. INTRODUCTION

The basic concept of radar is relatively simple even though in many instances its practical implementation is not. Radar operates by radiating electromagnetic energy and detecting the echo returned from reflecting objects (targets). The nature of the echo signal provides information about the target [1] [2]. The received echo signal is varying inversely with square of the distance between source and receiver. So, there must be the threshold power below which the target will not be able to detect and this threshold power is called as minimum power to detect the signal, as atmospheric interference is there in the line of sight which also obstructs the signal to reach the receiver. Thus again there is reduction in echo signal. So to detect the target the power should be more than threshold power [5] [7]. The purpose of this paper is to estimate the minimum power which is required to detect the target using various radar bands (L, S, C, X, Ku, K, Ka) by using MATLAB algorithm and to calculate which band is more suitable for the particular target detection.

II. PRINCIPLES OF RADAR

The word **RADAR** is an acronym for Radio Detection and Ranging. Radar is an electromagnetic system for the detection and location of objects.
It operates by transmitting a particular type of waveform and detects the nature of echo signal. Radar can operate in situation like darkness, fog, rain, or when the object is located far away. In such situation human eye is almost useless [3] [4]. However, perhaps the most important attribute of radar is that in can also measure the distance or range of object. Radar consists of three main parts: (1) A transmitting antenna, (2) A receiving antenna, (3) An energy (signal) detecting device.
The transmitting antenna emits electromagnetic radiation; a portion of which is reflected by the target as shown in Fig 1. The receiving antenna receives this reflected energy and delivers it to the receivers. The receivers processes this energy to detect the presence of the target and to extracts its location and other information. This energy emitted by the radar is usually in the form of a train of narrow, rectangular shaped pulses called RADAR waveform.

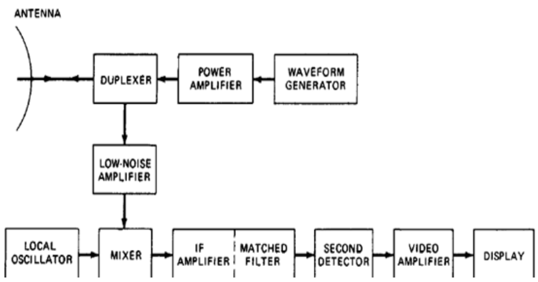

Fig 1: Block Diagram of RADAR

III. Radar Equations

The radar equation relates the range of radar to the characteristics of the transmitter, receiver, antenna, and target [6] [8]. The radar equation is useful

- In determining the distance of the target from the radar.

- As a tool for understanding radar operation
- In serving as a basis for radar design.

The equation of radar is

P_{min} = ——— (1)

P_{min} = Minimum detectable power
P_t = Transmitted power (in watt)
G_t = Gain of transmitted antenna
G_r = Gain of receiving antenna
λ = Wavelength of a signal
R_{max}= Maximum range of radar up to which target can be detected

Range performance of radar

R_{max} = ——— (2)

III. METHODOLOGY

Fig 2 shows the steps performed in analyzing the performance under various RADAR Bands. Table 1 depicts the parameters used during analysis.

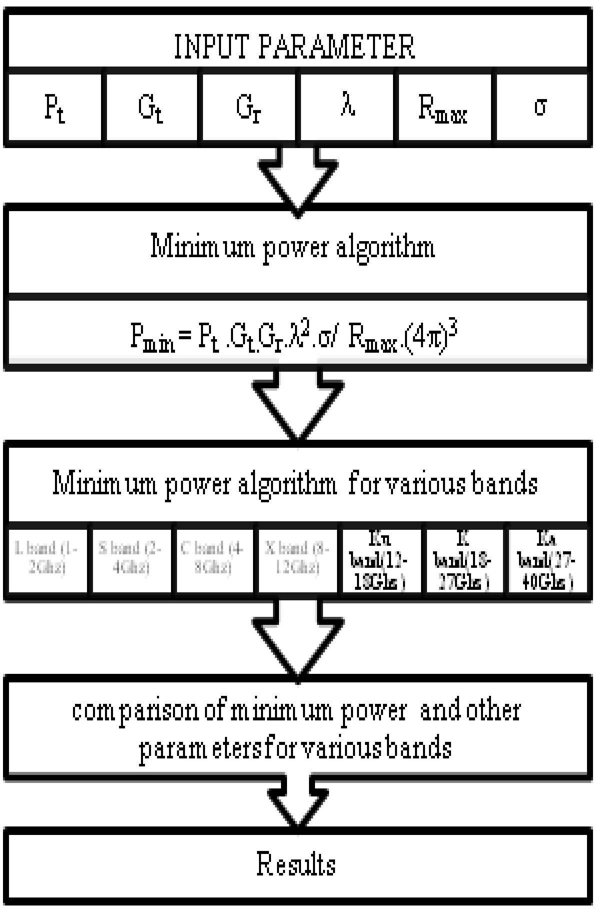

Fig 2: Methodology

Table 1: Performance Parameters

Input parameters	Fig 1	Fig 2	Fig 3	Fig 4
Transmitted power (P_t)	10kw	10kw	10kw	10kw
Radar cross section(σ)	1.2 m^2	1.2m^2	Varying from 1-5m^2	1.2m^2
Wavelength (λ)	Band constant	Band varying	Band constant	Band varying
Gain of transmitted antenna (Gt)	5000	5000	5000	5000
Gain of received antenna (Gt)	5000	5000	5000	5000
Range	variable	30km	30km	5000
Received power	----	-----	-----	10^{-8}

IV. RESULTS

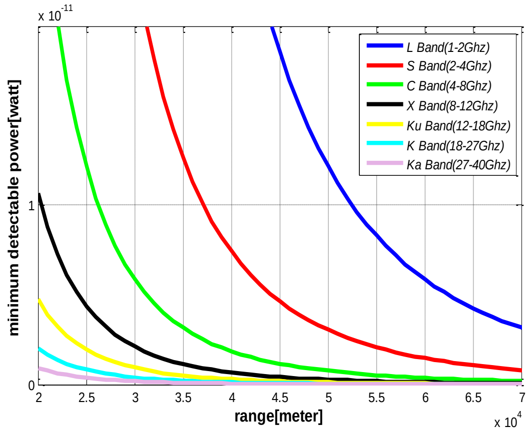

Fig 3: Variation of Minimum Detectable Signal with the Range

Fig 3 shows that on increasing the range, minimum detectable power for each band decreases. For low frequency band it is inferred that the decrement is less because of its lower frequency range i.e. on increasing the frequency for the particular transmitting signal (power) the receiving signal energy would decrease.

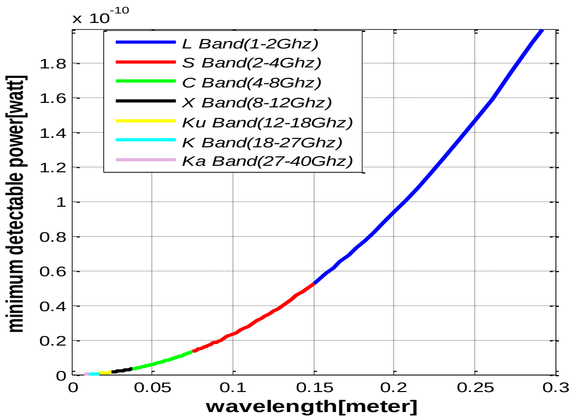

Fig 4: Representation of power with respect to wavelength for various bands

Fig 4 shows that on increasing the wavelength, the minimum detectable power for each band increases. For lower frequency band it is inferred that the increment is more because of its low frequency range, i.e. on increasing the wavelength (or decrease in frequency) for the particular transmitting signal (power), receiving signal energy would increases.

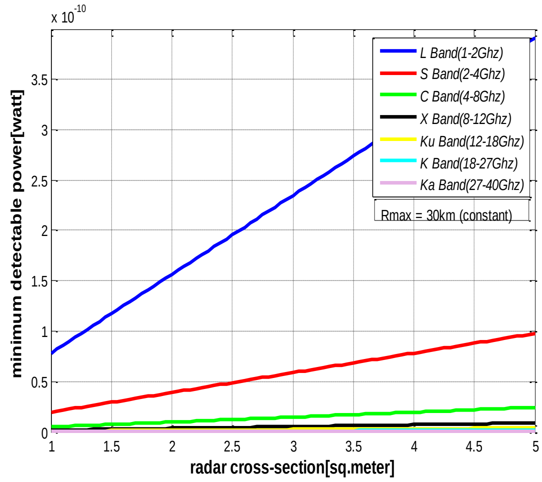

Fig 5: Plot for Obtained Power With Respect to Radar Cross Section

Fig 5 shows that on increasing radar cross-section the minimum detectable power for each band increases. For the lower frequency band it is inferred that the increment is more because of its low frequency range, i.e. on increasing the frequency for the particular transmitting signal (power) receiving signal energy would decrease.

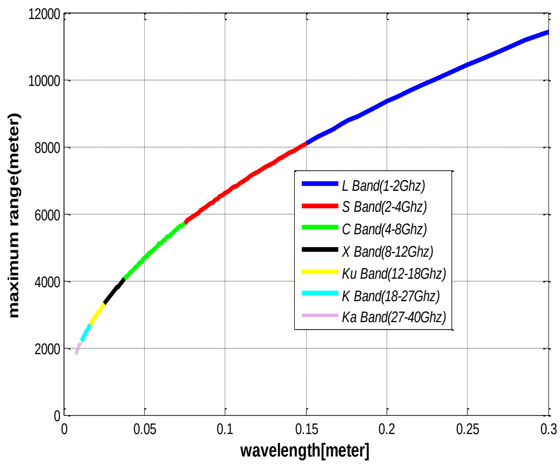

Fig 6: Variation for range verses wavelength for various radar bands

Fig 6 shows that on decreasing wavelength, the maximum range for each band decreases. For the lower frequency band it is inferred that the decrement is less because of its low frequency range, i.e. on increasing the frequency for the particular transmitting signal (power), receiving signal energy would decrease.

V. Conclusion

In this paper, it has been analyzed that the bands which are operating for lower frequency range are more suitable for nearby target detection while the bands which are operating for higher frequency range like Ku, K, Ka are more suitable for far away located targets. Ku band can be used for communication in deep space but the limitation with the other higher bands operating for far away located objects is that these bands require much larger size of dish used in antennas.

References

[1] I. Skolnik Merril, "Radar Handbook: Introduction and principle of radar", *McGraw-Hill, 1990, Sec. 1.2-1.6.*

[2] Kraus J. D., "Antenna", *Mcgraw-Hill, 1988, Sec.2-22.*

[3] J.W. Crispin Jr and K.M. Siegel, "Method of radar cross section Analysis", *New York, Academic, 1962, Chap 8.*

[4] Brookner, E., "Radar Technology", *Dedham, MA. Artech House, 1977, Chap 3.*

[5] Blake L. V., "Radar Range-performance Analysis", *2ed. Norwood, MA. Artech House, 1986.*

[6] Meyer D.P. and H.A. Mayer, "Radar Target Detection", *New York, Academic, 1973.*

[7] Ridenour L.N., "Radar System Engineering", MIT Radiation Laboratory Series, McGraw-Hill, 1947, 592.

[8] Mahafza, Bassem R., "Radar Systems Analysis and Design Using MATLAB", *CRC Publishers, 2013.*