PERFORMANCE STUDY OF SELF SCREENING AND STAND-OFF RADAR JAMMERS

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ABSTRACT

RADARs are mainly used to detect and locate the position of objects. In the war fields it is very important that the target identity is masked so that the enemy attacks can be overcome. In order to mask the targets and create the false identity jammers are very useful. There are various types of jammers and self screening jammers and stand-off jammers are the most protecting jammers. Hence we have analysed all the parameters related to self screening jammers (SSJ) and stand-off jammers (SOJ). The variation of the cross over range with respect to jammer peak power, RADAR peak power, attenuation in SSJ and the variation of range reduction factor with respect to frequency, RADAR to jammer range, jammer peak power in SOJ are analysed using MATLAB in this article.

***Keywords:** RADAR, Jammers, Self Screening Jammers, Stand-Off jammers, Cross Over/Burn Through Range, Range Reduction Factor*

INTRODUCTION

RADAR meant for Radio Detection and Ranging. Generally RADAR systems use the modulated waveform and directive antennas to transmit electromagnetic energy into specific volume in space for targets. Targets which are kept in a limited volume reflect energy back to the RADAR. Then the processed echoes are received by RADAR to extract target information such as range, velocity, angular position, and other characteristics.

The equation of radar is given as

$$P_r = \frac{P_t G_t}{4\pi R^2} \frac{\sigma}{4\pi R^2} A_e \qquad (1)$$

$$A_e = \frac{\lambda^2 G_r}{4\pi} \qquad (2)$$

P_r = Received power
P_t = Transmitted power
G_t = Gain of transmitter
G_r = Gain of receiver
σ = RADAR cross section

R = Distance between target and transmitter
A_e = Effective area of the receiving antenna
If we attempt to disturb the normal RADAR operation intentionally it is called as electronic counter measure (ECM). ECM accomplishes one or several objectives such as denying proper target detection, generate operator confusion, creating false tracks of targets. The purpose of electronic attack is to reduce use of portion of electromagnetic spectrum to an enemy. Jammer's effective radiated power (ERP) which is the product of radio frequency power arriving at antenna and the power gain produced by the antenna is used to detect energy radiated in a particular direction.

RADAR JAMMING TECHNIQUES

Generally jamming techniques are of two types. They are noise jamming and deception jamming.

A. NOISE JAMMING

The objective of noise jamming is to introduce disruptive signal into hostile environment to obscure the wanted signal. The noise is due to Data link, Communication medium and RADAR receiver. On other hand in spot jamming, receiver senses the signal that is to be jammed and aligns the jammer to a particular operating frequency. By employing techniques like frequency agility, frequency hopping and spread spectrum we can detect spot jamming. This is done by drawing the jammer into broad band barrage mode.

The barrage jammer operates over wide band of frequencies rather than discrete frequencies. Barrage jamming used against frequency agile transmitters. To generate high power over wide band of frequencies comes at high cost, weight and size. When the obscuring noise appears similar to thermal noise of victim's receiver, ideal jamming is achieved. In this situation, the presence of target is not observed by the transmitter.The main advantage of noise jamming is that only little information is enough to know the characteristics of victim emitter for jamming to be effective. Indiscriminate use of noise jammers increase the cost of jamming resources and also compromise the safety of jamming platform. If the emitter is non-radiating, it is meaningless to jam it. So most jammers use a receiver which may be a resource on the platform such as RADAR warning receiver to monitor the electromagnetic environment.

B. Deception Jamming

Deception jamming is a countermeasure against search and tracking RADARS. Signals similar to that of signals expected by RADAR receiver are generated but with higher power. The deception jammer receives the transmitted signal and retransmits them with appropriate amplitude and phase modulations. The basic forms of deception jamming include generation of multiple false targets, range gate pull-off, velocity gate pull-off. To jam the hostile RADAR used for tracking, a jamming signal of sufficient power at an appropriate frequency must be generated so that operation of enemy RADAR receiver is disrupted. When the strength of jamming signal exceeds the signal reflected from the platform to be protected, the RADAR will be unable to derive accurate range and bearing information. In practical, travelling wave tubes (TWT) and solid state devices and hybrid of both are used. These approaches find application in an overlapping spectrum of frequencies and available powers.

In general solid state devices offer lower distortion and better gain linearity than TWT's over much of their dynamic range. These devices also provide higher maximum gain and lower noise. Substitution of solid state amplifiers for traditional TWT amplifiers failed for two reasons

1. The efficiency of wideband solid state amplifiers is much lower than TWT amplifiers.
2. The maximum power provided by the solid state microwave monolithic integrated circuit (MMIC) amplifier was low about 1 watt.

To achieve required RF power, many parallel solid state amplifiers are necessary and losses in recombination process needed to get power into a single output made solid state technology even more inefficient. The idea for exploitation of solid state devices was performing recombination process of solid state paralleled amplifiers directly in air through phased array antenna

SELF SCREENING JAMMERS

Self-screening jammers are a class of ECM systems carried on the vehicle they are protecting. SSJ exhibit the properties of barrage jammers. Self-screening jammers, also known as self-protecting jammers, are a class of ECM systems carried on the vehicle they are protecting. Escort jammers (carried on vehicles that accompany the attacking vehicles) can also be treated as SSJs if they appear at the same range as that of the target.

$$P_{SSJ} = \frac{P_j G_j \ AB}{4\pi R^2 \ P_J \ L_J} \qquad (3)$$

P_{SSJ} = Power received at Radar from Jammer
P_J = Jammer's peak power
A = Effective area of RADAR
B_J = Operating Bandwidth of Jammer
R = Distance between Target and RADAR
B = Bandwidth of RADAR
L_J = Losses

A. Burn through range:

J/S crossover range is the radar-to-target range when the power received (S) from the radar skin return from the target equals the power received (J) from the jamming signal transmitted from the target. When the ratio of radar power to jammer power is unity the range is known as cross over or burn through range (R_{co})

$$(R_{co})_{SSJ} = \left(\frac{P_T G \sigma B_J L_J}{4\pi P_J G_J B L}\right)^{1/2} \quad (4)$$

B. Radar cross-section

The ability of target to reflect the RADAR signals in the direction of RADAR receiver is known as RADAR cross section. It is ratio of backscatter power per steradian in the direction of the RADAR from target to the power density that is intercepted by the target.

STAND-OFF JAMMERS (SOJ)

Stand-off jammers (SOJ) emit ECM signals from long ranges which are beyond the defence's lethal capability. The power received by the radar from an SOJ jammer at range Rj is

$$P_{SOJ} = \frac{P_J G_J}{4\pi R^2} \frac{\lambda^2 G'}{4\pi} \frac{B}{B_J L_J} \quad (5)$$

The gain term **G'** represents the radar antenna gain in the direction of the jammer and is normally considered to be the side lobe gain.

The SOJ radar equation is

$$\frac{S}{S_{SOJ}} = \frac{P_t G^2 R_J^2 \sigma B_J L_J}{4\pi P_J G_J G' R^4 B L} \quad (6)$$

When $s = S_{soj}$ then the range cross over range is given as

$$(R_{CO})_{SOJ} = \left(\frac{P_t G^2 R_J^2 \sigma B_J L_J}{4\pi P_J G_J G' B L}\right)^{1/4} \quad (7)$$

And the detection range is

$$R_D = \frac{(R_{CO})_{SOJ}}{\sqrt[4]{(S/S_{SOJ})_{min}}} \quad (8)$$

When the S/Ssoj is minimum value when compared to the signal to jammer power such that the target detection can occur.

A. Range Reduction Factor:

Range reduction factor (RRF) is given as the ratio of the jamming effective RADAR range to the detection range.

RESULTS

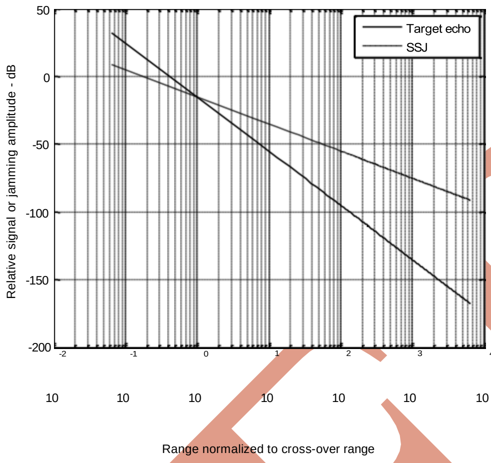

Fig 1 Cross Over Range to signal attenuation

The normalised range of the RADAR signal coinciding with the jammer signal is called range cross over. As the range cross over increases, the signal attenuation increases.

If we consider cross over range on y axis and jammer peak power on x axis, as cross over range increases the peak power of jammer decreases logarithmically. Similarly if we consider RADAR peak power on x axis and cross over range on y axis, with the increase in cross over range, RADAR peak power increases logarithmically.

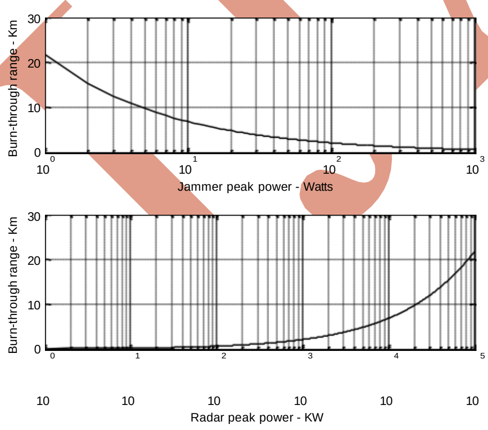

Fig 2 Jammer Peak Power and Radar Peak Power to Cross Over Range

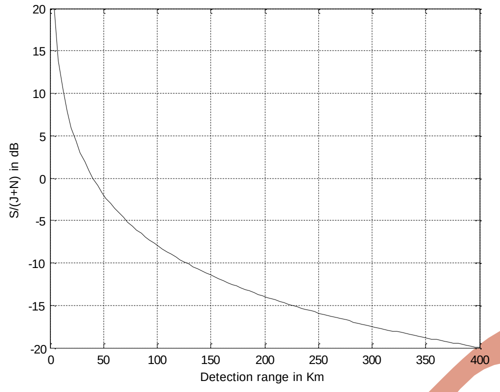

Fig3 Detection Range and signal to jammer power

This proves that with the raise in the detecting range of the target, the S/(J+N) i.e cross over range decreases.

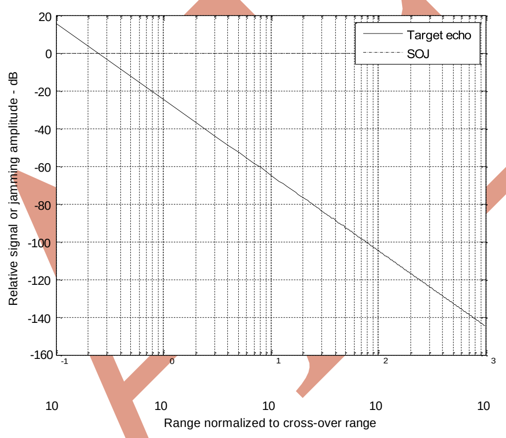

Fig 4 Jammer and Target Echo signal

When the wavelength increases the detection range decreases but when the radar to jammer range is increased the range reduction factor also increases and also jammer peak power increases range reduction factor decreases.

The below graph shows that as frequency increases the range reduction factor also increases as the jamming detection range reduces.

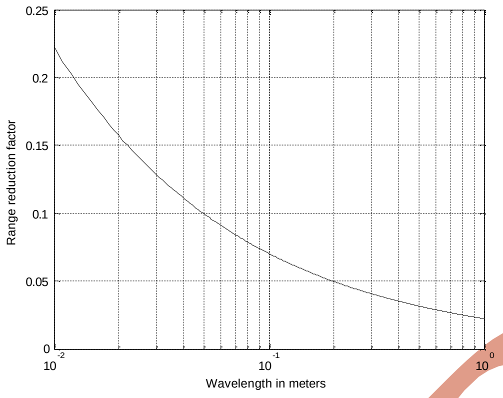

Fig 5 Range reduction factor versus radar operating wavelength.

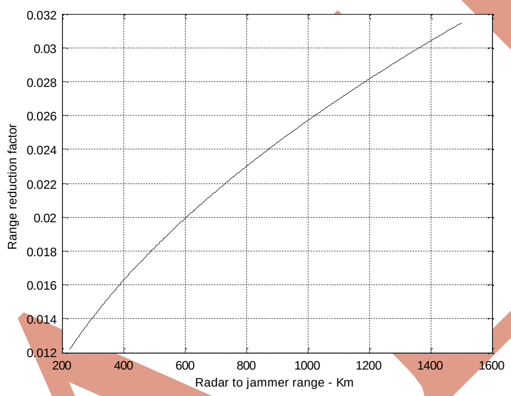

Fig 6 Range reduction factor versus radar to jammer range.

As RADAR to jammer range increases the range reduction factor also increases with some nonlinearity.

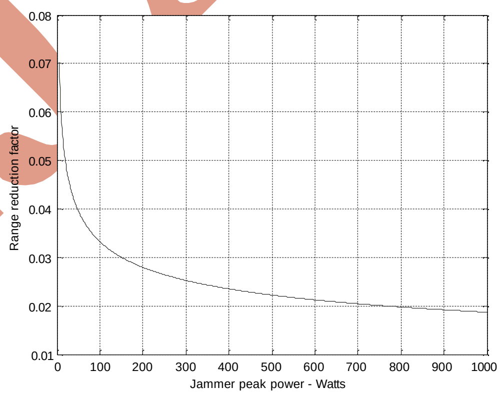

Fig 7 Range reduction factor versus jammer peak power.

As the power transmitted at the RADAR is increasing the range reduction factor reduces exponentially.

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CONCLUSION

RADAR transmission is a two-way transmission. It has to be emerged from the RADAR and hit the target where the signal is dispersed in all the directions and some part of the signal is echoed towards the RADAR which is a weak signal compared to the original signal that is transmitted. In other hand transmission through jammer is one-way, where it has to travel from target to the RADAR which is a direct signal from the jammer possessing high signal strength which can dominate the original RADAR signal. As the cross over range increases the signal attenuation increases, so the signal weakens. As operating frequency increases, there is an exponential decrease in detection range. As RADAR to jammer range increases the range reduction factor also increases with some nonlinearity. Range reduction factor and transmitted power are inversely related.

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