Test Procedure to Verify Demonstrable ECCM Functions for Passive Radars using Field BITE

Shashank S Chachadi [1], Udayashankar M [1] Supreeth K S [2,]
[1,] Bharat Electronics Limited, Bangalore – 560013, India.
[2,] LRDE, C V Raman Nagar, Bangalore – 560093, India

udayashankarm@bel.co.in, shashanksc@bel.co.in

Abstract:

Electronic counter-counter measures (ECCM) are a part of electronic warfare (EW) including variety of practices which attempt to reduce or eliminate the effect of electronic countermeasures (ECM) on electronic sensors (ES).

ECCM measures in Weapon Locating Radar (WLR) type Radars include two parts- detection of jammer and counter measures for the detected jammer. These are explained with new test procedure to demonstrate ECM/ECCM using field BITE. Using this test set up, Radar is designed to detect jamming/Least Jamming Frequency considering field BITE as a jammer station. The specific techniques for detection namely Pulse compression, Frequency hopping, Side lobe blanking using field BITE is explained. The Field BITE is used for target generation for this test. The search pattern is designed with a scanning of ±45° in Azimuth & 0° to 10° in elevation. The Field BITE receives the simulated Radar signal via IF cable & re-transmits in C-Band back to the WLR system. ECM test jig is used to simulate jamming environment and radiate towards Radar from the same location as that of Field BITE.

I. INTRODUCTION:

The purpose of Weapon Locating Radar (SWATHI) is to detect the launch point of an enemy projectile and to establish a segment of the trajectory of the projectile of sufficient length and positional accuracy to enable a computer to determine the location of the gun or launcher. Counter action may be then taken against the gun or launcher. This technique is known as back track location or back extrapolation because the computer follows back along the measured portion of the projectile path to the point where it intersects ground.

As part of Electronic Counter Counter Measure (ECCM) capability, the system should be resistant to electronic counter measures, with built in survivability features that will ensure the system operational performance in a hostile electronic environment. To demonstrate the ECCM capability of the Radar, a Field BITE facility is incorporated to simulate the jamming environment by adding noise in the specific frequency of operation of the BITE signal and radiating back onto the Radar Antenna. At the receiver input of the Radar, the Radar Computer checks for reduction in the range and the echo received from Receiver at any position of azimuth and elevation for a particular frequency, the noise level of receiver after processing is monitored to be of certain threshold above normal to declare the presence of jamming and suitable counter measures are invoked. The inherent ECCM system capabilities of the Radar are as listed below,

[1]. Selectivity
[2]. Low Side-Lobe Antenna
[3]. Constant False Alarm Rate
[4]. Pulse Compression
[5]. Fast Electronic beam switching and Agility
[6]. Multiple Target tracking capability with narrow beam-width
[7]. Monopulse Tracking and
[8]. Polarization
[9]. Staggered Waveform
[10]. Jam Strobe Presentation (JSP)
[11]. Dwell based Frequency Agility
[12]. Least Jammed Frequency (LJF)
[13]. Sector Blanking
[14]. Facility for providing azimuth of Jammers station

Receiver Noise			
Boltzman's constant	k	Joule/^{o}K	1.38E-23
Reference Temperature for Noise Figure	T_o	^{o}K	300
Noise Figure of the System	F_N	dB	2
IF Bandwidth	B_{IF}	Hz	B_{IF}
Noise at Receiver input	N_{Rx}	dBm	104.8402965
Receiver Sensitivity		dBm	104.8402965

Receiver Gain Set= 70 dB

Noise input at ADC = -104.84 + 70 = -34.84 dBm

ADC Noise input at PSP is (mV) = Antilog (-34.84+56)/20
= 11.4 mV (P-P)

Threshold Noise should be > 12mV (P-P)

Threshold Noise V rms = 12mV/2*1.414= 4.24 mV

No of counts declared = 4.24/128 uV = 33

Minimum Noise count required is = 33

Finally noise count kept for LJF is 35 counts

Therefore More than 35 counts or 12 mV noise LJF is declared.

II. TEST OBJECTIVE:

The purpose of the test is to verify the demonstrable ECCM features as per GSQR requirements viz.

1. LJF (Least Jam Frequency).
2. Beam Lifting
3. Sector Blanking

III. TEST DESCRIPTION:

Test set up for ECCM Demonstration using Field BITE

The Field BITE unit is basically a RF up converter. It receives the RF signal 60MHz from radar, up converts to C-band frequency and radiated back to Radar. The set up shows Radar vehicle, Field BITE vehicle as in Fig 1

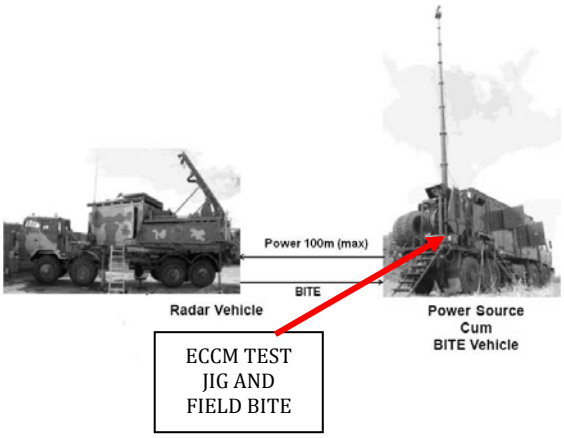

Fig 1: Radar Vehicle and Field BITE Vehicle

The Distance between Radar antenna and field BITE antenna to proper beam formation Far-field distance determination is given by mathematical expression:

$$R > 2D^*D/\lambda$$

Where:

R = Range length (separation distance between transmit and receive antennas)

D = Aperture of antenna under test

λ = Measurement wavelength (shortest of the ones tested)

where, radiates a power P_{t_BITE} from its Horn antenna of gain G_{Horn}, the power density P_d at range R, where the beacon is placed is given by

Pd=(Pt_BITE *Gt_BITE)/(4*Pi*R*R) --------- 1

The receive antenna of Radar (gain = G_{Radar}) capture a portion of the transmit energy incident on it. The receive signal power becomes

Pr_radar= Pt _BITE*G radar*Ae/(4*Pi*R*R) ----2

where,

A_e = effective aperture of BITE receiver antenna = (G_{radar} λ^2 / 4 π)

λ = wavelength

The retransmitted power level from the BITE is adjusted by a digital attenuator so that the received power at Radar is well within its dynamic range. The BITE tracking for a particular frequency is initiated to check the normal functioning of the Radar. In order to check the ECCM capability of the Radar, ECCM test jig is used to simulate jamming environment, noise will be injected in the power Combiner of the Field BITE and the same will be radiated towards WLR antenna as shown in the Fig 2.

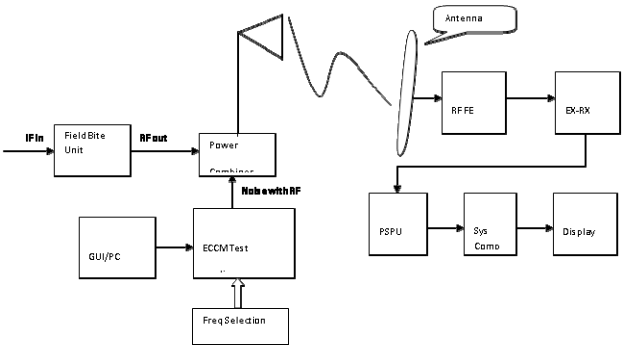

Fig 2: ECCM test jig introduced

The Noise threshold above the normal system noise will be sensed as jamming as shown below in Fig 3

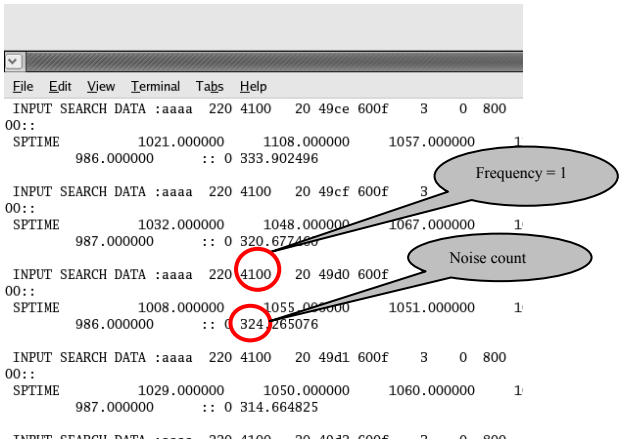

Fig 3: Noise threshold above normal

The ECCM capability of the Radar is demonstrated w.r.t the Nose jammers ECM, However False target and Range Gate Pull off ECM techniques are not part of the ECCM requirement.

In Noise Jammer ECM technique, the Noise Modulated RF signal of Desired Coverage around the Radar Frequency is generated and transmitted to the Radar for disruption of its overall operation. The ECM TEST JIG system provides the Noise Coverage Band of 10 MHz, 20 MHz, 50 MHz, 100 MHz, 200 MHz and 500 MHz respectively. The GUI for the Jammer and the ECM test Jig are as shown in Fig 4

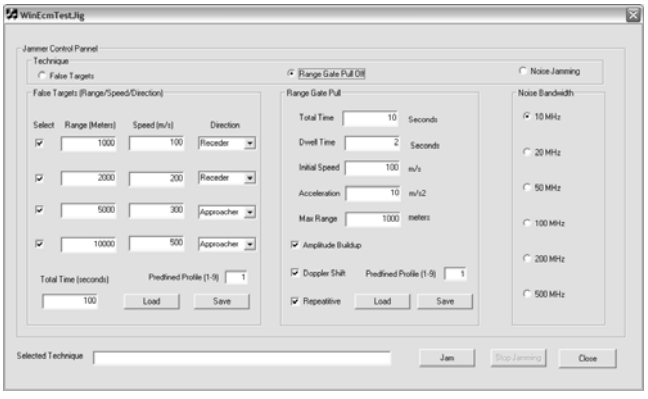

Fig 4: ECM GUI and Test Jig

For spot jamming, single jam frequency is selected and 20MHz bandwidth is selected. For band jamming 200MHz bandwidth is selected. The power level is adjusted by using attenuator pads. Frequency will be selected using toggle switches and band width is selected through GUI software.

When the jammer is switched ON, enough noise will be injected through Field BITE into the radar. Depending on the noise level, Jamming Frequencies are declared as shown in Fig 5. Once the jamming is sensed, the Jam strobe will be presented on the Radar Display as shown in Fig 6, the Operator can then select either to go for Manual mode or automated mode of handling the jamming frequency.

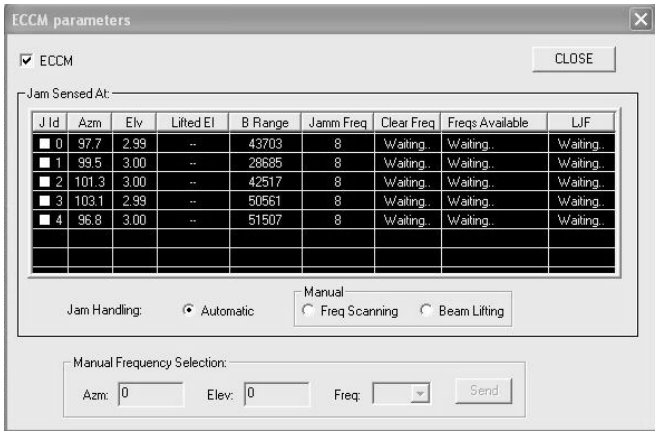

Fig 5: Display showing Jammed Frequencies

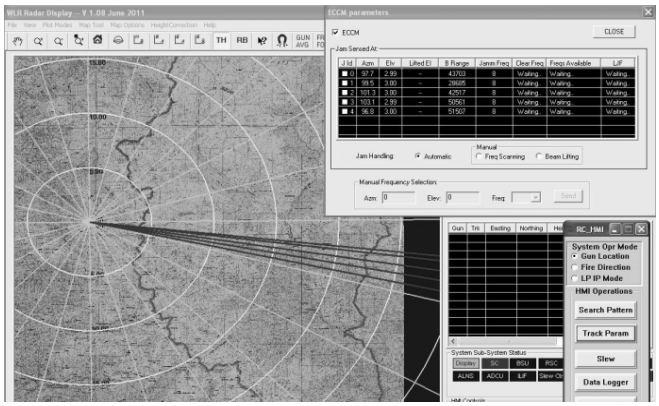

Fig 6: Display showing Jam Strobe Presentation

If the operator selects Automated mode, the information will be sent to radar computer from HMI. The Radar Computer sends request to scan the jammed position with all available frequencies for each scan. Out of all available frequencies, which are not jammed, Radar Computer selects the frequency which is farthest from the jammed frequency for the next scan at that jammed position. If all the available frequencies are jammed, then the operator has to select whether to go for least jamming frequency mode or Beam lifting mode. In least jamming frequency mode, the least jamming frequency will be used for the jammed position.

In Beam lifting mode, the radar computer lifts the beam by 1° beam width in elevation in the jammed position during next scan. Again after lifting the beam the scanning will be done for all available frequencies in the lifted position and the above procedure continues. If the threshold value of noise at the lifted beam position is more as compared to previous unlifted beam position, RC will unlift beam and declare at that particular azimuth position as Blank zone at that position Radar will not put the beam in further scan and thus demonstrating the ECCM capabilities of the Radar.

IV. CONCLUSION:

The ECCM techniques are demonstrated in presence of hostile jamming environment illustrating the system capability to handle ECM. The cost effective process can be further extended to other Radars making use of Field BITE facility negating the need of specific aircraft based ECM or use of special test equipment.

REFERENCES

[1] Electronic Warfare, Defence Scientific Information & Documentation Centre (DESIDOC)

[2] Merill. I. Skolnik, *Radar Handbook,* McGraw-Hill, Second Edition, 1990.

[3] Wiegand, R. J., Radar Electronic Countermeasures System Design, Artec House, Inc., Norwood, MA, 1991.

[4] Merill. I. Skolnik, *Introduction to Radar Systems,* TATA McGraw-Hill, Third Edition, 2001.

BIODATA OF AUTHORS

Shashank S Chachadi was born in Belgaum, (Karnataka) in 1982. He received his degree in Electronics and Communications from Bapuji Institute of Engineering and Technology, Davangere in 2004. He is working in D&E (Military Radar), Bharat Electronics. He has more than 8 years of experience in the field of Radar development and engineering.

Udayashankar M was born in Bangalore (Karnataka) in 1969. He received his degree in Electronics and Communications from B.M.S College of Engineering, Bangalore in 1997. He is working in D&E (Military Radar), Bharat Electronics. He has more than 12 years of experience in the field of Radar development and engineering.

Supreeth K S was born in Bangalore, (Karnataka) in 1985. He received his degree in Electronics and Communications and is presently working in Electronics and Radar Development Establishment (DRDO) as Scientist "C". He has more than 4 years of experience in the field of Radar data processors and Radar Controller.