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Design, Development and Testing of ATE for E/J Sector Receiver used for ESM Systems

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Abstract:Electronic Support Measure (ESM) systems are a part of modern Electronic Warfare (EW) systems that are capable of detecting, measuring and analysing the parameters and are wide open in nature. E\J sector receiver is also to be wide open and it operates from 2 to 18 GHz and it is characterized by many parameters and is needs to be tested in wide frequency range before the place in the system. So, in this paper, the cost effective method to be proposed for testing the E/J sector receiver which is design, development and testing of ATE for E\J sector receiver used for ESM systems.Development of Automatic Test Equipment (ATE) is very useful for ESM systems to measure the parameters of E\J Sector receiver and for achieve accurate results of parameters automatically.. The measurement of parameters like TSS, Log linearity, frequency flatness, DC offset, PRF, rise time, settling time, VSWR, etc., takes lot of time for testing because of that an Automatic Test Equipment (ATE) is used for reducing the testing time. An Extended Detector Log Video Amplifier (EDLVA) component is one type of Front End Receiver which is used in testing process of ATE. In this method, advanced equipment like Signal generator, Digital multi meter, DSO etc., test jig, Ethernet or GPIB will be used for interfacing and controlling purpose and application software(Visual C++) also used for carrying the parameter settings and measurements of results automatically.

Key words: Electronic Warfare systems, Electronic Support measure (ESM) systems, Automatic Test Equipment (ATE), Extended Detector Log Video Amplifier (EDLVA), test jig.

I. INTRODUCTION

Electronic Warfare (EW) is defined as the usage of electromagnetic spectrum to detect, interpret, analyse and locate the enemy assaults via the spectrum and to impede the enemy attacks through spectrum. The purpose of electronic warfare is to deny the opponent advantages and ensure friendly unimpeded access to the electromagnetic (EM) spectrum.Modern Electronic Warfare (EW) systems are built with state of the art electronic circuits and complex algorithms, are installed on different varieties of military platforms that Guard country's security continuously. Our three armed forces are equipped with modern EW systems that are capable of detecting, measuring, identifying, classifying, analysing, threat prioritizing and jamming of wide variety of hostile radars including complex Low probability of Intercept (LPI) radars used in military applications. EW systems are wide open systems in frequency, space and parameters and hence EW system functionality is complex.Electronic Warfare includes major subdivisions such as electronic attack (EA), electronic support measure (ESM) and electronic protection (EP).[1]

Electronic Support Measure (ESM):

ESM is a part of EW and shall measure and analyse the parameters of the EM signals radiated by radars before they were analysed by radars available across the world.ESM system have very important capabilities like antenna performance, detection capabilities, parameter measurement techniques and accuracies, operational sensitivity, processing speed.ESM systems are characterized by type of receiver (analogue, digital, wide open or narrow band), processor, and software and associated antennas. These systems are wide open in nature, so the receivers are also to be wide open. The receiver operates with wide frequency range from 2 to 18 GHz or 6 to 18 GHz with required specifications. The development of ATE plays key role while measuring receiver parameters or testing the Front End Receiver (FER) before plays in the system and because of using ATE the testing time of FER to be reduced. [2]

II. FRONT END RECEIVER IN ESM SYSTEMS

E/J Sector is built with many receiver functions which are amplification, filtering, detection, compression. These functions are useful to meet the ESM functionality and the receiver has many parameters which are important for operation of modern ESM systems.

2.1 E/J Sector Receiver:

E/J Sector receiver which operating frequency is in between two RF bands i.e., E-band and J-band. "Extended Detector Log Video Amplifier (EDLVA)" is one type of RF receiver and it operates in the frequency range of 2 to 18 GHz. The parameters of EDLVA are to be measure and testing by automatically using proposed ATE method.Some parameters of FER are TSS, frequency range, log accuracy, DC offset, VSWR, logging Range, log slope, amplitude matching, rise time, settling time, RF gain, etc., and all these parameters have its own specification. In every ESM system, the receiver must be tested before placing in the system and that testing time always increased because of every receiver have minimum 15 parameters so those are all to be measured in testing process of FER. This E/J Sector receiver provides two output ports one for video out and another for RF out and it has many capabilities like, detection, amplification, filtering, and compression and so on.

2.2 Block diagram of RF FER:

RF Front End Receiver comprises a switch, filter, limiter, an EDLVA and a RF amplifier and show in figure 2.1.The RF signals fed at RF input port are detected and logarithmically amplified to generate video output signals and receiver also provides RF amplification of input signals.

FER Provides two input ports which are RF input and RF BITE. The RF pulse signals from out sourcing are received at RF input port and the RF BITE input is a system input which can receives the signal from internal. The receiver also has a controlling switch, two output ports (RF out and Video Out), supply ports and two DLVAs. The Detector log video amplifier (DLVA) has provides multiple functions which are detecting, logarithmically amplification andgenerally, the FER takes RF input from system antenna in "Normal" mode of operation and from RF BITE source in "BITE" mode of operation.FER operates with +15V DC and -15V DC power supply and which supply and control signals are provided from external power supply and test jigs through 9 pin micro miniature "D" type connector for testing stand-alone mode.

2.3 Limiter:

Mainly, a simple Limiter consists of PIN diode and a parallel inductor for dc return. Limiter circuits are designed for protecting the RF components from ESD.

2.4 Filter:

Filter is a circuit which is used for removing unwanted frequency components from signal.

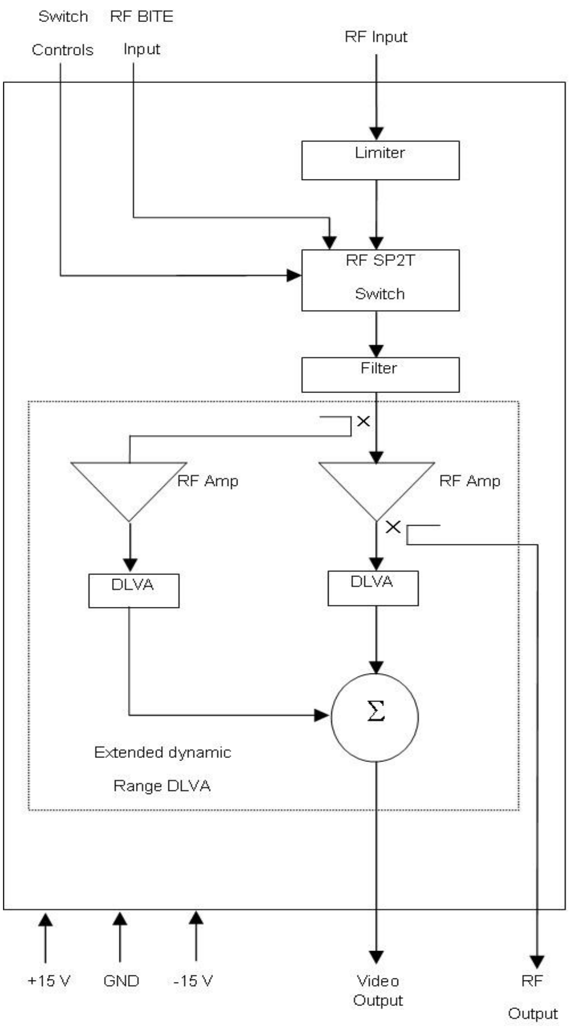

Figure 2.1: Block diagram of FER in ESM systems

In FER, Switch is used to select the input ports either RF In or RF BITE In, an EDLVA is provides the extended dynamic range and RF amplifier provides necessary RF gain.

III.PROPOSED METHOD

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In this method, Automatic Test Equipment (ATE) designing and developing process performed and testing of ATE is also performed for E/J Sector Receiver by measuring the parameters like log linearity, frequency flatness, DC offset, rise time, settling time, etc., of receiver. Generally, we have different type of ATEs which are cost effective and those setups are also complex to view. So, we proposed new approach ATE with advanced instruments, software application and interfacing components for testing the E/J sector receiver and this new approach ATE is a programing ATE which is fully based on VC++ programing. Mainly, new ATE setup involves E/J receiver component, advanced instruments like Signal generator, Digital Multimeter, Power Meter, Digital Storage Oscilloscope (DSO), etc., Power Supply, controlling part and interfacing part. Test JIG and Ethernet or GPIB used for controlling and interfacing the instruments to the PC or Laptop. Application software Visual C++ used for carrying the parameter settings and measurement results automatically. This total new approach depends upon the application software which is user interface. [3]

3.1 Block Diagram of ATE setup:

ATE setup involves Receiver component, advanced equipment, software application, power supply and controlling part.

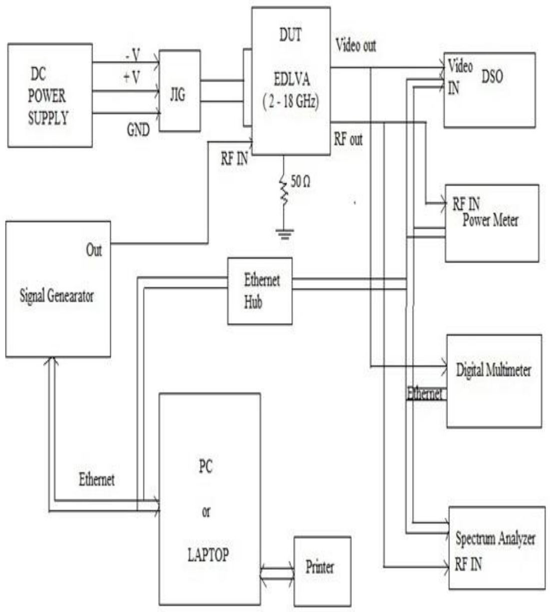

Figure 3.1: Block diagram of ATE Setup

In the ATE setup, the testing process begins from execution of software application in PC or Laptop. when instructions are received signal generator from PC, then signal generator generates RF pulse signalwith appropriate signal parameters like frequency, power level, pulse width and PRF and it could be send to receiver, it carried out the some output it may be video output or RF output that output goes to instruments and finally, we get the measurement data in PC.

3.2 Extended Detector Log Video Amplifier:

EDLVA is a one type of front-end super component and it has high sensitivity. The operating range of EDLVA is 2 – 18 GHz and basically it was used in RADAR to find the frequency and amplitude of the incoming signal. EDLVA component have different parameters like Tangential Signal Sensitivity (TSS), Log linearity, Frequency flatness, DC offset, Pulse width, PRF, rise time, Settling time, VSWR etc., and each parameter have own specification.This receiver component has three ports i.e. one for input and two for output and it provides Video out and RF out.

3.3 Advanced instruments:

In ATE setup, we have used advanced instruments for measuring parameters of receiver accurately and those instruments are Signal Generator (E8257D), Power meter (437B), Digital Storage Oscilloscope (DSO), Digital Multimeter, Spectrum analyser, etc. All instruments support interfacing connections like Ethernet, LAN and GPIB between instruments and PC or Laptop. In these instruments, the main important instrument is signal generator which provides the one dummy RF pulsed signal for testing receiver and remaining instruments are provides required outputs for each parameter. Some instruments are shown in figure 3.3.1. [4]

Figure 3.3.1: Instruments used in ATE setup [6]

3.4 Interfacing and controlling part:

DC power supply givens to receiver component through Test JIG and component have controlling part which is included in component. Ethernet or GPIB could be used for interfacing purpose.

3.5 Software application:

The main controlling part of ATE setup is Software part and the software application includes the programming of parameter settings, instrument settings and socket networking program. The program is in Visual C++ and that application is user interface which is developed in Microsoft Visual Studio (MVS) tool. We are measuring parameters automatically through that software application and the printer also use for printing test data record which is created using an MS Excel.

IV SOFTWARE DEVELOPMENT

In this method, proposed ATE is fully based on software development for each parameter measurement and from this development a user interface software application can be designed by using one important tool of Microsoft which is MS Visual Studio. The MS Visual Studio is a one type of user interface tool which majorly used creating user interface projects, web based applications, etc., and it provides to create the project using different languages like C, C++, VC++, VB.NET and etc., it also involves the drag and place type of windows, different type of buttons and check boxes so on. Come to this method, VC++ would be used for creating windows based template and this software application is totally user interface andVC ++ program is automatically generated when dragging the some buttons on windows template in MS Visual Studio tool. We only be write the VC ++ programming for different parameter functions and for settings of different instruments which are controlled through windows in MS Visual Studio. For interfacing purpose, some interfacing programming we have to write in this method GPIB interfacing connection used between PC and instrument. Some sample screen shot of template are shown in figure 4.1. [5]

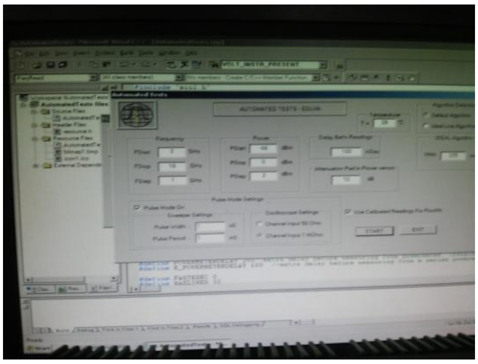

Figure 4.1: Sample template for settings

Screen of that was divided into some parts those are Frequency, Power level, pulse mode settings.

V MEASUREMENT RESULTS

The parameter measurements are done in manual testing and automatic testing of FER but some parameters are measured in both. In automatic testing, we just run execution file in PC after that parameter settings are given in the screen of settings template and finally we get the required data in the PC screen. The parameters have own those test procedures depending on that procedure parameters are measured either manual or automatic.

5.1 Automatic testing measurements:

The automatic test setup is shown in screen shots in figure 5.1.1

Figure 5.1.1: Automatic test setup with supply.

Using this test setup we have only few parameters are to be measure those are log linearity, frequency flatness, DC offset and Video output (minimum and maximum) and remaining parameters are measured by manual testing. In this testing setup, each parameter is measure by giving some individual commands in software application. Some screen shots regarding the automatic testing are shown below-

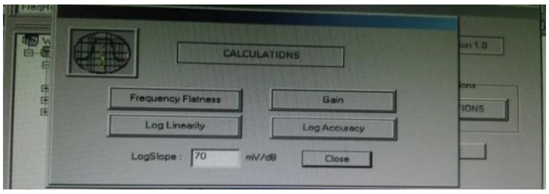

Figure 5.1.2: Calculations template

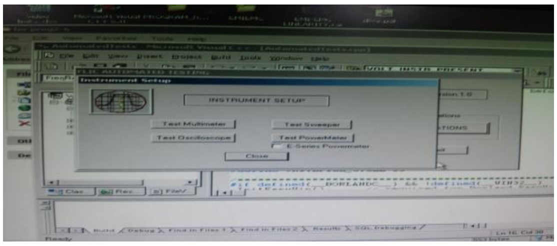

Figure 5.1.3: Instruments setup screen shot

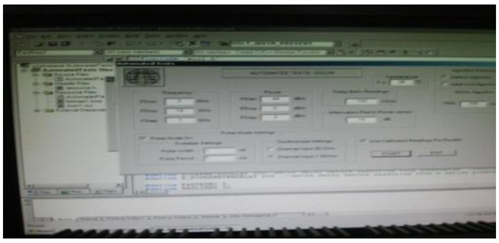

Figure 5.1.4: Parameter Settings template

Parameter	Specification	Measured value
Log Linearity	± 3.0dB	± 2.66 dB
Frequency Flatness	± 3.5 dB	± 2.5 dB
DC offset	± 75 mv	33 mv
Minimum Video output	230 mv	180 mv
Maximum Video output	5.3 v	1.21 v

Table 5.1.1: Automatic testing results

5.2 Manual testing measurements:

The receiver parameters like Tangential Signal Sensitivity (TSS), rise time, settling time, recovery time, RF gain, VSWR, DC offset and video output are measured by manual using manual setup and depend upon the appropriate testing procedures.

Parameter	Specification	Measured value
TSS	-75 dBm	-70 mv
Video output (min)	230 mv	220 mv
Video output (max)	5.3 v	1.43 v
Rise time	50 ns	35 ns
Recovery time	350 ns	292 ns
RF Gain	40 dB	33 dB
VSWR	2.5 : 1	2.2
DC offset	±75 mv	33 mv
Settling time	50 ns	40 ns

Table 5.2.1: Manual testing results

From the above measurements, we clearly observe the measured value of each parameter is within limit of specification and three parameters (DC offset, minimum video output, and maximum video output) are measured manually and automatically.

5.3 Comparison of manual and automatic testing measurements:

In all parameters of receiver, only five parameters are measured in both automatic testing and manual testing and remaining parameters are measured using manual testing. The Table 5.3.1 shows the comparisons of different parameters of receiver which are measured by using automatic and manual testing.

Parameter	Manual testing value	Automatic testing value
Log Linearity	-----------	± 2.66dB
Frequency Flatness	------------	± 2.5 dB
TSS	-70 dBm	------------
Video output (min)	220 mv	180 mv
VSWR	2.2	------------
Rise time	35 ns	------------
Recovery time	292 ns	------------
RF Gain	33 dB	-----------
Video output (max)	1.43 v	1.21 v
DC offset	33 mv	33 mv
Settling time	40 ns	------------

Table 5.3.1: Comparison between manual and automatic testing results.

VICONCULSION

In this paper, the new approach of Automatic Test Equipment (ATE) designed and developed with basic advanced instruments, interfacing components and some software application which is user interface application. With developed ATE the FER parameters like Log linearity, Frequency Flatness, Video output and DC offset are measured automatically and the other parameters of E/J sector receiver are measured by manual. Comparison of manual and automatic testing results is presented in this paper. The details about advanced instruments like signal generator, power meter, digital storage oscilloscope and network analyser etc., and interfacing components are presented. The software application development with the help of GUI tool Microsoft Visual Studio (MVS) was presented and the total programming of that application was in VC ++ code. Some screen shots of measurement process of ATE are presented in this paper. The further work carries developing the VC++ programing for remaining parameters of receiver and developments in ATE for measuring or testing all parameters of receiver at a time.

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VIII BIO DATA OF AUTHOR(S)

Natani Venkateswararao completed his schooling and intermediate in Narasaraopet, Guntur dist., Andhra Pradesh .He has done hisB.Tech from Tirumala Engineering Collegenear Narasaraopet from the stream of Electronics and Communication Engineering.He has qualified in GATE 2012 and presently pursuing M.E (Electronics Instrumentation) from Andhra University College of Engineering, Andhra university .At present he is doing his project work in Bharat Electronics Limited, Hyderabad as part of his M.E. curriculum.

Ch Viswanadham, born in Ampolu, a village in suburbs of Srikakulam, Andhra Pradesh, India joined Bharat Electronics Limited, a premier defence electronics industry in 1990 immediately after B.Tech (ECE) from Nagarjuna University, Guntur, and Andhra Pradesh. He worked in various Naval EW Systems from design to field trails. He has received internal R&D award for developing light weight ESM system for Indian Naval Ships. He has been deputed to Israel, Spain & South Korea to participate in technical discussions on EW systems with international companies. He has completed Master's degree in Digital Systems from Osmania University, Hyderabad in 1997, while working at BEL. Presently he is working as Senior Deputy General Manager (D&E) and heading RF & MWP group. He has presented many technical papers in BEL-House journal, national & international journals and conferences. He is Fellow of IETE & IE (I), Life member of SEMCE (I) & CSI and MIEEE. He is pursuing PhD in Andhra University, Visakhapatnam. His areas of interest are antennas, radomes, RF & Microwave designs and wide band / narrow band receivers.

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