DESIGN AND IMPLEMENTATION OF DUAL CHANNEL MONOPULSE RECEIVER

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Abstract - *In Airborne and Missile applications, Monopulse receivers are of great importance. They are used in tracking systems like Radio Detecting And Ranging (RADAR) and Identification of Friend or Foe (IFF). Receiver is a major subsystem of tracking systems which receives and amplifies the echo of the target. Sequential lobing, Conical scan and Monopulse techniques are the major types of receivers used in tracking systems. In conical and sequential lobing techniques, the exact angular position of the moving target cannot be determined. These techniques are replaced by Monopulse receiver which exactly determines the position of the target using a single pulse. Monopulse is a classical radar technique of precise direction finding of a source or target [1]. In the present work, the receiver is designed to operate in L-Band (1-2 GHz) and the important parameters considered are Sensitivity, Noise figure. These parameters are achieved in a better way by using Low Noise Amplifier (LNA) at the front end of the receiver and the total noise is also reduced. Therefore, this work is of great interest especially in airborne and missile applications.*

Keywords- **Monopulse Receiver, Radio detecting and Ranging, Identification Friend or Foe, Low noise Amplifier, L-band.**

1. INTRODUCTION

One of the many requirements in electronic warfare is to acquire and track targets at ranges from a few kilometers to hundreds of kilometers. Radio Detection and Ranging (RADAR) is used for this purpose. The basic concept of Radar is relatively simple even though in many instances its practical implementation is not. A 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. The range or distance to the target is found from the time it takes for the radiated energy to travel to the target and back. It can detect relatively small targets at near or far distances. It can measure their range with precision in all weather conditions, which is its chief advantage when compared with other sensors [1].

Receiver is a major sub system of a Radar which receives and amplifies the echo of the target. The most widely used technique is called Monopulse receiver. Improved angle tracking, resolution and angular accuracy detected by Monopulse Radars are their main advantage over classic Radar systems. In order to track and report on targets, surveillance Radars detect their presence and estimate their locations. Usually a Monopulse Radar has a Two-channel receiver in order to extract full angle information from each pulse.

2. SPECIFICATIONS OF RECEIVER MODULE

Operating band	: L-Band
Bandwidth	: 10MHz
Dynamic range	: 65Db
Sensitivity	: -90bBm
Maximum input	: -25dBm
Minimum input	: -90dBm
Rise time	: <100 ns
Fall time	: <250 ns

3. RECEIVER TECHNIQUE AND ITS TYPES

Any angular deviation of the target from the system boresight-axis generates an Error Signal (ES), which is equivalent to the angular deviation of the target, and tracking is so accomplished by supplying the ES to the servo-system, which positions the system boresight-axis back again on the target. Several technique have been employed to generate the ES [2, 3]. It also explains how phase information can be contained in the amplitude of a difference signal. When phase sensing is used, angle information is in relative phase of the signal and when amplitude sensing is used, angle information is in the relative amplitude of the signal since both the relative amplitude and phase of the signal vary across the antenna aperture. Fig 2.1 shows a basic block diagram of tracking Radar. Some of these techniques include the sequential lobing, conical scan and monopulse techniques [4].

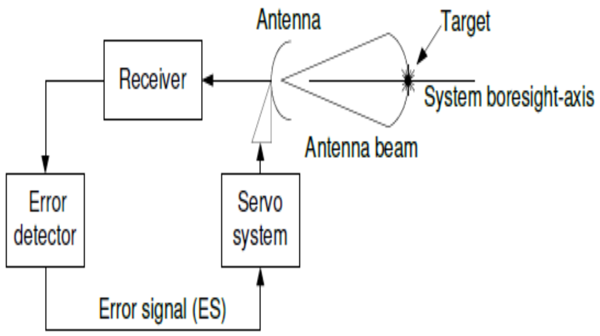
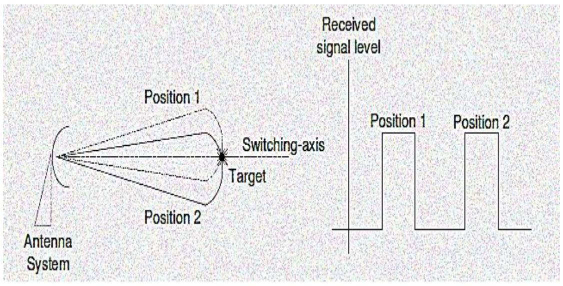


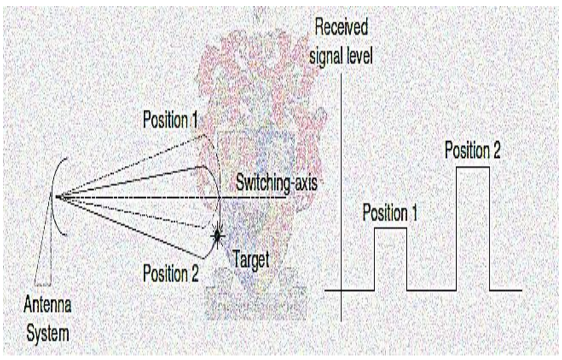
Fig 1: Block diagram of Tracking Radar [4].

1) Sequential lobing technique

A sequential lobing technique uses a squinted antenna beam which alternatively switches between two positions as shown in figure 2.2. The difference in amplitude of the voltages obtained from these two positions forms the required error signal (ES). For a target on the switching axis, for example, the difference is zero and this establishes a well-defined system boresight-axis, which is along the switching-axis [4].



a) Target on the switching axis



b) Target off the switching axis

Fig 2: Sequential Lobing technique [4].

2) Conical Scan Technique

In a conical scan technique a single antenna beam, but tilted by a small angle, called squint angle is rotated about the rotation-axis as shown in figure 2.3. The signals received at the antenna are amplitude modulated and the amount of modulation, which depends on the location of the target, forms the error signal (ES). For a target on the rotation-axis, for example e, the modulation is zero and this establishes a well-defined system boresight-axis, which is along the rotation-axis [4].

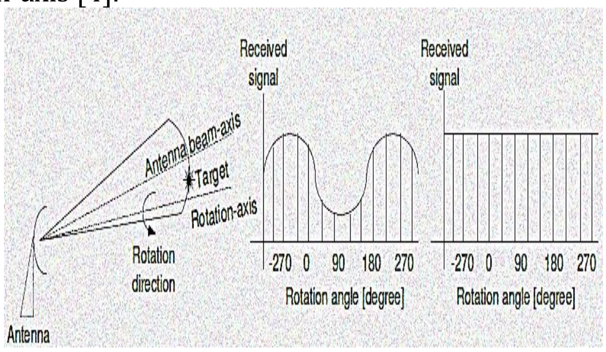


Fig 3: Conical scan Technique [4].

3) Monopulse Technique

Pulse to Pulse variations, mainly due to external noise, impose an estate limitation in the accuracy and performance of the above-mentioned tracking techniques [2, 3]. To overcome this problem a Monopulse, also called simultaneous lobing, technique was developed [5].

3.1 Principles of Monopulse radar

Monopulse is one of three methods employed by continuous angle-tracking radars [7, 8]. A continuous tracking radar supplies continuous tracking radar supplies continuous tracking data on a particular target. A track while scan radar is not continuous because it only supplies sampled data on one or more targets.

The basic difference between Monopulse, sequential lobing, and conical scan radars is the method by which angle information is extracted from the target return. A Monopulse radar has two stationary receiving beams in any tracking plans as shown in Fig 2.4(a). The two squinted beams are used for amplitude sensing and two parallel beams are employed for phase sensing. A sequential lobbing radar has one transmitting and receiving beam switching mechanically between two positions as in Fig 2.4(b). A conical scan radar has one transmitting and receiving beam moving continuously around the target shown in Fig 2.4(c). A Monopulse radar can extract complete angle information on each received pulse in the two tracking planes. Conical scan and sequential lobing radars, one the contrary, cannot extract complete angle information on each received pulse because they do not extract angle information in the same manner as Monopulse radars do. In the case of sequential lobing and conical scan radars, the radar video output contains the angle tracking error information in the envelope of pulses [4].

The percentage modulation is proportional to the angle-tracking error, and the phase of the envelope function relative to the beam-scanning position contains direction information. Angle-tracking error detection (error demodulation) is accomplished by a pair of phase detection using a reference input from the scan motor.

A key element of a Monopulse radar is the antenna. A Monopulse antenna has two receiving beams in azimuth and two receiving beams in elevation. In the present system, the beams are formed with a four-horn feed with a parabolic reflector. Then to extract angle information one needs to compare either the amplitudes or the phases of the target return. Amplitude comparison Monopulse consists of comparing the amplitudes of the target return for two receiving beams in any plane. The antenna used in this research employs amplitude sensing in the elevation plane and phase sensing in the azimuth plane. The obtained signals are passed through an RF sum and difference network which gives at its output a Σ (sum) signal, a Δ_{az} (azimuth difference) signal, and Δ_{el} (elevation difference) signal.

A sum and difference network is a Monopulse comparator since it does amplitude comparison for the elevation plane and phase comparison for the azimuth plane [6].

3.2 MONOPULSE RECEIVER

Receiver is a major subsystem of radar which receives and amplifies echo of target. Monopulse receiver is a tracking type of receiver that provides accurate angular position of a moving target just by extracting information by using a single pulse (Mono).Used in tracking radar to find Position, speed and target tracking. Monopulse receiver is mainly used in Airborne and Missile system applications such as tracking systems like RADARs. Prior to the error signal detection. The Σ and Δ obtained are filtered, amplified using Σ-channel and Δ-channel. The 2-channels should be balanced in terms of gain and phase. When target in the bore sight axis, SUM is having maximum power level, Δ will have less power.

RF DESIGN

The RF part can be divided into two parts. The function of the first part is amplification, which is accomplished with a combination of bandpass filters (BPF) and RF amplifiers. The function of the second part is envelope detection which extracts the envelope of the input RF signal, similar to an amplitude modulation (AM) demodulator. There are two kinds of BPF available at 1.09 GHz with bandwidth of 15 MHz and 12 MHz This is narrow enough for amplification, so there is no need to implement an intermediate frequency (IF) stage for further channel selection. Thus this is a tuned radio frequency (TRF) receiver and only works at 1.09 GHz.

Since the distance between the receiver's antenna and the aircraft may vary from less than one kilometer to several hundred kilometers, the RF part requires both high sensitivity and high dynamic range. Moreover, RF frontend signal is generated by a logarithmic detector which measures the overall input signal power, so the noise added by the amplification stages has to be minimized. Also, the overall power consumption has to be low because this receiver is designed to be powered from the USB bus which can provide maximum power P=5V×500mA=2.5 W. The block diagram of the receiver module is as shown in Fig4.

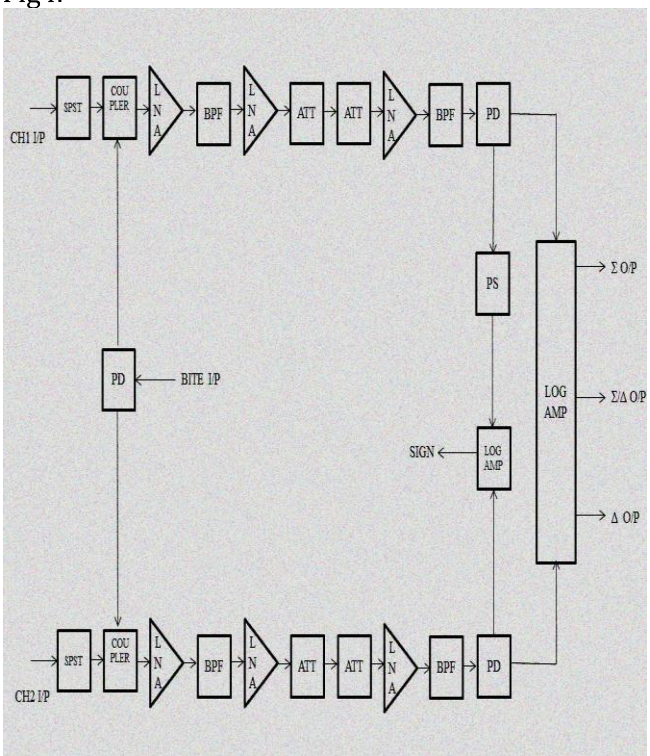


Fig 4. Block diagram of Receiver module

5. CIRCUIT SIMULATION & RESULTS

The circuit for video amplifier is designed and simulated using the Multisim software package. The circuit is shown in fig 5. And results are shown in fig 6.

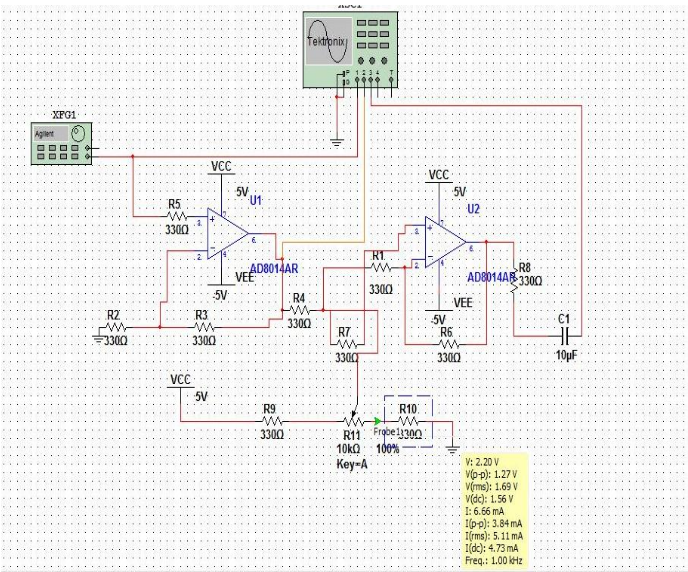


Fig 5: Circuit diagram of video amplifier.

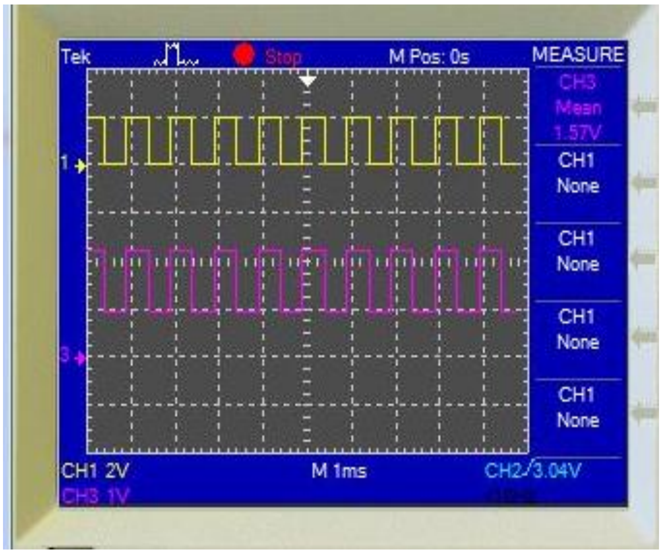


Fig 6: Waveforms of the video amplifier.

6. CONCLUSION

The main aim of thesis to design, build and test an L-band receiver for Radar. During design and implementation process, special attention was given to the optimization and balancing the corresponding subsystems of the receiver which showed in accurate tracking. Prior to the actual implementation of the receiver, a system level analysis was performed to decide on the architecture of the receiver and specification of the several sub-systems used to design the receiver. The results which were obtain after testing of the receiver are well within the specifications and are satisfactory.

ACKNOWLEDGEMENT

Authors are grateful to the Management, BMS Educational Trust, Principal and Vice-Principal, BMS College of Engineering for their valuable support. Authors are thankful to TEQIP-BMSCE, for the extended support.

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