Design of X-Band FMCW Short Range Radar

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Abstract— **This paper researches on a X-band FMCW short range radar. It has 160us sweep time and 600MHz bandwidth. The gain variable amplifier is used to remove the internal noise and compensate the path-loss. Range resolution is 25cm and measurement data has less than 17cm error.**

Keywords-component; formatting; X-band, SRR, FMCW, Radar

I. INTRODUCTION

The range measurement and tracking system technology is classified according to source type. Ultrasound radar and microwave radar are widely used. Ultrasound radar can measure accurate range with less than 10cm range resolution and is mainly used in robotics and industrial equipment. But, this radar is sensitive to the weather condition and range resolution is decreased in bad condition such as fog, rain, temperature, etc.

The microwave radar can measure the distance and acquisition of rough shape of the obstacles in any weather condition.[1] Microwave radar system used a short pulse signal or continuous-wave signals for the range detection. Pulse radar can detect the distance of multiples targets. However, it needs high power source to detect an object. In contrast, frequency modulation continuous wave (FMCW) radar can detect the distance of multiple targets and the speed of a moving object with lower power. In addition, it can be easily implemented due to the simple structure.[2] The microwave radar has a high technical accuracy for Precision range measurement and tracking.[2-5]

The size of the microwave radar system can be reduced by using higher frequency. But, some disadvantages are expensive and difficulty of producing. Regardless of the center frequency, short-range radar requires sufficient bandwidth in order to improve the distance resolution, but sufficient bandwidth is not allowed. So a compromise is needed in frequency band selection.

Proposed Radar system is based on microwave FMCW and has 600MHz bandwidth in x-band with under 0dBm output power

II. SHORT RANGE RADAR SYSTEM

A. System Architecture

The block diagram of the proposed radar system is shown in Fig.1.

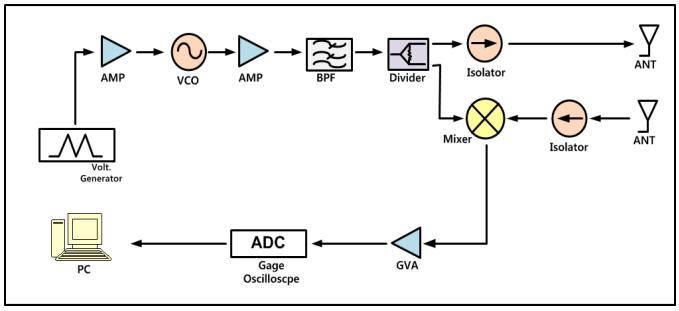

Figure 1. Block diagram of Radar System

Proposed radar system is bi-static radar type. It is adopted for increasing the isolation between Tx and Rx. Isolators are used to removing the noise such as reflected signal from antennas due to impedance mismatch, received signal at transmitting antenna.

The VCO is able to sweep on the range 10.2~10.8 GHz according to modulation voltage that gives from voltage generator. The modulation voltage signal is triangular type with 160us sweep time.

The Band pass filter is used for blocking the harmonics of the VCO's output. The swept signal is amplified by means of amplifier; after that the swept signal is divided, by means of a power divider. A portion of the swept signal is coupled to the mixer as reference signal. The final transmitted power of the system is under 0dBm.

Received echo signal from the Rx antenna is injected to mixer. This signal is mixed with reference signal and down converted. The intermediate frequency signal (output of the mixer) is amplified at GVA; after that the IF signal is sampled and acquired by PC.

B. Gain Variable Amplifier in SRR

In short range radar, unwanted noise such as reflected signal from ground and directly received signal from the Tx antenna and leakage signal in circuit is located near the beat signal with high amplitude. It should be removed because noise is fatal to calculate the accuracy distance.

In addition, radiated signal has path loss depending on the distance in free space. The path loss is inversely proportional to the square of wavelength and proportional to the square of distance. It leads to the difference amplitude in beat signal depending on the distance. This difference of amplitude interferes with distance calculation.

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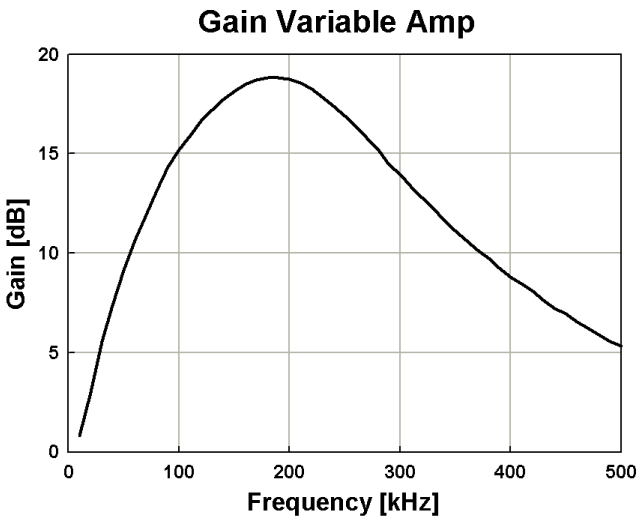

Figure 2. Characteristic of Gain Variable Amp

In this paper, gain variable amplifier is used to remove noise and compensate the path loss. Fig.2 shows characteristic of GVA. GVA has different gain depending on the frequency.

III. RANGE MEASUREMENT

To evaluate the performance of FMCW radar, a set of simple test has been conducted. The specifications of the proposed FMCW radar are summarized in Table. I . The microwave signals are transmitted and received via two pyramidal horn antennas (Gain : 22dBi, -3dB beam-width : 17^{o} @ 10.5GHz). The operation of the FMCW system was verified using a 50 x 50 cm2 piece of flat aluminum plate as a target. The target is positioned in front of antennas at intervals of 10cm from 0.5m to 5m. The beat frequency is achieved according to varying the location of the target using FMCW radar.

The result of measurement is shown in Fig.3. The solid line is measured result and dash line is ideally expected result.

The measured range and the actual position of the target have compared. The maximum measurement error is less than 17cm.

TABLE I. SPECIFICATIONS OF FMCW RADAR

Frequency	10.2~10.8GHz
Bandwidth	600MHz in X-Band
Range Resolution	0.25m
Sweep type	Triangular
Sweep time	160us
Sampling Frequency	1Mbs
Target Range	0.5~5m
Target	50 x 50 cm^2 Aluminum
Antennas	X-Band Horn Antenna

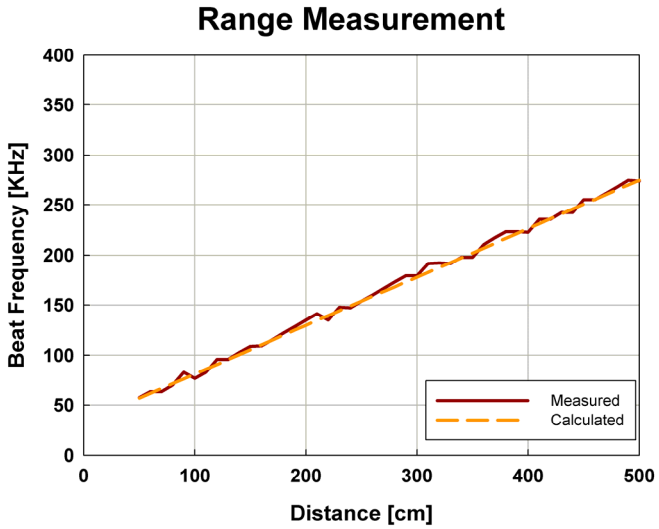

Figure 3. Range measurement

IV. CONCLUSION.

Short range radar system has been presented. The proposed FMCW short range radar has 600MHz bandwidth and 160us sweep time (80us rising sweep and 80us falling sweep) with triangular sweep type. The GVA is used to remove unwanted noise and compensate the path-loss. And beat frequency signal was achieved according to the location of target.

The operative frequency range and the radiated power follow the most recent international recommendations and it is possible to classify the system as a low power device for radio determination. The system has range error less than 17cm in 5m range. This system can be implemented in many functions such as the parking aids, the stop-and go and the pre alarm of the air bags.

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