Design and Development of DAGC for WiMAX Receivers

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ABSTRACT

In this work, an automatic gain control (AGC) algorithm is designed to obtain the constant output power. This algorithm is proposed for gain splitting on variable gain amplifier (VGA). A 4-bit digitally controlled lookup table is used along with VGA to vary gain range and gain step with low gain error. The gain steps like 6dB, 4dB, 1dB are designed for a better performance of a system with a low-gain error by reducing the settling time and improving the efficiency.

I. INTRODUCTION

The communication system is a process of sensing information from source to destination and it is collection of individual communication networks, transmission systems, relay station, tributary stations, data terminal equipment (DTE).

According to the communication medium it is classified as wired and wireless communication systems. Transmitting data over wire-based communication technology is referred as wired communication. Cable television, telephone networks etc are the examples of wired communication.

A wireless network is referred toflexible data communication system, it uses wireless media such as radio frequency technology to transmit and receive data. The two main components in wireless systems are transmitter and receiver. The transmitter transmits the radio signal and it will be received by the receiver. Wireless receiver which consists of AGC is a type of radio frequency receiver. Depending upon the applications, wireless receivers are available in two different configurations like single antenna and diversity antenna. One receiving antenna and a tuner is utilized by a single antenna, similar to an FM, radio. Two separate antennas spaced at a short distance and two separate tuners are used in diversity receiver and there are several distinctions among dual antenna systems.

WiMAX stands for Worldwide Interoperability for Microwave Access, it is defined in a group of “IEEE 802.16” standards. Alike Wi-Fi which operates at shorter distance, WiMAX operates at higher speeds over greater distances and for large number of users. WiMAX tower and WiMAX receivers are the two important components of this system. By using a high bandwidth WiMAX tower station can connect directly to the internet. There are two forms of wireless service that WiMAX actually can provide. They are Non-Line-of-Sight and Line-of-Sight services. The range of frequency used by Non-Line-of-Sight is 2GHz to 11GHz and by Line-of-Sight service is 66GHz.

The received signal power in the wireless communication systems will have many variations by changing distance between transmitter and receiver. Hence the automatic gain control (AGC) algorithm is used to obtain the constant power of the received signal. In many new applications Automatic gain control (AGC) is an essential function. To realize the AGC function there are two different ways where the amplitude of the signal is sensed and the gain is adjusted respectively.

There are two loops in which the AGC follows. The AGC loop moves forward in the received signal direction, if the input signal is employed then this loop is called "feedforward loop". The AGC loop moves backward in the signal direction, if the output VGA signal is sensed, then the loop is called "feedback" loop. Feedback loop is the most popular loop while designing the AGC in which it requires narrow dynamic range and it provides higher linearity. The AGC is designed with an algorithm to control the variable gain amplifier (VGA) and also it utilizes gain splitting on variable gain amplifier (VGA) with adjustable gain. The gain reduction is provided by the AGC even for the weak signals, hence the adjustable gain is provided in the proposed algorithm.

In the AGC system the variable gain amplifier (VGA) is referred as a core cell, it is signal conditioning amplifier with adjustable gain. The incoming signal can be optimized for a desired level by amplifying or attenuating the signal according to a gain function, the gain function depends on a control signal provided by the AGC loop. The AGC specifications such as noise, harmonic distortion and bandwidth are directly affected by VGA. The VGA should limit the frequency operation or the linearity of the system to obtain the better overall performance.

The VGA provides gain steps like 1dB, 4dB, 6dB have been set, it also provides the maximum gain range of 47dB by adopting 4-bit digitally controlled look-up table while maintaining good gain accuracy.

The related work is introduced in section 2, the circuit description of the proposed VGA is introduced in section 3. Section 4 presents post-layout simulation results. Section 5 provides conclusion.

II. RELATED WORK

YEAR	AUTHOR	PROPOSED WORK
2017	Peter John Green Goh Lee Kee Syed Naveen Altaf Ahmed	In this paper the author describes the architecture and operation of an automatic gain control(AGC)scheme for abursty wireless communication system which is designed for point-to-multipoint links. The entire AGC system is

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		simulated in MATLAB to study its transient and steady state behaviour in various conditions. This system is implemented in real time on Xilinx board, it is said that the designed AGC is robust in operation and works for different conditions to obtain optimum steady state and for better BER performance.
2017	Hoon Kang Jong-Scon No	In this work the AGC algorithm are developed to make constant power of received signal. For high adjacent channel interference (ACI) the conventional algorithm does not work well hence the FFT is used to enhance the receiver demodulation. The proposed algorithm is used for gain splitting on variable gain amplifier (VGA) and also performs the better bit error rate (BER) than convolutional algorithm by reducing clipping noise. In future this work can be implemented for the ACI detection and AGC switching mechanism to evaluate the bit error rate (BER) performance
2017	Jie Wang XiaoGuang Hu Enyi Guan Tongyun Li ZhuShun Ding Yidong Yao	This paper refers to the feed-forward segmented digital automatic gain control (FSD-AGC) algorithm is proposed for long term evolution (LTE) digital radio-over-fibre (DRoF) systems. Based on the real-time FPGA's the algorithm using DRoF is demonstrated. In this

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		system the power status can be updated with short delay and can able to adjust the gain precisely. It maintains a stable peak-to average ratio without any oversaturation by making use of analogue-to-digital convertor to reduce the overall cost and minimizing the deterioration of error vector magnitude (EVM) in LTE systems. The results of this DRoF system shows a mean EVM below 4.5%
2017	Wei-Han Chen Kea-Tiong Tang	In this paper the automatic gain control amplifier is proposed for high voltage spindle recording. It consists of following amplifiers, fix-gain amplifier and a voltage gain amplifier with threshold detecting logic to control the gain of VGA. To control the gain and bandwidth two-stage amplifier is used in this work. The three different gain set: 54dB, 60dB and 66dB is provided by the system and also the system covers 0.5Hz-1.5KHz of system bandwidth. The input noise is referred as 5.5uV and the power is 7.7uW with threshold detecting logic. The system can avoid saturation when high voltage spindle happens.

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III. PROPOSED WORK

3.1 Working ofBlock Diagram

The Digital Automatic Gain Control (DAGC) is designed such that it monitors received power continuously and decide how much gain to be changed in VGA module to maintain a constant output. The operation of AGC is described and entire AGC system is simulated in MATLAB Simulink.

The gain range and gain steps which is programmable is obtained by variable gain amplifier (VGA), the output is maintained constant by providing a low gain error.

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

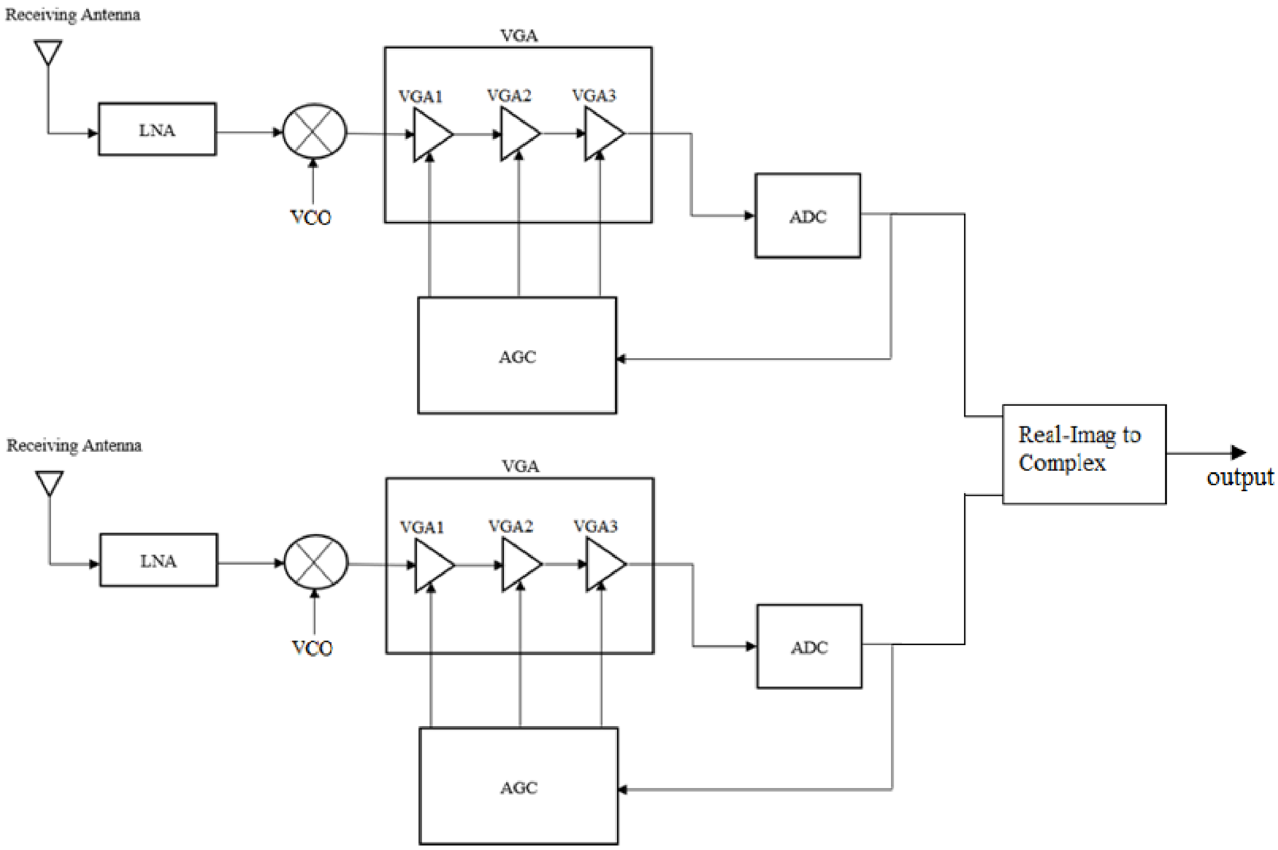

Fig1. Block Diagram

The signal is received by the receiving antenna. A very low-power signal may be received by the receiving antenna in terms of mV. The low-power signal which is received is then amplified using a LNA (Low Noise Amplifier) without decreasing the signal-to-noise ratio (SNR) and also reduces the additional noise.

The amplified signal is fed the multiplier, the resulting signal is fed to VGA module, VGA module consists of VGA1, VGA2, VGA3, it generates a constant output by optimizing the dynamic range of the system,it consists

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of several gain steps like 1dB, 4dB, 6dB which have been set to reach the different requirements, the output signal of the VGA module is then given to the analog to digital converter (ADC). Analog to digital converter converts the incoming analog signal into digital signal.

The resulting signal of ADC is then fed to the AGC circuit as a feedback signal, the AGC is a closed-loop feedback regulating system. The received signal varies from place to place hence AGC algorithm is designed to obtain constant output power irrespective o5f variations in the input signal. The proposed algorithm is used for gain splitting on variable gain amplifier (VGA). The signal is split in such a way that VGA1 will have 6dB which acts as course, VGA2 will have 4dB which also acts as course, VGA3 will have 1dB which acts as fine.

3.2 Digitally controlled VGA

The proposed VGA with a digitally controlled look-up table is used to overwhelm the limitations of non-integer gain step by changing the ratio of squared pseudo-exponential gain equations.

$$M_{in} = \frac{\left(\frac{W}{L}\right)_{input}}{\left(\frac{W}{L}\right)_{in}} = \frac{I_{input}}{I_0} = 1 + D_{in0}\cdot 2^0 + D_{in1}\cdot 2^1 + D_{in2}\cdot 2^2 + D_{in3}\cdot 2^3 \tag{1}$$

$$M_{lo} = \frac{\left(\frac{W}{L}\right)_{load}}{\left(\frac{W}{L}\right)_{lo}} = \frac{I_{load}}{I_0} = 1 + D_{lo0}\cdot 2^0 + D_{lo1}\cdot 2^1 + D_{lo2}\cdot 2^2 + D_{lo3}\cdot 2^3 \tag{2}$$

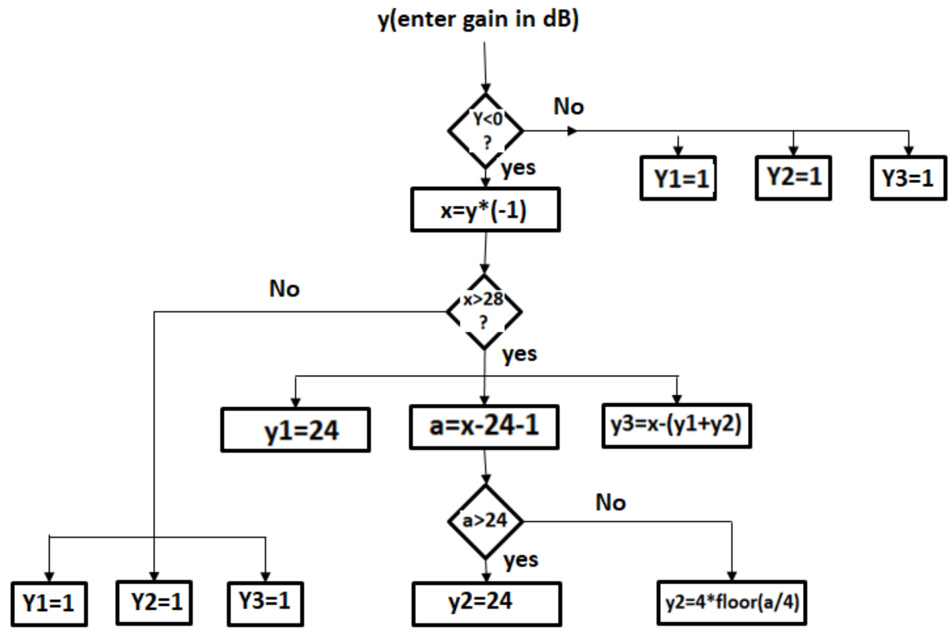
The voltage gain of the proposed VGA can be written as shown in the below expression

$$A_V = \sqrt{\frac{\left(\frac{W}{L}\right)_{input}\cdot I_{input}}{\left(\frac{W}{L}\right)_{load}\cdot I_{load}}} = \frac{M_{in}}{M_{lo}} \tag{3}$$

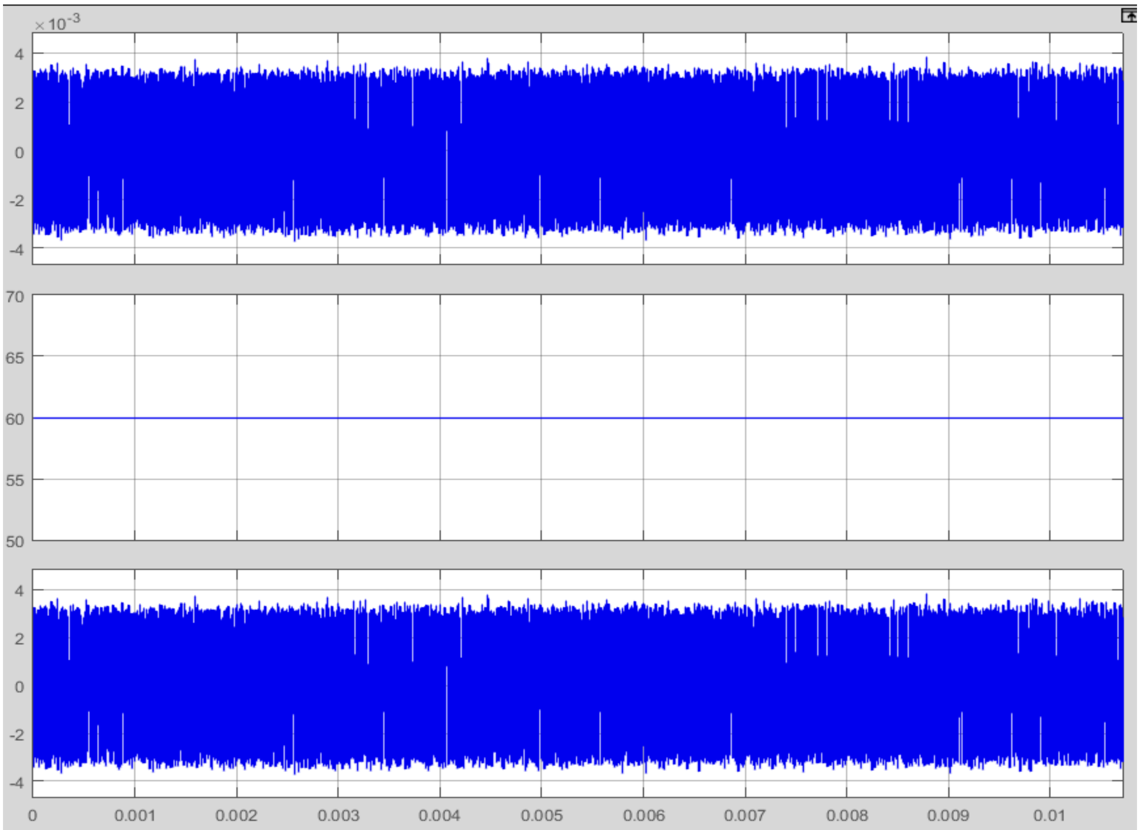
Table 1

Gain range	Gain step (dB/step)	Ratio of $\frac{M_{in}}{M_{lo}}$ a
± 24 dB	1.0	$\frac{16}{1}, \frac{14}{1}, \underline{\frac{13}{1}}$ b, $\frac{11}{1}, \frac{10}{1}, \frac{9}{1}, \frac{16}{2}, \frac{14}{2}, \underline{\frac{13}{2}}, \frac{11}{2}, \frac{15}{3}, \frac{9}{2}, \frac{12}{3}, \frac{14}{4}, \frac{16}{5}, \frac{14}{5}, \frac{10}{4}, \frac{9}{4}, \frac{10}{5}, \frac{9}{5}, \frac{11}{7}, \frac{10}{7}, \frac{10}{8}, \frac{9}{8}, \frac{8}{8}$
± 24 dB	4.0	$\frac{16}{1}, \frac{10}{1}, \underline{\frac{13}{2}}, \frac{12}{3}, \frac{10}{4}, \frac{11}{7}, \frac{8}{8}$
± 24 dB	6.0	$\frac{16}{1}, \frac{16}{2}, \frac{12}{3}, \frac{10}{5}, \frac{8}{8}$

3.3 Flow Chart



IV. RESULT AND DISCUSSION



Output: SNR=10dB

Fig.2

The output of the above Fig.2 is 3V peak to peak for which the input signal is 3mV peak to peak, and the SNR is

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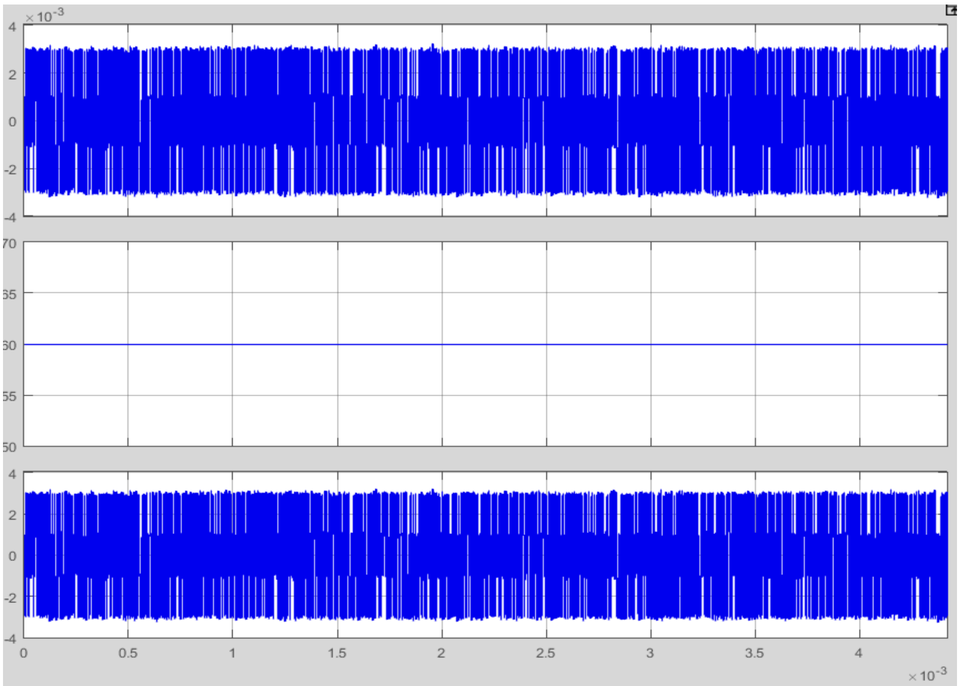
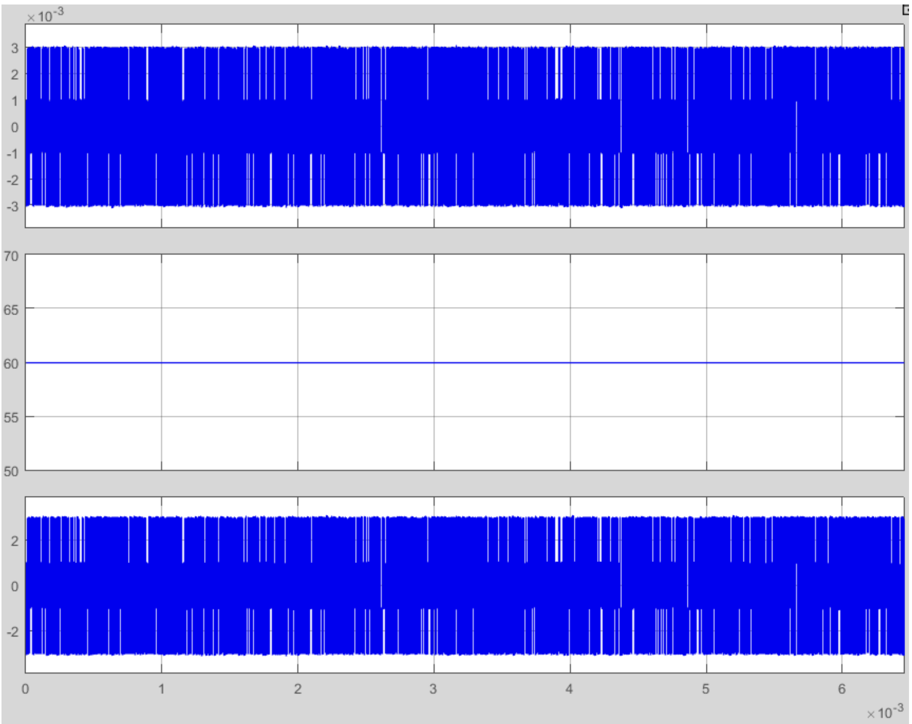
10Db. The Y-axis represents amplitude and X-axis represents time.



Output: SNR=20dB

Fig.3

The output of the above Fig.3 is 3V peak to peak for which the input signal is 3mV peak to peak, and the SNR is 20Db. The Y-axis represents amplitude and X-axis represents time.



SNR=30dB

Fig.4

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The output of the above Fig.4 is 3V peak to peak for which the input signal is 3mV peak to peak, and the SNR is 30dB. The Y-axis represents amplitude and X-axis represents time.

V. CONCLUSION

The gain range and gain steps like 6dB, 4dB and 1dB are varied by the variable gain amplifier (VGA) with low gain error. The proposed algorithm of AGC is used to obtain a constant output irrespective of the variations in the input signal.

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