Application of AGC Technology in Software Radio

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***Abstract*—The characteristics of software radio are flexibility, openness, scalability. The hardware platform of software radio should be a general platform. This paper discusses automatic gain control(AGC) technology in software radio receiver and introduces an AGC algorithm applicable for DSP implement. This algorithm is tested in matlab and simulation results are provided.**

Keywords-Software Radio; Characteristics; AGC; Matlab

I. INTRODUCTION

At present, software radio technology is widely used in wireless communication, its basic idea is to use hardware as the basic platform of wireless communication. The A/D sampling data of signals are processed by various algorithms, and various communication functions are realized by means of software. This paper discusses the automatic gain control (AGC) algorithm in software radio. The function of AGC is to automatically adjust the gain of the amplifier according to the strength of the input signal received. Keep the output signal basically unchanged when the input signal changes in strength. An efficient AGC scheme suitable for DSP operation is proposed, which has fast convergence and accurate steady-state response characteristics. Moreover, it is simple to implement and can satisfy the needs of software radio system very well.

II. CHARACTERISTICS OF SOFTWARE RADIO

(1) flexibility. Software radio can be achieved by adding software modules. It's easy to add new features. It can communicate with any other radio station and act as radio frequency relay of other radio stations.

(2) openness. Software radio adopts a standardized and modular structure. Its hardware can be updated or expanded with the development of devices and technologies.

(3) scalability. Software radio can be upgraded by loading new software.

III. ARCHITECTURE OF SOFTWARE RADIO

Software radio architecture is the concrete design structure torealize the concept of software radio. It includes hardware, software and interface protocol. The design content must take into account the current situation and long-term development of wireless communication technology. Really unifies each standard. The structure of ideal software radio is mainly composed of antenna, RF front end, broadband A/D-D/A soft converter, General and special digital signal processors and various software components. The antenna of software radio generally covers a wide frequency band. For example, 1MHZ-2GHZ requires that the characteristics of each frequency band be uniform. To meet the needs of various businesses. The RF front-end mainly completes the tasks of up-conversion, filtering, power amplification and so on. Receiving realizes filtering, amplification, down conversion, and other functions. After digitizing the analog signal, the processing task is completely completed by the DSP software. In order to reduce the processing pressure of general AGC, A/D converter is usually used to transmit digital signals. After special digital signal processing devices, Reducing data flow rate, After the signal is changed to baseband, the data is controlled.

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IV. Software and Hardware Platform of Software Radio

The hardware platform of software radio should be a general platform. It may not have the highest efficiency for a particular communication system. But its openness and scalability enable it to adapt to a variety of wireless communication systems. And it can be flexible to add, subtract and modify. First, The hardware structure of software radio designed by people is basically a streaming structure. This structure is similar to the logical structure of wireless communication system. So its efficiency is higher. However, Because the direct coupling of each module in this structure is too close, There is a problem of pulling the trigger and moving the whole situation. Based on this situation, Bus architecture has been proposed. The bus structure has good openness. It is an ideal choice to realize software radio. There are many bus standards for industrial control bus. For example, ISA, PCI, EISA, VEM and so on. ISA bus and VME bus are widely used in current digital signal processing and industrial control. VEM bus has more advantages than ISA bus. The data of ISA bus is 16 bits. The address bus is 24 bits. Address space 16MB. Its bus bandwidth is only a few MHz. The data width of VME bus is 32 bits. There are 32 address lines. The address space is 4GB. The bus bandwidth is tens of MHz. VEM bus is designed for multi-processor system. The ISA bus is a single processor bus. So VME bus is often used in software radio.

Software radio operates in the so-called "software bus" mode. Its software structure consists of software modules with standard interfaces. Each software module defines different application functions. The integrated operation can be achieved by inserting the bus. Realize the complete communication function. The integrated operation mode of "Software Bus" requires the unification of software interface standards. Improve software openness and reusability. Realize online software sharing in multiple environments. Applications based on JAVA technology can work on various platform systems. JAVA only needs to be written once. It can run anywhere. It is easy to implement function expansion and module embedding. It can realize the rapid opening of new business. JAVA plays an important role in realizing software reusability.

V. Principle of Automatic Gain Control by Software

The block diagram of the principle of automatic gain control is shown in Figure 1.The IF sampling signal x(n) is amplified by a controllable gain amplifier. The gain is A (n).The output signal y(n)= A(n)x(n),Calculate the logarithmic value of the level of signal y(n).Compared with reference level log(R),An error level e(n) is generated. The gain of the amplifier is continuously adjusted by negative feedback with e(n).The output log (y (n) is gradually approached to the reference level log (R) until the circuit reaches equilibrium. The parameter alpha controls the adjustment time of AGC circuit, which is a constant related to time. The logarithmic and exponential operation of signal level in circuit is to make the constant of adjusting time of control circuit independent of input level. The mathematical analysis of the block diagram is as follows:

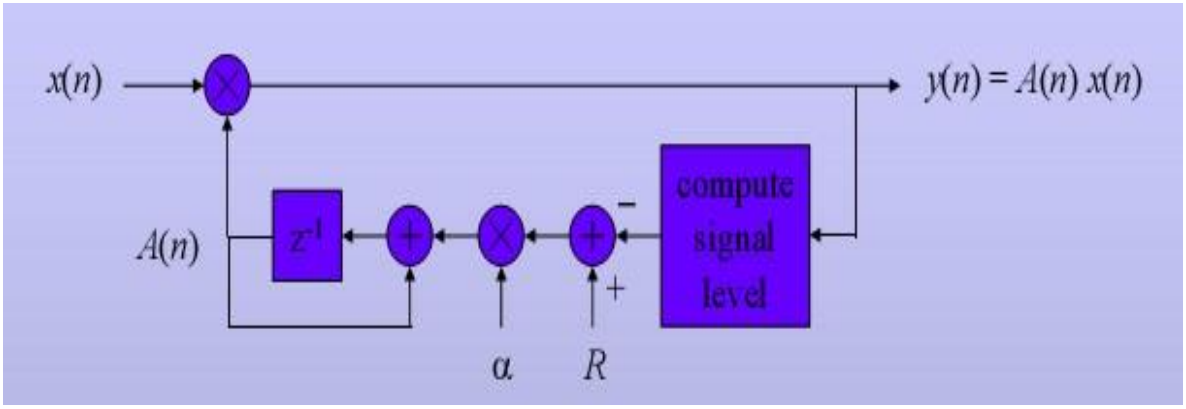

Figure 1. AGC algorithm implementation principle1

The recurrence formula of magnification factor is as follows:

$$A(n+1) = A(n) + a[R - |A(n)x(n)|] = A(n)[1 - a|x(n)|] + aR$$

When the amplitude after passing through the IF amplifier is less than R, $R - |A(n)x(n)|$ as positive, The amplification factor increases. $y(n)$ increases, Similarly, when the magnitude is greater than R, $R - |A(n)x(n)|$ as negative. The magnification decreases. $y(n)$ reduce, thus small signal amplification can be realized. Large signal attenuation, the signal is controlled within a certain range. Suppose the input signal is $x(n) = cu(n)$

$$A(n+1) = A(n)[1 - ac] + aR$$

$$A(n) = \frac{R}{c}[1 - (1 - ac)^n]u(n)$$

The gain after reaching a fixed state is $\frac{R}{c}$, Time constant is $\frac{1}{ac}$

The schematic diagram of AGC's second scheme is as follows:

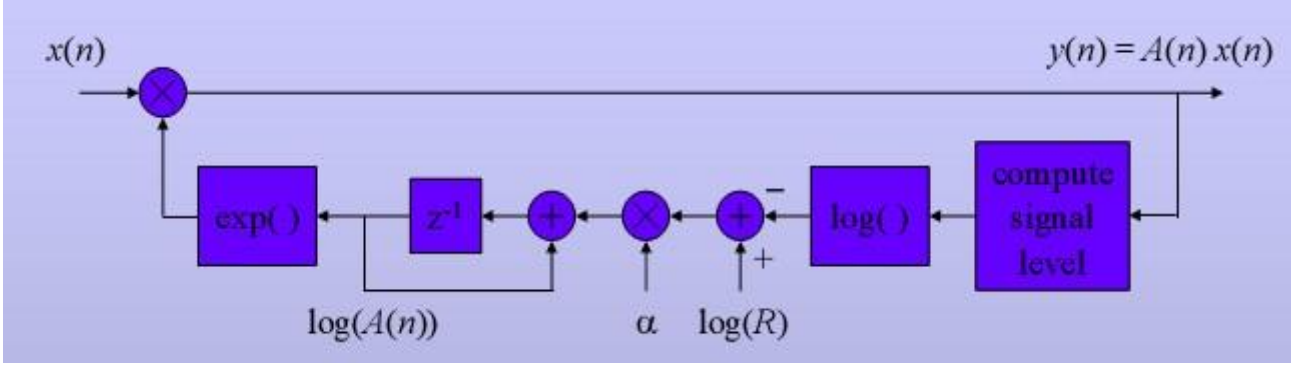

Figure 2. AGC algorithm implementation principle2

The recursive formula is:

$$\log\{A(n+1)\} = \log\{A(n)\} + a[\log\{R\} - \log\{|A(n)x(n)|\}]$$

In order to make the response time faster, Before comparing with the comparative value R, The output value of the amplifier $y(n) = A(n)x(n)$ is logarithmic before comparison. When the magnitude is less than R, $\log\{|A(n)x(n)|\}$ is less than $\log\{R\}$ .Therefore, $\log\{R\} - \log\{|A(n)x(n)|\}$ is positive. The magnification becomes larger, Thus, the small signal is enlarged. When the magnitude is greater than R, $\log\{|A(n)x(n)|\}$ is larger than $\log\{R\}$, therefore $\log\{R\} - \log\{|A(n)x(n)|\}$ is negative, The amplification factor $A(n)$ decreases, thus the attenuation of large signal is realized. Through the above algorithm, the small signal is enlarged, Large signal attenuation. Suppose the input signal is $x(n) = cu(n)$, have

$$\log\{A(n+1)\} = \log\{A(n)\}[1 - a] - a\log\{c/R\}$$

$$\log\{A(n)\} = -\log\{\frac{c}{R}\}[1-(1-a)^n]u(n)$$

As can be seen from the above formula, The gain of the stabilized signal is $\frac{R}{c}$, The time constant is approximately equal to $\frac{1}{a}$

VI. SIMULATION RESULTS

The AGC algorithm is implemented by matlab. Two AGC algorithms are added to the demodulation of a narrowband QPSK signal. By observing and comparing the AGC output signals, The two schemes are proved to be completely feasible. The magnification becomes larger, Thus, the small signal is enlarged. When the magnitude is greater than R, $\log\{|A(n)x(n)|\}$ is larger than $\log\{R\}$, therefore $\log\{R\}-\log\{|A(n)x(n)|\}$ is negative, The amplification factor $A(n)$ decreases, thus the attenuation of large signal is realized.Through the above algorithm,The simulation results of two AGC schemes are shown in Fig. 3 and Fig. 4 respectively.

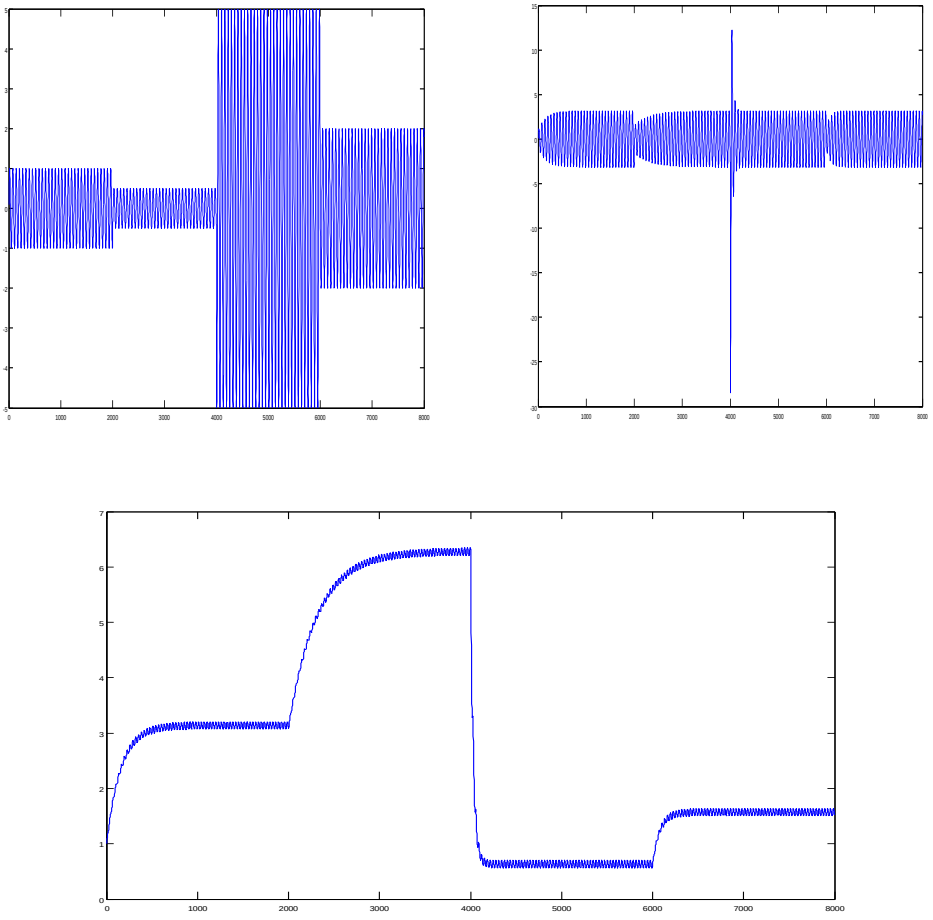

Figure 3. The simulation results of AGC algorithm when the input signal of the first AGC scheme change

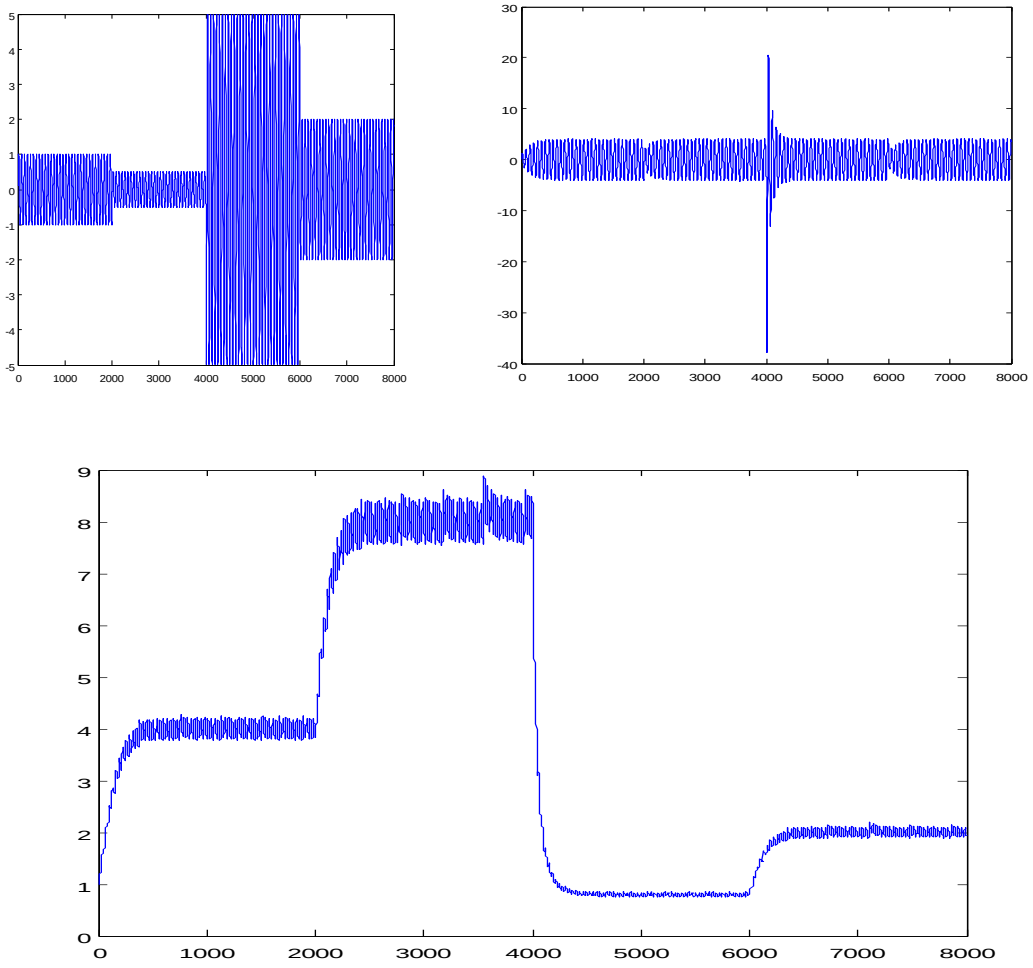

Figure 4. The simulation results of AGC algorithm when the input signal of the second AGC scheme changes

VII. CONCLUDING REMARKS

Since the introduction of software radio,its brand-new software value concept solves the problem of wireless standard interoperability.， Then it triggered a worldwide research climax. Software radio receivers, Whether the signal amplitude is stable or not will affect the timing synchronization and phase synchronization recovery of the receiver. This will determine whether the signal can be received with high quality, so automatic gain control (AGC) is applied to the input signal. High quality signal reception can be achieved. These two AGC schemes have fast convergence and accurate steady-state response characteristics, and the algorithm is simple.It is convenient for software radio system to be realized by DSP.

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