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지능형 AGC 회로 설계

Intelligent AGC Circuit Design

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ABSTRACT

A problem that arises in most communication receivers concerns the wide variation in power level of the signals received at the antenna. These variations cause serious problems which can usually be solved in receiver design by using Automatic Gain Control (AGC). AGC is achieved by using an amplifier whose gain can be controlled by external current or voltage. However, the AGC circuit does not respond to rapid changes in the amplitude of input. If input changes instantaneously, then even if op-amps could follow the change, the envelope detector capacitor could not, since the capacitor's voltage could not change instantaneously. To alleviate this deficiency, we present Improved Automatic Gain Control Circuit (IAGCC) replacing AGC circuit to FLC.

Key Words : Automatic Gain Control, Fuzzy logic, Intelligent control

1. INTRODUCTION

AGC is one method to adjust automatically the gain of the amplifier circuit according to the intensity of signal. During the procedure in transfer of signal, it is changed by noisy because of electronic bias change and environment effect. So it is necessary to modify the signal to acceptable range in the receiver part. AGC circuit is widely used in receivers, recorders and measure machines. The design is superior but it is not adapted to the fast, wide range changing signal and different frequency signal due to the existence of capacitor [1][2]. We can solve the problem using Fuzzy Logic Controller (FLC). Fuzzy Logic is a paradigm for an alternative methodology which can be applied in developing both linear and nonlinear systems for embedded control [3][4]. This paper is organized as follows: In section 2, the configuration of AGC circuit is introduced. The improved AGC system using Fuzzy Logic is designed in section 3, simulation results are shown in section 4. Finally, conclusion are presented in section 5.

2. CONFIGURATION OF AGC CIRCUIT

2.1 Theory of Automatic Gain Control

Commercially available AGC circuits, the LM13600 AGC amplifier, employ a control current source within an Op-Amp, as shown in Fig 1. In this circuit, T3 act as the constant-current source supplying current I_{AGC} where

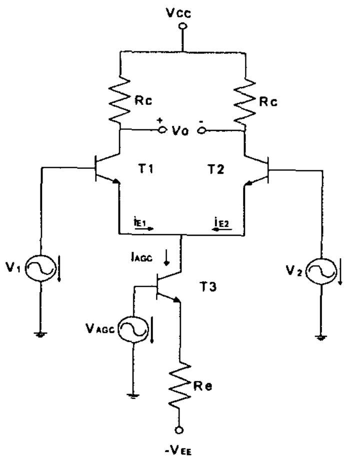

Figure 1. A gain-control difference amplifier.

$$I_{AGC}=\frac{V_{AGC}-0.7+V_{EE}}{R_e}$$
(1)

Using the small signal emitter currents analysis, we can know that the output voltage of Vo (setting $v_1=0$) is

$$v_o=(\frac{R_c}{2V_T}I_{AGC})v_2(t)$$
(2)

If $v_2(t)=V_{2m}(t)\cos\omega_0 t$, we arrange to have I_{AGC} inversely proportional to the envelop of the input voltage,

$$I_{AGC}=\frac{K}{V_{2m}(t)}$$
(3)

Then (2) becomes

$$v_0=(\frac{R_cK}{2V_T})\frac{v_{2t}}{V_{2m}(t)}$$
(4)

And the amplitude voltage of the output is kept constant.

2.2 Calculation of the AGC's Output Voltage

The output voltage v_{o1} of the gain controlled Op-Amp A_1 shown in Fig 2 as follows:

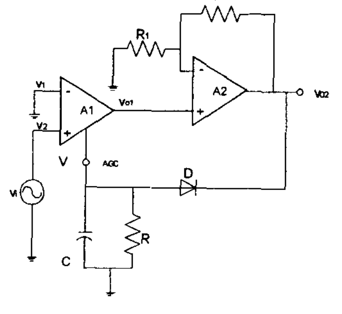

Figure 2. The simple AGC system.

$$v_{o1}=(\frac{R_cK_1}{2V_T}I_{AGC})v_i$$
(5)

$$v_{o2}=(\frac{R_c}{2V_T}K_1K_2I_{AGC})v_i$$
(6)

K_1 is the proportional constant, $K_2=1+R_2/R_1$, the gain of amplifier A_2. The output voltage $v_{o2}(t)$ is envelope detected so that the AGC voltage V_{AGC} is negative voltage. If $v_i(t)=V_{im}(t)\cos\omega_o t$ and $v_{o2}(t)=V_{o2m}(t)\cos\omega_o t$, the AGC voltage can be shown as

$$V_{AGC}=-V_{o2m}(t)$$
$$=-(\frac{R_c}{2V_T}K_1K_2I_{AGC})V_{im}(t)$$
(7)

The gain-control voltage and current are also related by (1). Substituting (7) into (1) and solving for I_{AGC} yields:

(8)

$$V_{o2}=(\frac{R_c}{2V_TR_e}K_1K_2)\cdot\frac{V_{EE}-0.7}{1+(R_c/2V_TR_e)K_1K_2V_{im}(t)}v_i(t)$$
(9)

The gain K_1 and K_2 are usually made large enough to ensure that

(10)

Finally

$$v_{o2}\approx(V_{EE}-0.7)\frac{v_i(t)}{V_{im}(t)}$$
(11)

From the important equation (11), we can see that v_{o2} is proportional to $v_i(t)/V_{im}(t)$. So no matter how the peak value of v_i changes the output v_{o2} keeps constant. However, the AGC circuit responds only to slowly varying changes in the envelope because the envelope detector-RC circuit act slowly, of which a typical term value is 1sec. So the AGC circuit does not respond to rapid changes in the amplitude of v_i.

Thus, an AGC circuit is considered a "slow-acting" limiter. Otherwise, the peak value detector is useful for just one frequency because of the fixed RC circuit. Therefore, the two disadvantages make the AGC system tremendously limited.

3. IMPROVED AGC SYSTEM USING FUZZY LOGIC

3.1 Block Diagram of Previous AGC System

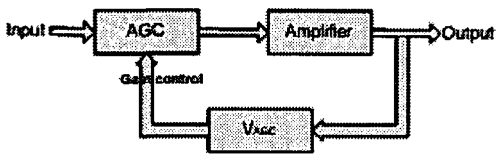

Figure 3. Previous AGC System.

The diagram definitely shows the configuration of the AGC system.

3.2 Block Diagram of Proposed AGC System

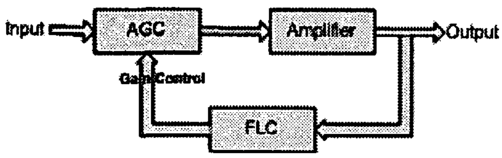

Figure 4. Proposed AGC system.

Fuzzy logic describes complex systems using knowledge and experience by fuzzy rules. It does not require system modeling or complex math equations governing the relationship between inputs and outputs. To overcome the problems of AGC circuit that discussed in previous section, we just need to change the envelope detector part by Fuzzy Logic Controller. And we need not to calculate strictly the relation between the input and output voltage.

4. COMPUTER SIMULATION

4.1 Simulation of the AGC Circiut

In the Proteus 6 Professional environment we can simulate this AGC circuit conveniently. Figure 3 is drawn using Proteus.

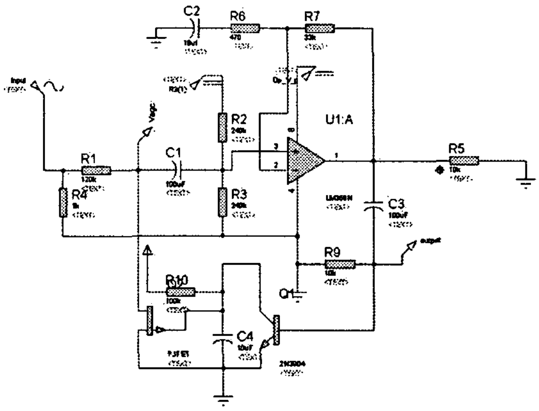

Figure 5. Simulation of AGC Circiut.

Figure. 5 shows a good example of AGC circuit which gets the I_{AGC} by feeding back circuit. We can see that if the output is big enough the Q1 passes. Therefore, a corresponding I_{AGC} gets the voltage of the V_{AGC} point increase to make the input point current decreases, so the output I_{AGC} keeps the same level. On the other hand, if the output decreases, the function can make the voltage of the V_{AGC} goes up to maintain the output the same level [3].

We can get the result as shown in Figure 4:

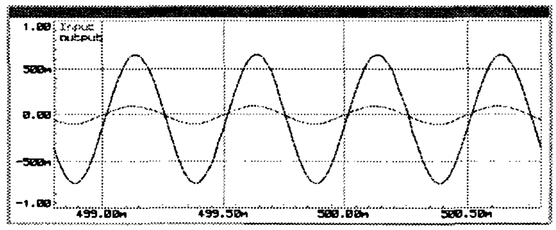

Figure 6. Result of the Simulation.

The green line is the input signal and the red line is the output signal. We can change the peak amplitude of the input signal at the period of 50mv ~ 1.2v we can find the approximate output 650mv.

When we apply the windows wave file (chord.wav) as the input signal, we get the following chart.

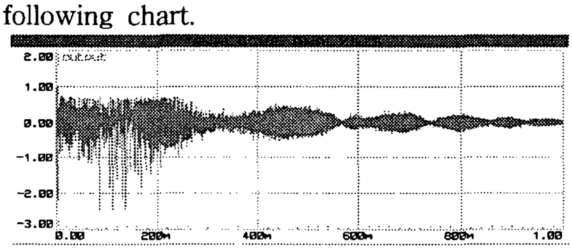

Figure 7. The Output of the Chord.wav.

From this picture we can see obviously that when the amplitude of input signal is changing fast, the output can not be kept constant as what we have talked about before [3].

4.2 Construction of the Fuzzy Logic Controller

Determine the state variables and control variables as follows:

(a). state variables (the input variable of the FLC)
- -the input of the circuit
- -the output of the circuit

(b). control variable (the output variable of the FLC)
- -Vagc

Using Matlab 7.0 we can make the Fuzzy rule and get the output. The input1 of the fuzzification is the input of AGC circuit, the input2 is the output of AGC [1],[2]. Membership function of FLC is shown as follows:

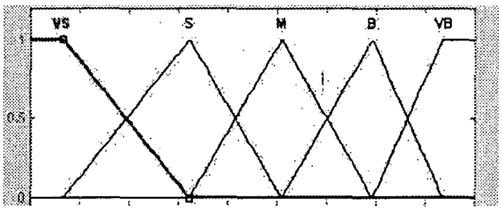

Figure 8. Input1.

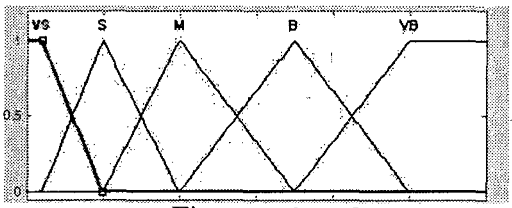

Figure 9. Input2.

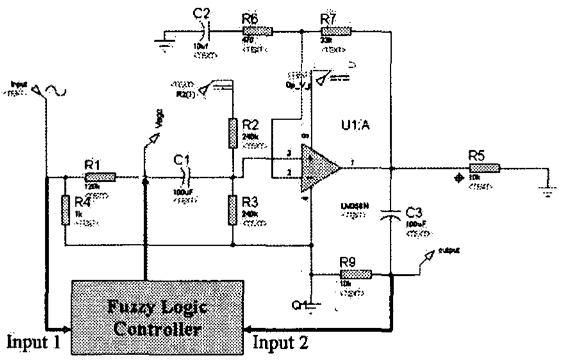

Figure 10. Improved AGC System Using FLC.

Table 1. Testing Results.

In this table, Vin is the input voltage, Vout1 is the output voltage of the circuit which unused FLC, VAGC derives from FLC, Vout2 is the final output of the AGC system. From the testing results table we obtain clearly the nearly constant output - Vout2 of the improved AGC circuit.

	V_{in}	V_{out1}	V_{AGC}	V_{out2}
1.	8mv	318mv	10.3mv	705mv
2.	70mv	2.47v	10.1mv	713mv
3.	230mv	5.55v	9.92mv	700mv
4.	379mv	7.28v	9.20mv	650mv
5.	463mv	8.01v	9.01mv	636mv

Then we simulate the No.3 data to get the following figure:

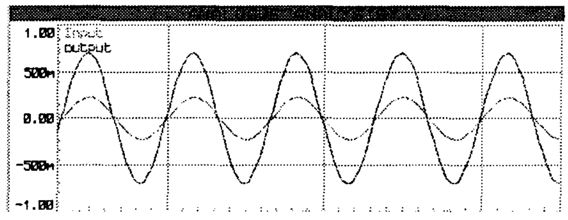

Figure 11. Result of the simulation using No.3 data

From this figure we can see that even the input signal is very small, the output is kept constant.

5. CONCLUSION

AGC circuit is an ingenious circuit and is used widely. In practice, capacitors are fixed to boards, so it is very hard to change the capacity of them. During the transmission of signals, there are too many unknown conditions affection. Therefore we have to find a way to increase the adaptability of receiver part. When we add the Fuzzy Logic Controller to AGC, we can make it more precise and efficient. And it is easy to redesign the circuit by making different rules without changing the circuit.

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