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EE325
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Lab 3 – Design and Implementation of a "Brick Wall" AGC in a beat determining device

## Introduction

*Objective*
Implement an AGC circuit in an existing beat detection circuit to promote accurate triggering and to reduce false triggering.

*Background*
It is relatively simple to design a circuit that can "find" the beats or impulses of a particular song. The only requirement is that the impulse be linear and uniform. However, if the beat has other low frequency components or there is low frequency noise in the audio signal (low frequency < 160), the device will trigger incorrectly.

There are several types of Automatic Gain Controlling circuits that range from simple to complex. Some AGCs apply a form of compression (2:1, 4:1) which allows for dynamic control of the music. Compression AGCs have a very low level of clipping, that is - the audio signal will not get lost or distorted by the circuit.

The AGC for this lab is known as a "brick wall" AGC. It takes an input signal and drives it at a maximum output voltage. This is different from a normalizing circuit because a brick wall AGC will flatten an input signal if necessary. The audio input will sound distorted.

An important aspect of the AGC is its attack and decay which manifest themselves in the form of resistors and capacitors.

*Application*
In this case, the AGC will be used to "monitor" the low pass filter's output. The low pass filter will capture the bass drum impulses. The purpose of the AGC is to "catch" the first instant of this impulse and sharply emit this wave form into the detection phase of the circuit. Because of the attack and decay parameters of the circuit, it is possible to create an AGC that recovers at a rate suitable to the tempo of music being fed in. In this case, the tempo will vary from 120 beats per minute to 140 beats per minute. In addition, these parameters effectively reduce the possibilities of false triggering.

## Analysis
*Circuit function*
The schematic at the end of this report shows the design of this circuit. At very low input signals transistor Q2 (BJT) is off. The gate of the JFET is at 5V and appears as a huge resistance in the circuit. At greater input signals the output from the LM358 is large enough to bias transistor Q2 Turning on Q2 essentially lowers the JFETs gate to source

voltage and thus reduces its resistance. It essentially attenuates the signal to allow the opamp to maintain a 1.2v output.

R9 and C4 constitute the circuit's attack time and decay time respectively. Resistance added in addition to R9 allows for a greater attack and less resistance allows for a smaller one. The capacitor and the resistor create a time constant that is the decay time of the circuit. The decay is measured by how long it takes the capacitor to recharge after it discharges at a bass drum impulse.

*Choosing the Attack & Decay*

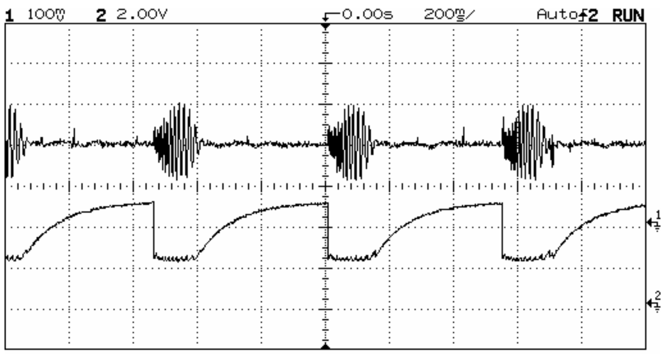
This aspect was essentially trial and error. A decay that is too slow means triggering once and possibly missing critical impulses because the capacitor is charging too slowly. Too fast means recovering midway between an impulse which leads to over triggering. An RC constant of 1 second proved most affective. A small attack proved better than a large one. With a large attack the AGC would pass too much of the impulse and this could lead to low frequency noise.

**Results**

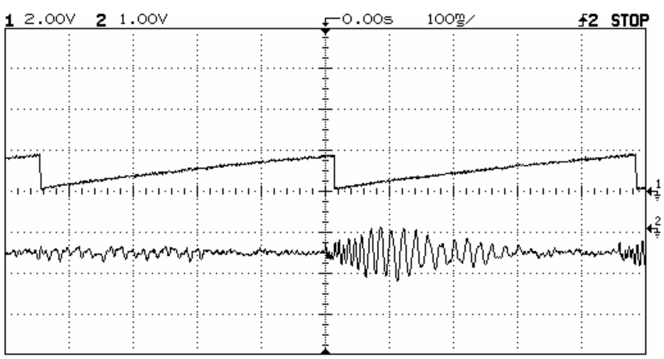
Once the AGC constants were configured correctly the circuit integrated seamlessly into the present design. The AGC looks for the initial impulses and emits them as very large peaks (due to the small attack). This waveform is essentially the highly amplified initial impulse. Because the attack is small, it will only pass the "loud" initial impact of the waveform, thus severely reducing signal noise that would falsely trigger the LED. In terms of the circuit, the capacitor must recharge between triggering for the JFET to conduct.

Because of the time dependence of the circuit, it is vulnerable to music that strays from 120-140 beats per minute. Quicker tempo music will need a faster decay, that is the capacitor valued should be lowered to account for the increased tempo. A value of of 8 or 9μF should work.

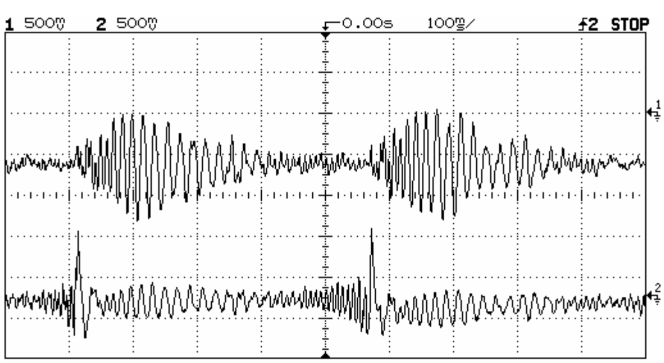
**Data/Results**



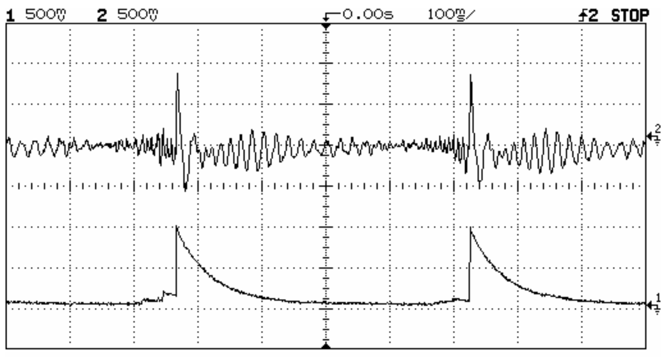

Here is an unfiltered input waveform and the rise time of the capacitor. This rise time is fairly quick. If the input waveform had been more complicated, this circuit would trigger incorrectly.



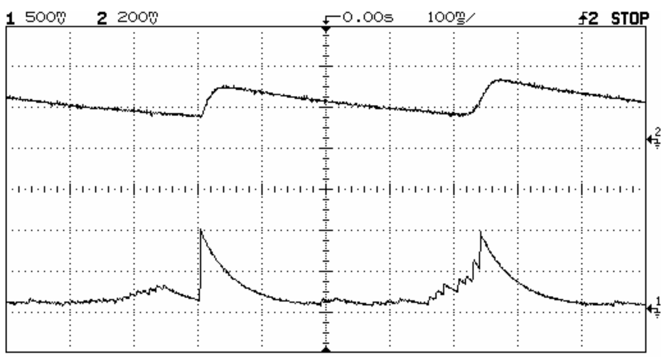

This figure depicts the optimum setting of the AGC. This is with the 10uF/100K RC network. The network is set at a second, and the fact that the rise time looks linear shows that the RC network recharges at an extremely slow rate. This setting proved most effective in use.




Channel one is a filtered waveform and channel two is the actual output from the AGC that is fed into the follower. The high spikes on the AGC output show how it first raises the input to a max voltage (1.2v) and then falls because the capacitor discharges and the JFET conducts very little. This graph visually demonstrates this, the audio output falls very sharply after the discharge. This is an example of short attack/long decay. This setting resulted in near 100% accuracy.




This is the AGC output fed into the first follower. The clear peak is what allows for such accurate triggering.



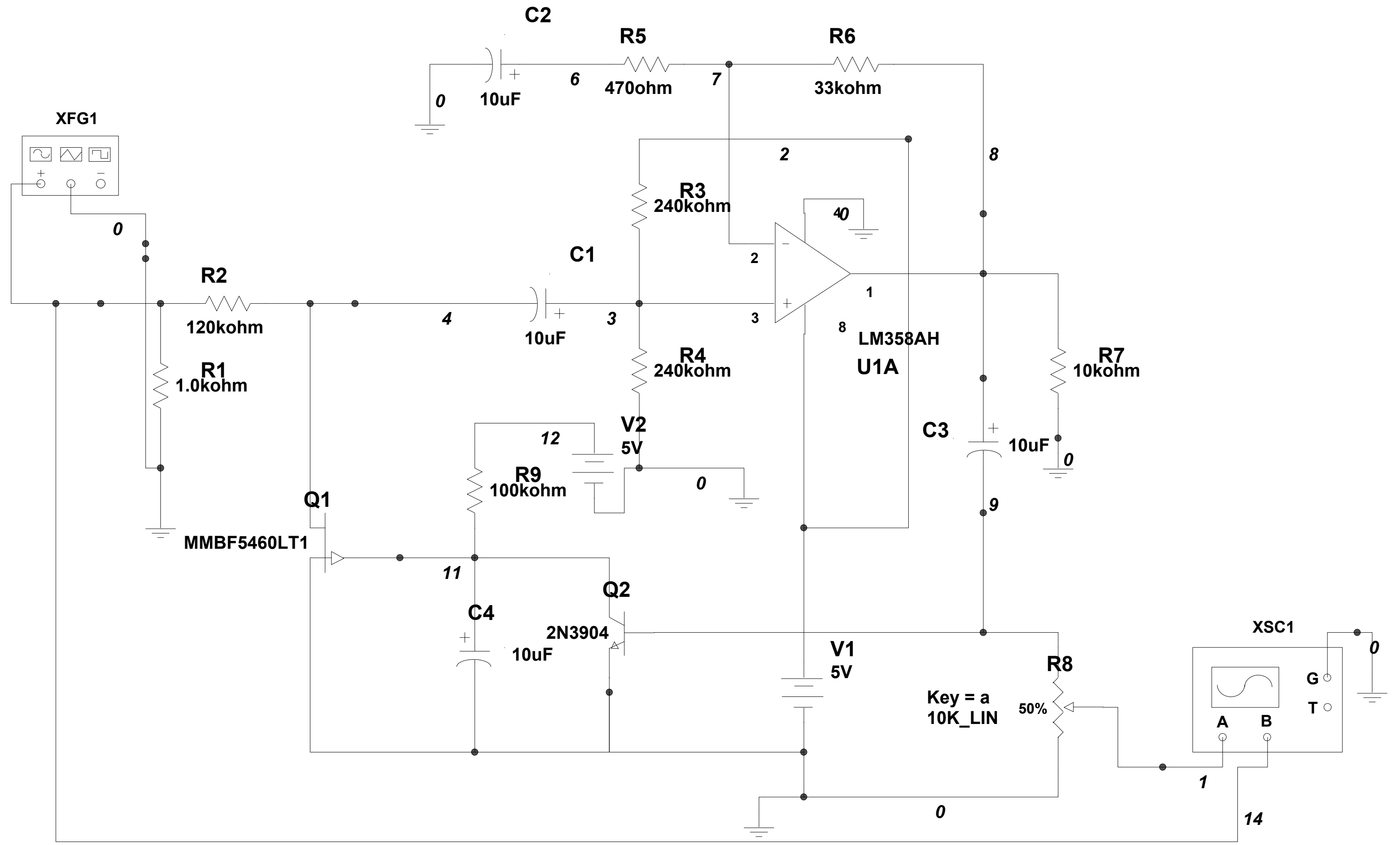

Finally, this graph shows the threshold controller (follower of channel 1) and the beat detector. The clarity of the peaks is well defined.

**Conclusion**

The addition of the AGC to the beat detector was an immensely successful step forward in accurate beat detection. As an interesting aside, the circuit could even find peaks in the music even when there was no clear bass drum impulse. For example, if a bass guitar impulse was repeated over a bar (or any length) and was uniform and linear, then the circuit would attempt to trigger from those peaks. That was made possible by the short attack. Before this implementation, the LED would flash at irregular and improper times, reflecting the circuits response to dozens of small peaks.

*Works consulted*:

George, Joseph P. "Effective AGC Amplifier Can Be Built At a Nominal Cost." *Ideas for Design*.

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| Title: **agc_1** | | |
| **Automatic Gain Control Circuit** | | |
| Designed by: **Matt A** | Document N **0001** | Revision **1.0** |
| Checked by: | Date **Apr 27, 2003** | Size **A** |
| Approved by: | Sheet **1** of **1** | |

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