Lecture 32: Automatic Gain Control

The AGC serves to keep the audio output at nearly a constant level as you tune across the frequency band. This nearly constant level is maintained even though the received signals may be varying dramatically in strength – **perhaps 10^6 to 1**!

An AGC will reduce the audio amplifier gain for strong signals and increase it for weak signals.

The AGC in the NorCal 40A is described and constructed in Probs. 32 and 33. We'll discuss it in stages, as in the text.

The first stage of the AGC construction is shown in Fig. 13.9, which we discussed in the previous lecture:

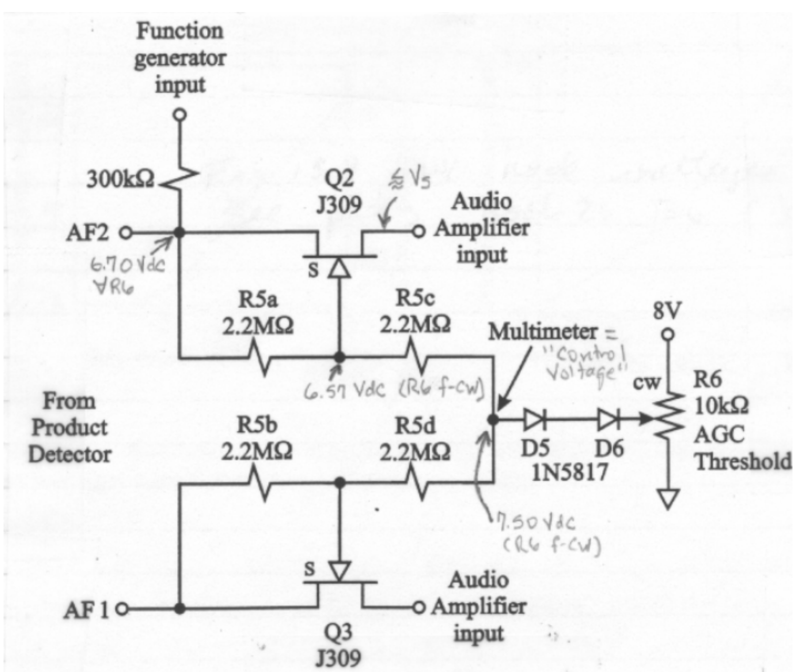


Figure 13.9. The AGC attenuators.

Also shown in this figure are the dc node voltages I measured in my radio with R6 fully CW.

Here are some important points to note in order to understand the operation of this AGC circuit:

1. The Q2 and Q3 drain voltage are less than but approximately equal to their respective source voltages. Thus, Q2 and Q3 operate in the VCR region, with r_{ds} controlled by V_{gs}.

2. R5a and R5c, as well as R5b and R5d, act as simple voltage dividers so that

$$V_{g,\text{Q2}} = \frac{V_{AF2} - V_{control}}{2}$$

However, referring to the previous figure and observing the voltages I measured, this voltage divider relationship doesn't appear to hold true with R6 fully CW.

Why?

Because R5 is very large (2.2 MΩ). Consequently, the current in R5a, R5b, etc., is on the order of 100 nA, which is likely comparable to the leakage current in the gate of Q2.

3. Now, with R6 fully CW producing $V_{gs} \approx 0$, this implies minimum attenuation, as we can infer from Fig. 13.5(a):

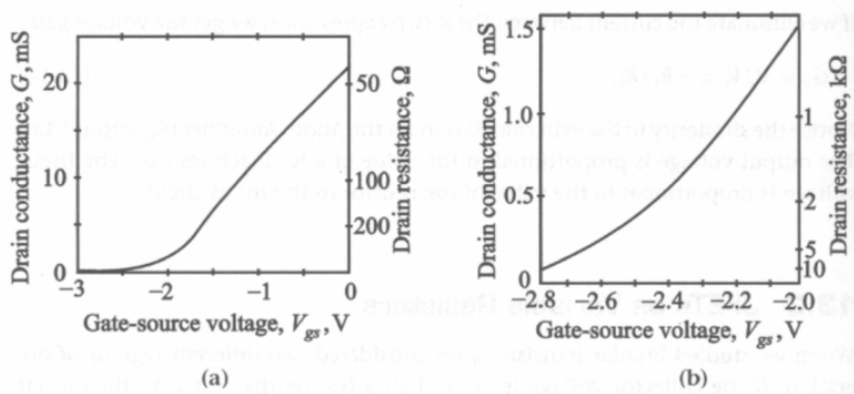
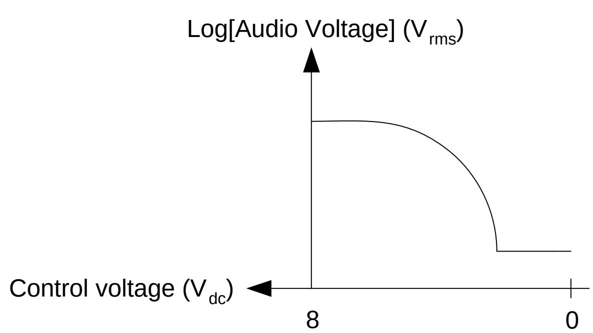


Figure 13.5. Drain conductance in the linear region for the J309 JFET as a function of the gate voltage (a), and the high-resistance region near cutoff (b).

4. When the control voltage (anode of D5) decreases, then $V_{gs,Q2}$ becomes more negative. From Fig. 13.5 we see that r_{ds} increases, which implies more attenuation of the audio signal passing through Q2 (and Q3) from U2 (Product Detector) to U3 (Audio Amplifier). Neat!

In Prob. 32.A, you will record data and make a plot to quantify this attenuation property of the AGC versus the control voltage. Your plot should be constructed as follows:



You'll plot the RMS audio voltage (speaker voltage) versus the dc control voltage (anode of D5). How do you vary this control voltage? Simply adjust R6, the AGC threshold.

The "Automatic" in Automatic Gain Control

Putting the "automatic" into AGC is the second step in the AGC construction. It is accomplished in a wonderfully elegant and simple manner by simply adding the two capacitors C29 and C30, as shown in Fig. 13.10:

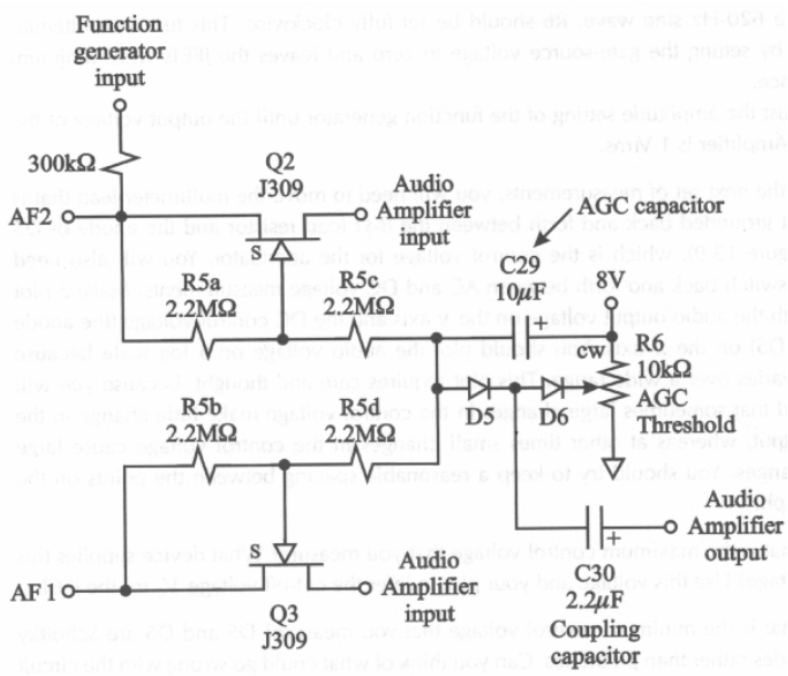


Figure 13.10. Adding the AGC capacitor C29 and the coupling capacitor C30.

The functions of these two capacitors are:

- C30 is the **coupling capacitor**. It provides feedback by coupling the audio output signal back to the AGC control voltage.
- C29 is the **AGC capacitor**. This capacitor *may* become charged – if the audio output is large enough – and subsequently decrease the control voltage. This in turn will

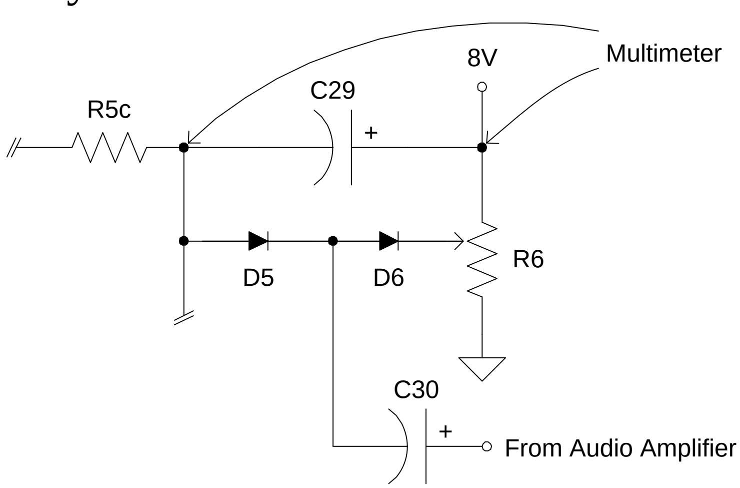
increase r_{ds} of Q2 and Q3 and increase their attenuation of the audio signal fed to the LM386.

This process is called the "attack" of the AGC.

More specifically, the charging of C29 occurs when the audio voltage is negative. Current through C29, D5 and C30 charges C29. Hence, when C29 charges, the control voltage becomes smaller, which increases r_{ds}.

On "recovery," C29 discharges through R5. Since R5 is so large, the recovery time will also be large, which is desirable for an AGC. Recovery occurs when the audio signal has decreased in level and requires a smaller level of attenuation.

In Prob. 33.B, you will calculate what the recovery time should be. To do this, you need to measure the dc voltage of C29 before and after recovery:



Measure V_{C29} (dc) with the function generator set at 0.1 V_{rms} and then at 3 V_{rms} as used in Prob. 33.A. This difference in voltage can be used to predict the recovery time Δt as

$$V_{C29} = V_{\text{initial}} e^{-\Delta t / \tau}$$