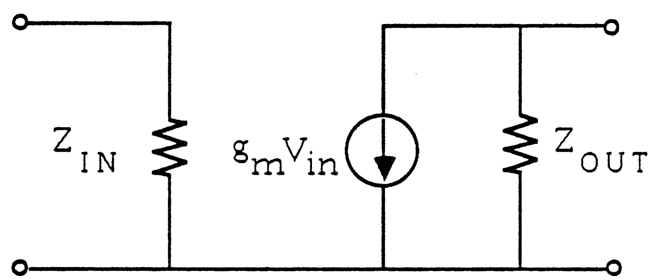
AUTOMATIC GAIN CONTROL

Automatic Gain Control (or AGC) is used to control the dynamic range of radio receivers. As an example, the input signal to a radio receiver can vary by a factor of over a million while the linear range of most amplifiers is a thousand or less and the useful range of most amplifiers and other linear active networks is only a factor of ten. What an AGC circuit does is measure the average (average means that any signal modulation present is removed by filtering, or averaging) value of the input signal and adjust the amplifier gain so as to keep the output signal constant. In general, amplifiers with AGC exhibit a constant gain until some signal threshold is reached and then decrease their gain so as to keep the output signal at some maximum value.

How can one electronically control the gain of a transistor amplifier? The most common method is to somehow vary the amplifier transconductance g_m. Consider the role of g_m in the simplified hybrid-pi transistor amplifier model shown below. For BJTs operating in the region where the model shown is valid, several mechanisms peculiar to BJTs can be used for AGC purposes.



One such mechanism is the fact that the β of certain transistors decreases not only as the emitter current decreases but as V_{CB} decreases. In a practical amplifier, a change in V_{CB} from 1.2 to 2.5 volts can change the amplifier gain by a factor of 100. An AGC amplifier using this principle is called a forward acting AGC circuit.

Another method used for AGC is controlling the emitter current of an amplifier which changes the input impedance and, indirectly, the gain of the amplifier. For example, as I_E increases the transistor h_{ie} decreases. As h_{ie} changes, the input voltage divider relationship changes varying the fraction of source voltage which gets to the amplifier.

On the other hand, transistors such as the popular 2N3904 have a β which increases with emitter current. This means that if we decrease the emitter current as we increase the input signal we also have an AGC amplifier. This method is particularly easy to implement but requires that the emitter be at ac ground. Why? Because if the emitter is unbypassed the amplifier gain is determined by the ratio of collector to emitter resistance – independent of β. How can we control the emitter current? If we recall how we stabilized the bias point of a BJT amplifier we stabilized (controlled) the emitter current by stabilizing the base voltage. That same principle can be used in an AGC amplifier: vary the base voltage to vary the emitter current which varies the β and consequently the amplifier gain.

How might a real AGC circuit based upon this principle work? If we consider the relevant application of a typical AM radio with a 455 kHz intermediate frequency amplifier we can consider a simple germanium diode detector, i.e. a diode rectifier/filter. The output of the i.f. amplifier is an amplitude modulated 455 kHz signal. If this signal is rectified by the germanium diode and then filtered to remove the carrier frequency we have the case of a standard diode AM detector. However, if this signal is further filtered to remove the ac modulation we have a dc voltage which is proportional to the strength of the AM carrier, i.e. the input signal. If the diode detector polarity is such as to produce a negative dc voltage we can add a low-pass filter with a time constant of 1-10 Hz to remove the modulation from the detector output. This signal is proportional to the carrier signal level and may be appropriately amplified and then coupled through a resistor to the base of the transistor which acts as the AGC amplifier. As the input signal level increases the diode detector will produce a larger negative output voltage. Filtered by the lowpass filter this results in a slowly varying negative voltage which, when appropriately coupled to the base of the AGC amplifier transistor, will decrease the base voltage of the AGC amplifier and reduce the amplifier gain.

One problem that must be considered when designing an AGC circuit of this type is the isolation between the AGC amplifier and the the circuit producing the AGC control voltage.

Inadequate isolation between the two can result in oscillations. Furthermore, too much filtering by the AGC filter can also result in oscillation.

REFERENCES

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