A Low Distortion AM Detector and AGC System

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Abstract

This document describes the operation and implementation of a relatively simple and inexpensive, low distortion AM detector and AGC system, which can be added to existing (or new) receivers with minimal changes to the receiver itself, resulting in high-fidelity detection and reception of AM signals.

Overview and Background Information

The Problem

One of the biggest problems I've encountered over the years with receivers, particularly with older vacuum tube Amateur receivers, is distortion in the received audio caused by a poor detector and/or AGC system.

Typically, the distortion is caused by one or more of the following:

1) Clipping of negative modulation peaks by the detector before 100% modulation is reached.
2) Non-linearity in the detector circuit, causing distortion, particularly of positive peaks in excess of 100% modulation
3) Low frequency audio components appearing on the AGC voltage and/or AGC voltage changing with modulation. The later will cause a "compression" effect in the received signal, with the former causing intermodulation distortion and a reduction in low frequency response.

Some Sources and Causes of Detector and AGC Related Distortion

The causes of detector problems can be numerous, however the most common problem – clipping of high negative modulation peaks – is generally the result of back biasing of the detector diode [often due to stored DC in the AGC system or DC blocking capacitor], causing the detector to cease conducting at some point in the audio cycle. When the diode does not conduct, the resulting output will be clipped.

The second common problem – non-linearity and subsequent distortion, particularly on high positive modulation peaks – is usually caused by improper loading of the detector output, causing an excessive voltage drop across the detector diode and/or a decrease in the output of the last IF amplifier stage that feeds the detector.

The third problem results from the AGC system. The AGC system can be a significant source of distortion and other problems. Many receiver AGC systems back-bias the AGC detector, causing more AGC voltage to be developed under modulation than would be developed with an unmodulated carrier. This causes a compression effect of the demodulated signal. If the AGC signal is not sufficiently filtered at audio frequencies, the resultant audio on the AGC signal will cause intermodulation distortion, where low audio frequencies will actually modulate higher audio frequencies as a result of the audio on the AGC voltage. This is very undesirable, and the effect will generally be worse on strong signals than on weak ones.

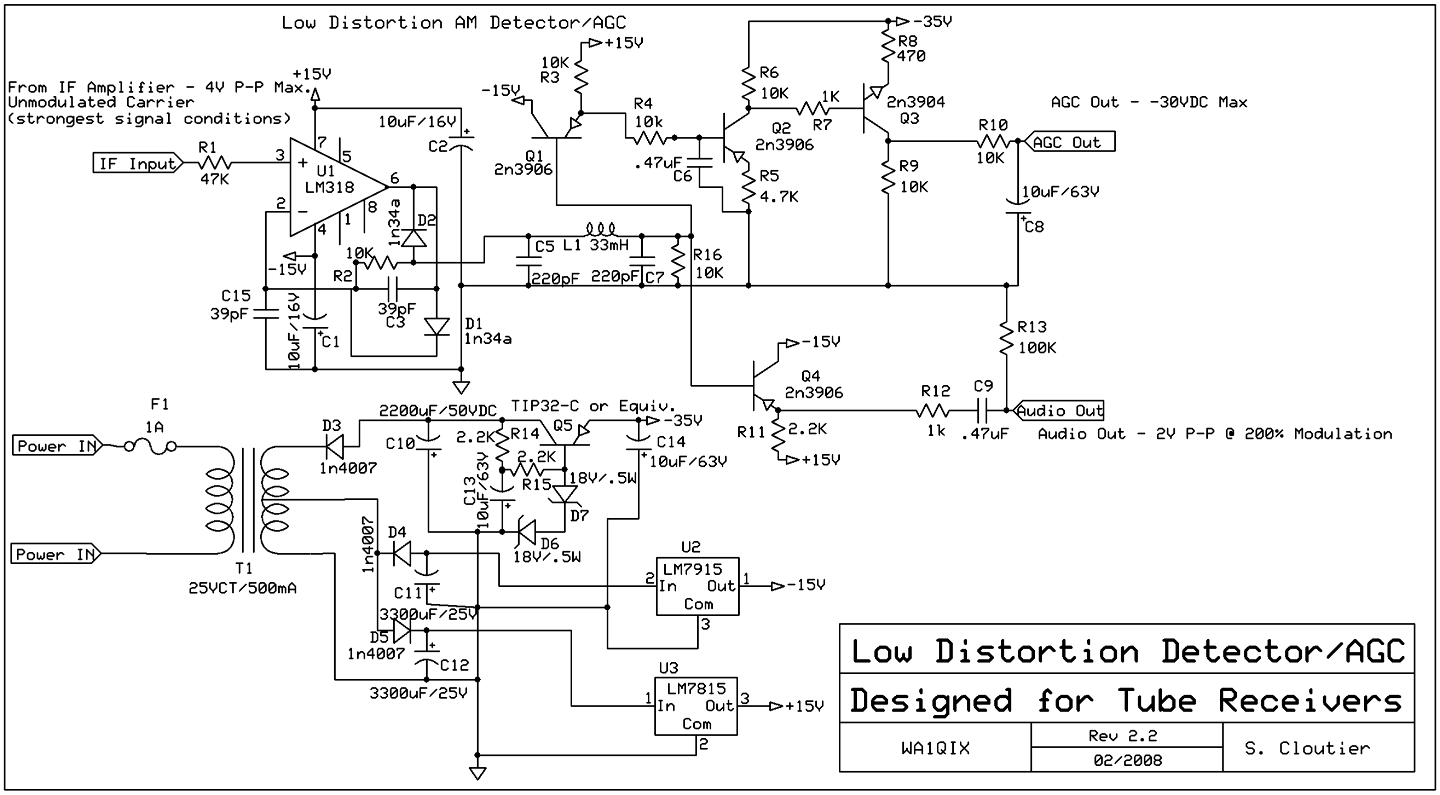
Making Receiver Circuit Changes to Correct the Problem

It is possible to correct all of the aforementioned problems by rebuilding the detector and/or AGC circuitry within the receiver itself. However, such an undertaking is often extremely difficult, if not impossible – given component and space limitations - to accomplish. Furthermore, the modifications can often be significant, requiring major circuit and/or physical changes to the receiver. This can diminish the value of the receiver as a vintage piece of equipment, and for this reason alone, significant circuit modifications may not be an option.

Using External Circuitry

A more attractive (and generally easier to implement) alternative to major receiver modification is to simply add a small copper clad board to the receiver (usually underneath the receiver chassis), on which the detector and AGC systems are implemented. Doing so will require the minimum changes to the receiver itself, and will also result in a superior implementation due to the fact that the circuitry available with modern components is not practically implementable with vacuum tubes.

Circuit Description and Implementation



Circuit Description

The schematic shows a complete circuit diagram of the Low Distortion AM Detector and AGC system.

The 455kHz IF signal from the last IF amplifier of the existing receiver is fed to the IF input of the detector circuit. The input is a very high impedance (in the order of many mega ohms), and does not significantly load the last IF stage of the receiver.

The LM318 op-amp (U1) forms a precision rectifier, which creates a very low distortion detector. The negative-going output of the detector is filtered by C5-L1-C7. The filter output is buffered by transistor Q4, which forms an emitter follower. The output of Q4 is then fed to the audio system.

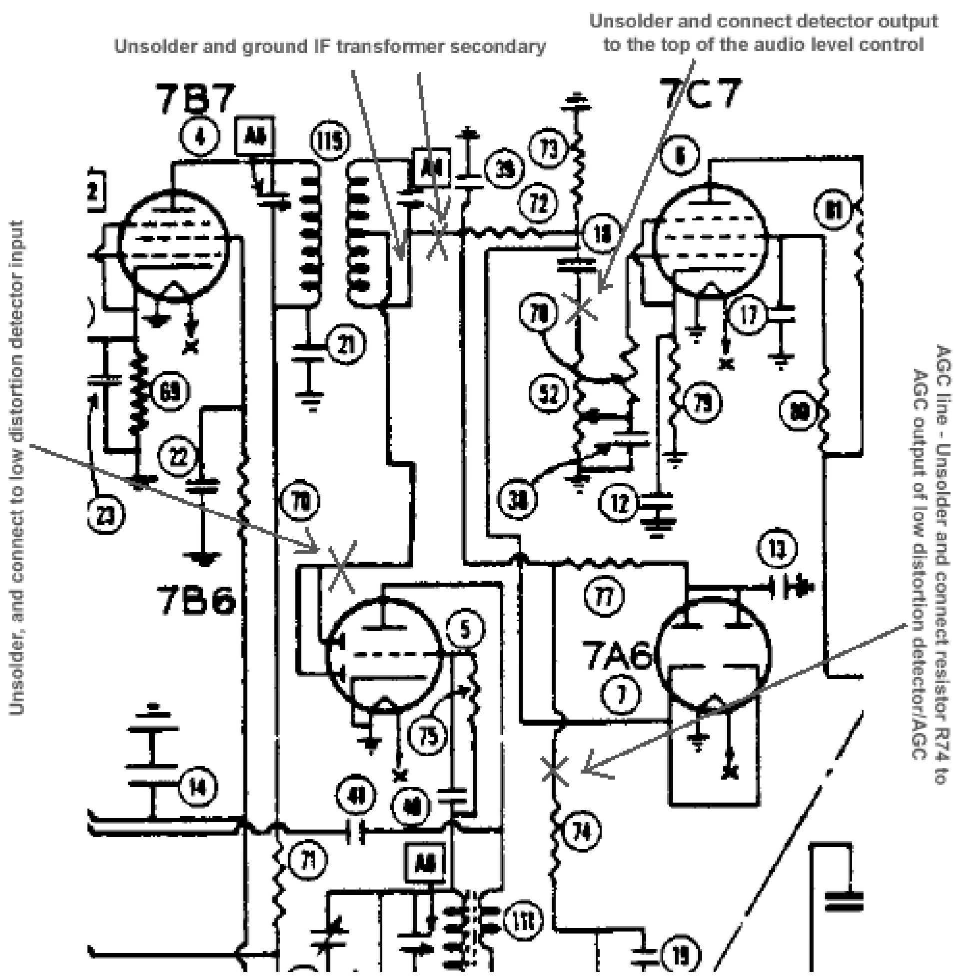
A second buffer amplifier, Q1, drives the AGC amplifier formed by Q2 and Q3. The AGC signal is filtered in two places: by R4-C6 and by R10-C8. The filter effectively removes any audio frequencies greater than a couple of cycles per second from the AGC output. The AGC output is connected directly to the AGC line of the receiver, and up to –30 volts can be developed. This is generally more than sufficient to cut off most vacuum tubes, and should be sufficient for virtually all applications.

The power supply delivers three voltages using a single center-tapped transformer and three voltage regulators.

Implementation and Connection to the Receiver

The circuit should be built on a piece of copper clad board. So-called “dead bug” construction works very well for this application, as the circuit does use RF energy, and therefore good bypassing and a good ground plane are very important for stable operation. Perf board or other non-ground plane construction techniques are not recommended.

The connection to the receiver is straight forward. If the circuit is not located VERY close to the last IF amplifier, a shielded cable should be used to connect the output of the last IF to the detector circuit. This may require a realignment of the last IF transformer, due to the added capacitance of the cable.



The schematic section shows the last IF and detector/AGC of an RME-45 receiver, and the connection points for the low distortion detector. This is one example. Other receivers will most certainly vary in their detector/AGC implementations, however by locating the appropriate connection points, connection of the low distortion detector should be possible with virtually all vacuum tube receivers.

It is very important that the receiver’s IF output be DC ground referenced. One side of the IF transformer secondary should be at RF ground, and preferably at DC ground as well. The other side of the IF amplifier secondary should feed the detector circuit. If it is not possible to achieve a DC ground referenced IF output, a suitable RF choke should be installed between the IF output and ground to establish a DC ground reference.

No other circuitry should be connected to the last IF amplifier output, and in most cases the secondary can be disconnected from the existing receiver circuitry, and connected to the low distortion detector circuit. Since one side of the last IF transformer is connected to the detector in the receiver, this can be disconnected and connected to the low distortion detector. The other side of the IF transformer secondary can usually be grounded, at least at RF.

Generally, there is a single feed point for the receiver's AGC. This point should be located by consulting a schematic diagram of the receiver, and should be disconnected from the original AGC circuitry within the receiver. The AGC line is then connected to the AGC output of the low distortion detector.

The audio output can be connected back to the receiver's audio system, if desired. Since the receiver's audio system is generally not designed with fidelity in mind, it is usually very desirable to completely bypass the internal audio circuitry, and simply use an external high fidelity amplifier/speaker system. With most receivers, it is fairly simple to connect an external audio system to the wiper of the audio level control of the receiver, and remove the audio output and other associated vacuum tubes, reducing heat and power consumption.

Questions or comments about this document can be directed to me at: cloutier@classeradio.com