Automatic Volume Control as a Servicing Aid

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I have been working on an article about radios that seem to underperform, and how to assess them and decide whether they need to be fixed. A big part of that is looking at the Automatic Gain Control (AGC) or Automatic Volume Control (AVC) operation. (AGC and AVC are two terms for the same thing) Looking at the behaviour of the AVC voltage gives an indication of the health of the radio. I decided that AVC could warrant an article on its own.

What is AVC?

Almost all superheterodyne radios made after about 1932 have Automatic Volume Control (AVC). The purpose of AVC is to control the gain of a radio so that it has high sensitivity when receiving weak stations and low sensitivity when receiving strong stations. If the gain was held constant, then local stations would be deafening and distorted, and distant stations would be weak. Tuning across the band would require continual adjustment of the volume control. This feature is not just a sales gimmick; it makes a remarkable difference to the convenient operation of a radio. The fact that it costs very little to implement made it almost universal in superheterodyne radios, even into the solid-state era.

The graph (taken from the Radiotron Designers Handbook, 4th edition) shows a radio's output power on the Y axis vs. signal voltage input on the X axis. Curve A shows radio operation without AVC, and curve D shows operation with standard AVC. At high signal levels, AVC can reduce radio gain by over 40dB.

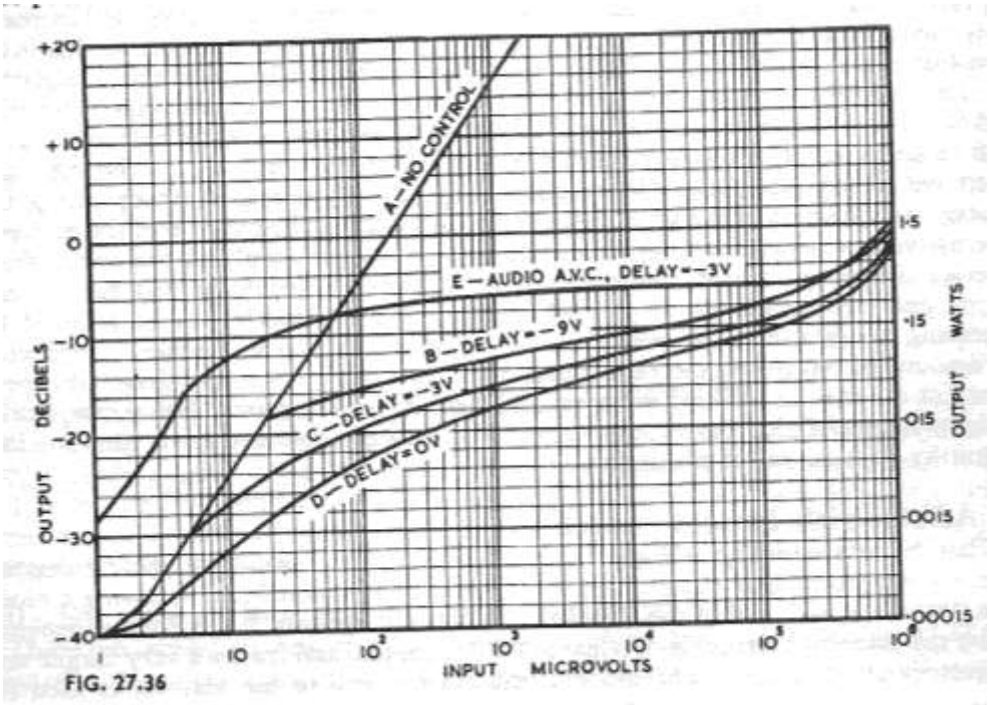
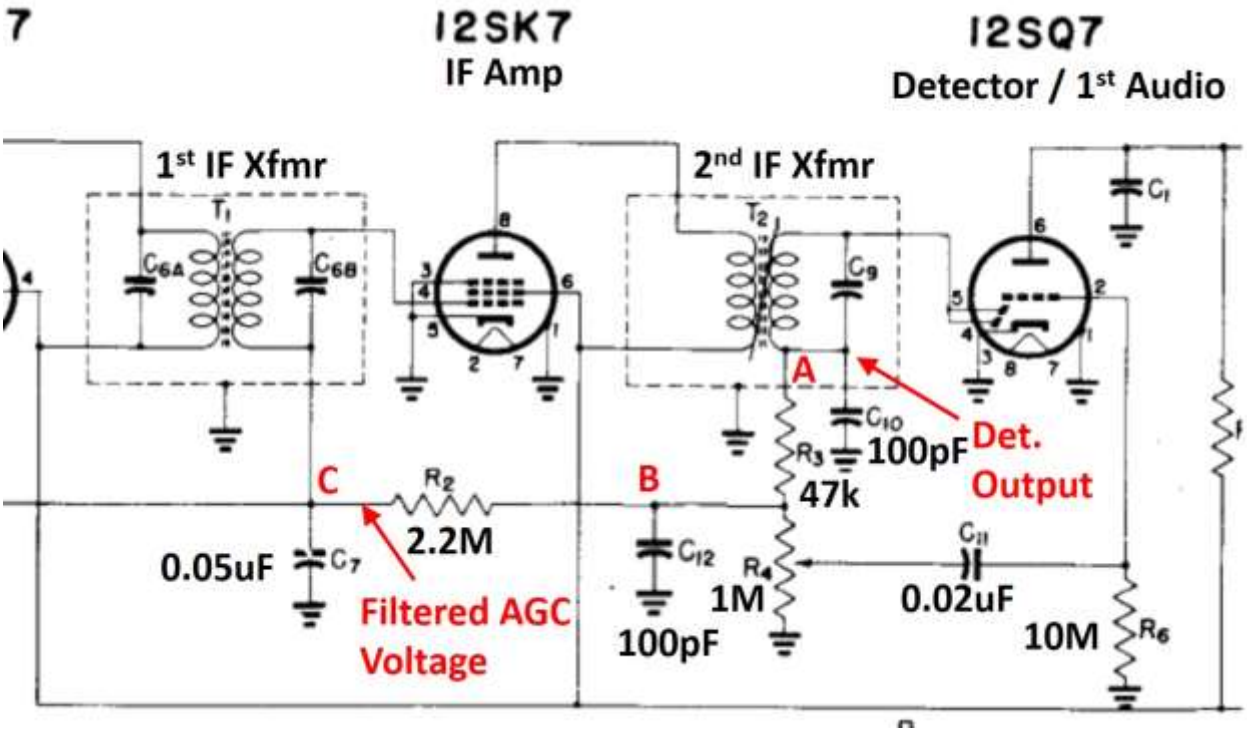


FIG. 27.36

AVC became practical with the invention of “Variable mu” or “remote cutoff” pentodes that are used as IF and RF amplifiers; the gain of these tubes can be changed by adjusting the grid voltage. Tubes like the 58, 6D6, 6K7, 1T4, 6SK7, or 6BA6 are designed for AVC control. Some converter tubes behave the same way. The voltage to control this tube is generated by filtering (to remove audio frequency variations) the output of the detector; the diode in tubes like the 75, 6B6, 6Q7, 6SQ7, 6H6, 1U5, or 6AV6.

Where is the AVC voltage?

The detector output can generally be found on the last IF transformer output. The schematic below is from a simple “All American 5” radio, but most superheterodyne radios look similar enough. Node “A” marks the raw detector output in the schematic. This node still has IF energy, plus the audio with a DC offset from the modulated RF carrier that the radio station transmitted. This voltage is filtered by C10, R3 and C12 to remove the IF components, producing an audio voltage with a DC offset at “B” (which is fed into the audio amplifier). The audio is filtered out with R2 and C7 to produce just a negative DC voltage at “C”, roughly proportional to the radio station strength. This AGC voltage is applied to the control grid of the IF amplifier and/or the RF amplifier and/or the converter, usually through a transformer or coil or resistor. Any of these voltages can reasonably be called the AVC voltage. Measuring the voltage at “B” will introduce less error (caused by loading the node with a voltmeter) than “C”.



AVC Behaviour

Unfortunately, schematic diagrams that list tube voltages seldom mention the AVC voltage. AVC voltage is best measured with a VTVM or DVM (high input impedance meter) with a strong signal injected into the radio, but most of us do not have a calibrated signal generator to do a quantitative test. The best we can do is use rules-of-thumb when receiving high power local stations. In Ottawa, we have 2 high power AM stations (1310 has recently gone off the air):

CFRA 580kHz 50kW day /30kW night
CFGO 1200kHz 50kW

Which one is best for you will depend on your location and antenna. Most metropolitan areas have a 50kW station that you can use as a reference.

If you measure the AVC voltage at “B”, you should always see a negative voltage with respect to ground. When receiving no station, this would generally be less than -1V. Strong stations will increase it significantly. (Throughout this article, when I refer to the AVC voltage which is negative, an increased voltage means it is more negative) With a long external antenna and local stations, expect to see -6V on an “All American 5” AC/DC set without a power transformer, and maybe -10V on a 5-tube AC set with a power transformer. Battery sets will be a little lower, especially sets that use a 1U4 IF amplifier which is “sharp cutoff” pentode (which gives more like -2V). AC radios with an additional RF amplifier or IF amplifier can show -20V on a local station with a good antenna. Don’t worry about the exact value of the voltage, but it should be “several” negative volts or more when tuned into a local station. The voltage should change significantly as the radio is tuned from station to station. If the voltage is *always* substantially negative (regardless of the tuning), suspect oscillation. (See the Fall 2023 newsletter for a discussion about oscillation) If the voltage at “B” behaves properly, but “C” stays low and the radio plays really loudly, then something is preventing the AVC voltage from getting back to the gain stages, maybe a shorted AVC decoupling capacitor (C7) or open AVG resistor (R2). If the voltage stays low, and the radio lacks volume, then something is killing the gain in the RF or IF stages. There are many suspects, like the tubes, the IF transformers, alignment, and the antenna coil circuit.

If you have an oscilloscope, check the voltage at point “C”. It should not have significant audio, and certainly should not have “Hum”. If it does, it can make the audio sound garbled and distorted. This can happen if the antenna picks up 60Hz AC voltage that is not adequately filtered by the AVC capacitor C7.

Disabling the AVC

When doing an alignment, it is advisable to disable the AVC. Having the AVC on tends to compensate for mistuned IF transformers, making it more difficult to find the perfect tuning. You can disable the AVC by shorting “C” to ground; point “A” or “B” will still have the AVC voltage on them which can be used in the alignment process. If you disable the AVC voltage by shorting “A” to ground, all stages are running at maximum amplification and you should find that the AVC voltage out of the detector (“B”) is substantial. I have seen anywhere from -30V to -100V when tuned to a local station with an external antenna. Shorting the AVC voltage at “C” should also increase the volume in the speaker, probably causing distortion. This test is also a good troubleshooting aid. If disabling the AVC in this manner still results in middling performance and low AVC voltage (at “B”), then something in the RF-converter-IF is not working well. Assuming all tubes are good, quick alignment is what I would try first. If AVC voltage behaves as expected but the radio is not performing well, suspect something in the audio chain.

Delayed AVC

It is worth mentioning “Delayed AVC”. If you are trying to receive a distant station, it would be counterproductive for the AVC to be reducing the gain. In some high-end radios, the AVC voltage is inhibited when receiving weak stations. “Delayed AVC” acts to prevent the AVC from having any effect until a station’s strength reaches a threshold for comfortable volume. (so, the “delay” is not a time

delay) Back on the graph, curve B and C show operation with delayed AVC, at 2 different voltage delays. Notice that the curves are “flatter”, noticeably at low signal levels.

Pretty much any of our superheterodyne radios with an external antenna (or a good loop or ferrite antenna) should be able to receive local stations (2 in Ottawa) during the day, and a few distant stations at night. I find that I can usually receive WABC at 770kHs or WCBS at 880kHz (New York City) in Ottawa after sunset. Tuning in these stations may cause a volt or so of AVC voltage. With an external antenna, the local stations should pretty much close the tuning eye, if there is one. It should be loud enough to comfortably fill a room on a local station, and produce several volts on the AGC line.