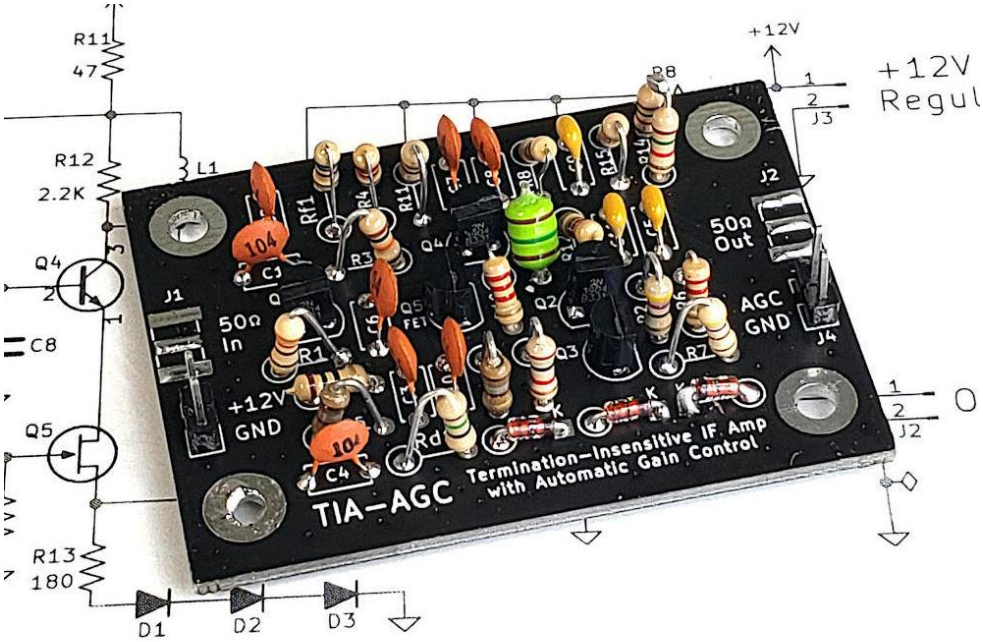
TIA-AGC

Programmable-Gain Termination-Insensitive IF Amplifier with Automatic Gain Control



User’s Guide

A termination-insensitive IF amplifier makes it easier to maintain a 50Ω system impedance in a receiver, transmitter, or transceiver. No matter what's connected to either of its ports, the other port still presents a 50Ω load to the rest of the world. By "programming" the values of its feedback and emitter resistors, this termination insensitivity is maintained while allowing for a range of gain between 7 and 24dB. The circuit on which this broadband TIA IF amp is based was devised by Wes Hayward, W7ZOI, and Bob Kopski, K3NHI.

Though not be any means necessary, it's also nice to have *automatic gain control* (AGC) of the audio output of a receiver. This minimizes ear-straining faintness on the one hand, and ear-blasting loudness on the other. In most superhet-type receivers, this is done by controlling the gain of IF amplification prior to "detection" (demodulation to audio), usually in the last IF amp. In this refinement of the original TIA design, W7ZOI used a "hycas" (hydrid-cascode) arrangement (previously worked out with Jeff Damm, WA7MLH) in the gain-controlling stage.

The TIA-AGC offers these features:

- Buffered 50Ω input and output.
- Gain programmable between 7 and 24dB by changing two or three bias and feedback resistors. Input return-loss between 24 and 36dB (1.03 to 1.14 SWR).
- Requires +12VDC supply voltage.
- 0.83 x 1.57" (21 x 40mm): small, but still comfortably using discrete, through-hole parts.
- Four mounting holes for 4-40 or M3 screws.
- Board-edge footprints for SMA connectors (not included) or for directly-soldered wires.
- Available as a bare board, a kit including PCB and discrete components (connectors not included), or as a fully-assembled and tested amplifier.

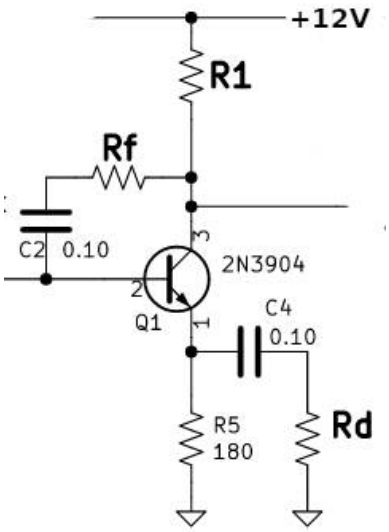
APPLICATION

The *primary* intended use of the TIA-AGC is as an IF (intermediate frequency) amplifier to make up for the insertion loss of mixers and filters used in the IF stages of a rig, *and* to *distribute* the gain required from the antenna to the speaker or headphones (typically 100 to 120dB). It is usually desirable to use low or moderate gain in any particular stage before the audio to minimize distortion and to maximize the dynamic range of the system as a whole. This is true especially for receivers. Typically, the greatest amount of gain is left to the audio stages where there is less danger of signal degradation. In the IF stages, though, moderation is a virtue. The range of *static* gain settings available for the TIA-AGC is well suited for this purpose. These settings are determined through the choice of the values for the gain-setting bias resistors installed on the TIA-AGC board.

A *secondary* purpose of the TIA-AGC is to provide for *dynamic* gain control based on the level of the incoming signal. A voltage proportional (inversely) to this level is fed back to the TIA-AGC's hycas stage, controlling the drain voltage of that stage's FET. Other IF amplifiers having automatic gain control generate the AGC voltage internally (e.g., Hayward and Damm's original hycas design as detailed in their 2007 *QST* article--see below for reference). The TIA-AGC does not. It provides an input for the AGC voltage generated elsewhere. Though several AGC schemes exist, the one most-commonly employed uses diode rectification of a sample of the audio output. This DC signal is then filtered and scaled with an op-amp. Further refinements add RC-based time delays to avoid "pumping" and other instantaneous--and annoying--audio effects.

PROGRAMMING STATIC GAIN

The gain of the three-stage TIA-AGC is determined by the values of the three bias-setting resistors in the first-stage "feedback" amplifier: **R1** (with R5 sets collector-emitter current), **Rf** (sets signal feedback), and **Rd** provides "degeneration" feedback.



These resistors are labeled on the PCB in bold. The values of each of these are shown in the following table by desired gain:

Resistor Values for Gain Programming			
dB Gain	**R1**	**Rf**	**Rd**
7	330	270	27
10	330	390	22
13	330	510	18
16	330	680	15
19	330	1000	10
24	330	1800	4.7
15	470	620	20
22	470	1500	10

These gain figures are approximate due to component variations and tolerances. Note that the small-value resistors for **Rd** should be measured and selected for actual value rather than rely on color code.

The subsequent two stages of the TIA -AGC are buffers to maintain termination insensitivity. They have little role in determining overall gain.

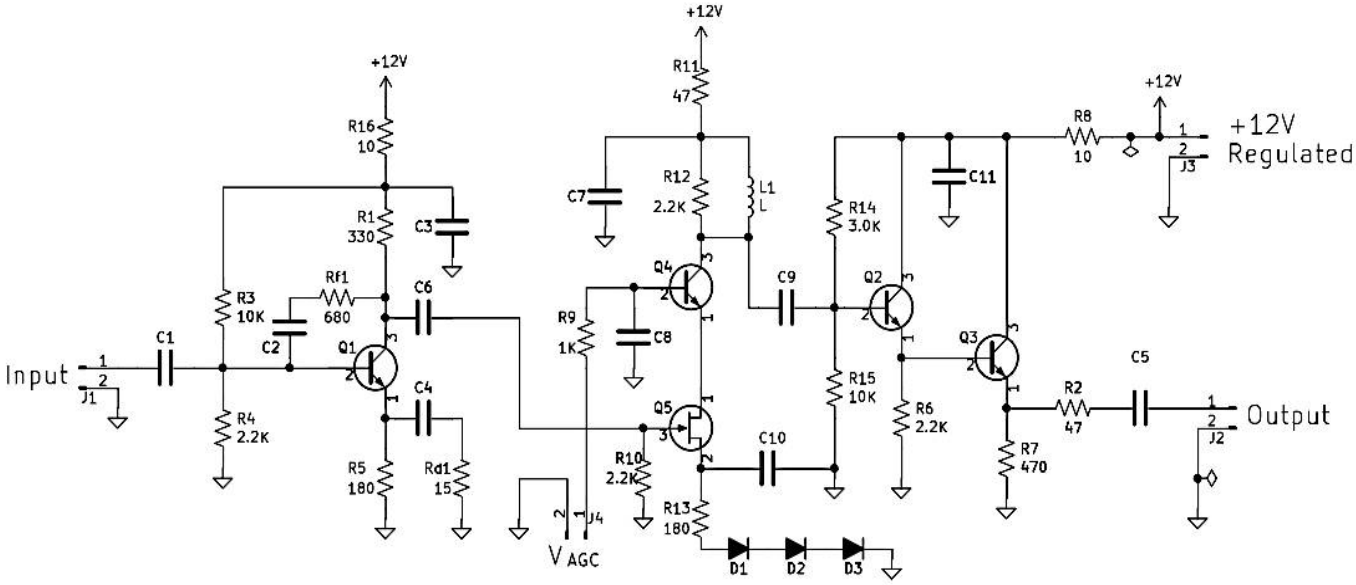
ASSEMBLY

If you purchased the TIA-AGC as a kit of parts, use the schematic diagram along with the silk-screen legend printed on the PCB to place components. The component numbers on both are identical to those used by Hayward and Kopski in their original paper. Though not difficult to solder, it is worthwhile to insert, solder, and trim the leads of the transistors first before adding the resistors and capacitors along the top and bottom edges. As usual, it is also a good idea to test the transistors before installing them.

The Hayward/Kopski schematic calls out and the TIA-AGC kit includes 2N3904s for the three transistors. Similar NPN bipolar transistors (*Ic > 50mA, hfe ≈ 100, fT > 100MHz) can be substituted for 3904s, though the resulting gain profile will likely be somewhat different than specified.

See also:

Wes Hayward and Bob Kopski. "A Termination Insensitive Amplifier for Bidirectional Transceivers" (June 2009) <w7zoi.net/bidirectional_matched_amplifier.pdf>.



For a scalable PDF of the schematic, go to: mostlydiyrf.com/tia-agc/