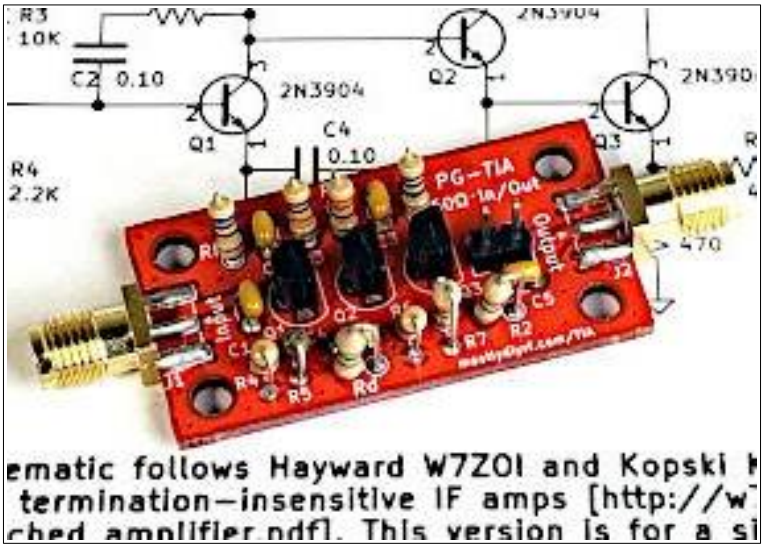
PG-TIA

Programmable-Gain Termination-Insensitive IF Amplifier



User’s Guide

The PG-TIA makes it easier to maintain a 50Ω system impedance in a receiver, transmitter, or transceiver by making its input impedance insensitive to whatever is attached to its output, and its output impedance insensitive to whatever is attached to its input. This simplifies the design of the mixers, modulators, product detectors, and filters these TIA amplifiers serve in a complete radio system. 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.

The PG-TIA 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.

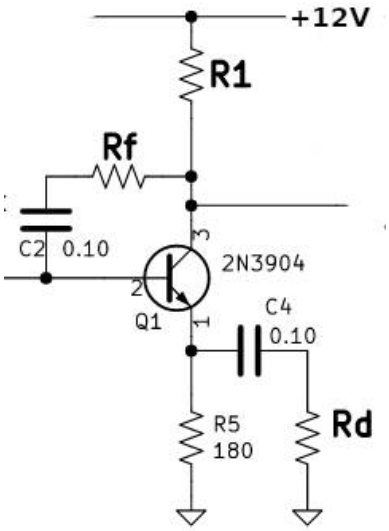
APPLICATION

The intended use of the PG-TIA 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 gain settings available for the PG-TIA is well suited for this purpose.

The PG-TIA can also be used for incoming, pre-mixer RF from the antenna. For use on the HF bands below 20 meters, though, this is usually neither needed nor advisable. It can, in fact, lower dynamic range by amplifying band noise along with the desired signal and by over-driving the first mixer. For use as a pre-mixer amplifier, it is doubtful the PG-TIA should be used beyond 7dB gain, and then only with provision for subsequent attenuation (a simple potentiometer, for instance). In addition, such use should be combined with either low-pass or band-pass pre-selection filters to minimize the amplification of wide-band signals and noise.

PROGRAMMING GAIN

The gain of the three-stage PG-TIA 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 PG-TIA are buffers to maintain termination insensitivity. They have little role in determining overall gain.

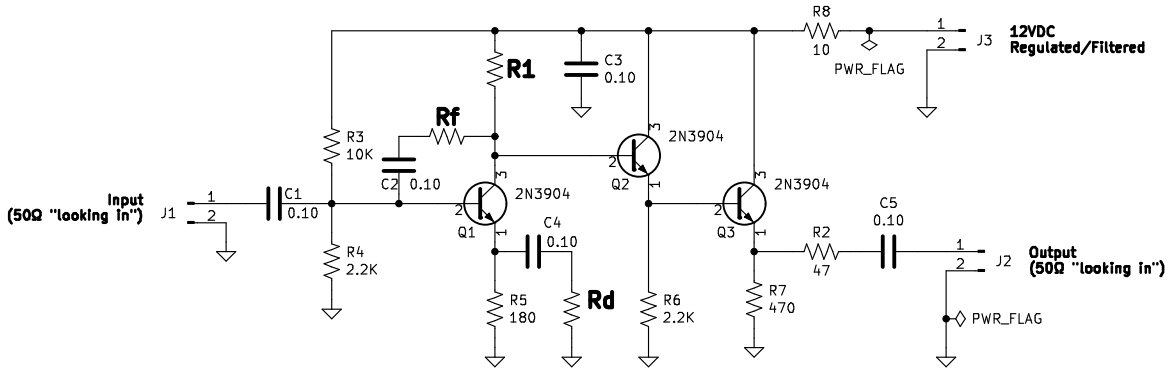
ASSEMBLY

If you purchased the PG-TIA 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 PG-TIA 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>.



Note 1: This schematic follows Hayward W7ZOI and Kopski K3NHI paper (2009) on termination-insensitive IF amps [http://w7zoi.net/bidirectional_matched_amplifier.pdf]. This version is for a single rather than bi-directional amp. This makes it usable in non-bi-directional systems or paired together for bi-directional use.

Note 2: All transistors are 2N3904. All resistors are 1/4 Watt 5%. All capacitors are 0.10uF disk or MLCC types. Component reference numbers (R8, C3, etc.) follow the Hayward/Kopski original.

Note 3: The gain "programming" resistors are indicated in large bold typeface. See the "Gain Programming" table for resistor values.

Resistor Values for Gain Programming

dB Gain*	R1	Rf	Rd**
7	330	270	27
10	330	390	22
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***Gain figures are approximate due to component variations and tolerances.**

****Small-value resistors for Rd should be measured and selected for actual value rather than rely on color code.**

PG-TIA Programable Termination Insensitive IF Amplifier

mostly DIY RF

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Drawn by T.F. Carney

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