BY DOUG DeMAW, W1FB

DOUG'S DESK

CONSTRUCTION PROJECTS, TECHNIQUES, AND THEORY

A Multi-Purpose Broadband Amplifier

Would you like to amplify the output of a signal generator for various circuit development and testing procedures? Low-power signal sources need to be amplified at times in order to obtain sufficient waveform deflection when using an oscilloscope. A broadband amplifier is useful for this purpose.

I use a surplus military URM-25 signal generator in my lab. Although it puts out a fairly robust signal, there are times when substantially greater output power is required. The thought occurred to me that the URM-25 could serve as the frequency control for a 1 watt broadband system that I could use for testing solid-state RF power amplifiers, antennas, and Transmatches. This would eliminate the need for taking my HF-band transceiver to the lab or into the field. This article describes the system I developed for boosting the power from a crystal oscillator, VFO, or signal generator. The amplifier system will produce up to 1 watt of output power from 1 MHz to 50 MHz It will, in fact, work satisfactorily down to approximately 200 kHz with reduced output power.

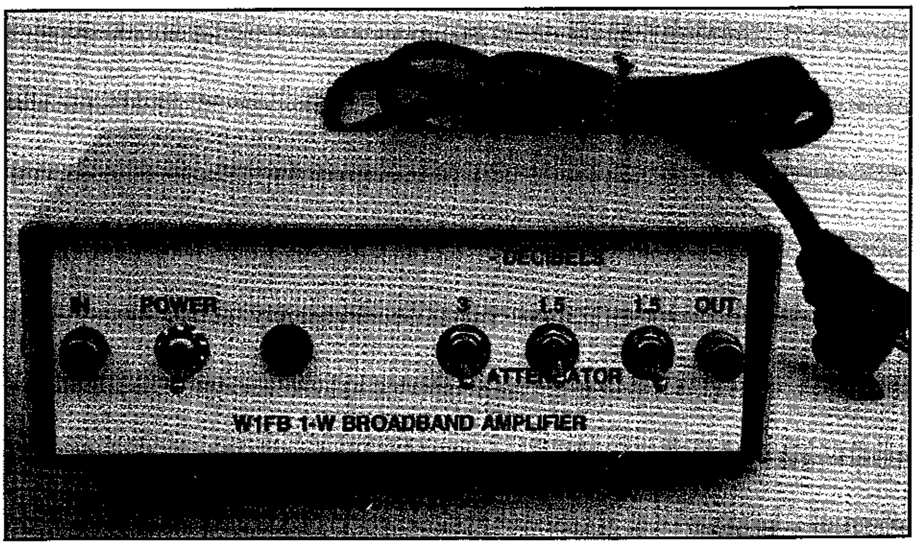

Photo A– The completed W1FB 1 watt broadband amplifier.

The Basic Amplifier

Fig. 1 shows the circuit I use as the core of the system. I developed this amplifier some years ago for inclusion in the second edition of *W1FB's QRP Notebook.*[1] The circuit uses three low-level, fed-back RF amplifiers to drive a 2N3866 power stage. All four stages operate in class A linear service. This contributes to relatively clean output waveforms without RF filtering if the input waveform is a sine wave. Overdriving the amplifier strip will, of course, cause distortion and square waves.

With the feedback arrangement shown in fig. 1 the input of each stage has a 50 ohm characteristic The outputs of Q1, Q2, Q3, and Q4 exhibit a 200 ohm impedance. This makes it convenient to use 4:1 broadband transformers for interstage and output coupling. The feedback constants were developed some years ago by my colleague, Wes Hayward, W7ZOI. He used 15 μH RF chokes rather than broadband transformers in the collector supply lines. Direct coupling with capacitors was employed between stages.

R13 may be eliminated by jumpering

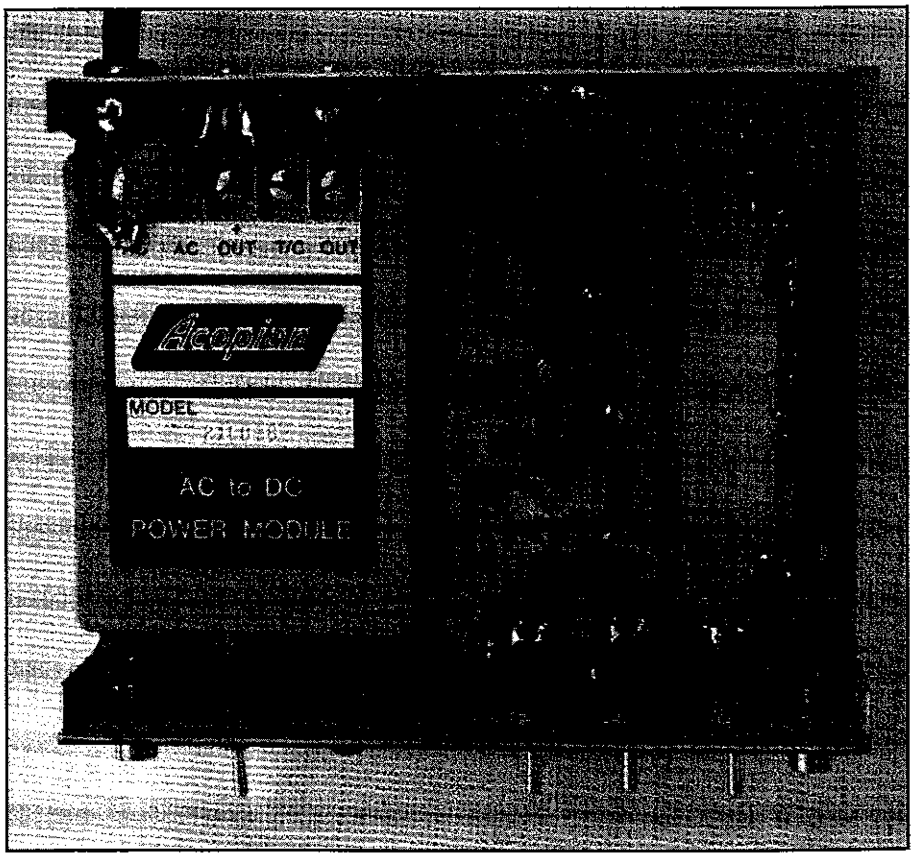

Photo B– Interior view of the assembled broadband amplifier. The power supply is at the left. At the far right, mounted vertically, is the fig. 3 amplifier. The fig. 1 amplifier strip is seen at the center of the photo.

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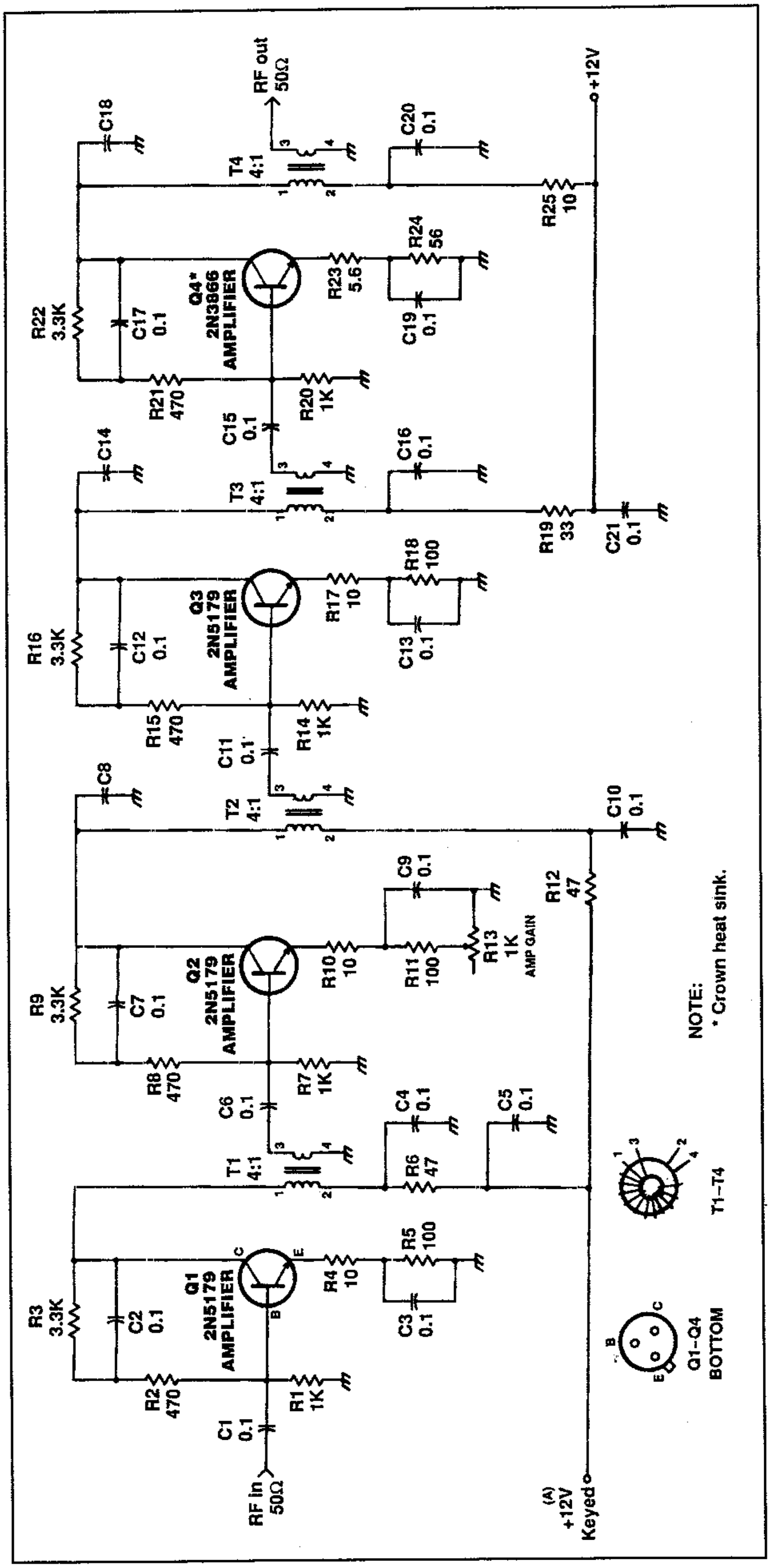


◄ *Fig. 1– Schematic diagram of the 0.5 watt, 40 dB broadband linear amplifier for use from 1 to 50 MHz. Capacitors are in µF (see text). Resistors are 1/4 watt carbon or carbon film. T1, T2, and T3 have 12 primary turns of No. 26 enam. wire on Amidon FT-37-43 (850 µi) toroid cores. Secondaries have 6 turns of No. 26 enam. wire. T4 has 12 turns of No. 24 enam. wire on an Amidon FT-50-43 toroid. Secondary has 6 turns of No. 24 enam. wire. R13, if used (see text), is a panel-mounted 1K ohm linear-taper carbon control. C8, C14, and C18 are not used in this application (see text).*

the PC-board pads to allow R11 to be grounded directly. I chose to do this so that the step attenuator in fig. 2 could be used at the input of the amplifier strip. Amplifier gain for the fig. 1 circuit is 40 dB or greater.

Q1, Q2, and Q3 are 2N5179 CATV transistors. These were chosen because of their high f_T rating. Devices such as the 2N2222A, 2N3904, and 2N4401 may be used in the first three stages, but gain and upper frequency performance may be degraded slightly. Q4 was chosen because of its relatively high f_T rating. Other TO-5 transistors with equivalent f_T and power ratings may be used at Q4. T1, T2, T3, and T4 are conventional broadband transformers. Slightly better efficiency can be obtained by using transmission-line transformers at these circuit points.

Q4 draws nearly 100 mA of current when biased as shown. This requires a heat sink for transistor protection. I used a husky Thermalloy No. 2215B heat sink on Q4, and on Q1 of fig. 3. This heat sink has two halves that screw together with the TO-5 device inside. They have become difficult to find. Two AAVID press-on finned heat sinks (Mouser part No. 532-323005B00[2]) may be used. A thin layer of epoxy cement is required between the two finned heat sinks to hold them together. Only one of these units will fit over a TO-5 transistor, so they need to be stacked as described.

Small "matchhead" type capacitors are best for all circuit points where 0.1 µF units are specified. They have small bodies and provide efficient bypassing and coupling to aid amplifier stability. Physically small disc ceramic capacitors may be used.

Capacitors C8, C14, and C18 are used only when it is desired to roll off the upper frequency response of the fig. 1 amplifier for special applications. The values chosen will depend upon the desired upper frequency roll off.

Attenuator

Fig. 2 shows the three-section attenuator I use ahead of the fig. 1 circuit. It is de-

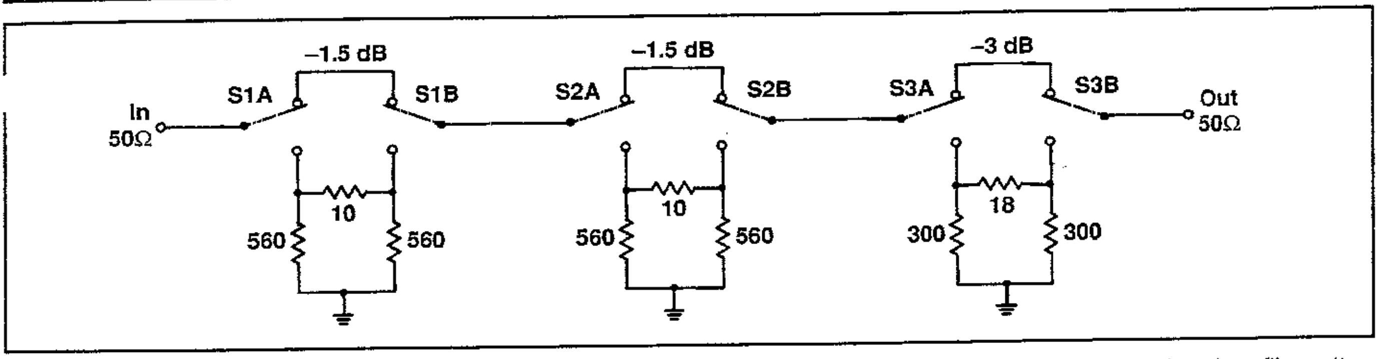


Fig. 2– A three-section step attenuator that uses miniature DPDT toggle switches. Resistors are 1/4 watt, 5% carbon film units.

signed for 50 ohms. S1 and S2 each provide 1.5 dB of attenuation. S3 offers an additional 3 dB of attenuation. With S1 and S2 engaged, the attenuation is 3 dB. When all three switches are engaged, the attenuation is 6 dB. The engagement of S1 and S3 results in 4.5 dB of attenuation. The attenuator is useful when the signal fed to the fig. 1 amplifier is too powerful to ow undistorted amplifier output. Miniature DPDT toggle switches are used. DPDT slide switches may be substituted.

The Final Amplifier

Q1 of fig. 3 boosts the amplified signal to 1 watt. Although Q4 of fig. 1 is capable of doing this, the four-stage strip would need to be driven rather hard, thereby causing waveform distortion. The add-on amplifier solves this problem. It operates class A and is biased for 90 mA of resting collector current.

A 2N3553 or 2SC799 transistor is suitable for use at Q1 of fig. 3. TO-5 transistors with equivalent characteristics may be substituted. A large heat sink is necessary, as mentioned earlier, because of the high value of resting collector current. Note that the input transformer is arranged for a 1:4 step up (50 to 200 ohms) to the base of Q1.

Output Filtering

Simple half-wave, 50 ohm LC, low-pass filters may be connected to at the amplifier output port when it is desired to minimize harmonic currents. For most applications and for casual testing purposes it is unnecessary to filter the RF output. Better filtering can be realized when using 5- or 7-element Butterworth low-pass or bandpass filters. Complete information about filter design may be found in *The ARRL Handbook*

Construction Notes

The PC board for the fig. 1 amplifier strip is available from a vendor.[3] A double-sided board is used to ensure circuit stability. The ground conductor on the etched side of the board should be bonded to the

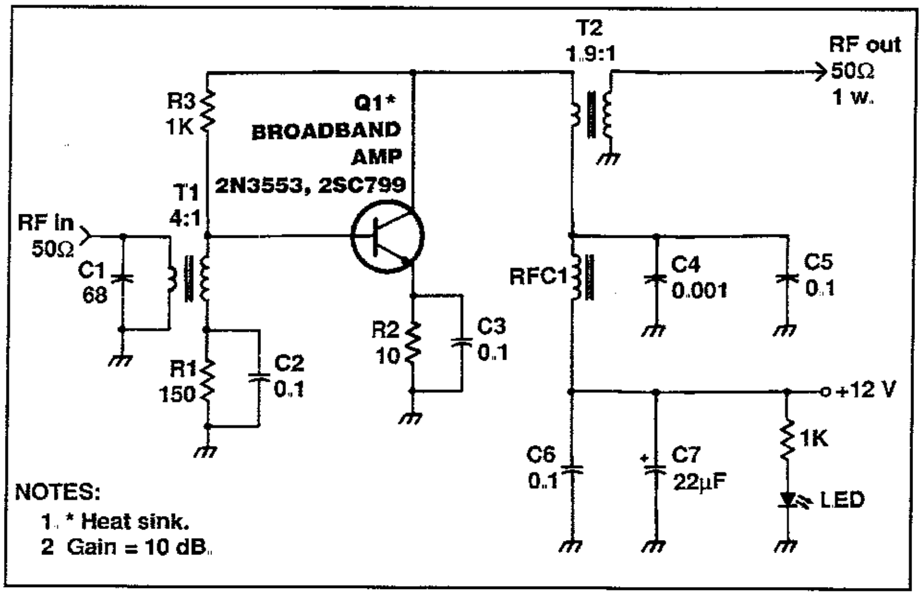


Fig. 3– An add-on linear amplifier for use with the fig. 1 circuit to produce 1 watt of output power. C1 is located on the etched side of the PC board. C7 is a 22 μF, 16 volt electrolytic or tantalum capacitor. Resistors are 1/4 watt carbon. RFC1 contains 12 turns of No. 26 enam. wire on an Amidon FT-37-43 toroid. T1 (see text) has 12 turns of No. 26 enamel wire on an Amidon FT-37-43 toroid. The primary has 6 turns of No. 26 enam. wire. T2 uses 8 turns of No. 26 enam. wire through an Amidon BN-43202 balun core or it can be wound on an Amidon FT-50-43 toroid. The secondary has 6 turns of No 26 enam. wire.

component-side ground plane at six or more points. Half-inch strips of solder wick may be bent into a U shape and soldered to both sides of the PC board along its outer perimeter. Connections that are made through the PC board, and soldered on each side, do not permit the free flow of RF energy unless the copper is removed around each hole.

Photo B shows a large module at the left. It is a surplus +20 volt regulated power supply that was obtained at a hamfest. A three-terminal regulator is bolted to the rear wall of the box to reduce the voltage to +12. The cabinet serves as a heat sink for the regulator. A +12 volt, 500 mA plug-in wall transformer may be used in place of the built-in power supply.

Scale etching patterns for the main and add-on amplifier boards are presented in fig. 4. Parts placement guides for both boards are given in fig. 5.

The RF connections between the amplifier boards, the attenuator, and the input and output jacks are made with miniature RG-174 coaxial line. The shield braid should be grounded at each end of each cable. RCA phono jacks are used for the input and output ports of this amplifier. BNC jacks would be a better choice for maintaining a 50 ohm characteristic at the upper frequency range of the unit.

This amplifier is housed in a 2"H × 5 1/2"W × 6"D metal box that once contained an A/B switch for selecting two computer printers. It cost $1.00 at an amateur radio fleamarket. A similar box can be made inexpensively from sections of PC board.

The panel face was created with my computer while using WordPerfect 6.0. A

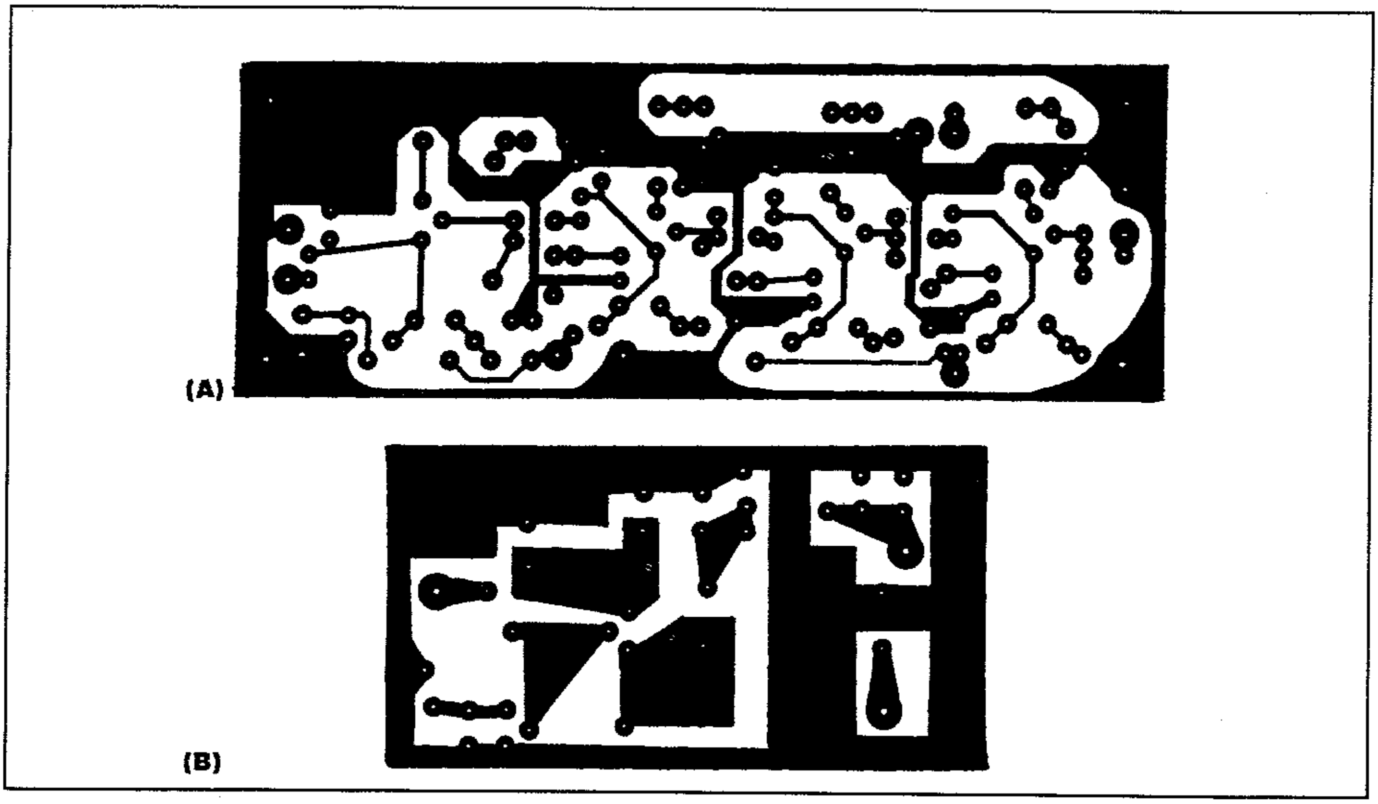
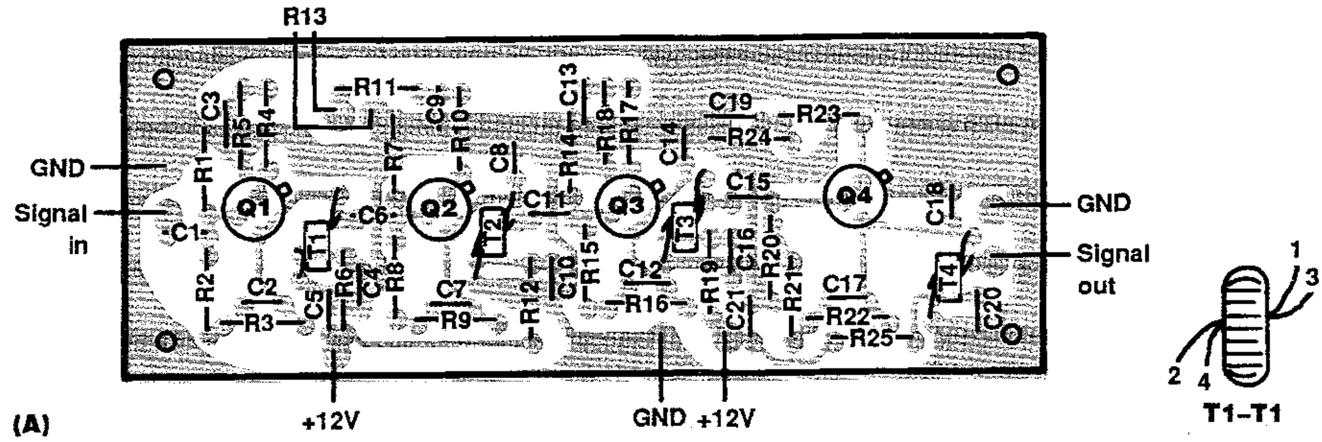
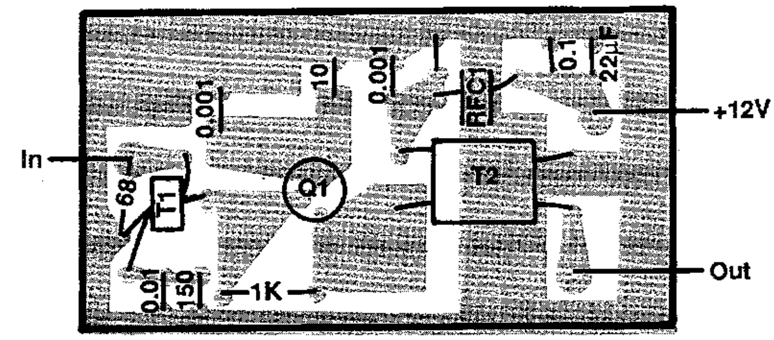


Fig. 4– Scale etching patterns for the two broadband amplifier PC boards. Board A is viewed from the etched side. Board B is seen from the component side to facilitate the use of Tech-200 or Press-N-Peel PnP Blue film, which requires a mirror image for the etching artwork.



(A)



(B)

Fig. 5– Parts-placement guides for both amplifier boards. These are x-ray views as seen from the component sides of the boards (not to scale).

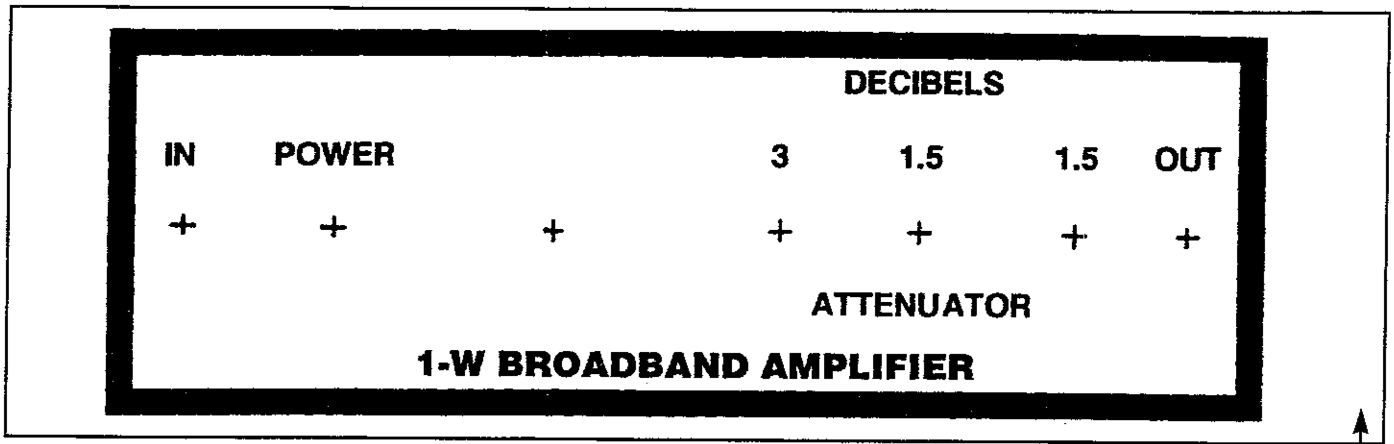


Fig 6– A scale layout for the front panel of the broadband amplifier (see text).

figure box with a thick border was made first. The labels were then printed in boldface Helve 1 font. The pattern was photocopied onto white posterboard, cut to size, and sprayed with two coats of clear lacquer. The finished piece was glued to the front of the box with contact cement. The word "Attenuator" in the title-page photo has been moved down from the switches. The corrected layout is presented in fig. 6.

Final Comments

The fig. 1 circuit could be used as part of an amateur HF transmitter. Since it is a broadband linear amplifier, it requires no band switching. It is suitable for AM, CW, and SSB applications. It can be used also as a 1/2 watt QRP transmitter if excited with a crystal oscillator or VFO. A low-pass filter should be used at the amplifier output if this is done. The combined fig. 1 and fig 2 circuits can be used in a like manner for 1 watt QRP operation. For CW operation it is necessary to key the +12 volt lines to Q1 and Q2 of fig. 1. QRPp operation can be realized by utilizing the attenuators at the amplifier input port.

Footnotes

1. Available from The ARRL, 225 Main Street, Newington, CT 06111, or ARRL book dealers.

2. Mouser Electronics, Inc., 2401 Hwy. 287 N., Mansfield, TX 76063-4827 (phone 1-800-346-6873 to order or for a catalog).

3. FAR Circuits, 18N640 Field Court, Dundee, IL 60118 (708-426-2431). Cost $3.50 plus $1.50 s&h.

4. Amidon Associates, Inc, 250 Briggs Ave, Costa Mesa, CA 92626 (phone 714-850-4660 to order or for a catalog).

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