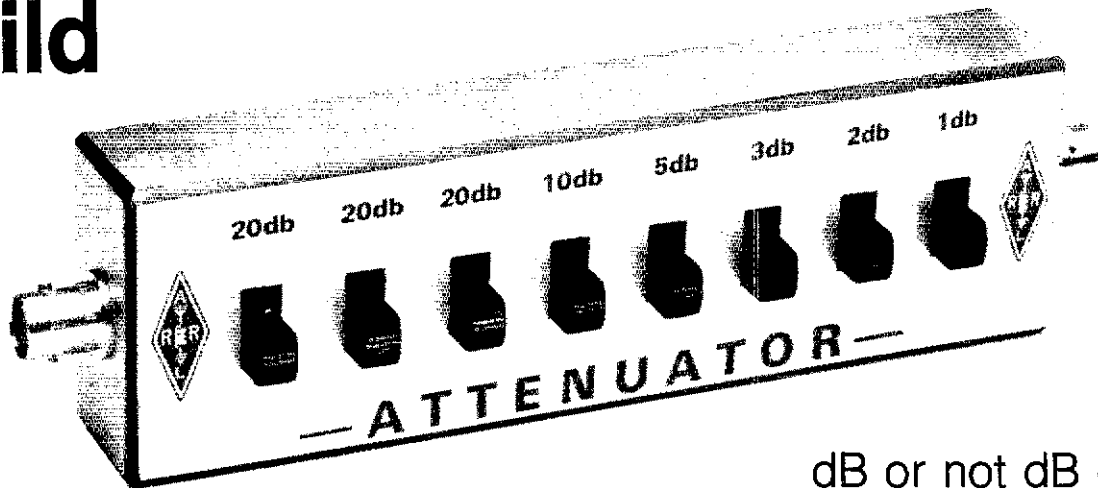


A Step Attenuator You Can Build



dB or not dB — you decide! This low-cost, high performance addition to your shack or workshop is a worthy project.

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There probably are a number of *Handbook* and *QST* readers who need a low-cost, 1-dB step attenuator for the workbench or shack. Purchasing a commercially made unit may be out of the question because of the expense involved. Certainly the concept of the attenuator is simple, the formulas and resistor values are at hand,¹ and the components are inexpensive and readily available. But layout of the unit and concern for the careful assembly involved (if good, reliable results are to be obtained) are, for many, enough to put the idea far out of mind.

Well, take heart! At last you can have that attenuator without agonizing over the parts layout! The mechanics have been worked out for you. If you have an aversion to cutting rectangular switch holes, a complete kit — with prepunched switch holes — may be purchased.² Doesn't that sound attractive?

Description

Fig. 1 is the schematic diagram of the attenuator. Eight pi-network resistive sections are employed; the attenuation is variable in 1-dB steps. A total attenuation

value of 81 dB may be had with all the sections switched in. The maximum attenuation of any single section is limited to 20 dB because leak-through would probably spoil the effect of higher attenuation sections and result in inaccuracy.

This is a low-power attenuator; it is not designed for use at power levels exceeding 1/4 watt. If for some reason the attenuator will be connected to a transceiver, a means of bypassing the unit during transmit periods must be devised.

Parts

All the switches are dpdt standard-size slide types. Stackpole S-5022CD03-0 units are used here. Other switch types may work as well, but have not been tested. The use of subminiature switches should be avoided. An earlier prototype using such switches was constructed, but the results obtained were inadequate, owing to poor isolation and mechanical switch construction.

Carbon-composition or film, 1/4-watt, 5%-tolerance resistors are used. The calculated resistance values and the actual values used are shown in Table 1. Ideally, the resistors should be selected using a reliable ohmmeter; this will ensure accuracy.

Double-sided pc board is used for the enclosure. Dimensions for the model described here are given in Fig. 2. The kit version of the attenuator has identifica-

tion lettering etched into the top surface (or front panel) of the unit. This adds a nice touch, and is a permanent means of labeling. Of course, rub-on transfers or Dymo tape labels could be used as well.

Female BNC single-hole, chassis-mount connectors are used at each end of the enclosure. These connectors are small and easy to mount, have excellent rf qualities, and provide a means of easily connecting and disconnecting the attenuator by a simple twist of the wrist. They are available from many suppliers, including Radio Shack.³ For the economy-minded builder, perhaps the best place to scrounge this type of connector is at flea markets. They are usually offered as "pull outs" and at attractive prices.

Construction

After all the box parts are cut to size and the necessary holes are made, scribe light lines to locate the inner partitions. Carefully tack-solder all partitions in position. A 40-watt pencil type of iron should provide sufficient heat. Dress any pc-board parts that do not fit squarely. Once everything is in proper position, run a solder bead all the way around the joints. Caution: Do not use excessive amounts of solder, as the switches must later be fit flat inside the sections. The top, sides, ends and partitions can be completed. Dress the outside of the box to suit your taste. For instance, you might wish to bevel the

¹Notes appear on page 13.

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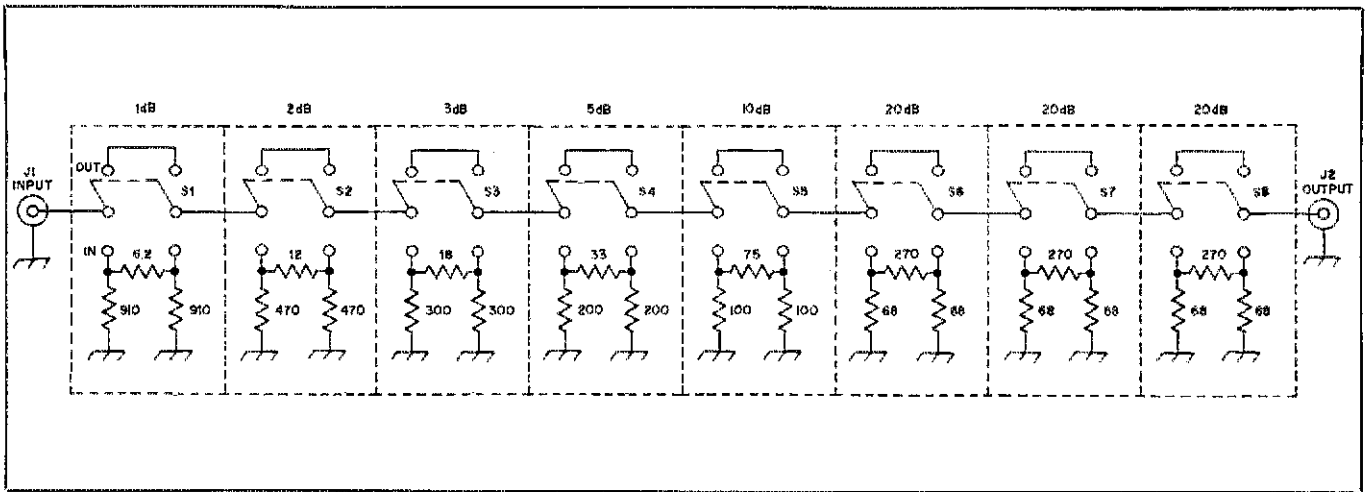


Fig. 1 — Schematic diagram of the attenuator. Resistors are 1/4-W, 5%-tolerance, carbon-composition or film types. Resistances are given in ohms.

Table 1
PI Network Attenuator Resistance Values for 52 Ohm Impedance

dB	Calculated Value		Standard Value Used	
	R1, R3	R2	R1, R3	R2
1	904	6	910	6.2
2	453	12	470	12
3	304	18	300	18
5	185	31	200	33
10	100	74	100	75
20	63	257	68	270

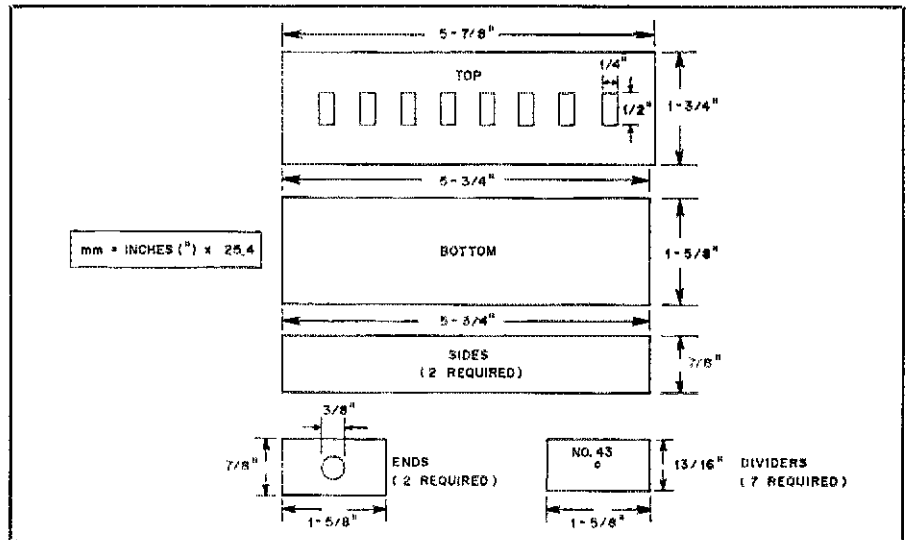
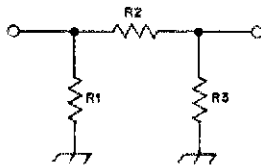


Fig. 2 — Mechanical dimensions of the attenuator enclosure.

box edges. Buff the copper with steel wool, add lettering, and finish off the work with a coat of clear lacquer or polyurethane varnish.

Using a little lacquer thinner or acetone (and a lot of caution), soak the switches to remove the grease that was put in during their manufacture. When dry, spray the inside of the switches lightly with a TV-tuner cleaner/lubricant. Using a sharp drill bit (about 3/16 inch will do),⁴ countersink the mounting holes on the attenuator side of the switch mounting plate. This ensures that the switches will fit flush against the top plate. At one end of each switch, bend the two lugs over and solder them together. Cut off the upper halves of the remaining switch lugs. (A look at Fig. 3 will help clarify these steps.)

Solder the horizontal members of the pi

sections between the appropriate switch lugs. Try to keep the lead lengths as short as possible, and do not overheat the resistors. Now solder the switches in place to the top section of the enclosure by flowing solder through the mounting holes and onto the circuit-board material. Be certain that you place the switches in their proper positions; correlate the resistor values with the degree of attenuation. Otherwise, you may wind up with the 1-dB step at the wrong end of the box — how embarrassing!

Once the switches are installed, thread a piece of no. 18 bare copper wire through the center lugs of all the switches, passing it through the holes in the partitions. Solder the wire at each switch terminal. Cut the wire between the poles of each individual switch, leaving the wire con-



Fig. 3 — Close-up of the switch detail.

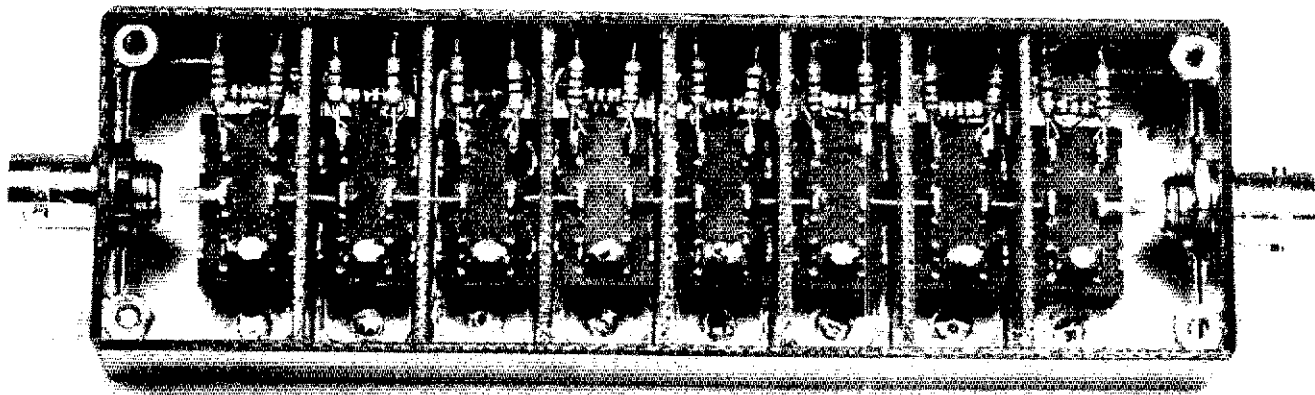


Fig. 4 — An inside view of the completed attenuator. Use of short, direct leads enhances the performance of the unit. Brass nuts soldered at each of the four corners allow machine screws to be used to secure the bottom cover. File one corner of each nut to permit a flat, two-sided fit within the enclosure.

necting one switch pole to that of the neighboring one on the other side of the partition, as shown in Fig. 4.

At each of the two end switch terminals, leave a wire length of approximately 1/8 inch. Install the BNC connectors, and solder the wire pieces to the connector center conductors.

Now install the resistors that comprise the vertical (grounded) legs of each pi section. Use short lead lengths. Remember that physical symmetry is conducive to good performance. Do not use excessive amounts of heat when soldering.

Solder a no. 4-40 brass nut at each inside corner of the enclosure. Recess the nuts approximately 1/16 inch from the bottom edge of the box to allow sufficient room for the bottom panel to fit flush. Secure the bottom panel with four no.

4-40, 1/4-inch machine screws and you're done!

The End Result

ARRL lab tests proved the attenuator to be a good performer. A Hewlett-Packard 8640B signal generator and a 8554B spectrum analyzer were used with a Tektronix 2701 step attenuator in the test setup. Results of the insertion-loss measurements, with no attenuation switched in, are shown in Table 2. The

homemade attenuator exhibited a maximum error of less than ± 1 dB through 450 MHz, the maximum error occurring in the 20-dB attenuator sections. Such a degree of accuracy should be more than adequate for most applications.

We hope you enjoy building this weekend project. You're sure to find a number of uses for it in the shack and in the workshop. It's a simple — and accurate — piece of test equipment you can build yourself!



Table 2

Attenuator Insertion Loss

Frequency (MHz)	29.7	50	144	220	450
Insertion loss (dB)	<0.1	<0.2	0.5	0.5	1.2

Notes

¹D. DeMaw, *ARRL Electronics Data Book* (Newington: ARRL, 1976), p. 32.

²A complete kit of parts is available from Circuit Board Specialists, P.O. Box 969, Pueblo, CO 81002. Price: \$15.

³Part no. 278-105.

⁴mm = in. \times 25.4.