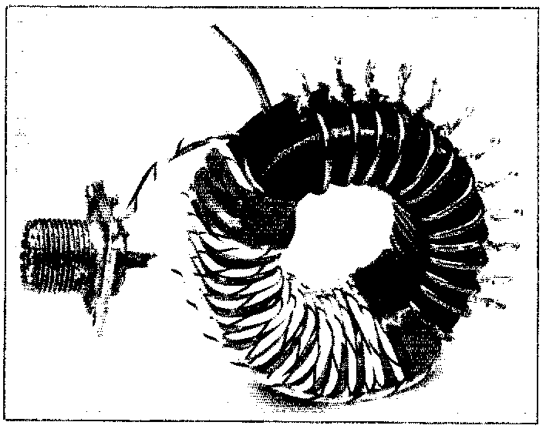
A "Multipedance" Broadband Transformer



A tapped broadband transformer helps solve problems in experimental work. Here's a toroidal type that covers a wide range of impedance transformations.

By Doug DeMaw,* W1FB

Is a multi-impedance transformer a scientific wonder? Shucks, no! The concept is as old as electronics, but is often overlooked by amateur experimenters. Being an inveterate experimenter myself, I find it useful to have as many "fudging" tools in the workshop as possible. Certainly, a broadband switchable-impedance transformer qualifies as an important piece of test apparatus. Furthermore, this type of device can be used for determining the necessary number of turns for a fixed-ratio transformer that will be put to permanent use in a circuit.

Applications

A variable-impedance transformer can be used to approximate the value of an unknown impedance within its matching range. It is necessary only to know one of the two impedances with which we are dealing. For antenna work we can generally assume that the feed line to the transmitter or receiver is 50 ohms, although in some cases it may be 75 ohms. This becomes our known factor, and a fixed number of turns are laid on the transformer core to comprise the 50- or 75-ohm winding. Although an rf noise bridge or a sophisticated rf impedance bridge can be used to measure unknown impedances, they require associated items of test equipment and ac or dc power to operate them. The variable-impedance transformer needs nothing other than a VSWR indicator, thereby making it more convenient for field use.

I find my greatest application for the transformer in experimental work with antennas. Many times when a new idea is being tried, the impedance of the antenna feed point is unknown. The variable-impedance transformer provides a match to 50-ohm coaxial line and gives me a reasonable idea of what the feed impedance is. I can then leave the transformer in the line and test the antenna under transmitting and receiving conditions. Later, if I consider the antenna worth using over a longer period of time, the transformer can be replaced with a suitable matching network, or I can wind a fixed-ratio transformer and install it at the feed point. Practically, the gadget is a time-saver.

Another application for the transformer would be between the exciter and a linear amplifier, if the amplifier did not present a suitable impedance to the exciter. The correct transformer tap point would be selected to provide a low VSWR.

Construction Notes

I elected to wind a transformer that would handle the output from a 1-kW transmitter. Therefore, if I wanted to leave the unit in the line for extended on-the-air testing, it would accommodate the full power from my station without arcing or saturating. Owing to the high flux densities of powdered-iron cores over ferrite ones (per unit cross-sectional area), the former was chosen. The circuit is shown in Fig. 1. The core is an Amidon (Micrometals Corp.) jumbo T-225A-2, which is roughly equivalent to a pair of T-200 cores stacked one on top of the other.

The fixed-value winding has an X_L of 200, four times (recommended) the 50-ohm level at which it will be used. If the lowest operating frequency is to be 3.5 MHz, the required inductance of the winding will be 9 μH (17 μH for use at 1.8 MHz). The A_L factor of this toroid core is 275, which requires a winding of approximately 18 turns for an X_L of 200 ohms. This is determined by

$$\text{turns} = 100\sqrt{L/A_L}$$

where A_L is the manufacturer's index, and L is in μH. Hence, for use at 1.8 MHz, the fixed winding would require 25 turns. The tapped winding (secondary) would have to be increased accordingly to provide the range of impedances represented in Table 1.

The blank core should be wrapped with a layer of 3M brand glass epoxy tape or something of equivalent dielectric strength. This will help to prevent arc-over and abrasion of the windings. The tapped winding is laid on the core first. My transformer (see photograph) has only 12 taps, and was set up to give transformations upward from 50 ohms. However, each turn can be tapped to obtain a range from less than 50 ohms to greater than 50 ohms. Table 1 contains data for a transformer with 27 taps. The enamel insulation is scraped from the winding at each tap point. Then, a short piece of heavy bus wire is formed into a loop and soldered to the winding at each tap point.

The fixed-turn winding of the transformer is wound last. The turns lie between the turns of the larger winding. I used some Teflon-insulated no. 18 wire I

*QST Senior Technical Editor

had on hand. This is recommended to provide a high degree of insulation between the two windings. Alternatively, one might use Teflon sleeving over enameled copper wire, or glass epoxy tape could be wound over the larger winding (beneath the fixed winding) to isolate the

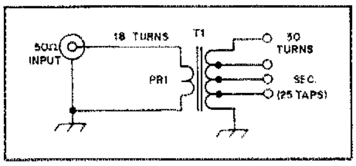


Fig. 1 — Schematic diagram of the variable-impedance transformer.

Table 1

Approximate Load Resistance and Transformation Ratio of the Broadband Transformer

Turn No.	*Impedance Ratio (approx.)*	*Load Resistance (Ω) (approx.)*
5	13:1	3.85
6	9:1	5.55
7	6.6:1	7.57
8	5:1	9.87
9	4:1	12.50
10	3:1	15.43
11	2.5:1	18.80
12	2.2:1	22.22
13	1.9:1	26.25
14	1.6:1	30.51
15	1.4:1	34.72
16	1.2:1	39.85
17	1.1:1	45.35
18	1:1	50.00
19	1.1:1	55.70
20	1.2:1	61.72
21	1.4:1	68.00
22	1.5:1	74.70
23	1.6:1	81.63
24	1.8:1	88.88
25	1.9:1	96.45
26	2:1	104.32
27	2.2:1	112.50
28	2.4:1	120.98
29	2.6:1	130.00
30	2.8:1	139.00

Numbers have been rounded off in some instances. Values are based on a fixed impedance of 50 ohms at the transformer input. Higher step-up ratios can be had by increasing the number of turns on the transformer secondary. This may be necessary for obtaining a matched condition between some exciters and the input of a power amplifier.

windings. A durable version of this transformer could be had by encapsulating the completed transformer in casting resin of good dielectric quality. I have had good results with the resin sold by Tandy Corp. The terminals of the transformer would need to be brought out of the mold for access later on. A coating of silicone grease will prevent the resin from adhering to the terminals.

Application

When one is dealing with low impedances, it is important to keep the leads to the transformer taps as short as possible. The slightest amount of lead length will introduce reactances that can confuse the results of measurements. This means that a switched version of the transformer should be laid out carefully to avoid unwanted stray inductance or capacitance.

The most accurate test results will be had if the fixed-value winding (50 ohms) is terminated in a known 50-ohm resistance. A 6-dB pad can be built easily for inclusion in the line to the transformer primary. It must be capable of accommodating the power of the signal source. A pad made with 2-watt resistors would be entirely suitable for use with a 2-watt transmitter during antenna-matching experiments. A pad of this type is shown in Fig. 2, which contains a block diagram of a typical test setup for using the transformer.

Having a multi-impedance transformer in your workshop could prove useful for a variety of test applications. Try one — you might like it!

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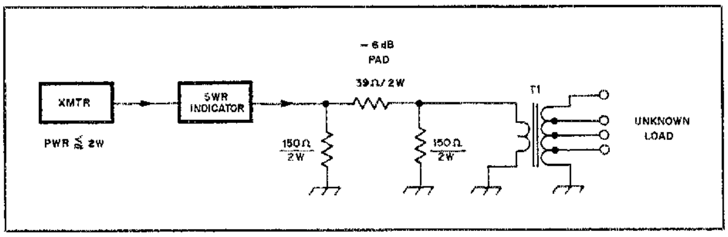


Fig. 2 — Hybrid diagram showing a typical arrangement for using the transformer discussed in the text. Values for the resistors in the 6-dB pad are given to the nearest standard values. Noninductive carbon resistors should be used, with the pigtails and connecting leads as short as possible.

Strays

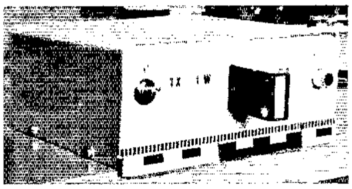
QRP, DL STYLE

☐ Many times we have heard about the masterful work done by the elves in the Black Forest, and the photographic example seen in this Stray might easily suggest that the equipment was built by those famous gnomes in Germany. Not so, but the equipment was built in DL-land, by Adolf Vogel, DL3SZ.

Building one's own radio gear is a popular pastime abroad, perhaps more so than in the USA. Adolf says that most of his transmitters have been homemade for years, but he couldn't resist constructing the "Little Joe" universal QRP rig from August 1981 *QST* ("Experimenting for the Beginner").

Adolf uses the QRP transmitter on 40 meters along with three FT-243 style crystals. The package size is approximately 12 × 12 × 45 mm. With his micro power he has worked the USA, Europe and other DL stations. He worked N3EA and received an RST 339 report. Adolf says that N3EA was a "Big Joe" station, running a kW into a 3-element Yagi!

Adolf says further that the *QST* article was very helpful for newcomers, and the project will be discussed at the local DARC meetings. Keep up the good work, Adolf. And, just think what your "Little Joe" could do if you had a 3-element, 40-meter Yagi to use with it! — *Doug DeMaw, W1FB*



This rig may not be the work of elves, but, judging from the excellent results Adolf Vogel, DL3SZ, gets with his homemade 40-meter QRP transmitter, the unit may indeed be charmed. *(photo courtesy DL3SZ)*

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Hints and Kinks

Conducted By Larry D. Wolfgang,* WA3VIL

"MULTIPEDANCE" BROADBAND AUTOTRANSFORMER

□ After reading Doug DeMaw's article on a multipedance broadband transformer, I decided this was a piece of equipment I needed.[1] I had plenty of no. 24 wire to wind the transformer, and did not want to buy heavier gauge wire for the project. Some method of providing higher current-carrying capacity was needed, at least for the lower-impedance taps.

Fig. 1 shows my solution. I used six parallel strands of wire to start, then decreased the number of strands as the impedance ratio increased. First, I cut six pieces of no. 24 wire to different lengths, as shown in Fig. 1A. The shortest pieces were long enough to make five turns on the T225A-2 toroidal core, spaced to fill the entire periphery. The fifth-turn tap point was placed alongside the starting point, as shown in Fig. 1B. All six wires connect to the tap, and three of them continue to the next tap. I kept the wires in a flat bundle, with each succeeding five-turn winding adjacent to the last.

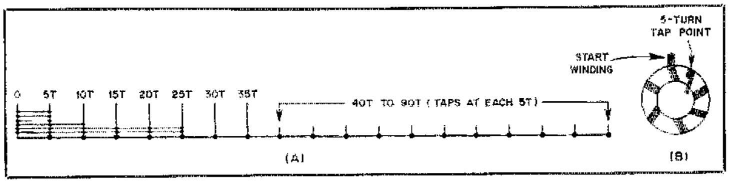

Fig. 1 — The wire layout used by WØOD for his multipedance autotransformer is shown at A. B shows how the first set of five turns was positioned on the core.

To insulate the tap points, I placed the tapped turn in a fold in a piece of 10-mil-thick fish paper (used to insulate transformer windings). Turns 25 through 90 have only one strand of wire, with taps placed every fifth turn. Fig. 2 shows my completed autotransformer. There was just enough room on the core for five turns of fiberglass string between the starting and ending turns of the entire winding.

To finish the project, I sewed the folded ends of fish paper together and coated the entire unit with casting resin, as suggested by DeMaw. You could also place a primary winding over this one and use it as a conventional broadband transformer. — *Frank Thompson, WØOD, Baudette, Minnesota*

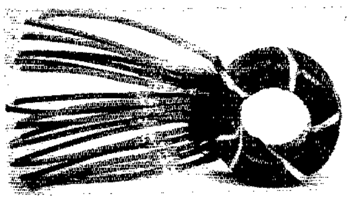

Fig. 2 — Photo of the completed transformer. Note the insulating paper between tap points.

AUXILIARY CRYSTAL SOCKET FOR THE DRAKE T-4X

□ I recently purchased the crystals needed to operate my Drake T-4X and R-4A on 30 meters. Installing the new crystal in my receiver was simple because there are 10 auxiliary sockets, readily accessible from the rear of the chassis. The transmitter has only four auxiliary sockets, located so that the top cover must be removed each time a crystal is changed. I had already filled the four sockets with crystals covering the 160- and 10-meter bands. (Each crystal provides coverage of a 500-kHz segment.)

My solution to this problem was to install a socket on the right side of the T-4X chassis, so crystals can be changed without removing the cover. Installation of the new socket was facilitated by the fact that my rig had the required holes already drilled in the chassis. The older T-4 had a socket installed on the side, and apparently the same chassis was used for at least some of the T-4Xs. Later versions may not have the holes drilled, but it should not be too difficult to locate a suitable mounting position and drill the holes.

I moved the wire to the crystal-selector-switch from socket number four to the front-panel crystal switch. I soldered this wire to one terminal of the new socket and used a short piece of hookup wire to connect the other terminal to the common side of the original sockets. Now the crystal-selector switch selects the new socket when it is in position number four. Changing crystals is now an easy task.

The owner's manuals specify the crystal frequencies for a desired operating range. A 20.8-MHz crystal is required to transmit on the 30-meter band. It is necessary to add 9.7 MHz to the dial reading to determine your operating frequency. This poses no problem because the 21.1-MHz receive crystal provides direct dial readings from 10.0 to 10.5 MHz. I calibrate my receiver to WWV and spot the desired transmit frequency on my receiver. — *Donald Stickle, K2OX, Lake Hopatcong, New Jersey*

JOHNSON VIKING II ON 10 MHz

□ When the FCC announced the opening of the 10-MHz band for amateur operations, I realized that my four-year-old Kenwood TS-520S would not operate in this new band. I began to think about the possibility of using my old Hammarlund HQ-140X receiver and Johnson Viking II transmitter. I had kept both in operating condition, and even used them for an occasional QSO.

The HQ-140X tunes continuously from 0.54 to 30 MHz, and has a bandspread tuning dial with scales calibrated for the 80, 40, 20, 15 and 10-meter bands. I prepared a frequency chart so that I would know the actual frequency for any given bandspread dial reading. With the main tuning dial set on 10.25 MHz, 10.10 to 10.15 MHz lies between the 7.00- and 7.10-MHz markings on the bandspread dial.

According to the Viking II instruction manual, 10-MHz output can be obtained by using a 5-MHz crystal and setting the band switch to 20 meters. The oscillator, buffer and final stages are all tuned to 10 MHz. Since I wanted to use the Model 122 VFO, I would have to modify it to provide a 5.05- to 5.075-MHz output. This VFO has three ranges: 1.75 to 2.00 MHz, 7.00 to 7.425 MHz and 6.7 to 6.85 MHz. I do not use the last range, so that is the one I modified. A study of the wiring diagram indicated that the only change required was to add some additional capacitance across C56. I found a couple of air-dielectric padder capacitors that would provide 135 pF when wired in parallel. These were installed, and I found the VFO to cover the range 5.05 to 5.075 MHz with dial readings from 7.00 to 7.13 MHz on the original scale.

To ensure good keying characteristics, the Viking and VFO should have the Johnson Time Sequence Keyer modification. Otherwise, you may have a signal with chirps and clicks. — *Walt Bollinger, AF3V, Pittsburgh, Pennsylvania*

DETUNING SLEEVE FOR THE RINGO RANGER

□ One problem experienced by many users of the original Cushcraft Ringo Ranger 2-meter antenna is the lack of any method to decouple the antenna from the transmission line. This results in the flow of antenna currents on the outside of the coaxial-cable feed line. Owners of the Ringo Ranger II report greatly improved operation because of the decoupling system incorporated with that antenna. Not wanting to replace my antenna, I found a way to retrofit a decoupling system to it.

The operating principle of my system is found in *The ARRL Antenna Book*.[2] A 1/4-λ sleeve, open at the top and shorted to the coaxial-cable shield at the bottom, is placed over the feed line. The impedance at the top of the sleeve is high, and very little current can flow on the outside of the tubing. The detuning sleeve acts as an rf choke, isolating the antenna from the rest of the feed line.

Fig. 3 shows the construction details. A 1/4-λ section of 2-inch aluminum tubing serves as the detuning sleeve.[3] I fabricated a brass bushing for the base of the sleeve. This bushing is made to fit inside the aluminum tubing, and is machined to allow a long double-female coupling (the type with threads over the entire length) to thread through the center. The coaxial cable attaches to this coupling on each side of the bushing, feeding the signal through to the antenna. A Plexiglas® spacer in the top of the sleeve keeps the cable centered. Use a hacksaw to slit the bottom of the tubing, and secure it to the bushing with a hose clamp. — *Rudy Knauck, W7FGQ, Seattle, Washington*

[1] D. DeMaw, "A 'Multipedance' Broadband Transformer," *QST*, Aug. 1982, p. 39.

*Assistant Technical Editor

[2] *The ARRL Antenna Book* (Newington: American Radio Relay League, 1982), p. 5-8.

[3] mm = in. × 25.4.