

• *Beginner and Novice*

The Ultimate Transmatch

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SOME amateurs assume that because they use coaxial feed lines they don't need a Transmatch. This can be an incorrect assumption, and we'll try to show why in this article.

The Harmonic Problem

A large number of hams have found to their sorrow that the harmonic suppression in their transmitters may leave much to be desired. The FCC issues many citations to Novices each year for second-harmonic violations.

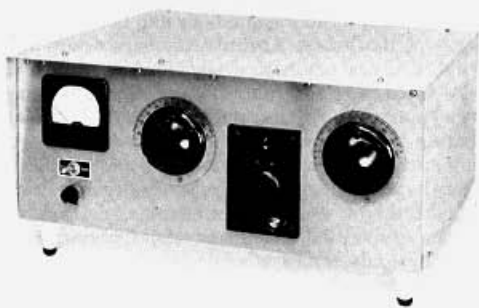
A typical Novice station might consist of a transmitter and receiver, with direct coax feed to a trap dipole or vertical antenna. In a properly adjusted transmitter of typical design, often there is insufficient attenuation of the second-harmonic energy. This can mean that the second harmonic of the signal can reach the antenna and be radiated. What is required to eliminate or reduce the second harmonic, and higher-order harmonics, is more selectivity between the transmitter and the antenna. A Transmatch is an excellent aid in taking care of the harmonic problem.

The 50-Ohm-Load Problem

Still another reason for using a Transmatch is because nearly all manufacturers of transmitters design their rigs to work into a nonreactive, 50-ohm load. Any departure from this load impedance causes difficulty in tuning and loading the final-amplifier stage. It might be pertinent to point out that simply because a ham uses 50-ohm coax, it doesn't necessarily follow that he will have a 50-ohm load. Basically, in order to have a 50-ohm load when using 50-ohm coax, the coax must be terminated in a 50-ohm resistive impedance. In other words, the antenna impedance must be 50 ohms.

*Novice Editor

Most hams would like to own a Transmatch that could cover 80 through 10 meters, and work during coax-to-coax or balanced-lines conditions. Here is just such a unit. It will match the proverbial bedsprings, or any other nonresonant or resonant antenna, and without plug-in coils or band switching — even on 160 meters.



The kW version of the Ultimate Transmatch. The knobs and dial counter are standard Millen components. The front bottom of the cabinet is tilted by means of two 2-inch standoff insulators used as feet.

When the terminating impedance of the coaxial cable is other than 50 ohms, then the transmitter will be "looking" at some value other than 50 ohms. It is practically impossible to design a single antenna that will have an impedance of 50 ohms on all of the bands a ham might want to use. One answer to the problem is to employ a device that will "match" the unknown load to the 50-ohm impedance required by the transmitter. One such circuit or device is a Transmatch. A Transmatch is simply an adjustable rf transformer that can match the unknown load presented by the transmitter end of the feed line to the required 50-ohm transmitter impedance.

Receiver Cross-Modulation

In addition to taking care of the problems just outlined, a Transmatch can serve another very useful function at the receiver. Some receivers are susceptible to what is known as cross-modulation, or front-end overloading, by strong nearby radio stations. This is particularly true on 160 or 80 meters when a broadcast station is nearby. The broadcast station overloads the front end of the communications receiver, causing "birdies" and other unwanted responses across the band. A Transmatch will eliminate or greatly reduce this problem in nearly all instances.

The Ultimate Transmatch

We shall describe two Transmatches — one for the Novice power limit, and another for the legal 2-kW PEP limit. We have found that many amateurs on the verge of taking their General, or higher-class licenses, would rather invest initially in a unit that will take care of all of their future needs.

Some years ago,¹ a Transmatch was described that was designed for use with coaxial feed lines. It was called "the 50-Ohm Transmatch." This particular unit handles mismatches on the order of 4 to 1. It can transform a load of about 200 ohms, or 12 ohms, to a 50-ohm impedance. The circuit of the Transmatch described in this article, Fig. 1, is similar, but with two notable exceptions. In place of a tapped, switched inductor, a variable inductor is used, the idea for this innovation coming from Al LaPlaca, K2DDK. The variable inductor is a coil wound on an insulated form that can be rotated so that a movable wheel shorts out and grounds the unused portion of the coil. Using the roller inductor, along with the two variable capacitors, the Transmatch provides an almost unlimited matching range, plus the feature of 80- through 10-meter coverage without band switching. With the values shown in the units, it is even possible to add one fixed capacitor to obtain 160-meter coverage.

The other exception is the use of a 1-to-4 (unbalanced-to-balanced) balun transformer on the output side of the Transmatch, which permits the use of balanced feed lines. This means that a Transmatch can cover 160 through 10 meters (including the MARS frequencies). It can be used to match into coaxial lines, random-length end-fed wires, or balanced feeders, and can do the job without using switches.

The two units shown in the photographs underwent extensive tests as to efficiency, power-handling capabilities, and methods of adjustment. In coax-to-coax tests, power inputs and outputs through the Transmatch were carefully measured while using Bird ThruLine wattmeters and an adjustable dummy load. As carefully as could be measured, and with indicated mismatches of up to 15 to 1, the Transmatches showed an efficiency of over 95 percent. This small loss in efficiency more than outweighs the usefulness of the device.

Many tests were made with the high-power version to check heating of the roller inductor and the balun. Under a key-down condition, with 1200

¹ "The 50-Ohmer Transmatch," July 1961 QST.

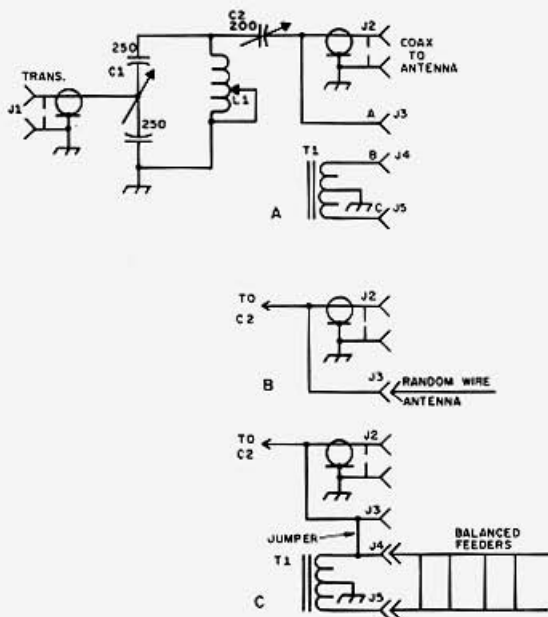


Fig. 1 — Circuit diagram of the Ultimate Transmatch.

C1 — Split-stator variable, 250 pF per section; see text. For low-power version, E.F. Johnson type 16250; or similar, for high-power version, Millen type 16250, or similar.

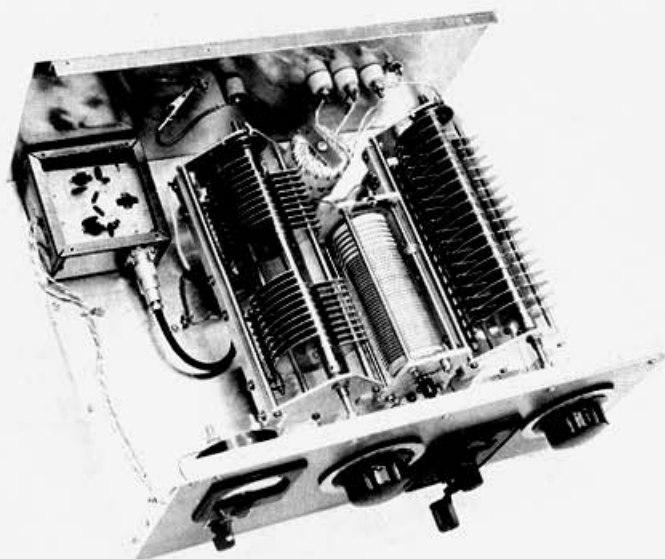
C2 — 200-pF variable, for low power, E.F. Johnson type 167-12 or similar, for high power, Millen type 16520, .171-inch spacing, 16520A, .077-inch spacing, or similar.

J1, J2 — Coax chassis fitting, type SO-239.

J3, J4, J5 — Feed through insulators.

L1 — Roller inductor, see text. If 160-meter operation is desired, total inductance should be 28 uH, E.F. Johnson type 229-203; otherwise, 18 uH is adequate, E.F. Johnson type 229-202.

T1 — 1-to-4 balun; see text for details, cores are Amidon type T-200-2.



At the rear of the roller inductor is the 1-to-4 balun. The balun is set on top of a standoff insulator and is held in place with a piece of insulated board and a screw. The fixed capacitor mounted on the rear wall is the 160-meter unit. Both the variable capacitors and inductor are mounted on 1-inch high standoff insulators.

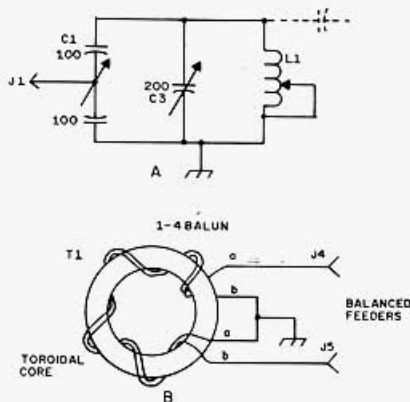


Fig. 2 — At A, details for padding a low-value variable for C1 by installing a second variable, C3, the same value as the low-power unit C2. In the case of tuning 160 meters, using an inductor of 28 μH for L1, and 250 pF per section for C1, a fixed capacitor of 100 pF can be used at C3, Centralab type 850-100N, or similar. At B, details for connecting the bifilar windings on the balun are given. The ungrounded leads a and b are connected to J3 and J4, the feed through insulator terminals.

watts indicated power through the Transmatch, the transmitter was kept on for 15-minute periods. In one test, the measured rf current through the coil was in excess of 15 amperes. The roller inductor used in the unit is rated at 5 amperes, so this was considered a fairly rugged test. The coil did get warm, but not enough to be a cause for concern. Keep in mind that in regular amateur work, 15 minutes would be a ridiculous figure for continuous operation.² In cw and ssb operation, the duty cycle would be in terms of seconds or even fractions of seconds.

The balun used for balanced operation in the high-power unit was made up from three Amidon 1-kW cores — more about that in a moment.

²Ed. Note: However, teletype operation would be continuous (to say nothing of those long-winded a-m operators!).

WIKLK, on our staff, has made extensive checks on a single-core balun, for use in an upcoming Transmatch article. It was found that a single core would easily handle 500 watts of power during severe mismatch conditions. Failure of the core, most likely due to saturation and heating, took place at the 700-watt level. In the high-power Transmatch shown here, three cores are used. They are wrapped with glass insulating tape and then wound with Teflon covered wire. Wire insulation material can be important because of the extremely high rf voltages that may be developed with some load conditions. In many tests of long duration, using up to 1400-watts output into a dummy load, it was almost impossible to detect any heating of the balun.

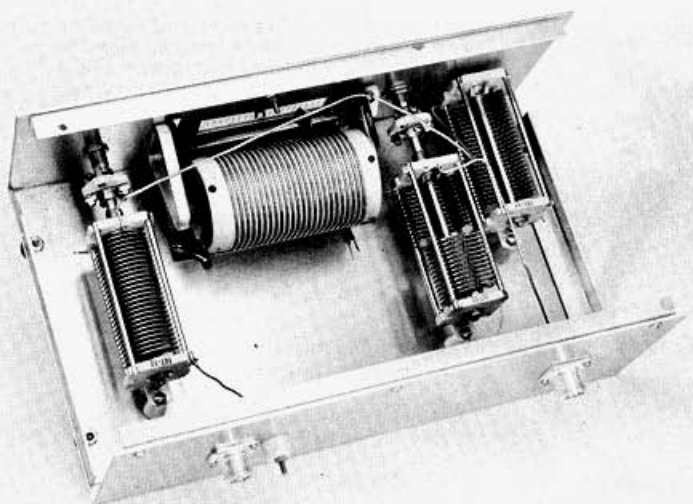
Bear in mind that the balun would only be needed if balanced-line operation were desired. For coax-to-coax or random-wire feed, the balun can be omitted.

Construction Information

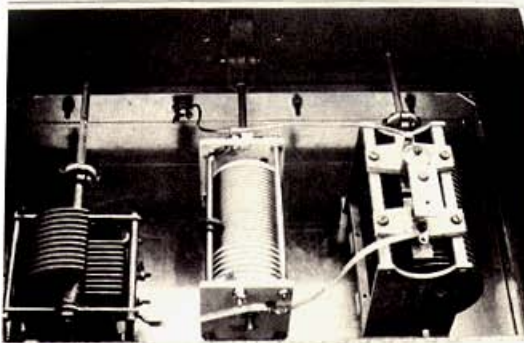
A look at Fig. 1, at A, will show that the circuit is a very simple one. The input line from the transmitter is connected to the rotor of C1, a split-stator capacitor. This means that the capacitor must be insulated from the chassis, using standoff pillars, and from the panel by means of an insulated shaft coupler. The same is true for C2. In the kW unit shown, we have installed a power bridge. Construction details are not given here for the bridge because such a unit was described in detail in a recent issue of *QST*³ Also, many amateurs already have a Monimatch⁴ or some other type of SWR indicator. An SWR bridge or matching indicator is needed in the 50-ohm line between the rig and the Transmatch to show when the Transmatch is correctly adjusted.

Layout of the components should follow the same arrangement shown in the photographs, C1 at the input side, the roller inductor at the center, and then C2. If a balun is going to be installed, allow enough room behind the roller coil for mounting the balun. In the two units shown, the

³"In-Line RF Power Metering," Dec. 1969 *QST*.
⁴*Understanding Amateur Radio*, page 209.



This is the low-power Transmatch. The salvaged roller inductor is mounted on the front panel, making use of the original mounting brackets.



Here is an inside view of the Ultimate Transmatch as made by Al LaPlaca, K2DDK, who came up the idea of using the roller inductor. The installation on top the right-hand capacitor is the home made 160-meter switch and fixed loading capacitor.

cabinets are made up from aluminum sheet stock. If desired, a commercial chassis and cabinet can be used. In the low-power Transmatch, leave at least 1/2-inch spacing between the edges of the capacitors and any part of the chassis and cabinet. Allow 1-inch spacing in the kW unit.

Balun Details

For the low-power Transmatch, a single toroid core will more than handle the power. Incidentally, the low-power unit was tested under all conditions at about 100 watts through the Transmatch. The power-handling capabilities of the units depend primarily on the plate spacing used for C1 and C2, aside from the balun requirements mentioned earlier. At the 100-watt level, a plate spacing of .03 inch is adequate. A .045-inch spacing should handle 500 watts. In the kW unit shown, C1 has a .077-inch spacing. While a .077-inch spacing capacitor wasn't tried at C2, such plate spacing should work at the kW level.

In making the low-power balun, wind two layers of Scotch brand electrical tape around the core before putting on the wire. This will provide extra insulation, and will protect the edges of the wire to prevent the enamel from being scraped away. Fig. 2, at B, shows a sketch of the winding. The winding consists of 10 bifilar turns of No. 14 Formvar insulated wire. Connected as shown, this will provide a 1-to-4, unbalanced-to-balanced configuration.

Three cores are needed in the high-power balun. Each core is covered with two layers of 3-M type 27 glass-cloth insulating tape. Next, the three cores are stacked, then covered with two more layers of the tape. The winding consists of 15 bifilar turns of either No. 12 or 14 insulated wire. The insulation should have a minimum rating of 1000 volts and can be either Teflon or vinyl-nylon (or any other suitable covering with a minimum voltage rating of 1000 volts).

In making the low-power Transmatch, a roller coil from a junked 40-meter ARC-5 transmitter was salvaged and installed in the unit. Many

amateurs know other hams who have old ARC-5 gear, and these units are a good source for the roller coils. However, some hams may not be able to locate used ARC-5 transmitters, so we have included some information on sources of surplus and new roller inductors. There may be surplus outlets in your area worth investigating. Look for a roller coil that has a minimum inductance of 10 μ H when used with C1 having a value of 200 pF per section. Such a combination will cover a low frequency of 3500 kHz. In the unit shown, in addition to the ARC-5 roller, we used a value of 100 pF per section for C1 and padded that capacitor with another of 200 pF (single section) in order to provide the required coverage. This added capacitor is shown in Fig. 2 at A. By using this approach, it is sometimes easier to save money then when trying to locate a 200-pF-per-section variable for C1. (Incidentally, you can use a variable at C1 of more than 200 pF per section for good coverage with the roller inductance specified above.)

An even better approach to get the required capacitance for C1, because it is better to maintain the symmetry of the circuit as shown in Fig. 1 at A, would be to gang two 200-pF variables to make up your own split-stator capacitor, with the desired plate spacing. (There may be some around, but we couldn't find any manufactured split-stator with the required plate spacing and capacitance). Still another approach would be to clip fixed transmitting-type mica capacitors across each section of C1 to obtain the required capacitance for use on 160 and 80.

Finding the Parts

As most hams are finding out, it is becoming more and more difficult to buy, or find, components for construction projects. Some searching was done, and the following information is worth passing on. Barry Electronics of New York City has informed us that they will fill any order for any amateur component at the manufacturer's current amateur net price. The parts specified in Fig. 1 are currently-manufactured items. Also, Fair Radio Sales in Lima, Ohio has some surplus roller inductors and counter dials in stock. The roller-inductor catalog number is 5950-199-6469, and the counter dial is listed as RT-45. Also, Millen components can be purchased directly from Millen (write to Wade Caywood, W1KRD).

Using the Transmatch

One of the first considerations in using a setup for "coax-to-coax" is exactly how much, or how high an SWR can be tolerated. As has been pointed out, this Transmatch will handle *any* mismatch on the line. Without getting into a lot of details, a few observations about coaxial lines are in order. First, the higher the SWR, the greater the losses in coaxial lines. The amount of losses depends on the line construction and the frequency at which the line is used — the lower the frequency, the less will be the losses. For example, RG-8/U has a loss per 100 feet of line of only 3/10 of a dB at 3.5 MHz with an SWR of 1 (a matched condition). At 28

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mode switch in the cw position, the signal goes on the air when the jack is closed. Thus you cannot switch from ssb to a-m, or back again, without putting a burst of cw on the frequency. During the VHF SS, for some hours we wondered about the beeps we often heard when we snagged some of the more difficult Sections, until we suddenly realized that they were produced by some of our TR-6-using competitors, moving in for a shot at the new multiplier, and switching modes!

The description of the TR-6 given here is by no means complete. Rather, we have mentioned mainly those items in which this equipment is unusual or unique. Just about every other feature normally found in hf sideband gear is included in the TR-6. Operators who have had experience with other Drake equipment will find much of the TR-6 familiar. — *W1HDQ*

Drake TR-6 50-MHz Transceiver

Height: 5 7/16 inches.

Width: 10 3/4 inches.

Depth: 14 1/4 inches.

Weight: 15 3/4 pounds.

Power Requirements: 650 volts dc at 500 mA, 250 volts dc at 175 mA, -60 volts adjustable into 30,000-ohm load, 12.6 volts at 5.5 A. These voltages are furnished by the Drake AC-3, AC-4, DC-3, DC-4 and DC-24 power supplies.

Price Class: \$600, less power supply, speaker and other optional accessories.

Manufacturer: R. L. Drake Co., Miamisburg Ohio 45324.

The Ultimate Transmatch

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MHz, this same line would have a loss of slightly less than 1 dB. However, as the SWR rises, so do the losses. With an SWR of 10 to 1, for example, the additional losses at 3.5 MHz would amount to about 0.6dB, or an overall loss of about 1 dB. For the same SWR at 28 MHz, the losses would be about 2.5 dB, or a total loss of about 3.5 dB. For the benefit of the Novice, a loss of 3 dB would mean half of the output power from the rig would be dissipated in 100 feet of line. Therefore, one could easily tolerate the condition at 80 meters, but the losses would be prohibitive at 28 MHz. Following this reasoning, it would mean that the amateur would be wise to keep the match at the antenna feed point as close to 50 ohms as possible, and thereby keep the SWR low.

With trap or multiple dipoles, the SWR should be less than 5 to 1, and with such a system the Transmatch would be ideal. Keep in mind that you must provide a load for a transceiver or amplifier that is close to 50 ohms. The Transmatch will provide a means.

In a coax-to-coax system, set both C1 and C2 at maximum capacitance (plates fully meshed), then feed enough power through the Transmatch to get a full-scale forward reading on your SWR indicator. It is always important to use low power when adjusting a Transmatch. Next, switch the SWR bridge to read reflected power, then run the roller inductor slowly through its range. At some point you will notice a sharp dip in the reflected-power reading. Once this point is reached you should adjust C1 and C2, with possibly a slight adjustment of the roller coil, to get a perfect match. Power can then be increased to the desired level. You'll find that several different settings of the Transmatch may provide a perfect match. The one to shoot for is the condition that requires the most capacitance at C1 and C2 for a matched condition.

If a random-length, end-fed antenna is used, merely connect the end of the antenna to terminal J3, Fig. 1B, and go through the adjustment procedures outlined above. It is helpful to have an

earth ground connection on the Transmatch. Also, if possible, use an antenna length that comes out to a quarter wavelength, or odd multiple thereof. Such an antenna will be of low impedance, and will reduce the chances of high rf voltages appearing on the Transmatch or associated equipment.

If balanced feeders are used, the feeders should be connected to terminals J4 and J5 with a short jumper connected between terminals J3 and J4. Again, the previously-discussed tune-up and adjustment procedures should be followed in setting up the Transmatch.

Some Other Thoughts

Some amateurs might be concerned about the amount of voltage that can be developed in a mismatched coaxial line. In a matched condition, with 1000 watts in a 50-ohm line, the rf voltage would be about 220 volts. With a standing-wave ratio of 20 to 1 (!), the increase in voltage would be 4 1/2 times, or approximately 990 volts. This, however, is well within the rating of the RG-8/U cable.

This Transmatch should satisfy the needs of those hams who desire a multiband unit without switches or plug-in coils. Once the settings for the controls are determined, a chart can be made up for any given installation. Band changing is then quickly done. QST—

