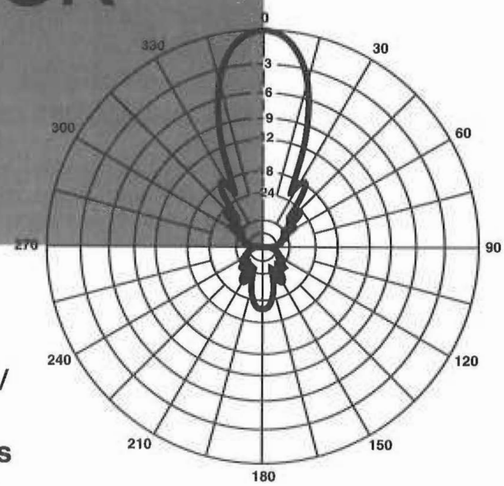
THE ARRL ANTENNA BOOK



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THE COVER

Left photo: SKØUX, in Stockholm, Sweden: A 100-ft tower with 5-el 20-meter beam, a VHF/UHF tower and a 60-ft tower with a log-periodic beam for 10, 12, 15, 17 and 20 meters. *Photo courtesy Henryk Kotowski, SMØJHF.*

Right photo: The WØUN antenna farm, La Salle, Colorado. A 160-foot rotating tower (left side of photo) provides plenty of room for the four beams: 4-el 40-m at 160 ft, 7-el 15-m at 120 ft, another 4-el 40-m at 80 ft and another 7-el 15-m at 40 ft. The 85-ft tower holds a 4-el 40-m beam at 85 ft. For good measure, the telephone pole at the far right holds an 8-el 15-m beam at 58 ft. *Photo courtesy John Brosnahan, WØUN.*

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Contents

Broadband Toroidal Baluns

Air-wound balun transformers are somewhat bulky when designed for operation in the 1.8- to 30-MHz range. A more compact broadband transformer can be realized by using toroidal ferrite core material as the foundation for bifilar-wound coil balun transformers. Two such baluns are described here.

In Fig 25A, a 1:1 ratio balanced to unbalanced line transformer is shown. This transformer is useful in converting

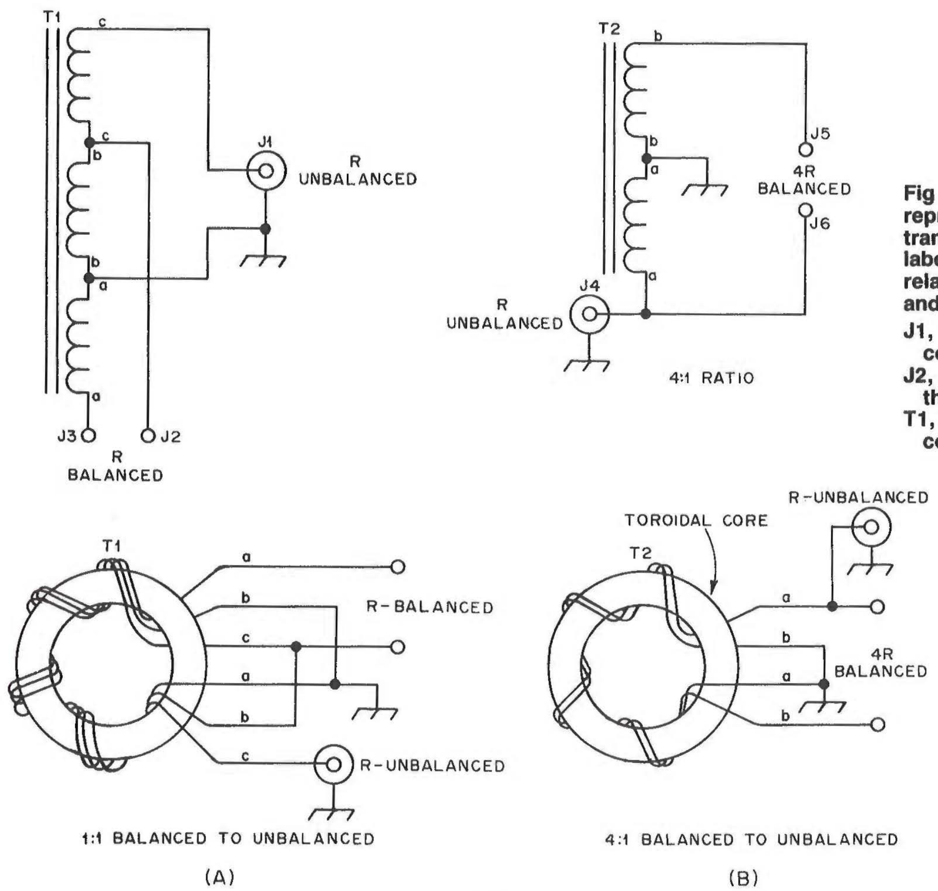

Fig 25—Schematic and pictorial representations of the balun transformers. The windings are labeled a, b and c to show the relationship between the pictorial and schematic illustrations.

J1, J4—SO-239-type coax connectors or similar.

J2, J3, J5, J6—Steatite feed-through bushings.

T1, T2—Wound on CF-123 toroid cores (see text).

a 52-Ω balanced line condition to one that is 52 Ω, unbalanced. Similarly, the transformer will work between balanced and unbalanced 75-Ω impedances. A 4:1 ratio transformer is illustrated in Fig 25B. This balun is useful for converting a 208-Ω balanced condition to one that is 52 Ω, unbalanced. In a like manner, the transformer can be used between a balanced 300-Ω point and a 75-Ω unbalanced line. Both balun transformers will handle 1000 watts of RF power and are designed to operate from 1.8 through 60 MHz.

Low-loss high-frequency ferrite core material is used for T1 and T2. The cores are made from Q2 material and are 0.5 inch thick, have an OD of 2.4 inches, and the ID is 1.4 inches. The permeability rating of the cores is 40. Packaged 1-kilowatt balun kits, with winding instructions for 1:1 or 4:1 impedance transformation ratios, are available, but use a core of slightly different dimensions. Ferrite cores are available from several sources. See Chapter 21.

Winding Information

The transformer shown in Fig 25A has a trifilar winding consisting of 10 turns of no. 14 Formvar-insulated copper wire. A 10-turn bifilar winding of the same type of wire is used for the balun of Fig 25B. If the cores have rough edges, they should be carefully sanded until smooth enough to prevent damage to the Formvar wire insulation. The windings should be spaced around the entire core as shown in Fig 26. Insulation can be used between the core material and the windings to increase the breakdown voltage of the balun.

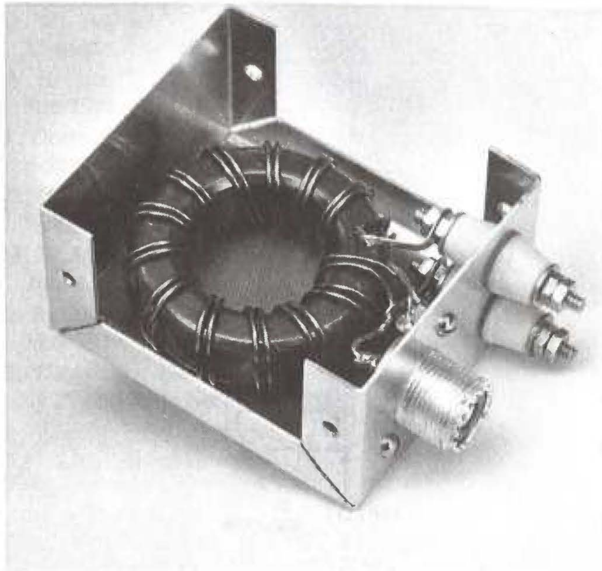

Fig 26—Layout of a kilowatt 4:1 toroidal balun transformer. Phenolic insulating board is mounted between the transformer and the Minibox wall to prevent short-circuiting. The board is held in place with epoxy cement. Cement is also used to secure the transformer to the board. For outdoor use, the Minibox cover can be installed, then sealed against the weather by applying epoxy cement along the seams of the box.

A 52- to 75-Ohm Broadband Transformer

Shown in Figs 27 through 29 is a simple 52- to 75-Ω or 75- to 52-Ω transformer that is suitable for operation in the 2- to 30-MHz frequency range. A pair of these transformers is ideal for using 75-Ω CATV Hardline in a 52-Ω system. In this application, one transformer is used at each end of the cable run. At the antenna, one transformer steps the 52-Ω impedance of the antenna up to 75 Ω, thereby presenting a match to the 75-Ω cable. At the station end, a transformer is used to step the 75-Ω line impedance down to 52 Ω.

The schematic diagram of the transformer is shown in Fig 27, and the winding details are given in Fig 28. C1 and C2 are compensating capacitors; the values shown were determined through swept return-loss measurements using a spectrum analyzer and a tracking generator. The transformer consists of a trifilar winding of no. 14 enameled copper wire wound over an FT-200-61 (Q1 material) or equivalent core. As shown in Fig 28, one winding has only half the number of turns of the other two. Care must be taken when connecting the loose ends so the proper phasing of the turns is maintained. Improper phasing will become apparent when power is applied to the transformer.

If the core has sharp edges it is a good idea to either sand

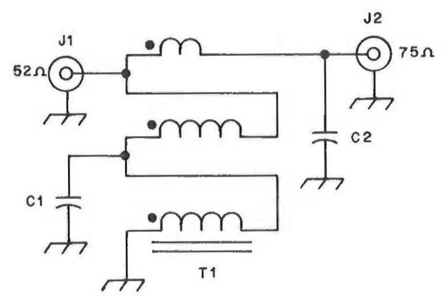

Fig 27—Schematic diagram of the 52- to 75-Ω transformer described in the text. C1 and C2 are compensating capacitors.

C1—100 pF silver mica.
C2—10 pF, silver mica.
J1, J2—Coaxial connectors, builder's choice.
T1—Transformer, 6 trifilar turns, no. 14 enameled copper wire on an FT-200-61 (Q1 material, μ_i = 125) core. The upper winding has one-half the number of turns of the other two.

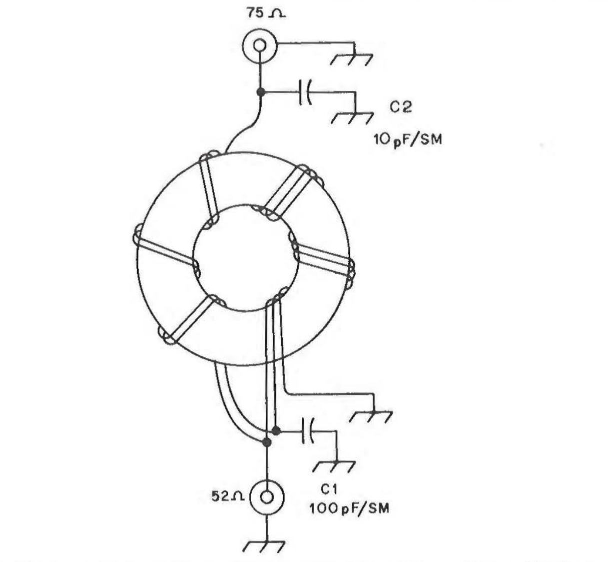

Fig 28— Pictorial drawing of the 52- to 75-Ω transformer showing details of the windings.

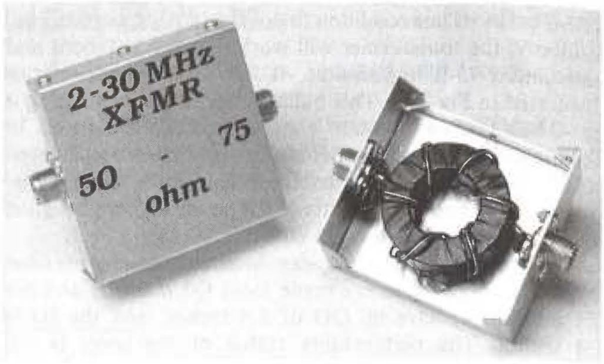

Fig 29—The 52- to 75-Ω transformers. The units are identical.

the edges until they are relatively smooth or wrap the core with tape. The one shown in the photograph was wrapped with ordinary vinyl electrical tape, although glass-cloth insulating tape would be better. The idea is to prevent chafing of the wire insulation.

Construction

The easiest way to construct the transformer is to wind the three lengths of wire on the core at the same time. Different color wires will aid in identifying the ends of the windings. After all three windings are securely in place, the appropriate winding may be unwound three turns as shown in the diagram. This wire is the 75-Ω connection point. Connections at the 52-Ω end are a bit tricky, but if the information in Fig 28 is followed carefully no problems should be encountered. Use the shortest connections possible, as long leads will degrade the high-frequency performance.

The balun is housed in a homemade aluminum enclosure measuring 3½ × 3¾ × 1¼ inches. Any commercial cabinet of similar dimensions will work fine. In the unit shown in the photograph, several "blobs" of silicone seal (RTV) were used to hold the core in position. Alternatively, a piece of phenolic insulating material may be used between the core and the aluminum enclosure. Silicone seal is used to protect the inside of the unit from moisture. All joints and screw heads should receive a generous coating of RTV.

Checkout

Checkout of the completed transformer or transformers is quite simple. If a 75-Ω dummy antenna is available connect it to the 75-Ω terminal of the transformer. Connect a transmitter and SWR indicator (52 Ω) to the 52-Ω terminal of the transformer. Apply power (on each of the HF bands) and measure the SWR looking into the transformer. Readings should be well under 1.3 to 1 on each of the bands. If a 75-Ω load is not available and two transformers have been constructed, they may be checked out simultaneously as follows. Connect the 75-Ω terminals of both transformers together, either directly through a coaxial adapter or through a length of 75-Ω cable. Attach a 52-Ω load to one of the 52-Ω terminals and connect a transmitter and SWR indicator (52 Ω) to the remaining 52-Ω terminal. Apply power as outlined above and record the measurements. Readings should be under 1.3 to 1.

The transformers in the photo were checked in the ARRL laboratory under various mismatched conditions at the 1500-watt power level. No spurious signals (indicative of core saturation) could be found while viewing the MF, HF and VHF frequency range with a spectrum analyzer. A key-down, 1500-watt signal produced no noticeable core heating and only a slight increase in the temperature of the windings.

Using the Baluns

For indoor use, the transformers can be assembled open style, without benefit of a protective enclosure. For outdoor installations, such as at the antenna feed point, the balun should be encapsulated in epoxy resin or mounted in a suitable weatherproof enclosure. A Minibox, sealed against moisture, works nicely.

Balun Terminations

A word about baluns in Transmatches may be in order. Broadband transformers of the type found in many Transmatches are not suitable for use at high impedances. Disastrous results can be had when using these transformers with loads higher than, say, 300 Ω during high-power operation. The effectiveness of the transformer is questionable as well. At high peak RF voltages (high-Z load conditions such as 600-Ω feeders or an end-fed random-length antenna), the core can saturate and the RF voltage can cause arcs between turns or between the winding and the core material. If a balanced-to-unbalanced transformation must be effected, try to keep the load impedance at 300 Ω or less. An airwound 1:1 balun with a trifilar winding is recommended over a transformer with ferrite or powdered-iron core material.

The principles on which baluns operate should make it obvious that the termination must be essentially a pure resistance in order for the proper impedance transformation to take place. If the termination is not resistive, the input impedance of each bifilar winding will depend on its electrical characteristics and the input impedance of the main transmission line; in other words, the impedance will vary just as it does with any transmission line, and the transformation ratio likewise will vary over wide limits.

Baluns alone are convenient as matching devices when the above condition can be met, since they require no adjustment. When used with a matching network as described earlier, however, the impedance-transformation ratio of a balun becomes of only secondary importance, and loads containing reactance may be tolerated so long as the losses in the balun itself do not become excessive.

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Source material and more extended discussion of topics covered in this chapter can be found in the references given below and in the textbooks listed at the end of Chapter 2.

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