

WIDEBAND ANTENNA BALUNS

Few antennas are co-operative when it comes to feedpoint impedance. Matching them up or down to the required 50 ohms (occasionally 75 ohms) often proves awkward. Roger Harrison shows the easy way round.

IN ANY COMMUNICATIONS system the weakest link in the chain is always the antenna system. Even if the best antenna to suit the particular circumstances is chosen, it is necessary to provide efficient transfer of power to or from the antenna feedpoint. However, the antenna feedpoint impedance is not always conveniently the same as that of the feedline, the transmitter output impedance or the receiver input impedance. The latter are usually either 50 or 75 ohms to match the coaxial transmission lines normally employed. Coaxial transmission lines are, by nature unbalanced electrically, whereas many types of antennas have balanced feedpoints and thus require a balanced transmission line. To correct this a 'balun' is necessary — the word being derived from 'balanced — to — unbalanced'. Originally, the term applied to a device which only involved changing from the balanced to unbalanced condition without a change in impedance. Where a change in impedance is necessary the term transformer is, strictly speaking, the correct term.

There are a wide variety of methods of making antenna baluns and impedance matching devices. However, most techniques are suitable for use on a single, narrow frequency band. The most versatile technique, which results in baluns that may be used over a wide frequency range, employs sections of made-up transmission line wound on a ferrite core, usually in the form of a toroid or some other convenient shape. Sections of transmission line are wound together and connected in a series or parallel combination to effect the desired balanced-to-unbalanced transformation and/or an impedance transformation. Winding the transmission line sections on a ferrite core increases the inductance of the length of transmission line used. This article shows how to make the most useful types using locally available components.

High Power Transmitting Baluns

The following baluns to be described all employ toroids and are for use

in transmitting applications at power levels up to 200 W, and up to 1 kW, CW or PEP output. Only two toroids are specified, both from the Neosid range. For applications up to 200 W, the toroid type 4328R/2/F14A/EC is employed, while that for powers up to 1 kW employ the type 4324R/3/F14A. The first has an outside diameter of 25.4mm, an internal diameter of 19.05 mm and a thickness of 9.52 mm. It is coated in an enamel paint. The second, and larger toroid has an outside diameter of 38.1 mm, an inside diameter of 25.4 mm, is 19.05 mm thick and is uncoated. Both have bevelled edges and will not nick or cut the insulation of wire wound around them.

The smaller toroid may be used for purely receiving applications if desired, particularly for the higher transformation ratios of 9:1 and 16:1.

The baluns described are suitable for use from 2 MHz to 30 MHz and in some cases a wider range.

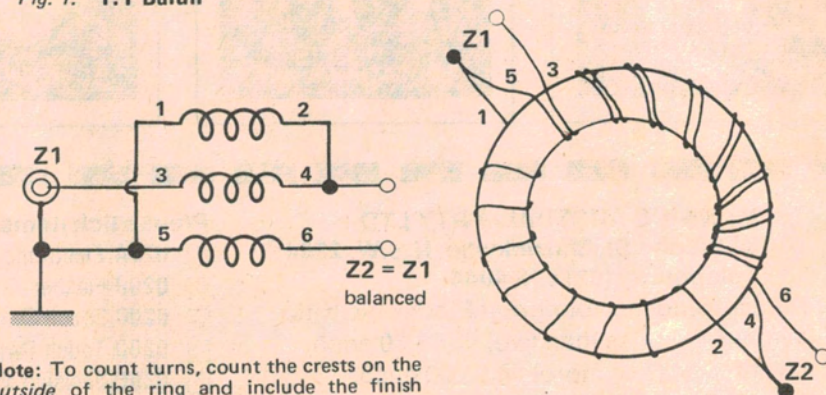
1:1 Balun

The circuit and connections for a 1:1 balun are given in Figure 1. This uses a bifilar winding wound around half the core and a single winding around the other half as illustrated. One wire in the bifilar winding is connected in series with the single winding. This balun is some times described with a trifilar winding but balance and bandwidth are not as good as with the method described.

This type of construction exhibits excellent balance at the Z2 termination and operates over a bandwidth of 1 MHz to 30 MHz in 50 ohm systems for assemblies on either toroid. The bandwidth is considerably better for 75 ohm systems constructed on either toroid, extending to 60 MHz for the 1 kW assembly but only 40 MHz for the 200 W assembly.

The exact gauge of the wire used is not very critical, a latitude of plus or minus one gauge being tolerated. When winding on the heavy gauge wires, a

Fig. 1. 1:1 Balun



Note: To count turns, count the crests on the outside of the ring and include the finish lead. The 1:1 balun illustration has eight turns on each winding.

	200W	1KW
Winding details:	8 turns, 20 or 22 SWG enamelled wire for both bifilar and single windings.	6 turns, 18 SWG enamelled wire for both windings.
Response		
50 — 50 ohms:	1 — 30 MHz	1 — 30 MHz
75 — 75 ohms:	1 — 40 MHz	1 — 40 MHz

neat winding can be obtained by carefully forming each bend, holding the already wound part firmly against the core.

Some confusion arises when counting turns of a winding on a toroid. To count turns, count the 'crests' on the outside of the ring and include the finish lead. The assembly illustrated in Figure 1 has eight turns on each winding.

4:1 Balun

An unisolated balun has a dc connection between input and output, the isolated type is a true transformer.

Figures 2 and 3 illustrate unisolated types. A 4:1 isolating balun is in Fig. 4.

A single bifilar winding is used. The wires may be twisted together lightly or wound together around the core as illustrated. The latter method is preferable. Identify the ends and connect in series as shown. The bifilar winding is spread around most of the circumference. For the larger toroid, it is difficult to spread six turns around the circumference so the winding is distributed around about two-thirds of the circumference of the toroid.

Balance of the high impedance is excellent. Bandwidth for both toroids is best for Z1 of 50 ohms. The 1 kW assembly in this case has the best bandwidth for either 50 or 75 ohm systems.

The same assembly can be connected as an unbalanced transformer. The arrangement is shown in Fig. 3. Bandwidth is limited in this application but most vertical or loaded vertical antenna systems are used on the lower bands, below 15 MHz in any case. Best bandwidth is obtained for transformation from about 19 ohms to 75 ohm systems.

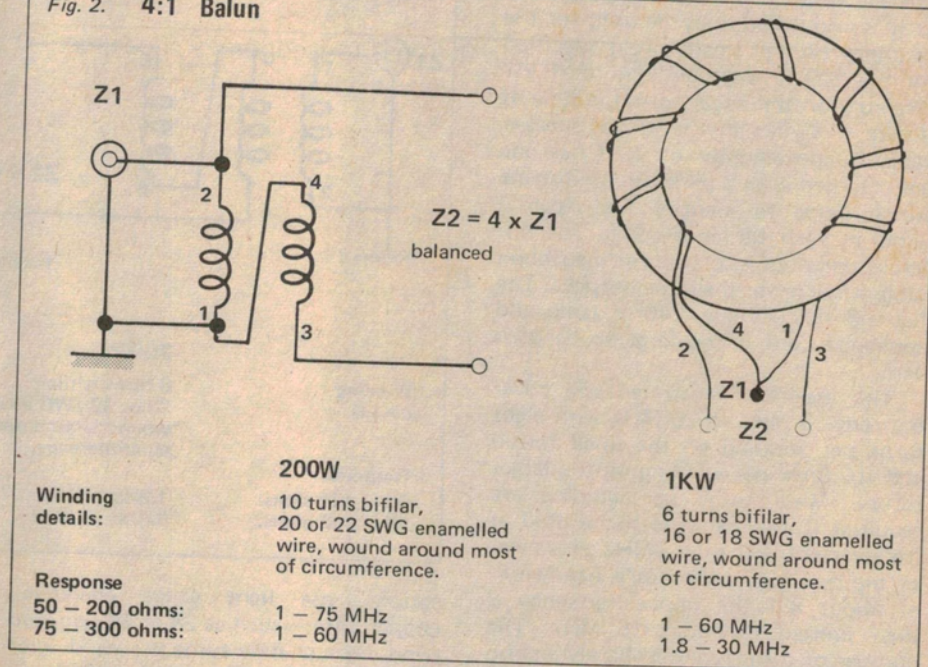
The isolated type is illustrated in Figure 4. This consists of a trifilar winding having two of the wires connected in series for the high impedance winding, the third wire being the low impedance, unbalanced winding.

The 1 kW assembly has the best bandwidth, when matching to 50 ohm systems. However, the full HF range is covered by both assemblies.

9:1 Balun

Baluns providing high impedance ratios are rarely described. Recently, wide-band transformers for use in HF transistor linear power amplifiers, having impedance ratios as high as 36:1, have been described, but the techniques used

Fig. 2. 4:1 Balun



are not generally adaptable to the applications considered here.

Many types of HF beam antennae have high impedance feedpoints, such as the Lazy-H, Sterba curtain, V-beams and Rhombics, therefore presenting a matching problem that is usually solved by using resonant matching devices or 'match-boxes' involving tuned transformers. The wide bandwidth advantage of the V-beam and the Rhombic is compromised by such devices and a wide-band balun provides a much better solution to the problem of matching the balanced, high impedance feedpoint to the unbalanced, low impedance transceiver antenna terminal. You don't have to tune up each time you change bands.

Conversely, you lose the harmonic and spurious suppression advantages of the tuned matching system. However, it is always good practice to insert a low-pass filter in the transmission line immediately following the transceiver, regardless of the matching system used.

For antennas having a feedpoint impedance close to 600 ohms the balun illustrated in Figure 5 is applicable. It consists of three separate bifilar windings wound on the ferrite toroid as shown. One wire from each winding is connected so that each is in series, this forming the balanced high impedance winding. The remaining wires from each winding are all connected in

4:1 Unbalanced transformer

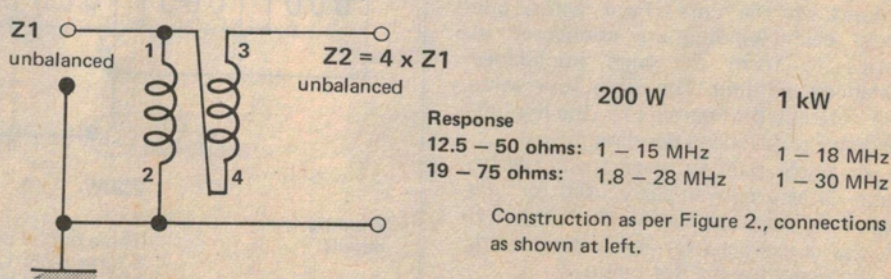


Fig. 3. Circuit for 4:1 unbalanced to unbalanced transformer. Construction is similar to that in Fig. 2. This type of transformer is suitable for matching to low impedance unbalanced antennas.

WIDEBAND ANTENNA BALUNS

parallel for the unbalanced low impedance winding.

A single pair stripped from a length of suitable ribbon cable, or rainbow cable as it is also called, may be used for the windings on the small toroid specified for the 200 W assembly. For the 1 kW assembly on the larger toroid, a type of 'figure - 8' flex that is sold as speaker cable is conveniently used. It has one lead marked with a dark-coloured stripe which helps to identify the separate wires in each bifilar winding. The different coloured insulation of the ribbon cable wires serves the same purpose. The figure-8 flex sold as 240 V lamp and appliance cord is too large to be used here.

The assembly illustrated will cover the range 3 MHz to 25 MHz with eight turns per winding on the small toroid and six turns per winding on the larger toroid. More turns per winding are required if the balun is to be used at frequencies lower than 3 MHz. However, as the assembly only has a bandwidth of about 8:1 the upper frequency is then limited to about 15 MHz. The number of turns required barely fits on each core in this case.

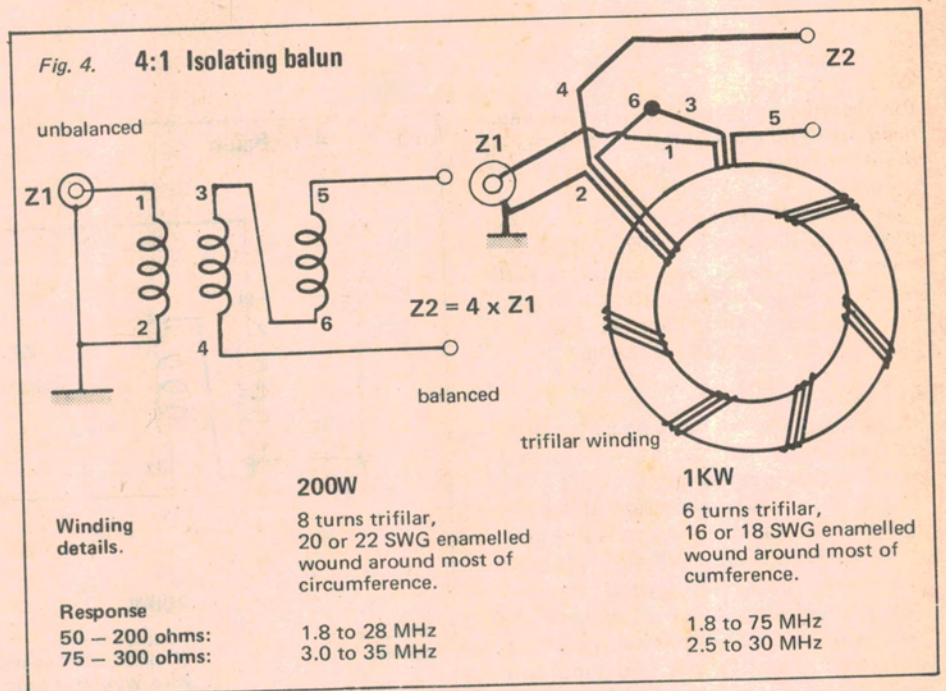
Although the balun described is specified for matching 600 ohms to 75 ohms it can also be used to match antennas having impedances close to 450 or 500 ohms, to 50 ohms. The upper frequency limit is then reduced to about 20 MHz in this case. A slight impedance mismatch is readily tolerated by most equipment and there is little to be gained in trying to get an exact match.

16:1

For antennas having feedpoint impedances in the vicinity of 800 ohms the balun illustrated in Figure 6 is applicable for matching to 50 ohms. It is constructed in a similar manner to the previous one. Four bifilar windings are wound on the core. Four wires, one from each winding are connected in series to form the high impedance balanced winding. The other four wires are connected in parallel for the low impedance unbalanced winding.

A single pair stripped from ribbon cable is also conveniently used for this balun on the small toroid, while figure-8 flex is convenient for the larger toroid, as discussed for the 9:1 balun.

This balun covers 3 to 25 MHz for assemblies wound on either toroid. Sufficient turns will not fit on the smaller toroid if you wish to go below 3 MHz. For purely receiving appli-



cations, use light gauge enamelled copper wire - such as 28 or 30 swg, and wind eight or nine turns per winding of bifilar pairs on the small toroid. As receivers are usually fairly tolerant of some degree of mismatch, a balun constructed in this manner may be used over the range 1 MHz to about 25 MHz.

The larger toroid will fit sufficient turns to cover the range down to 1.8 MHz but, as for the 9:1 balun, the upper frequency limit is about 15 MHz.

TOROIDS

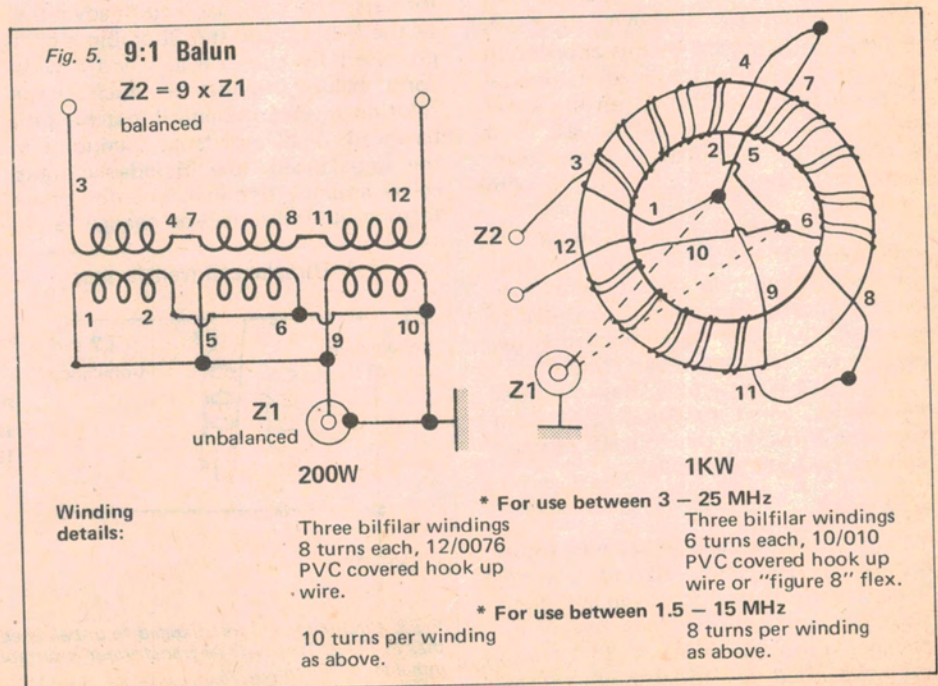
200W: 4328R/2/F14A/EC

Size: 25.4 mm x 19.05 mm x 9.52 mm (od, id, depth). Suitable up to 200 W and for receiving applications. Also available from DAVID REID Electronics, 104-106 King Street, Newtown (PO Box 317) 2042.

1 kW: 4324R/3/F14A

Size: 38.1 mm x 25.44 mm x 19.05 mm (od, id, depth)

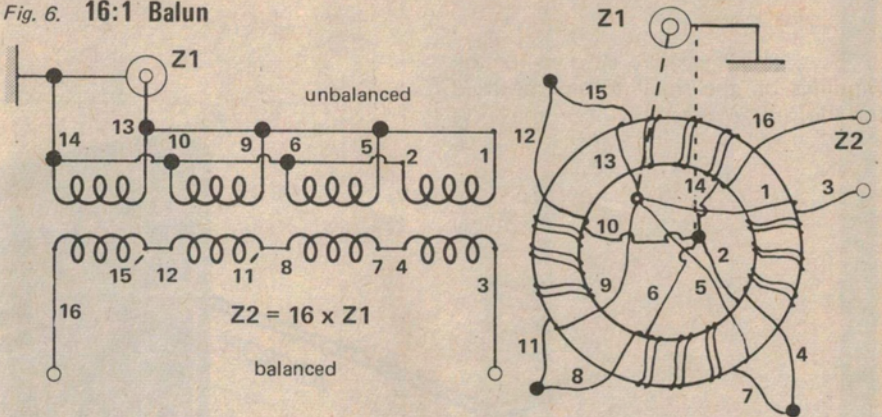
The toroids specified are manufactured by Neosid (Aust.) Pty Ltd, 23-25 Percival St, Lilyfield NSW 2040; phone (02) 660-4566.



Encapsulating Balun Assemblies

Where necessary, to protect them from the weather, the balun assemblies may need to be encapsulated. A suitable mould may be fashioned from stiff paper or cardboard and the balun assembly potted in a suitable epoxy compound. The input and output terminations may be potted along with them, ensuring that no short circuits are possible in the process. Alternatively, they may be sealed in a suitable plastic moulding such as those produced for 240 V electric cable conduit. These are available as T-junctions etc, and are generally obtainable from hardware stores in sizes suitable to contain the toroids specified. A complete balun and dipole feedpoint termination can be encapsulated in an appropriate fitting. A suitable coax socket and eye-bolts to take the antenna strain are readily included also. The exact construction is left up to the individual to suit the circumstances, A little imagination goes a long way. ●

Fig. 6. 16:1 Balun



Winding details:

200W

Four bifilar windings
6 turns each, 12/0076
PVC covered hook up
wire.

Sufficient turns will
not fit on the toroid.
See text.

1KW

* For use between 3 – 25 MHz

Four bifilar windings
4 turns each, 10/010
PVC covered hook-up
wire or "figure 8" flex.

* For use between 1.8 – 15 MHz

6 turns per winding
as above.