Application of Broad-band Balun Transformers

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New low-loss ferrite materials used for toroidal cores can provide efficient and compact balun transformers for broad-band r.f. work at wide power ranges. Presented here are some new and useful applications.

THE ferrite-core broad-band transformer has been with us ever since the development of low-loss, high-permeability ferrite materials. The term "broad-band" is relative. Typically, ferrite toroidal-core baluns have bandwidths of 10 to 1, such as for the frequency range from 3 to 30 MHz. However, for some applications much greater bandwidths may be obtained. These transformers are low loss and may be constructed sufficiently large to handle the full legal transmitter power level, if desired. They must be terminated resistively for proper operation, at impedance levels from 5 to 1000 ohms. The higher-resistance terminations tend to decrease the useful bandwidth. The application of balun transformers to antenna problems has been covered by a number of others.[1,2] McCoy has thoroughly discussed the need for baluns in antenna systems.[1] This article will describe other forms and uses for broad-band ferrite transformers.

Fig. 1 shows some basic transformers and a few applications. Figs. 1A and 1B show the basic 1:1 and 4:1 baluns. The 1:1 balun has been modified slightly from previous designs in that the third winding has been separated on the core from the bifilar winding. This modification results in improved balance at the higher frequencies with no change in other characteristics. The third winding is a core magnetizing winding which is effective only in extending the low-frequency range of the balun. The third winding may be omitted entirely if operation is confined to frequencies above about 10 MHz.

Fig. 1C is a two-stage transformer wound on a single core, and has an impedance step-down ratio of 4:1, unbalanced-to-balanced. This version may be very useful in feeding close-spaced beams where the driven-element impedance can be lower than 20 ohms.

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[1] McCoy, "Is a Balun Required," *QST*, December, 1968.
[2] See other references listed at the end of this article.

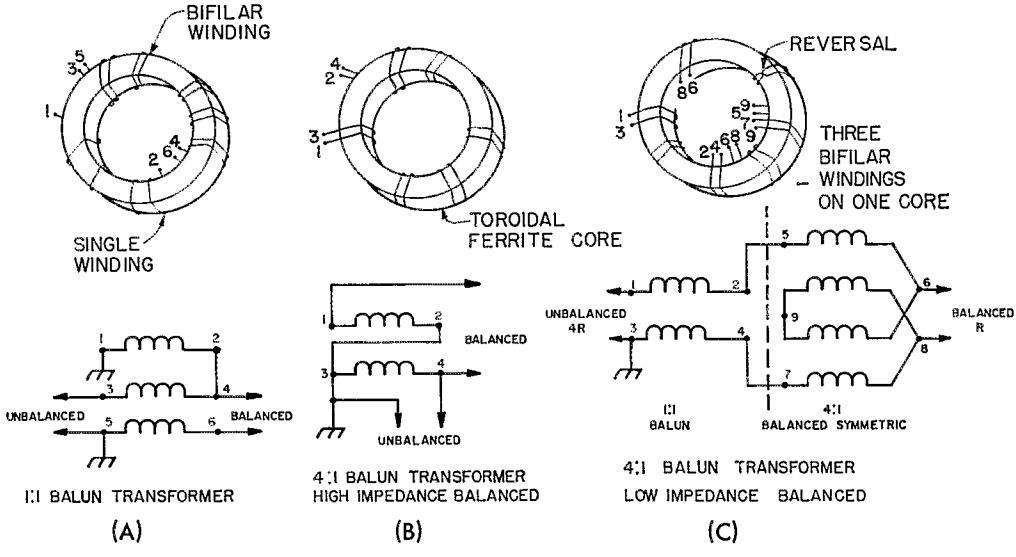

Fig. 1—Basic broadband balun transformers and a few applications. Bifilar windings are six to ten turns, depending on the ferrite-core permeability. In the formulas associated with Figs. 1D and 1F, *k* equals the ratio of the number of tapped turns to the total number of turns in the tapped winding. A suitable ferrite material is Ferramic Q_1 with a permeability of 125. Very small size cores may be used for receiving and low power applications. For full-power applications a 2½-inch o.d. Ferramic Q_1 core with ½-inch cross section wound with No. 14 Formex copper wire, seven turns per winding, is recommended. See text for discussion of applications.

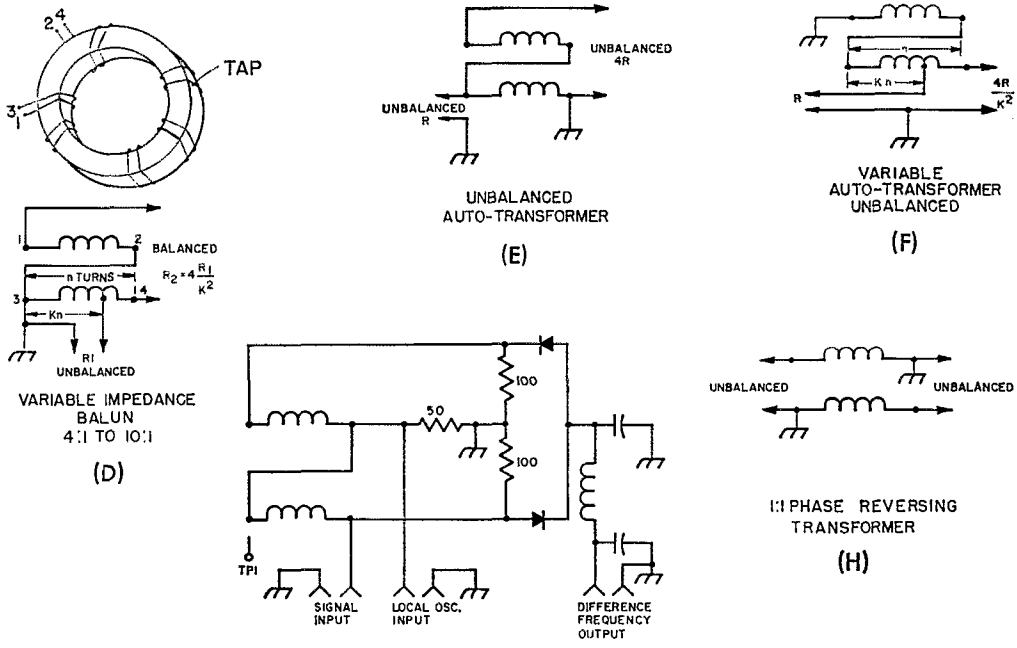

Fig. 1 (Cont.)

Fig. 1D is an innovation combining a variable-impedance transformer and a balun onto one core, and resistive ratios of from 4:1 to 10:1 may be obtained with this arrangement. Although still higher ratios may be obtained, the bandwidth will suffer. For single-band operation, the number of turns on the windings may be altered for minimum reactance.

Impedance ratios in the range 1:1 to 4:1 may be obtained by replacing the 1:1 balun portion of Fig. 1C with the variable-impedance balun of Fig. 1D simply by changing the wiring connections in Fig. 1C.

Fig. 1E shows the 4:1 balun transformer connected as an unbalanced autotransformer. This arrangement is especially useful as a broad-band interstage transformer between transistor amplifier stages, and as an input or output line-matching transformer.

Fig. 1F is a variable unbalanced autotransformer. For balanced impedance levels less than the unbalanced levels, it will be necessary to employ a cascade of two transformers on separate cores. Figs. 1F connected to the unbalanced end of the transformer in Fig. 1C will give transformation ratios of 1:1 down to 1:4.

Another use of the 4:1 balun transformer is shown by Figure 1G. Here the transformer is used as a 180-degree hybrid transformer in a balanced mixer, modulator, or phase detector. For best broad-band operation, terminating resistors are included. Similarly, the 4:1 balun transformer may be employed as a 3-db. power splitter and phase-reversing transformer. The common or balanced terminal of the transformer, shown as TP_1, has interesting uses. For instance, a detector connected between this terminal and ground will serve as an indicator of parallel-mode currents on a balanced transmission line when the transformer is used to connect a coaxial line to a balanced two-wire transmission line.

Finally, Fig. 1H shows a 1:1 polarity-reversing transformer with d.c. isolation between input and output. This transformer is useful in phasing problems with both circuits and antennas.

Because these transformers are broad-band, they are all useful in short pulse application with MHz. repetition rates.

A few variations of the ferrite-core balun transformer have been shown along with applications. Fig. 1 is presented as a guide and reference for these transformers. It is suggested that for further construction details of the cored transformers, the reader consult the references. QST

References

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