United States Patent [19]

Fritz et al.

[11] **3,846,721**

[45] **Nov. 5, 1974**

[54] **TRANSMISSION LINE BALUN**

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[73] Assignee: **AMP Incorporated,** Harrisburg, Pa.

[22] Filed: **Aug. 8, 1973**

[21] Appl. No.: **386,812**

[52] **U.S. Cl.** .... **333/26,** 333/84 M

[51] **Int. Cl.** **H01p 5/10,** H03h 7/42

[58] **Field of Search**.......... 174/68.5, 117 F, 117 FF, 174/117 PC; 333/26, 84 R, 84 M, 4, 5, 10, 11; 343/865

[56] **References Cited**

UNITED STATES PATENTS

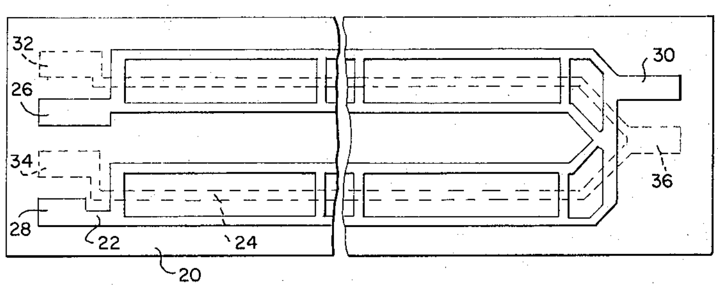
3,432,775	3/1969	Duttamel	333/11
3,609,600	9/1971	Kassabgi et al.	333/84 R
3,678,418	7/1972	Woodward	333/26
3,764,727	10/1973	Balde	333/84 M X

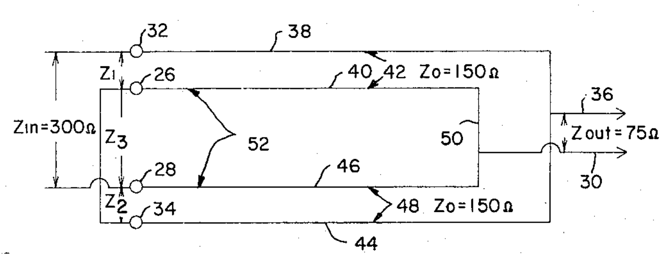
Primary Examiner—Paul L. Gensler

[57] **ABSTRACT**

A flexible printed transmission line balun is disclosed to replace the coaxial cable and relatively expensive hand wound balun coil currently used in T.V. receivers. The present transmission line balun includes a first circuit disposed on one side of a flexible insulator substrate and a second circuit disposed on the opposite side of the substrate. Both circuits are formed on the substrate by conventional means which include etching and printing techniques.

12 Claims, 5 Drawing Figures





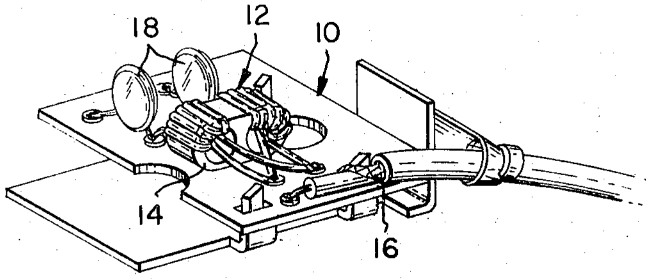


FIG. 1

PRIOR ART

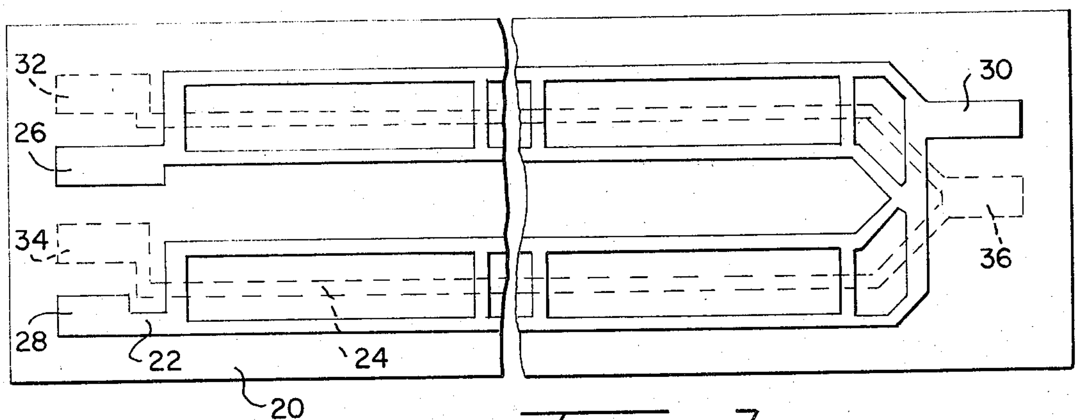


FIG. 2

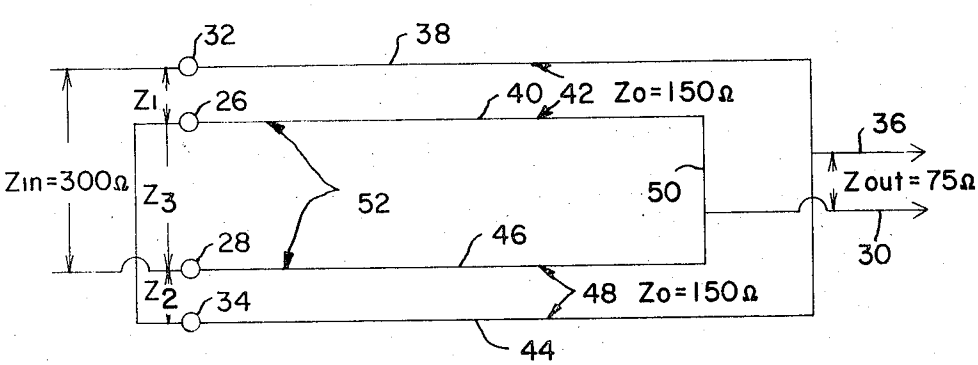


FIG. 3

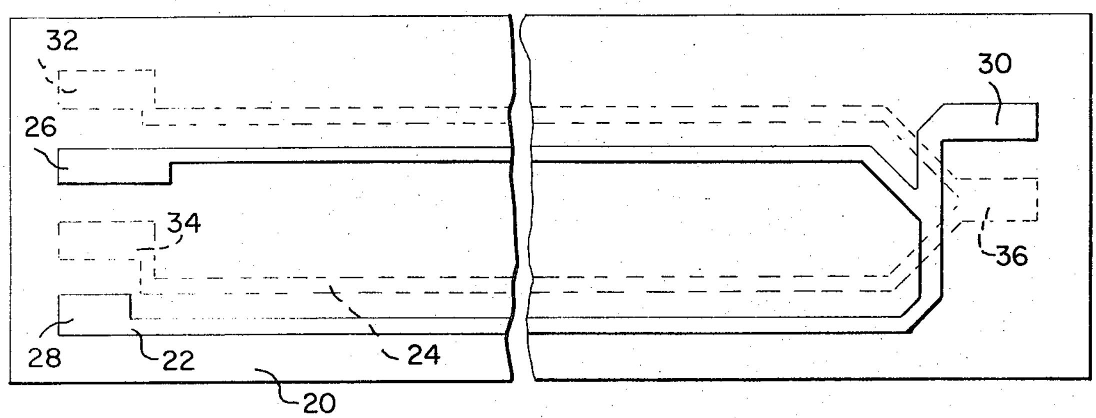
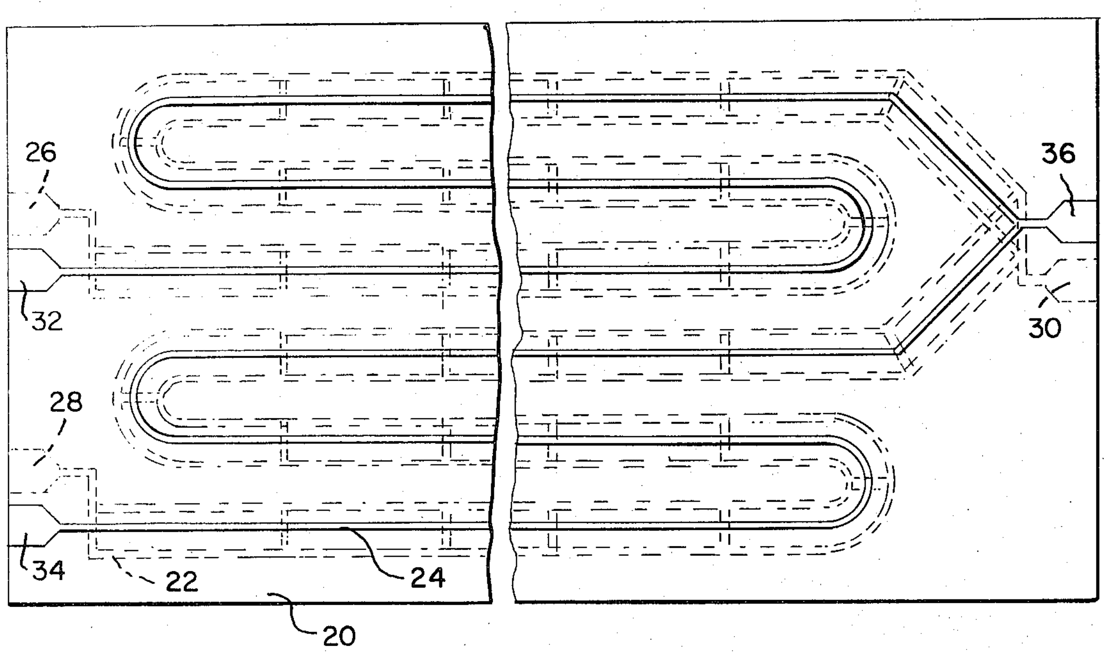


FIG. 4

FIG. 5



TRANSMISSION LINE BALUN

BACKGROUND OF THE INVENTION

1. The Field of the Invention

The present invention relates to an impedance matching device and more particularly to a balun for matching an unbalanced transmission line to either a balanced transmission line or a balanced antenna. The present invention is of special use for the connection of a balanced antenna to the unbalanced input of a television receiver.

2. The Prior Art

Most of the present T.V. antennas use a hand wound balun transformer and a 75 ohm coax cable between the standard 300 ohm dipole antenna and 75 ohm tuner input. The voltage standing wave ratio (VSWR) of this interconnection should be less than 2 to 1 over a frequency range of 54 to 216 megahertz. It has been known to employ transmission line baluns at frequencies where the electrical length is an odd multiple of a quarter wave length. In order to make these transmission line baluns wide band, they had to be coiled to isolate input from output at frequencies of other than odd multiples of quarter wave length. The necessity to coil the transmission line makes this type of arrangement impractical for T.V. applications.

A representative example of the prior art is U.S. Pat. no. 2,865,006 which discloses, with reference to FIG. 5, an impedance matching transformer for coupling a 300 ohm antenna line to a 75 ohm input. While this is electrically similar to the results achieved by the present invention, the patented device requires the use of a ferrite core which is both bulky and heavy. Further examples of such prior art devices may be found in U.S. Pat. Nos. 3,025,480 and 3,686,594.

There are many prior art devices which have the form of a strip line and are used to replace rather bulky transformers, couplers, etc. Examples of such known strip line devices may be found in U.S. Pat. Nos. 3,516,024; 3,626,332; 3,678,418 and 3,729,694. Pat. No. 3,678,418 is of particular interest since it discloses a printed circuit balun in which first and second circuits are formed on opposite sides of a dielectric substrate. However, the geometry of the two circuits is rather complex and bulky.

SUMMARY OF THE INVENTION

The present invention provides a simple and economical transmission line balun for coupling an antenna to a television tuner input. The subject transmission line balun includes a pair of flexible transmission lines formed by first and second circuits which are located on opposite sides of a flexible insulator substrate strip.

It is therefore an object of the present invention to teach a method for connecting a dipole antenna to a television input tuner without requiring bulky and expensive hand wound transformers of the type currently used in television receivers.

It is another object of the present invention to construct an improved transmission line balun which is formed on a flexible substrate and subsequently folded in accordian fashion so that it may be stretched as needed to make the desired antenna to tuner connection.

It is yet another object of the present invention to provide a transmission line balun which may be readily and economically produced.

The means for accomplishing the foregoing and other objects of the invention will become apparent to those skilled in the art from the following description taken with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view showing an example of a prior art balun transformer assembly;

FIG. **2** is a shortened plan view of a first embodiment of the subject transmission line balun;

FIG. **3** is a schematic diagram for explaining the function of the subject invention;

FIG. **4** is a shortened plan view of a second embodiment of the subject transmission line balun; and

FIG. **5** is a shortened plan view of a third embodiment of the subject transmission line balun.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

The example of a known balun transformer assembly **10**, shown in FIG. **1**, includes a handwound transformer **12** having a rather bulky and heavy ferrite core **14**. A coaxial cable **16** is used to connect the balun to a tuner (not shown). Capristors **18**, which include a parallel circuit of a resistor, a capacitor and a spark gap, are also included in this assembly.

The subject transmission line balun will be discussed with reference to a particular exemplary use, namely, for television receivers. The embodiment shown in FIG. **2** includes a flexible substrate **20**, such as Mylar, having one circuit **22** formed on one side and another circuit **24** formed on the opposite side thereof. Both circuits are preferably formed on the substrate in the same fashion by one of the well known techniques, such as etching or printing. The one circuit **22** includes terminals **26, 28** and **30**, and is preferably used as the ground line, while the other circuit **24** includes terminals **32, 34** and **36.** These circuits form two transmission lines. The first transmission line includes terminals **26, 30, 32** and **36.** The second transmission line includes terminals **28, 30, 34** and **36.** Each of these lines has a characteristic impedance Z_o. When the subject balun is used with a balanced source or load of impedance 2 Z_o, the lines are connected in parallel at terminals **30, 36** and connected in series at terminals **26, 28, 32, 34.** In the particular use cited, terminals **30, 36** are connected to a television tuner input having an impedance of $Z_o/2$ and terminals **28, 32** are connected to an antenna having an impedance of 2 Z_o, both connections being made by means which are not shown. The length of the transmission line formed as shown in FIG. **2** is such that at any operating frequency the electrical length is not equal to one half wave length or multiple thereof. This may be accomplished by a straight section, as shown, or by meandering the lines (see FIG. **5**) if a more compact form is required. The reason for this length requirement will become obvious in the following discussion.

Referring now to the schematic diagram of FIG. **3,** the subject balun is shown with terminals **28, 32** connected to a 300 ohm balanced output from an antenna (not shown) and terminals **30, 36** connected to a 75 ohm unbalanced tuner input (also not shown). The circuit, as seen from the antenna input end **28, 32,** consists of conductors **38** and **40**, which form a first transmission line **42** having a designed characteristic impedance Z_o equal to 150 ohms, connected in series with conductors **44** and **46**, which form a second transmission line **48** also having a designed characteristic impedance Z_o equal to 150 ohms. Conductors **40** and **46** are connected together by conductor **50** to form a shorted transmission line **52** having a characteristic impedance Z_{os}. The shorted transmission line **52**, by way of terminals **26, 34**, is in parallel with the second transmission line **48**. Z_1, Z_2 and Z_3 are the impedances seen at the input to lines **42, 48** and **52** respectively. The balun input impedance, Z_{in}, seen across antenna connections **28, 32** will be:

$$Z_{in} = Z_1 + Z_2Z_3/Z_2+Z_3$$

Ideally, for proper matching of the 300 ohm antenna, Z_{in} should be equal to 300 ohms. This can be realized by making Z_3 large compared to Z_2 for then Z_1 equals Z_2 equals Z_o ohms, and

$$Z_{in} = 2\ Z_o = 2 \times 150 = 300 \text{ ohms}$$

The input impedance, Z_3, of the shorted transmission line **52** is:

$$Z_3 = j\ Z_{os} \tan 2\ \pi\ l/\lambda$$

where

λ is wavelength,

l is the line electrical length, and

Z_{os} is the characteristic impedance of the line.

When l is equal to zero, a half wave length or any multiple of a half wavelength, Z_3 will be zero and transmission line **48** will be shorted at its input regardless of the value of Z_{os}. This will result in a large mismatch and, therefore, we see the reason for the requirement that the line lengths must not be equal to any multiple of one-half wavelength for any frequency within the desired operating range.

For the balun to present a reasonable match to the antenna from 54 to 216 megahertz, the line lengths and the characterisitc impedance, Z_{os}, must be designed such that Z_3 does not appreciably shunt line **48** at any frequency within this 4 to 1 range. As an example, if the lines are one-tenth of a wavelength long at the lower frequency, the minimum value of Z_3 as observed at the frequency extremes of **54** and **216** megahertz will be $+j.73\ Z_{os}$ and $-j.73\ Z_{os}$ ohms respectively. Accordingly, if Z_{os} is designed to be much larger than Z_o, say 1000 ohms, we would expect the balun to perform with a low value of voltage standing wave ratio from 54 to 216 megahertz. A sample line constructed with these design criteria did, in fact, operate from 34 megahertz to 248 megahertz with a voltage standing wave ratio less than 1.5 to 1. This is well within the T.V. receiver voltage standing wave ratio requirement of 2 to 1 over the frequency range of 54 to 216 megahertz.

Further voltage standing wave ratio improvement can be realized by increasing the loss in the medium which the energy in line **52** propagates. This is accomplished by alternate plating of copper and permalloy, each to a thickness greater than a skin depth at the lowest frequency, on conductors **40, 46** and folding the lines such that the permalloy surfaces are adjacent. The advantage of this, provided that high enough loss at the lowest frequency of interest is realized, is that reflections due to the short will not appear at the input and Z_{in} of line **52** will be equal to Z_{os} and not a function of frequency. Improved wide band matching will therefore be achieved. One should realize that even with this lossy system Z_{os} must be much greater than Z_o to keep the mismatch and the insertion loss low. Z_{os} still shunts transmission line **48** and energy that propagates in transmission line **52** is absorbed in the line.

It is contemplated, that the subject flexible circuit, or Mylar, should be approximately 21 inches in length for the desired frequency range of 54 to 216 megahertz. This circuit is preferably preformed to accommodate an accordian fold which will allow the circuit to be inserted into television receivers of different sizes and simply stretched or compressed as needed to make the requisite antenna to tuner connections.

Capristors, such as those shown in FIG. **1** and including a spark gap, a capacitor and a resistor in parallel, may be used in conjunction with the present invention either as separate components or, when conditions such as space and component values permit, they can be deposited directly on the flexible substrate. All of the portions of a capristor can be fabricated on a flexible substrate, such as Mylar, by known techniques.

The second embodiment of the subject transmission line balun, see FIG. **4**, differs from the first embodiment in that the first circuit **22** is formed with a pair of single conductors rather than split conductors. The split conductor first embodiment provides improved shielding and is prefered when this is a criteria in addition to a low voltage standing wave ratio. However, the single conductor second embodiment provides the desired good impedance matching.

The third embodiment shown in FIG. **5** uses split conductors for the first circuit **22** and also has both circuits folded upon themselves to shorten the overall length of the transmission line balun. A further modification (not shown) of this folded embodiment has the two conductors of the second circuit **24** following meandering paths extending substantially normal to each other.

The present invention as has been described with reference to a single embodiment which should be considered as illustrative only and not restrictive. Many modifications and variations may be made to the subject invention without departing from the spirit or essential characteristics thereof.

What is claimed is:

1. An improved transmission line balun for providing an impedance transition over a desired operating range of frequencies comprising in combination:

a flexible substrate having two substantially parallel spaced side portions;

a first circuit formed on a first side of said substrate extending from one end of said substrate to the opposite end thereof, said first circuit including two conductors connected together adjacent one end of said substrate; and

a second circuit formed on the second side of said substrate extending from one end of said substrate to the opposite end thereof, said second circuit including first and second conductors each of which is so positioned as to lie parallel to a respective conductor of said first circuit and being connected together adjacent said one end of said substrate, said conductors of said first and second circuits forming a pair of transmission lines, said first and second circuits having an electrical length which is not equal to one half wave length or multiple thereof at any operating frequency.

2. An improved transmission line balun according to claim 1 wherein said substrate is formed of Mylar.

3. An improved transmission line balun according to claim 1 wherein said first and second circuits are substantially rectilinear.

4. An improved transmission line balun according to claim 1 wherein the two conductors of said first circuit are parallel.

5. An improved transmission line balun according to claim 1 wherein each of the conductors of said second circuit are split into two parallel portions so positioned on said substrate that the respective conductors of said first circuit fall between the parallel portions of said second circuit.

6. An improved transmission line balun according to claim 1 wherein said first and second circuits follow a meandering course on said substrate.

7. An improved transmission line balun according to claim 1 wherein said balun is preformed into an accordian configuration hereby it may be stretched and compressed as needed in order to effect the desired connections.

8. An improved transmission line balun according to claim 1 wherein the flexible substrate is Mylar, and the operating frequency range is 54 to 216 megahertz and the length of the circuits is 21 inches.

9. An improved transmission line balun according to claim 1 wherein each of said circuits is formed by alternate plating of copper and permalloy each to a thickness greater than a skin depth at the lowest operating frequency, and

folding the balun such that the permalloy surfaces are adjacent.

10. An improved transmission line balun according to claim 1 wherein one of said circuits is a ground circuit.

11. An improved transmission line balun according to claim 1 further comprising capristor means connected in series with each of said transmission lines.

12. An improved transmission line balun according to claim 11 wherein said capristor means are formed on said substrate along with said circuits.

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