

[54] COUPLING DEVICE AND METHOD FOR SIMULTANEOUS IMPEDANCE BALANCING

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

[58] Field of Search **333/10, 26, 34, 25, 32; 343/859, 863**

[56] References Cited

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[57]

ABSTRACT

A wide range coupling device for simultaneously balancing and matching two arbitrary impedances is provided which comprises a tapered line extending over several wavelengths and coiled into a helix of gradually increasing pitch. The tapered line comprises two equal lengths of conductive wire insulated with respect to each other. Taper dimensions are determined by first specifying and interconnecting said impedances and in a single plane adjusting the taper for minimum reflection utilizing time-domain reflectometry. An adhesive material is utilized to fix taper spacing. The tapered line is then rolled into a helix. Time-domain reflectometry is again utilized and helix pitch is adjusted for minimum reflection. The device when interconnecting both said impedances provides balancing and matching thereinbetween.

4 Claims, 3 Drawing Figures

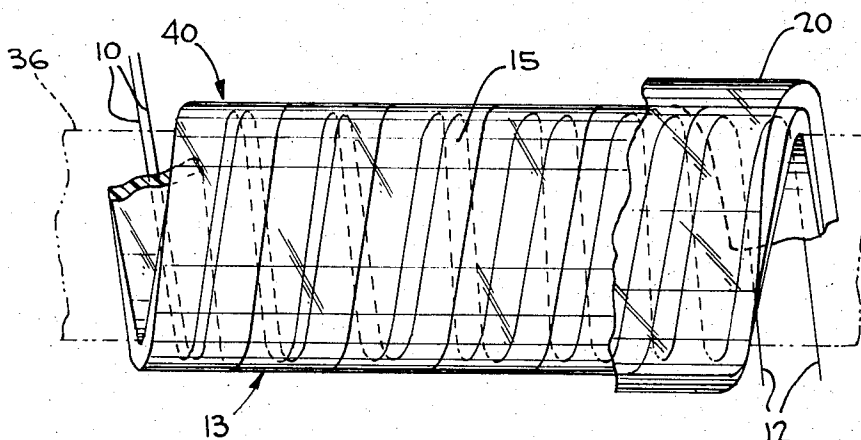


FIG. 1

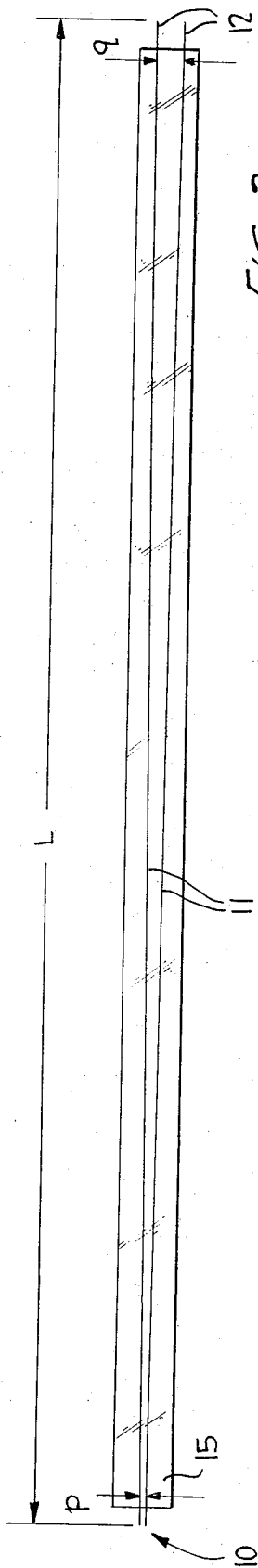
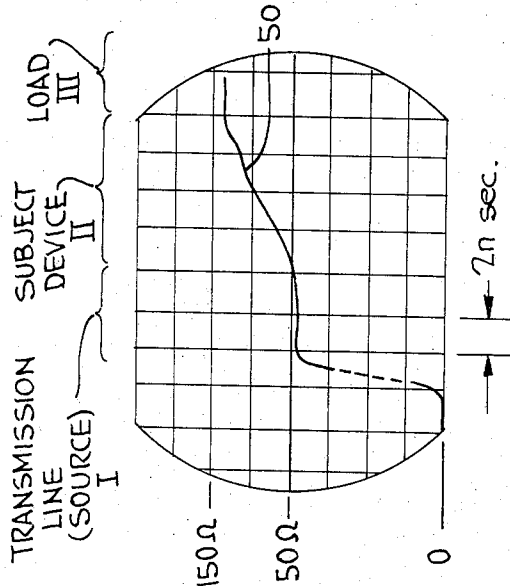
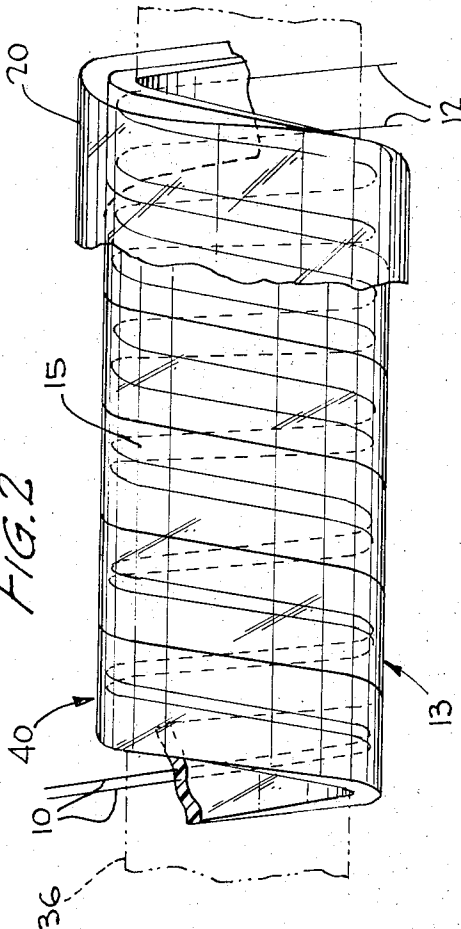


FIG. 3



TIME-DOMAIN REFLECTOGRAM
OF ANTENNA IMPEDANCE MATCH

FIG. 2



COUPLING DEVICE AND METHOD FOR SIMULTANEOUS IMPEDANCE BALANCING

RIGHTS OF THE GOVERNMENT

The invention specified herein may be used, manufactured, or licensed by or for the United States Government for governmental purposes without the payment to the inventor of any royalty thereon.

BACKGROUND OF THE INVENTION

Heretofore in order to balance and match two arbitrary impedances either a combination of devices or a bulky asymmetrical device had to be utilized. Moreover, previously developed devices have been characterized as having narrow bandwidth. Others in use are subject to extremely narrow ranges of operation before impedance mismatches again occur.

Specifically, there exists a general class of devices for RF coupling between balanced and unbalanced sources and loads: Such devices are known in the art as "baluns". Most, however, are able to match only equal impedances or, an impedance ratio of 4 to 1.

Heretofore, transformers were also used. However, bandwidth is a problem with such means. In particular for tuned transformers the bandwidth is extremely narrow. Because of field perturbations in many situations the asymmetrical geometry of the transformer renders it inadequate for matching and balancing. Moreover, in utilizing transformers, direct current distribution is always disturbed which in many situations makes their effective use considerably more difficult.

It is therefore an object of this invention to provide a coupling device for simultaneously balancing and matching between arbitrary impedances over a wide range of frequencies.

It is therefore another object of this invention to provide a coupling device for simultaneously balancing and matching between arbitrary impedances which is very small, symmetrical, and does not affect direct current distribution.

It is yet another object of this invention to provide a coupling device which can match between any two-terminal loads and sources regardless of balanced or unbalanced conditions, different or equivalent.

These and other objects of the present invention will become more fully apparent with reference to the following specifications and drawings which relate to a particular preferred embodiment of the present invention.

SUMMARY OF THE INVENTION

In accordance with this invention a new and novel coupling device for simultaneously balancing and matching between two arbitrary impedances by providing an electrical impedance match and an electrical balance for the terminations of said impedances is specified. This coupling device comprises a tapered line usually extending over several wavelengths and coiled into a helix of gradually increasing pitch. The tapered line comprises two equal lengths of conductive wire insulated with respect to each other by a dielectric material, said tapered line also being immersed in said material. Tapered dimensions are determined by first specifying arbitrary impedances and with said lines fixed in a single plane adjusting taper to match one set impedance to another set impedance utilizing time-

domain reflectometry for minimum reflection. The tapered line is rolled into a helix and the pitch of said helix is then adjusted by time-domain reflectometry to provide minimum reflection within said device. The device when interconnecting the said impedances provides balancing and matching for the interconnection of said impedances.

BRIEF DESCRIPTION OF THE DRAWINGS

The specific nature of this invention as well as other objects, aspects, uses, and advantages thereof will clearly appear from the following description and from the accompanying drawings, in which:

FIG. 1 is an illustration of a tapered line adjusted by time-domain reflectometry to provide matching between a 50 ohm and 130 ohm impedance.

FIG. 2 is an illustration of the device of this invention.

FIG. 3 is a time-domain reflectogram of an antenna impedance match by the device of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The device and method for making the device of the present invention will be easily understood in its particular aspects by reference first to FIG. 1 wherein there is shown a tapered line, having a twisted portion at the more closely spaced end, for use in the specific embodiment of this invention. The particular embodiment to be described is utilized to match a spiral antenna having an input impedance of 130 ohms to an unbalanced coaxial line having an impedance of 50 ohms.

To provide a transition from the unbalanced 50 ohm coaxial line to a balanced spiral antenna having an input impedance of 130 ohms at 550 megacycles, two lengths 11 of wire of no. 30 gauge are selected having a length of approximately 3 feet. Therefore, L equals 3 feet. In FIG. 1 for this particular application and specification, impedance Z_1 is equal to 50 ohms and is connected at point 10. An impedance Z_3 is 130 ohms and is connected to the tapered line at termination 12. The separation p near termination 10 is approximately 0.01 inches and the separation q at termination 12 is approximately 0.05 inches. Utilizing 30 gauge insulated copper wire having a length L equal to 3 feet provides a tapered line having an impedance Z_2 of approximately 276 ohms. The dimensions of the tapered line shown in FIG. 1 are determined utilizing time-domain reflectometry whereby the impedance Z_3 of the spiral equivalent to 130 ohms is matched to the impedance Z_1 equivalent to 50 ohms by adjustment of the taper, i.e., the relative dimensions of the spacings p and q, by adjustment for minimum reflection. The tapered line 11, once the above dimensions are determined and fixed, is coated with a flexible epoxy 15 or similar material such as silastic. While the flexible epoxy 15 or similar material is permitted to set the spacing q is readjusted using time-domain reflectometry in order to compensate for the dielectric constant of the epoxy 15.

The tapered line 11 once the epoxy is permitted to set after readjustment for the dielectric constant is rolled on a teflon core 36 into a helix 13, depicted in FIG. 2. The pitch of the helix 13 is adjusted for minimum reflection within said helix 13 by utilization of time domain reflectometry to provide minimum reflection between terminations 10 and 12. The device as rolled into helix 13 is coated with epoxy 20. The pitch

of the helix is again readjusted to compensate for the dielectric constant of the added epoxy 20 by utilization of time-domain reflectometry to provide minimal reflection when said device is interconnected between impedances Z_1 and Z_3 . The epoxy 20 is permitted to set. Upon setting, the teflon core 36 is removed and the internal space of the helix is filled with more epoxy. The epoxy filling the core of said helix is permitted to set and as a consequence of said setting a device 13 as depicted in FIG. 2 is provided.

The device shown and illustrated in FIG. 2 provides balanced energy transmission between a 50 ohm coaxial input and a 130 ohm balanced input of a spiral antenna. This device, in coupling between said input and said antenna, also provides matching between said impedances. This device as depicted in FIG. 2 has a length equal to 2.5 inches, a 0.25 inch diameter, and an average spacing between alternate turns approximately equal to 0.075 inches.

In FIG. 2, the tapered line 11 of FIG. 1 is shown rolled into a helix 13 imbedded in epoxy material 15 and 20 having input termination 10 and output termination 12 to form a coupling device for simultaneously balancing and matching between the two above specified impedances.

It is useful to note that the helical structure manufactured by the above described step is first a tapered line whose line of symmetry is equidistant from each said wire and centrally located in the dielectric sheet of the device. When the device is rolled on the teflon core the line of symmetry becomes flexed into the geometry of a helix.

In FIG. 3 is shown a time-domain reflectogram 50 whereby with the above specified device a 50 ohm transmission line of source input is matched to a 130 ohm spiral antenna impedance. Region I is indicative of the transmission line. Region II is indicative of the preferred performance of the coupling device as presented herein in this invention. Region III is indicative of the spiral antenna having an input impedance of approximately 130 ohms.

The helix provides inductive reactance large compared to the impedances to be matched and as a result

accommodates different conditions of unbalance between the input and output.

The helix may also be built and suspended in air or a vacuum. In these embodiments and in an embodiment which uses a flexible dielectric the electrical parameters of the device may be varied by stretching or compressing it. By virtue of this variable feature the device can be adapted to other preselected and arbitrarily related impedances.

It is to be understood that the inventor does not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art.

What is claimed is:

1. In combination with a radio frequency coupling device of the type comprising a helix of two conductive lines wherein each line has an input terminal and each line has an output terminal and wherein said input terminals are separated from each other by a first spacing therebetween and said output terminals are separated by a second spacing therebetween different from said first spacing, and wherein said lines have an approximately linearly increasing separation therebetween and wherein said lines are adapted to interconnect two preselected arbitrary impedances and adapted to electrically match and electrically balance these arbitrary impedances, the improvement comprising:

means for adjusting the length of said helix while maintaining constant said separation between said lines.

2. The invention of claim 1 wherein said means comprises a flexible strip of solid dielectric material, having uniform thickness and width, wound onto a hollow cylinder, said strip having said lines embedded lengthwise therein.

3. The combination of claim 2 wherein said device is completely immersed in an inflexible dielectric material.

4. The combination of claim 3 wherein said flexible dielectric material and said inflexible dielectric material are both thermosetting substances.

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