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UNBALANCED LINE DIRECTIONAL COUPLERS AND TELEVISION FREQUENCY TRANSLATING SYSTEMS UTILIZING SAID COUPLERS

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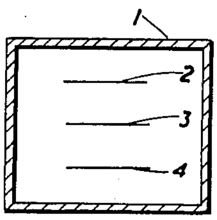

FIG. 1.

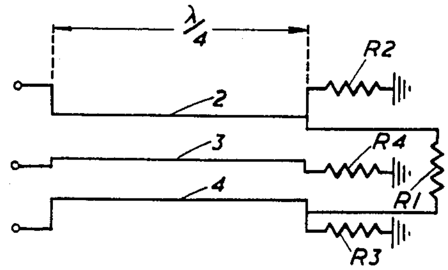

FIG. 2.

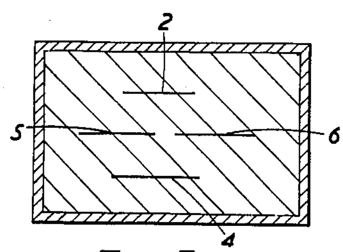

FIG. 3.

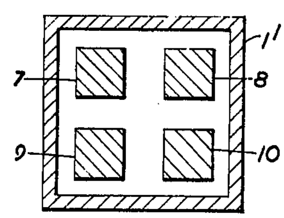

FIG. 4.

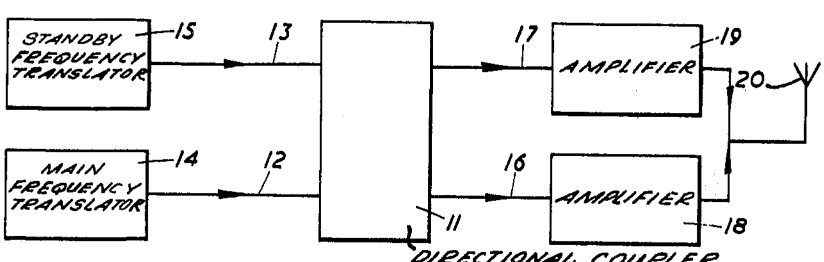

FIG. 5.

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UNBALANCED LINE DIRECTIONAL COUPLERS AND TELEVISION FREQUENCY TRANSLATING SYSTEMS UTILIZING SAID COUPLERS

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11 Claims. (Cl. 333—10)

This invention relates to directional couplers and has for its object to provide improved directional couplers of the unbalanced line type.

According to this invention an unbalanced-line directional coupler comprises at least three conductors of length equal to an odd number (including unity) of quarter wavelengths at a frequency within the range for which the coupler is designed to operate, each of said conductors forming, in conjunction with a ground plane, an unbalanced line, two of said conductors being in coupling relationship with the third but otherwise substantially uncoupled to one another, matching terminations for said conductors at corresponding ends thereof and signal connecting means at the other corresponding ends thereof. Preferably said signal connecting means comprise means for applying input singals to either of said two conductors and means for taking output signals from the third.

According to a feature of this invention an unbalanced-line directional coupler comprises four conductors of length equal to an odd number (including unity) of quarter wavelengths at a frequency within the range for which the coupler is designed to operate, each of said conductors forming, in conjunction with a ground plane, an unbalanced line, each of said conductors being in coupling relationship with two of the others but otherwise substantially uncoupled to the remaining one, matching terminations for said conductors at corresponding ends thereof, means for applying input signals to either of two substantially uncoupled conductors and means for taking output signals from the remaining conductors.

Preferably said two uncoupled conductors are so connected to one another at said corresponding ends that signals induced in one of them and resulting from signals applied to the other are substantially cancelled.

Preferably, also, said two conductors are connected, at the ends opposite those having said matching terminations, to equal impedances through paths differing in electrical length by an odd number (including unity) of quarter wavelengths.

In one arrangement said conductors are flat strip conductors and in another arrangement they are bars, preferably square-section bars.

In one embodiment in accordance with the above-mentioned feature of the invention there are four flat strip conductors, two being mounted with their faces parallel in the one plane and the other two mounted one on each side of said one plane and in planes parallel thereto, each of said other two conductors being arranged to couple equally to both the co-planar conductors.

In another, and preferred, embodiment in accordance with the above-mentioned feature of the invention, there are four square sectioned bar conductors arranged at the four corners of a square, each bar presenting a flat face to the two adjacent bars.

According to a subsidiary feature of the invention a television frequency translating system includes a directional coupler in accordance with the above-mentioned feature of the invention, two television frequency translator only one of which is arranged to be operative at any one time, means for connecting each of said translators to a different one of said two conductors to apply

input signals thereto, two amplifiers and means for connecting the input of each amplifier to a different one of the two remaining conductors.

Preferably said two translators are similar and are connected to said directional coupler through paths which differ in electrical length by an odd number (including unity) of quarter wavelengths.

The invention is further described with reference to the accompanying drawings in which FIG. 1 illustrates schematically an embodiment of the invention using only three conductors; FIG. 2 is a theoretical diagram referring to the embodiment of FIG. 1; FIGS. 3 and 4 are schematic diagrams of embodiments of the invention using four conductors; and FIG. 5 is a block schematic diagram of a television frequency translating system in accordance with the invention.

Referring to FIG. 1, **1** is a ground plane conductor surrounding an enclosure. Three strip line conductors **2**, **3** and **4**, each a quarter of a wavelength long at a frequency within the range for which the coupler is designed to operate, are arranged in equally spaced parallel planes with the faces of the conductors towards one another. Preferably the conductors **2**, **3** and **4** are surrounded by a solid dielectric which serves to support them. At one end of the conductors **2**, **3** and **4** there are provided coaxial connectors (not shown), one for each of the three conductors, and at the other end there are provided three resistive matching terminations (not shown), each connected between a different one of said three conductors and the ground plane conductor **1**.

Preferably conductors **2** and **4** constitute input signal conductors and conductor **3** the output signal conductor, and in use input signals are applied at any one time to only one of the conductors **2** and **4** while the input end of the other is preferably connected to an impedance of the same value as the impedance of the signal source connected to said one conductor.

Referring to FIG. 2 in which corresponding conductors carry the same references as in FIG. 1, it may be shown that when an input signal is applied to one of the input conductors, say the conductor **2**, when the conductors are properly terminated there will be set up on conductor **3** two travelling waves of equal amplitude. The phase relation between these two waves is such that there exists a standing wave on conductor **3** having a voltage node at the matched end of the conductor and a voltage antinode at the other end. Furthermore, due to the coupling between conductors **3** and **4**, a travelling wave will also be set up on conductor **4** and the existence of a mismatched load at one end of the conductor **4** will cause a variation in the amplitude of the standing wave on conductor **3**. This defect, however, may be overcome as shown in FIG. 2 by connecting a resistance R1 between the matched terminated ends of conductors **2** and **4** of such value as to set up in conductor **4** a second travelling wave which will cancel that induced from conductor **3**. In the arrangement illustrated in FIGS. 1 and 2 the values of the resistance R2 and R3 are of course so chosen in conjunction with the value of resistance R1 that the conductors **2** and **4** are properly terminated, for example in a practical case, in resistances of 50 ohms, while the value of resistance R4 is such as to properly terminate conductor **3**.

It will be appreciated that, if desired, the coupler of FIG. 1 may be used as a power splitter to produce two equal amplitude, in phase, output signals by applying input signals to conductor **3** and taking output signals from conductors **2** and **4**.

In accordance with a feature of the invention the output conductor **3** of FIGS. 1 and 2 is replaced by two conductors, each of which couples substantially equally to the input conductors but is substantially uncoupled to the other. FIG. 3 shows such an embodiment of the invention in which conductor **3** of FIG. 1 is replaced by two conductors **5** and **6**. Conductors **5** and **6** are again strip line conductors arranged in the same plane and each coupling substantially equally to conductors **2** and **4**. In other respects the embodiment of FIG. 3 is similar to that of FIG. 1 and, as will be obvious, conductors **2** and **4** may be the input conductors and conductors **5** and **6** the output conductors, or vice versa. Preferably, however, whichever two conductors are chosen as the input conductors will have a resistance, such as the resistance of **R1** of FIG. 2, connected between them at their matched terminated ends for the purposes already described with reference to FIG. 2. It will be appreciated that with the embodiment of FIG. 3 input signals applied to either of the two input conductors will induce two equal in-phase signals on the two output conductors.

FIG. 4 shows a further embodiment in accordance with a feature of the invention in which the grounded plane conductor **1'** is square in cross-section and in which the four coupling conductors **7**, **8**, **9** and **10** each comprise a square section bar with the four bars arranged at the corners of a square, each bar presenting a flat face to the two adjacent bars. In this embodiment the dielectric within the ground plane conductor **1'** may conveniently be air and the bars may be supported in obvious manner at both ends. In the embodiment of FIG. 4 conductors **7** and **10** may be the input conductors and conductors **8** and **9** may be the output conductors, or vice versa. In all other respects the embodiment of FIG. 4 is similar to that of FIG. 3.

Referring to FIG. 5 which shows a television frequency translating system, a directional coupler **11**, which may be as shown in either FIG. 3 or FIG. 4, has its two input conductors connected via paths **12** and **13** to two similar frequency translators **14** and **15** only one of which is operative at any one time, one being a so-called main translator and the other a so-called stand-by translator. The frequency translators **14** and **15** are of course devices which serve to change the frequency of an incoming carrier wave from one value to another. Such frequency translators are well known in the art and therefore do not require further description herein. A number of suitable frequency translators that could readily be used in practicing the invention are disclosed in the treatise, Electronics and Radio Engineering, by F. E. Terman, Fourth Edition, 1955, at pages 568 to 581 which concern the topic of frequency translation. Specifically, the pentagrid mixer circuit referred to in Section 16–11, pages 570 and 571, and illustrated by FIGURE 16–17 of Terman, op. cit., may serve as the frequency translators **14** and **15**. Whichever translator is not operative is nevertheless always connected to the coupler **11** so that the impedances presented at the translator ends of the paths **12** and **13** are always the same. Furthermore, the paths **12** and **13** are arranged to differ in electrical length by a quarter of a wavelength at the operating frequency so that any out-of-balance signals appearing on the two input conductors of coupler **11** will cancel one another after reflection at the translators **14** and **15**.

The output conductors of coupler **11** are connected over paths **16** and **17** to two similar amplifiers **18** and **19** whose outputs, which are of equal value and in phase, are combined, as conventionally illustrated, and fed to a common aerial **20**. The amplifiers **18** and **19** are also of known construction so that a detailed description of them is unnecessary. But reference may be had, if required, to Electronics and Radio Engineering, Terman, op. cit., pages 412 to 424, describing a number of amplifiers which could be used with the present invention. Specifically, the double-tuned wideband amplifier described by Terman in Section 12–7, pages 416 to 418, and shown in FIGURE 12–11 (b) may be employed for each amplifier **18** and **19**.

In the case in which the two amplifiers **18** and **19** are not properly matched to the coupler **11**, isolation between the two coupler outputs may be achieved by connecting a resistance of proper value between the terminated ends of the two output lines of the coupler in similar manner to that in which the resistance **R1** is connected between the lines **2** and **4** in FIGURE 2.

It will be seen that the directional coupler in accordance with the present invention provides a very simple means for deriving from a single input signal two output signals. Although in one practical embodiment the two output signals are arranged to be 12db down on the input signal, this is not essential and the couplings may be varied in accordance with known principles to give any desired relationship between input and output.

I claim:

1. An unbalanced line directional coupler of comprising a ground plane, at least three conductors of length equal to an odd number (including unity) of quarter wavelengths at a frequency within the range for which the coupler is designed to operate, each of said conductors forming, in conjunction with said ground plane, an unbalanced line, two of said conductors being in coupling relationship with the third but otherwise substantially uncoupled to one another, a matching termination for each of said conductors at corresponding ends thereof, and signal connecting means at the other corresponding ends of said conductors.

2. A coupler as claimed in claim **1** wherein said signal connecting means comprise means for applying input sigals to either of said two conductors and means for taking output signals from the third.

3. An unbalanced line directional coupler comprising a ground plane, four conductors of length equal to an odd number (including unity) of quarter wavelengths at a frequency within the range for which the coupler is designed to operate, each of said conductors forming, in conjunction with said ground plane, an unbalanced line, each of said conductors being in coupling relationship with two of the others but otherwise substantially uncoupled to the remaining one, a matching termination for each of said conductors at corresponding ends thereof, means for applying input signals to either of two substantially uncoupled conductors, and means for taking output signals from the remaining conductors.

4. A coupler as claimed in claim **3**, and further comprising means connecting said two conductors to one another at said corresponding ends for substantially cancelling signals induced in either one of them which result from signals applied to the other.

5. A coupler as claimed in claim **2** wherein said two conductors are connected, at the ends opposite those having said matched terminations, to equal impedance through paths differing in electrical length by an odd number (including unity) of quarter wavelengths.

6. A coupler as claimed in claim **1** wherein the conductors are of flat strip conductors.

7. A coupler as claimed in claim **3** wherein the conductors are conductive bars.

8. A coupler as claimed in claim **3** wherein there are four flat strip conductors, two being mounted with their faces parallel in the one plane and the other two mounted one on each side of said one plane and in planes parallel thereto, each of said other two conductors being arranged to couple equally to both the co-planar conductors.

9. A coupler as claimed in claim **7** wherein there are four square sectioned bar conductors arranged at the four corners of a square, each bar presenting a flat face to the two adjacent bars.

10. A television frequency translating system including a coupler as claimed in claim **3**, two television frequency translators only one of which is arranged to be operative at any one time, means for connecting each of said translators to a different one of said two uncoupled conductors of the coupler to apply input signals thereto, two amplifiers, and means for connecting the input of each amplifier to a different one of the two remaining conductors of said coupler.

11. A television frequency translating system as claimed in claim **10** wherein the two translators are similar and are connected to the coupler through paths which differ in electrical length by an odd number (including unity) of quarter wave lengths.

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