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DIRECTIONAL COUPLER

Filed Dec. 24, 1959

Fig. 1

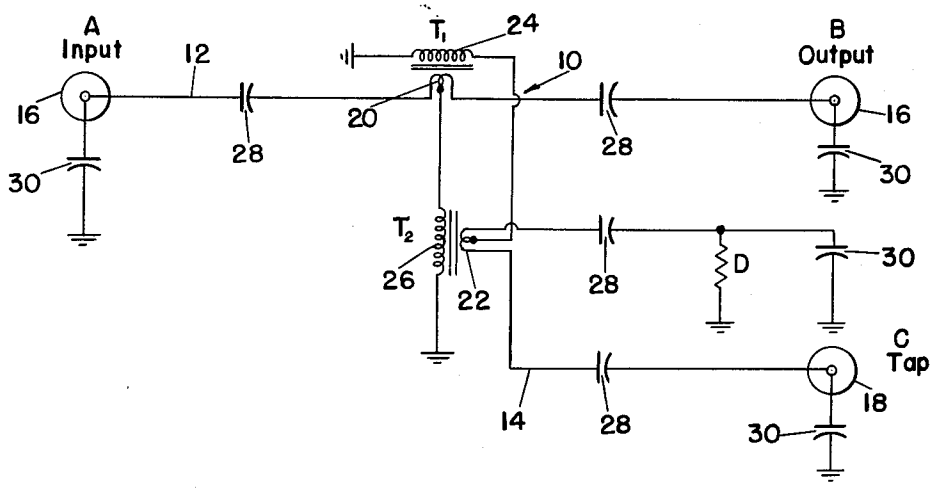
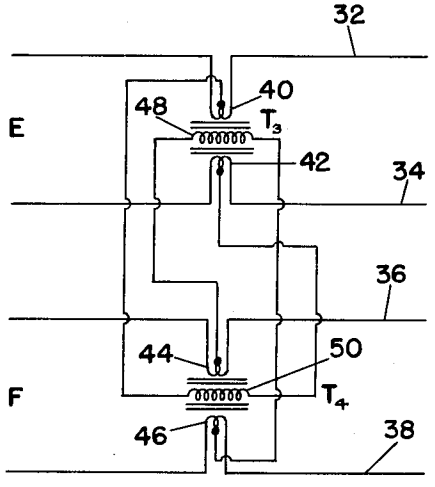


Fig. 2



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DIRECTIONAL COUPLER

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This invention relates to a coupler, a tapping device to divert a minor portion of the energy passing in a main transmission line to a tap or branch line. The coupler may be used either as a splitting or as a mixing device for trunk or feeder line applications or for line bridging amplifying equipment and the like.

The primary object of the invention is to provide a coupler or tapping device which is directional so that it is more sensitive to a wave arriving from one direction than it is to a wave arriving from the other and whose directivity remains high over many decades.

Another object of the invention is to provide a directional coupler whose response is essentially unaffected by frequency over many decades anywhere within the range from sub-audio to several hundred megacycles.

Another object of the invention is to provide a directional coupler having a symmetrical circuit which is inherently impedance matched.

A further object of the invention is to provide a directional coupler having a circuit making available a wide range of tap losses by the variation of one simple parameter.

Yet another object of the invention is to provide a directional coupler which is economical to produce from readily available components.

These and other objects of the invention will become more apparent as the following description proceeds in conjunction with the accompanying drawing, wherein:

FIGURE 1 is a circuit diagram of the directional coupler as applied to coaxial transmission lines; and

FIGURE 2 is a circiut diagram of the directional coupler as applied to two-wire transmission lines.

Specific reference is now made to the drawings wherein similar reference characters are used for corresponding elements throughout. The directional coupler, generally indicated at 10, is adapted for connection at input and output terminals A and B to a main coaxial transmission line and for connection to a branch coaxial transmission line via tap C. The inner conductors of the main and branch lines are shown at 12 and 14 respectively while the outer shields are shown at 16 and 18.

Two substantially identical transformers T_1 and T_2 are provided, the respective primary and secondary windings 20 and 22 of which are connected in series with the main and branch line inner conductors 12 and 14 respectively. The secondary winding 24 of transformer T_1 is connected between the center tap of the primary 22 of transformer T_2 and outer shield 18 of the branch line, while the primary winding 26 of transformer T_2 is connected between the center tap of the primary winding 20 of transformer T_1 and the outer shield 16 of the main line.

Because the primary winding of transformer T_1 responds to the current in the main line and the primary winding 26 of T_2 to the voltage, the coupler inherently possesses basic directional characteristics. A wave arriving at input terminal A, for example, would be partially diverted, a major portion of its energy appearing at output terminal B, and a minor portion, depending on the turns ratio, appearing at terminal C, the branch line output terminal. A very much smaller portion of the total energy would appear at the reverse termination D. Simultaneously, a wave arriving at terminal B would produce a slightly attenuated output at terminal A, the diverted energy would be chiefly dissipated in reverse termination D and an extremely minor portion would appear at the tap output C. Maximum directivity can be realized when care is taken to make the transformers T_1 and T_2 as nearly alike as possible and stray capacitance is kept to a minimum.

Since the construction results in the insertion of impedances both in series and in shunt with each transmission line, it is capable of producing a system which is impedance matched at all four terminals. Moreover, because the only devices involved in the operation of the coupler are transformers, it is readily possible to design them so that the performance is essentially unaffected by frequency over a very wide frequency range. It has been found possible to build couplers operating according to this principle over a frequency range in the order of 100 to 1 for any frequency from sub-audio to several megacycles. To extend the low frequency response, the circuit may include capacitors 28 in series with the main and branch lines which compensate for shunt inductances of the windings 24 and 26. To extend the high frequency response, the circuit may include capacitors 30 in shunt with the main and branch lines which compensate for the series inductances of the windings 20 and 22.

Additionally, a desired charactertistic of a directional coupler is the availability of a wide range of tap losses which, in the instant coupler is readily provided by simply varying one parameter, namely the turns ratio of the transformers, the tap loss increasing with an increase in turns ratio. Because of the symmetry of the circuit, excellent impedance match is obtained at the four terminals over a range of tap losses from 8 db to 30 db (turns ratio from 2.5 to 30).

The applicability of the principles of the instant coupler to two-wire transmission lines is shown in FIGURE 2. The main transmission line E contains two wires 32 and 34 whereas the branch line F contains two wires 36 and 38. A transformer T_3 is provided whose primary windings 40 and 42 are connected in series with the wires 32 and 34 respectively of the main line E. A second transformer T_4, substantially identical with the first, is provided whose secondary windings 44 and 46 are connected in series with the wires 36 and 38 of the branch line F. The secondary winding 48 of transformer T_3 is connected between the center tap of the winding 44 and the center tap of the winding 46 of transformer T_4 and thus across the branch line F. Similarly, the primary winding 50 of transformer T_4 is connected between the center tap of the primary winding 40 and the center tap of the primary winding 42 of the transformer T_3 and thus across the main transmission line E.

Capacitors may be inserted in series and in shunt with the elements of the two-wire coupler to extend its frequency response in the manner directly analogous with that indicated hereinabove in the case of the coaxial line coupler.

While preferred embodiments of the invention have here been shown and described, minor variations may be made by skilled artisans without departing from the spirit of the invention and the scope of the appended claims.

I claim:

1. In combination with a main and a branch transmission line, a means to divert a minor portion of the energy passing in the main line to the branch line, said means having directional properties and consisting essentially of a pair of input terminals and a first and a second pair of output terminals for coupling to said main and branch transmission lines, and a circuit consisting only of bidirectional circuit elements coupling said input terminals to said first and second output terminals, said circuit including first and second substantially identical transformers each having primary and secondary windings, and means coupling said windings to transmit signals from said input terminals to said output terminals

and to minimize transmission of signals from said first pair of output terminals to said second pair of output terminals, said coupling means including means connecting said windings to insert impedances both in series and in shunt with said branch and main transmission lines for impedance matching throughout the circuit, the primary winding of said first transformer being connected in a path between one of said input terminals and one of said first output terminals, the secondary winding of said first transformer and part of the secondary winding of said second transformer being connected in series between said second output terminals, and the primary winding of said second transformer being connected to the primary winding of said first transformer and in shunt with said path between said input and first output terminals.

2. The combination of claim 1 wherein said terminals are adapted for connection to two-wire transmission lines.

3. In combination with first and second impedance matched transmission lines, each line including two conductors, a means to divert a minor portion of the energy passing in the first line to the second line, said means having directional properties and consisting essentially of first and second substantially identical transformers each having primary and secondary windings, the respective primary and secondary windings of said first and second transformers being connected in series with at least one conductor of said first and second transmission lines respectively, the primary winding of said second transformer being connected between the conductors of said first transmission line, and the secondary winding of said first transformer being connected between the conductors of said second transmission line.

4. A directional coupler for coupling a first transmission line to a second transmission line comprising an input terminal and a first output terminal adapted for connection to the first line, and a second output terminal adapted for connection to the second line, and a circuit consisting only of bidirectional elements coupling the input terminal to the first and second output terminals to transmit signals from the input to the output terminals but to minimize transmission of signals from said first to said second output terminals, said circuit being symmetrical and including first and second substantially identical transformers each having primary and secondary windings, the primary windings of the first transformer being connected between said input terminal and said first output terminal, the secondary winding of said first transformer being connected to an intermediate tap on the secondary of said second transformer, a terminal of the secondary winding of said second transformer being connected to said second output terminal, and the primary winding of said second transformer being connected to an intermediate tap on the primary of said first transformer.

5. A directional coupler for coupling a first transmission line to a second transmission line comprising an input terminal and a first output terminal adapted for connection to the first line, and a second output terminal adapted for connection to the second line, and a circuit consisting only of bidirectional elements coupling the input terminal to the first and second output terminals to transmit signals from the input to the output terminals but to minimize transmission of signals from said first to said second output terminal, said circuit including first and second transformers each having primary and secondary windings, the primary winding of the first transformer being connected between said input terminal and said first output terminal, the secondary winding of said first transformer being connected to an intermediate tap on the secondary of said second transformer, a terminal of the secondary winding of said second transformer being connected to said second output terminal, and the primary winding of said second transformer being connected to an intermediate tap on the primary of said first transformer, and means for providing a terminating impedance for signals transmitted from said first output terminal, said terminating means being coupled to another terminal of the secondary of said second transformer.

6. A directional coupler as recited in claim 5 wherein said circuit further includes capacitors connected in series between said terminals and the primary winding of said first transformer and the secondary winding of said second transformer, and a separate capacitor connected to each of said terminals so as to be in shunt with the associated one of said lines.

7. A directional coupler for coupling a first transmission line to a second transmission line comprising a circuit consisting only of bidirectional elements for coupling to said lines for transmitting signals along said first line and signals to said second line in accordance with the direction of transmission along said first line, said circuit including first and second transformers each having primary and secondary windings, means for connecting the primary winding of the first transformer in series with the first line and the primary winding of said second transformer across said first line, the secondary winding of said first transformer being directly connected to an intermediate terminal on the secondary of said second transformer, the primary winding of said second transformer being directly connected to an intermediate terminal on the primary of said first transformer, and means for connecting the secondary of said second transformer in series with said second line and the secondary of said first transformer across said second line.

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