

MICROWAVE LOOP DIRECTIONAL COUPLER

FIELD OF THE INVENTION

This invention relates to couplers for electromagnetically coupling any amount of a microwave signal to an adjacent conductor by forming a loop between the input and coupled output.

BACKGROUND OF THE INVENTION

Directional couplers are used to perform a variety of functions in many applications. However, their primary function is to couple a predetermined amount of an incoming signal onto a closely placed conductor. The spacing between the input (excited) line and the output (coupled) line is very critical in determining the amount of coupled signal. Naturally, a smaller spacing is required for increased coupled signal power. The reduced spacing between the conductors makes fabrication of the coupler very difficult and highly impractical. Several forms of coupled lines have been developed to alleviate the problem of reduced coupled line spacing with increased coupling. However, these couplers introduce new difficulties such as connection of bond wires which adds to cost and may cause performance deviations.

OBJECT OF THE INVENTION

It is a primary object of the invention to provide a coupler for electromagnetically coupling any amount of microwave signal power onto an adjacent passive conductor. It is another object of the invention to provide a coupler which can be realised with entirely planar means thereby making it suitable for use with both ceramic and soft substrates.

2-19-11-13

SUMMARY OF THE INVENTION

The directional coupler includes an input microstrip-line, a loop-shaped microstrip line and an output microstrip line. A microwave applied to the input line is coupled by electromagnetic coupling to the loop and then travel a quarter wavelength long uniform impedance line before it is coupled to the output line. The rest of the microwave travels another quarter wavelength along

the uniform impedance line before it is coupled to the input line from the opposite direction. The input line is separated from the loop by a uniform distance s_1 for a length l_1 . The input line and that section of the loop have the same width w_1 . The output line is separated from the loop by a uniform distance s_2 for a length l_2 . The loop is one wavelength long at the design centre frequency.

In one embodiment of the present invention, the coupled section employs uniform microstrip lines with smooth coupled edges. In another embodiment, the coupled section employs sawtooth, sine or rectangular wave or wiggly, shaped coupled edges with uniform outer edges. In yet another embodiment, the directional coupler is formed by cascading two or more loop couplers. This arrangement effectively increases the frequency bandwidth of the directional coupler. The cascaded couplers can use both uniform and sawtooth-like or other wiggly shaped coupled edges. Yet in another embodiment of the invention the directional coupler uses coplanar structure.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings which are incorporated into and constitute a part of the description of the invention, illustrate embodiments of the invention and serve to explain the principles of the invention. It is to be understood that the drawings are designed for purposes of illustration only, and not as a definition of the limits of the invention for which reference should be made to the claims appearing at the end of the description.

FIG. 1 is a plan view of one embodiment of a microwave directional coupler according to the present invention showing the input and output lines and the loop thereof;

FIG. 2 is a transverse sectional view taken along the line A-A of FIG. 1 showing the microstrip coupled lines of the loop coupler.

FIG. 3 is a plan view of another embodiment of a microwave directional coupler showing the coupled lines with sawtooth-like inner edges for the purpose of phase velocity equalisation.

FIG. 4 is a plan view of another embodiment of a microwave directional coupler constructed by cascading two similar loop couplers of FIG. 1.

FIG. 5 is a plan view of another embodiment of a microwave directional coupler constructed according to the present invention using coplanar lines;

FIG. 6 is a transverse sectional view taken along the line B-B of FIG. 5 showing the coplanar nature of the loop coupler.

DESCRIPTION OF THE EMBODIMENTS OF THE INVENTION

FIGS. 1 and 2 show one embodiment of the present invention. The loop coupler, indicated by reference numeral 10, is defined by an input coupler 11, an output coupler 13, and a loop 12, formed by connecting the input coupler 11 to the output coupler 13. The uniform microstrip lines indicated by 14 and 14a have the same characteristic impedance; the lines indicated by 14a are a quarter wavelength long. The length of the loop is thus equal to the wavelength. When the gaps s_1 15 and s_2 16 are equal we have a loop filter which is reported in the prior art in Japanese patent specifications numbers 6097703 (Mitsuo & Munenori), 6037520 (Mitsuo, Kazuaki & Munenori), 6037503 (Kazuaki, Makoto & Mitsuo), 5315805 (Kazuaki, Mitsuo & Munenori), and U.S. patent specification 5369383 (Munenori, Makoto, Mitsuo & Kazuaki) and European patent specification 571777 (Fujimura, Hasegawa, Makimoto & Takahashi). When the gaps s_1 15 and s_2 16 are equal

the loop resonates at that frequency which makes its length equal to a wavelength. The present invention uses different gaps for s_1 15 and s_2 16 thereby controlling the amount of power coupled 200. This means that the power at the direct port 400 is no longer nil and hence the loop coupler 10 is formed. Therefore, it is to be understood clearly that using different gaps for s_1 15 and s_2 16 in a microstrip medium is a primary object of the present invention.

Another embodiment of the present invention is shown in FIG. 3 which uses sawtooth-like microstrip lines for the inner edges of the input coupler 11a and the output coupler 13a. When the loop coupler 10 is used as a sampler or for similar applications, the isolated port 300 may be terminated by the characteristic impedance level of the design as it is unused. However, some applications require all the ports of the coupler 10; the isolated port 300 is then required to behave isolated. In order to enable this the coupled sections are modified by a sawtooth-like, rectangular wave-shaped, or other wiggly line to slow down the odd-mode and make it equal to the even-mode.

FIG. 4 shows another embodiment of a microwave loop directional coupler constructed according to the present invention. A loop coupler 10a is cascaded with another loop coupler 10b. The loop coupler 10b is designed to operate at a different frequency so that when its output is added to the output of loop coupler 10a wideband loop coupler 10c is obtained. It should be understood clearly that cascading more than two loop couplers is possible with the present invention and that the cascaded couplers may have coupled sections whose inner edges are modified by sawtooth-line shapes for the purpose of improved isolation.

In the embodiment shown in FIGS. 5 and 6, a loop coupler 10d is constructed using coplanar waveguide technology. This geometry simplifies construction of the coupler as all the lines are constructed on the surface of the substrate. It will be apparent that this embodiment of the present invention may also be used in a cascaded configuration as shown by the embodiment given in FIG. 4. The operation and use of the loop coupler 10d is similar to 10a and 10b. While only a few embodiments of the present invention have

been described and illustrated, it is to be understood that many changes, modifications and variations could be made to the microwave loop coupler of the present invention without departing from the scope or spirit of the invention.

CLAIMS

1. A microwave loop directional coupler comprising an input coupler, an output coupler and a loop formed thereof by connecting the two couplers, characterised in that the spacing between the coupled lines and the loop and the said loop directional coupler is for the said input coupler and output coupler are different and the said spacing is easily realisable by using conventional photolithographic techniques.
2. A microwave loop directional coupler formed by cascading two or more of the microwave loop directional coupler of claim 1 designed to operate at conveniently spaced different frequencies thereby providing an increased frequency band of operation.
3. The microwave loop directional coupler of claim 1 or claim 2, wherein the inner edges of the coupled lines and the corresponding edges of the loop are modified and the said modification is a sawtooth, sinusoidal or rectangular wave, or other wiggly shape.
4. The microwave loop directional coupler of claim 1, 2 or 3, wherein the construction is completely planar using microstrip technology.
5. A microwave loop directional coupler comprising an input coupler, an output coupler and a loop formed thereof by connecting the two couplers, characterised in that the spacing between the coupled lines for the said input coupler and output coupler are different and the said spacing is easily realisable and the said loop directional coupler is realised using coplanar waveguide technology.
6. A microwave loop directional coupler formed by cascading two or more of the microwave loop directional coupler of claim 5 thereby providing an increased frequency band of operation.



7. A microwave loop directional coupler of claim 2 or claim 6, wherein the said cascading is formed by connecting two loop directional couplers with quarter wavelength long lines.

