Extensive Study of Microstrip Directional Coupler Directional Coupler

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Abstract: In the last decade a tremendous changes has been noticed in the field of radio frequency (RF) as well as the microwave communication systems. Directional couplers are comprehensively microstrip couplers are indispensable RF components which are used along with the patch antenna, slot antenna, spiral antenna, dielectric resonator as well as antenna arrays for the purpose of circular polarization as well as directrion finding applications. In this paper the review over latest trends which are based on directional couplers is present. Directional couplers are also used for the designing purpose of the amplifiers, mixers as well as modulators. Since, the couplers are quite simple as well as precise components which can be used for the measurement of microwave signal samples. This paper reviews the designs of microstrip/stripline based designs, single section/two section couplers and coupled/uncoupled transmission lines introduced in between the coupled line sections.Multi section coupled line couplers provide increased bandwidth.

Keywords: Coupled Line Couplers, Directional Coupler, Directivity, Coupling, Uncoupled Transmission Lines.

I. INTRODUCTION

The need to use directional couplers comes from the fact by providing the monitoring to power as well as sampling devices in the microwave circuits. While traversing from time the development stage of the couplers were quite weak coupling as well as it contained narrow bandwidths. But now it is possible to design a rigid couplers, containing any transfer of power (starting from very weak coupling to the total transfer of power) in the respective direction. In this field the bandwidth as well as the capacity to handle power is tremendously improved.

Now comes to the directional coupler- it is mainly a device that samples a small amount of microwave power for the purpose of measurement. The measurement of power includes incident power, reflected power, VSWR values, etc. A directional coupler contains a 4-port waveguide square which contains first or primary main waveguide as well as second or auxiliary waveguide. In the Figure 1 directional coupler is shown. Directional couplers are the passive microwave device which forms the circuits in the microwave applications. The nature of directional couplers should be matched as well as lossly coupled so the possibility to achieve desired coupling will be possible for the desired applications, directivity as well as isolation high as possible, with low insertion losses as well as wide bandwidth.

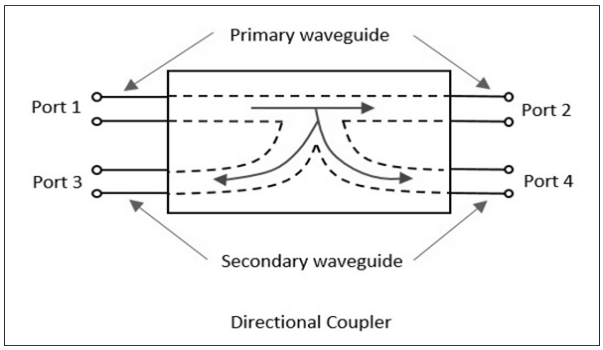

Figure 1: Architectural overview of directional coupler.

Some other application of directional couplers are- measurement of frequency, measurement of power, signal leveling as well as reflection coefficient measurement, measurement of the stationary wave, combination of the microwave signals etc.

Typically coupled-line couplers- this type of directional couplers contains a single or multiple quarter wavelength coupled-line segments which allows the broadening of the operational badwidth. In the recent years a completely new design approach is developed in which the coupled-line sections get connected to each other with the transmission lines.

TRANSMISSION LINE- This section can be used for improving the directivity factor as the delay lines are responsible for the phase velocities in order to become equal and so an overview of these designs helps to enhance the flexibility in the designs of the directional couplers.

This is to the detriment of minor data transfer capacity decrease, marginally poorer directivity as well as inconsistent speeds in even and odd mode mostly in view of the inhomogeneous mode of a microstrip transmission line [2]. As an answer for this issue, Epsilon Negative Transmission Line, lumped-component compensation, an inductor stacked microstrip directional coupler, Coupler multilayer microstrip design are various strategies proposed for improving directivity and coupling element of a coupled line coupler [2]. Different strategies, for example, Lange type couplers, altered Lange type couplers

joining the coplanar waveguide (CPW) and the microstrip procedures, broadside-coupled CPW couplers, pair associated couplers, single-layer structures with a designed ground plane were effective in expanding directivity yet had some flaws on the fronts of holding between the microstrip lines, region involved and entangled structure as well as the manufacturing process [3]

Properties of Directional Couplers

The properties of an ideal directional coupler are as follows.

- Firstly, all the terminations must be matched to the respective ports.
- Whenever the travelling of power occurs from port 1 to port 2, in that case some portion of it gets coupled to port 4 but should not go to port 3.
- Since, it is a bi-directional coupler, so whenever the power travels from 2 port to 1 port, so, some portion should get coupled to 3 port but not 4 port.
- If the power is incident through Port 3, a portion of it is coupled to Port 2, but not to Port 1.
- If the power is incident through Port 4, a portion of it is coupled to Port 1, but not to Port 2.
- Port 1 and 3 are decoupled as are Port 2 and Port 4.

Ideally, the output of Port 3 should be zero. However, practically, a small amount of power called **back power** is observed at Port 3. The figure 1 indicates the power flow in a directional coupler.

II. LITERATURE SURVEY

It is also a type of directional couplers which are generally implemented using the wave guide technology. In which the waveguide microstrip circuits are quite compact as well as light weighted. The microstrip circuits can be build up on the idea by using simple printed circuit board (PCB) approach that will also reduced cost at some level. Further, the microstrip circuits can be integrated with other stripline and coplanar waveguide (CPW) circuits in the same substrate. Branch-line couplers, coupled-line couplers, rat-race couplers are certain couplers that can be implemented in microstrip technology. Branchline and coupled-line couplers offer quadrature phase difference between the output ports. Rat-race couplers offer in-phase and 180º out of phase difference [17].

In this paper [18] author describes Branch-line directional couplers are well-known components in microwave electronics. Typically, such circuits are designed for single-ended operation, in which all the couplers' ports are excited with respect to the common ground potential. Recently there is a growing interest in design of differentially-fed microwave circuits due to their superior response in terms of common-mode interference rejection. In this paper we investigate the possibility of an enhanced bandwidth differentially-fed branch-line directional coupler design. The coupler is designed as a substrate-integrated element, which is required to decrease the overall size of the microwave electronics PCB and allows to utilize outer top and bottom metallization for populating active and passive SMD components of the complex integrated design [18].

In the review [19] author used A novel full-band square waveguide coupler design based on directional couplers which couple the TE10 and TE01 orthogonal modes in a square waveguide is presented. This waveguide coupler is aimed at the calibration of polarization receivers. This is composed of a pair of rectangular waveguide directional couplers, which are rotated 90° between them and both are coupled to the main square waveguide through each one of the square section walls. The coupler covers the full frequency band from 10 to 18.9 GHz. It has inherent low cross-polarization, which allows obtaining any known elliptically polarized wave at a square waveguide when a signal is applied to the couplers. The fabricated prototype of this coupler exhibits 31 dB of coupling, with flatness of ±3.8 dB and excellent cross polarization better than 50 dB over the whole band [19].

this manuscript [20] author used traditional microstrip directional couplers we get coupling of 8-40 dB range and the directivity is generally 20dB. The presented design deals with two practical problems faced in the traditional microstrip coupled line couplers, after refering the top view of the design layout [20] we identify that, there is a problem of narrow separation between the coupled transmission lines. This is generally greater than 0.1 mm in the PCB fabrication process. Secondly, there is a difference in even and odd mode velocities in the coupled lines which also cause less directivity. In this design, two coupled-line sections are combined, which are different from the other designs which employ non-coupled connecting delay lines. The performance of this design is evident with tight coupling coefficient and high-directivity performance which can be replicated in a PCB microstrip structure [20].

This design [21] of coupler provides tight coupling over a wide range of bandwidth. It used Composite right/left-handed transmission line (CRLH) transmission lines and a much advanced conductor material YBCO thin film high temperature superconductor (HTS) in place of Copper. The use of a superconducting material is responsible for achieving high directivity. In traditional coupled line couplers conducting material is Copper which is inhomogenous which leads to loss in directivity, the

superconducting material ensures that directivity is not lost while CRLH transmission lines ensure a tight coupling is achieved over a wide range of frequencies. CRLH unit cells helps in controlling characteristic impedance and dispersion relation in the lines while use of HTS ensure low conductor losses and high directivity. Both these improvements improved the performance of CRLH HTS based directional coupler [21].

III. PROBLEM DEFINITION

In this section some problems which seems to be occurred in the previous work are mention-

1. Firstly, there is a problem of narrow separation between the coupled transmission lines.
2. Secondly, there is a difference in even and odd mode velocities in the coupled lines which also cause lessdirectivity.

IV. CONCLUSION

In this review paper we have gone through the latest trends followed in the outlet design of the directional couplers. Also some new materials also introduced in this paper which are helpful in the design process as well as improving the efficiency of the couplers. Some meta-materials are being used in order to improve the coupling. The high temperature superconductors are also finding their applications in order to brin out better directivity as compare to the presently used inhomogenous conductor which is copper. So, these are the primary factor of improvement in coupling, directivity, bandwidth and control of losses will pave way towards more efficient power networks and wide range of applications.

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