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# A Survey On Theoretical Analysis Of Different Planar Transmission Lines

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***Abstract* — *This paper describes the comparative analysis of different types of planar transmission lines. Basically the stripline, microstrip and coplanar waveguide (CPW) has been discussed in brief. This paper shows focus on the advantage and tremendous characteristics of coplanar waveguide over the other transmission lines and with the help of CPW transmission techniques, substantial amount of efficiency has been achieved. The analysis is based on the basis of various parameters like, characteristics impedance, strip width, dielectric constants of the substrate, modes of field, dispersion, attenuation, component mounting, radiation and the frequency applied.***

***Keywords* — *CPW, microstrip, stripline, fringing field, Quasi-TEM***

## I. Introduction

### [A] Striplines

Striplines are the first planar version of the coaxial transmission line for use in RF and Microwave ICs. Striplines are essentially a printed circuit version of the coaxial transmission line. Strip line requires three layers of conductors where the internal conductor is commonly called the "trace or hot conductor," where as the other two, always associated with signal ground are called "ground" conductors [6]. Its dominant mode of propagation is pure transverse electromagnetic (TEM). In strip lines the possibility of generating unwanted parallel-plate modes (even or odd) at high frequency due to two parallel ground planes, so the strip lines is more suitable for use at low microwave frequencies [11]. On the behalf of configurationally analysis the considerations are:-

i. In a stripline configuration, the trace is sandwiched between ground layers providing the trace an excellent reference and shielding on both sides. The downside generally requires more layers and it is not possible to achieve this arrangement with a two layer board.
ii. The stripline have the same relative dielectric constant on both sides of the trace and have better grounding when compared to micro strip. But strip line trace is slower than a micro strip because of effective $\varepsilon_r$ is more.

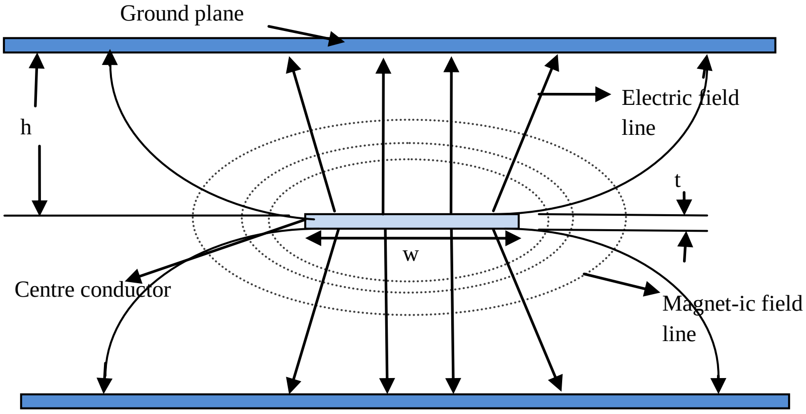


**Fig. 1 Schematic diagram of stripline transmission line with field pattern.**

On the behalf of observation and study, stripline requires some attention and having some drawbacks: -
In stripline the parallel-plate mode is suppressed with metalized via holes connecting the two ground planes so the attention is to keep that, vias should be placed properly (spacing between them should be of the range one-eighth of a wavelength in the dielectric) so that the potential difference between two ground planes becomes same. The mistakes can change the parameter like [11]:-

a) When the vias are closely placed to the edge of the strip, they can disturb its characteristics impedance.
b) When the vias are separated largely than a pseudo rectangular waveguide mode can be excited.

 

c) Any practical Stripline has three Sources of Attenuation, due to:
   - Finite conductivity of its conductors.
   - Finite resistivity and dumping phenomena of the dielectric.
   - Magnetic resonances.

d) The dielectric loss is proportional to frequency, and it is the dominant loss factor at higher frequencies.

e) The ohmic skin losses in the strip conductor and the ground plane, depends on the conductivity of the metal conductors and on any surface roughness may be caused in fabrication of the transmission line and in some cases it becomes more.

**[B] Microstrip**

The microstrip is the printed circuit version of a wire over a ground plane, and so it tends to radiate as the spacing between the ground plane and the strip increases. The microstrip line is widely used as planer transmission for RF and Microwave circuits due to its planar nature, ease of fabrication, ease of integration with solid-state devices, good heat sink, and good mechanical support [8].

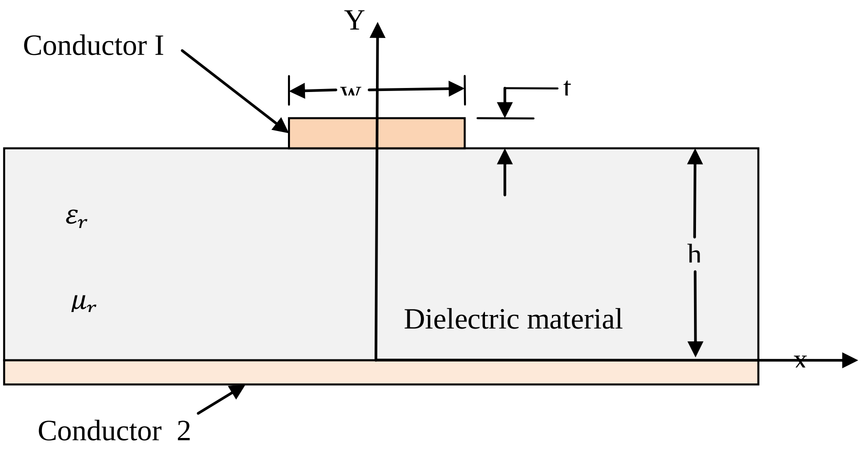


**Fig. 2 Microstrip transmission line**

In case of microstrip some attentions, source of attenuation and drawbacks are always being concern:-

a) Source of attenuation:-
   - Line conductors have finite conductibility.
   - Finite resistivity of the substrate and its dumping phenomena.

b) With the increase in frequency, the effective dielectric constant ($\varepsilon_{eff}$) Increases towards that of the substrate, so that the phase velocity gradually decreases.

c) In microstrip the radiation effects are present due to as the microstrip is an open transmission line.

d) As the microstrip using high dielectric material and accurate matching, conductor and dielectric losses are predominant.

e) As the microstrip having the decreasing ratio of strip width of conductor (w) to substrate thickness (w/h) so dispersion is predominant [2].

f) The conductor losses increase with increase in characteristics impedance due to greater resistance of narrow strip (w).

g) The power handling capacity of microstrip is limited by increase in temperature which is caused by conductor (ohmic) and dielectric losses.

**[C] Coplanar waveguide**

The coplanar waveguide (CPW) is an alternative to microstrip and strip line that place both, the signal and ground current on the same layer [9]. Since 1969 it has rapidly gained widespread use of RF and Microwave integrated circuits due to its many attractive features such as active device can be mounted on top of circuit, elimination of via holes in connecting circuit elements to ground, it has very high frequency response, immediate access to adjust power plane, low radiation and dispersion loss, continuous, lower cross talk as well as CPW design technique allows to reduce the circuit size by about 30%, it facilitates easy shunt as well as series surface mounting of active and passive devices, ease in realizing compact balanced circuits, easy integration with solid-state devices and ease the fabrications too with respect to other conventional transmission lines or devices [9]. The coplanar technology provides the possibility to design highly condensed microwave integrated circuits, especially if additional use is made of a lumped element technique. Very small circuit layouts can be made up to highest frequencies. Because the fundamental coplanar waveguide does not use a conducting ground plane on the backside of the substrate material, the parasitic capacitances of the lumped circuit components like spiral inductors or inter-digital capacitors are small compared to the microstrip case. This results in a much higher first resonant frequency of these components so that even at millimetre-wave frequencies (e.g., 40–60 GHz) a lumped element technique can be used in coplanar monolithic integrated circuits.

 

Structure:- basically in coplanar waveguide (CPW) structure the conductor formed a centre strip separated by a narrow gap from two ground plane on either side. The gap in the coplanar waveguide is usually very small and supports electric fields primarily concentrated in the dielectric [10].

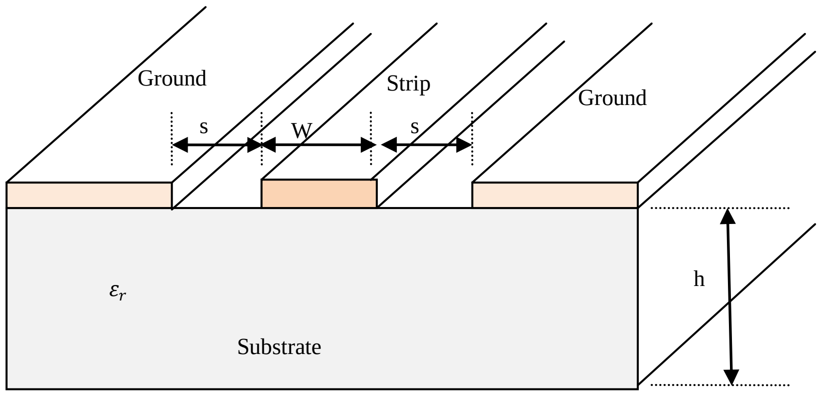


**Fig. 3 coplanar waveguide of finite substrate.**

The coplanar waveguide has some drawbacks but many of the useful characteristics which leads to the other transmission lines like: -

a) Since the number of the electric and magnetic field lines in the air is higher than the number of the same lines in case of microstrip, the effective dielectric constant ($\varepsilon_{eff}$) of coplanar waveguide is typically lower than the effective dielectric constant ($\varepsilon_{eff}$) for microstrip, so the maximum characteristics impedance value are higher than the microstrip value [6].
b) In case of coplanar waveguide the actual dimensions of the centre-strip, the separation, the thickness and permittivity of dielectric substrate determined the effective dielectric constant, attenuation and the characteristics impedance of the line.
c) We can minimize the radiation in case of coplanar waveguide and to concentrate the fields in the substrate area by the help of making dielectric substrate thickness equal to about twice the gap width.
d) As the coplanar waveguide has two ground planes, so the ease in maintaining at the same potential to prevent unwanted modes from propagating.
e) It is well studied that a coplanar waveguide containing little fringing field in the air space, so the coplanar waveguide (CPW) exhibits low dispersion.
f) Frequency dispersion in the case of coplanar waveguide is generally small, but there is a slight dependence on line dimensions, and narrow lines are less frequency dispersive than the wide lines [4].
g) The grounded coplanar waveguide (GCPW) is used on printed circuit boards as an alternative choice of microstrip line. With vias connecting the ground planes, the grounded coplanar waveguide is less possibility to radiate and has higher isolation than microstrip.
h) There is always a ground plane exists between any two adjacent lines, hence cross talk effects between adjacent lines are very week [1]. So regarding these facts coplanar waveguide circuits can be made denser than conventional microstrip circuits.

## III. Conclusion

In this paper we studied the stripline, microstrip line and coplanar waveguide characteristics by analysing the different modes, parameters, physical structure and its fabrications. A true alternative to the stripline and microstrip especially for application in modern and highly condensed microwave integrated circuit design and hybrid circuit design is the coplanar waveguide.

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