ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 14, March 2016

DESIGN OF ECPW FOR HIGH SPEED DEVICES

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ABSTRACT-In communication, a Transmission line is a specialized cable or other structure designed to carry alternating current of radiofrequency, that is current with a frequency high enough that their wave nature must be taken into account. Transmission Lines are used for the purpose such as connecting radio transmitters and receivers with their antennas, distributing cable television signals, trunklines routing calls between telephone switching centers, computer network connections and high speed computer data bus. The phase velocity, higher impedance, low insertion loss are the main characteristics required for a transmission line. These characteristics are prevailing in Elevated coplanar waveguide (ECPW).The characteristic impedance and dielectric constant are the parameters computed and analyzed with various substrate and slot widths. Model of ECPW performance has been analyzed based on the characteristic impedance and dielectric constant. The ECPW model exhibits less return loss when compared with CPW which is suitable for high speed devices.

1.INTRODUCTION

Coplanar waveguides are a type of transmission line used in microwave integrated circuits (MICs) and in monolithic microwave integrated circuits(MMICs)[1]. The unique feature of this transmission line is that it is uniplanar in construction, which implies that all the conductors are placed on the same plane. It has several advantages like less radiation loss, easy fabrication and it is cost effective.CPW is used in high speed devices and its applications include Amplifiers, Active Combiners, Frequency Doublers, Mixers, and Switches.

Although having various advantage when frequency is increased the characteristic impedance tend to increase which will widen the circuit and lead to circuit complexity[2].To overcome this difficulty ECPW model is proposed in

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which a dielectric substrate is inserted in between the conductor and substrate[3].The elevated structure reduce the return loss and circuit complexity which occured in the CPW. By this way the RF performance improvement of ECPW over CPW is analyzed using HFSS software[4] .

2.DESIGN OF LOADED AND UNLOADED CPW:

2.1 ***UNLOADED CPW***

In CPW the center strip is separated by a narrow gap from two ground planes on either side. The dimensions of the center strip, gap, thickness and permittivity of the dielectric substrate determines the effective dielectric constant, characteristic impedance and the attenuation of the line.

These parameters are obtained by conformal mapping method by assuming that the waveguide is in TEM mode. Figure1: shows the structure and dimensions of CPW. The CPW center width conductor is 2a and the distance of separation between the two semi-infinite ground planes in 2*b*. Consequently the slot width *W* is equal to *b-a*. The dielectric substrate thicknesses are designated as *h*1. The relative permittivity is designated as ε_r. The thickness of the CPW conductors is *t*. The assumptions made are that the conductor thickness *t* is zero.

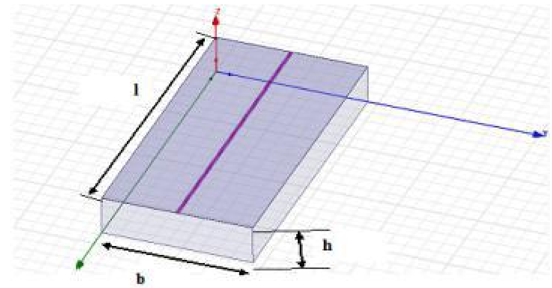

Figure1:Structure and dimensions of CPW

2.2 FORMULA USED

The CPW center strip conductor width *S* is equal to 2*a* and the distance of separation between the two semi-infinite ground planes in 2*b*. The slot width *W*=*b-a*. The dielectric substrate thicknesses are designated as *h*1. The relative permittivity are designated as ε_r. The thickness of the CPW conductors is *t*, height of the substrate is h. CPW conductors and the dielectric substrates are assumed to have perfect conductivity and relative permittivity respectively. In this section expressions for determining characteristic impedance and effective dielectric constant using conformal mapping techniques are presented. The assumptions made are that the conductor thickness *t* is zero. The CPW is then divided into several partial regions and the electric field is assumed to exist only in that partial region. In this manner the capacitance of each partial region is determined separately. The total capacitance c_{cpw}

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is then the sum of the partial capacitances.

$C_{cpw}=C_1+C_2+C_3$

In this equation C_1 and C_2 are the partial capacitance of the CPW with only the lower and the upper dielectric layers, respectively. Further C_{air} is the partial capacitance of the CPW in the absence of all the dielectric layers. The capacitance of CPW is given by

$$C_{ECPW} = 2\,\varepsilon_0\,(\varepsilon_{r1}\ 1)\,\frac{K_1(k)}{K_1(k')} + 4\,\frac{K_0(k)}{K_0(k')}$$

where $\frac{K_1(k)}{K_1(k')}$ is

$$\frac{K(k)}{K(k')} = \frac{\pi}{2\ln\left(\sqrt{\{1-k'\}/\{1+k'\}}\right)}$$

$$k_1 = \{\sinh\left(\frac{\pi s}{4h_1}\right)\}/\{\sinh\left(\frac{\pi(s+2w)}{4h_1}\right)\}$$

$$k_1' = \sqrt{1-k_1^{\,2}}$$

Using these formulas characteristic impedance and effective dielectric constant is obtained. The insertion loss and return loss are analyzed using HFSS software.

2.3 LOADED CPW

In loaded CPW single and multiple switch are placed in the center conductor using post and performance are analyzed. Initially single switch is placed at the center conductor and analyzed. Later multiple switches are placed in equal spacing and the results are analyzed using HFSS software. Then the difference between loaded and unloaded condition is compared. The loaded CPW is as shown in the figure2.

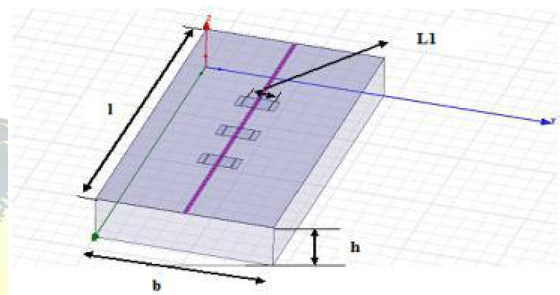

Figure 2 a: Structure and dimensions of CPW when the switch is off.

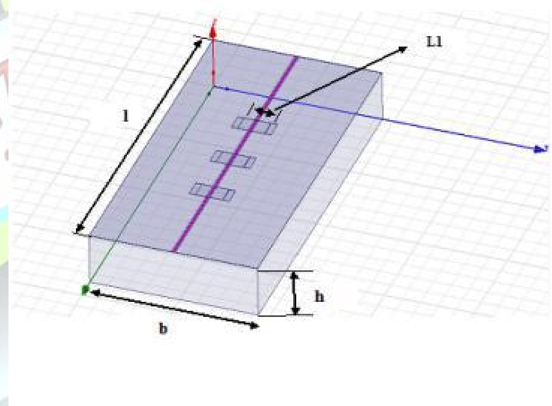

Figure 2 b: Structure and dimensions of CPW when the switch is on.

3.DESIGN OF LOADED AND UNLOADED ECPW

Elevated CPW has been proposed to overcome the problem of implementing high impedance CPW

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transmission lines. Elevated structure is applicable for low-loss Si-MMIC application upto radio frequency. A ground plane is placed on top of the substrate to provide near complete isolation of the elevated CPW traces from the substrate.

*3.1 **UNLOADED ECPW***

In the ECPW structure, the SiO2 under the center strip conductor is higher than that under the ground planes. The elevated CPW not only isolates the CPW from substrates but also weakens magnetic field apparently. The structure provides a transmission line with much reduced dielectric loss, return loss ,insertion loss and provide wide impedance range and it is shown in the figure3.The characteristic impedance is calculated using the formula.

$$Z_0 = \frac{1}{cc_{air}\sqrt{\varepsilon_{eff}}}$$

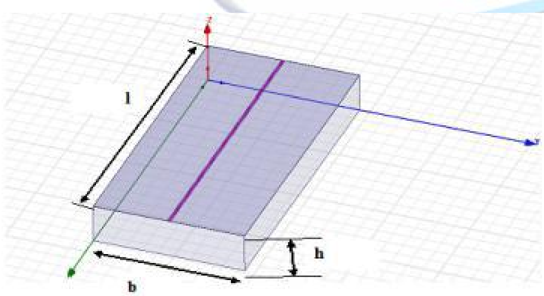

Figure 3:Structure of unloaded ECPW.

3.2 LOADED ECPW

ECPW is loaded by a shunt capacitive switches. Switches are composed of thin metal membrane, which can be electro statically actuated to the RF line using a dc-bias voltage. A shunt capacitive switches consists of a thin metallic membrane "bridge" suspended over the center conductor of a ECPW. When the switch is up, the switch presents a small shunt capacitance to ground. When the switch is pulled down, to the center conductor, the shunt capacitance increases by a factor of 20-100, presenting an RF short. The structure of loaded ECPW is as shown in the figure 4.

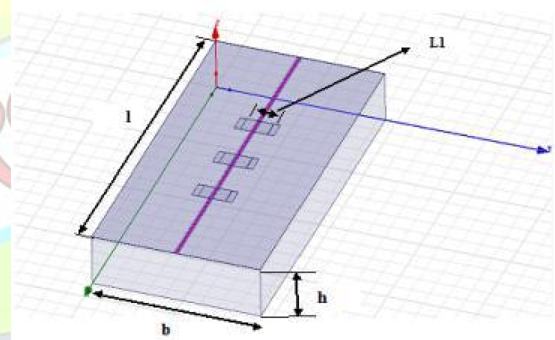

Figure 4a: Structure of loaded ECPW when the switches are on.

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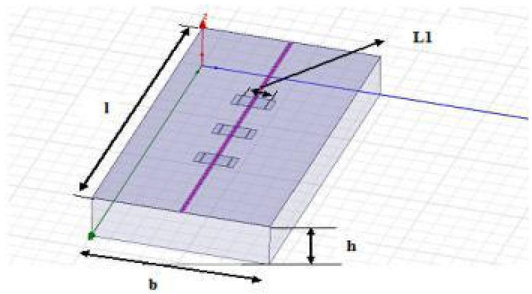

Figure 4b: Structure of loaded ECPW when the switches are on.

The switches has more advantages. It has very little dc power consumption and has very low inter modulation products and can be measured on a high resistivity silicon substrate. The switch length is 300 µm and the anchors are 40 µm from the ECPW ground plane edge. The membrane height is 1.5-2 µm and the membrane width is 2 µm.

5.RESULTS

RETURN LOSS

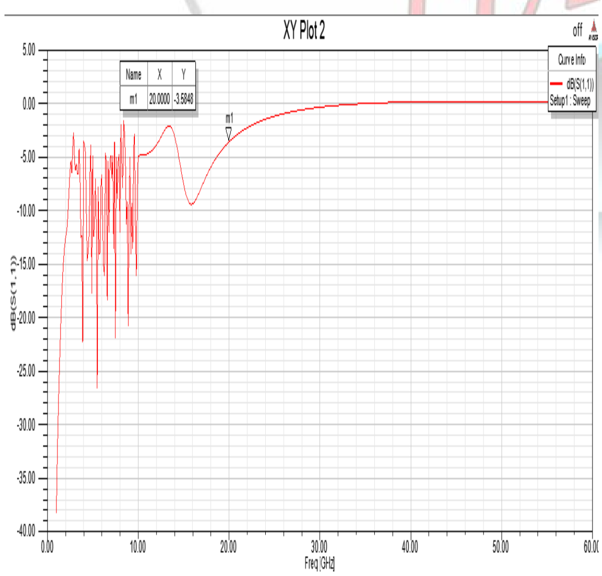

Figure 5: Return loss of unloaded CPW

INSERTION LOSS

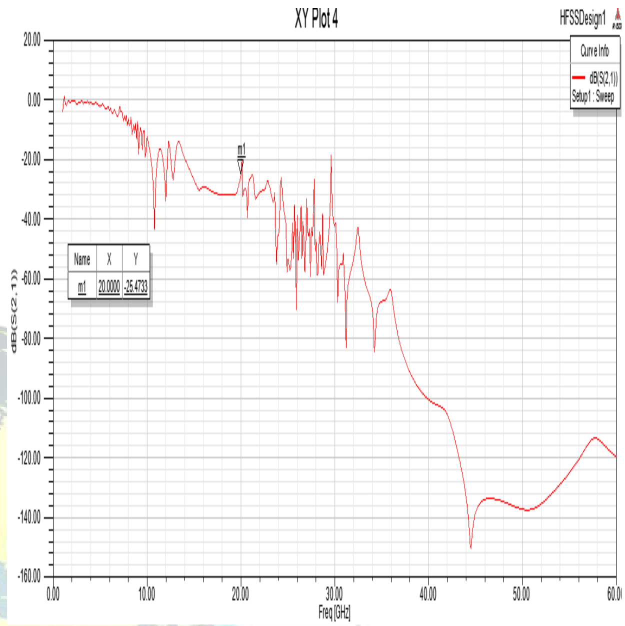

Figure 6: Insertion loss of unloaded CPW

RETURN LOSS

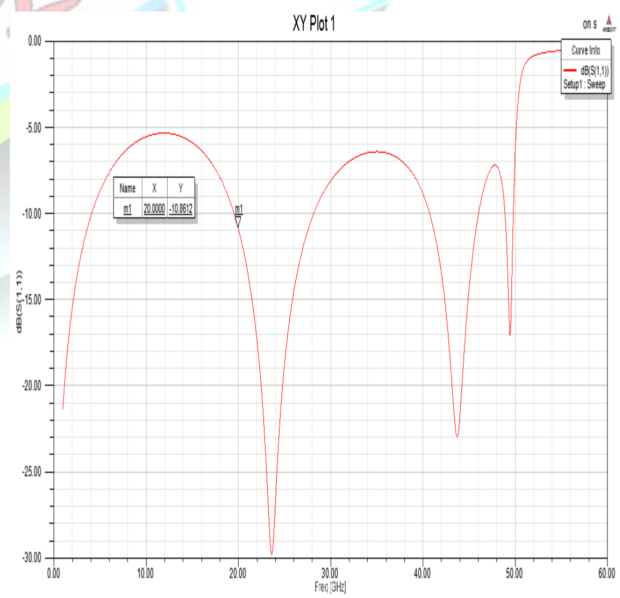

Figure 7: Return loss of loaded CPW when the switches are off

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INSERTION LOSS

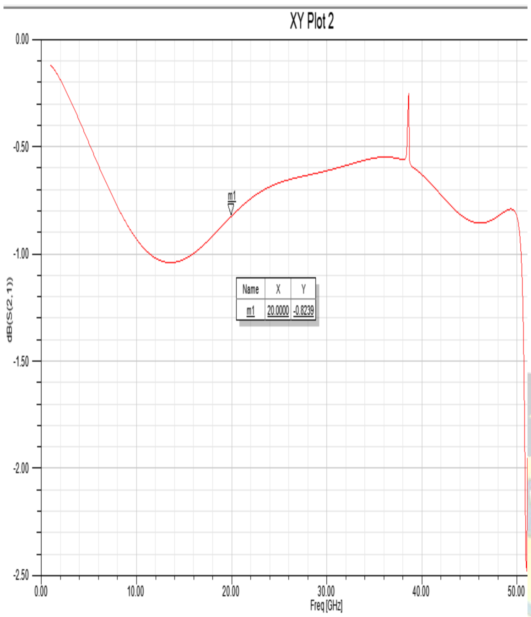

Figure 8: Insertion loss of loaded CPW when the switches are off

RETURN LOSS

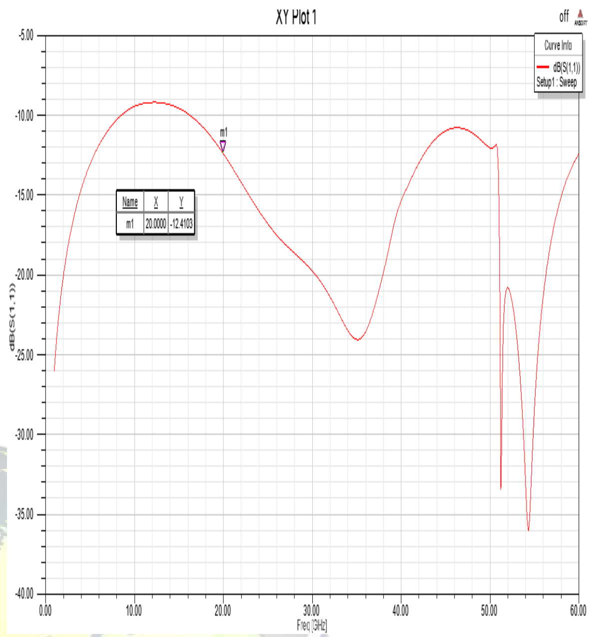

Figure 9: Return loss of loaded CPW when the switches are on

INSERTION LOSS

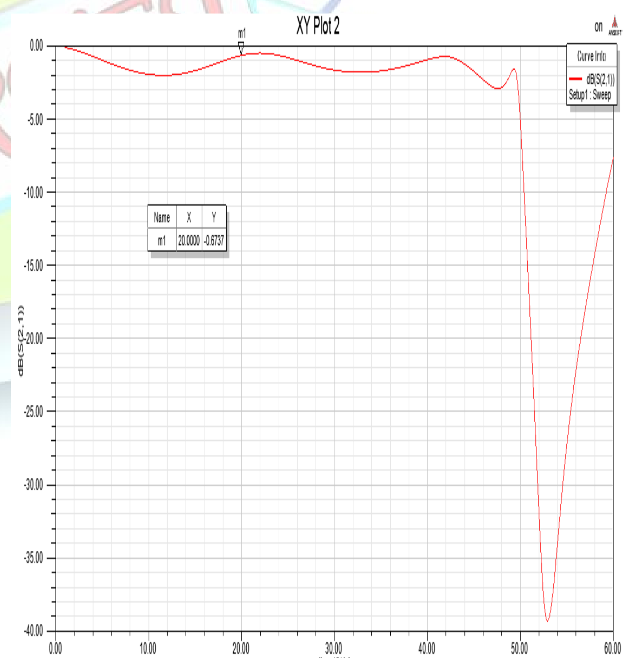

Figure 10: Insertion loss of loaded CPW when the switches are on.

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RETURN LOSS

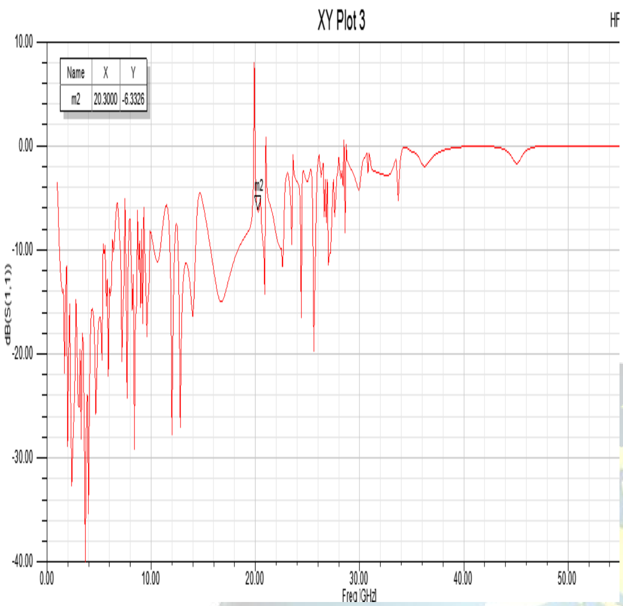

Figure 11: Return loss of unloaded ECPW

RETURN LOSS

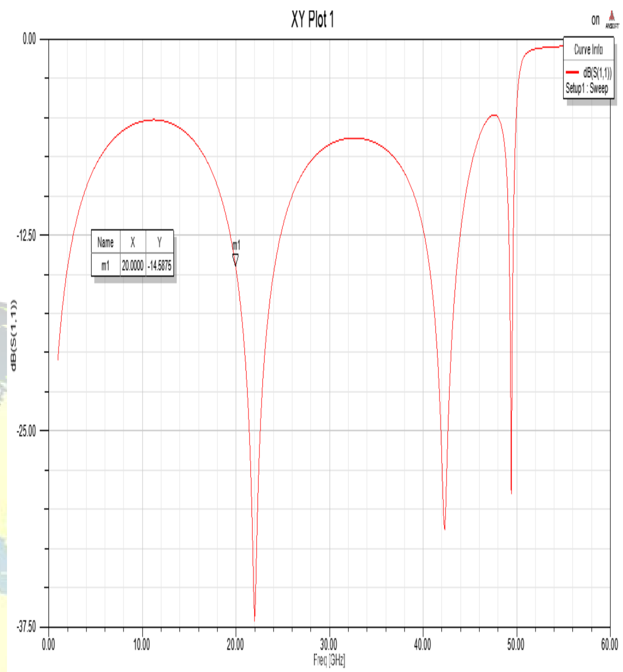

Figure 13: Return loss of loaded ECPW when the switches are off

INSERTION LOSS

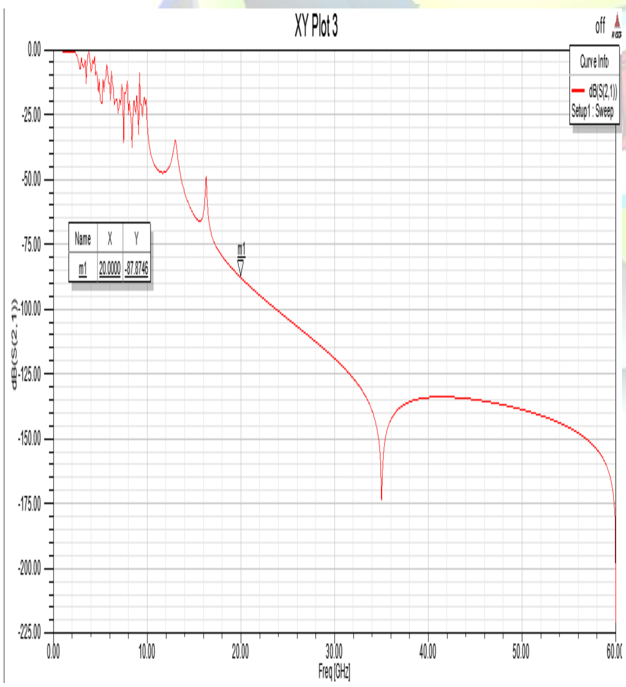

Figure 12: Insertion loss of unloaded ECPW.

INSERTION LOSS

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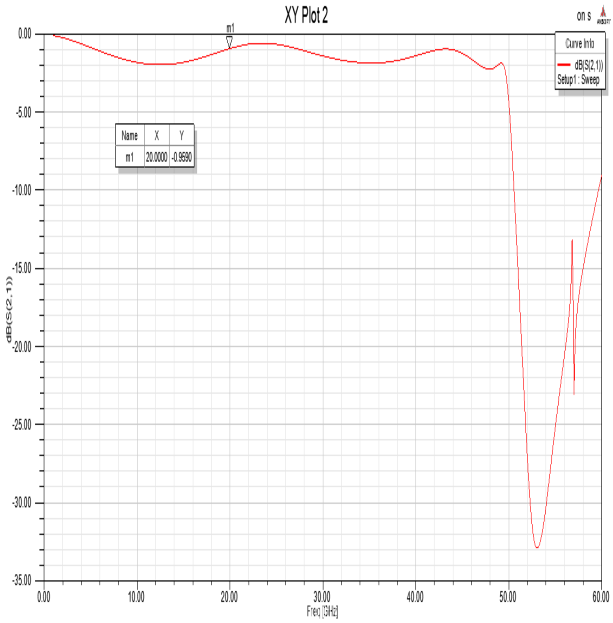

Figure 15: Insertion loss of loaded ECPW when the switches are off.

RETURN LOSS

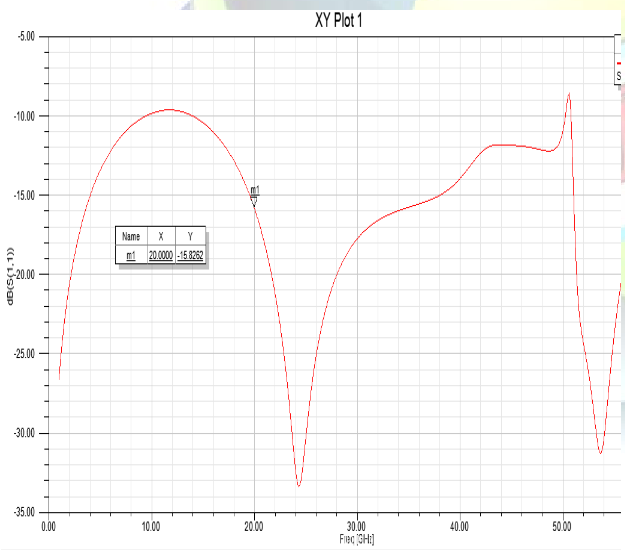

Figure 14: Return loss of loaded ECPW when the switches are on

INSERTION LOSS

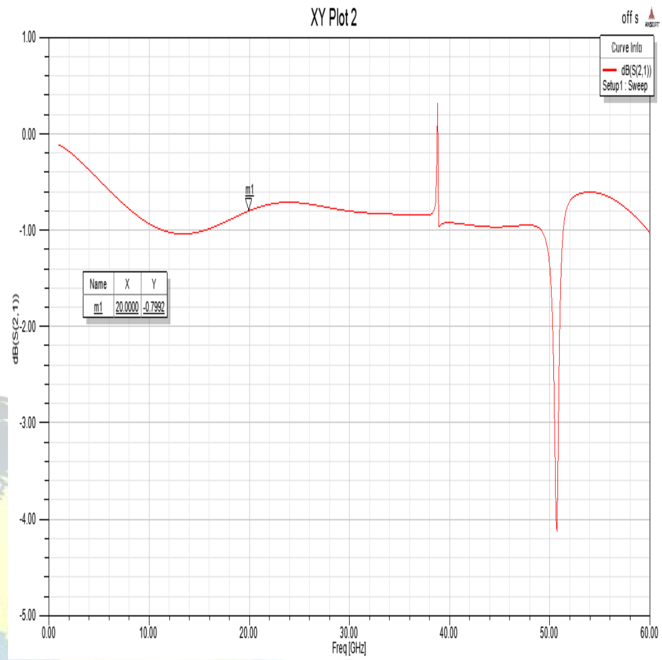

Figure 16: Insertion loss of loaded ECPW when the switches are on.

4.PERFORMANCE MEASURE

WAVEGUDIE / SWITCH STATE	CPW		ECPW	
LOSSES	R.L	I.L	R.L	I.L
ON STATE	-12.4103	-0.6737	-15.8262	-0.7992
OFF STATE	-10.8612	-0.8239	-14.5875	-0.9590

5. CONCLUSION

The RF performance measure such as characteristic impedance ,return loss and insertion loss has been measured. The developed design show good reasonable RF measure. A simple equation has been formulated to calculate the measures. The performance of ECPW is good in agreement. When loaded, it is seen that the loss of switch in up state is limited by transmission lines. Low loss and a simple MMIC compatible fabrication process make ECPW a promising transmission media for MMIC application at the very high end of the mm-wave frequency spectrum.

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