Design Stripline Circulator at 2.5 GHz for Radar Applications

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ABSTRACT

This paper describes the design and simulation of a Y-junction Stripline circulator at 2.5GHz frequency. we show that this nonreciprocal device when externally tuned as a circulator exhibits RLs and ISs of better than 16dB across a wide band; the ILs are on the order of 1 dB within this same band. Results confirm the conclusion that a ferrite with linewidth 480 Oe, saturation magnetization 3900 Gauss and permeability is 11.7 suitable for circulator radar applications.

Keyword: *- stripline circulator; ferrite; fr4 ; optimization design; radar*

1. INTRODUCTION

The circulator is defined as a passive device with 3 or more ports, where power is transferred from one port to the next in a prescribed order. That means for a 3-port circulator (fig.1) power entering port 1 leaves port 2, port 3 is decoupled; power entering port 2 leaves port 3, port 1 is decoupled; and power entering port 3 leaves port I, port 2 is decoupled.

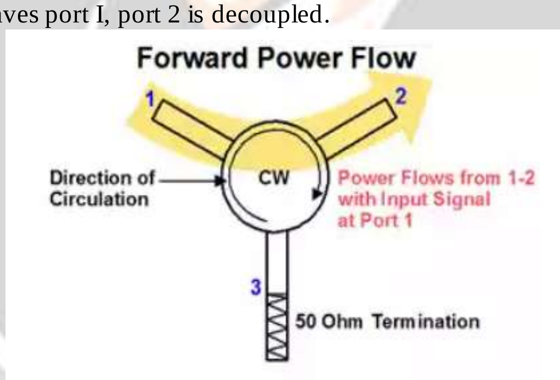

Figure 1 Block diagram of single flow in circulator

In this paper we develop new passive component caring out the function of the circulator. This non reciprocal component will use magnetic material films in order to miniaturize the component and. thus. increase the electronic integration of microwave elements. No external magnets should be used. Among various envisaged structures. The stripline structure was adopted because this planar structure satisfied constraints miniaturisation.

After a theoretical study. design rules of the Y-junction circulator were made. This component was sized according to circulation frequency and maternal parameters. Simulation results are given and a parametric study was proposed to optimise the circulator performances.

2. .CIRCULATOR STRUCTOR AND MAGNETIC MATERIAL

In microstripline Y-junction three-ports circulator is composed of a circular inner conductor from leave three 120 oriented. Below of this inner conductor, there are one circular pucks of ferrite then, one ground planes. Usually. external permanent magnets located on either side of the component provide the magnetic DC field ensuring a longitudinal magnetic polarisation (see figure.2)

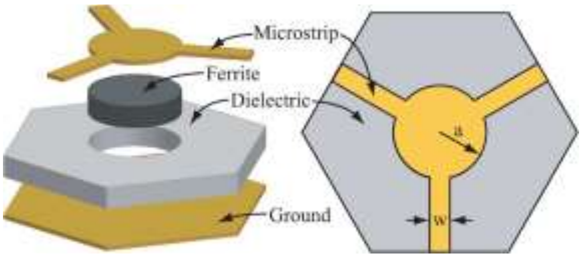

Figure 2 microstripline circulator

The microwave non reciprocal components such as isolators or circulator are based on the gyromagnetic properties of ferrites. I will chose the Nikola zinc(Ni- Zn) ferrite because this magnetic material has a strong uniaxial anisotropy and can be used without permanent magnet, that is very interesting for integration. The magnetic material used for simulation is close to that is deposited at Laboratory. The saturation magnetisation is 3900 Gauss. the magnetic line width is 480Oe and permeability is 11.7.

3. STRIPE LINE CIRCULATOR

A. Design rules of microstripline circulator

Theoretical results obtained by Bosma [9] and Fay and Comstock [8], resulting in proportioning of microstrip line Y-junction three-ports circulator. This is an approximate analytic method which comes before three dimensional electromagnetic simulations realized with Ansoft HFSS software.

1. The internal field Hi of ferrite is defined by

$$H_i = \frac{\lambda \; Ho \; 4\pi Ms}{\sqrt{3} \; w} - 4\pi Ms$$

where λ is the electromagnetic wavelength. W is the stripline width ,4πMs the saturation magnetization

2. External bias field Ho

$$H_0 = \frac{\omega}{\Upsilon}$$

ϒ=gyromagnetic ratio

C= $2.218*10^5$ rad*m/A*sec

3.The radius of ferrite disks is given by

$$R = \frac{1.84 \; \lambda}{2\pi\sqrt{\mu eff}\sqrt{\varepsilon}}$$

where ε is the permittivitvt of ferrite

λ=c/f

c= 11.8*10⁹ inch/sec

4. Effective permeability is define by

$$\mu eff = \frac{Hi+4\pi Ms}{Hi}$$

5. k and u is the potor tensan component of the ferrite. u and k is define by

$$K = \frac{m(h^2-1)}{(h^2-1)^2+s^2}$$

$$\mu = 1 + \frac{hm\,(h^2-1}{(h^2-1)^2- s^2}$$

where

$$m = \frac{4\pi Ms}{Ho}$$

$$h = \frac{Hi}{Ho}$$

$$s = \frac{\Delta H}{Ho}$$

NUMERICAL RESULTS

If we consider the first Bessel's solution of the first resonance mode. we have xj1j = 1.84 and the microstrip line circulator will have the following dimensions R = 6.5mm, h = 2mm with W = 2mm, Hi = 2345 Gauss, Ho= 1100Oe ueff=2.66 and k/u = 0.31 come out for a 2.5 GHz operation. The microstrip line Y-junction three-port circulator described above was simulated with the three-dimensional electromagnetic Ansoft HFSS software. This software operate with finite elements method to mesh the structure and calculate the electromagnetic field of each tetrahedron.

4. SIMULATION CIRCUITS

Hear show in the figure .this is the simulation circuit in HFSS software to following above numerical results

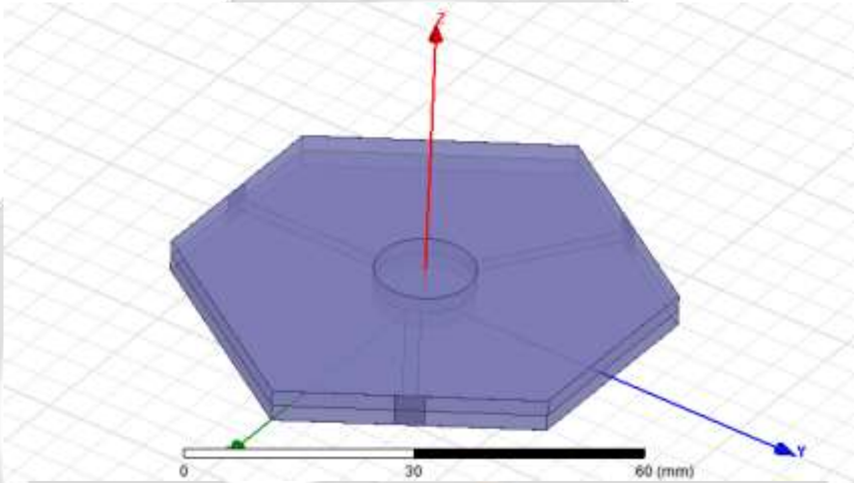

Fig 3 : sneps of stripline in HFSS

5. SIMULATION RESULTS

a. By different radius of ferrite

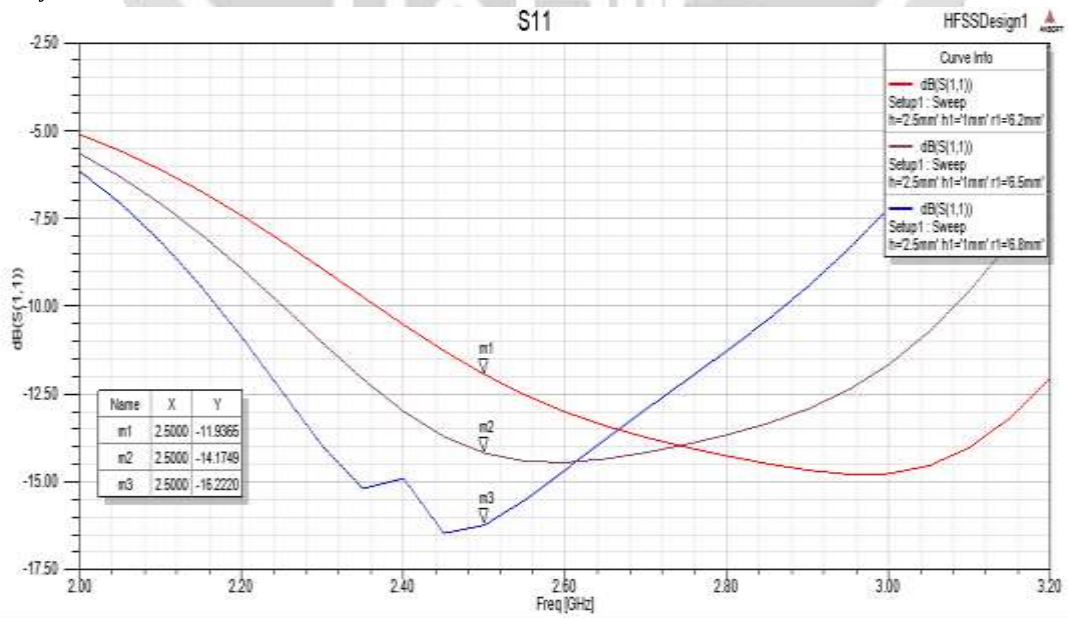

Fig.4:S11 at different radius of ferrite

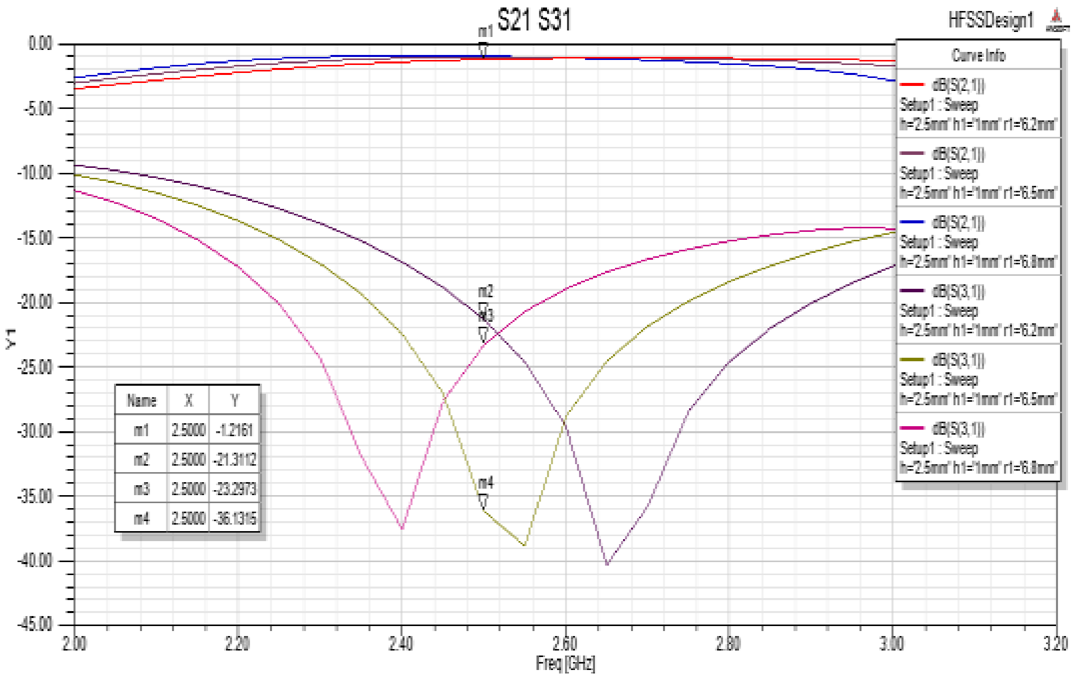

Fig.5:S21and S31 at different radius of ferrite

Hear show the above very radius of stripline optimization graphs. Hear we will increase the radius of stripline then increase the return loss but the isolation is increase up to 6.5 mm radius after increase the radius then decrease the isolation values. Hear also observe the insertion loss is constant.

b. By different height of ferrite

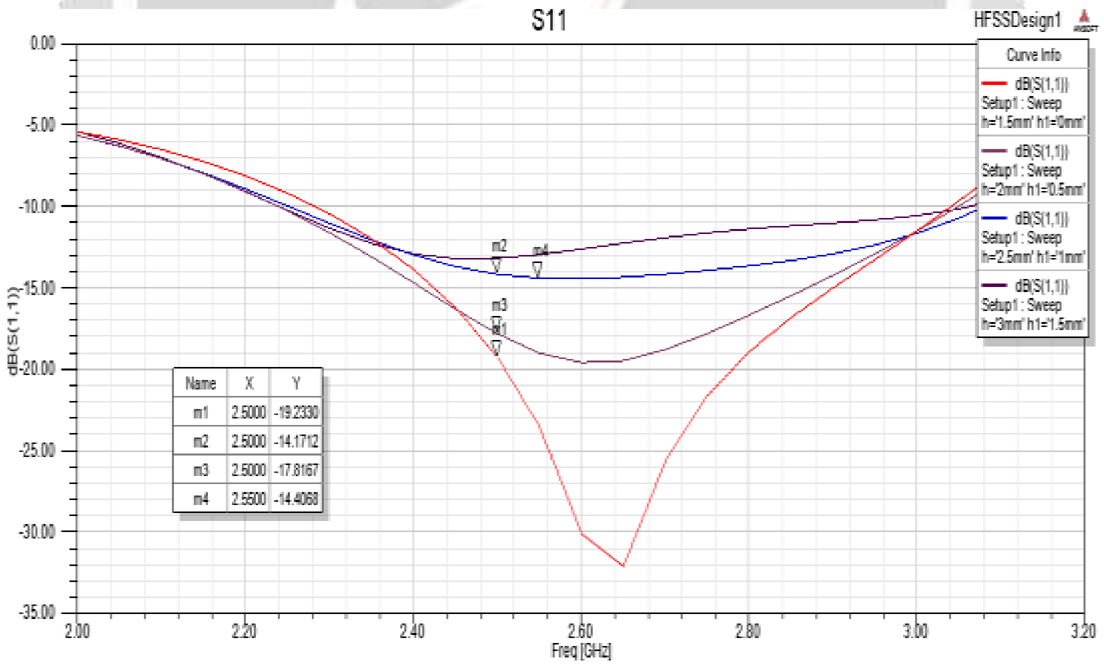

Fig.6:S11 at different height of ferrite

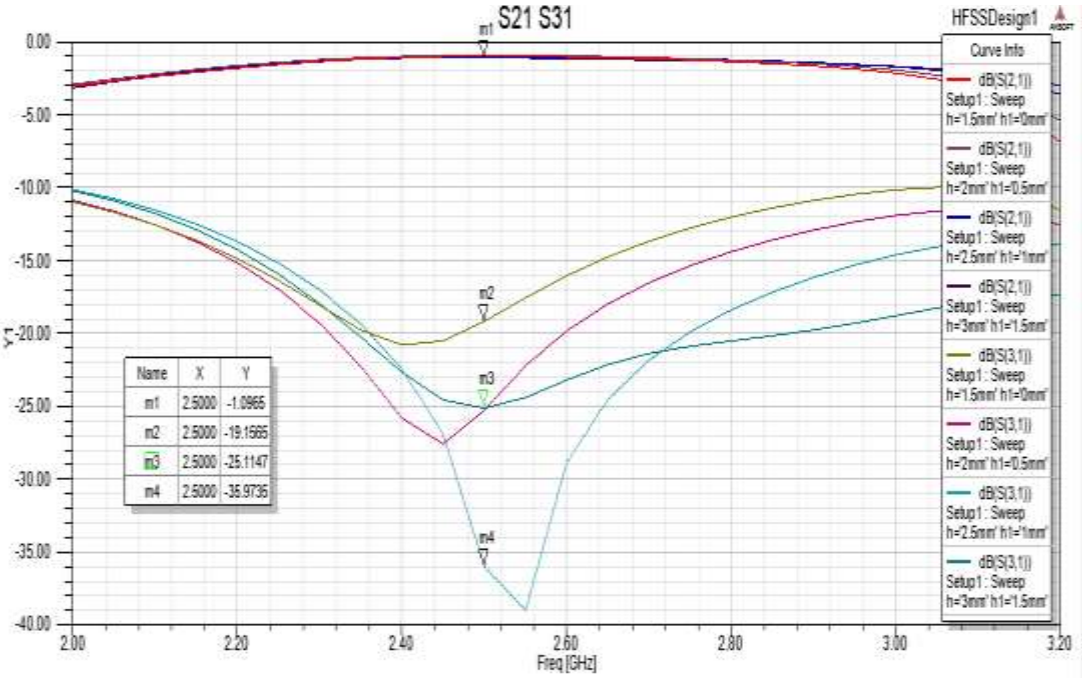

Fig.7:S21 and S31 at different height of ferrite

Hear show the above very height of the stripline optimization graphs. Hear we will increase the ferrite height then increase the isolation up to 2.5mm after increase the height of ferrite then decrease the isolation. Return loss is increase up to 1.5 mm height after increase the height of ferrite then decrease the return loss values. Hear also observe the insertion loss is constant.

C.By different width of stripline

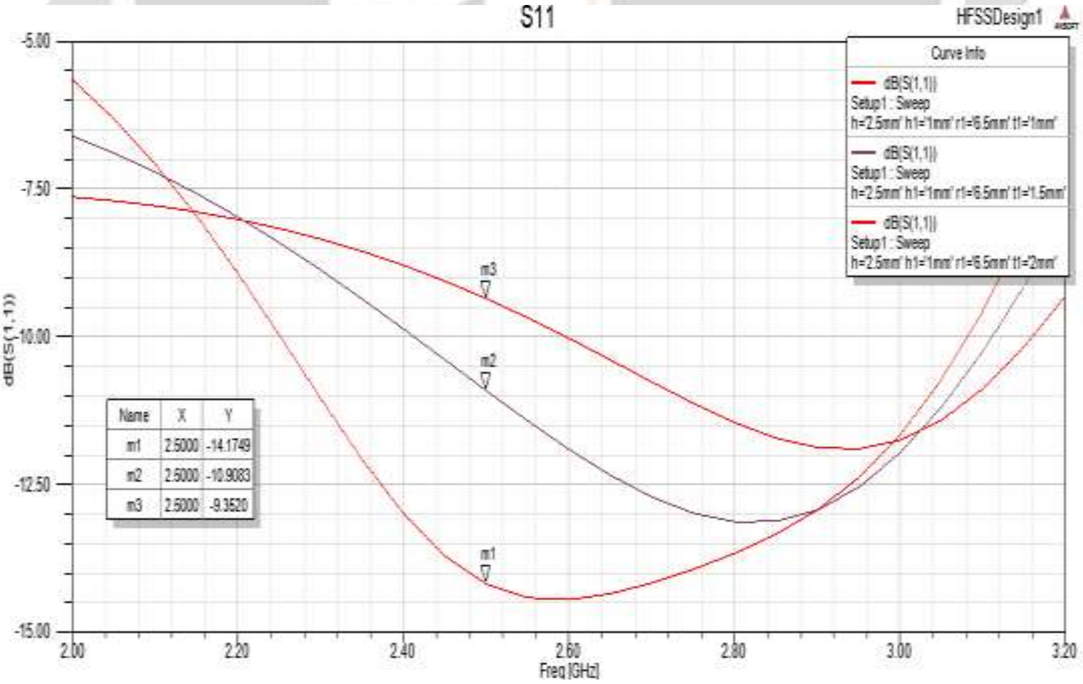

Fig.8:S11 at different width of the stripline

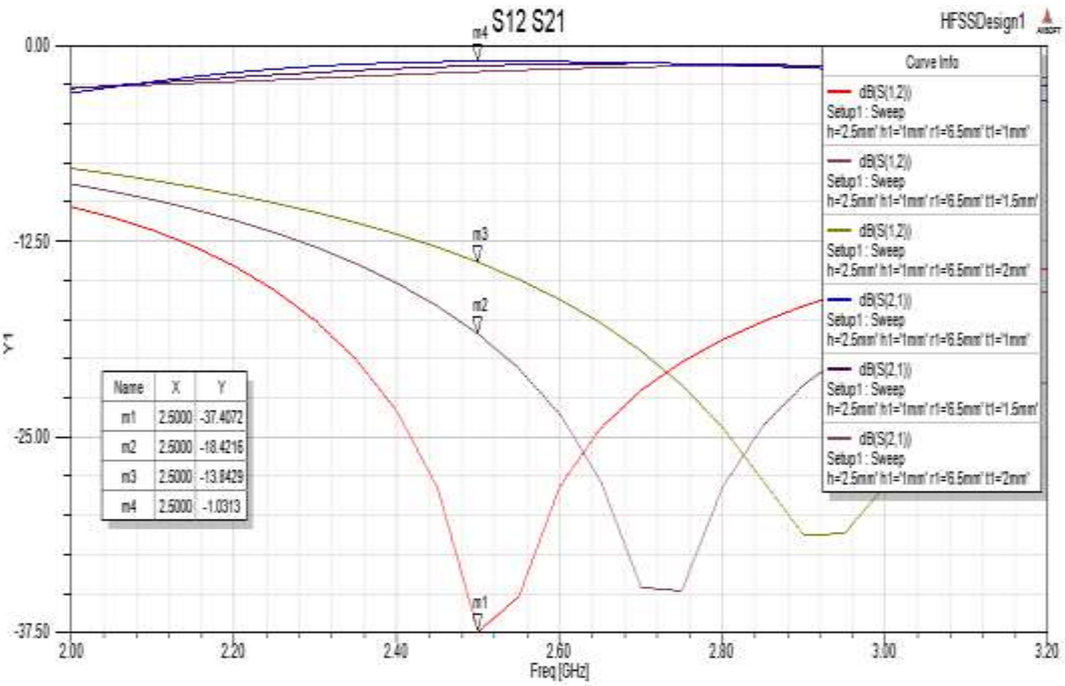

Fig.9:S12 and S21 at different width of the stripline

Hear show the above very weight of stripline optimization graphs. Hear we will increase the weight of stripline up to 2mm then increase the return loss after increase the weight of stripline then decrease the return loss. Same for the isolation but hare also shift the frequency. Hear also observe the insertion loss is constant.

6. Final results of Stripline

A. at port 1

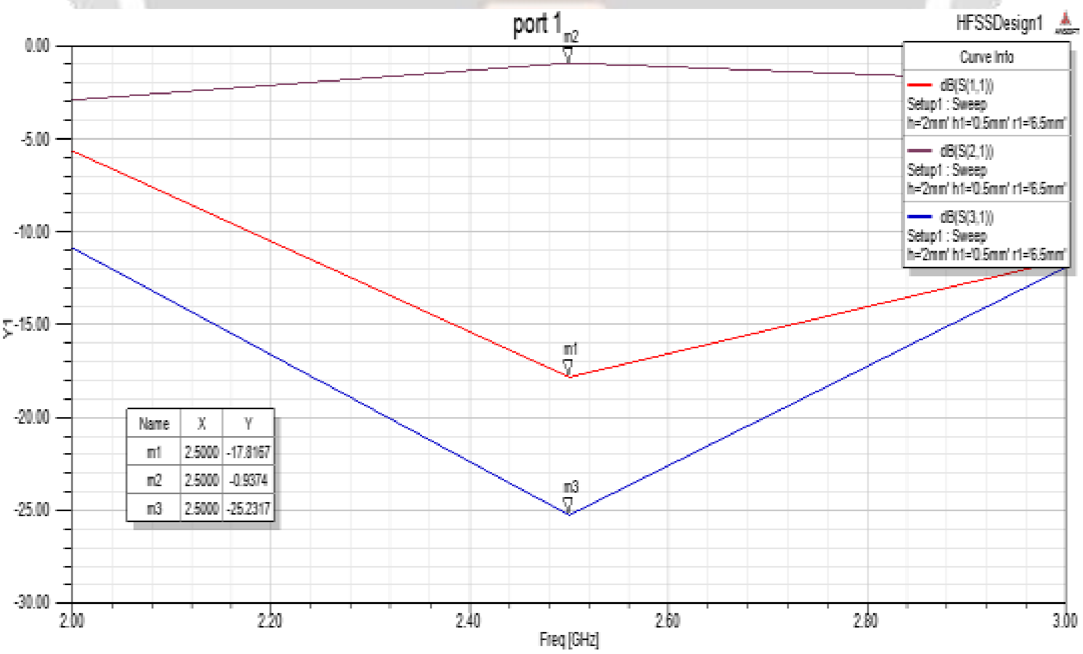

Fig.10:S11 at 6.5mm radius and 2mm height

After optimization finally results will be achieve at 2.5 GHz central frequency. Hear show in above figure when we will apply the input at port 1 and consider the parameters values 6.5mm radius, 2mm height and 2mm width then the return loss (S_{11}), isolation (S_{31}) and insertion loss (S_{21}·) is achieve -17.81,-25.23 and -0.9 respectively.

B. at port 2

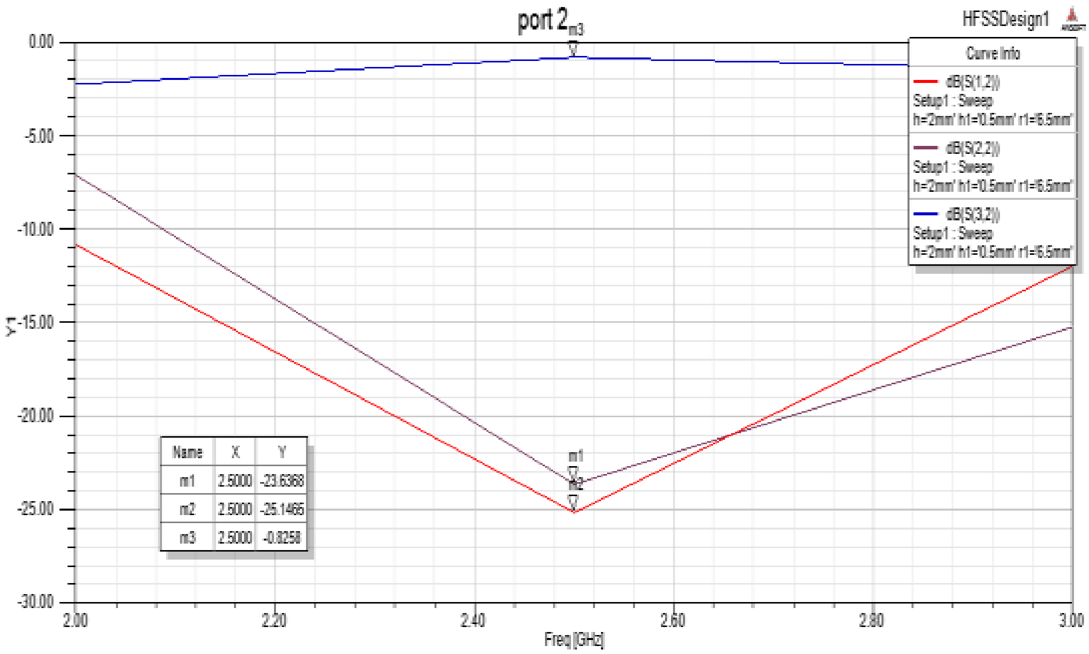

Fig : 11: S21 and S31 at 6.2mm radius and 2mm height

After optimization finally results will be achieve at 2.5 GHz central frequency. Hear show in above figure when we will apply the input at port 2 and consider the parameters values 6.5mm radius, 2mm height and 2mm width then the return loss (S_{22}), isolation (S_{12}) and insertion loss (S_{32}·) is achieve -23.63,-25.14 and -0.8 respectively

C. at port 3

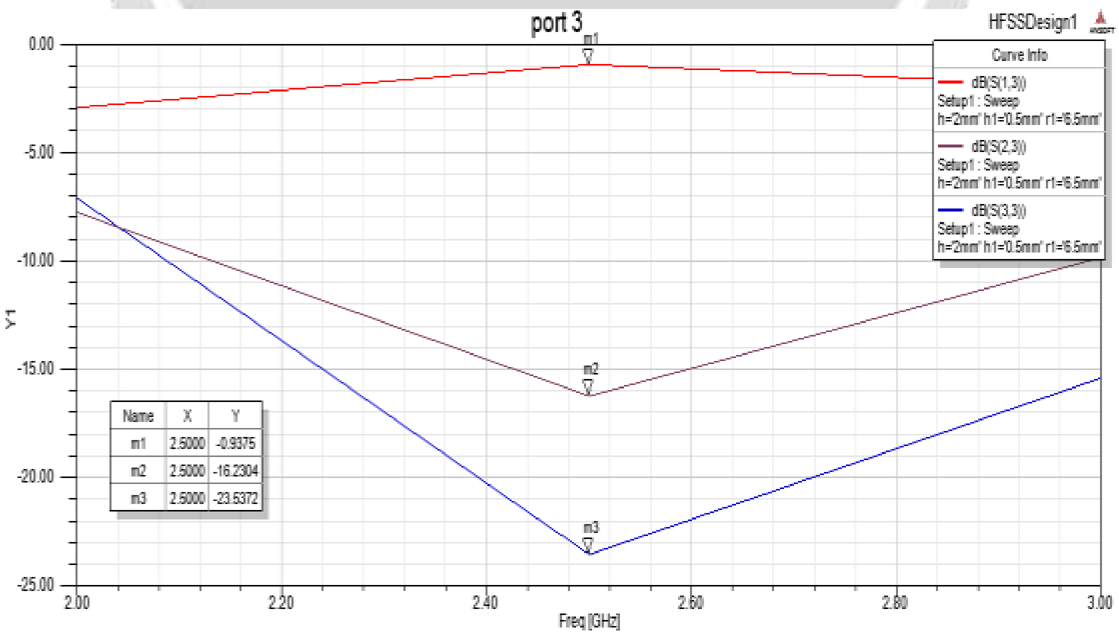

Fig : 12: S22 at 6.5mm radius and 2mm height

After optimization finally results will be achieve at 2.5 GHz central frequency. Hear show in above figure when we will apply the input at port 3 and consider the parameters values 6.5mm radius, 2mm height and 2mm width then the return loss (S_{33}), isolation (S_{23}) and insertion loss ($S_{13'}$) is achieve -23.53,-16.23 and -0.9 respectively.

CONCLUSION

A stripline circulator working at 2.5 GHz frequency. Hear we will use the Li Zn ferrite at 3900 Gauss saturation magnetization, line width 480 Oe and 11.7 permeability. It is presented the isolation and return loss is measured above 16 dB. The measured results are in good agreement with simulated results. While all the target specifications are met, the insertion loss is lower than the desired one.

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