DESIGN OF HYBRID LINE COUPLER USING MICROSTRIP LINE.

Design of a hybrid Branch Line Coupler(BLC):

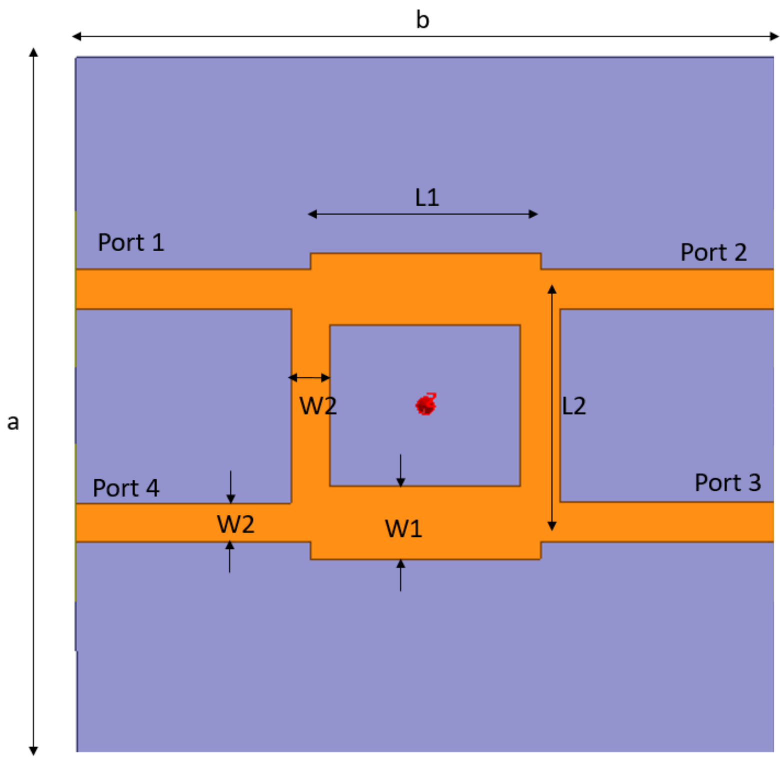

Fig.1. Layout of Branch Line Coupler (BLC)

Fig.1 shows the top view of the designed branch line coupler. The wave ports are not visible as they are in orthogonal plane. Radiation box's visibility is turned off.

- **Components:**

  - Metal: **Copper**

    - Conductivity: 58000000 Siemens/m
    - Relative Permittivity (εr): 1

- Substrate: **Rogers RO4003C**
    - Relative Permittivity (εr): 3.55
    - Dielectric Loss Tangent ($tan\delta$): 0.0027

Design Specifications:

- a = 20mm
- b = 20mm
- h = 0.508mm (Substrate thickness)
- t = 0.017mm (Metal thickness)
- L_1 = 6.649mm
- W_1 = 2.104mm
- L_2 = 6.766mm
- W_2 = 1.136mm

Design Criteria:

- Frequency of Operation: 7.8 GHz

Results:

- **Magnitude Plot of S11 Parameter**

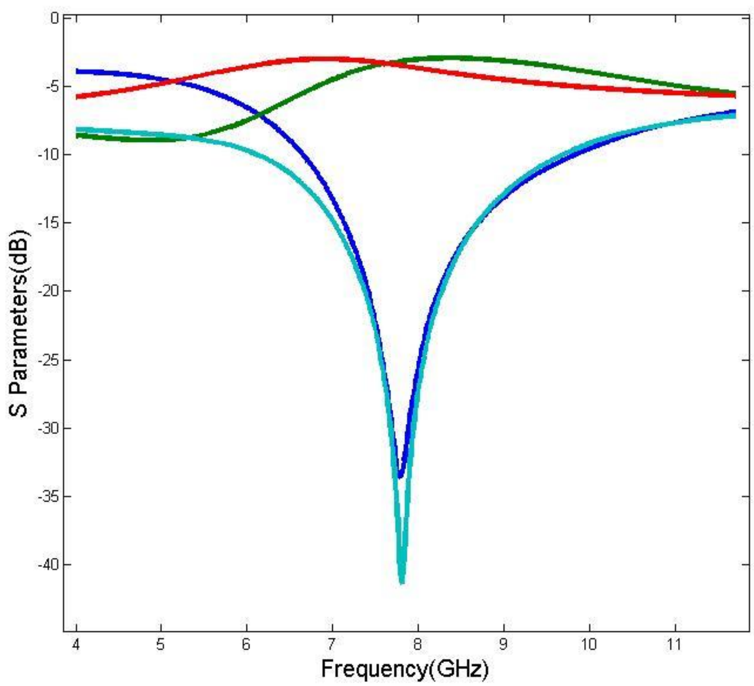

Fig.2. Magnitude Plot of S11 Parameters

- **Plot in degree $\angle S_{21}$ - $\angle S_{31}$**

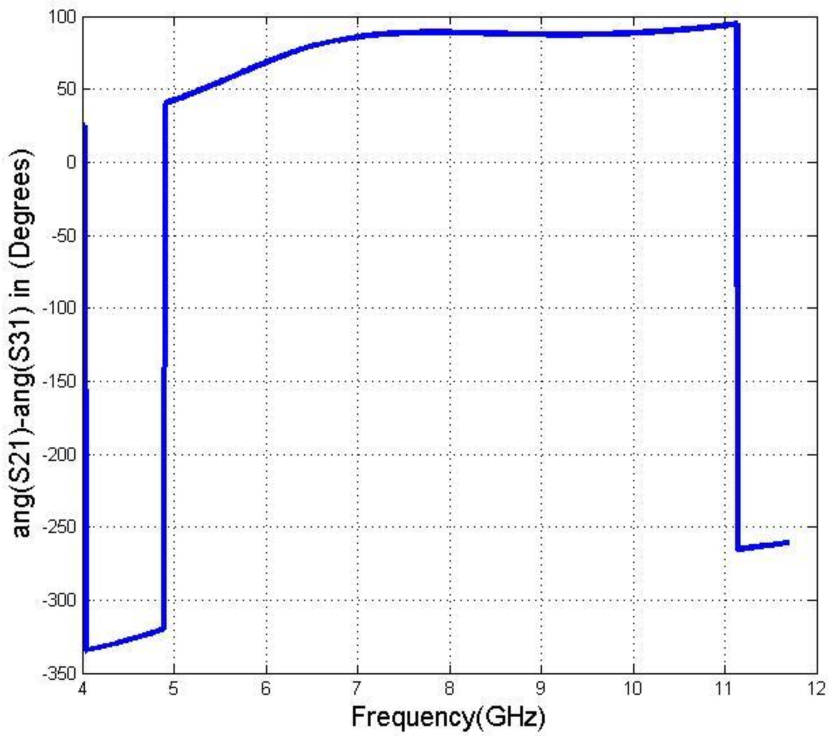

Fig.3. Difference between plots of $\angle S_{21}$ - $\angle S_{31}$

- **Plot of $|S_{21}|$ - $|S_{31}|$ in dB**

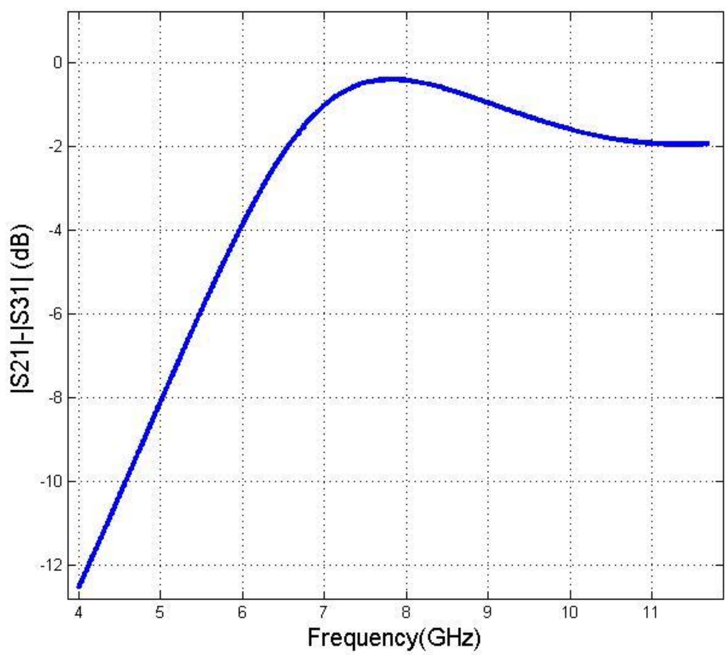

Fig.4. 3D Polar plot of patch antenna at 7.8 GHz

Calculations

- In order to find the effective bandwidth of the branch line coupler we have to determine the following bandwidths:

- $|S_{11}| < -20$ dB
- $|S_{41}| < -20$ dB
- $|S_{21}| - |S_{31}| < 0.5$ dB
- $\angle S_{21} - \angle S_{31} < 90° \pm 5°$

- The bandwidth of $|S_{11}| < -20$ dB is found to be 0.83 GHz ranging from 7.41 GHz to 8.24 GHz.

- The bandwidth of $|S_{41}| < -20$ dB is 0.91 GHz starting from 7.37 GHz to 8.28 GHz.

- The bandwidth of $|S_{21}| - |S_{31}| < 0.5$ dB is 0.7 GHz from 7.5 GHz to 8.2 GHz and that of $\angle S_{21}$-$\angle S_{31}$ is 4.21 GHz ranging from 6.92 GHz to 11.13 GHz.

- Therefore, the effective bandwidth of the coupler is 0.7 GHz which is the lowest among these four bandwidths.

Conclusion

- A branch line coupler is designed on an Rogers RO4003C substrate having dielectric constant 3.55 and dielectric loss tangent 0.0027 using HFSS and its characteristics are studied through Fig.2

- An essential feature of directional couplers is that they only couple power flowing in one direction. Power supplied to port 1 is coupled to port 3 (the coupled port), while the remainder of the input power is delivered to port 2 (the through port). In an ideal directional coupler, no power is delivered to port 4 (the isolated port).

- These are clearly seen in Fig.2. The reflection curve remains below -30 dB indicating good matching at the resonant frequency 7.8 GHz.

- The isolation curve is also below -30 dB indicating good isolation between port 1 and port 4.

- The transmission coefficients are nearly at -3.5 dB, which indicates that almost half of the power is being coupled to port 3 and the remaining half is being delivered to port 2.

- Ideally the transmission through the coupler is supposed to be at -3 dB at both the ports 2 and 3 as the power transmitted through coupler should be equally divided in the two ports of the coupler, the simulation shows good agreement with the theory because of low loss tangent value of Rogers RO4003C substrate.

- The quadrature hybrid or BLC should have a 90° phase shift between ports 2 and 3 when fed at port 1. With all the ports matched in Fig.1, the power entering port 1 is evenly divided between ports 2 and 3, with a 90° phase shift between these outputs.

- Fig.3 shows the difference between the angles of S_{21} and S_{31} where there is a 90° phase shift between the ports 2 and 3 at the resonant frequency 7.8 GHz.