Experiment – 4: Design and Simulation of Microstrip Antenna using ANSYS

1. **Aim**: To design and analyze a Rectangular microstrip patch antenna at 2.4 GHz
2. **Objective**: Design and simulate a rectangular microstrip patch antenna with ε_r=4.4, at an operating frequency of 2.4 GHz and height of substrate 1.6 mm .

3. **Requirements**
   - Ansys software

4. **Pre-experiment Exercise:**

   Brief Theory

Patch antennas are assigned different names such as printed antennas, microstrip patch antennas or microstrip antennas (MSA). Microstrip antennas are often used where thickness and conformability to the surfaces are the main requirements. These antennas are low profile, conformable to planar and non planar surfaces, simple and inexpensive to manufacture using modern printed circuit technology, mechanically robust when mounted on rigid surfaces, compatible with Monolithic Microwave Integrated Circuits (MMIC) designs, and when the particular patch shape and mode are selected they are very versatile in terms of resonant frequency, polarization, radiation pattern and impedance.

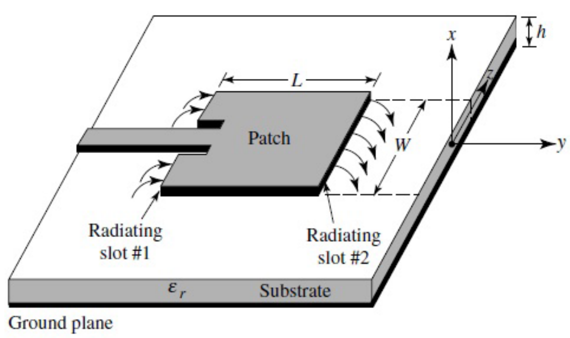

Fig. 1: Rectangular Patch Antenna

A rectangular microstrip antenna, as shown in Figure 1, consists of a very thin ($t \ll \lambda_0$) where

λ_0 is the free-space wavelength) metallic strip (patch) placed a small fraction of a wavelength $(h \ll \lambda_0)$, usually $(0.003\lambda_0 \le h \le 0.05\lambda_0)$ above a ground plane. The microstrip patch is designed so its pattern maximum is normal to the patch (broadside radiator).

In order to design a rectangular microstrip patch, the following design procedure is used:

1. For the specified design frequency f_r, the width of the patch is determined using

$$W = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

2. Determine the effective dielectric constant using

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-1/2} \qquad (2)$$

3. Once W is found using (1), determine the length extension ΔL using

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \qquad (3)$$

   where v_0 is the velocity of light in free space.

4. The actual length of the patch can now be determined using

$$L = \frac{v_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \qquad (4)$$

5. Laboratory Exercise

A. Design Calculations:

Sr. No.	Parameter	Value
1.	Width of the patch (W)	
2.	Effective dielectric constant (ε_r)	
3.	Length extension (ΔL)	
4.	Actual length of patch (L)	

B. Procedure:

1) Design a Rectangular Mictrostrip Antenna comprising of
   Ground Plane of 60mm x 60mm, FR-4 Substrate of 60mm x 60mm x 1.6mm and
   a Rectangular Patch of 29.4 mm x 38mm.
2) For 50 ohm impedance connect an inset feedline of width 3mm.
3) Assign boundary as Per E to the patch, feedline and ground plane.
4) Assign lumped port for excitation.
5) Create a radiation box enclosing the antenna completely.
6) Set up the simulation environment and Save the file
7) Validate the structure for all assignments and excitation
8) Post validation, analyze the same and check the response
9) Open the S_{11} graph and interpret the same

6. Post Experiment Exercise:

6.1 Results:

Sr. No.	*Parameter*	*Calculated values*	*Simulation Result*
1.	Resonant frequency (f_r)		
2.	Impedance Bandwidth	-	

6.2 Conclusion

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6.3 Questions:

1. Compare the feeding methods of microstrip antennas and draw their equivalent circuits.
2. Design a rectangular microstrip antenna on FR-4 substrate with dielectric constant 4.4 and substrate thickness 1.6 mm to resonate at 1800 MHz.

3. Write the advantages and disadvantages of MSA.