Design of RF Energy Harvesting Antenna using Optimization Technique

Design and Performance Parameters

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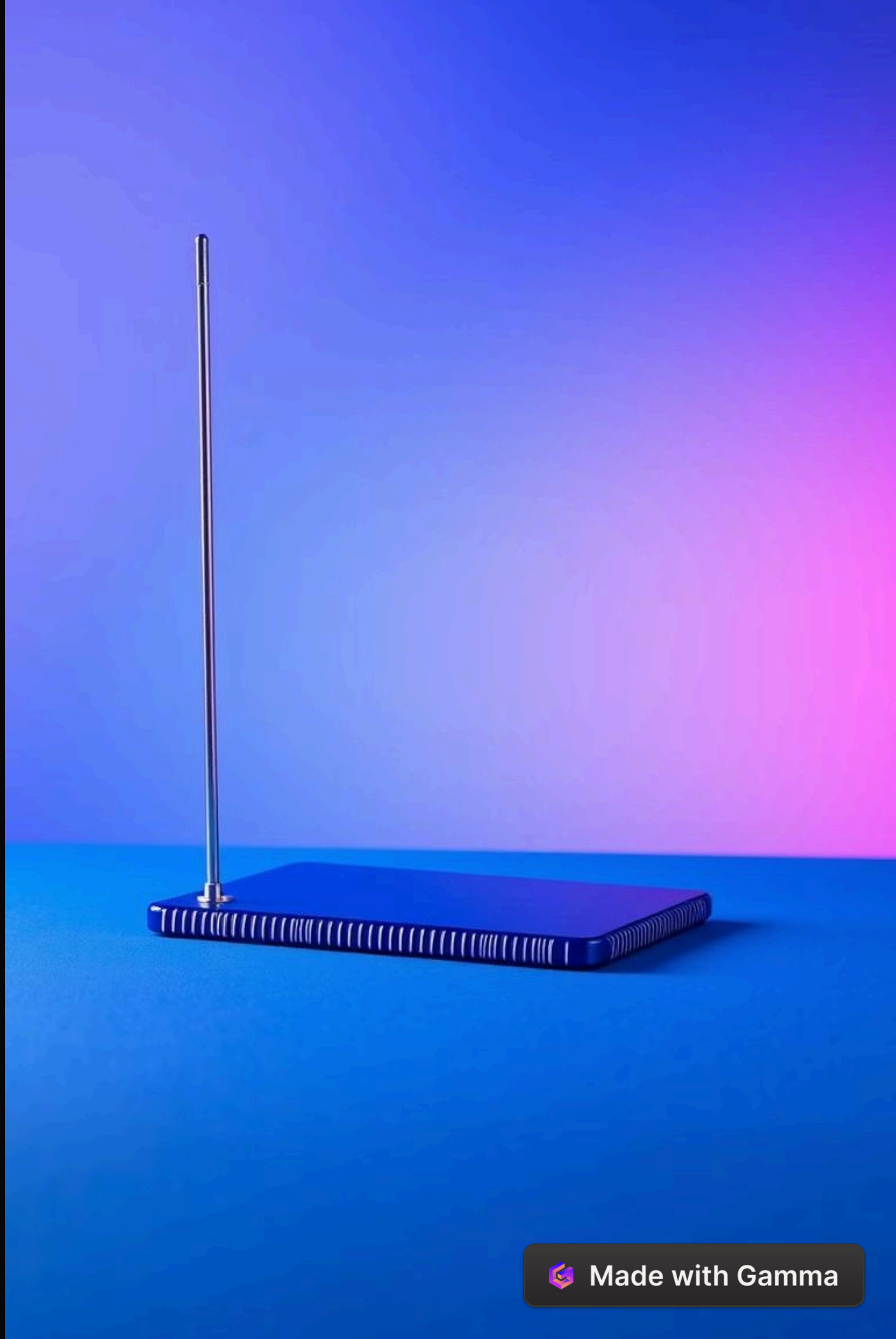


Introduction to Patch Antennas

Wireless Communication

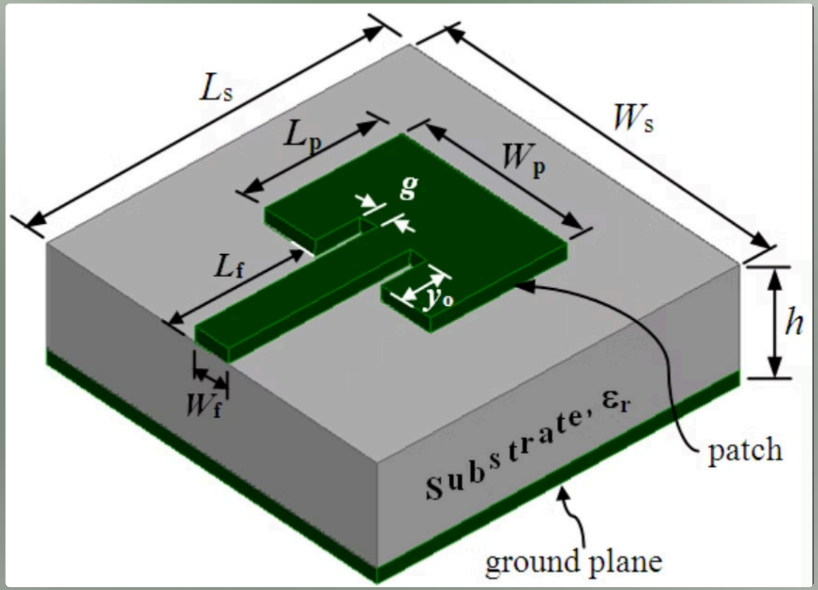
Widely used in wireless communication.

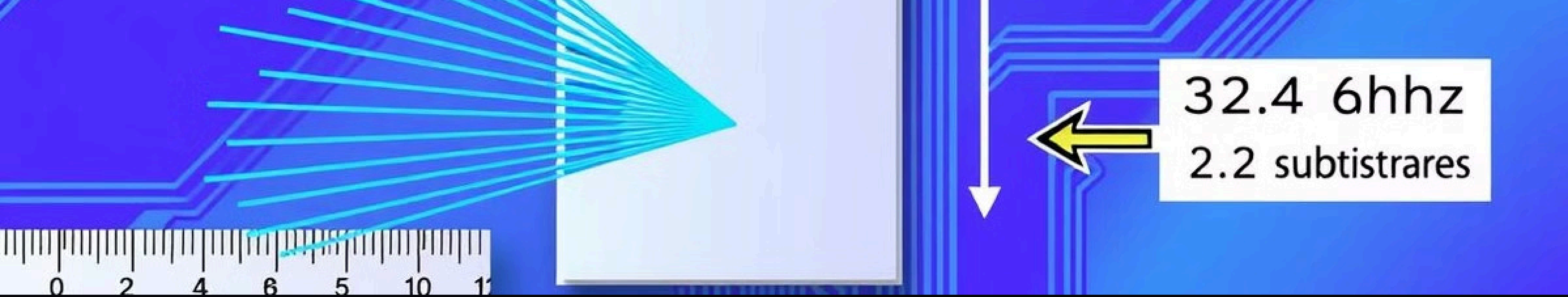
Construction

Patch on a dielectric substrate.

Microwave Frequencies

Operates at 2.4 GHz





Monostrip Patch Antenna Design

Frequency

2.4 GHz

Substrate

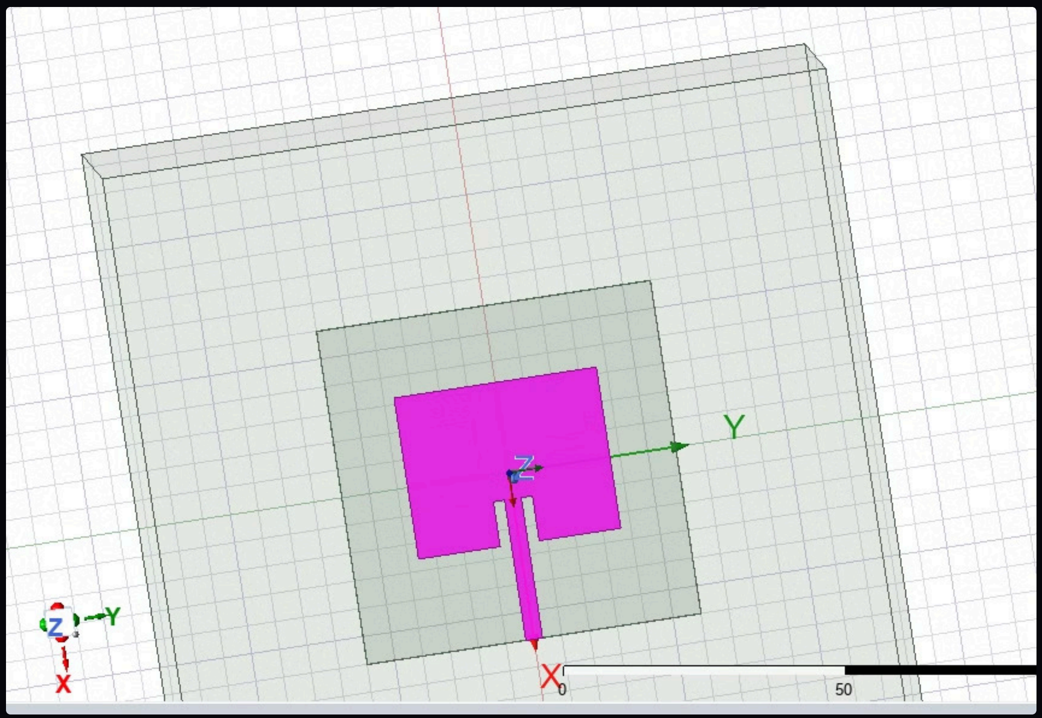
FR4 or Rogers RT/duroid

Dimensions

Width: 38 mm, Length: 29 mm

The energy harvesting is the method through which energy is derived from external sources like: solar power, thermal energy, wind energy and kinetic energy which are captured and fed to small electronic wireless operating devices like wireless sensor networks etc. Lot of RF energy gets wasted due to non reception of the device. In order to make use of renewable energy resources (Radio Frequency) to drive low power appliances and make it battery free RF energy harvesting antenna is mainly used. This enhances the usability and reliability of the device . The idea of energy harvesting is not innovative rather it came hundred years ago. The method of energy harvesting is to extract energy from the environment in order to produce electricity is called energy harvesting or energy scavenging . Usually the energy harvesters will not provide sufficient amount of power for feeding electronic devices, the reason for this is mainly because there are no such technologies have developed in order to extract more and more RF energy. But this technology can provide enough amount amount of energy sufficient of operating low power devicesin order to operate them separately .However it is observed that a standard microstrip patch antennas should possess very narrow operating bandwidth. Many procedures have been introduced to solve this problem to some extent they are listed as: use a substrate of high dielectric permittivity , use of defected ground structures at the ground plane , and addition of slots on the patches and use of patches with H & E Shape instead of other shapes and optimization of patch shapes and gain by introducing one of the optimization algorithms like genetic algorithm for better antenna performance. These challenges are efficient in order to attain broader bandwidth and to achieve more gain and directivity for energy harvesting application .

ANTENNA DESIGN



Microstrip patch antennas are more popular because of low cost and ease of fabrication. Microstrip patch antenna consists of dielectric material, radiating element and the ground plane. The rectangular shape is widely considered to realize the microstrip antenna. The simulation tool used for antenna design is High Frequency Structure Simulator (). The simple microstrip patch antenna is designed using the substrate FR4_epoxy because of its low cost and ease of fabrication. It has the dielectric constant value of 4.4 and the loss tangent is 0.02 and the resonating frequency is 2.4GHZ

The proposed microstrip patch antenna is designed with an input impedance of 50Ω.The parametric values are calculated from the given specific equations and the values are mentioned in the given table. With those calculated numerical values the simple microstrip patch antenna are designed as shown in the Figure . For an antenna to radiate, it should attain a return loss of more than -10dB. In order to further improve the return loss for better performance two slots are introduced on the patch. Thus in this proposed design shaped slots are introduced in the antenna.Patch is fed by microstrip inset feed .This enhances the better performance of the antenna with improved return loss and vswr values. In order to improve the gain and directivity, we optimize length and bredth of patch This improves the gain, directivity and overall efficiency of the antenna

Key Design Parameters

Resonance Frequency

Determines operational frequency(2.4 GHZ).

Dielectric Constant(we use FR4 Epoxy having dielectric constant 4.4)

Affects size and efficiency.

Substrate Thickness(1.6mm)

Impacts bandwidth and efficiency.

Voltage Standing Wave Ratio (VSWR)

Indication

Indicates impedance matching quality.

Ideal Value

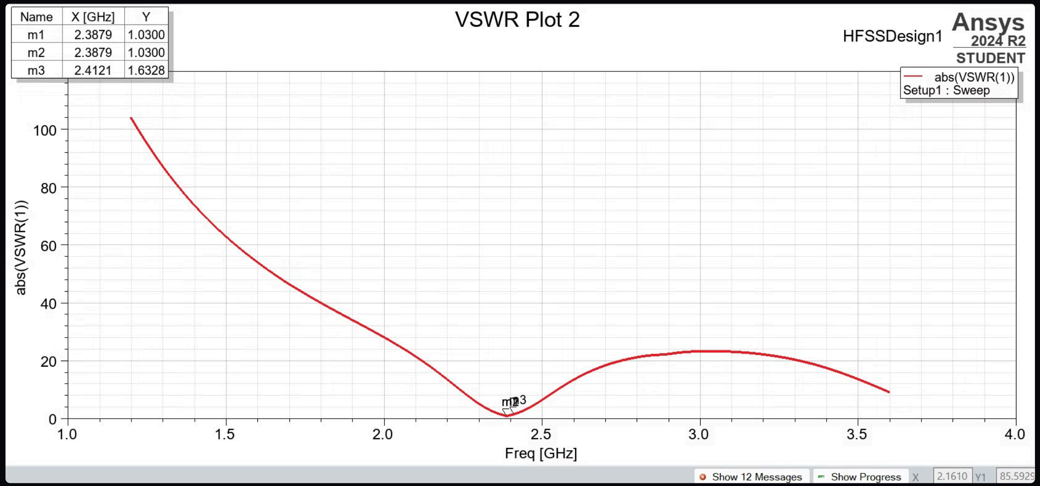
1.0 (perfect match)

Acceptable Range

1.0 - 2.0

Impact

Higher VSWR means lower efficiency.



VSWR

The Voltage Standing Wave Ratio (VSWR) obtained after optimization from the given design is 1.03

Gain of the Patch Antenna

1

Definition

Directs energy in a specific direction.

2

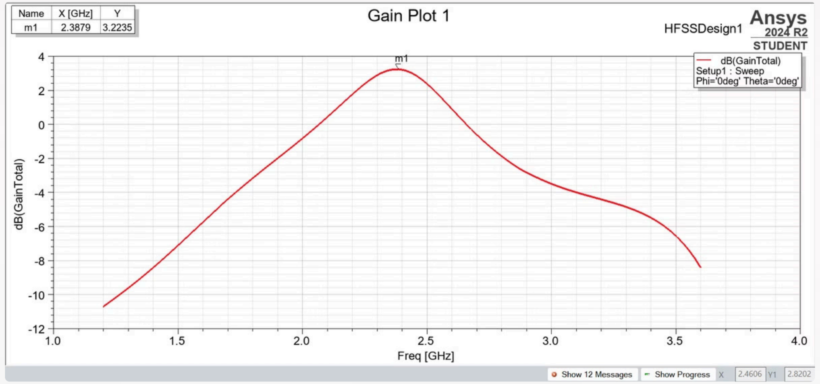
Typical Gain

~6-9 dBi at 2.4 GHz

3

Higher Gain

Focuses energy in a narrower beam.



Radiation Pattern

1

Directional

Power radiates in a direction.

2

Main Lobe

Strongest radiation direction.

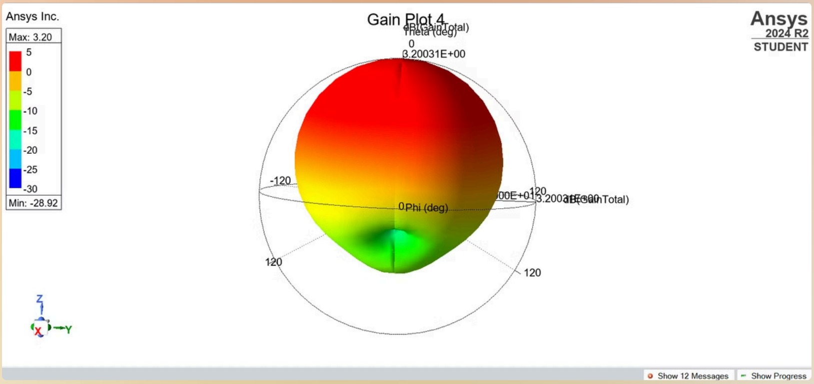
3

Side Lobes

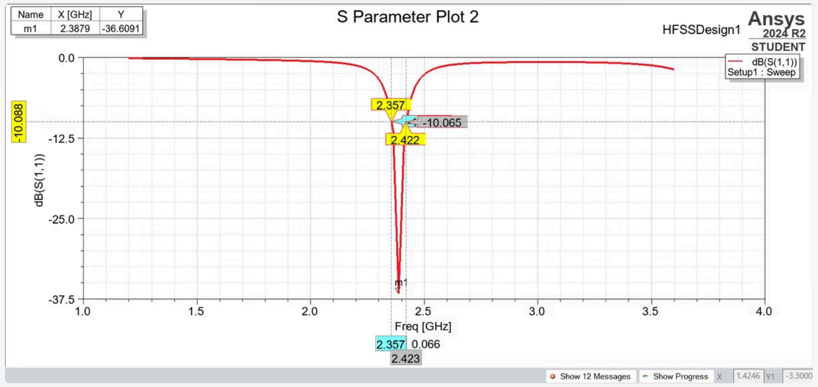
Minimize to reduce interference.

Radiation pattern

The observed Gain for given microstrip patch antenna before optimization is 5dB



Made with Gamma



Return Loss (S11) and Impedance Matching

-10dB

Ideal S11 Value

Less reflection

50Ω

Impedance

Typically designed for impedance.

design antenna gives gainof -36.6DB at 2.387GHz with a bandwidth of 0.066Ghz

Design Specifications for Energy Harvesting Antenna

Operating Frequency	2.4GHz
Substrate dielectric constant	4.4
Substrate Thickness	1.6mm
Substrate Width	60mm
Substrate Length	60mm
Substrate height	1.6mm
Patch Length	29.0307591mm
Patch width	36.35209702mm
Transmission line length	17.2mm
Transmission line width	3.01mm
Ground length	60mm
Ground width	60mm
Slots length	9mm
Slots width	2mm
Antenna resistance	50 ohm

S-Parameters and Patch Antennas

S11 Parameter

S11 (Return Loss) indicates power reflected from the antenna.

A lower S11 value signifies better impedance matching.

Impedance Matching

Efficient power transfer from the source to antenna.

Poor matching leads to signal reflections and power loss.

Antenna Performance

Analyzes antenna's ability to radiate power effectively.

Crucial for optimizing the antenna design.