

# Quad band frequency reconfigurable printed monopole antenna with switchable stub for unwanted resonance suppression

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## Abstract

The objective of this study is to design and develop quad band frequency reconfigurable printed monopole antenna with minimum control lines and minimum active switching components with a primary focus on frequency bands and radiation characteristics. The quad band frequencies are 0.915 GHz, 1.2 GHz, 2.4 GHz and 5.2 GHz. The switching between the different frequency bands is achieved by using GaAs beam lead Schottky diodes.

**Keywords:** quad band reconfigurable antenna, switchable stub, GaAs beam lead diode

## 1. INTRODUCTION

Antenna can be made reconfigurable with respect to operating frequency, polarization, radiation pattern and the combination of above. Reconfigurable antenna offers several advantages compared to conventional antennas, like compact size, similar radiation pattern for all frequency bands, efficient use of electromagnetic spectrum and frequency selectivity useful for reducing the adverse effects of co-site interference and jamming. The objective of the paper is to design and develop low-cost, compact, nearly omnidirectional antenna working at four different frequency bands (0.915 GHz, 1.2 GHz, 2.4 GHz and 5.2 GHz). In the past, several work have been reported on reconfigurable antennas, one is the quad band reconfigurable printed dipole for wireless communication [1], which used six solid state switches for the reconfigurability of four bands and having a size of 10cm × 10cm, some indeed only on a limited frequency range, by varying lumped loads [2], and costly, MEMS based fully reconfigurable planar antennas.

The work described here is an extension of [1] and implemented a reconfigurable printed monopole antenna that uses only three switches to reconfigurable four bands and fourth switch is used to select desired frequency from several frequency bands. Due to wideband coverage of these frequency bands, selecting only desired frequency band at each time can make difficulties. This technique is known as loaded antenna feed line stub technique and till now it is implemented in single antenna only for harmonic trapping [3, 4].

To achieve reconfigurability GaAs beam lead Schottky diodes are implemented (Model: MGS-901; Make: Aeroflex). The diodes have low insertion loss and good isolation properties. Particular care has been taken to minimize the effect of control lines for the switches to avoid the negative effects on radiation.

## 2. ANTENNA GEOMETRY

The simulation and optimization of antenna is done in 3D Electromagnetic CST microwave studio software version 10 [5]. The antenna geometry is a printed monopole whose length can be adjusted via GaAs Schottky switches. The Fig. 1 shows the fabricated pictures of the antenna. The antenna is printed on both the sides of a 0.762 mm thick GML 1000 substrate with the permittivity of 3.2 and is fed through a 50 Ω connector. The feeding port is located at the middle of the top edge of the substrate. From the feeding point the microstrip shrinks linearly to a width of 0.4 mm. Fig. 1(a) shows the taper ground plane which acts as a BALUN transformer as well as reflector and Fig. 1(b) shows the radiating arms with diodes, inductors and resistors configurations. When all diodes are OFF, the antenna resonant at 5.2 GHz. The antenna is going to be resonant at other three frequencies simply by changing its length using three switches (D1, D2, and D3). The

diode D4 connects stub to the feed line to suppress unwanted resonances only when antenna is tuned at two lower frequency bands i.e., at 0.915 GHz and 1.2 GHz.

When D1 is ON antenna resonant frequency is 2.4 GHz, when D1, D2 and D4 are ON antenna resonant at 1.2 GHz and finally when all diodes are ON it resonant at 0.915 GHz. The diodes used are GaAs beam lead schottky (Model: MGS-901; Make: AeroFlex) having forward resistance of  $4 \Omega @ 5\text{mA}$  and reverse capacitance of  $0.04 \text{ pF}$ . The diodes are connected in between the two arm length with the help of conducting epoxy. Epoxy get solidified after heating upto  $100^{\circ}\text{C}$  for about 20 minutes on hot plate. L1 to L5 are the chip inductors having values of  $0.1 \mu\text{H}$ , part of diode biasing circuits which provide isolation between RF and DC signals. The chip resistors R1 and R2 are current limiting resistors used to limit the flow of current into the diodes. To bias four diodes only five control lines are required.

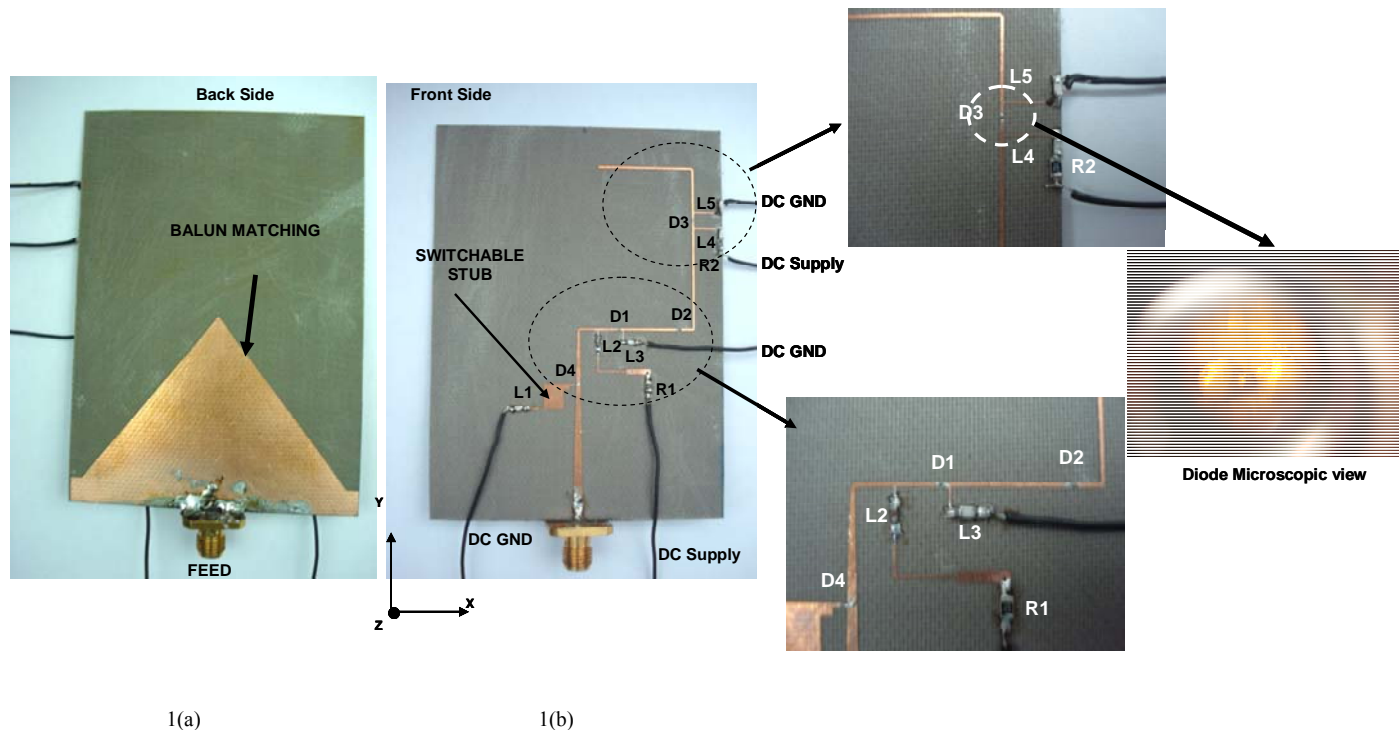


Figure 1: Quad Band Frequency Reconfigurable printed monopole antenna

### 3. SWITCHING PERFORMANCE

Antenna switching performance is measured on R & S Vector Network Analyzer (VNA). For biasing the diodes, two 9V DC batteries are used with  $1 \text{ K}\Omega$  potentiometer to lower down the voltage to values of 5V to 6V. Switching performance is done at four desired frequency bands and compare with the simulation performance. The measured results are in good agreement with simulated results. The magnitude of the return loss in undesired frequency band is less than 5 dB. Fig. 2 to Fig. 5 shows the switching performance of the antenna at 5.2 GHz, 2.4 GHz, 1.2 GHz and 0.915 GHz respectively.

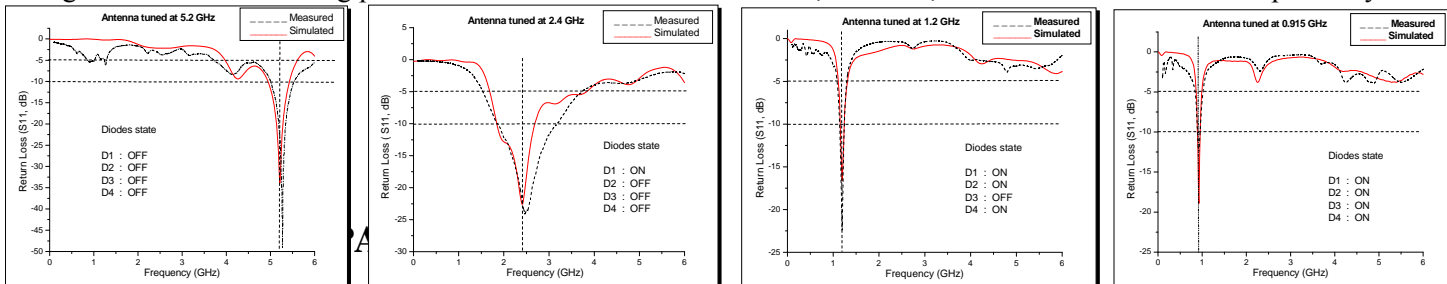


Figure 2: Antenna at 5.2GHz    Figure 3: Antenna at 2.4GHz    Figure 4: Antenna at 1.2GHz    Figure 5: Antenna at 0.915GHz

Radiation patterns of the antenna in E and H plane is done in anechoic chamber. Since antenna is not symmetrical therefore E plane measurement is done in two planes i.e., E (YZ) and E (XY). Fig. 6 to Fig. 9 shows the normalized radiation pattern performance of antenna at four desired frequency bands respectively. The figures shows that measured radiation patterns slightly deviated from simulated results because of the presence of DC biasing wires.

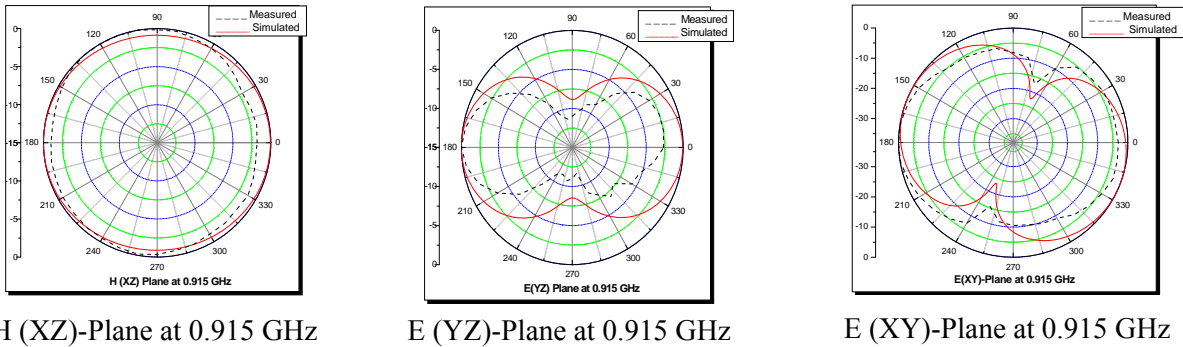


Figure 6: Radiation Patterns at 0.915 GHz

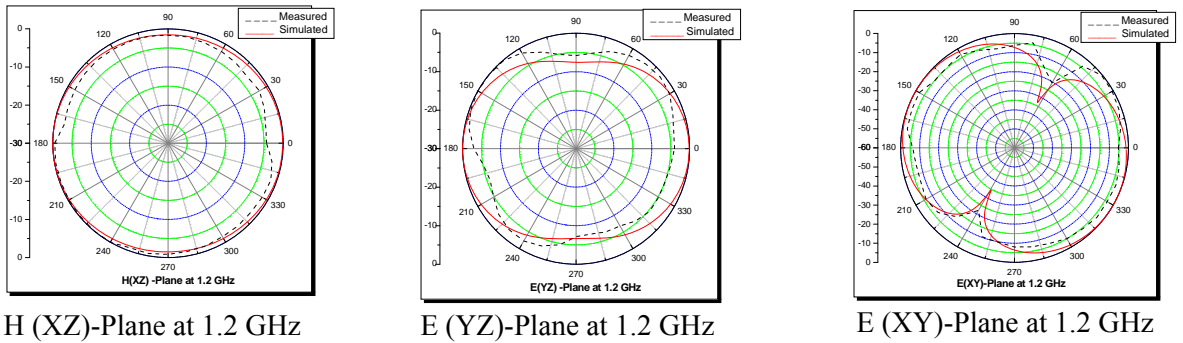


Figure 7: Radiation Patterns at 1.2 GHz

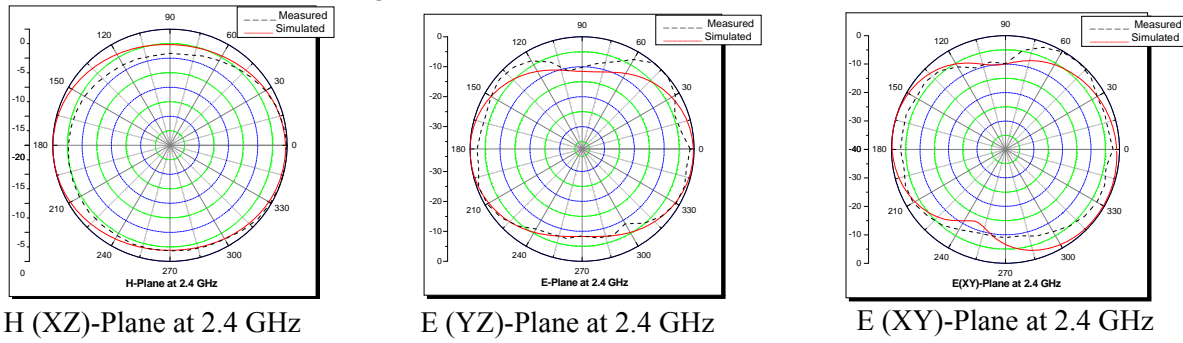


Figure 8: Radiation Patterns at 2.4 GHz

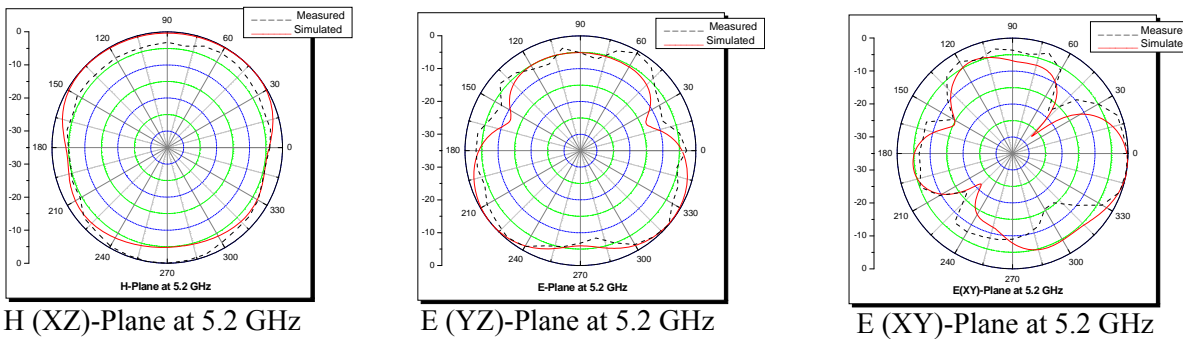


Figure 9: Radiation Patterns at 5.2 GHz

The radiation patterns of the antenna were measured at the resonance frequencies of the selected frequency bands. As it can be seen from the Fig. 9, few nulls occur at the higher frequency band i.e., at 5.2 GHz especially in E-plane. This degradation is due to the tapered ground plane. The tapered ground plane acts as a reflector and can degrade the radiation patterns. It is worse for the higher frequency bands where the tapered ground size is larger in comparison with operating wavelength.

#### 4. CONCLUSIONS

The concept of reconfigurable stub to suppress the unwanted resonances when antenna is tuned at lower frequency bands is implemented. The measured switching and radiating performance of antenna are matched with simulated results. The GaAs Schottky diodes presents a non-negligible  $R_{on}$ , hence the antenna gain has a drop, especially at the lowest frequency (0.915 GHz), where all the switches presents high currents and high losses. Table 1 shows the antenna gain at four corresponding frequencies. The antenna gain for the lowest frequency is -0.53 dBi and for the highest frequency is 1.84 dBi.

Table 1

FREQUENCIES (GHz)	Gain (dBi)
0.915	-0.53
1.2	0.64
2.4	0.83
5.2	1.84

#### REFERENCES

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