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Design and Implementation of Reconfigurable Antenna

Ms. Pagire T. G.
Department of E&TC, Pune University
GHRCOEM, Ahmednagar, India
tejalpagire@gmail.com

Abstract— In this project, antenna reconfiguration is done using a improved & effective technique or method. Conventional antennas operate at a specific frequency range hence that is designed for particular application and we cannot operate it on multiple frequencies. Prior to conventional antennas, reconfigurable antennas discussed in this paper operate at different frequency ranges. It improves the performance as it uses single antenna structure to operate at multiple frequencies. For this, here we used frequency reconfiguration techniques i.e. PIN diode switching due to which it can switch among different frequency band. HFSS software is used for simulation and analysis.

Keywords— Reconfigurable antenna, PIN diode, frequency reconfigurability, microstrip patch antenna

INTRODUCTION

With increase in number of wireless communication system and development of modern satellite communication, especially in case of MIMO system, many applications requires integrated, adaptive, multifunctional terminals. Reconfigurable antenna represents recent innovations in antenna design that dynamically changes frequency, pattern polarization to modifiable structures that can be adapted.

The reconfiguration of an antenna is achieved by altering the radiated fields of the antenna's effective aperture. It is based on a purposeful rearrangement of the antenna currents or a reconfiguration of the antenna's radiating edges. This redistribution of properties results in a change in the antenna's functionalities. Such change of functions allows users to propose reconfigurable antennas for various wireless communication platforms.

There are four reconfiguration properties that a reconfigurable antenna can achieve. An antenna can exhibit a reconfigurable frequency of operation, a reconfigurable radiation pattern, a reconfigurable polarization behavior, or a combination of any of these properties [1], [2].

As for the selection of the reconfiguration technique, it is based on the reconfigurable antenna property. An antenna designer selects a technique that satisfies the imposed constraints and at the same time completes the antenna design task efficiently. There are several reconfiguration techniques that have been proposed since the rise of reconfigurable antennas. The proposed reconfiguration techniques are divided into four major categories: electrical, optical, mechanical, and material change of switches to connect and disconnect antenna parts as well as to redistribute the antenna currents. Radio frequency micro-electromechanical systems (RF-MEMS) have been proposed for integration into reconfigurable antennas since 1998 [5]. Many designs have resorted to RF MEMS to reconfigure their performance. RF MEMS based reconfigurable antennas rely on the mechanical movement of these switches to achieve reconfiguration. The isolation of RF-MEMS is very high and they require minimal power consumption. The switching speed of RFMEMS is in the range of 1–200 usec which may be considered low for some applications [10]

P-i-n diodes or varactors have appeared to be a faster and a more compact alternative to RF-MEMS. The switching speed of a p-i-n diode is in the range of 1–100 nsec [2]. Reconfigurable antennas using to p-i-n diodes have more dynamic reconfiguration ability.[12] Other reconfigurable antennas resort to varactors where varying the biasing voltage can result in varying the capacitance of the corresponding varactor. Such antennas enjoy a vast tuning ability that is based on integrating a variable capacitance into the antenna structure. It is important to indicate that while electrical switching components may present efficient reconfiguration ability, they require an appropriate design of their biasing networks.

The new technique of PIN diode is used as the switching device. There are various reconfiguration parameters such as frequency, polarization, radiation pattern, input voltages and compound patterns. Here we are implementing frequency reconfigurable antenna. Because it is probably easy feature to reform. It switches the frequency from one to another. This frequency switching can be done by using PIN diode switching circuitry. PIN diodes are having advantages of less insertion loss, provides better isolation, and power handling capacity of PIN diode is high and low cost.

In case of pattern reconfiguration, it is related to radiation pattern of individual antenna and we cannot change it in different ways. Polarization reconfigurability demonstrated by linear polarization (LP) or circular polarization (CP).[9]

The microstrip antennas are used for simulating the reconfigurable antenna in software tool. HFSS is used for getting simulation results. The patch antennas provide advantage of light weight, less size, low fabrication cost, capable of dual and triple frequency observation. The main aim is to compact size of antenna hence we use patch antenna.

Here we analyze the simulated results in HFSS software, and we get return loss of less than -10dB shows antenna efficiency. The frequency tuning is achieved by inserting switches and depending on the status of switch the range of frequency operation is selected.

Table -1: comparison of switching techniques

Electrical property	RF MEMS	PIN Diode	Optical Switch (Si)
Voltage [V]	20-100	3-55	1.8-1.9
Current [mA]	0	3-20	0-87
Power consumption [mW]	0.05-0.1	5-100	0-50
Switching Speed	1-200 usec	1-100 nsec	3-9 usec
Isolation [1-10GHz]	Very High	High	High
Loss [1-10 GHz] [dB]	0.05-0.2	0.3-1.2	05-1.5

For design of reconfigurable antenna we use microstrip patch antenna. Microstrip antennas are planar resonant cavity that leak from their edges and radiate EM waves. It consists of radiating patch on one side of a dielectric substrate having a ground plane on other side.

II Design of Antenna

For designing Microstrip reconfigurable antenna we have to first select the proper substrate material. Here we use FR-4 as a substrate. Rogers's material for PCB that is FR-4 material provides the base standard for the PCB substrate, it deliver a effective maintenance of cost, various electrical properties, manufacturability, performance and durability.

A substrate having a high dielectric constant is to be selected so that antenna dimensions are reduced. In order to increase radiated power a low value of dielectric constant should be selected

For design of reconfigurable antenna we use microstrip patch antenna. Microstrip antennas are planar resonant cavity that leak from their edges and radiate EM waves. It consists of radiating patch on one side of a dielectric substrate having a ground plane on other side. The basic patch antenna is as shown in fig.1 below.

III SYSTEM DEVELOPMENT

SYSTEM FLOW

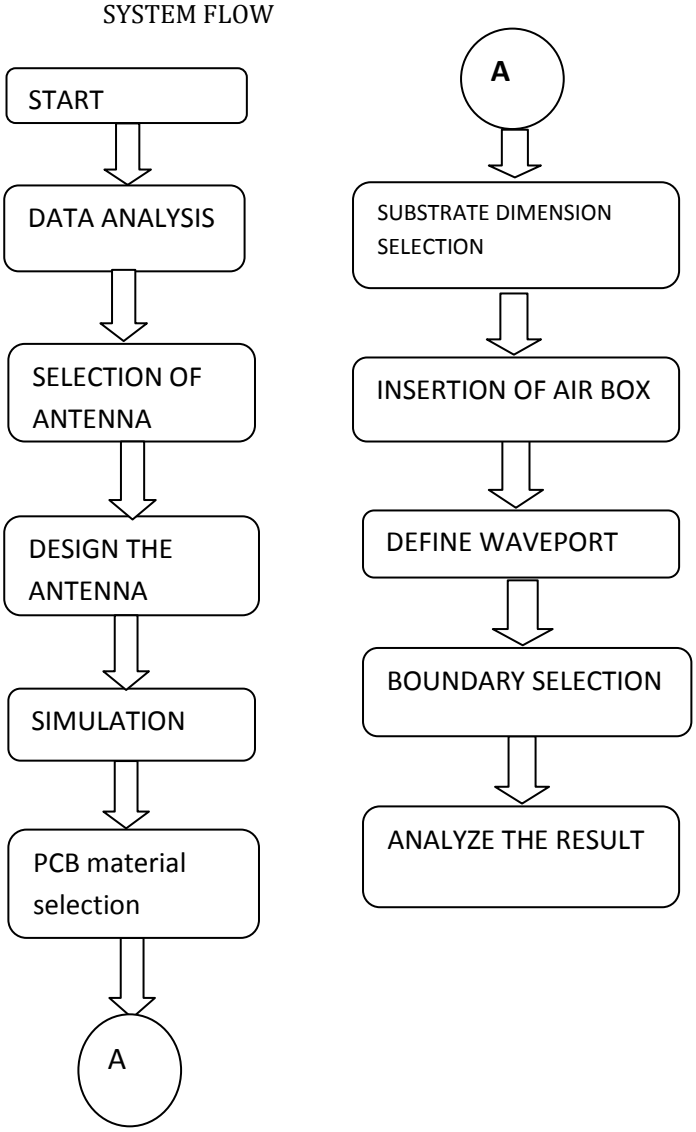

Fig. 1. System flow

IV. SOFTWARE DESIGN

Proposed antenna structure designed in HFSS software is as shown in fig.3 and 4. In order to generate radiation a space or the environment for the patch antenna is created by inserting an air box around antenna. An air box has to be inserted in to model open space due to which the radiation from the structure is not reflected back and totally absorbed. Hence rectangular patch antenna design is enclosed in an air container in order to achieve reconfiguration.

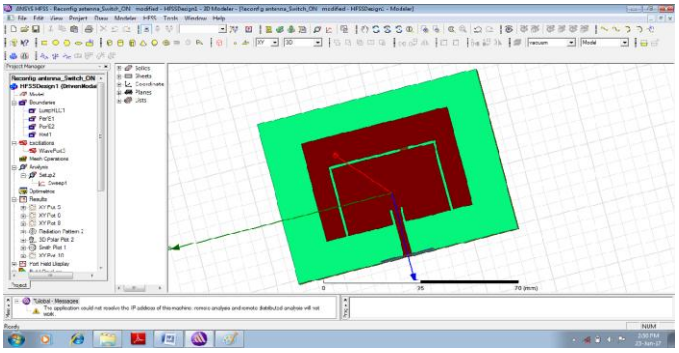

Fig. 2 The proposed design of antenna in HFSS when PIN diode switch is ON

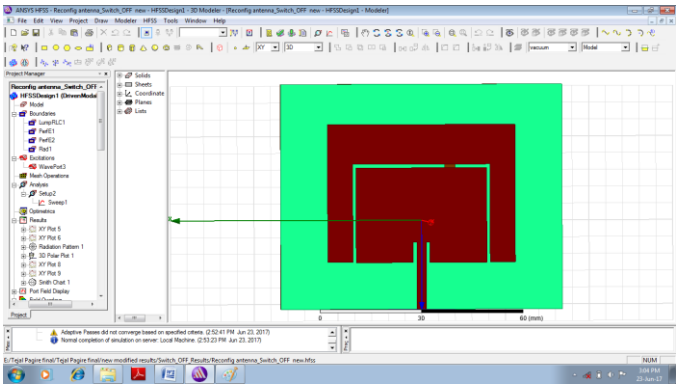

Fig. 3 The proposed design of antenna in HFSS when PIN diode switch is OFF

V. Results

1. software simulation results

The simulation of microstrip patch reconfigurable antenna is done using HFSS software using PIN diode depending on the status of PIN diode i.e. on/off the resonant frequency is resonated. Following fig. shows the simulated results of rectangular patch antenna. The two resonant frequencies designed are 2.44GHz when switch is ON and 2.62 GHz when switch is OFF as shown in fig. below.

A. PIN DIODE SWITCH IS ON

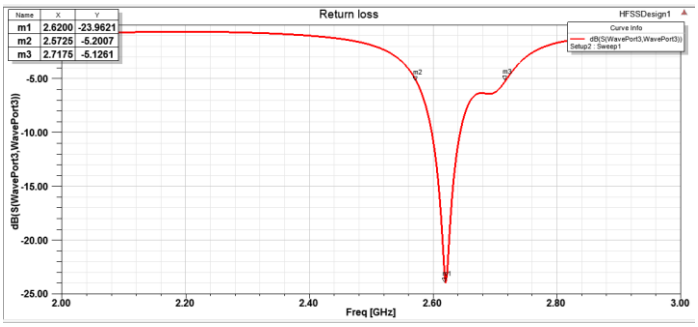

Fig. a. Simulated result of return loss

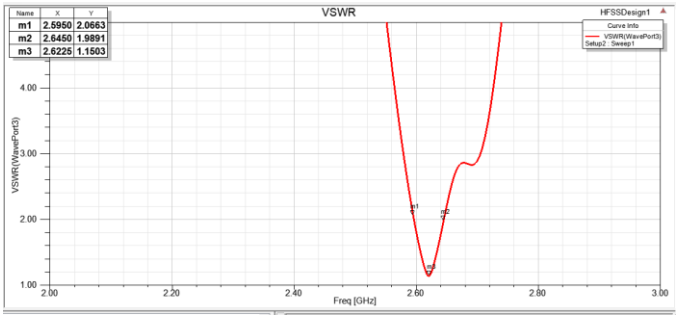

Fig. b. Simulated result of VSWR

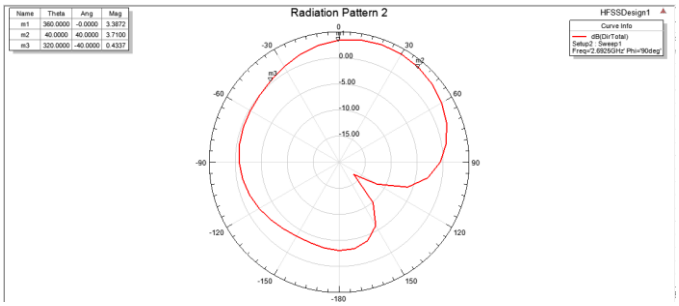

Fig. c. Simulated result of Radiation pattern

B. PIN diode switch is OFF

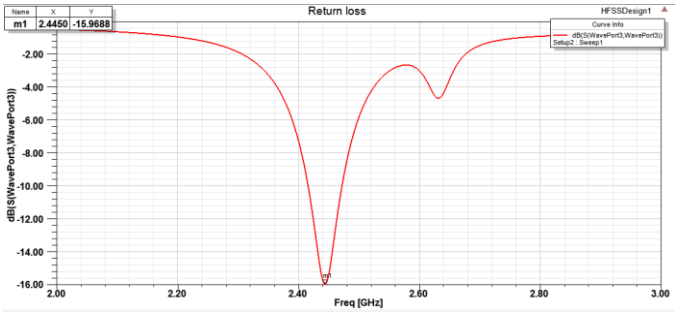

Fig. d. Simulated result of return loss

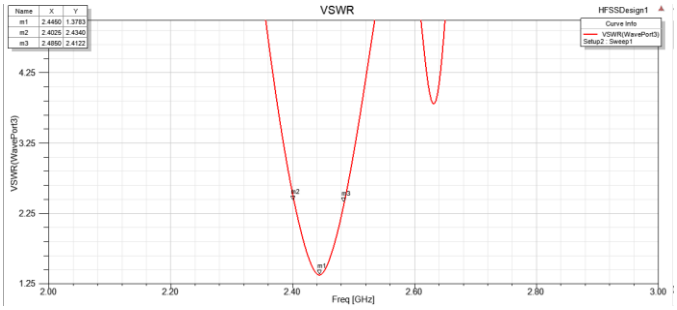

Fig. e. Simulated result of VSWR

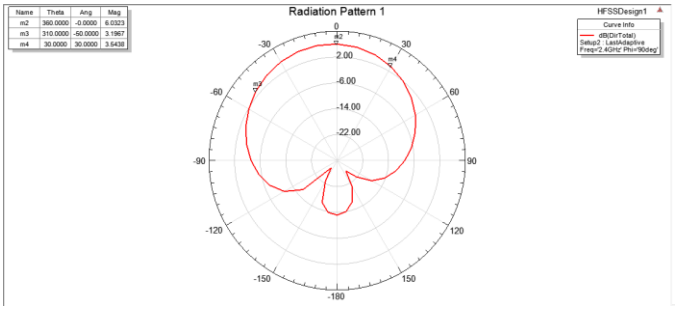

Fig. f. Simulated result of Radiation pattern

2. Hardware results

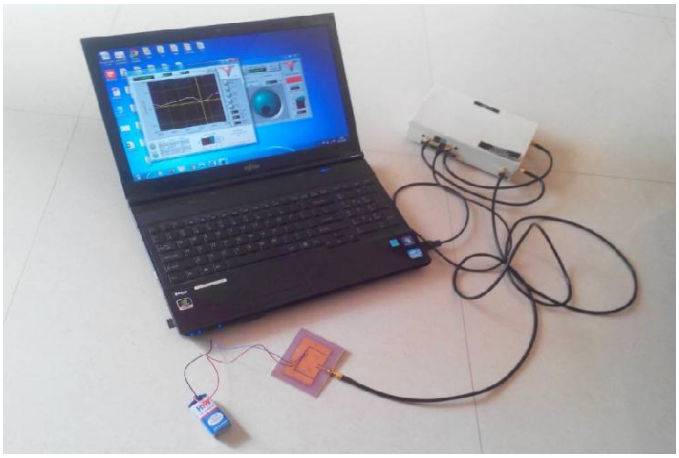

Fig. g Fabricated antenna

A. Testing results when PIN diode is ON

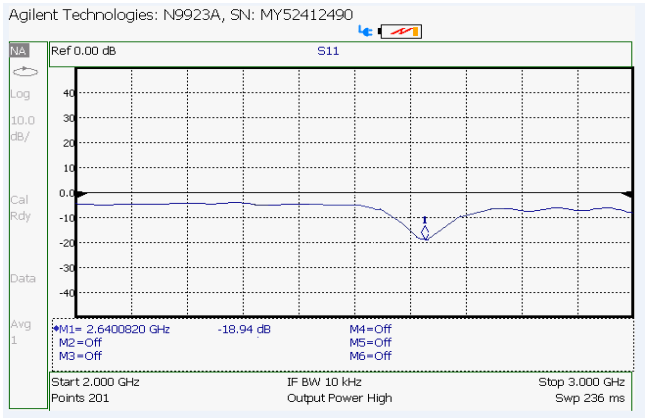

Fig.h Simulated result of return loss

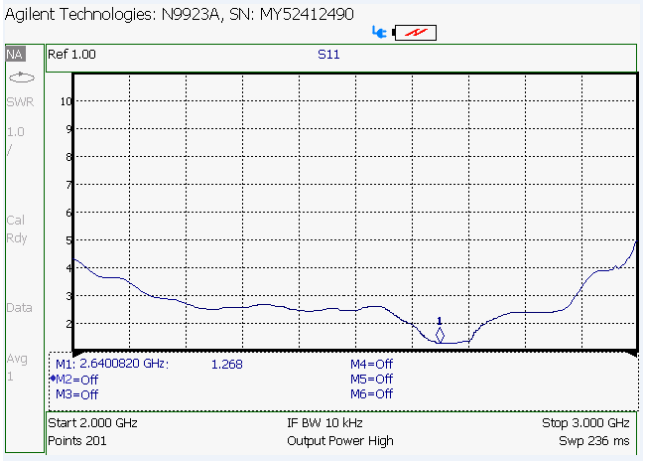

Fig.i Hardware result of VSWR

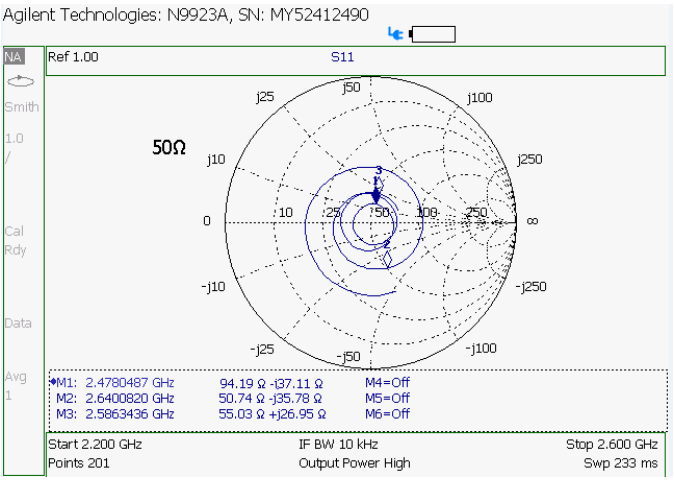

Fig. j Smith chart

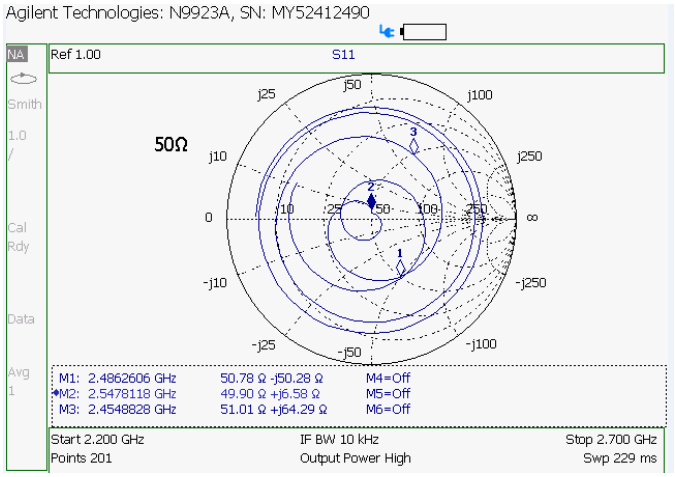

Fig.l Smith chart

B. Testing Results when PIN diode is OFF

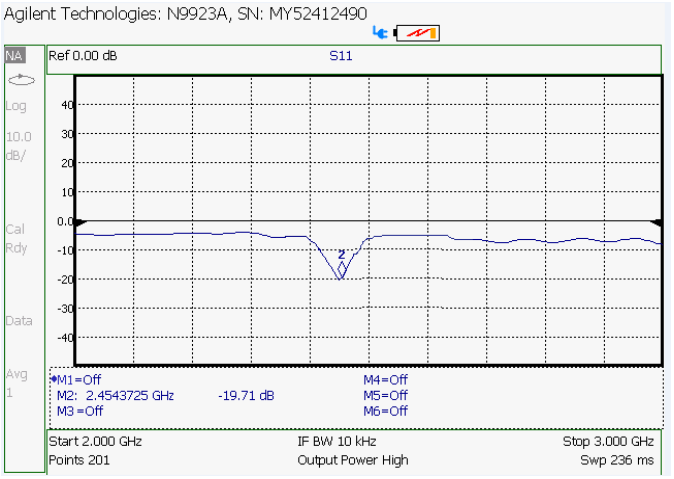

Fig. Hardware result of return loss

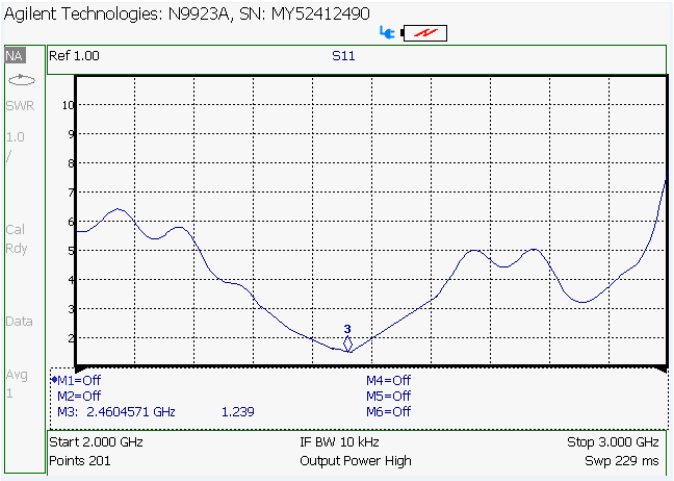

Fig. k Hardware result of VSWR

Table -2: Result Comparison Table

Sr no	Results	Switch conditions	Freq (GHz)	Return loss (dB)	VSWR
1.	Simulated Results	Switch ON	2.62	-23.96	1.15
		Switch OFF	2.44	-15.96	1.37
2.	Measured Results	Switch ON	2.64	-18.94	1.25
		Switch OFF	2.45	-19.71	1.23

VI. conclusions

The proposed antenna design is having resonant frequencies as 2.44 GHz and 2.62 GHz. The antenna is simulated using HFSS software tool which is efficient one. The proposed antenna is having compact structure and provides easy integration and fabrication with other components of microwave communication. Comparing the measured results with simulated results provides very good agreement.

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