# DESIGN AND ANALYSIS OF REDUCED SIZE CONICAL SHAPE MICROSTRIP ANTENNA USING REDUCED BUTLER MATRIX FOR 2.4GHZ FREQUENCY BAND

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## Abstract

*In this paper the conical shape reduced size microstrip patch antenna is connected to the reduced size butler matrix network and low cost smart antenna is form. This antenna is intermediate step between smart antenna and conventional antenna i.e. this antenna is cost effective solution for the smart antenna. Butler matrix network is used for beam switching. This design is realized on a low cost substrate FR4 with dielectric constant 4.4 and height of substrate is 1.6mm.Here antenna is operated at 2.4GHz frequency. The simulation result is obtained using HFSS.*

***Keywords****- Butler Matrix, Beam forming Network (BFN), Micro-strip Antenna, VSWR, Return Losses*

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## 1. INTRODUCTION

In recent years, wireless technology has rapid growth in creating new and improved services at lower costs. In wireless communication it is very important to separate desired signal from unwanted signal. Thus to overcome this problem smart antenna system is developed. There are main two types of smart antenna systems. One is Switched beam system and another is Adaptive array system. Here smart antenna is form by using reduced size butler matrix and redused size conical shape microstrip patch antenna.

In this paper the microstrip patch array is use as a radiating element and butler matrix is use for beam switching. Here reduced butler matrix network is use. There are number of advantages of using this network the advantages are low profile, easy fabrication and less cost. The diagram shows the reduced size butler matrix network it consist of hybrid coupler, phase shifter and crossover. The main advantages of microstrip antenna are low profile, simple and inexpensive to manufacture, possible to have dual or triple frequency operations.

The figure below shows reduced butler matrix

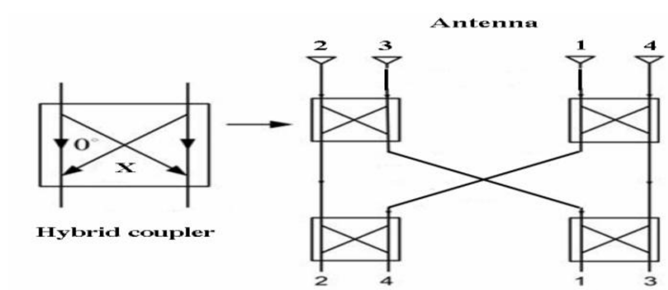


**Fig 1** Butler Matrix

## 2. DESIGN AND ANALYSIS

### 2.1 Rectangular Patch Antenna(Microstrip Antenna)

To design microstrp antenna we must know the length and width of patch. The width and length of antenna is calculated by formula

$$W = \frac{C}{2f} \times \sqrt{\frac{2}{\mathcal{E}_r + 1}} \quad \ldots\ldots\ldots\ldots\ldots\ (1)$$

$$\mathcal{E}_{reff} = \frac{\mathcal{E}_r + 1}{2} + \frac{\mathcal{E}_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{(-0.5)} \quad \ldots\ldots\ (2)$$

$$\Delta L = 0.412 \times h \frac{(\in_{reff} + 0.3) \times (\frac{w}{h} + 0.264)}{(\in_{reff} - 0.258) \times (\frac{w}{h} + 0.8)} \quad \ldots\ldots\ldots\ (3)$$

$$L = \frac{\lambda}{2} - 2 \times \Delta L \text{ ................. (4)}$$

The figure2 shows the antenna created in HFSS software. This antenna is designed for 2.4GHz range of frequency.

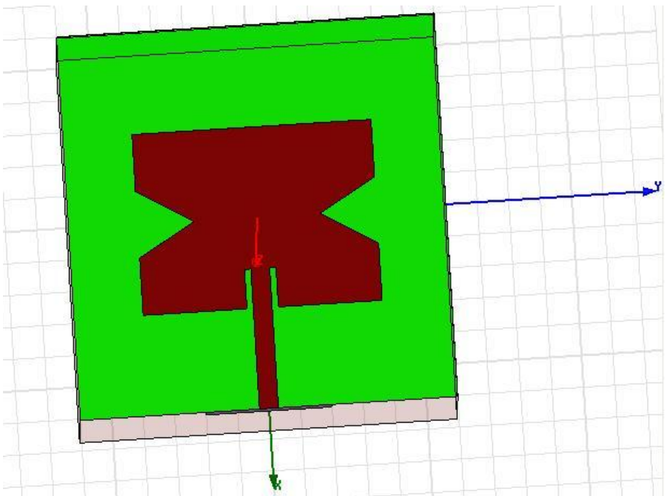

**Fig 2** Conical shap Patch Antenna at 2.4GHz

Figure no 3,4,5 shows the simulation result of designed antenna in HFSS softewar at 2.4GHz frequency.Here return loss and VSWR of antenna is minimum for 2.4GHz rang of frequency.because of conical shape of antenna the size and cost of antenna is reduced here.

Calculated value of patch antenna

| | |
|---|---|
| Antenna Width | 35mm |
| Antenna Length | 24.25mm |
| Substrate Height | 1.6mm |

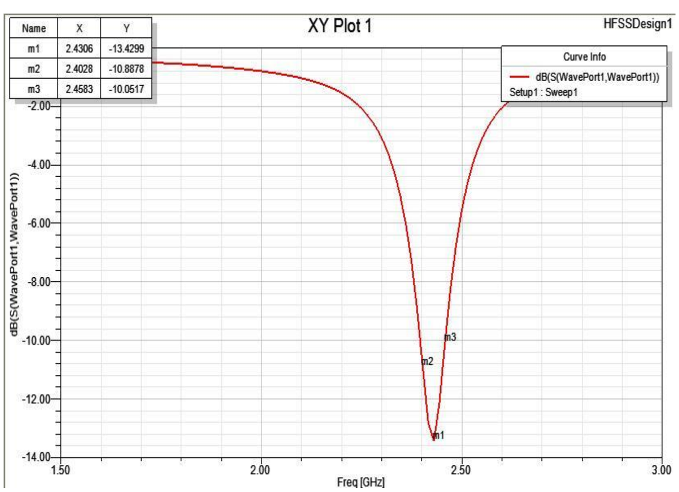


**Fig 3** Return Loss

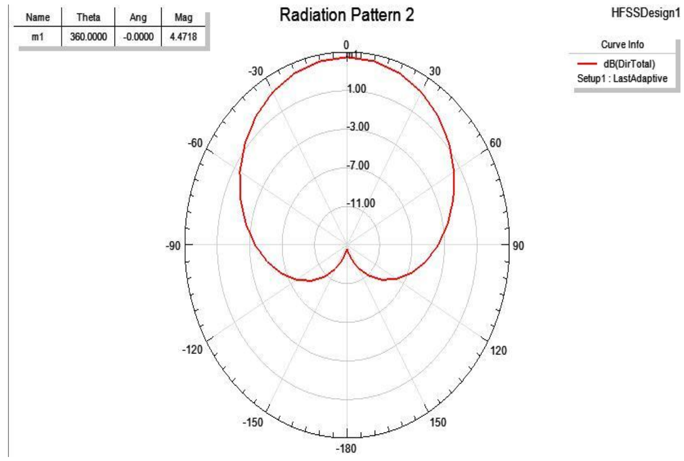


**Fig 4** Radiation Pattern

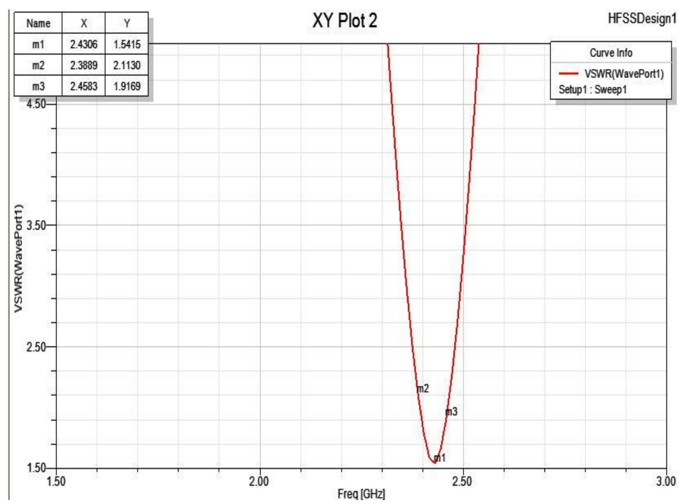


**Fig 5** VSWR

### 2.2 Design of Butler Matrix Array

The butler matrix is a NxN network consisting of N input ports and N output ports. The NxN Butler matrix creates a set of n orthogonal beams is space by processing the signal from N antenna elements.

The components of Butler Matrix are

1. 90° Hybrid
2. Crossover
3. Phase Shifter

#### 2.2.1 90° Hybrid

The design of hybrid can be calculated by following formulae.

a. $\lambda = \frac{c}{f}$ ………………… (5)

b. $\lambda/4$ ………………… (6)

c. feed length = $\frac{\lambda}{4\sqrt{\mathcal{E}_r}}$ …… (7)

d. width of hybrid is given by

$$Z_{50} = \frac{377}{\sqrt{\mathcal{E}_r}(\frac{W}{h}+2)} \text{ …… . (8)}$$

Where
$Z_{50}$ is the impedance of 50ohm line
W is the required width
h is the height of substrate

Obtained results are as follows

a. λ/4 = 30mm

b. feed length = $\frac{\lambda}{4\sqrt{\mathcal{E}_r}}$ = 15mm

c. Width of hybrid = 3mm

d. L = 4.8 mm

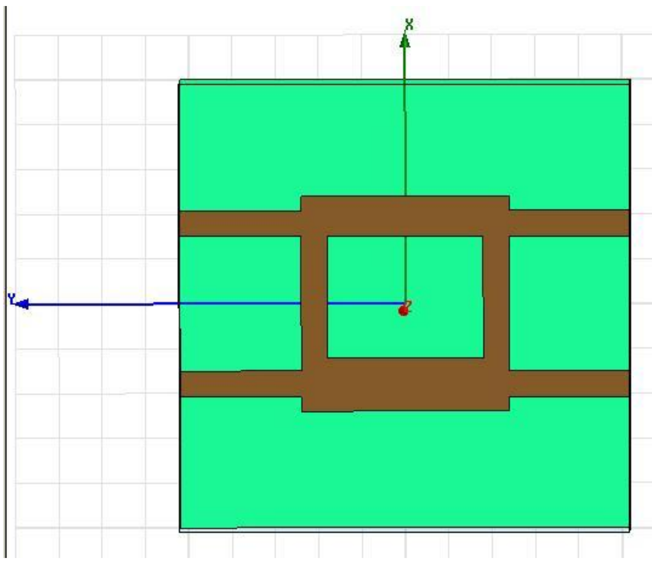

**Fig 6** Hybrid coupler

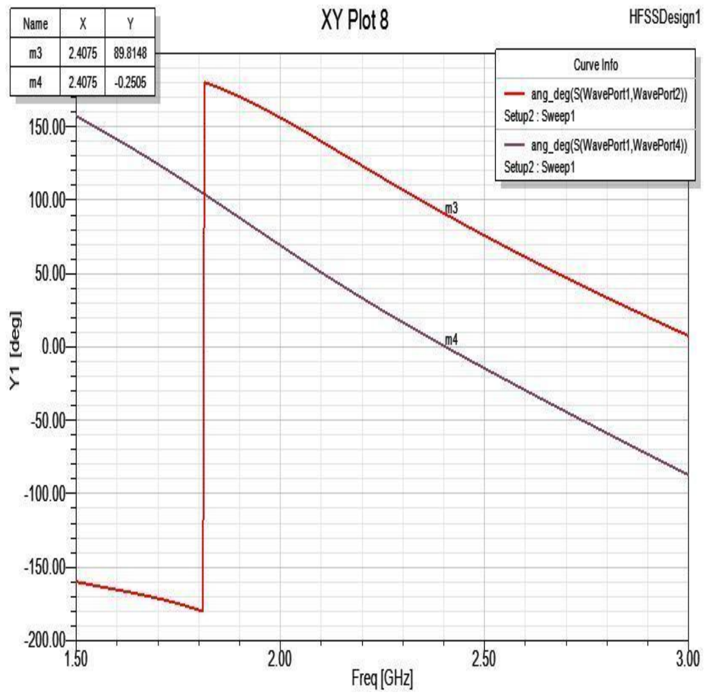


**Fig 7** simulation result of hybrid coupler

Here graph shows that when we feed signal to the port 1 then at output of port2 and port4 there is phase shift of 90 degree

### 2.2.2 Crossover

Crossover is use to transmit information from one hybrid coupler to another without loss of information.

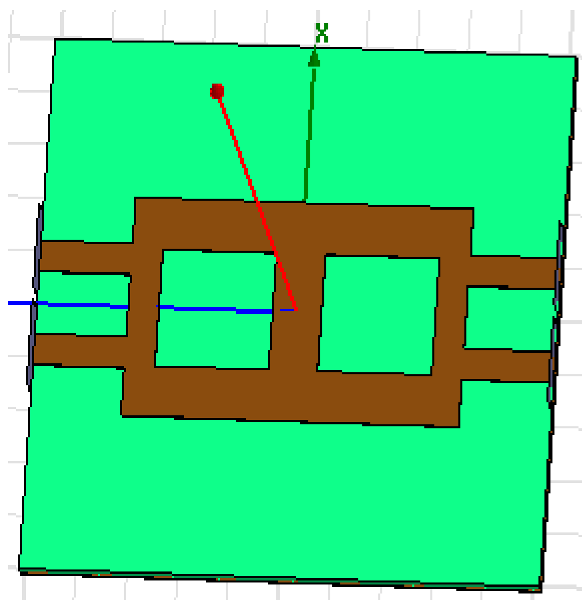

**Fig 8:** Crossover created in HFSS software

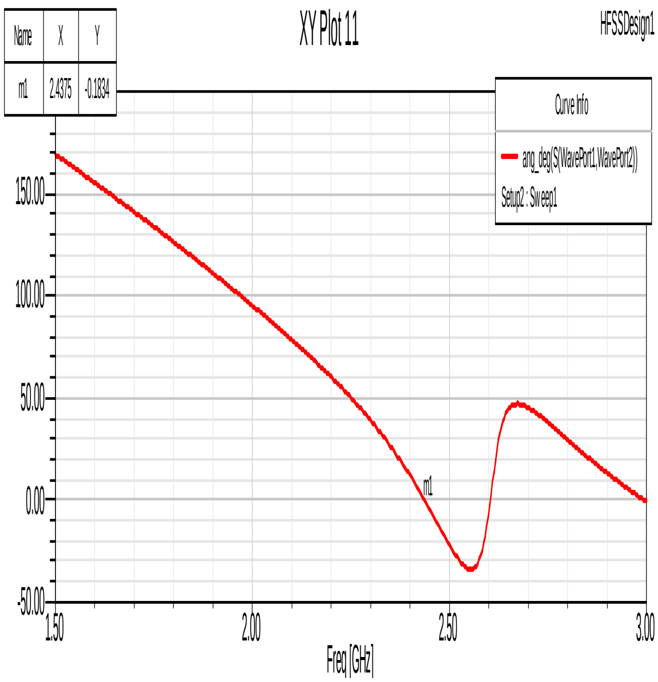


**Fig 9:** Simulation result of crossover in HFSS

Graph shows that when we feed signal to the port1 then at port 2 there is a 0 degree phase shift.

### 2.2.3 Phase Shifter

Phase shifter is use to provide phase shift to the signal. Here phase shifter is provided 90degree phase shift.

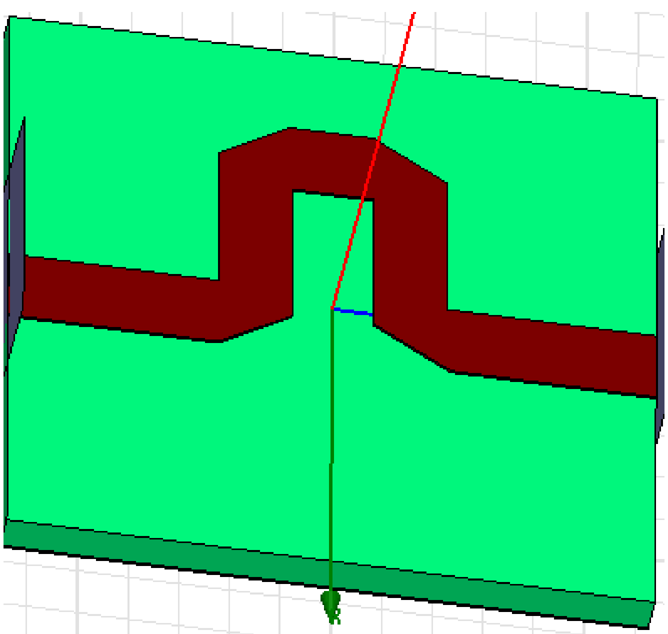

**Fig 10:** Phase shifter

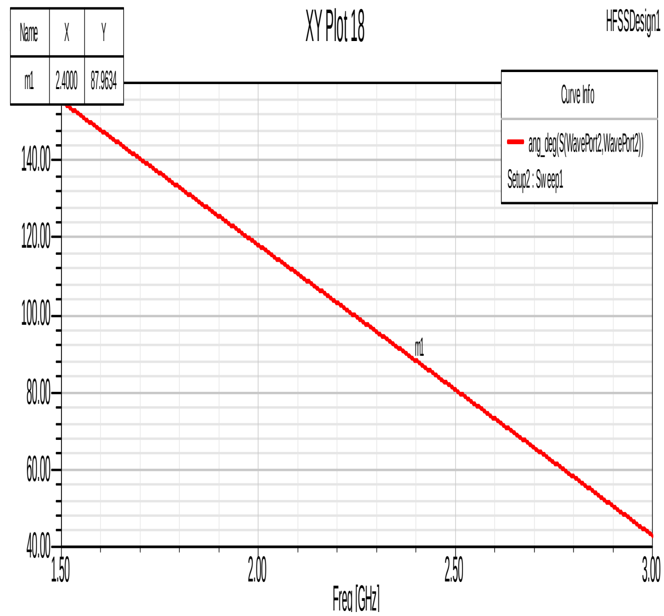


**Fig 11:** Simulation result of phase shifter inHFSS

Here graph shows that when we feed signal to the port1 then at the port 2 there is phase shift of 90 degree

### 2.3 Design of Butler Matrix-

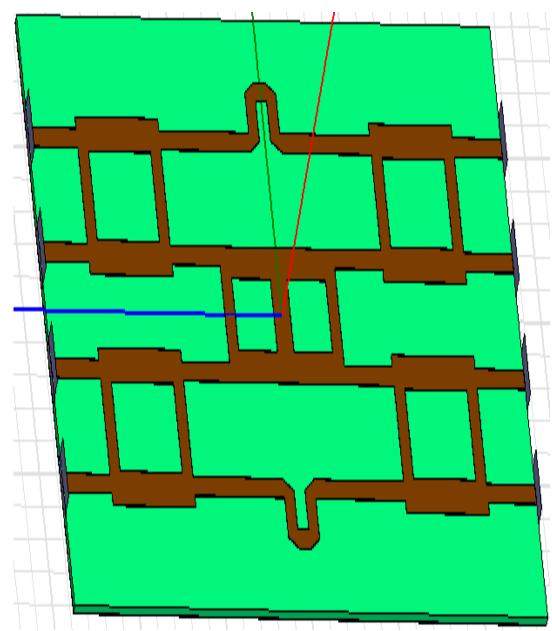

**Fig 12:** Reduced Butler network created in HFSS software

Fig.12 shows the reduced size butler matrix.Here only one crossover is required to form a butler matrix,so cost and size of network is reduced.Here port 1,2,3,4 are input ports and port 5,6,7,8 are output ports.

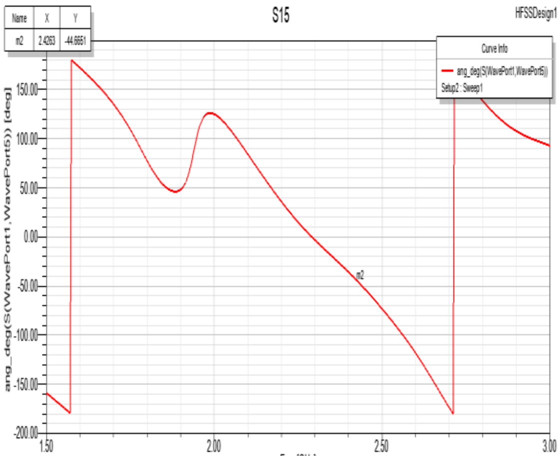


**Fig 13:** Simulation result of Butler network in HFSS

This fig.13 shows that when signal is fed to port 1then at output at port 5 output- 45 degree phase shift present.

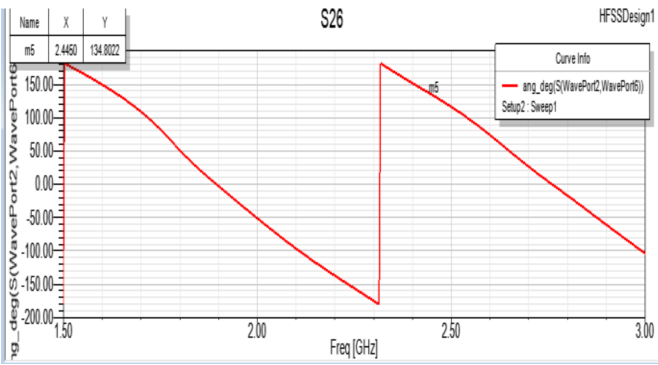


**Fig 14:** Simulation result of Butler network in HFSS

Fig. 14 shows that when signal is fed to port 2 then at port 6 there is 135 degree phase shift present.

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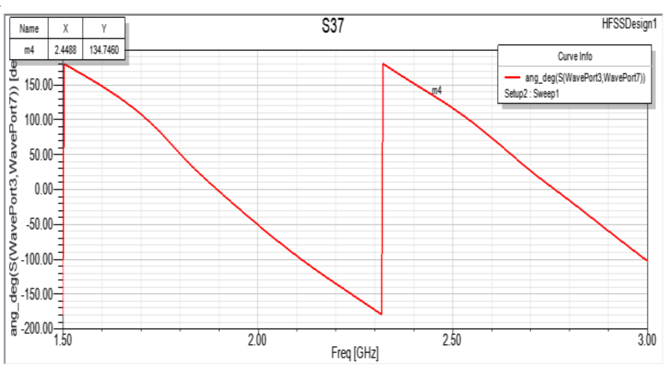


**Fig 15:** Simulation result of Butler network in HFSS

This fig.15 shows that when signal is fed to port 3 then at port 7, there is 135 degree phase shift present.

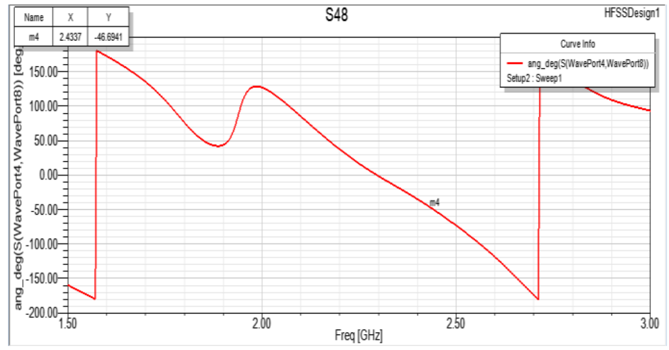


**Fig 16:** Simulation result of Butler network in HFSS

This fig.16 shows that when signal is fed to port 4 then at port 8 there is -45 degree phase shift present.

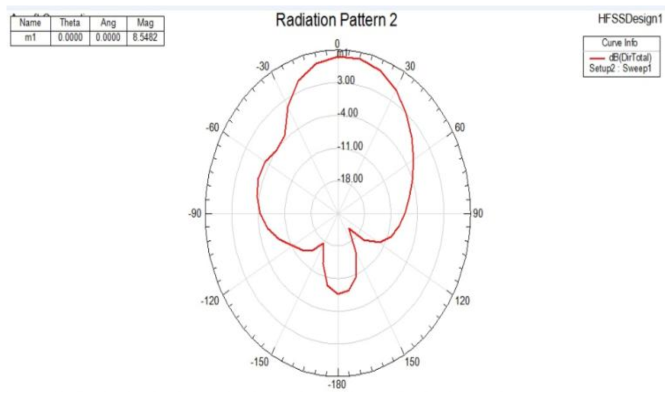


**Fig 17:** Simulation result of conical shape antenna when connected with reduced size butler matrix network in HFSS.

Up to this all the components have been tested and also combined testing of network has been done here. after this hardware will be prepared in which antennas will be connected to butler network in such a way that beams will be focused in all direction.

### 2.4 Final Hardware Result of Antenna:

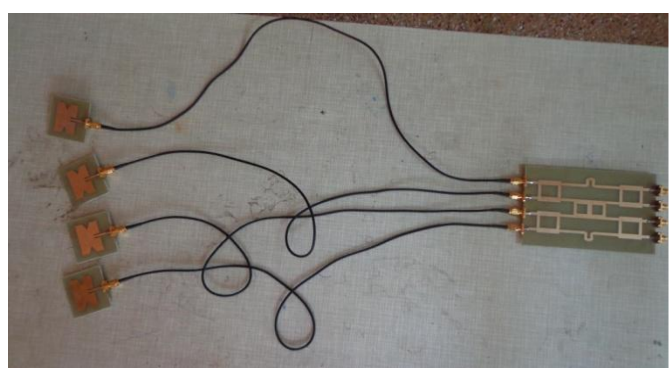

**Fig 18:** conical antenna with reduced butler matrix

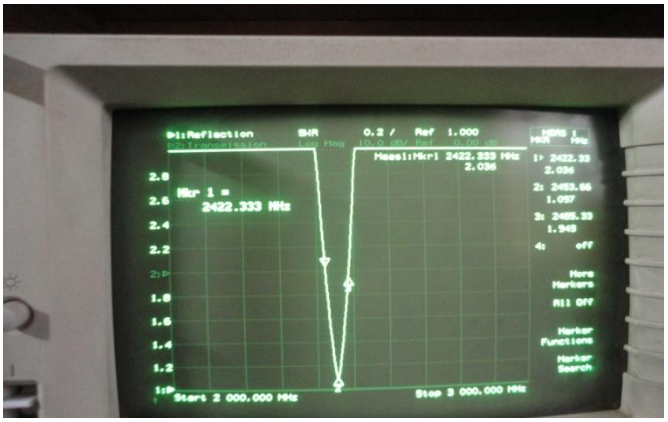


**Fig 19:** VSWR of conical shaped antenna

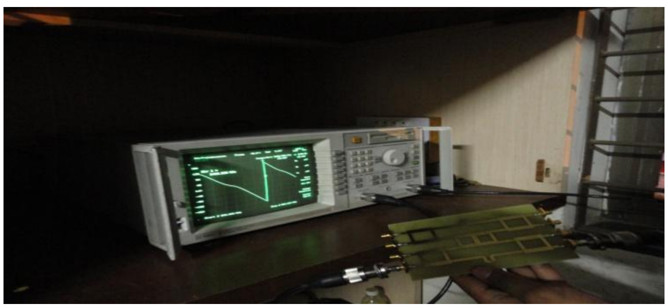

**Fig 20:** Phase shift of reduced butler matrix

## 3. CONCLUSIONS

This paper represents optimum design of butler matrix for ISM band application. Here because of conical shape antenna and reduced butler network cost of implementation is reduced and size is also reduced. The formulae for designing antenna are mentioned in paper. The results are simulated in HFSS.

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