PARAMETRIC ANALYSIS OF TRIPLE H-SHAPED RECONFIGURABLE MICRO- STRIP PATCH ANTENNA

Faisal Mustafa, M. R. Anjum, Imran Sarwar Bajwa, Usman.A. Khan, Shafqat Hussain
Department of Electronic Engineering
The Islamia University of Bahawalpur, Pakistan
Corresponding Author:faisalmustafa1411@gmail.com,

ABSTRACT— *In this paper parametric analysis with reconfigurability of triple H-Shaped micro strip patch antenna has been presented. The purpose of this research is to develop such features in the design of patch antenna that can provide different operating bands at different switching states. There are three metal tabs based switches in this patch antenna, so there are eight modes in which this antenna can operate and the antenna will cover different wireless applications lying in operating frequency bands between 0.5 to 2.5 GHz i.e. GSM, ISM, GPS and many others applications. In order to enhance the VSWR at specific operating frequency parametric analysis has performed, this analysis reveals that patch antenna can be tuned to any shift in operating frequency by changing the height of substrate which is made of FR-4 material with permittivity 4.4. The simulation is performed in CST MWS, the results of S11 Parameter along with their detailed analysis are briefly discussed in this paper.*

Keywords— GSM, ISM, GPS, return loss (S11), Microstrip patch antenna, Reconfigurable.

I. INTRODUCTION

With the development of wireless communication technologies, multiple bands antenna is necessary. In the past single antenna with multiple bands was made, but now a days an antenna can be operated in multiple bands by just using electronic switches. Many microstrip patch antennas were designed to turn it into reconfigurable antenna which can change their directivity as well as operating points by using PIN diode [1] or RF switches i.e. MEMS (Micro-electromechanical Systems) and by changing the capacitance of diode by applying reverse voltage to varactor [3]. But these methods caused problems as it requires biasing voltage in order to change ON and OFF states of the switches, this biasing voltages required very careful design so that it does not affect antenna's radiation patterns [4]. With the increase in number of switches antenna reconfigurable task becomes more and more difficult although many methods were proposed to eliminate the effects of diodes [5-6] but it is not applicable to all situations. There are many methods like pressure driven mechanism of fluidic system [7] and EGaln [8] to turn an antenna into reconfigurable.

In Parametric analysis the microstrip patch shows the change in different parameters, operating frequency points and directivity in different directions.

In our Triple H-Shaped multiple band Microscript Patch Antenna (MPA) by varying the height of substrate different frequency operating points are obtained. The author of this paper explains frequency reconfigurability of triple H-Shaped patch antenna against different state of switch and effect of variation in the height of substrate.

II. DESIGNED PARAMETERS OF MPA

The diagram of Triple H shaped Microstrip Patch antenna is shown in fig.1. There are three switches labeled as S1, S2 and S3. Each switch configuration has different frequency operating bands. The substrate used here is FR-4 with permittivity of 4.4 and patch is made of pure copper annealed material

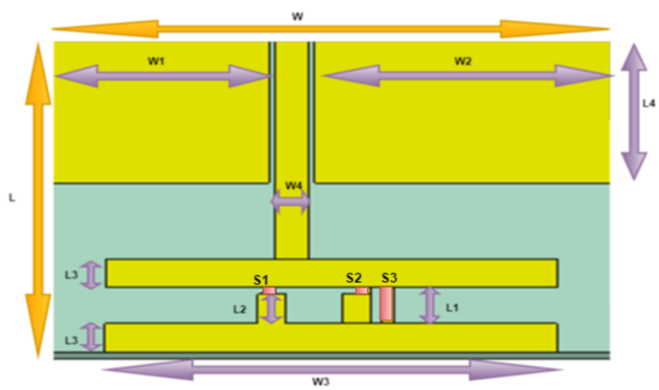

Fig.1: Triple H-Shaped Patch Antenna

The labled parameters in Fig 1 are listed in table I,

TABLE I

Parameter	Value (mm)
W	50
L	43.6
W1	19.5
W2	26.5
W3	40
W4	3
L1	5
L2	4.1
L3	4
L4	20

III. SIMULATION RESULTS

For parametric analysis, height of substrate is increased or decreased which results in shift of operating point. There are different 8 cases explained below

A. Case:1 (S1=S2=S3=OFF)

In this case all switches i.e. S1, S2 and S3 are in OFF state. When the height of substrate is changed from 1.57mm to 1.37mm, there is back shift in operating point which can be seen from fig.2 represented in green (- - -) line plot as compared with S11 plot at 1.57mm height of substrate which is denoted by (- . -) orange line . In the same way when height of substrate is increased from 1.57mm to 2.57mm then there is forward shift in operating point and plot is denoted by blue (. . . .) line

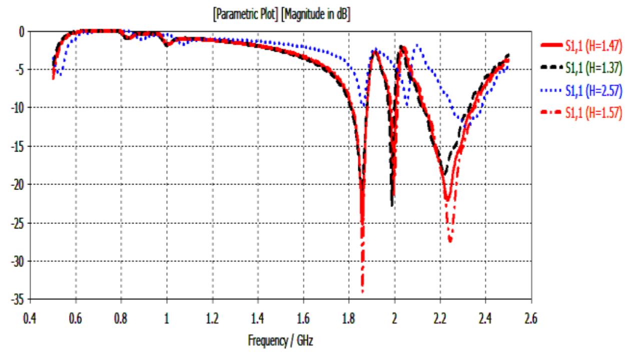

Fig.2: S11 parameter for case 1

Summary of results by varying the height of substrate are listed in table II, from this table it can be seen that there is forward shift in operating point when height of substrate is increased and back shift in operating point when the height is decreased. It is also observed that when the height increases then there is less bands of operating point as compared to less height of substrate like (1.57mm).

TABLE II

Switch State	S1=S2=S3=OFF		
Height of Substrate (mm)	Operating Points (GHz)		
1.37	1.8636	1.988	2.2169
1.47	1.8594	1.99	2.24
1.57	1.8578	1998	2.249
2.57	2.308		

B. Case:2 (S1=S2= OFF and S3=ON)

In this case switches S1 and S2 are in OFF state and S3 is in ON state. When height of substrate is changed from 1.57mm to 1.37mm, there is back shift in operating point which can be seen from fig.3 represented in blue (. . .) line plot as compared with S11 plot at 1.57mm height of substrate which is denoted by (-----) red line, In the same way when height of substrate is increased from 1.57mm to 2.57mm then there is forward shift in operating point and plot is denoted by orange (. . . .) line

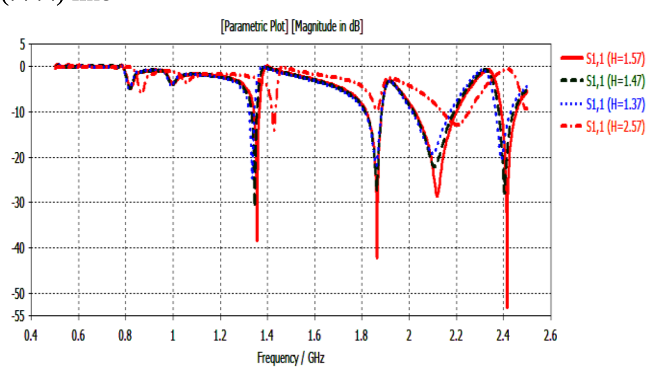

Fig.3: S11 Parameter of Case2

Summary of results by varying the height of substrate are listed in table III, from this table it can be seen that there is forward shift in operating point when the height of substrate is increased increases and back shift in operating point when the height is decreased. It is also observed that when the height increases then there is less bands of operating point as compared to less height of substrate like (1.57mm)

TABLE III

Switch State	S1=S2=OFF and S3=ON			
Height of Substrate (mm)	Operating Points (GHz)			
1.37	1.242	1.8758	2.2131	
1.47	1.25	1.87	2.23	
1.57	1.27	1.8786	2.2098	2.2546
2.57	1.35	2.3166		

C. Case:3 (S1=S3= OFF and S2=ON)

In this case switches S1 and S3 are in OFF state and S2 is in ON state. When height of substrate is changed from 1.57mm to 1.37mm, there is back shift in operating point which can be seen from fig.4 represented in blue (. . .) line plot as compared with S11 plot at 1.57mm height of substrate which is denoted b (-----) red line. In the same way when height of substrate is increased from 1.57mm to 2.57mm then there is forward shift in operating point and plot is denoted by orange (-.-.-) line

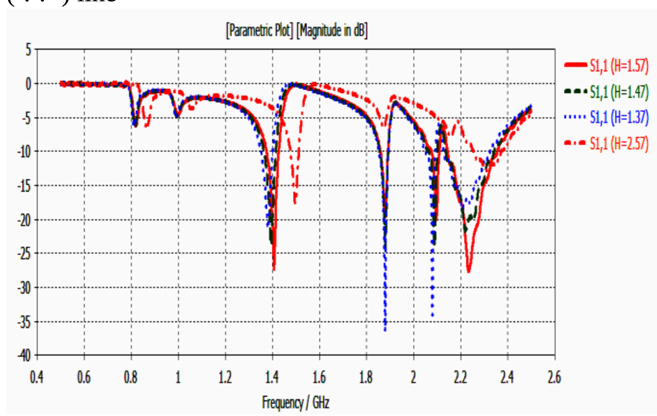

Fig.4: S11 parameter of Case 3

Summary of results by varying the height of substrate are listed in table IV, from this table it can be seen that there is forward shift in operating point when the height of substrate is increased and back shift in operating point when the height is decreased. It is also observed that when the height increases then there is less bands of operating point as compared to less height of substrate like (1.57mm)

TABLE IV

Switch State	S1=S3=OFF and S2=ON			
Height of Substrate (mm)	Operating Points (GHz)			
1.37	1.37	1.87	2.07	2.22
1.47	1.39	1.88	2.09	2.23
1.57	1.40	1.877	2.09	2.238
2.57	1.499	2.3079		

D. Case:4 (S1= OFF and S2= S3=ON)

In this case switches S1 is in OFF state and S2,S3 are in ON states. When height of substrate is changed from 1.57mm to 1.37mm, there is back shift in operating point which can be seen from fig.5 represented in blue (. . .) line plot as compared with S11 plot at 1.57mm height of substrate which is denoted by (-----) red line, In the same way when height of substrate is increased from 1.57mm to 2.57mm then there is forward shift in operating point and plot is denoted by orange (. . . .) line

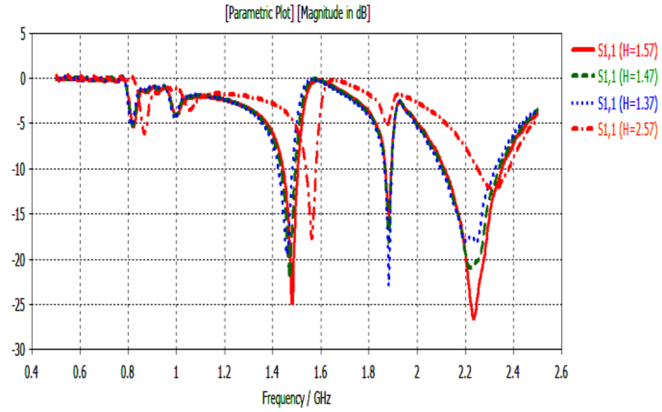

Fig.5: S11 parameter of Case 4

Summary of results by varying the height of substrate are listed in table V, from this table it can be seen that there is forward shift in operating point when the height of substrate is increased and back shift in operating point when the height is decreased. It is also observed that when the height increases then there is less bands of operating point as compared to less height of substrate like (1.57mm)

TABLE V

Switch State	S1=OFF and S2=S3=ON		
Height of Substrate (mm)	Operating Points (GHz)		
1.37	1.45	1.88	2.22
1.47	1.46	1.88	2.23
1.57	1.47	1.88	2.2393
2.57	1.5667	2.3158	

E. Case:5 (S1= S2=OFF and S3=ON)

In this case switches S1=S2 are in OFF state and S3 is in ON state. When height of substrate is changed from 1.57mm to 1.37mm, there is back shift in operating point which can be seen from fig.6 represented in blue (. . .) line plot as compared with S11 plot at 1.57mm height of substrate which is denoted by (-----) red line, In the same way when height of substrate is increased from 1.57mm to 2.57mm then there is forward shift in operating point and plot is denoted by orange (. . . .) line.

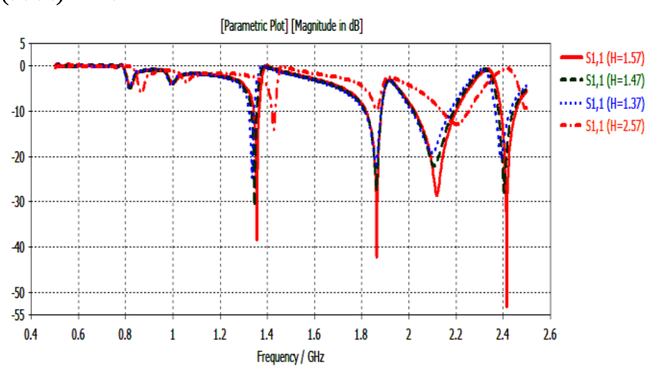

Fig.6 S11 parameter of Case5

Summary of results by varying the height of substrate are listed in table VI, from this table it can be seen that there is forward shift in operating point when the height of substrate is increased and back shift in operating point when the height is decreased. It is also observed that when the height increases then there is less bands of operating point as compared to less height of substrate like (1.57mm)

TABLE VI

Switch State	S1=ON and S2=S3=OFF			
Height of Substrate (mm)	Operating Points (GHz)			
1.37	1.33	1.86	2.09	2.38
1.47	1.34	1.86	2.11	2.40
1.57	1.35	1.86	2.1144	2.413
2.57	1.4307	2.1987		

F. Case:6 (S1= S3=OFF and S2=ON)

In this case switches S1=S3 are in OFF state and S2 is in ON state. When height of substrate is changed from 1.57mm to 1.37mm, there is back shift in operating point which can be seen from fig.7 represented in blue (. . .) line plot as compared with S11 plot at 1.57mm height of substrate which is denoted by (-----) red line, In the same way when height of substrate is increased from 1.57mm to 2.57mm then there is forward shift in operating point and plot is denoted by orange (. . . .) line.

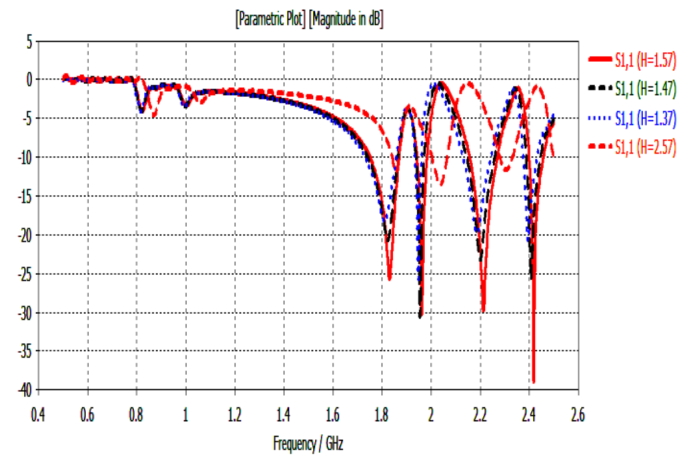

Fig.7: S11 parameter of Case6

Summary of results by varying the height of substrate are listed in table VII, from this table it can be seen that there is forward shift in operating point when the height of substrate is increased and back shift in operating point when the height is decreased. It is also observed that when the height increases then there is less bands of operating point as compared to less height of substrate like (1.57mm)

TABLE VII

Switch State	S1=S3=ON and S2=OFF			
Height of Substrate (mm)	Operating Points (GHz)			
1.37	1.81	1.94	2.18	2.39
1.47	1.82	1.95	2.19	2.40
1.57	1.8277	1.9624	2.2153	2.4179
2.57	1.85	2.04	2.30	

G. Case:7 (S1= S2=ON and S3=OFF)

In this case switches S1 and S2 are in ON state and S3 is in OFF state. When height of substrate is changed from 1.57mm to 1.37mm, there is back shift in operating point which can be seen from fig.8 represented in blue (. . .) line plot as compared with S11 plot at 1.57mm height of substrate which is denoted by (-----) red line, In the same way when height increased from 1.57mm to 2.57mm then there is forward shift in operating point and plot is denoted by orange (. . . .) line.

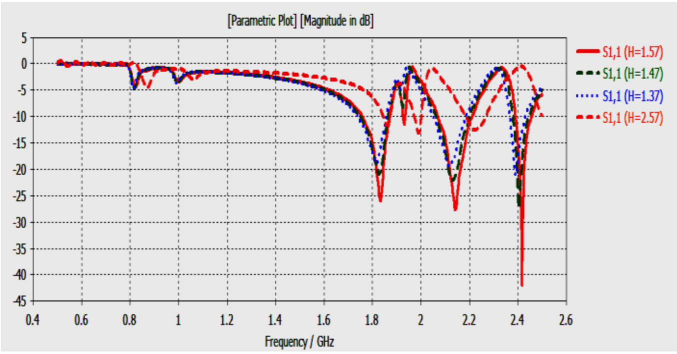

Fig.8: S11 Parameter of Case7

Summary of results by varying the height of substrate are listed in table VIII, from this table it can be seen that there is forward shift in operating point when the height of substrate is increased and back shift in operating point when the height is decreased. . It is also observed that when the height increases then there is less bands of operating point as compared to less height of substrate like (1.57mm)

TABLE VIII

Switch State	S1=S2=ON and S3=OFF			
Height of Substrate (mm)	Operating Points (GHz)			
1.37	1.8196	2.1138	2.388	
1.47	1.82	2.13	2.40	
1.57	1.8308	1.9324	2.14	2.4159
2.57	1.85	1.99	2.2212	

H. Case:8(S1= S2=S3=ON)

In this case switches S1=S2=S3 are in ON states. When height of substrate is changed from 1.57mm to 1.37mm, there is back shift in operating point which can be seen from fig.9 represented in blue (. . .) line plot as compared with S11 plot at 1.57mm height of substrate which is denoted by (-----) red line, In the same way when height increased from 1.57mm to 2.57mm then there is forward shift in operating point and plot is denoted by orange (. . . .) line.

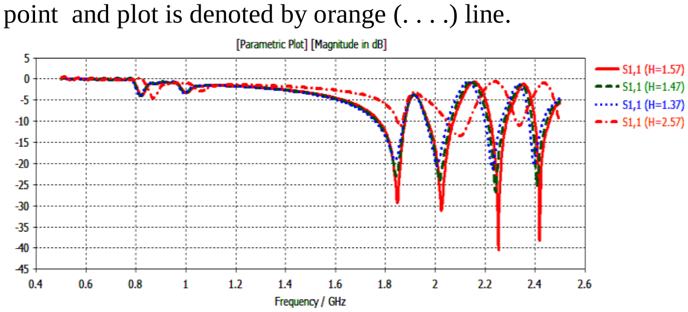

Fig.9: S11 parameter of Case8

Summary of results by varying the height of substrate are listed in table IX, from this table it can be seen that there is forward shift in operating point when the height of substrate is increased and back shift in operating point when the height is decreased. It is also observed that when the height increases then there is less bands of operating point as compared to less height of substrate like (1.57mm)

TABLE IX

Switch State	S1=S2=S3=ON			
Height of Substrate (mm)	Operating Points (GHz)			
1.37	1.84	2.009	2.22	2.39
1.47	1.84	2.013	2.24	2.40
1.57	1.85	2.0263	2.25	2.41
2.57	1.86	2.09	2.33	

IV. CONCLUSIONS

The simulating results of proposed reconfigurable patch antenna reveals that this antenna can cover multiple bands with good return loss just by changing the state of switches. Moreover from the parametric analysis of patch antenna it can be observed that by varying the height of substrate the operating point can be shift in forward or backward direction by increasing or decreasing the height of substrate respectively. This antenna is simulated between 0.5 to 2.5GHz frequency so it can cover applications including GSM, GPS and ISM.6

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