IoT and Microstrip Patch Antenna Frequency Reconfigurability

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Abstract— Frequency reconfigurability techniques of the Microstrip patch antenna are presented in this paper. Substrates choice of patch, shape, and size of the patch is the frequency reconfigurability techniques discussed in this paper. The proposed microstrip patch antenna is designed and simulated the patch with various shapes and sizes (with stubs and resonators) to measure its reconfigurable frequency scaled up to 60GHz i.e. in the range of mm waves frequency. Comparison and validation of the proposed microstrip patch antenna with the available literature patch antennas presented by the graphical results. S_{11} Simulation of a basic patch antenna, improved patch antenna, patch antenna with shunt inductor at 32mm above from feed point, patch antenna with microstrip resonators, patch antenna with microstrip symmetrical resonators, patch antenna without harmonic suppressions and patch antenna with harmonic suppressions are compared in tables and graphs.

Keywords—*5G, microstrip patch antenna, frequency reconfigurability, Internet of Things (IoT)*

I. INTRODUCTION

The third decade of the 21st century is the start of the Internet of Things (IoTs) and 5G is the mm waves [1] frequency signals flow over the networks which supports the mega demands of our daily needed wireless device all around us in homes, offices, and public places. The connection of the billions of wireless devices over the network requires massive IoT infrastructure to meet this mega demand. A higher data transmission rate over the limited bandwidth is the key to a 5G network to make it possible to have (highly connected and distributed systems) IoTs. Connections of billions of wireless devices over the network also require a huge amount of power, which could be limited by the microstrip patch antennas used for connection in wireless devices. A low-profile but high gain and high efficiency microstrip patch antenna is the prominent and fundamental element of wireless devices and networks. Freedom of the using various patch antenna substrates provides device engineers with great flexibility, reconfiguration options and bandwidth enhancement [2]. Dual band wide bandwidth microstrip patch antenna (MPA) with bandwidth extension of up to 2.45/5GHz is applicable to WLAN [3]. Dual band microstrip patch antenna provides bandwidth or frequency reconfiguration ability because of flexibility in designing its patch with two cuts at its two edges. Recently published MPA antenna for 5G applications with multiple input multiple outputs (MIMO) is reconfigurable up to 32-46 GHz with higher data rate transmission and high gain [4]. The frequency reconfigurability of MPA [5] by varying the lamped parameter of the patch antenna is reconfigurable up to 60GHz. The frequency reconfigurability of MPAs shows flexibility in Patch designing [4] and reconfigurable options by switching techniques like varying the lamped parameters of the patch antenna [5], both of the reconfigurability techniques succeed to enhanced the operating frequency of MPAs and gain as well. A reconfigurable MPA for the 5G (28GHz) applications, especially IOTs [6], explicitly presents the finite integration technique and finite element method-based simulation and analysis. Multiple cut patch antenna MPA for the same 5G applications (26.5 to 40 GHz) with metamaterial substrate is providing frequency reconfigurability [7] results. Wideband frequency reconfigurability in MPA for 5G (24 to 29.5 GHz) applications explicitly presents reconfigurability by varying the shape of the patches into 11 different shapes [8]. While radiation reconfigurability, polarization reconfigurability and hybrid reconfigurability can also be done in patch antennas as polarization reconfigurability can be achieved by using a graphene substrate [11-13]. This work is focused on frequency reconfigurability only which includes five sections I Introduction, II patch antenna structure, Section III Antenna parameters, IV results and section V conclusion.

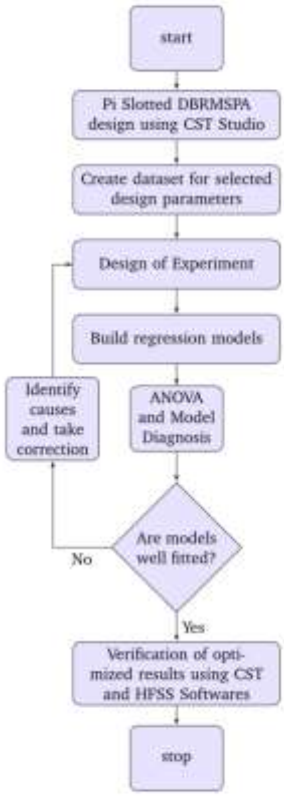

Fig. 1 shows Optimization algorithm to ensure efficient energy utilization based on optimized results for the IOTs [11].

II. PROPOSED PATCH ANTENNA STRUCTURE AND VARIANTS

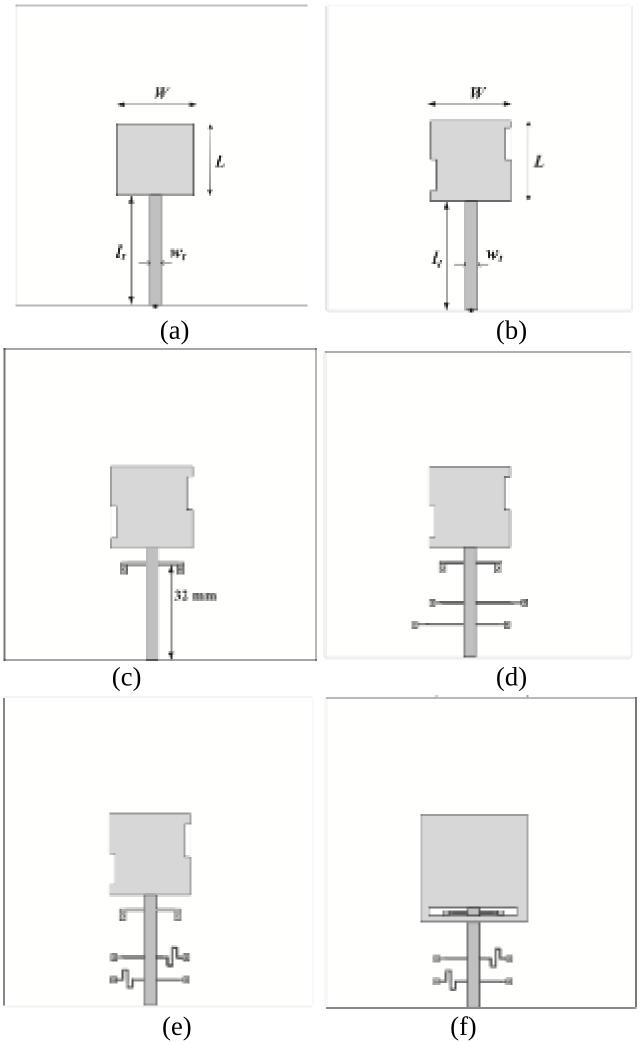

Fig. 2 (a) Basic patch antenna with dimensions (L = W = 28mm, l_t = 36mm and w_t = 2.8mm), (b) Improved patch antenna with the asymmetrical cut at left and right edges, (c) Improved patch antenna with shunt inductor at 32mm above from feed point, (d) Improved patch antenna with microstrip resonators, (e) Improved patch antenna with microstrip symmetrical resonators, and (f) Improved patch antenna with parasitic patch and slot.

Patch antenna structure with different variants started with the basic patch antenna, improved patch antenna with the asymmetrical cut at left and right edges, improved patch antenna with shunt inductor at 32mm above from feed point, microstrip resonators, and parasitic patch and slot is given in II section. Patch antenna parameters detail is given in III sections in Table 1, Table 2 and Table 3 compared the proposed antenna.

III. PROPOSED ANTENNA PARAMETERS AND MEASUREMENTS

Table 1 Simulated and measured gain of a basic patch antenna,

Frequency (GHz)	Simulation gain (dBi)	Measured gain (dBi)
2.4	-0.44	-0.38
2.45	-0.15	-0.13
2.5	-1.85	-1.85
5	-9.66	-9.33
5.2	1.09	1.12
5.4	-0.24	-0.19
5.6	-0.16	-0.13
5.8	0.11	0.13
6.0	-1.71	-1.65

Table 2 Average Simulated and measured gain of an improved patch antenna,

Frequency (GHz)	Simulation gain (dBi)	Measured gain (dBi)	Measured S_{11} (dBi)	Simulated S_{11} (dBi)
2.4	1.72	1.05	-3.69	-3.29
2.45	3.48	2.88	-7.01	-5.59
2.5	4.2	4.55	-25.89	-14.19
5	-9.88	-1.08	-2.34	-2.30
5.2	-5.147	1.6	-5.82	-8.77
5.4	1.8	3.85	-15.49	-15.33
5.6	3.22	4.5	-21.87	-24.74
5.8	5.01	5.12	-18.8	-15.77
6.0	2.05	2.93	-4.91	-5.80

Table 3 Comparison of the proposed work with literature works,

Parameters	Proposed work	Literature [3]	Literature [10]	Literature [9]
Antenna type Frequency (GHz)	Dual band patch Antenna Operating at 2.45 to 5 GHz WLAN bands	Dual band patch Antenna Operating at 2.45 to 5 GHz WLAN bands	Dual band patch Antenna Operating at 2.45 to 5 GHz WLAN bands	single band patch Antenna Operating at 2.45 to 5 GHz WLAN bands
S11 at 4.9	-1.9 dB	-2.0 dB	-2.0 dB	-3.0 dB
S11 at 5.2	-5.8 dB	-5.9 dB	-5.9 dB	NA
Peak gain at 2.45	3.55 dB	3.48 dB	-2.08 dB	NA
Peak gain at 5.8	5.0 dB	5.03 dB	5.03 dB	NA
Gain enhancement	yes	no	no	no

IV. Results and Discussion

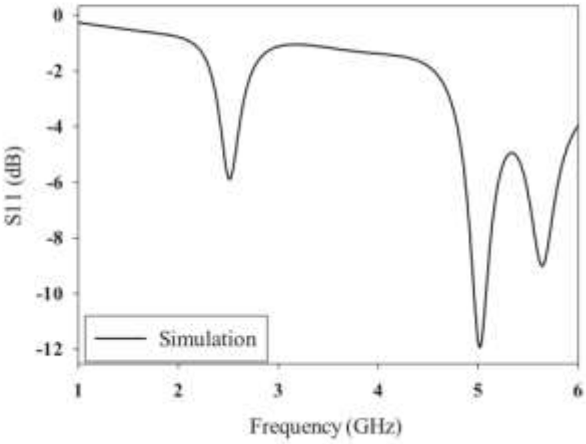

Fig. 3. (a)

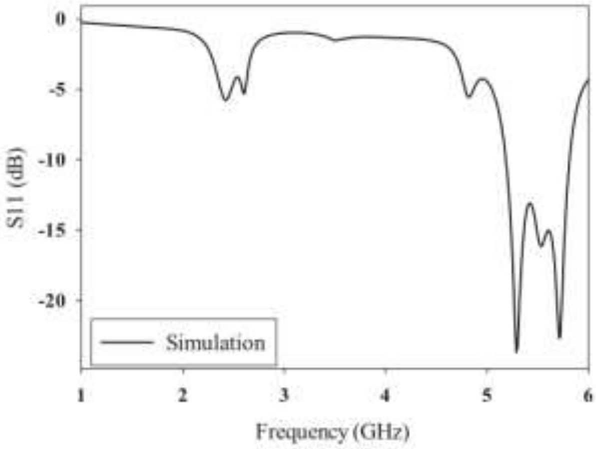

Fig. 3. (b)

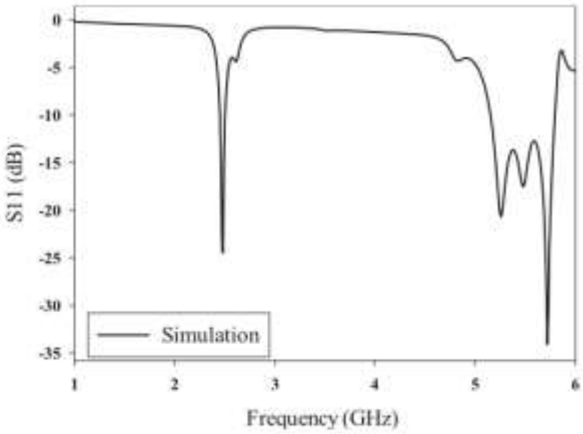

Fig. 3. (c)

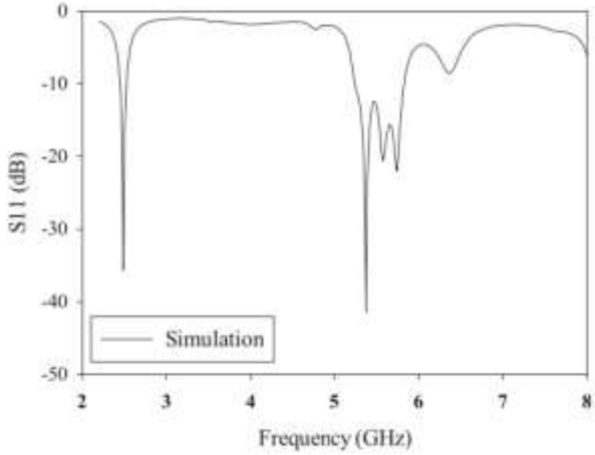

Fig. 3. (d)

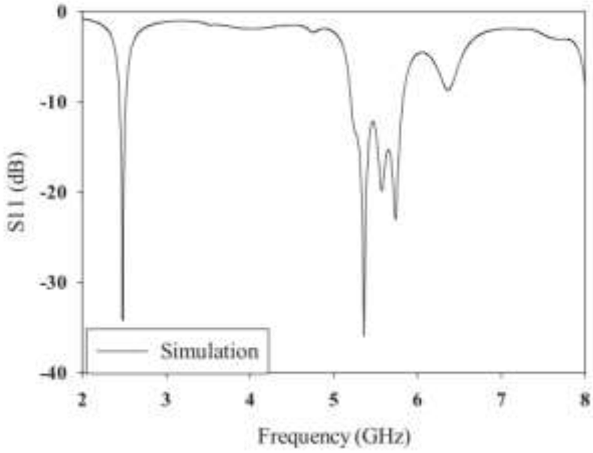

Fig. 3. (e)

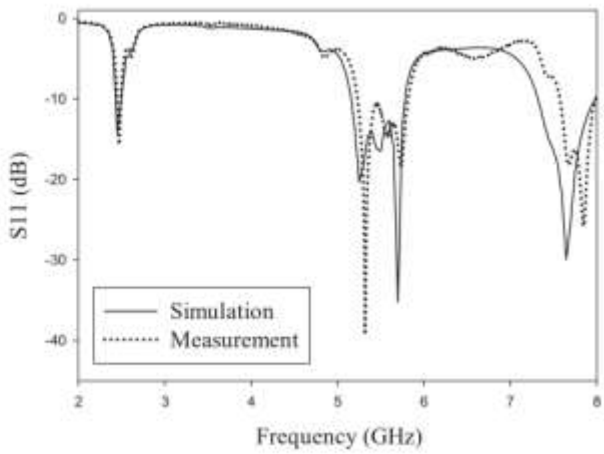

Figure 3. (f) Without harmonic suppression

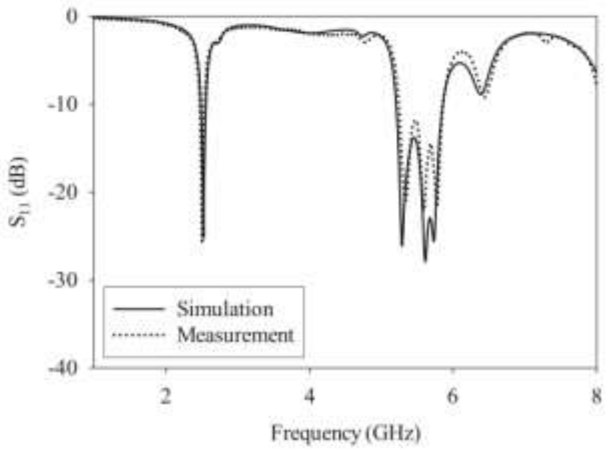

Fig. 1. (g) with harmonic suppression

Fig. 3 (a) Input reflection coefficient S_{11} Simulation of a basic patch antenna, (b) Input reflection coefficient S_{11} Simulation of improved patch antenna with the asymmetrical cut at left and right edges, (c) Input reflection coefficient S_{11} Simulation of improved patch antenna with shunt inductor at 32mm above from feed point, (d) Input reflection coefficient S_{11} Simulation of improved patch antenna with microstrip resonators, (e) Input reflection coefficient S_{11} Simulation of improved patch antenna with microstrip symmetrical resonators, (f) Input reflection coefficient S_{11} Simulation and measured of improved patch antenna without harmonic suppressions, (g) Input reflection coefficient S_{11} Simulation and measured of improved patch antenna with harmonic suppressions. All the simulation is performed on computer simulation technology (CST).

Input reflection coefficient S_{11} for the basic patch antenna and improved patch antenna for the cuts-in patch at the left and right edges are presented in the antenna structure diagrams. The cut in the patch means varying in the patch size, varying the patch size can provide frequency reconfigurability but also complicated the antenna geometry. Patch size variation mostly affects the reflection coefficient and gain. The addition of the shunt inductor at 32nm above the feed point improves the peak gain at 2.45 GHz frequency and also improves the overall gain of the antenna. The next improved patch antenna with a microstrip resonator, the introduction of resonators enhances the antenna gain from 5.01 to 5.12 dB at 5.8 GHz frequency. Patch antenna with resonators can shift the resonant frequency and so, make it antenna reconfigurable. Improved patch antenna with symmetrical resonators given in Fig. 2. (e) also provides frequency reconfigurability. The last improved patch antenna given in Fig. 2.9g) with a parasitic patch and parasitic slot is also considered for frequency reconfigurability. Thus, overall six types of patch antenna are considered in this work all for frequency reconfigurability ranges from 2.4 to 6 GHz and their corresponding reflection coefficients are given in Fig.3. The fundamental and pivotal parameters of patch antenna like operating frequency f_0, **the** thickness of the substrate (t) and relative permittivity of the substrate. Larger bandwidth and better, effective radiation pattern and higher working efficiency of the patch antenna is depending upon the selection of substrate i.e. low relativity and thickness of the substrate [11]. The simulation work, designing of the patch antenna and finding of reflection coefficients is inspired and motivated by the literature work [3]. To find the optimum wireless sensor network for the proposed antenna we have run the algorithm for the IOT applications given in Fig. 1.

V. Conclusion

The proposed microstrip patch antenna is designed and simulated the patch with various shapes and sizes (with stubs and resonators) to measure its reconfigurable frequency scaled up to 60GHz i.e. in the range of mm waves frequency. Comparison and validation of the proposed microstrip patch antenna with the available literature patch antennas presented by the graphical results. S_{11} Simulation of a basic patch antenna, improved patch antenna, patch antenna with shunt inductor at 32mm above from feed point, patch antenna with microstrip resonators, patch antenna with microstrip symmetrical resonators, patch antenna without harmonic suppressions and patch antenna with harmonic suppressions are compared in tables and graphs.

VI. References

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