Design and Implementation of Multiband Microstrip Patch Antenna for Wireless Applications

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Abstract

Multiband phased array antennas are required for today's multi-function communication applications. Generally Microstrip antenna arrays like Kotch array, Sierpinski array are used, but in some circuits where space is limited, arrays are not used. Therefore, to achieve the multiband operation with limited space, an antenna is designed with E-shaped in combination with split ring resonator to achieve the multiband operation. The simulation and experimental results show that the proposed antenna operates at four different frequencies, 1.8GHz, 3.6GHz, 4.53GHz and 5.73GHz, which can be used for different wireless applications like GSM 1800 (1.71– 1.78 GHz), Wi-MAX (3.4-3.69GHz) -IEEE 802.16 standards, Wi-Fi/WLAN (5.15-5.82 GHz). All the simulation results like resonant frequency, return loss, radiation patterns and fabricated antenna measured result is presented in this paper. The antenna is simulated using CST 2014 software.

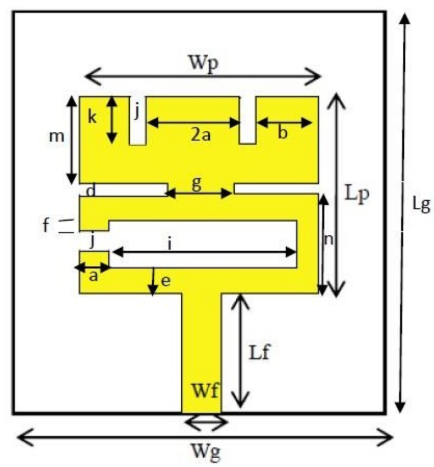
1. Introduction

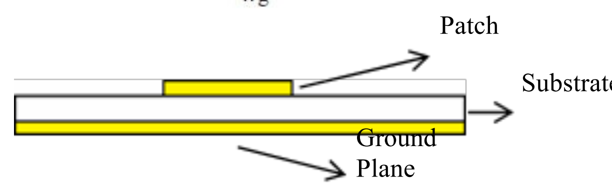
In the present generation wireless communication systems are rapidly developing due to increasing demand for the mobile equipment which is to be connected with different devices operating at multiple frequencies [1]. Multiband antenna plays crucial role in wireless communication systems as it can operate in multiple frequency bands for different wireless applications like Global System for Mobile communication (GSM), Wireless Local Area Network (WLAN), and Worldwide Interoperability for Microwave Access (Wi-MAX), and Wireless Fidelity (Wi- Fi).

The advantage of multiband antenna is their ability to integrate multiple frequency bands in a single antenna which makes the design and operation more complex than single and dual band antennas. From literature [2-3], the Fractal antenna arrays like Kotch array, Sierpinski array are also used to achieve the multiband operations. But, the Fractal antennas increase the design complexity. Microstrip patch antenna is a well suited device for wireless communications which can be easily integrated with microwave circuits because of their low volume, thin profile, light weight and low cost, which can work at multiple frequencies[1]. Hence, multiband Microstrip patch antenna is of great concern now-a-days.

2. Antenna Design

The proposed antenna is designed using FR4 substrate with a thickness of 1.6mm. The dielectric constant of the FR4 substrate is 4.4. The dimensions of the ground plane and the substrate are the same, i.e. (70×60 mm). The dimensions of the patch are taken as (35×30 mm). The front view and side view of the designed antenna and fabricated antenna are shown in Figure 1(a), (b) &(c).





(b) Side view.

Figure 1: Geometry of the Antenna

The antenna is designed and simulated using Computer Simulation Technology tool. Slots are made in the patch to obtain multiband characteristics [4-6]. The dimensions of the antenna are tabulated as shown in Table 1.

Table 1. Values of different parameters.

S.No	Parameter	Description	Value(mm)
1	Wg	Width of the ground plane	60
2	Lg	Length of the ground plane	70
3	Wp	Width of the patch	30
4	Lp	Length of the patch	35
5	Wf	Width of the feed	3
6	Lf	Length of the feed	17.5
7	a	Width of the SRR & center arm of E	4
8	b	Width of the E-arms	7
9	d	Gap between E & SRR	1
10	e	Width of the SRR-shaped slot	5.5
11	f	Length of SRR arm	1
12	g	Rectangular junction width between E & SRR	5
13	i	Length of the SRR-shaped slot	22
14	j	Slot length of SRR	3
15	k	Length of the slot in E-shape	12
16	m	Length of E	16.5
17	n	Length of SRR	16.5

Microstrip line feeding is used for the proposed antenna as it is easy to fabricate. The length and width of the slots determine the resonant frequencies of the antenna [7-12]. By changing the proportions of the length and width of the slots multiband characteristics may change. The optimized parameters of the slots are chosen for fabrication.

3. Simulation Results

By simulating the design, four different resonant frequencies are obtained as indicated in figure 2. The four resonant frequencies are 1.8GHz, 3.6GHz, 4.53GHz and 5.73GHz respectively.

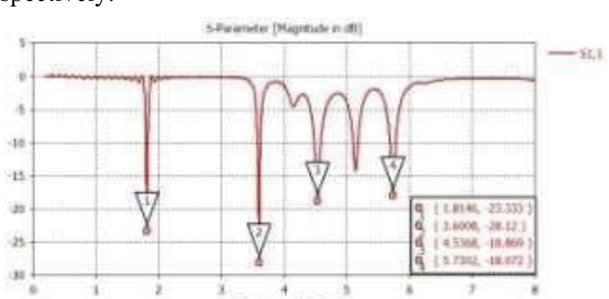


Figure 2: S_{11} parameter of the designed antenna.

For first resonating frequency i.e. for 1.8GHz, the return loss is -23.33dB. For second frequency i.e. for 3.6GHz the return loss is about -28.105dB, the third resonant frequency is obtained at 4.5GHz, where the return loss is about - 18.8dB.

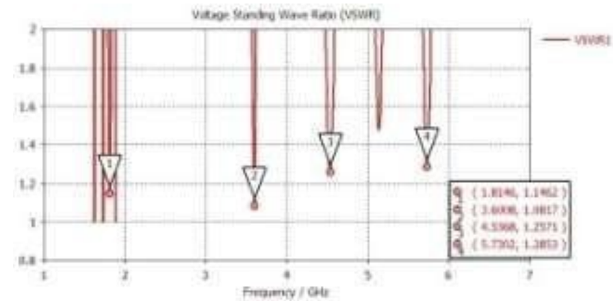


Figure 3.VSWR plot of the simulated antenna.

The fourth resonating frequency is obtained at 5.73GHz with a return loss of -18.072dB. Figure 3 shows the VSWR plot of the designed antenna.

Ideally, the VSWR ranges between 1-2 which has been achieved for all four frequencies, i.e. at 1.8GHz, 3.6GHz, 4.53GHz and 5.73GHz respectively. The VSWR values at 1.8GHz, 3.6GHz, 4.53GHz and 5.73GHz is 1.1493, 1.0817, 1.2572 and 1.2855 respectively.

The radiation pattern of the antenna at different frequencies is depicted in figure 4. It can be seen that the radiation patterns are omnidirectional in E-plane.

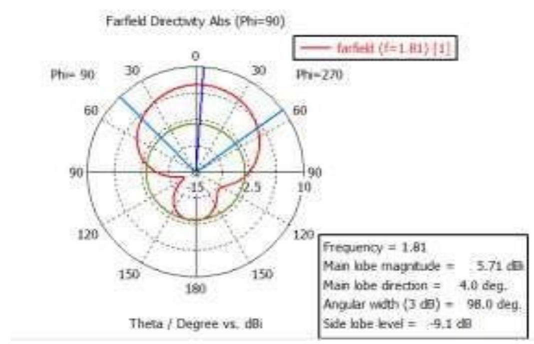


Figure.4.1: Far-field radiation pattern for 1.8GHz

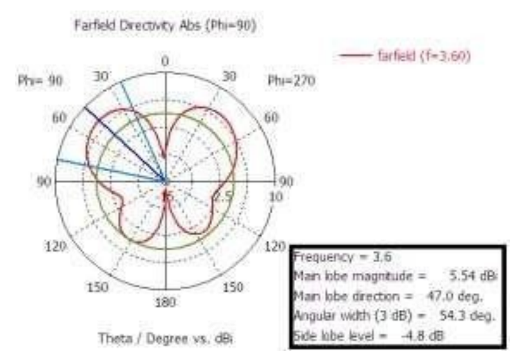


Figure 4.2: Farfield radiation pattern for 3.60GHz.

The radiation pattern shown in figure 4.2 at 3.6 GHz frequency shows the bidirectional nature with angular width of 54.3 deg. whereas the radiation pattern patterns shown in figures 4.1, 4.3 & 4.4 shows complete omnidirectional nature with greater angular widths i.e. 98 degrees at 1.81 GHz, 61.9 degrees at 4.53GHz and 117.8 degrees at 5.73 GHz. Therefore the angular width is reduces when the nature of the radiation pattern is changed from omnidirectional to bidirectional.

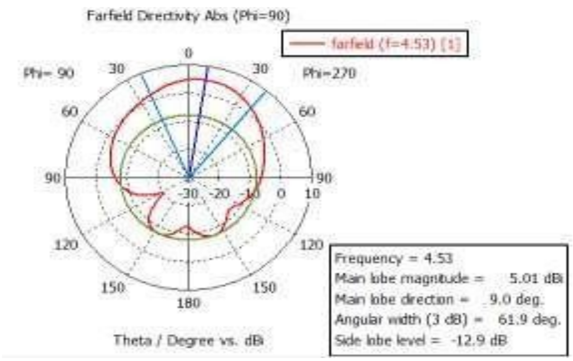


Figure 4.3: Farfield radiation pattern for 4.53GHz.

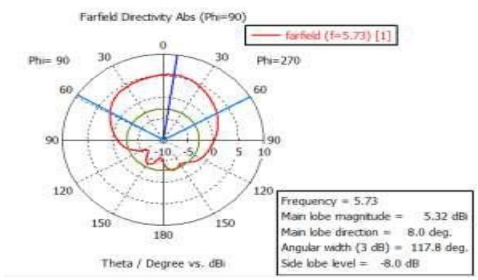


Figure 4.4: Farfield radiation pattern for 5.73GHz.

The radiation pattern shows directivity of 5.71 dBi and main lobe direction of 4.0 deg. for 1.8GHz frequency. The radiation pattern for 3.60 GHz frequency shows directivity of 5.54 dBi and main lobe direction as 47.0 deg. The radiation pattern shows directivity of 5.01 dBi and main lobe direction of 9.0 deg. for 4.53GHz frequency. The radiation pattern for 5.73 GHz frequency shows directivity of 5.32 dBi and main lobe direction as 8.0 deg. S11, VSWR and directivity of different frequencies are tabulated in table 2.

Table 2. Return loss, VSWR and directivity of different frequencies

S.No	Frequency (GHz)	S11(dB)	VSWR	Directivity
1.	1.81 GHz	-23.33dB	1.146	5.71dBi
2.	3.60 GHz	-28.11dB	1.08	5.54dBi
3.	4.53 GHz	-18.86dB	1.25	5.01dBi
4.	5.73 GHz	-18.07dB	1.28	5.32dBi

The surface current distribution along the antenna at different resonant frequencies is presented in figure 5.

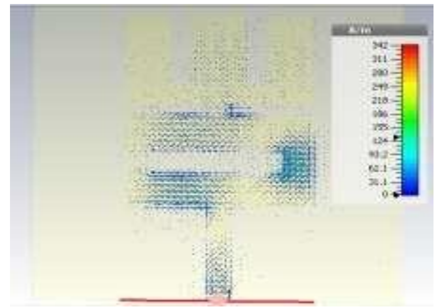


Figure 5.1: Surface current at 1.8GHz.

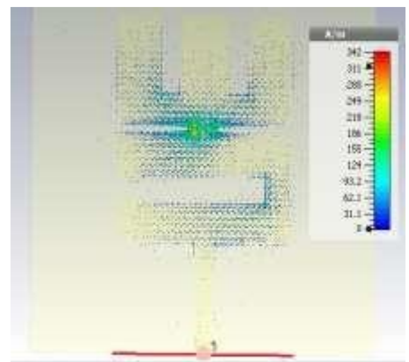


Figure 5.2: Surface current at 3.6GHz.

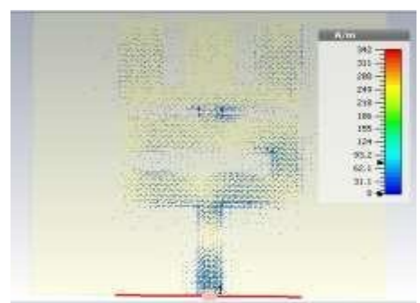


Figure 5.3: Surface current at 4.53GHz.

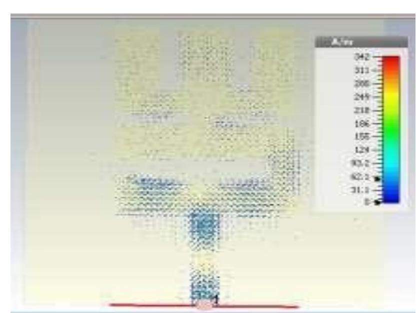


Figure 5.4: Surface current at 5.73GHz.

Different frequencies obtained and their applications are tabulated in table 3.

Table 3. Applications for different simulated frequencies

S. No	Frequency (GHz)	Applications
1.	1.81 GHz	GSM 1800
2.	3.60 GHz	Wi-MAX (IEEE 802.16)
3.	4.53 GHz	Used in defense for missile navigation
4.	5.73 GHz	Wi-Fi/WLAN(IEEE802.11a/h/j)

The proposed antenna is fabricated and measured using VNA, the return loss and VSWR measured results are depicted in figure 6.

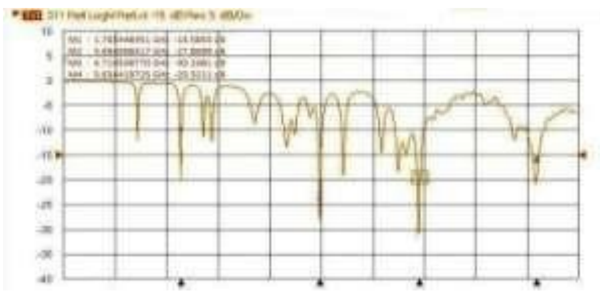
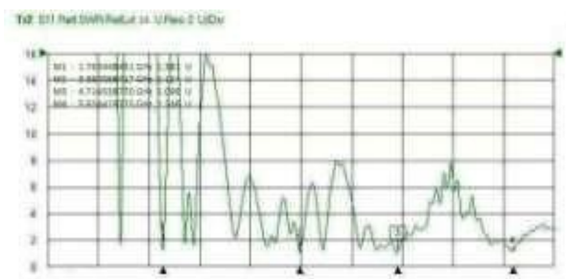


Figure 6.(a): Return loss Experimental result of the



Fabricated antenna using VNA

Figure 6.(b): VSWR Experimental result of the fabricated antenna using VNA

Comparison of simulated results and Experimental results are tabulated in table 4.

Table 4. Simulated results and Experimental results comparison

S. No	Frequency (GHz)	Simulated Results		Experimental Results	
		S11(dB)	VSWR	S11(dB)	VSWR
1	1.81 GHz	-23.33dB	1.146	-18.58	1.381
2	3.60 GHz	-28.11dB	1.08	-27.86	1.124
3	4.53 GHz	-18.86dB	1.25	-30.16	1.099
4	5.73 GHz	-18.07dB	1.28	-20.32	1.246

4. Conclusion

A Microstrip patch antenna which can be operated at five different frequencies is designed using CST software and fabricated. The resonant frequencies obtained are 1.8 GHz, 3.6 GHz, 4.5GHz, 5.13 GHz, and 5.73 GHz. This antenna can be used for wireless applications like Wi-Fi, Wi-MAX, GSM1800, and WLAN. Multiband performance is achieved by optimizing the length and width of the patch and by changing the length and width of the slots. Even the locations of the slots also affect the antenna performance. All the frequencies obtained by designing this antenna return loss much lesser than the desired value, i.e. -15dB and also compared with fabricated antenna measured results. For future simulation process, other shapes of slots can be implanted in order to achieve better effect and to cut the antenna size. The increase in bandwidth of the proposed antenna can be increased by utilizing other techniques like photonic band-gap structures and defected ground structures.

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