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C-Band Multi-Frequency Shorting Pin Loaded Elliptical Patch Antenna

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***Abstract*-In this paper, a multi frequency microstrip antenna (MSA) for wireless applications is designed. The proposed MSA comprised of elliptical patch antenna with shorting pin. This antenna is fed by coaxial probe. The design parameters are major and minor axis of elliptical patch, the position of shorting pin and feeding point of probe are mentioned in table-1. The proposed antenna can provide optimized multi frequency by varying the above design parameters. FR-4 substrate with dielectric constant 4.4 is chosen. The multi frequencies are 4.49GHz, and 6.69GHz, which covers the applications such as satellite communications, for full-time satellite TV networks.**

***Keywords*-Coaxial feed, Elliptical patch, C-band, Shorting pin.**

I. INTRODUCTION

The microstrip antenna is one of the most preferred antenna structures for wireless applications and handheld devices. These antennas are light weight, small in size, and low volume. The design of the antenna along with its parametric studies and executed using a softs high-frequency structure simulator (HFSS). The design in x-band is verified experimentally with the prototypes etched on RT Duroid 5880[1-3]. Nearly double the element bandwidth has been achieved which may result in about 8% impedance bandwidth of a circular patch predicted and measured bandwidth of an identical conventional patch is about 4%. Although much larger impedance bandwidths of a microstrip element can be achieved by different techniques [5] like cutting slots on microstrip patch, introducing parasitic elements, or by reactively loading the patch [6], those methods usually involve rigorous design and fabrication processes. Moreover, most of those designs suffer from various distortions in radiation patterns, high cross-polarized levels, and decrease their efficiency [4]. Generally, the multi-frequency patch antennas are divided into two categories, (a) multi-resonator antennas and (b) reactively loaded antenna. The first category antennas are achieved by means of multiple radiating elements, and each radiating element supports strong currents and radiation phenomena at its resonant frequency [7].

It includes the multilayer stacked-patch antennas using circular, annular, rectangular and triangular patches [7-8]. Multi resonator antennas in coplanar structures can also be fabricated by using aperture-coupled parallel microstrip dipoles [9], as these antenna structures usually involve multiple substrate layers and these are high cost. The large size is the drawback of multi-resonator antenna, which is difficult to be installed in hand-held terminals. The second category is reactively load patch antenna, for multi frequency operation of the antenna such as multi-slotted patch, rectangular patch with two T-slots, truncated circular patch with double U-slot, square spiral patch antenna and pi-shaped slot on rectangular patch [10—15]. These structures involve complex calculation, design, higher frequency ratio and lower bandwidth as compared to proposed antenna. Therefore, the proposed antenna consists of a simple shorting pin with ground which is loaded on the elliptical patch antenna and it is fed by coaxial feed probe. The dimensions of the proposed antenna are optimized and simulated in such a way that it provides multi-frequency.

II. ANTENNA DESIGN

The proposed antenna is shown in Figure-1 (top view) (front view). The elliptical patch of semi major axis 'b' and semi minor axis 'a' is printed on the FR-4 substrate ($\varepsilon_r = 4.4$). A pin is inserted at (-7, 3, 0) in between patch and ground the diameter of the pin is 1mm. the eccentricity of elliptical patch e (= $\sqrt{1} - (a|b)^2$), where 'b' is the semi major axis of the elliptical patch, 'a' is semi minor axis of the elliptical patch, $\boldsymbol{\varepsilon}_r$ is dielectric constant of the substrate. The multi frequency resonance can be obtained by properly designing the length and width of the substrate, patch, and also the feed point of the probe all dimensions are given in table-1.

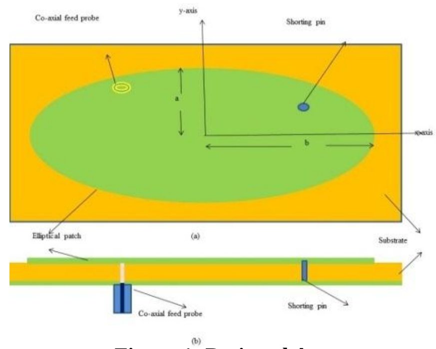

Figure-1: Designed Antenna

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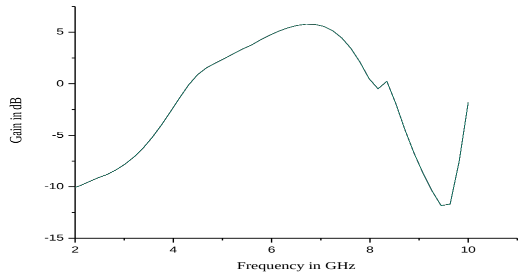
Table-1:
Specification of the elliptical antenna

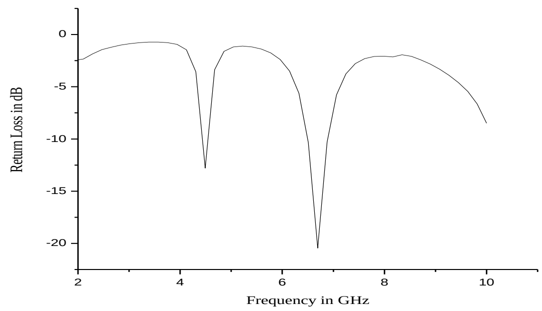
Design Parameters	Value
Substrate area	30mmX30mm
Semi major axis 'b'	14mm
Semi minor axis 'a'	5.6mm
Eccentricity 'e'	0.92
Substrate type	FR4
Substrate thickness h	1.8mm
Dielectric constant 'ε_r'	4.4
Shorting pin point	(7,1.5,0)
Feed point	(-7,3,0)
Patch Material	Copper
Patch thickness	0.07mm

The proposed antenna shows better return loss i.e. -12.7893dB, and -20.4519dB at the first and second band of the frequencies 4.4898GHz and 6.6938GHz respectively, Increasing negative value of return loss implies good impedance matching w.r.t the reference impedance of 50ohms.



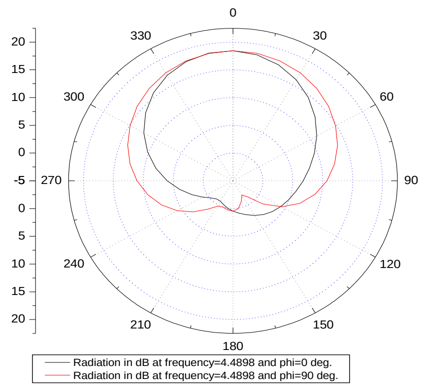
(a)

(b)

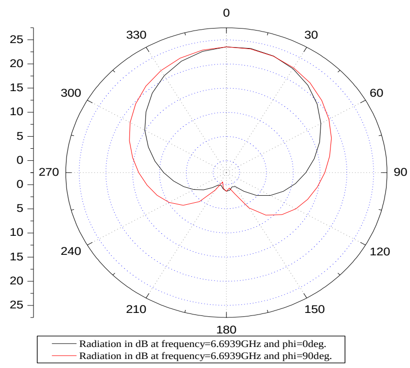


(c)

(d)



(e)



(f)

Figure-2: (a) Return loss, (b) VSWR, (c) Gain, (d) Directivity and (e) & (f) Radiation pattern

The VSWR of the proposed antenna shows 4.056dB and 1.6549dB at frequencies 4.4898GHz, and 6.6938 GHz respectively. This parameter implies the impedance matching between the sources to the feed is good, and it is essential requirement for the proper working of the antenna. VSWR value below 2 is successfully achieved for good antenna performance.

The designed antenna achieved good gain as 0.8742dB, and 5.7829 dB corresponding frequencies from lower to high.

Directivity of the antenna is the ability to focus energy in a particular direction when transmitting the power during the radiation, or to receive energy better from a particular direction. The directivity is achieved as 3.2464 dB and 6.5826 dB i.e. the maximum amount of radiation intensity at different corresponding frequencies as 4.4898GHz and 6.6938 GHz. As shown in Figure-2: (a) Return loss, (b) VSWR, (c) Gain, (d) Directivity.

The 2D radiation patterns for the elevation and azimuthal plane respectively of the proposed antenna is given in figure-2 (e) and (f). Radiation pattern is the graphical representation of the radiation properties of the antenna as a function of space. Radiation pattern describes how the energy is radiated out into the space by the antenna and how it is received onto to antenna. For the band of the frequencies 4.4898 GHz, and 6.6938GHz, the radiation pattern is nearly omnidirectional in the azimuthal and elevation plane.

Table-2:
Performance of purposed Antenna

Frequency in GHz	Return Loss in dB	VSWR in dB	Gain in dB	Directivity in dB
4.4898	-12.7893	4.056	0.8742	3.2464
6.6938	-20.4519	1.6549	5.7829	6.5826

III. Conclusion

The compact elliptical microstrip patch antenna with shorting pin is proposed for C-band applications, shows that by using elliptical patch and shorting pin, antenna are able to resonate at frequencies 4.4898GHz, and 6.6938GHz. The designed antenna is appropriate for C-band applications. The obtained return loss, directivity, gain, and VSWR is good and radiation characteristics are also appropriate, different feeding techniques may also be used for increasing the efficiency of antenna.

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