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Reconfigurable Printed Patch with Pair of U Shaped Strips for C-band Applications

Chamandi Priya.S
Dept. of Electronics and Communication
Valliammai Engineering College
Chennai, India
chandi592@gmail.com

Prithivirajan.V
Dept. of Electronics and Communication
Valliammai Engineering College
Chennai, India
Prithivi089@gmail.com

***Abstract*—Printed microstrip-fed patch antenna for selective set of frequencies within C band. The proposed antenna consist of a straight inverted f patch with extended pair of U- strips at both sides and it is partially grounded. Patch antenna is designed to operate at different frequency by using switching technique based on the current distribution. The simulated design shows that the designed antenna is capable of operating over frequencies at 4.0 GHz, 4.7 GHz and 5.6 GHz. An acceptable gain with enhanced bandwidth and return loss are achieved over the operating bands.**

Keywords—microstrip patch, resurn loss, inverted f patch, extended pair of U shape strips.

I. INTRODUCTION

Design of an antenna which supports more than one service has been attracting great interest. An antenna with capacity to radiate or receive multiple frequencies is required to develop. Multiple antennas are avoided using the proposed design. Microstrip patch antenna can be easily integrated with electronic components and can be easily integrated into arrays.

Past few years there has been an explosion in commercial applications involving RF and microwave systems [1]. Industrial applications such as satellite data transfer, vehicle tracking, and personal paging have been among the first to be developed. Another early application is the mobile telephone. The future will see even further penetration of RF and microwave systems into both the workplace and personal lives. The intelligent vehicle highway of the future will guide us through traffic jams and tell us about services along the way. Low cost demands easily produced components. The drive for smaller systems pushes not only the integrated circuit technology but also antenna technology [9]. Small, conformal antennas are aesthetically pleasing and increase product ruggedness by avoiding antenna breakage. Many applications currently use straightforward antennas (for example reflectors) partly because they are well understood and relatively easy to design.

FR4 material which is fire retardant, available at ease of cost. FR4 is used as a substrate. It is flame retardant. The proposed antenna is a single layer design. The different areas considered are basic material properties, circuit fabrication, reliability and end-use performance needs [11]. It is needed to improved electrical performance of the proposed design for frequency bands of interest laminate over an FR-4 substrate PCB. Multilayer hybrid PCBs designs using FR4 was difficult to design. Thus proposed design was choose to be a single layer design [11].

The radiation efficiency and directivity of printed antennas have been of current interest during recent decades. One reason for this interest is the widely use of microstrip patch antennas in communication systems, as well as their low profile and low weight. Several ways of increasing the radiation efficiency of the printed antenna, and to suppress radiation in the lateral directions, have been proposed. The patch structure can also increase the performance of the antenna [1].

The power transferred into the surface wave modes through the feed line does not contribute to the main radiation unless the proper path is designed, but is scattered off the edges of the finite ground plane and gives rise to spurious radiation. In this paper a characterization of surface waves in the patch is analyzed. Moreover, investigation on the role of an extended strips and introducing slots to suppress the surface waves and to increase the radiation efficiency of the antenna is also observed.

Firstly, we make pertinent representations of the fields inside and outside the substrate in terms of ground plane and a patch on the substrate and we state the fundamental equations these fields have to satisfy in the spectral domain. Moreover, the concept of propagators is enabled by feeding the patch by coax feeding technique. We introduce the wave splitting concept for the fields on then patch by introducing slots for enabling the patch to resonate in multiple frequencies. The radiation efficiency and directivity are illustrated in a series of computations for different frequencies. The paper ends with a series of results containing technical calculations and several simulation results.

Switches are introduced to attach and detach the structure. The varied length is responsible for the varying the frequency. The effective area which is inversely proportional to its wavelength concept is introduced in this paper. The patch design will resonate in respective frequency according to the state of the switches (i-e) ON and OFF state. The switches fixed can be varactor diode, PIN diode, photoconductive and RF-MEMS

II. PROPOSED ANTENNA DESIGN

Patch antenna reconfigured to more than one frequency in C band is designed using FR4 substrate at a height of 1.6mm. The height of the substrate is along the height of the feed. It is to prevent undesired radiation along the feed. Based on the passage

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of surface current the changes in the patch, structure in the patch design varied. Partial ground is introduced at the bottom layer at the height of the feed. Further to improve the bandwidth at the resonating frequency the extended patch structure is introduced at both sides from the center. The proposed design consists of pair of U shaped strips extended from the strait strip. Surface wave distribution couples with the coplanar strips. The main motive is to reduce the size of the patch. To resonate at different sets of frequencies; the structure of the patch is varied by attaching a rectangular strip and designing another structure by detaching it, allowing it to sense two different set of frequencies. It is a single layer design so the cost of fabrication is also less. Better bandwidth can be achieved by increasing the height of the substrate.

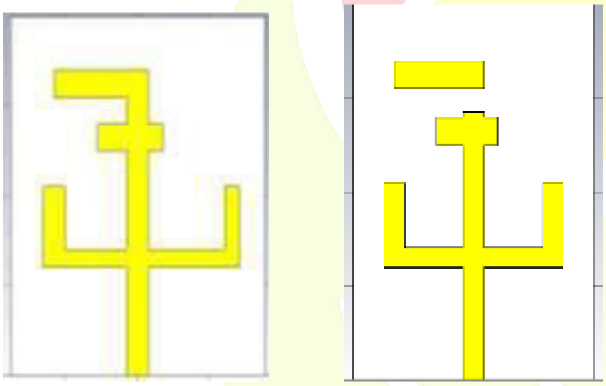

Fig 1: Proposed patch (strip attached & detached)

The horizontal strip is attached to the proposed design to enable the antenna to resonate in another set of frequencies. The two arms are responsible for frequencies at WLAN. The horizontal strip is responsible for the single resonation frequency at C-band.

Table 1: Dimensions of proposed design

QUANTITY	VALUE	UNITS
D1	4.4	-
Material	FR4	
L	40	mm
W	36	mm
h	1.6	mm
Feed	7.1022	mm
Resonant frequency	4.02, 4.7, 5.6	GHz

For the 3mm feed waveguide port setup is fixed, the width of the feed is calculated in such a way to match 50Ω. No loss impedance matching. In the space of 1mm which joints the horizontal structure and the proposed design, a switch is introduced. The switch used to reconfigure the frequencies. The switch is enabled to increase the surface area to allow the antenna to resonate in one set of frequency and disabled (i-e) in OFF state to decrease the patch length, so it will resonate in another set of frequency.

$L_{4.0}$= � / 4 (1)

$L_{4.7}$= � / 4 (2)

$L_{5.6}$= � / 4 (3)

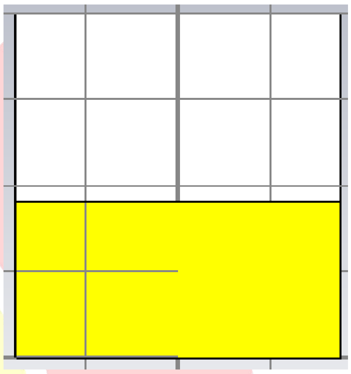

Fig 2: Ground structure

The ground structure is laid at the bottom layer. The height of the ground is same as the length of the feed line to avoid undesired radiations through the feed line. The length of the ground plane is calculated using the theoretical formula. The width is calculated to match the 50 Ω using the simulation tool CST MWS V14.

III. SIMULATION RESULTS

- S-Parameter

Return loss is the difference between forward and reflected power in dB. The return loss is given by PR/PT. For maximum power transfer, the return loss should be as small as possible, the return loss should be as large a negative number as possible. It is observed that S-parameters for the attached horizontal strip structure is shown in the figure 4 resonating for the frequency 4.02 GHz and 5.6GHz at -20 dB and 14 dB respectively.

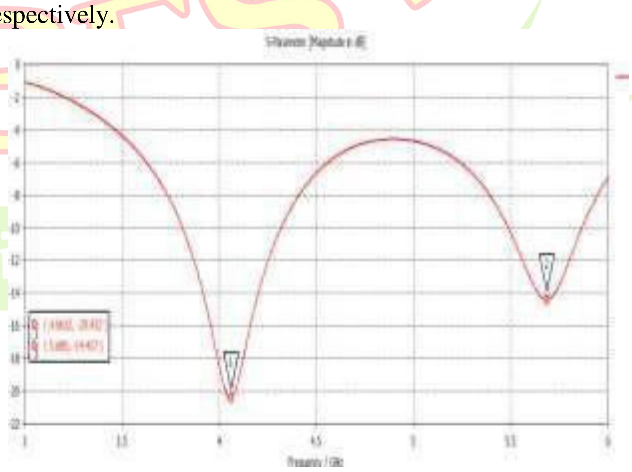

Fig 3: Return loss (strip attached)

The return loss for the detached horizontal strip structure is shown in the figure 4 resonating for the frequency 4.7 GHz at -44dB.

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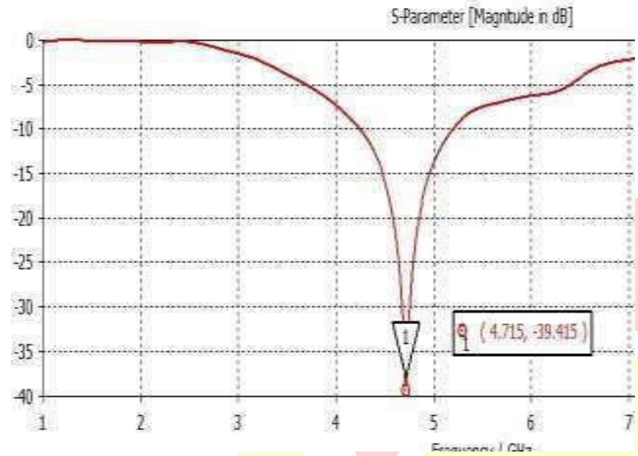

Fig 4: Return loss (strip detached)

- Gain

Acceptable gain of below -10dB is achieved by the proposed structure for all the three obtained frequencies in the C band.

Table 2: Gain of different frequencies

FREQUENCY (GHz)	GAIN IN (dB)
4.0	2.84
5.6	3.45
4.7	2.33

- Radiation pattern (strip attached)

The proposed patch antenna generates an ominidirectional radiation pattern for all the desired frequencies, 4.02GHz, 5.6 GHz and 4.7 GHz. The simulated pattern for the far field radiation is obtained is shown below in Figure 5, 6 and 7.

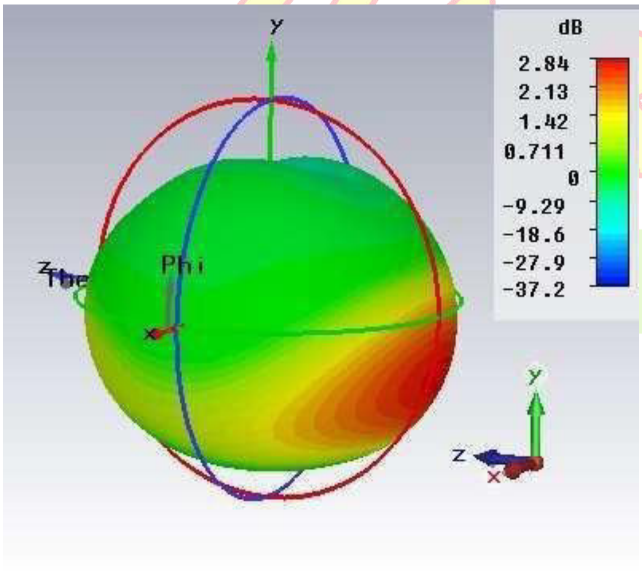

Fig 5: Radiation pattern for 4.02GHz (strip attached)

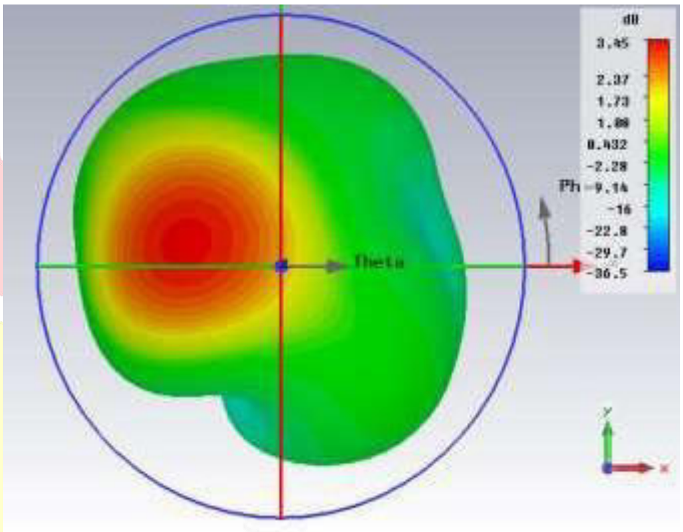

Fig 6: Radiation pattern for 5.6 GHz (strip attached)

The horizontal strip attached to the proposed structure resonates with gain of 2.84dB and 3.45 dB at 4.02GHz and 5.6GHz respectively.

- Radiation pattern (strip detached structure)

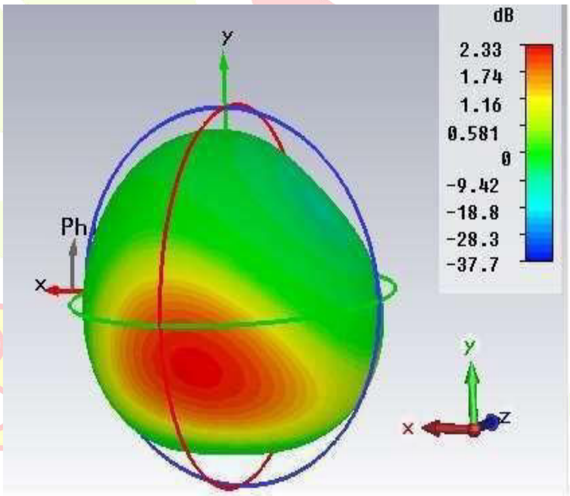

Fig 7: Radiation pattern of 4.7 GHz (strip detached)

The horizontal strip detached to the patch structure resonates with gain of 2.33dB at 4.02GHz.

III. CONCLUSION

The straight patch with extended U shape is proposed. The proposed patch design will reconfigure the frequency band by controlling the switches. It will resonates at frequency 4.13GHz and 5.7GHz at ON states of the switch and 4.7GHz at OFF state. The patch strips will be replaced by the real switches.

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