CAPACITIVE FED WITH ELECTROMAGNETIC COUPLED MICROSTRIP PATCH ANTENNA FOR WIRELESS APPLICATIONS

1ASMITA MHAMANE, 2MEENAKSHI PAWAR
1,2SVERIE’S, Pandharpur
E-mail: asmimhamane@yahoo.com, meenaskhee2000@gmail.com

Abstract: This paper describes new technique for wideband microstrip patch antenna. The enhancement of bandwidth is obtained in this paper. Microstrip patch antennas are very popular in wireless communication due to their low profile, light weight structure. But Microstrip patch antennas has some drawbacks of low efficiency, narrow bandwidth of the central frequency, its bandwidth is limited to a few percent which is not enough for most of the wireless communication systems nowadays. This wide bandwidth can be obtained by capacitive fed with electromagnetic coupled MSA. The structure is suspended above ground plane. The technique also helps to improve the bandwidth of MSA. Antenna design is simulated using HFSS software. Dielectric Substrate of FR4 having dielectric constant of 4.4 is used. The antenna has a Voltage Standing Wave Ratio less than 2 in the frequency band “1.827-2.788GHz”. Hence wide bandwidth is achieved. The design and simulation results are presented in this paper.

Keywords- MSA (Microstrip patch antenna), Capacitive fed, Electromagnetic coupled MSA and Suspended technique

I. INTRODUCTION

The research in area of designing wideband antenna for wireless application is increasing rapidly. Microstrip patch antennas have attracted much interest in wireless application due to their low profile, less weight, and low cost, together with ease of fabrication. However, the main disadvantage of microstrip antennas is the narrow bandwidth and low gain. So improvement in bandwidth becomes an important need for many wireless applications. Different techniques have been applied to overcome this problem of narrow bandwidth such as using thicker substrate, Using E shaped patch antennas, designing feeding structures, using array configuration, using suspended technique and optimizing antenna. However, many of these techniques combined to achieve wide bandwidth.

Modifying patch’s shape includes designing an E-shaped patch antennas or a U-slot patch antenna. E-Shaped patch antenna by introducing two parallel slots in to rectangular patch provides wide bandwidth [1], In the E shaped antenna, the current from the feed flows in two different paths generating two resonant frequencies. These two resonant frequencies are coupled each other, thus resulting in improved bandwidth, compared to a rectangular patch antenna. The antenna bandwidth can be improved by controlling the following antenna parameters the width (W) and length (L) of the patch, the height between the feeding line and the patch element, the height of the air gap, and the dimensions of the ground plane and substrate. The slot length, width, and position are optimized to achieve a wide bandwidth. E shape combined with U shape patch antenna which is able to operate at higher frequency range from 8.80 GHz to 13.49 GHz provides wide bandwidth [2]. There are several techniques like coaxial probe fed, microstrip line fed, edgefed and capacitive fed. A rectangular microstrip slot antenna fed by a microstrip line, which achieves a very large bandwidth on a relatively thin substrate. An additional square slot in the ground plane is used to produce the wideband characteristics of the antenna. A 36% fractional impedance bandwidth is achieved with respect to the centre frequency of 2.4 GHz and a relatively stable pattern with change of frequency [3]. The advantage of capacitive fed is that the inductive impedance of the probe is cancelled by the capacitive patch. As a result a higher substrate can be used to increase bandwidth. Hence capacitive fed antenna is most very effective antenna. The antenna structure with capacitive fed can achieve impedance bandwidth up to 51.13% in C and X band [4]. Suspended microstrip antennas provide wide bandwidth due to the reduced effective dielectric constant and surface waves. The air gap is introduced in between substrate and ground. Suspended E shaped microstrip antenna with a capacitive coupling feed is designed in order to be employed for Wireless communication applications. Employing only a single patch, a high impedance bandwidth is achieved about 23.1% [5]. A wide band circularly polarized truncated square Microstrip antenna with capacitive feeding is suspended over the ground plane with capacitive feed offers better impedance BW in the frequency range 1.15 -1.6 GHz [6].

Dual E-shaped antenna is designed by cutting four notches in the rectangular shaped microstrip antenna also shows good enhancement in bandwidth and gain [7]. The novel E-shaped microstrip antenna in which the edges of the antenna have been widened to increase the bandwidth in the frequency band of 5.15-5.35GHz. This frequency range may be used for Wi-Fi applications [8]. Asymmetric multi-slot patch antenna is designed with enhanced bandwidth and...
isolation, which can be used for Multiple Input Multiple output (MIMO) systems. Which is designed for two element MIMO system resonates at the tri band of frequencies 3.8 GHz, 6.6 GHz and 7.6 GHz with an improved impedance bandwidth of 20% [9]. The wideband U-slot and L-probe patch antennas in addition with Shorting pin and shorting wall techniques provides bandwidth greater than 20% [10]. Amicrostrip corner truncated antenna using an EMC feeding structure designed for rectangular and triangular patch. Bandwidths about 1200 MHz (52%) for the rectangular patch, whilst that of the triangular one is around 1300 MHz (56%) [11]. A compact broadband capacitive fed microstrip antenna with open end meandering slots in the radiating patch resonates at 5.2 GHz providing a size reduction of 17.60% with a bandwidth of 226 MHz.

This paper presents capacitive fed with electromagnetic coupled wide band microstrip patch antenna. To achieve wide bandwidth E shaped antenna is designed. Main patch is combination of three E shaped patches coupled electromagnetically. So bandwidth achieved is more than that of single patch. The configuration is suspended above ground plane.

II. ANTENNA CONFIGURATION

It is composed of rectangle ground plane and E shaped patch on substrate with dielectric constant $\varepsilon_r = 4.4$. The thickness of the substrate is $h = 1.6$ mm (with operating frequency, $f_0 = 2.4$ GHz). The substrate is suspended above ground plane with air gap of 11 mm [5].

The microstrip antenna is fed by capacitive probe feeding. A small feed patch is placed very close to the actual radiating patch. The distance of feed patch is 0.5 mm from main patch. The feed patch is excited by coaxial probe and the energy from the feed patch is electromagnetically coupled to the radiating patch. The advantage of this feeding mechanism is that all the elements reside on a single layer and that it is very easy to fine-tune the input impedance [6].

Two E shape patches are coupled electromagnetically with middle E shaped patch. In designed antenna the radiated energy obtained is more than single E shaped patch. The width of single patch is 40 mm. Total width of designed antenna is 122 mm.

The dimensions of antenna can be calculated by following formulas:

A. Calculation of the width of Patch (W):
Refer to “1” for calculating width of patch

$$ W = \frac{c}{2 f_0} \sqrt{\frac{\varepsilon r + 1}{2}} $$

For $c = 3 \times 10^8$ mm/s,

$$ f_0 = 2.4 \text{ GHz} $$

$\varepsilon_r = 4.4$

$W = 38.22$ mm.

B. Calculation of effective dielectric constant:
Refer to “2” for calculating an effective dielectric constant

$$ \varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \left[ 1 + \frac{12 h}{W} \right]^{-1/2} $$

$\varepsilon_{reff}$ = effective dielectric constant

$h$: height of dielectric substrate

For $\varepsilon_r = 4.4$, $h = 1.6$ mm, $W = 38$ mm

We get $\varepsilon_{reff} = 3.99$

C. Calculation of Length of Patch (L):

$c = 3 \times 10^8$ mm/s, $\varepsilon_{reff} = 3.99$, $f_0 = 2.4$ GHz

We get $L_{eff} = 30.25$ mm

Due to fringing the dimension of the patch as increased by $\Delta L$ on both the sides, given by:

$$ \Delta L = 0.412h \left( \frac{\varepsilon_{reff} + 0.3}{\varepsilon_{reff} - 0.258} \right) \left( \frac{W}{h} + 0.264 \right) $$

For $W = 38.22$ mm, $h = 1.6$ mm, $\varepsilon_{reff} = 3.99$

We get $\Delta L = 0.70$ mm

$L = L_{eff} - 2 \Delta L = 28.4$ mm

$L$: Length of patch

D. Calculation of Substrate dimension:

For this design this substrate dimension would be

$L_s = L_{eff} + 2 \times 6h = 59$ mm

$W_s = W + 2 \times 6h = 50$ mm (5)

$L_s$: Length of Substrate

$W_s$: Width of Substrate

The antenna bandwidth can be improved by controlling the following antenna parameters the width ($W$) and length ($L$) of the patch, the height between the feeding line and the patch element, the height of the air gap, and the dimensions of the ground plane and substrate.

“Fig.1” Shows Fabricated antenna with dimensions mentioned in Table (See Table I)

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Fig.1 Fabricated antenna

Table I Optimized parameters of antenna
III. SIMULATED RESULTS

A. Return Loss

Return loss is the power of the reflected signal in a transmission line. It is given in db.

\[ RL_{dB} = -20 \log_{10} |\Gamma| \]

Fig. 2 Return Loss vs. Frequency

"Fig. 2" shows the Return loss variation with respect to frequency of the antenna. The minimum returnloss for satisfactory operation of antenna is -10dB. The obtained return loss by simulation is -16.49 db.

B. VSWR

VSWR is the ratio between the maximum voltage and minimum voltage in the transmission line, and can be defined as

\[ VSWR = 1 + \rho / (1 - \rho) \]

Where \( \rho = |\Gamma| \).

When the system is matched the reflection coefficient approaches 0, while VSWR approaches to 1.

IV. RESULTS

This fabricated antenna is connected to vector analyser using SMA connector. The results such as Return Loss, VSWR can be seen on analyser.

VSWR obtained by simulation is 1.347 at centre frequency 2.47GHz. It is less than 2 for frequency range 1.915-2.83 GHz. In Capacitive fed with electromagnetic coupled MSA simulation results shows that antenna works on frequency range “1.915-2.83GHz”. The obtained bandwidth is 915 MHz (37%)
A. Return Loss

![Fig. 6 Return Loss Vs frequency](image)

“Fig. 6” shows that return loss is -17.11 dB at centre frequency 2.47 GHz better than that of simulated -16.498 db.

B. VSWR

![Fig. 7 VSWR Vs. Frequency](image)

VSWR obtained on analyser is 1.39 at centre frequency of 2.47 GHz. In Capacitive fed with electromagnetic coupled MSA, measured results shows that antenna works on frequency range “1.827-2.788GHz”. The obtained bandwidth is 961 MHz (38.9%).

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameters</th>
<th>Simulated</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Frequency Range</td>
<td>1.915-2.83 GHz</td>
<td>1.827-2.788 GHz</td>
</tr>
<tr>
<td>2</td>
<td>Return loss</td>
<td>-15.498 dB</td>
<td>-17.11 dB</td>
</tr>
<tr>
<td>3</td>
<td>VSWR</td>
<td>1.3477</td>
<td>1.39</td>
</tr>
<tr>
<td>4</td>
<td>Bandwidth</td>
<td>915 MHz</td>
<td>961 MHz</td>
</tr>
</tbody>
</table>

Table II Comparisons of simulated & tested results

CONCLUSION

Now the demand for wireless communication is increased. Therefore the use of MSA is increased. But wideband MSA is required in many wireless applications. The designed antenna provides bandwidth of 961 MHz i.e. the fractional bandwidth is about 38.90% with respect to the centre frequency 2.47 GHz. The proposed antenna design can be used in WLAN band 2.4 GHz, USB dongle, PCS, UTMS & Bluetooth (2.4 GHz - 2.484 GHz) communication.

REFERENCES


