Design of a Broadband Microstrip Patch Antenna by Microstrip Lange Coupler

NIRPENDRA MISHRA and GAURAV VERMA

Abstract- In this paper, microstrip broadband patch antenna is designed using langecoupler.Antenna feed by transmission line is presented. The proposed antenna is designed by decreasing Q factor. In the course of the project, a broadband microstrip patch antenna was manufactured to adequately cover the 5.5 - 6.5 GHz frequency band. The manufactured prototypes are characterized in terms of return loss, gain, and radiation pattern measurements. In this paper, a novel design technique for enhancing gain that improves the performance of a conventional microstrip patch antenna is proposed.

I.INTRODUCTION

Microstrip patch antennas offer an attractive solution to compact and ease-low-cost design of modern wireless communication systems due to their many advantages as light weight and low volume, low profile, planar configuration which can be easily made conformal to host surface, low fabrication cost, and the capability of obtaining dual and triple frequency operations. When mounted on rigid surfaces microstrip patch antennas are mechanically robust and can be easily integrated with microwave integrated circuits (MICs).

However, microstrip patch antennas suffer from a number of disadvantages as compared to conventional no printed antennas. Some of their major drawbacks are the narrow bandwidth, low gain, and surface wave excitation that reduce radiation efficiency. To overcome one of their more critical restrictions, narrow bandwidth,and several techniques can be used. First of all, a thicker substrate with a low dielectric constant or a ferrite composition provides a wider bandwidth but the first approach leads to no low-profile designs and increased in size, whereas the second solution is expensive. Secondly, non contacting feeding methods such as proximity/aperture coupled can be used to improve the impedance bandwidth, but this is difficult to fabricate. Another possibility is multiresonator stack configuration with the inconvenient of resulting large thickness prototype. The surface waves can be minimized using electromagnetic band-gap structures whereas for obtaining a high gain antenna an array configuration for the patch elements is needed. The research in the field of electromagnetic band-gap structures has become attractive in the antenna community and is considered to be a key technology for improving microstrip patch antenna performances. The use of meta materials, such as the frequency selective surfaces (FSS) is an alternative to face antennas and microwave circuit problems.

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In this paper, a novel multiple slotted patch is investigated for enhancing the impedance-bandwidth and gain. The design employs contemporary techniques such as:-

1. Decreasing Q factor by increasing substrate height and decreasing the dielectric constant; &
2. Using Libra Microstrip Lang Coupler to increase the directivity of the antenna.

These techniques are used to meet the design requirement. In addition, a highgain of 5.21312dBi is achieved compare to designs reported.

Another important parameter of any antennais the bandwidth it covers. Only impedance bandwidthis specified most of the time. However, it is importantto realize that several definitions of bandwidth exist impedance bandwidth, directivity band-width,polarization bandwidth, and efficiency bandwidth.Directivity and efficiency are often combined as gainbandwidth. The following definitions are important:

A. *Impedance bandwidth/return loss*:

This is the frequencyrange wherein the structure has ausable bandwidth compared to certain impedance, usually 50 ohm. The impedancebandwidth depends on large number of parameters related to the patch antennaelement itself (e.g., quality factor) and thetype of feed used. The plot below (Figure 1) shows the return loss of a patch antenna andindicates the return loss bandwidth at thedesired S11/VSWR (S11 wanted/VSWRwanted). The bandwidth is typically limitedto a few percent. This is the majordisadvantage of basic patch antennas. Severaltechniques to improve the bandwidth exist,but these are beyond the scope of this paper.

B. *Directivity/gain bandwidth:*

This is thefrequency range wherein the antenna meets acertain directivity/gain requirement (e.g., 1dBgain flatness)

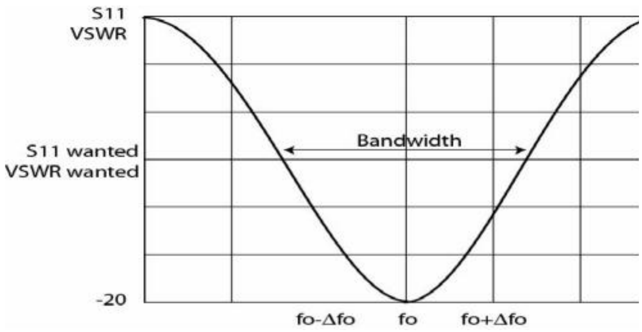

Fig.1 Return loss of patch antenna

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C. *Efficiency bandwidth:*

This is the frequency range where in the antenna has reasonable (application dependent) radiation/total efficiency.

D. *Polarization bandwidth*:

This is the frequency range where in the antenna maintains its polarization.

E. This bandwidth is related to the polarization bandwidth and this number expresses the quality of the circular polarization of an antenna.

II.ANTENNA LAYOUT AND STRUCTURE

It is known that increasing the thickness of the patch antenna will increase the impedance bandwidth. However, the thicker the substrate of the antenna, the longer the coaxial probe will be used and, thus,more probe inductance will be introduced (Yang et al. 2001), which limits the impedance bandwidth.Consequently, a patch antenna design that can counteract or reduce the probe inductance will enlarge the impedance bandwidth.

The proposed antenna is designed to operate in the 5.5 GHz to 6.5 GHz region.

The antenna is made up of copper plate which is etched in to substrate of thickness 7mm. The patch size is 7.2×5.2mm. In this design we used Libra Microstrip Lang Coupler (6 fingered) for coupling the power effectively in one direction and the material of substrate is Teflon whose dielectric constant is 2.0.

By incorporating extra slots in radiating edges, the gain and cross polarization has been improved. In addition, the antenna is relatively compact in comparison with the slotted antenna described in (Tariqul Islam et al.,2007). These techniques offer easy patch fabrications, especially for array structures

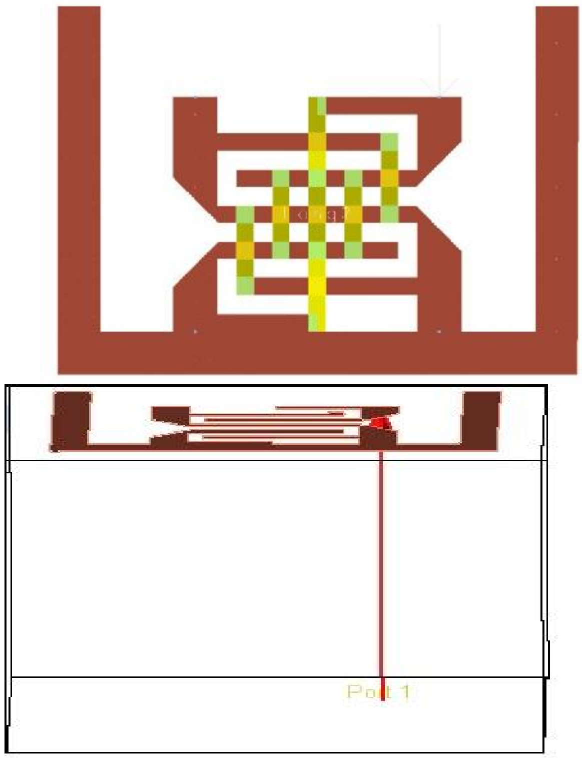


Fig.2 Geometry proposed patch antenna. (a) Top view, (b) Side view

Lange Coupler:

The Lange couplers are widely used as power combiners and splitters in RF amplifiers as well as in mixers and modulators. The coupling is derived from closely spaced transmission lines, such as microstrip lines. Typically the number of conductors or fingers (N) is even.

The effective dielectric constant is a function of the dielectric constant of the substrate as well as its thickness (h) and the conductor width (w) and thickness (t).The wavelength (λ_s) can also be computed as the average of the wavelengths of the odd and even modes.

The coupler is usually designed for 3 db of coupling between the “input port” (1) and the coupled (2) and direct ports (4). The phase angles of the coupled signals are 90 degrees out of phase with the input near the design frequency. The design requirements could be specified as:
S21 > - 3.5 db for $[(f_0 - \Delta f) < f < (f_0 + \Delta f)]$ for $\Delta f = 0.25\ f_0$
S41 > - 3.5 db for $[(f_0 - \Delta f) < f < (f_0 + \Delta f)]$ for $\Delta f = 0.25\ f_0$

For such a splitter, the theoretical maximum coupling is –3 db in each channel, i.e. half power. These coupling characteristics are most sensitive to the gap width (s) and the metal thickness (t) for a given number of fingers (N). The characteristics of the substrate are also a factor.

The requirements for return loss (S11) and transmission to the isolated port (S13) are commonly set less than some threshold in a frequency range (Δf) about f_0.

For example:

S11 < -15 db for $[(f_0 - \Delta f)< f <(f_0 + \Delta f)]$ for $\Delta f = 0.25\ f_0$

S31 < -15 db for $[(f_0 - \Delta f) < f < (f_0 + \Delta f)]$ for $\Delta f = 0.25\ f_0$

The phase of the isolated port and return loss and approximately zero and -180°, respectively.

The other two parameters involved are the width of the bridge wire (W2) and the conductor width at the port (W1) as defined in Figure 2. The width at the port is usually set by the associated circuit. The conductor width can be selected for characteristic impedance near 50 ohms. The bridge wire configuration is determined by manufacturing considerations. Coupler performance is relatively insensitive to either parameter. Linear models provide a fast, accurate method of performing design trades and system optimization. Figure 3 shows Schematic Symbols for microstriplange coupler (6 fingered)

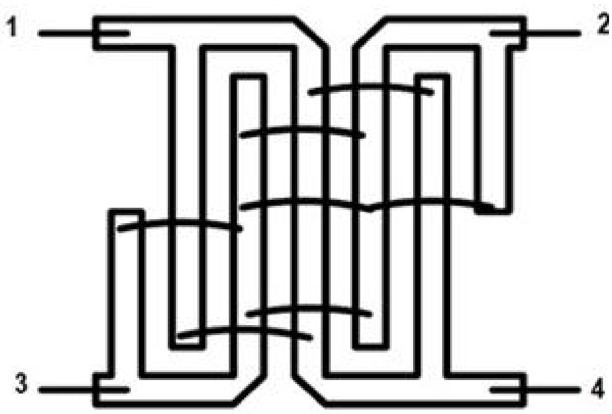


Fig.3 Microstrip Lange Coupler 6 fingered

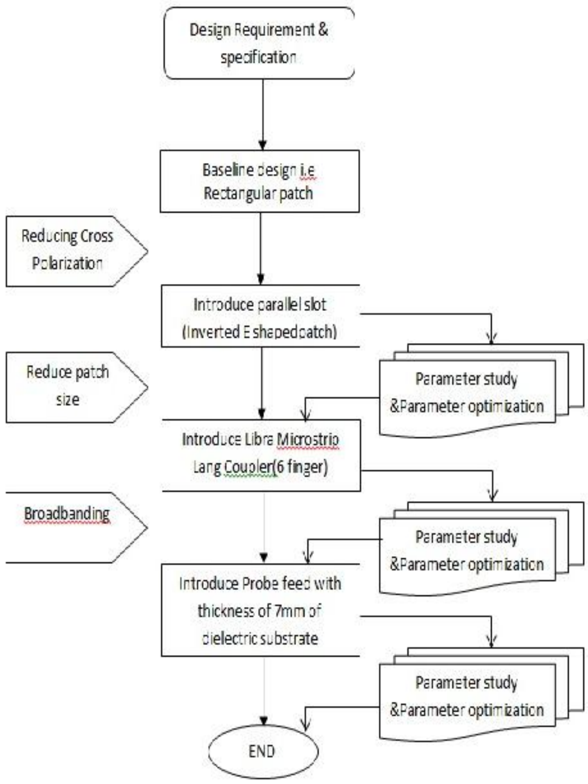
Hence, the essential parameters for the design are:

TABLE 1

Parameters	Value
Resonant frequency (f_o)	6.07 GHz
Dielectric constant (εr)	2.0
Length (L)	7.2mm
Width (w)	5.1mm
Height (h)	7mm

III.SIMULATION SETUP

Fig.4Design flow diagram for the proposed patch antenna



IV. RESULT AND DISCUSSION

Fig. 5 shows the simulated result of the return loss of the proposed antenna. The excited resonant frequencies at 6.07 GHz as shown in the figure gives the measure of the wideband characteristic of the patch antenna. The simulated ratio bandwidth is 101.48% at 10db return loss.

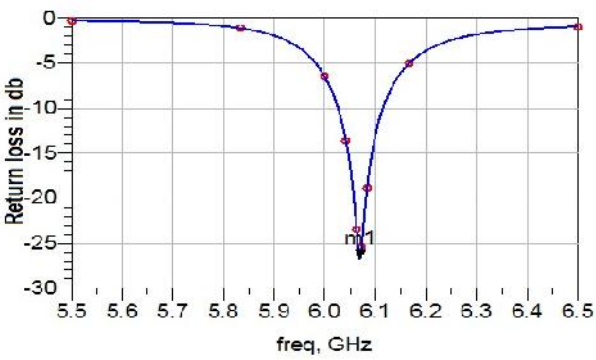


Fig.5 Simulated return loss of the proposed patch antenna.

The simulated radiation patterns ofresonant frequencies in the xz-plane and yz-planeare plotted in Fig. 6.The designed antenna displays good broadside radiation patterns in the xz-plane and yz-plane at upper resonant frequency.Notable, the radiation characteristics of the proposed antenna are better to those of the conventional patch antenna. The radiation patterns of 6.07GHz, are presented here.

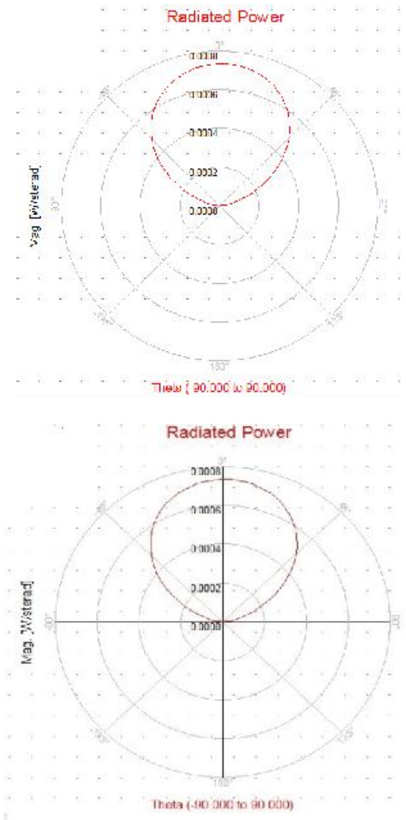


Fig.6Radiation pattern of proposed patch antenna at 6.07 GHz for *xz*-plane and *yz*-plane.

V.ANTENNA PARAMETER

TABLE 2

Power radiated	0.00177925	
Effective angle	2.42836	
Directivity	7.13897	
Gain	5.21312	
Angle	Magnitude	Phase
E_{θ}max	0.737444	-81.5307
$E_{\phi\ max}$	0.0907459	72.5114
E_x	0.714361	-82.7242
E_Y	0.203913	-71.1255
E_Z	0.0128702	98.4693

VI.CONCLUSION

A broadband microstrip patch antenna has been designed for high gain. A noveltechnique for enhancing bandwidth and gain of microstrip patch antenna is successfully designed inthis paper. The proposed microstrip patch antenna achieves a fractional bandwidth. The maximum achievable gain of the antenna is 5.21312dBi. The design has demonstrated thatpatch with multiple slots and probe fed can be used to form an antenna with the broadbandwidth of 5.5 to 6.5, furthermore due to its high gain and broad bandwidth more applications can be anticipated.

VII.ACKNOWLEDGEMENT

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