Comparison of Different Substrates with Constant Height for Better Performance

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Abstract

Microstrip patch antenna has found extensive application in compact wireless communication system. It is a type of radio antenna with a low profile, which can be mounted on a flat surface. They have advantages of low-profile, conformability, low-cost fabrication and ease of integration with feed networks. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane. The assembly is usually contained inside a plastic random, which protects the antenna structure from damage. Patch antennas are simple to fabricate and easy to modify and customize. This paper presents a rectangular patch antenna excited through an inset feed at a frequency at 5 GHz and three different substrates are analyzed using the transmission line model. The substrates are FR 4, glass and gml1000 having relative permittivity 4.5, 6.7 and 3.1 respectively. After analysis of result it is concluded that gml 1000 which has a dielectric constant of 3.2 with height 0.732 mm of the substrate performs best. The resonant frequency and the value of return loss depend on width of the inset feed and the dimensions of the slot above and below the feed.

Keywords-Microstrip patch antenna, microstrip line feed, return loss, radiation pattern, bandwidth.

1 Intoduction

Microstrip patch antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantages such as low weight, low profile planar configuration, low fabrication costs and capability to integrate with microwave integrated circuits technology, the microstrip patch antenna is very well suited for applications such as wireless communications system, cellular phones, pagers, Radar systems and satellite communications systems. Several designs have been investigated and reported to decrease the size of the antenna and to improve the bandwidth of the antenna.

2 Different Feed Techniques

2.1 Microstrip Line Feed

In this type of feed technique, a conducting strip is attached directly to the edge of the microstrip patch as shown in Figure 2.1. The conducting strip has small width as compared to the width of the patch. This kind of feed arrangement has an advantage that the feed can be etched on the same substrate with the patch to provide a planar structure.

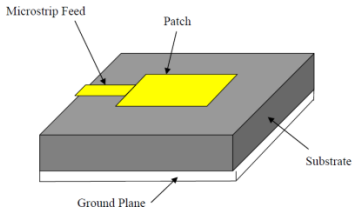

Figure 2.1 Microstrip Line Feed

The patch antenna was fed at the end, this typically yields high input impedance so we have to modify the feed. One method of doing this is by using an inset feed (a distance R from the end) as shown in Figure 2.2.

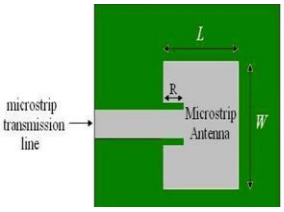

Figure 2.2 Patch Antennas with an Inset Feed.

Main advantage of this feeding technique is the ease of fabrication and feed as well as its simplicity in modeling and impedance matching.

3 Results and Analysis

3.1 Microstrip slotted antenna 1

This section describes the design of a single band rectangular microstrip patch antenna with gml 1000 as a dielectric substrate excited by microstrip line feed satisfying the given specifications and patch dimensions and ground dimensions are evaluated using the design procedure[1].

Table 1 Specification of Microstrip slotted antenna 1

Parameters	Value
Frequency of operation(f_o)	5 GHz
Dielectric constant of the substrate(ε_r)	3.2
Height of the substrate(h)	0.732mm
ε_{reff}	3.022

Patch Dimensions

Length (L)= 16.5mm

Width (W)= 20.7mm

Ground Dimensions

Length(Lg)= 20.9mm

Width(Wg)= 25.1 mm

3.1.1 Return Loss of slotted antenna 1

Figure 3.1 shows the S11 parameters (return loss) for the proposed antenna.

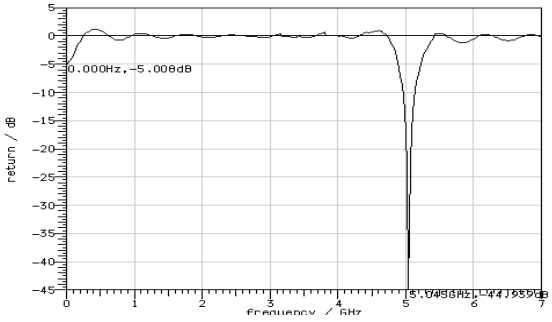

Figure 3.1 Return Loss(S11 in dB) v/s frequency (GHz) for antenna 1

The designed antenna resonates at 5.045 GHz. The return loss at 5.045 GHz frequency is -44.939dB as shown in Figure 5.1. In general the value of return loss must be less than -10dB.

3.1.2 Radiation Pattern of slotted antenna 1

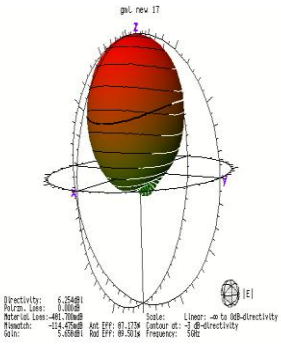

Figure3.2 Radiation Pattern for antenna 1

The radiation pattern showing the directivity, gain, antenna efficiency and radiation efficiency for the designed antenna has been shown in Figure 3.2. The directivity is 6.254 dBi, gain is 5.658 dBi, radiation efficiency is 89.501% and antenna efficiency is 87.173% at the resonating frequency of 5 GHz. In general, the value of directivity should be greater than 5 dBi.

3.1.3 Current Distribution of slotted antenna 1

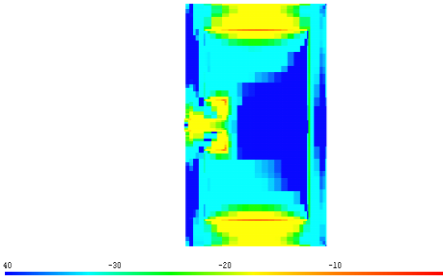

Figure 3.3Current Distribution for slotted antenna 1

The 3D current distribution plot gives the relationship between the co-polarization (desired) and cross-polarization (undesired) components. Figure 3.3 clearly shows that the patch antenna is linearly polarized. The current is maximal at the center and minimal near the upper and lower edges as can be seen in Figure 3.3

3.1.4 Bandwidth of slotted antenna 1

The bandwidth of the proposed patch antenna is 182 MHz at frequency is 5 GHz. The upper frequency is 5.140 GHz and the lower frequency is 4.958 GHz which can be observed from Figure 3.1 at value of -10dB. Hence giving fractional bandwidth equals to 3.64 %.

3.2 Microstrip slotted antenna 2

This section describes the design of a single band rectangular microstrip patch antenna with Fr 4 as a dielectric substrate using microstrip line feed satisfying the given specifications and patch dimensions and ground dimensions are evaluated using the design procedure[1].

Table 2 Specification of Microstrip slotted antenna 2

Parameters	Value
Frequency of operation(f_o)	5 GHz
Dielectric constant of the substrate(ε_r)	4.4
Height of the substrate(h)	0.732mm
ε_{reff}	4.186

Patch Dimensions

Length(L)= 14mm

Width(W)=18.1mm

Ground Dimensions

Length (Lg) =18.4mm

Width (Wg) =22.5mm

3.2.1 Return Loss of slotted antenna 2

Figure 3.4 shows the S11 parameters (return loss) for the proposed antenna.

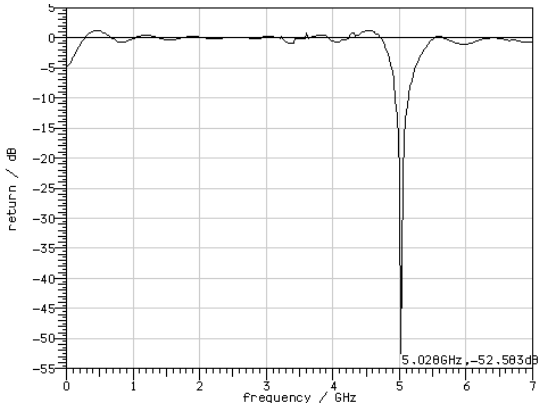

Figure 3.4 Return Loss(S11 in dB) v/s frequency (GHz) for slotted antenna 2

The designed antenna resonates at 5.028 GHz. The return loss at 5.028 GHz frequency is -52.583 dB as shown in Figure 3.4.

3.2.2 Radiation Pattern of slotted antenna 2

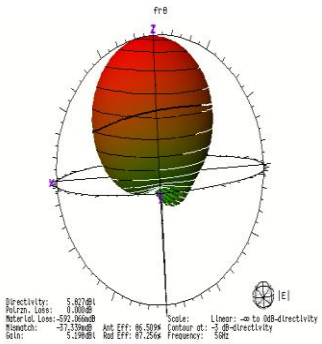

Figure 3.5Radiation Pattern for slotted antenna 2

The radiation pattern showing the directivity 5.827 dBi, gain has a value of 5.198 dBi, antenna efficiency of 86.50% and radiation efficiency is coming to be 87.256% for the designed antenna which has been shown in Figure.3.5.

3.3.3 Current Distribution of slotted antenna 2

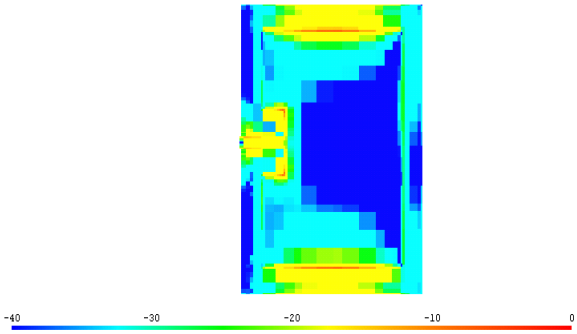

Figure 3.6 Current Distribution for slotted antenna 2

Figure 3.6 clearly shows that the patch antenna is linearly polarized. The slots alter the current path. The currents of the antenna are confined to a smaller area on the antenna surface, contributing to conductive losses.

3.3.4 Bandwidth of slotted antenna 2

The bandwidth of the proposed patch antenna is 193 MHz at frequency is 5 GHz. The upper frequency is 5.133 GHz and the lower frequency is 4.937 GHz which can be observed from Figure 3.4 at value of -10dB. Hence giving fractional bandwidth equals to 3.86 %.

3.3 Microstrip slotted antenna 3

This section describes the design of a single band rectangular microstrip patch antenna with glass as a dielectric substrate using microstrip line feed satisfying the given specifications and patch dimensions and ground dimensions are evaluated using the design procedure[1].

Table 3 Specification of Microstrip slotted antenna3

Parameters	Value
Frequency of operation(f_o)	5 GHz
Dielectric constant of the substrate(ε_r)	6.7
Height of the substrate(*h*)	0.732 mm
ε_{reff}	6.121

Patch Dimensions

Length (L) =11.5mm

Width (W) =15.3mm

Ground Dimensions

Length (Lg) = 15.9mm

Width (Wg) =19.7mm

3.3.1 Return Loss of slotted antenna 3

Figure 3.7 shows the S11 parameters (return loss) for the proposed antenna.

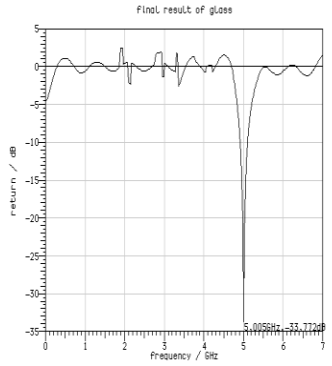

Figure 3.7 Return Loss(S11 in dB) v/s frequency (GHz) for antenna 3

The designed antenna resonates at 5.005 GHz. The return loss at 5 GHz frequency is -33.772.dB as shown in Figure 3.7.

3.3.2 Radiation Pattern of slotted antenna 3

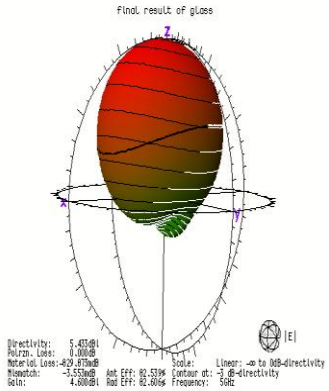

Figure 3.8Radiation Pattern for slotted antenna 3

The radiation pattern showing the directivity 5.433 dBi, gain has a value of 4.600 dBi, antenna efficiency of 82.53% and radiation efficiency is coming to be 82.606% for the designed antenna which has been shown in Figure.3.8.

3.3.3 Current Distribution of slotted antenna 3

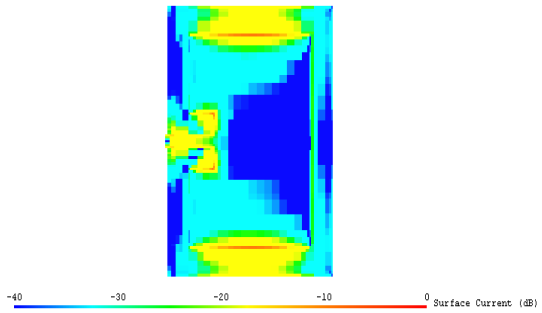

Figure 3.9 Current Distribution for slotted antenna 3

Figure 5.9 shows the surface current and also that the patch antenna is linearly polarized. The slots alter the current path as can be seen the above figure 3.9.

3.3.4 Bandwidth of slotted antenna 3

The bandwidth of the proposed patch antenna is 192 MHz at frequency is 5 GHz. The upper frequency is 5.106 GHz and the lower frequency is 4.914 GHz which can be observed from Figure 3.7 at value of -10dB. Hence giving fractional bandwidth equals to 3.84 %.

3.4 Comparison of different Antenna Parameters with thin substrate

Table 4 shows different parameters of three different antennas which have different substrates that are GML 1000, FR4 and Glass with same height of 0.732 mm. The parameter shown here are Return loss, frequency, antenna efficiency, Radiation efficiency, gain and directivity. From the above table it can be concluded that GML 1000 substrate is performing best for all parameters of an antenna.

The antenna with substrate of dielectric constant 3.2 is giving the best result, having an antenna efficiency of 87.173, radiation efficiency of 89.501%, gain of 5.658 dBi and directivity of 6.254 dBi.

3.5 Conclusion and Future Scope

The single frequency rectangular patch antennas have been designed for the resonant frequency of 5 GHz using microstrip line feeding with variable substrates. The designs have been successfully simulated using CST Microstripes 2009. After analysis of result it is concluded that gml 1000 which has a dielectric constant of 3.2 with height 0.732mm of the substrate performs best in case of AE and RE. It can also be observed that a trade-off has to be made between bandwidth and directivity as FR 4 has the better BW. Further analysis can be done by working on another height so as to get better conclusion.

Dielectric material	Relative permittivity	Return loss(d**B**)	Frequency (GHZ)	Antenna efficiency	Radiation efficiency	Gain (dBi)	Fractional Bandwidth	Directivity (dBi)
Gml 1000	3.2	-44.939	5.045	87.173%	89.501%	5.658	3.64%	6.254
FR 4	4.4	-52.583	5.028	86.50%	87.256%	5.198	3.86%	5.827
Glass	6.7	-33.772	5.005	82.53%	82.606%	4.600	3.84%	5.433

Table 4 Different Antenna Parameters with substrate height 0.732 mm

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