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DESIGN AND PERFORMANCE ANALYSIS OF VARIOUS PARAMETERS OF SINGLE AND MULTI LAYER OF MSPAs

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ABSTRACT

This paper is focused on return loss of rectangular substrate with rectangular and circular patches at various substrate thicknesses i.e., 1.6mm, 5mm and 8mm. The analysis of a micro strip antenna in terms of multilayered substrate and patch antennas. Microstrip antennas are attractive due to their light weight, conformability and low cost. These antennas can be integrated with printed strip-line feed networks and active devices. Execution examination of different parameters are S11, return loss, VSWR and Gain. The substrate utilized is Arlon Cu 217Lx having dielectric constant 2.2, Arlon AR 450 having dielectric constant 4.5 and Arlon AR 600 having dielectric constant 6. The point of this paper is execution examination of different parameters with single layer and multi layer substrates. Investigation is finished by utilizing CST tool.

KEYWORDS: *Micro Strip Antenna, Rectangular and Circular Patch, S11, Return Loss, VSWR and Gain.*

Article History

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INTRODUCTION

The microstrip antenna, sometimes called a patch antenna, is defined as an antenna which consists of a thin metallic conductor bonded to a thin grounded dielectric substrate. Microstrip antennas are low profile, small in size, and have low production cost. The feed can be connected directly to the conductor on the same substrate. There are many different of shape for patch antenna's radiating element. Some common shapes are square, circle, ellipses, triangle, circular ring, and dipole. The more commonly used shapes are square, rectangle, dipole, and circle are used because they are easier to analyze than other shapes. The purpose of this paper is to the performance characteristics like S11, VSWR, Return Loss and Gain of patch antenna by using different patch shapes and dielectric material for WLAN applications at 2.2 GHz. The patch was designed on substrate like Arlon Cu 217Lx, Arlon AR 450 and Arlon AR 600 and inset feed line is used as feeding method due to its simplicity of realization.

When an antenna has more than one patch over the dielectric substrate it is called as a Multipatch Microstrip antenna. When an antenna has more than one dielectric substrate in between patch and ground plane is called multi layer microstrip patch antenna. Multipatch Microstrip antenna provides basic information on patch antenna design and operation, directed to engineers who are mainly designers of RF/microwave circuits. Multipatch antennas are narrowband, wide beam antennas fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate with a continuous multi metal layer bonded to the opposite side of the substrate which forms a ground plane.

DESIGN

In this paper the proposed rectangular and circular patch antenna has been designed to operate at resonant frequency of 2.2 GHz with input impedance of 50Ω using substrate with Arlon Cu 217Lx, Arlon AR 450 and Arlon AR 600 and thickness h = 1.6 mm, 5mm and 8mm. The patch antenna parameters are calculated from the following standard antenna design equation at reference resonant frequency.

Design Parameters

Table 1

S No.	Parameters	mm
1	F_0	2.25GHz
2	Ɛr	4.4
3	h	1.6, 5, 8
4	W	40.57
5	ΔL	0.7344
6	L_{eff}	33.67

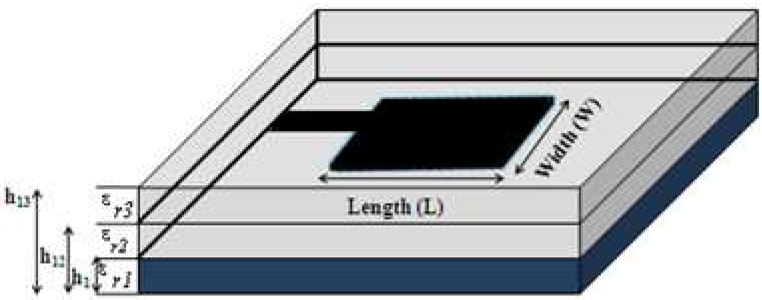

Figure 1: Multi Layer Microstrip Patch Antenna

In this model the MSA can be represented by two slots of width (W) and height (h) separated by transmission line of length (L). The width of the patch can be calculated from the following equation.

$$\text{Width } (W) = \frac{c}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}} \quad (1)$$

The effective dielectric constant (ε_{eff}) is less than(ε_r) because the fringing field around the periphery of the patch is not confined to the dielectric speared in the air also.

$$\text{Effective Dielectric Constant } (\varepsilon_{eff}) = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\sqrt{\frac{1}{\left[1+12\frac{h}{W}\right]}} \quad (2)$$

For TM10 mode the length of the patch must be less than (□⁄2). This difference in the length (ΔL) which is given empirically by

$$\Delta L = 0.412h\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.813\right)} \quad (3)$$

$$.L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{eff}}} \quad (4)$$

Where c=speed of light, L_{eff}=effective length, F_r =resonance frequency, ε_{eff} =effective dielectric constant.

RESULT ANALYSIS

The result analysis is done for multilayer substrate with single patch antenna and is compared with the single layer substrate. Here the shape of the antenna substrate is considered as rectangular and shape of the patch is altered from rectangular to the circular with different thickness. The thickness of the substrate is around 1.6mm, 5mm, 8mm is considered with different permittivity of substrate materials. The permittivity of material as 2.2, 4.5 and 6.

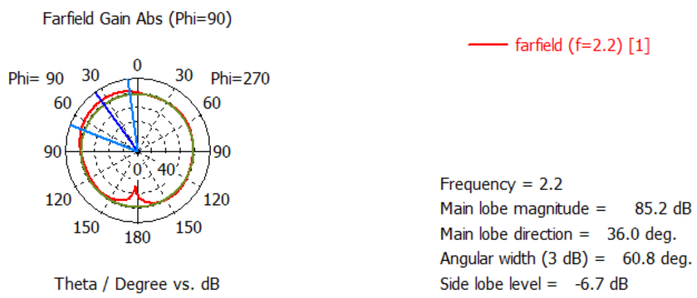

Figure 2: ε_r = 2.2 Single Substrate with Rect. Patch and h=1.6 mm and Frequency=2.2GHz, Gain = 85.2

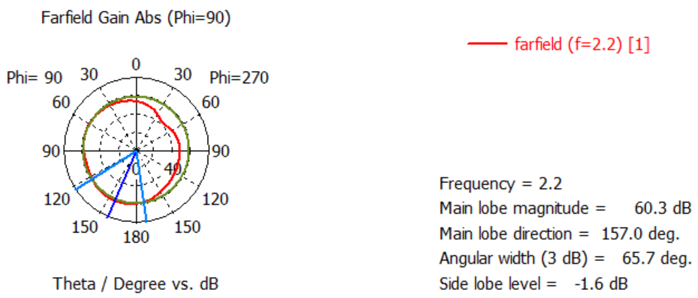

Figure 3: ε_r = 2.2 Multi Substrate with Rect. Patch and h=1.6 mm and Frequency=2.2GHz, Gain = 60.3

Comparison of single layer and multilayer substrate with single rectangular and circular patch and with different substrate materials:

Table 2: Comparison Between Single Layer and Multilayer Return Loss at ε_r=2.2 and With Different Thickness

S No	Shape of the Substrate	Shape of the Patch	Height of Substrate	Operating Freq. (GHz)	ε_r	Single Layer				Multi Layer			
						S11	RETURN LOSS	VSWR	GAIN	S11	RETURN LOSS	VSWR	GAIN
1.	Rectangular	Rectangular	1.6mm	2.2	2.2	-29.5266	43.2305	1.069	85.2	-31.2512	29.8973	1.0563	60.3
2.	Rectangular	Rectangular	5mm	2.2	2.2	-11.4412	21.1694	1	6.83	-16.3266	24.2579	1	6.12
3.	Rectangular	Rectangular	8mm	2.2	2.2	-9.7829	19.8093	1	6.46	-17.3836	24.8027	1.3125	6.09
4.	Rectangular	Circle	1.6mm	2.2	2.2	-29.0587	29.2655	1.073	21.9	-31.5626	29.9883	1.0542	-16.1
5.	Rectangular	Circle	5mm	2.2	2.2	-5.539	14.8686	1	6.87	-9.8357	20.8561	1.9509	6.52
6.	Rectangular	Circle	8mm	2.2	2.2	-9.7829	19.8093	1	6.46	-17.3836	24.8027	1.3125	6.09

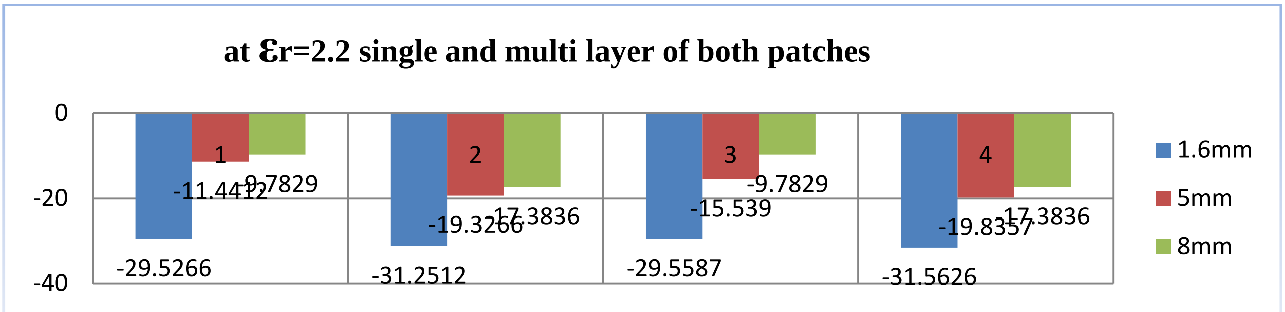

Figure 4: ε_r = 2.2 Comparison of Return Losses for Both Patches

Table 3: Comparison Between Single Layer and Multilayer Return Loss at ε_r=4.5 and With Different Thickness

S No	Shape of the Substrate	Shape of the Patch	Height of Substrate	Operating Freq. (GHz)	ε_r	Single Layer				Multi Layer			
						S11	RETURN LOSS	VSWR	GAIN	S11	RETURN LOSS	VSWR	GAIN
1.	Rectangular	Rectangular	1.6mm	2.2	4.5	-10.5735	20.4843	1.8409	5.04	-34.8621	30.847	1.0367	-12.3
2.	Rectangular	Rectangular	5mm	2.2	4.5	-3.306	10.386	1	6.51	-5.04	14.0486	3.5499	7.1
3.	Rectangular	Rectangular	8mm	2.2	4.5	-3.886	11.79	1	6.51	-7.5019	17.5034	2.4578	5.43
4.	Rectangular	Circle	1.6mm	2.2	4.5	-27.6942	28.8477	1.086	20.3	-30.1751	29.5929	1.0639	3.81
5.	Rectangular	Circle	5mm	2.2	4.5	-5.905	15.4243	3.054	7.43	-46.4506	33.3398	1.0095	3.59
6.	Rectangular	Circle	8mm	2.2	4.5	-7.9323	17.9879	1	7.55	-19.5532	25.8243	1.2353	0.806

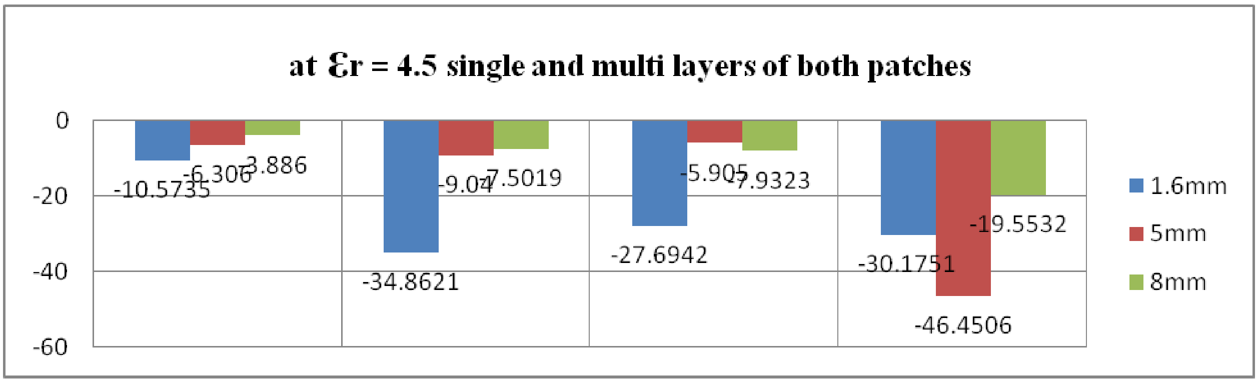

Figure 5: ε_r = 4.5 Comparison of Return Losses for Both Patches.

Table 4: Comparison Between Single Layer and Multilayer Return Loss at ε_r=6 and With Different Thickness

S No	Shape of the Substrate	Shape of the Patch	Height of Substrate	Operating Freq. (GHz)	ε_r	Single Layer				Multi Layer			
						S11	RETURN LOSS	VSWR	GAIN	S11	RETURN LOSS	VSWR	GAIN
1.	Rectangular	Rectangular	1.6mm	2.2	6	-10.4792	20.4065	1	4.04	-30.7136	29.7466	1	2.85
2.	Rectangular	Rectangular	5mm	2.2	6	-9.843	19.8625	1.9498	3.33	-13.3429	22.505	1.5484	4.98
3.	Rectangular	Rectangular	8mm	2.2	6	-4.27	12.60	1	6.27	-12.67	22.05	2.39	5.39
4.	Rectangular	Circle	1.6mm	2.2	6	-26.9167	28.6004	1.0944	19.7	-33.6995	30.5524	1.0421	8.53
5.	Rectangular	Circle	5mm	2.2	6	-7.1377	17.0711	2.5692	4.94	-22.7445	27.1375	1.1572	2.11
6.	Rectangular	Circle	8mm	2.2	6	-7.86	17.90	1	7.26	-13.53	22.62	1.17	3.73

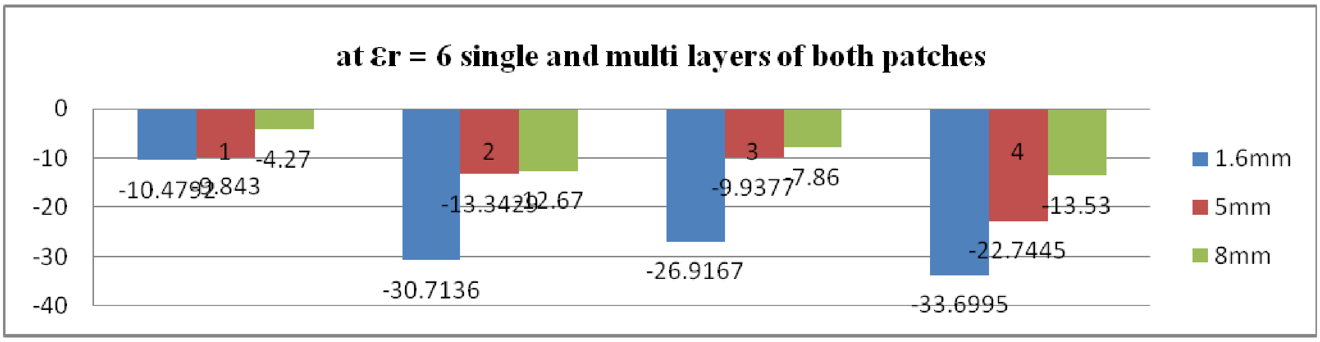

Figure 6: ε_r = 6 Comparison of Return Losses for Both Patches.

CONCLUSIONS

As per the results observed that the reflection coefficient (S11) of the antenna decreasing with increasing the number of the substrate layers. If S11=0 dB, then all the power is reflected from the antenna and nothing is radiated. Return loss are decreased in circular patch compare with rectangular patch. The values of VSWR and Gain also changes with respective substrate layers.

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