Design and Analysis of Rectangular and U Slotted Microstrip Patch using Optimization Program in Java for UHF Applications

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ABSTRACT

This paper presents Microstrip antenna in the application for a military band short range radio communication system ultra high frequency(UHF), at a frequency range of 1Ghz – 1.5Ghz. Currently, most military aviation platforms are equipped with UHF communication system for their operational requirements, a design studies in the development for a lightweight, low volume, low profile. Hence, in this paper, bandwidth enhancement techniques such as use of various substrate with low relative dielectric constant (ε r), size of antenna as well as U slotted patch antenna with coaxial probe feed technique are discussed and explained using optimization program in java and the genetic algorithm is developed.

General Terms

Microstrip antenna, communication, dielectric constant, frequency, bandwidth, java program, algorithm.

Keywords

Optimization program, genetic algorithm, UHF, U slot.

INTRODUCTION

Because of the booming demand in wireless communication system and UHF applications, microstrip patch antennas have attracted much interest due to their low profile, light weight, ease of fabrication and compatibility with printed circuits. However, they also have some drawbacks, such as narrow bandwidth, low gain spurious feed radiation limited power handling capacity . To overcome their inherent limitation of narrow impedance, bandwidth and low gain, many techniques have been proposed and investigated, e.g., for probe fed stacked antenna, microstrip patch antennas on electrically thick substrate, slotted patch antenna and stacked shorted patches using optimization program in java and the genetic algorithm. When we change the shape of a microstrip antenna and it is covered with a dielectric layer , its properties like resonance frequency, gain are changed which may seriously degrade or upgrade the system performance . Therefore, in order to introduce appropriate correctness in the design of the antenna, it is important to determine the effect of dielectric layer and shapes on these antenna parameters. This paper describes the use of Genetic Algorithm shown in figure 3, and optimization program to analyze the gain of a rectangular microstrip antenna. Genetic Algorithm is a class of search techniques that use the mechanisms of natural selection and genetics to conduct a global search of the solution and this method can handle the permittivity and the shape (U) slot of the rectangular microstrip antenna. The Genetic Algorithm program, for the optimization of microstrip antenna using this program ,The bandwidth is analyzed by changing the substrate material at the frequency range 1 GHz to 1.5 GHz and introducing the slots U. The results are simulated with java optimization program . Stack configuration with 2 patches, driven and parasitic, and the use of the various substrate loading technique increases the bandwidth of the antenna ranging from 23%-32%. If we increase the height(40mm) of the patch for $\varepsilon r=3$ (mylar) the bandwidth can be increased up to 61%.

2. ANTENNA CONFIGURATION

The configuration of the proposed patch antenna parasitic and driven is illustrated in Figure1 and Figure 3 respectively. For the U-slotted patch, the slots are embedded to the rectangular patch.where, L and W are the length and width of the patch. Er is the dielectric constant, ΔL is the length due to the fringing field .The fringing fields along the width can be model as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical dimensions. The dimensions of the patch along its length have now been extended on each end by a distance ΔL, which is given empirically by Hammerstad [1] as:

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)(W/h + 0.264)}{(\varepsilon_{reff} - 0.258)(W/h + 0.8)} \quad (1)$$

The effective length of the patch Leff now becomes:

$$L_{eff} = L + 2\,\Delta L \quad (2\text{-a})$$

Or

For a given resonant frequency fo, The effective length is given as:

$$L_{eff} = \frac{c}{2 f_o \sqrt{\varepsilon_{reff}}} \quad (2\text{-b})$$

For a rectangular Microstrip patch antenna, the resonance frequency for any TMmn mode is given by James and Hall [2] as:

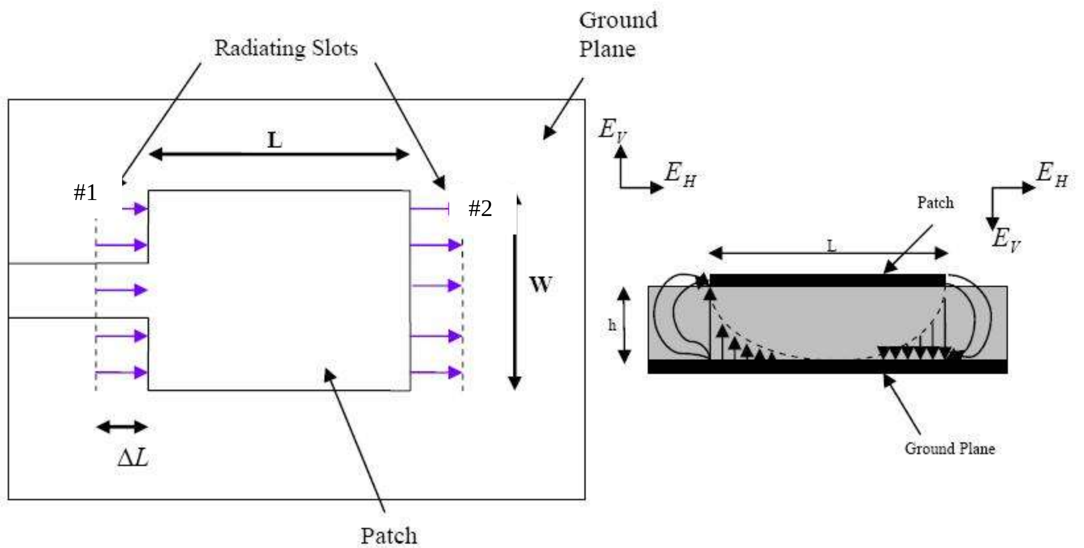

Figure-1 Rectangular Microstrip Antenna

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{1/2} \qquad (3)$$

The width W is given by Bahl and Bhartia [3] as:

$$W = \frac{c}{2 f_o \sqrt{\frac{(\varepsilon_r + 1)}{2}}} \qquad (4)$$

The Cunductance G and susceptance B as shown in Figure 2. The slots are labeled as #1 and #2. The equivalent admittance of slot #1, based on an finitely wide, uniform slot is given by [1]
Y1 = G1 + jB1. Since slot #2 is identical to slot #1

Hence Y2=Y1,B2=B1,G2=G1.

Total impedance Zin= (1/Yin)= Rin=(1/2G1)

%BW=((fhigh - flow)/fo)100 (5)

where fr is the resonant frequency, while fhigh and flow are the frequencies between the magnitude of the reflection coefficient of the antenna is less than or equal to 1/3. In general, bandwidth is proportional to the volume, which for a microstrip antenna at a constant resonant frequency can be express as

BW ~ volume = area x height = length x width x height

An empirical formula by Jackson and Alexopolus for the bandwidth (VSWR<2) is

BW=3.77[εr-1/εr2)(W/L)(h/λo)] (6)

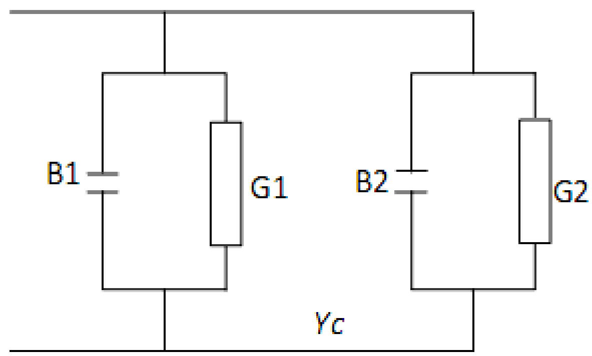

Figure-2 Transmission model of rectangular patch

3. DESIGN AND THEORITICAL CONCIDERATION OF U SLOT

This design procedure is a set of simple design steps for the rectangular U-slot mircostrip patch antenna on microwave substrates . Determine centre frequency, fo Set center frequency as fo and the lower and upper frequency bounds of the bandwidth as flow and fhigh, respectively.

a. Center frequency, fo = 1.25 GHz

b. Lower bound frequency, flow = 1 GHz

c. Upper bound frequency, fhigh = 1.5 GHz

Slot thickness E and F is defined as:

$$E = F = \lambda / 60$$

Slot width D:

$$D = \frac{c}{2\, flow \sqrt{\varepsilon reff}} - 2(L+2\,\Delta L - E) \quad (7)$$

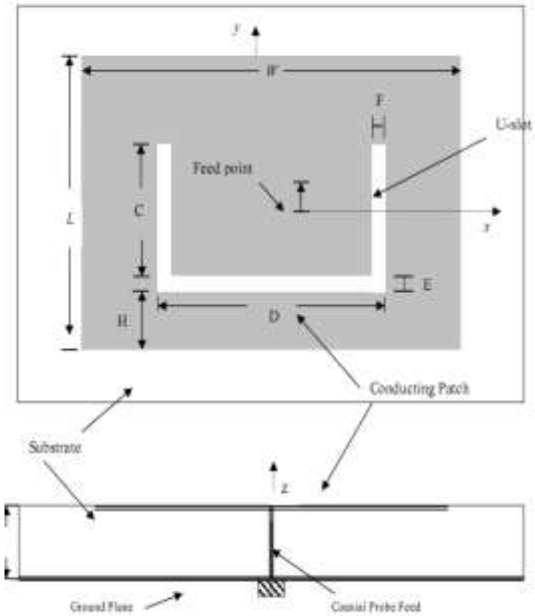

Figure -3 U Slotted Microstrip Antenna

4. OPTIMISING PARAMETER:

Using the optimization program, the user can set the lower bound and upper bound frequency to derive the bandwidth, while the dielectric constant is varied, Height = 35 mm of patch antenna. The optimized lower bound frequency, f low = 1 GHz, upper bound frequency, f high =1.5GHz ,Resonant Frequency Fr=1.25Ghz , wire resistance =50 ohm is selected .after going through various substrate values using the optimization program the design parameters has derived and the bandwidth has been optimized.

When εr = 2.2, Height = 35 mm , lower bound frequency, f low = 1 GHz, upper bound frequency, f high =1.5GHz ,Resonant Frequency Fr=1.25Ghz , wire resistance =50 ohm is selected for the parasitic patch and driven patch the computed results are shown in Table1 as:

Table 1

Normal Patch Readings		U slot patch readings	
Dielectric constant	2.2	Slot width	52.023
Width	94.46	Slot height	28.46
length	55.08	Effective dielectric constant	1.7848
Input impedance	151.30	Height of slot from base	12.05
Effective Dielectric constant	1.857	Driven patch length	25.96
Feed point location	16.804	Slot width E=F	4.0
Bandwidth(MHz)	294.153	Bandwidth(MHz)	618.68

When εr = 2.32, Height = 35 mm , lower bound frequency, f low = 1 GHz, upper bound frequency, f high =1.5GHz ,Resonant Frequency Fr=1.25Ghz , wire resistance =50 ohm is selected for the rectangular and U slot patch the computed results are shown below in table 2:

Table 2

Normal Patch Readings		U slot patch readings	
Dielectric constant	2.32	Slot width	51.06
Width	93.138	Slot height	27.9414
length	53.67	Effective dielectric constant	1.8612
Input impedance	154.11	Height of slot from base	10.082
Effective Dielectric constant	1.9411	Parasitic patch length	25.060
Feed point location	16.48	Slot width E=F	4.0
Bandwidth(MHz)	297.85	Bandwidth(MHz)	634.99

When εr = 2.6, Height = 35 mm , lower bound frequency, f low = 1 GHz, upper bound frequency, f high =1.5GHz ,Resonant Frequency Fr=1.25Ghz , wire resistance =50 ohm is selected for the rectangular and U slot patch the computed results are shown in Table3 as:

Table 3

Normal Patch Readings		U slot patch readings	
Dielectric constant	2.6	Slot width	49.06
Width	89.44	Slot height	26.83
length	50.68	Effective dielectric constant	2.0387
Input impedance	160.48	Height of slot from base	6.14
Effective Dielectric constant	2.135	Driven patch length	23.09
Feed point location	15.788	Slot width E=F	4.0
Bandwidth(MHz)	301.96	Bandwidth(MHz)	665.06

When εr = 3.0, Height = 35 mm , lower bound frequency, f low = 1 GHz, upper bound frequency, f high =1.5GHz ,Resonant Frequency Fr=1.25Ghz , wire resistance =50 ohm is selected for the rectangular and U slot patch the computed results are shown as given below in Table 4

Table 4

Normal Patch Readings	U slot patch readings

Dielectric constant	3.0	Slot width	46.64
Width	84.85	Slot height	25.45
length	47.01	Effective dielectric constant	2.29
Input impedance	169.16	Height of slot from base	1.74
Effective Dielectric constant	2.40	Driven patch length	20.606
Feed point location	14.90	Slot width E=F	4.0
Bandwidth(MHz)	301.08	Bandwidth(MHz)	696.109

If we increase the height=40mm of the patch for εr=3 (mylar) the bandwidth can be increased up to 61%. lower bound frequency, f low = 1 GHz, upper bound frequency, f high =1.5GHz ,Resonant Frequency Fr=1.25Ghz , wire resistance =50 ohm is selected for the rectangular and U slot patch the computed results are shown in Table5 :

		dielectric constant	
Input impedance	169.16	Height of slot from base	1.22
Effective Dielectric constant	2.387	Driven patch length	14.35
Feed point location	13.853	Slot width E=F	4
Bandwidth(MHz)	371.24	Bandwidth(MHz)	1144.19

5. CONCLUSION

Hence, it is proven by the results by changing the permittivity and introducing the slot (U) to the rectangular microstrip antenna, for the resonant frequency 1.25 MHz material at the frequency range 1 GHz to 1.5 GHz and introducing the slots U. The results are simulated with java optimization program . Stack

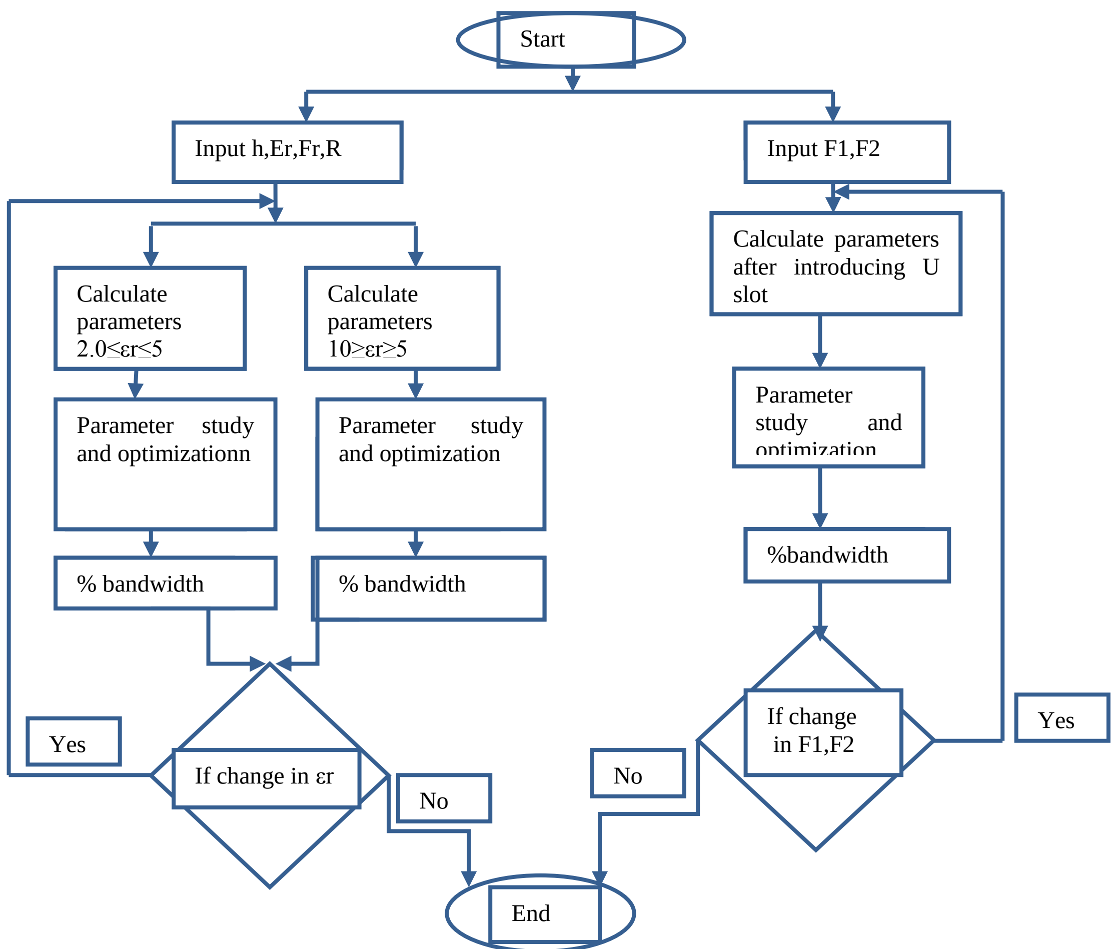

Figure-4 The Genetic Algorithm

Table 5:

Normal Patch Readings		U slot patch readings	
Dielectric constant	3.0	Slot width	46.83
Width	84.85	Slot height	25.45
length	43.696	Effective	2.27

configuration with 2 patches, driven and parasitic, and the use of the various substrate loading technique increases the bandwidth of the antenna ranging from 23%-32%. If we increase the height(40mm) of the patch for εr=3 (mylar) the bandwidth can be increased up to 61%.

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