Design Of 2x2 Shaped Rectangular Micro strip Array Antenna For GSM Application

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Abstract: -- In this paper, 2X2 shaped rectangular micro strip patch antenna for GSM application is presented. Design simulation and optimization processes are carried out with the aid of the HFSS simulator. The proposed antenna is fabricated on a 1.5 cm thick RT Duroid substrate with a relative permittivity of 2.33. The antenna offers excellent performance for GSM systems at center frequency 900MHz. The gain of these antennas are simulated and found adequate which is about 13.8 and 14.4dBi. Measured and simulated results of the resonant frequency, return loss, radiation patterns are presented.

Keywords: Micro strip Antenna, HFSS, Return Loss, Radiation Pattern

I. INTRODUCTION

Wireless communication has become an integral part for modern world .the most popular standard for mobile phones in today's world is GSM. The wireless providers use individual radio frequencies multiple times by dividing a service area into separate geographical zones, or cells, each cell requires its own radio transmitter/receiver antenna. GSM networks operate in different frequency ranges in different countries around the world. Most GSM networks operate in the 900 MHz or 1800 MHz bands in Asia and Europe.

Micro strip antennas are perfect choice for GSM application due to following features, low profile, small size and conformability. But micro strip antennas suffer from bandwidth limitations. The bandwidth can be increased by adding lossy elements but it affects efficiency of the antenna. So the better method is to use array antenna.

In this design of rectangular micro strip array antenna for GSM applications, the antenna array is expected to operate within 890MHZ-960MHz with center frequency 900 MHz, bandwidth 20MHz. This antenna array is fabricated in RT Duroid 5870 substrate with thickness 1.5cm and permittivity 2.33.

II. ANTENNA DESIGN

A. Inset fed micro strip patch antenna

First, a single micro strip antenna is designed for GSM application. Consider figure 1 below, which shows a rectangular micro strip patch antenna of length L, width W on a dielectric substrate of height h. the length and width of antenna can be calculated by transmission line method , as given below,
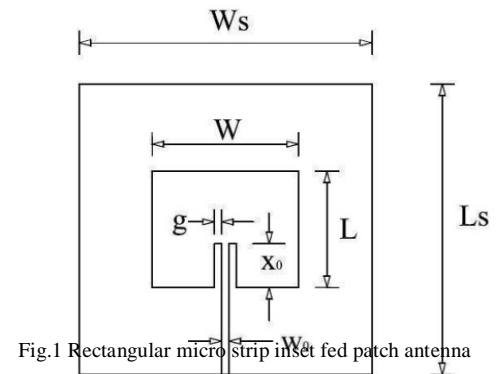

Fig.1 Rectangular micro strip inset fed patch antenna

Width of the antenna given by

$$w = \frac{c}{2f\sqrt{\frac{(\varepsilon_r + 1)}{2}}} \quad (1)$$

The effective dielectric constant is given by

$$E_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{w}\right]^{1/2} \quad (2)$$

The extension length is given by

$$\Delta L = 0.412h\frac{(\varepsilon_r + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{eff} - 0.258)(\frac{w}{h} + 0.8)} \quad (3)$$

The actual length, L in meters is calculated using

$$L = \frac{1}{2f_r\sqrt{\varepsilon_r\,\varepsilon_0\mu_0}} - 2\Delta L = \frac{v_0}{2f_r\sqrt{\varepsilon_r}} - 2\Delta L \quad (4)$$

The feed line width W_0 can be given by the formula

$$z = \frac{120\,\pi}{\sqrt{\varepsilon_r\left[\frac{h}{w} + 1.393 + 0.667\ln(\frac{h}{w} + 1.444)\right]}} \quad (5)$$

To find the feed location, consider

$$R_{in} = \frac{1}{2(G_r \pm G_{12})} \quad (6)$$

Where,

$$G_r = \frac{1}{90}(\frac{w}{\lambda}) \qquad \text{for} \qquad W \geq \lambda_0$$

$$G_r = \frac{1}{90}(\frac{w}{\lambda})^2 \qquad \text{for} \qquad W < \lambda_0 \qquad (7)$$

$G_{12} \ll G_r$ and so we can ignore, and

$$R_{in}(y = y_0) = \frac{1}{2 G_r} cos^2(\frac{\pi}{L}.y_0) \qquad (8)$$

y_0 – position of feed

L- length of feed

G_r – radiating conductance

B. Dimension of patch array antenna

The designed dimensions of the proposed rectangular patch antenna are L=22.58cm, W=14.2225cm, while length of patch is L1=3.94cm, W1=3.74cm The proposed antenna is fabricated on an RT Duroid 5870 substrate with a thickness of 1.5cm and a relative permittivity (ε_r) 2.33. To design a 2X2 micro strip patch antenna array, Co-corporate feed network is used. Figure shows the configuration of the 2 x2 micro strip patch array antenna design for GSM application. Here 4 patch elements are used and each element has same dimensions as mentioned above in order to increase the antenna performance.
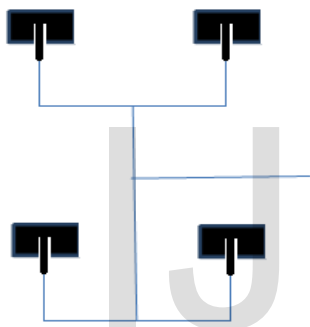

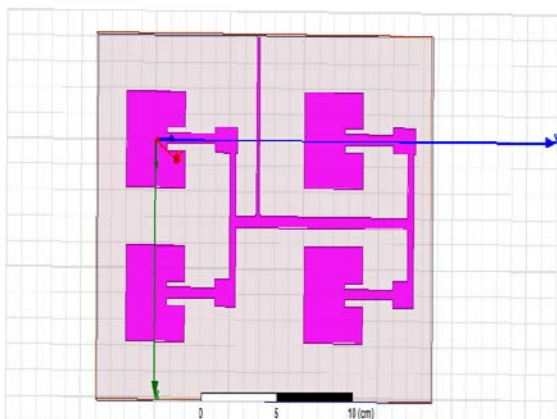Fig-2 Design of 2X2 rectangular patch array antenna

Fig-3 Design view of patch array antenna in HFSS

In this design, the patch elements are connected using quarter wavelength impedance transformer method.

III. SIMULATION PROCEDURE

Simulation in this scheme involved extending the feed line to the edge where the notch has been cut out. This way, the simulated input resistance is that of the edge where the notch has been cut out. For values of the longitudinal notch length varying from zero to L/2, the procedure above was again used to evaluate the input resistance along the center line. This was repeated along a line 5mm, 10mm and 15mm offset of the center line.

Starting from one of the non-radiating edges with the notch length set to 0mm, the feed position was changed transversally to the opposite edge with the input resistance being evaluated for each position. This was repeated feed position 4mm, 8mm and 12mm from the radiating edge and along the transverse center line. To characterize the behavior of the input resistance with notch gap, simulation was repeated along the longitudinal center line for the following notch gap g(as a fraction of feed line width W_0): g=0.3w, 0.7w and 0.9w

A. Abbreviations and Acronyms

GSM- Global System for Mobile Communication

HFSS- High Frequency Structure Simulator

B. Spacing

The distance between the patches in the E-plane and the H-plane always lies between λ /2 to λ. By varying the distance we can get the optimum result and at the optimum value of return loss, we keep the spacing along H-arm and E-arm.

The variation in the spacing should not compel to change the length or width of the substrate. The width of the patch is also adjusted to get the response at the required frequency.

C. Some Common Mistakes

- While designing of the array of inset fed patch array antenna, generally we don't use the quarter wave transformer, due to this the reflection loss increases. So, to reduce the reflection loss we must use to quarter wave transformer to match the impedance between the feed line and the patch.

- The height of the substrate should also be the within limitation which is generally ignored while designing.

- The dielectric constant of the substrate should be in the range from 2.2 to12.

- Since in HFSS design the air box dimension and its position also having more importance. The Air box should be place at the λ/4 distance from the dimension of the antenna geometry.

- We make sure that the excitation to the patch array should be the lumped port, because of the single radiating element.

IV. RESULT

A. S-PARAMETER PLOT FOR RETURN LOSS V/S FREQUENCY

S parameter calculation has been performed for rectangular micro strip 2x2 array antenna. The center frequency is selected as the one at which the return loss is minimum. Fig. 4 shows the antenna operates at a frequency range of 890-920MHz, with bandwidth 20MHz and center frequency of 900 MHz

The drawn diagram shows the minimum return loss at 900 MHz. Further it can also be improved by either inserting the cut mark or slot mark, which enhances the return loss. The diagram describe the result better.
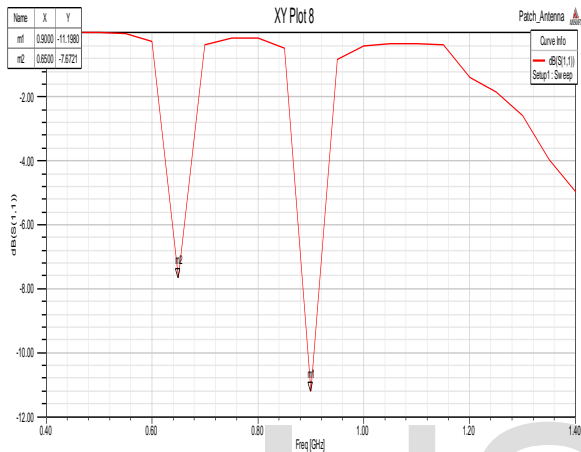
Fig-4 Return loss of 2X2 array patched antenna

.B.- ANTENNA PARAMETERS

Some of antenna parameters, such as the gain, directivity, antenna efficiency and 3 dB beam width for single patch and 2x2 array antenna are shown below. From the table, it is clear that gain and directivity of 2x2 phased array antenna is almost double than that of single patch antenna. The gain and directivity for 2x2 phased array antenna is shown below: As shown in the diagram, the radiation pattern taken for the all values of phi(0).
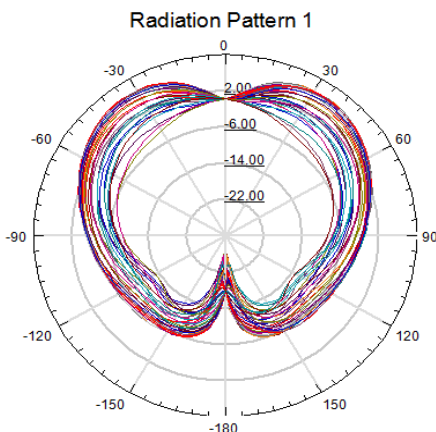
Fig-5 Radiation pattern of 2X2 array patched micro strip antenna

C. GAIN AND DIRECTIVITY GRAPH

The graph given below shows the gain and directivity of designed antenna.

The gain of an antenna in a given direction is the amount of energy radiated in that direction compared to the energy of an isotropic antenna would radiate in the same direction when driven with the same input
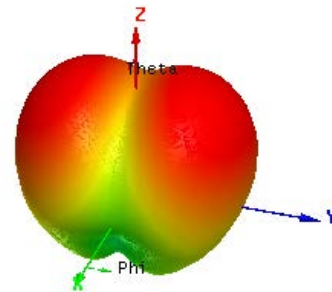
Fig-5 Gain of 2X2 array patched micro strip antenna

V- CONCLUSION

A 2x2 rectangular micro strip phased array antenna has been successfully designed. Here micro strip feed technique is used to feed single patch antenna. And corporate feed technique is used for 2X2 array antenna. S parameter calculation has been performed for the designed antenna. From the graph, it is clear that the designed antenna has been radiated in the prescribed range of frequencies defined for GSM application. Next gain, directivity, effective area, power radiated absolute field etc. are calculated for designed antenna. The solution frequency which is used is very much important for this network and by designing such antenna we are going to improve the efficiency and desired output power. This pattern of antenna can used in GSM application because of array formation it gives better radiation and return loss.

The future work is to design 4x4 and 8x8antenna array and square shaped conformal micro strip phased array antenna for GSM application.

VI ACKNOWLEDGMENT

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