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Single Polarized Microstrip Antenna Design for Mobile Communication Base Station

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***Abstract*— A single linear polarized antenna array element used in telecom base station is presented. It is of a considerable interest in broadband antenna element since it is simple to construct and also used as a low cost based station antenna designed for mobile communication system. In this paper, design and simulation was done through the use of 3D EM CST microwave studio and the results shows that high gain, low profile, wider bandwidth of operation, high isolation and low voltage standing wave ratio was achieved.**

Index Terms*— Microstrip antenna, *Mobile Communication, low profile, isolation, patch.

I. INTRODUCTION

The ever increasing demand for higher capacity in wireless communication systems has motivated recent research toward wireless systems that exploit space selectivity. This has resulted to many efforts on the design and development of smart antenna arrays [1]. The directivity of these antenna helps to reduce the delay spread of the radio channel and the diversity of the antenna guards against fading. Due to spatial gain, the output powers of mobile terminals (MT) can be decreased which results in longer battery lifetimes. Array antennas also serve to increase the range of the base stations (BSs) and interference power from (and to) neighbouring cells (service areas) can be significantly lowered [2].

Cellular Base Stations (CBS) are aimed at improving indoor coverage that has been receiving significant attention from mobile operators globally. Since coverage and capacity are the most essential dimensions in wireless network planning and are used to determine the balance between signal coverage and system capacity in service quality requirement, there is the need for base stations using high performance array element or antenna arrays to provide transmit and receive diversity. Although, there are other antennas used for mobile telecommunication systems, their challenges have resulted to choice of microstrip antenna for wireless communication. For instance, the wire antenna suffers from the demerits of shock hazard and single wire feed line which may be burnt. (Electronic.com). Besides, it could be a problem for lightning and also requires a tuner or matching system hence a low gain and directivity setback. Also, poor radiation pattern and low gain as well as a considerable amount of input power dissipated in the terminating resistor. (Electronics.com, 2011).

The phase array antenna also has the demerit of limited coverage to a 120 degree sector in azimuth and elevation and the possibility of beam to be deformed while deflecting, low frequency, very complex structure and high cost though it has the merit of very high gain with low sidelobes.(Radar Basics) and for lens antenna the design is complicated bulky and expensive. In the light of the forgoing, microstrip antenna has been preferred to other types of antenna in mobile communication systems.

This work, considered Single polarized Microstrip Antenna for Mobile communication base Station operating at a frequency range of 1.9-2.17 GHz. Selection of elements that can conform to the geometry of the device and the array architecture that could control the radiation pattern both in azimuth and elevation directions was also considered and this resulted in the selection of microstrip patches which are light in weight and low volume arranged in a planar configuration which can be easily made conformal to host surface. It can easily be integrated with microwaves integrated circuits (MICs) and combination of linear and circular polarizations in signal reception is selected to maximize the signal-to-interference ratio (SIR) for a given mobile whose polarization settings can then be used for transmission as well as to improve reception at the mobile. It should be noted that the number of radiating elements were chosen to meet beamwidth requirements while maintaining reasonable costs and complexity for hardware implementation.

II. SYSTEM MODEL DESIGN

The type of antenna element considered in this work is a microstrip antenna (also known as a patch antenna), since it is intended to be conformally mounted on a smooth surface or a similar device. For the design of the microstrip antenna, Computer Simulation Technology (CST) software was used. CST software is an accurate, efficient and computational solution to electromagnetic design and analysis and is used for the design and optimization of devices operating in a wide range of frequencies. The design in fig 1a and 1b shows a single polarized antenna using a square patch microstrip type. The frequency of operation of this design is 1.9-2.17 GHz. It consists of a rectangular substrate with a parasitic element deployed above it. Its antenna system bandwidth is increased by deploying a parasitic element above the driven patch element which increases the capacitance of the driven element. The MATHCAD program was used to calculate the Dimension of the microstrip antenna element as shown in figure 1.

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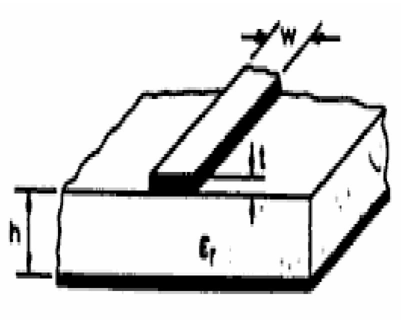


Fig 1: Sketch of microstrip antenna

From Figure 1,

w = the width of the patch which is the determinant of the frequency
t = the line thickness
h = the height of the substrate
ε_r = low frequency effective dielectric constant of the material. In this case, AD Arlon (loss free) is used and the value is 2.5

Assuming that;
Length (L) of substrate/Ground Plane = 130mm
Width (W) of Substrate/Ground Plane = 130mm
Dielectric constant of the AD Arlon loss free (λ_0) = 2.5
Height of the substrate (h) = 1.575mm
Height = H = 25mm
Line thickness (t) = 0.035mm
Maximum height (Printed Patch) = (h + t) = (1.575 + 0.035)mm = 1.61mm

A mathcad program was used to obtain the dimension of the printed patch element as shown below:

Given that
f = 2.05 Hz
c = 300 m/s
h = 1.575 mm
ε_r = 2.5
w =130 mm

Hence,

$$\lambda_0 = \frac{c}{f} = 146.341\ m \tag{1}$$

where λ_0 is the wavelength of the dielectric medium

The low frequency effective relative dielectric constant i.e. Eff, is given as

$$Eff = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} . \left(1 + 12 . \frac{h}{w}\right)^{-\frac{1}{2}} \tag{2}$$

Eff = 1.566

Therefore,

$$\lambda_g = \frac{\lambda_0}{Eff} \tag{3}$$

= 93.475 m

where λ_g is the wavelength in microstrip

Hence, the wavelength of the patch element,

$$\frac{\lambda_g}{2} = 46.738\ m \tag{4}$$

However, the design uses a transmission line model since this model is only applicable in square and rectangular patch geometry which gives a reasonable interpretation of radiation pattern mechanism. Transmission line model represents the patch antenna by two slots which are separated by low impedance normally represented by Zc (Balanis, 2006). Computer model design using CST software of a single polarization version is shown in Fig 2 while the computer model design with T-junction splitter is shown in fig 3. T-Junction splitter introduced increases balanced excitations to obtain increase isolation. The computer model design is shown in figure 3.

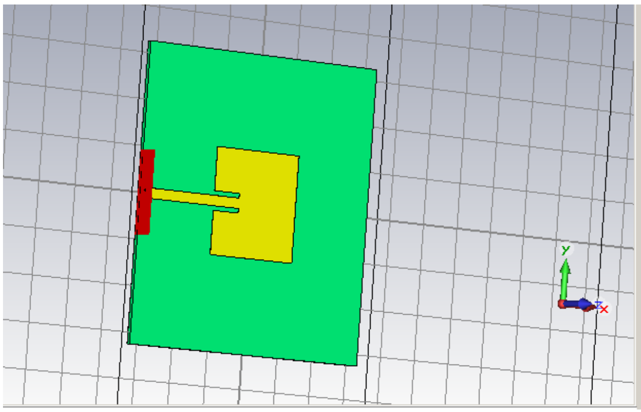


Fig 2: CST Design of Single Polarized Microstrip Antenna.

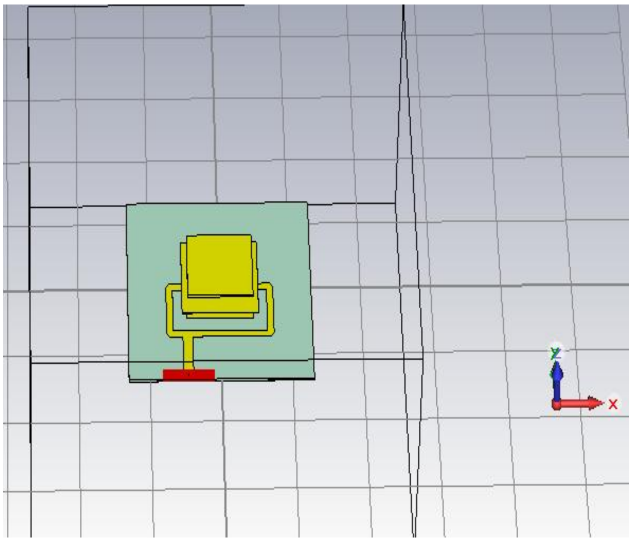


Fig 3: Single Polarized Microstrip Antenna with T-Junction Splitter

III. SIMULATION RESULT

The simulation result in figure 4 shows that at this range of frequency, 1.9-2.17GHz, a wider band of frequency is obtained and the radiation pattern shows that the band is within the 50Ω resistor track shown in S1,1 (49.74Ω). As the gain increases, bandwidth increases. In fig 6, the simulation result and smith chart shows that the signal are spitted to increase bandwidth. This consequently gives rise wider band of transmission and good return loss which in turn results to high quality signal transmission hence reduces reflections thereby minimizing bit errors.

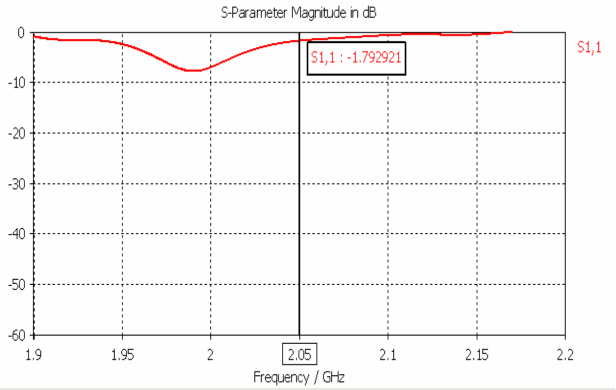


Fig 4: Simulation Result of Single Polarized Microstrip Antenna

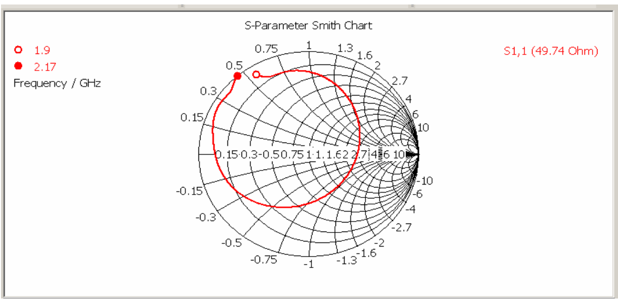


Fig. 5: Smith chart of Single Polarized microstrip antenna

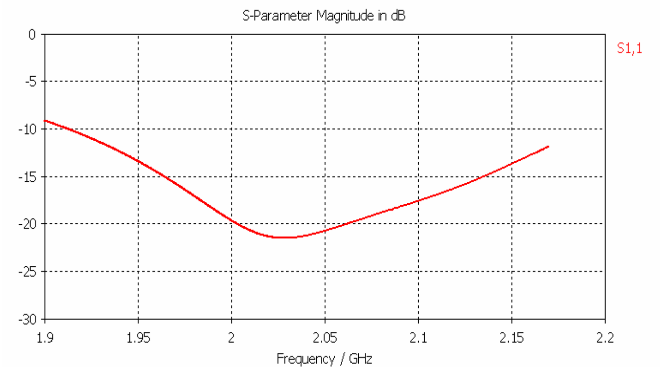


Fig 6: Simulation Result with T-Junction Splitter

In order to verify the simulation results, Figure 7 and 8 shows that the beam width (3dB) to be 58.3 degrees and a low voltage standing wave ratio (VSWR). The result also shows low side lobes of -18.3 dB. This implies that angular beam width is narrow hence giving rise to effective transmission without much signal loss.

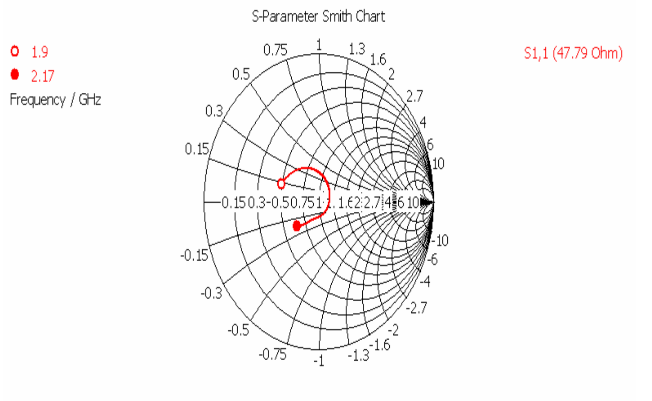
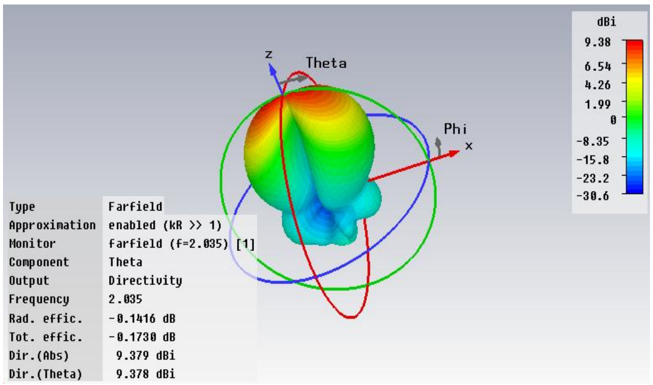


Fig 7: Smith Chart with T-Junction Splitter



Type Farfield
Approximation enabled (kR >> 1)
Monitor farfield (f=2.035) [1]
Component Theta
Output Directivity
Frequency 2.035
Rad. effic. -0.1416 dB
Tot. effic. -0.1730 dB
Dir.(Abs) 9.379 dBi
Dir.(Theta) 9.378 dBi

Fig 8: Radiation pattern (3D)

Table I summarizes the results of the single polarized antenna

Table I

Parameters	**Values**	**Remark**
Gain	9.3dBi	High
VSWR	1.15	Low
Beamwidth(3dB)	58.3 degree	Narrow
Isolation	-10	High

IV. CONCLUSION

The result from the design and simulation of the single polarized antenna shows a high gain with a high isolation and the low voltage standing wave ratio shows that there will be no mismatch between the load antenna and the transmission line impedance thus reduces reflection in the transmission line to the lowest minimum during signal transmission and hence low return loss.

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