Design of Balance Coaxial Feed and Unbalance Coaxial Feed Microstrip Patch Antenna with Slot for Wireless Communication

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Abstract— **This paper presents the design, simulation, fabricate and analysis of balance coaxial feed and unbalance coaxial feed with slotted antenna for wireless application. The antenna design was created in Computer Simulation tool (CST) version 2011. This antenna can be applied for 3G and 4G frequency spectrum bands. The analysis has been done for the microstrip patch antenna with balance coaxial feed, only single frequency will be resulted, but if change the coaxial to unbalance feed, the microstrip become a multiband microstrip patch antenna. For better result of the return loss, slot has been added to the microstrip patch antenna and the designs were compared and analyzed. The performance of the antenna was studied in terms of return loss and radiation pattern and half-power beamwidth (HPBW).**

Keywords— **Balance coaxial feed, unbalance coaxial feed, return loss, radiation pattern half-power beamwidth (HPBW).**

I. Introduction

Wireless communications area playing an ever increasingly important role nowadays. The conventional wireless communications such as cellular or mobile is the corner stone of society with more frequency and bandwidth being offered to the public. For example streaming video, using internet and presently these are being accepted by the public and such as a must have technologies nowadays. The wireless communication systems has continuous growth and unstoppable demand in order to integrate several frequencies using a single antenna that can operate in many frequency bands. An antenna that has a bandwidth that can cover several of frequency bands application is a challenge in the antenna development.

Microstrip patch antenna is an antenna that has a low profile, light weight, easy to fabricate, and conformability to mount hosts in additional size reduction and bandwidth so that it is fulfill the requirements of modern communication system [1]. Even though the microstrip patch antenna has a lot of advantages, but it is small impedance bandwidth for the disadvantage. There are many techniques in order to overcome the disadvantages of the bandwidth, such as increasing the thickness of the dielectric substrate, decreasing the dielectric constant [2], and using parasitic patches [3].

In this project, slotted microstrip patch antenna will be using as it has gained particular attention among the microstrip patch antenna due to its miniaturized size and high of bandwidth. Several of authors had presented a number of slotted antenna topologies to show the different between the design and the performance towards the microstrip patch antenna. The difference in orientation of the slot and position on the microstrip patch antenna cause these antenna configurations operate differently.

In this project, it shown that balance coaxial feed and unbalance coaxial feed cause different of frequency output. For balance coaxial feed only can operate in single frequency , while for unbalance coaxial feed, cause the multiband microstrip patch antenna that can operate in many frequencies. For the balance coaxial feed antenna frequency , the antenna was simulate for frequency 2.6 GHz while for unbalance coaxial feed antenna, the frequencies range was simulate for 1GHz to 3GHz. Some designs of slot also were added and analyzed.

II. ANALYTICAL ANALYSIS OF THE ANTENNA

A. Calculation

The value of width (W) and length (L) for this patch is determined by using Equation 1 and Equation 2 respectively.

$$W = \frac{1}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

$$L = \frac{v_0}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \qquad (2)$$

Where ε_{eff} and ΔL can be calculate by,

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{w}\right)^{-1/2} \qquad (3)$$

$$\Delta L = 0.412h\,\frac{\left(\varepsilon_{eff} + 0.3\right)\left(w/h + 0.264\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(w/h + 0.813\right)} \qquad (4)$$

B. Antenna Design

i. Balance coaxial feed antenna

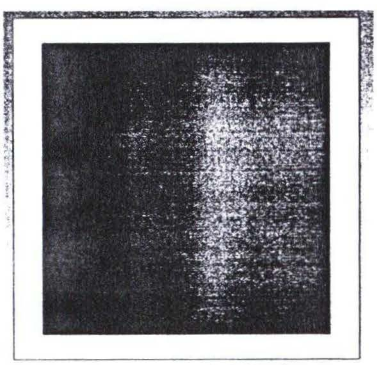

Fig.1 Balance coaxial feed antenna

ii. Unbalance coaxial feed antenna without slot

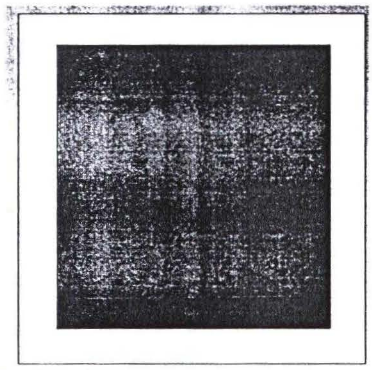

Fig.2 Unbalance coaxial feed antenna

iii. Unbalance coaxial feed antenna with slot

a. Design 1

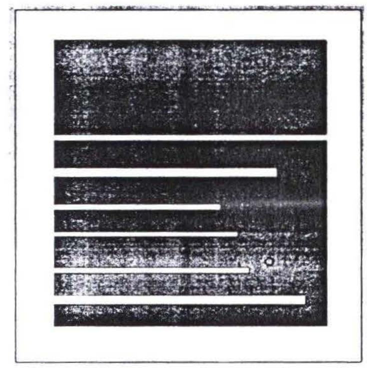

Fig.3 Design 1 for slotted antenna

b. Design 2

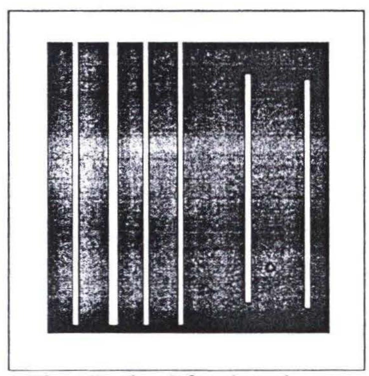

Fig.4 Design 2 for slotted antenna

c. Design 3

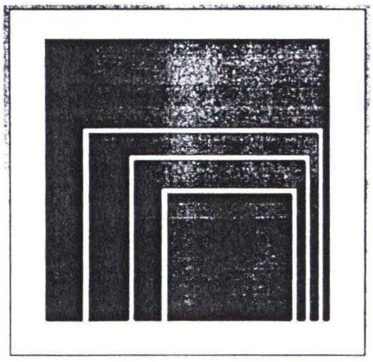

Fig.5 Design 3 for slotted antenna

TABLE I. DESIGN SPECIFICATION

Parameter (mm)	Calculated	Simulation
Length, L	26.26 mm	51.1502 mm
Width, W	34.17 mm	49.0 mm
Frequency, f	2.6 GHz	2.6 GHz
h	1.6 mm	1.6 mm
ε_r	4..7	4.7
σ	0.019	0.019
Ω	50	49.1519

III. CST SOFTWARE SIMULATION

The antenna was designed and simulated using CST software to verify the antenna operation of the proposed configuration. Before reaching to the final stage of designing the antenna, a parametric study was done by varying L and W of the patch. The result balance coaxial feed , unbalance coaxial feed and also unbalance coaxial feed with slot was shown in figure below. The adjustment of the feed cause the from single band to multiband. Single band was simulate in frequency 2.6 GHz , while when the antenna feed change to unbalance feed, it cause result of multiband frequencies. The unbalance coaxial feed antenna was simulated in frequency range 1 to 3 GHz.

A. Balance coaxial feed antenna

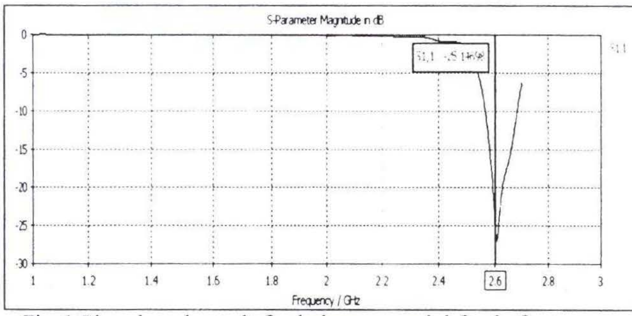

Fig.6 Simulated result for balance coaxial feed of return loss, S11 for 2.6 GHz

B. Unbalance coaxial feed antenna without slot

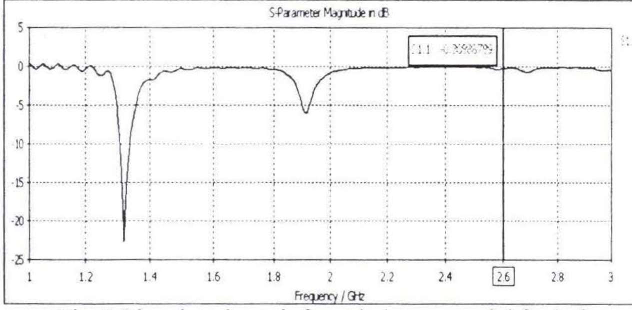

Fig.7 Simulated result for unbalance coaxial feed of return loss, S11

C. Unbalance coaxial feed antenna with slot

i. Design 1

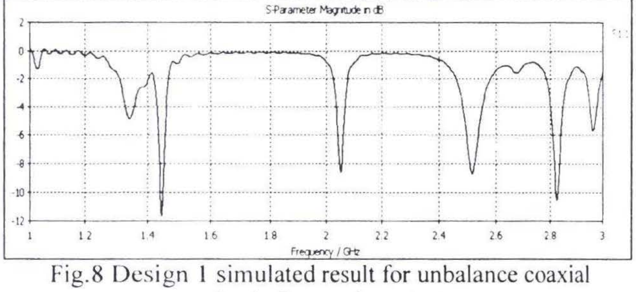

Fig.8 Design 1 simulated result for unbalance coaxial feed of return loss, S11

ii. Design 2

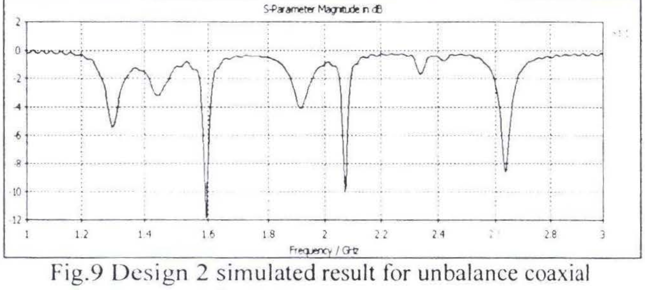

Fig.9 Design 2 simulated result for unbalance coaxial feed of return loss, S11

iii. Design 3

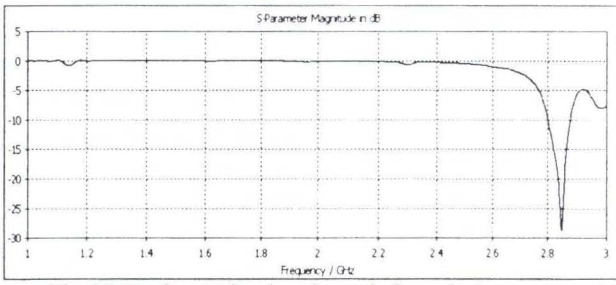

Fig.10 Design 3 simulated result for unbalance coaxial feed of return loss, S11

Return loss (S11) is a convenient way to characterize the input and output signal sources and its represents how much power is reflected from the antenna. The final result of balance coaxial feed antenna after optimization is equal to -25.14698 and near to -30 dB. The larger the return loss indicates higher power being radiated by the antenna which eventually increases the gain. The nearer the return loss to -30 dB, the antenna has a better reflection coefficient and power reaches the load with minimal losses. While for the unbalance coaxial feed antenna, the antenna produces several return loss at certain frequencies. The unbalance coaxial feed antenna is suitable for multiband antenna design as result of multiband antenna with many of frequencies.

D. Radiation pattern

The radiation pattern for all of the design shown in figure below :

i. Design 1

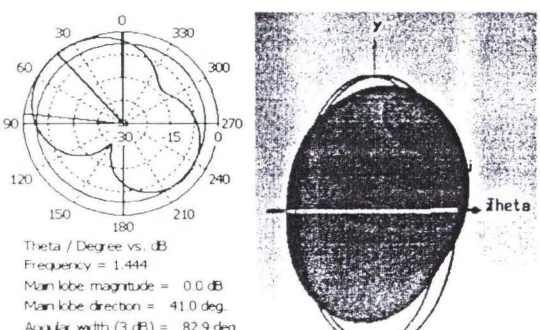

Fig.11 (a) Simulated radiation pattern for f-1.444GHz

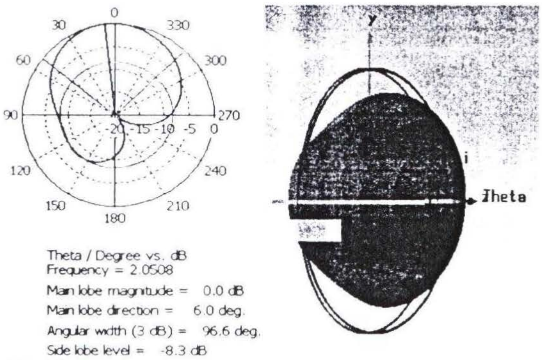

Fig.11 (b) Simulated radiation pattern for f-2.0508GHz

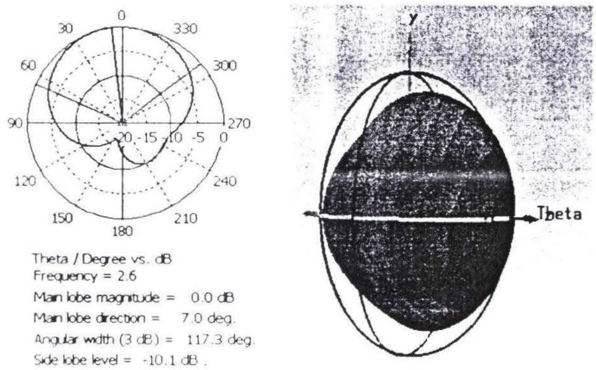

Fig.11 (c) Simulated radiation pattern for f-2.6GHz

ii. Design 2

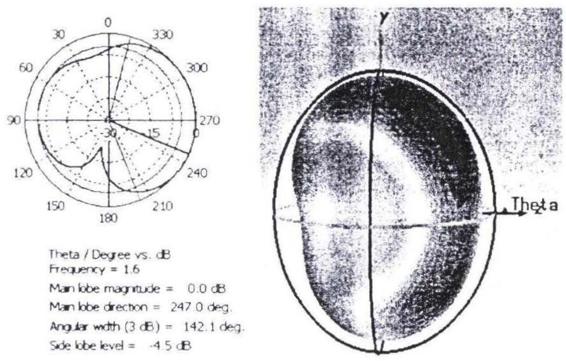

Fig.12 (a) Simulated radiation pattern for f-1.60GHz

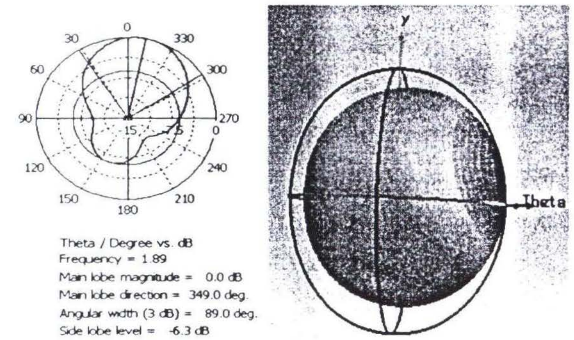

Fig.12 (b) **Simulated** radiation pattern for f-1.89GHz

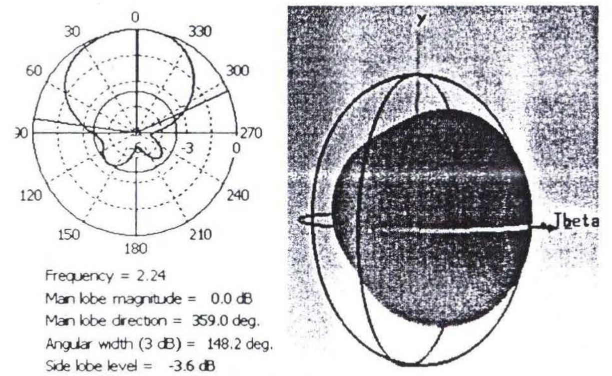

Fig.12 (c) **Simulated** radiation pattern for f-2.24GHz

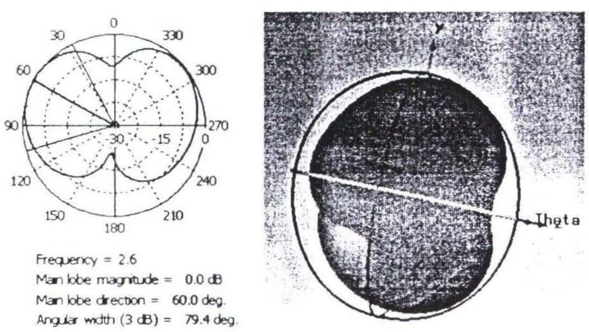

Fig.12 (d) **Simulated** radiation pattern for f-2.60GHz

iii. Design 3

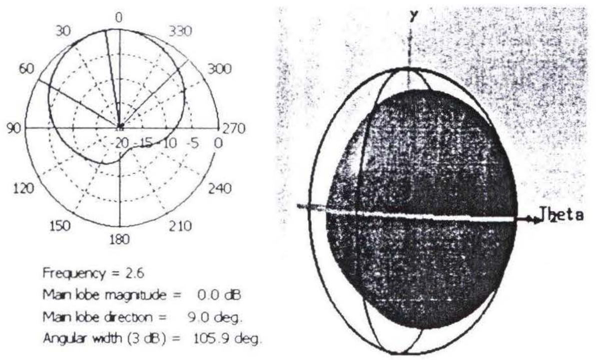

Fig.13 (a) Simulated radiation pattern for f-2.60GHz

TABLE 2.VALUES OF THE RADIATION PARAMETER

Design	1	1	1	-
Freq (GHz)	1.44	2.0508	2.6	-
Main lobe directional	41°	6°	7°	-
Angular width(3dB)-HPBW	82.9°	96.6°	117.3°	-
Design	2	2	2	2
Freq (GHz)	1.60	1.89	2.24	2.60
Main lobe directional	247°	349°	359°	60°
Angular width(3dB)-HPBW	142.1°	89°	148.2°	79.4°
Design	3	-	-	-
Freq (GHz)	2.6	3		
Main lobe directional	9°	16	-	-
Angular width(3dB)-HPBW	105.9°	135.4	-	-

Figure 11, 12 and 13 show the radiation pattern for the antenna at frequency range 1 to 3 GHz but in different design including half antenna power bandwidth (HPBW). HPBW is the angular separation which the magnitude of the radiation pattern from the peak of the main beam decreases by 50% or -3 dB.

IV. RESULT AND DISCUSSION

A. Fabrication result

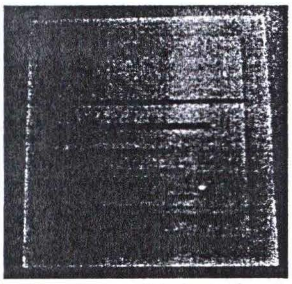

Fig.14 (a) Antenna fabricate for design 1

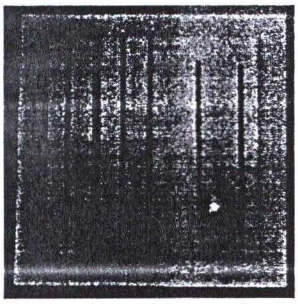

Fig.14 (b) Antenna fabricate for design 2

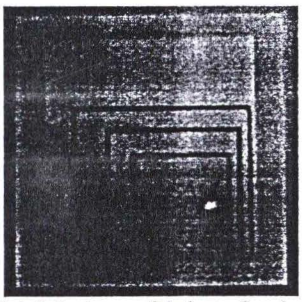

Fig.14 (c) Antenna fabricate for design 3

B. Simulation and measured return loss

i. Design 1

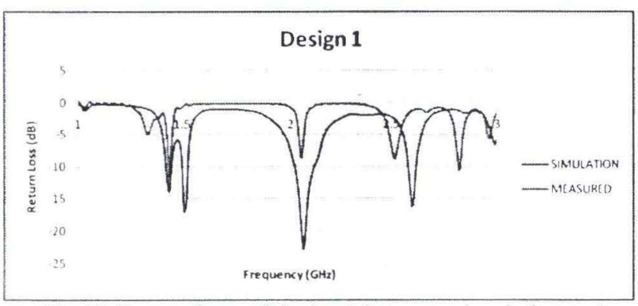

Fig.15 Comparison of design 1 between simulation and measurement result for S11

ii. Design 2

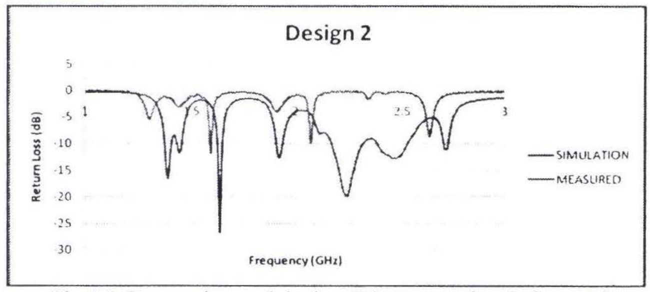

Fig.16 Comparison of design 2 between simulation and measurement result for S11

iii. Design 3

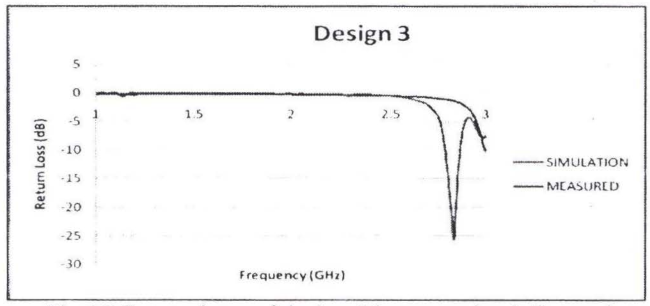

Fig.17 Comparison of design 3 between simulation and measurement result for S11

C. Simulated and measured radiation pattern :

i. Design 1

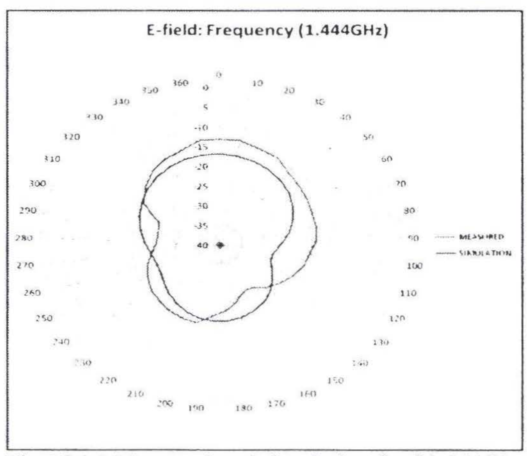

Fig.18 (a) Measured and simulation for f-1.444Ghz

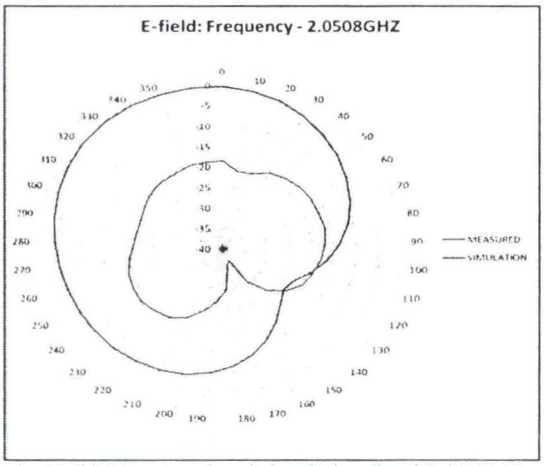

Fig.18 (b) Measured and simulation for f-2.0508Ghz

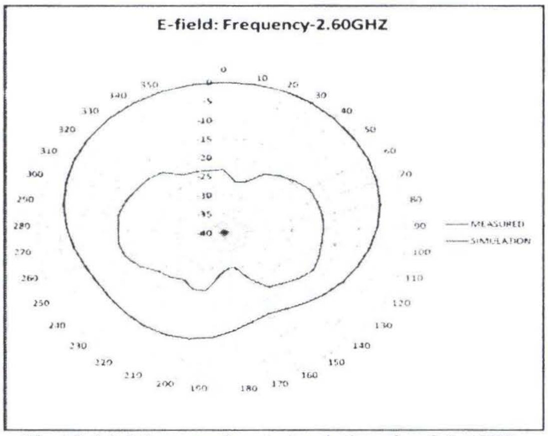

Fig.18 (c) Measured and simulation for f-2.6GHz

ii. Design 2

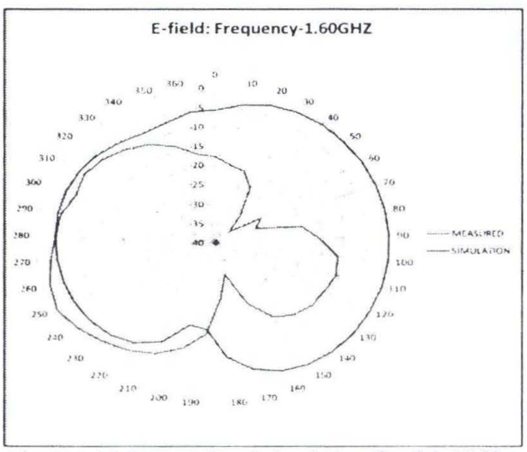

Fig.19 (a) Measured and simulation for f-1.60Ghz

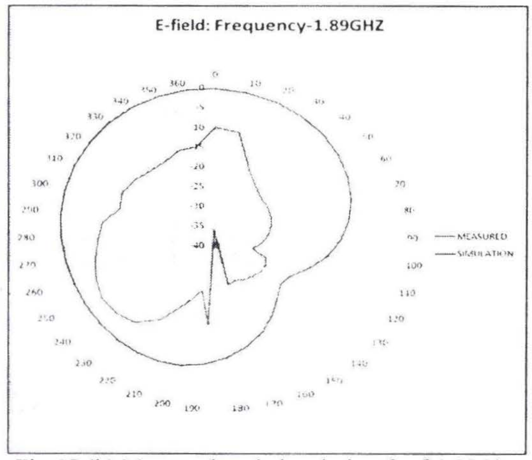

Fig.19 (b) Measured and simulation for f-1.89Ghz

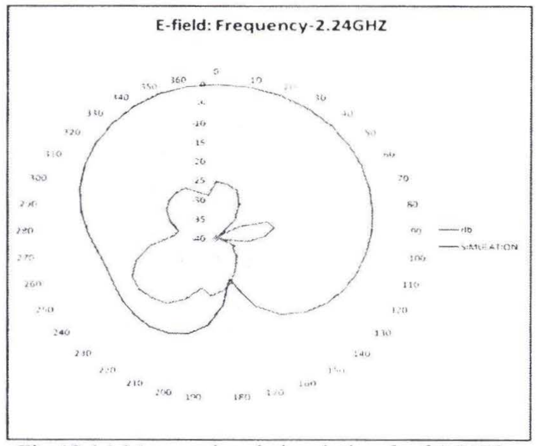

Fig.19 (c) Measured and simulation for f-2.24Ghz

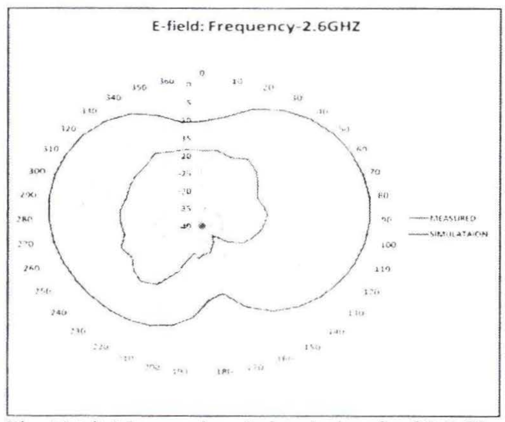

Fig.19 (d) Measured and simulation for f-2.6 Ghz

iii. Design 3

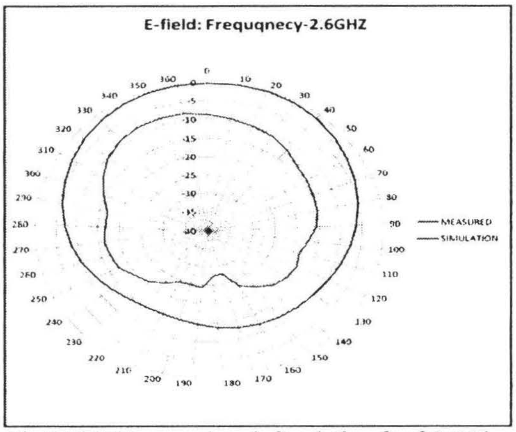

Fig.20 (a) Measured and simulation for f-2.6Ghz

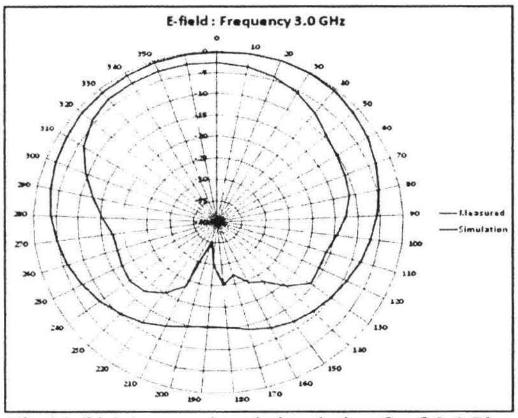

Fig.20 (b) Measured and simulation for f-3.0Ghz

The measured radiation patterns for both antennas are shown in Figure 18, 19 and 20. It can be observed that the E- plane radiation pattern is quite similar. Measurements errors are mainly because the antenna measurements did not carried out inside an anechoic chamber.

V. CONCLUSIONS

The antenna design and analysis for balance and unbalance coaxial feed antenna effects were carried out in this paper. A single microstrip patch antenna was design with balance coaxial feed. To get multiband antenna, some modification had been made to get the multiband microstrip patch antenna by change the feed type to unbalance coaxial feed. Some design of unbalance microstrip patch antenna with slotted also been added for the comparison. For the

VI. RECOMMENDATION

Based on the conclusions drawn and the limitations of the work presented, future work can be carried by using unbalance coaxial feed antenna with slotted to design multiband microstrip patch antenna with different type of frequencies such as for 2G, 3G and 4G or others wireless and mobile applications. The size of antenna also can be reduce by adding DGS effect.

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