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Compact Dual-Band Microstrip Patch Array Antenna for MIMO 4G LTE and WLAN Systems

By

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Abstract:

In this paper, a compact dual-band microstrip patch array antenna for both the MIMO 4G LTE and the WLAN systems is developed. Design simulation and optimization processes are carried out with the aid of the Advanced Design System (ADS) electromagnetic simulator that uses the full–wave Method of Moment (MoM) numerical technique [1]. The losses that are caused by both the substrate and metallization are taken into account during the simulation process. Array compactness was our target during the design process to integrate the array with the new mobile communication equipments.

Keywords:

Dual-Band Antenna, Microstrip Patch Array Antenna, MIMO Antenna and 4G antenna systems.

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1. Introduction:

MIMO (Multiple Input Multiple Output) systems have been studied extensively during the recent years. It is clear from the theoretical point of view that the use of MIMO systems increases the capacity of transferred signal as compared to the use of SISO (Single Input Single Output) and SIMO (Single Input Multiple Output) systems [2]. 4G handheld telephones, iphones, and other new compact cellular equipments recommend the use of small-scale, multi-band MIMO antennas [3]. In this paper, a compact 1x4 U-slotted dual-band microstrip linear patch array antenna prototype is designed, fabricated and measured. It covers both the 4G LTE (Long-Term Evolution) and the WLAN (Wireless Local Area Network) bands and can be used in other MIMO antenna applications. Microstrip antenna type is preferable due to its easy fabrication, low cost, small-size, low weigh, integrate-ability and compatibility with standard manufacturing process [4]. Good agreement has been obtained between numerical simulations and experimental results. The paper is constructed as follows. The developed array antenna design and simulation including the single element, 1x2 and 1x4 linear arrays are presented in section 2. The fabrication and measurements are discussed in section 3. Finally, the work is concluded in section 4.

2. Design and Simulation:

The geometry of an antenna element is optimized and is shown in Figure (1) (in mm). Rogers substrate [5], RT-Duriod 5880 (ε_r =2.2) single substrate is used with 62 mil thickness. U-shaped slotted patch is used to provide the dual-band for both the LTE and WLAN applications. Figure (2) shows that the reflection coefficient S_{11} is -23.83dB at 3.5GHz with a frequency bandwidth of 75MHz (LTE frequency band), and is -20.88dB with a frequency bandwidth of 80MHz at 5GHz (WLAN frequency band). This ensures good matching. Fig. 3 shows the meandering of the surface current on the radiating U-slot patch this result in an increase of the length of the equivalent surface current path. Fig. 4 shows that the gain is better than 7dBi with antenna efficiency of 93.43% at 3.5GHz. The simulation also shows that the gain is 7.09dBi with antenna efficiency of 80% at 5GHz.

2.1. Single Antenna Element

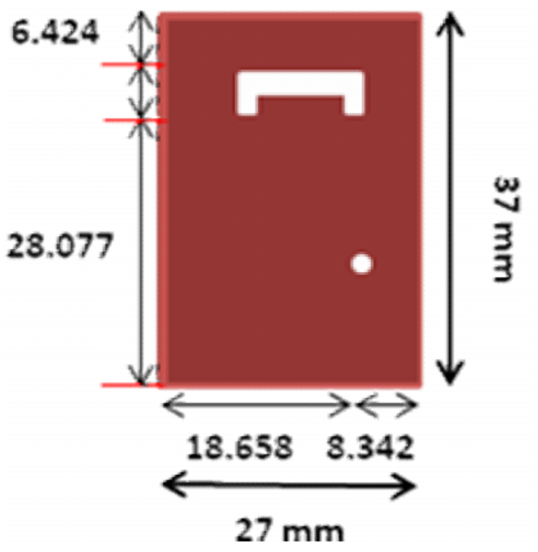


Figure (1)
Geometry of a U-slotted antenna element

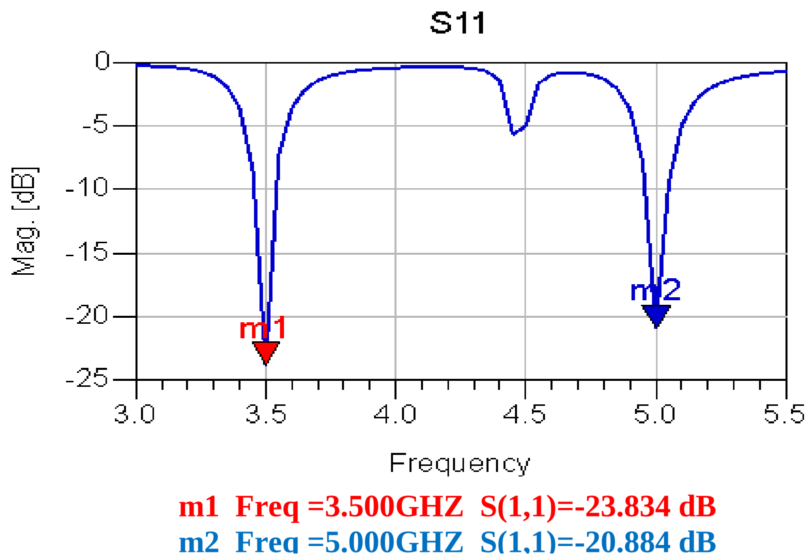


Figure (2)
Single element reflection coefficient S_{11}

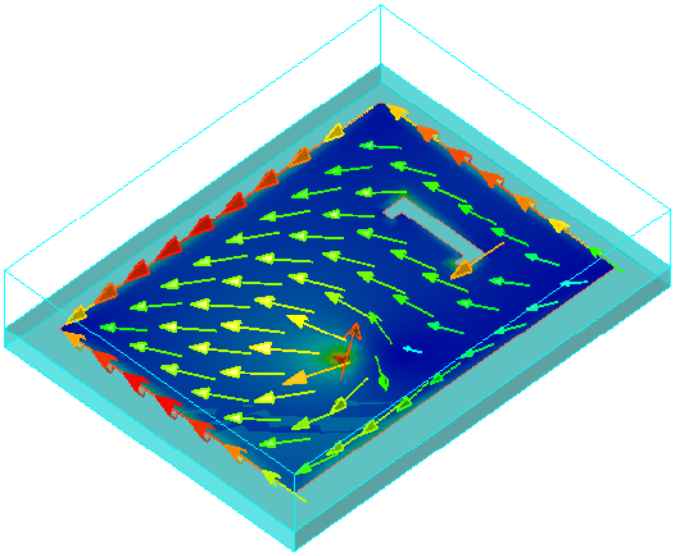


Figure (3)
Meandering of the surface current on the radiating U-slotted patch

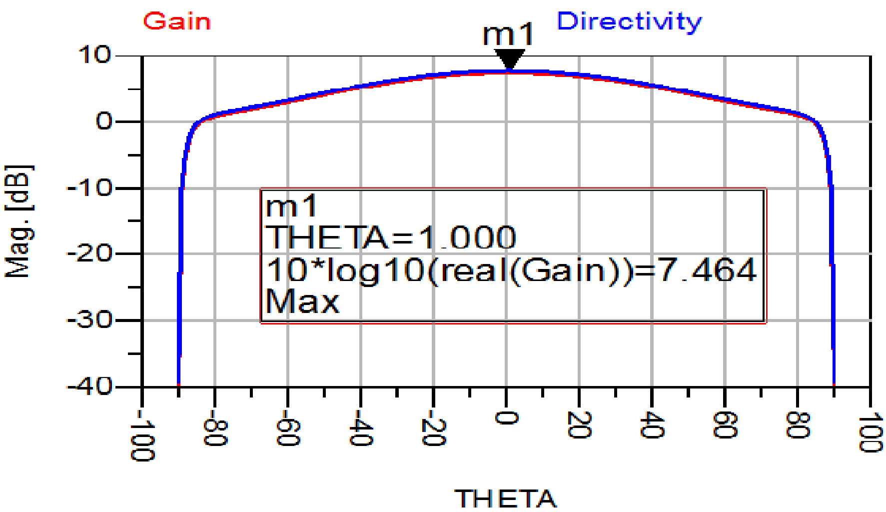


Figure (4)
Single element gain is better than 7 dBi with antenna efficiency of 93.43 % at 3.5 GHz

2.2. 1x2 Linear Array Antenna

Figure (5) shows the 1x2 linear array antenna with edge to edge separation of 10mm and separate feeding ports. Figure (6) shows the reflection coefficients S_{11} and S_{22}. Figure (7) shows that the coupling between ports 1 and 2 is better than -18.61dB at 3.5GHz and -16dB at 5GHz. Fig. 8 shows that the gain is better than 9.5dBi with antenna efficiency of 98.03% at 3.5GHz.

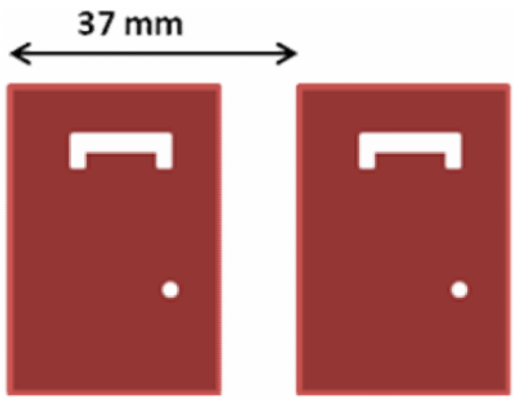
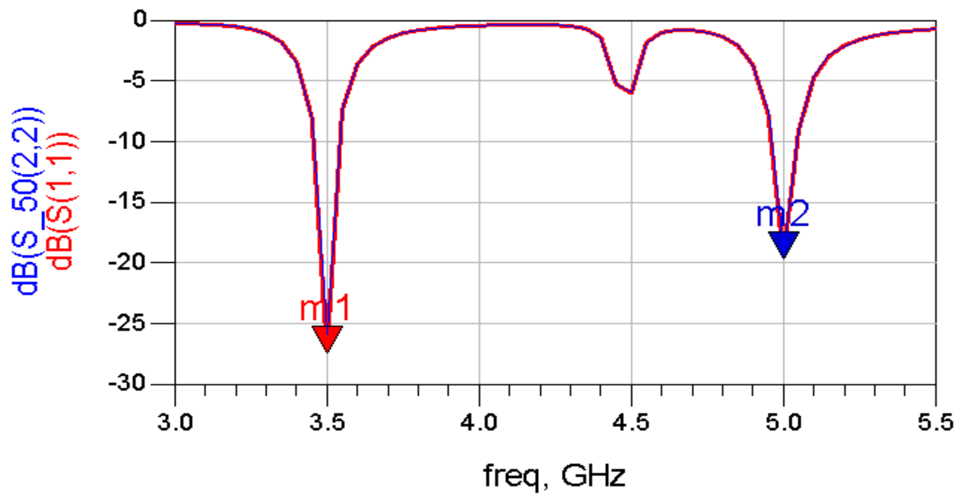


Figure (5)
The 1x2 linear array antenna



m1 Freq =3.500GHZ S(1,1)=-27.394 dB
m2 Freq =5.000GHZ S(1,1)=-19.618 dB

Figure (6)
The reflection coefficients S_{11} and S_{22}

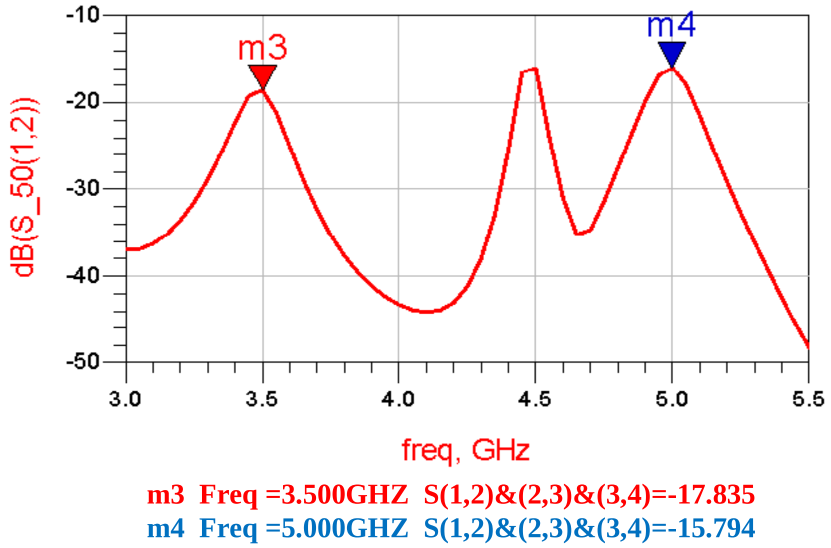


Figure (7)

The coupling coefficients S_{12}

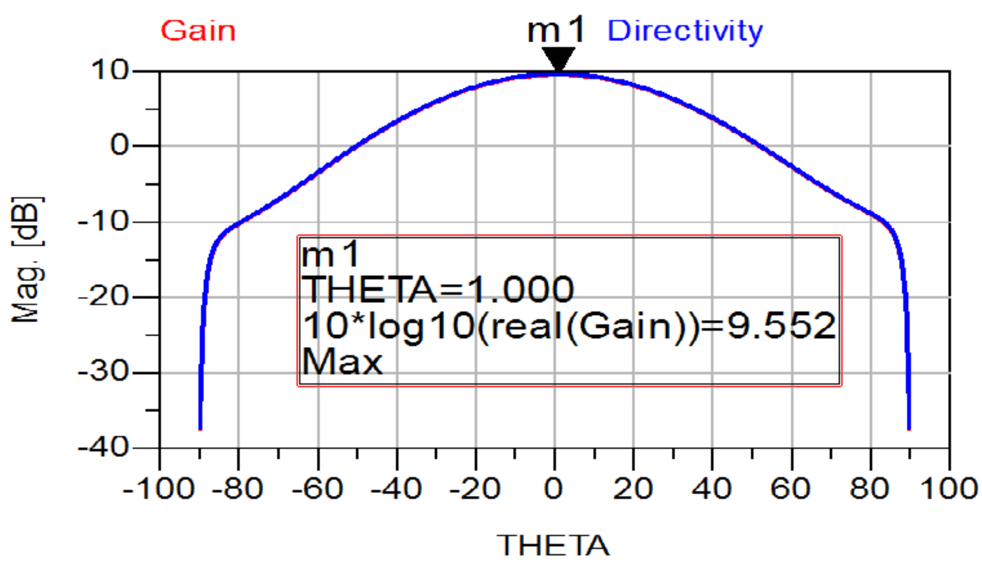


Figure (8)

The 1x2 linear array gain is better than 9.5dBi with antenna efficiency of 98.03% at 3.5GHz

2.3. 1x4 Linear Array Antenna

Figure (9) shows the 1x4 linear array antenna. Figure (10) shows the reflection coefficients S_{11}-S_{44}. Fig. 11 shows the coupling between different ports at 3.5GHz and 5GHz. Fig. 12 shows that the gain is better than 12.33dBi at 3.5GHZ. Fig 13 shows the antenna efficiency of 98.46% at 3.5GHz.

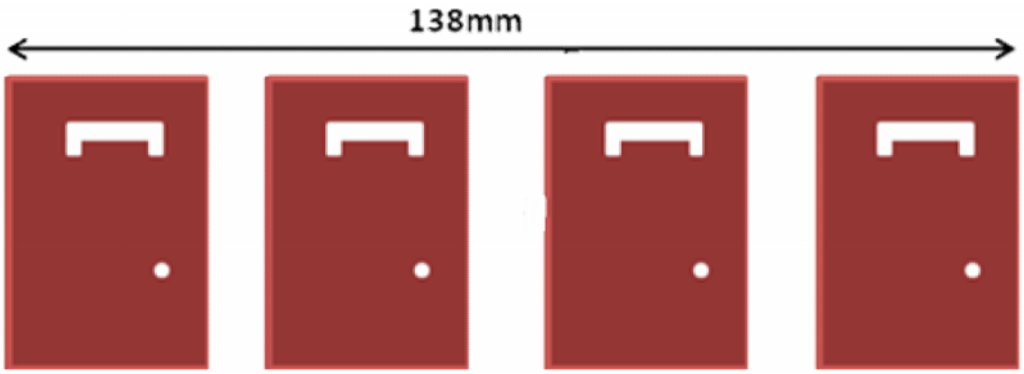


Figure (9)
The 1x4 linear array antenna

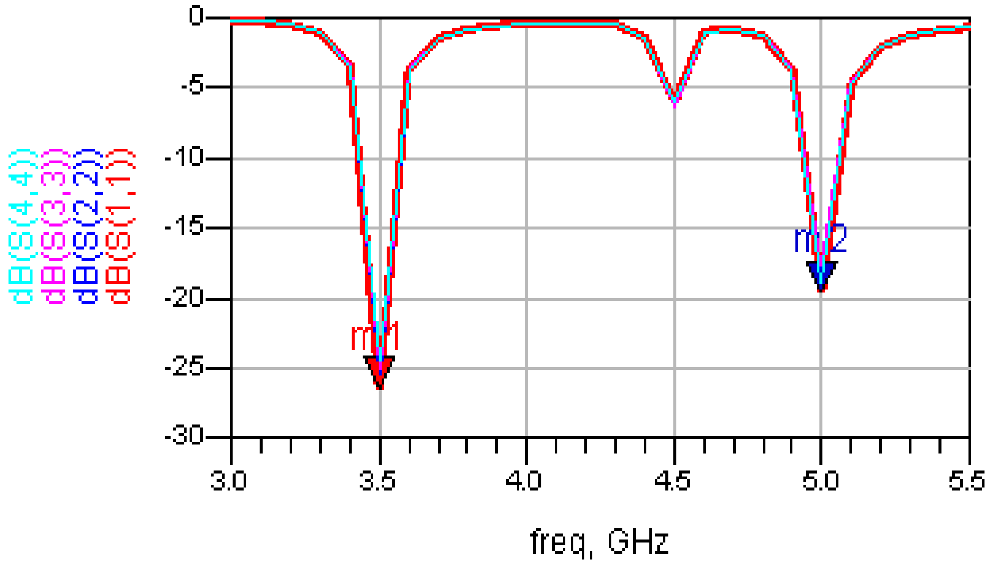


Figure (10)
The reflection coefficients S_{11}-S_{44}

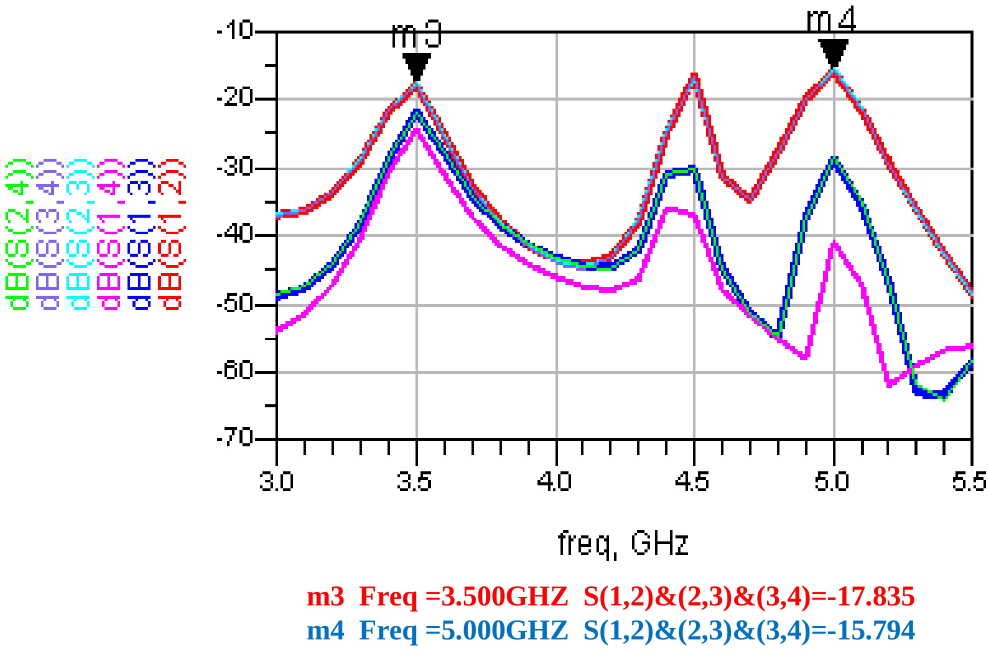


Figure (11)
The coupling between different ports at 3.5GHz and 5GHz

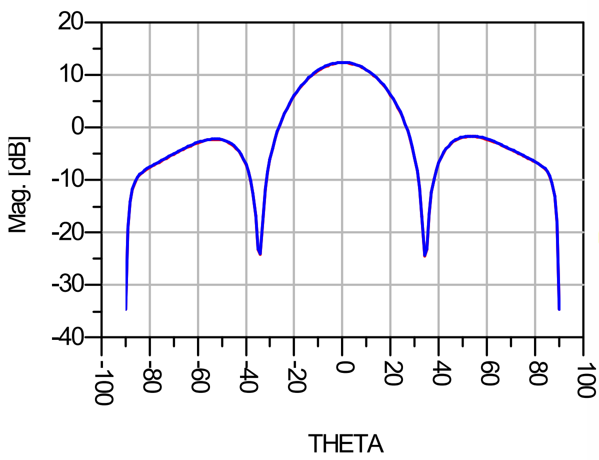


Figure (12)
The 1x4 linear array antenna gain at 3.5GHz

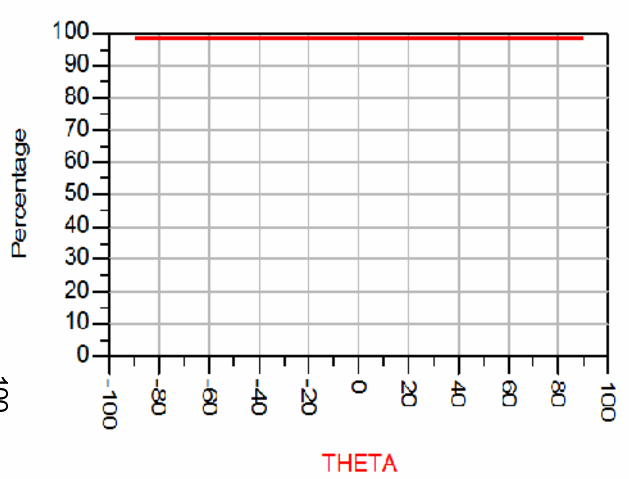


Figure (13)
The 1x4 linear array antenna efficiency of 98.46% at 3.5GHz

3- Fabrication and Measurements:

Figure (14) shows the fabricated single element. Figure (15) shows that the measured S_{11} is equal to -18.98dB at 3.5GHZ with a band width of 70MHZ and equals to -27.44dB at 5GHZ with a band width of 90MHZ. Good agreement between the measured and the simulation results is achieved for the single element. Figure (16a) shows the fabricated 1x2 linear sub-array, Figure (16b) shows the measured reflection coefficients S_{11} and S_{22}. Figure (16c) shows the measured coupling coefficient S_{12}. Figure (17a) shows the compact fabricated 1x4 linear sub-array. Figure (17b) shows the measured reflection coefficients S_{11}, S_{22}, S_{33} and S_{44}. Figure (17c) shows the measured coupling coefficients S_{12}, S_{13} and S_{14}. Figure (17d) shows the measured coupling coefficients S_{23} and S_{24}. Figure (17e) shows the measured coupling coefficients S_{34}.

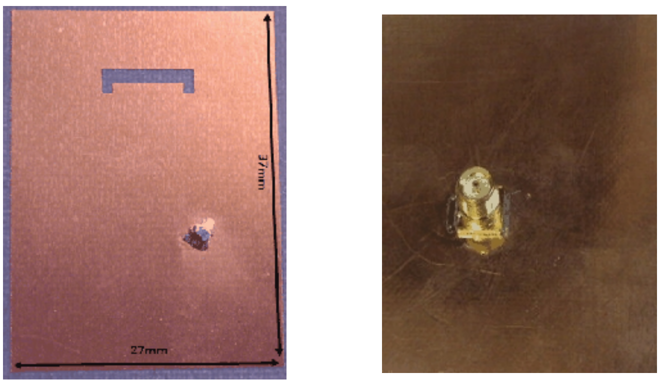


Figure (14)
The fabricated single element

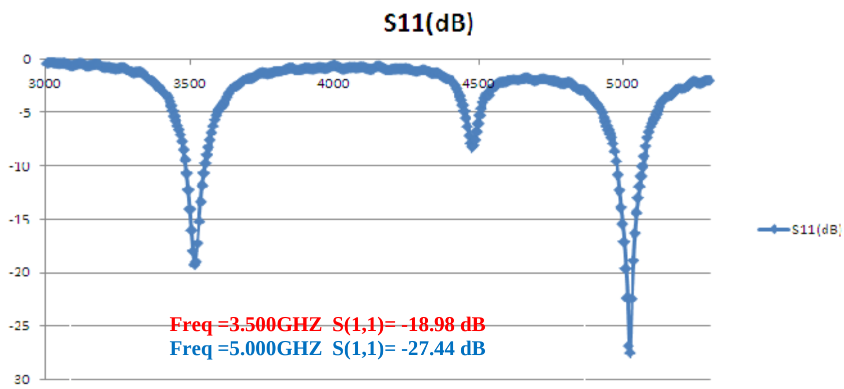
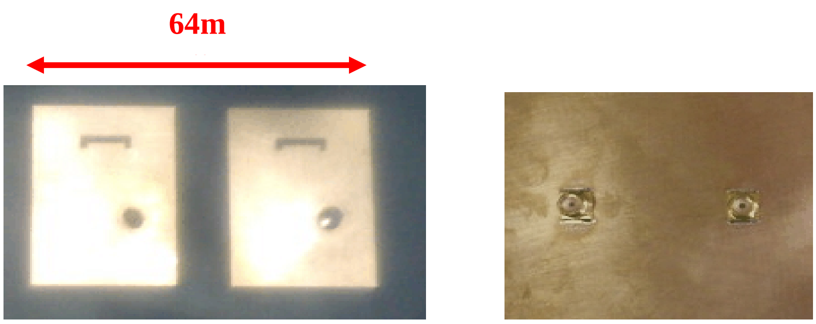
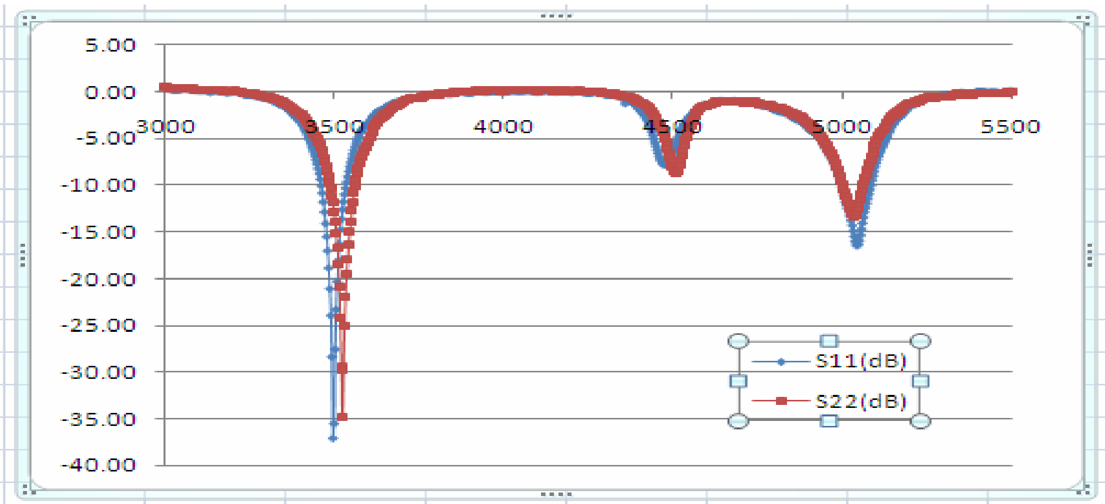


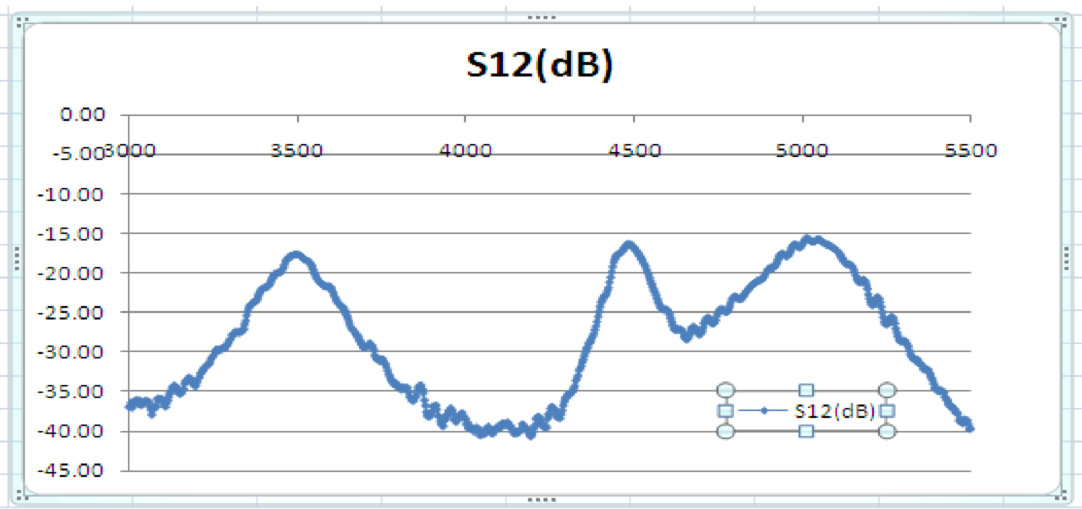
Figure (15)
The measured S_{11}



(a)



(b)

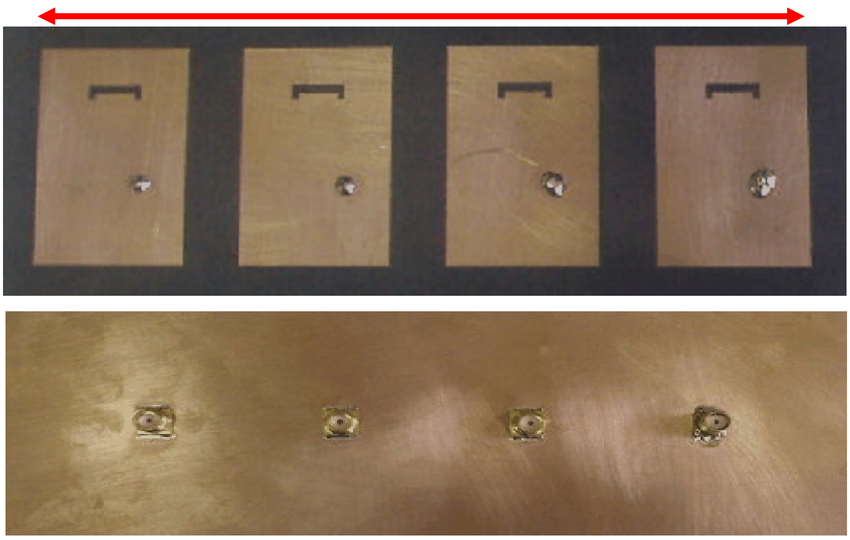


(c)

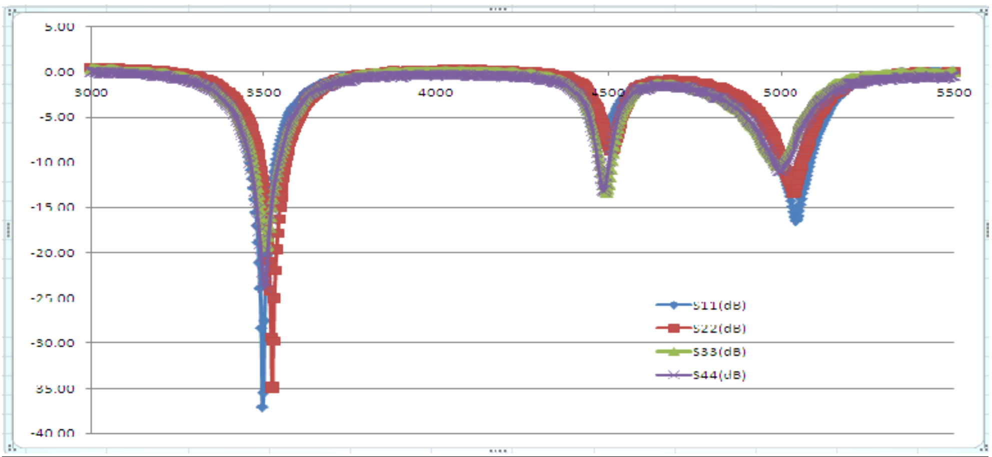
Figure (16)

(a) shows the fabricated 1x2 linear sub-array, **(b)** shows the measured reflection coefficients S_{11} and S_{22}. **(c)** shows the measured coupling coefficient S_{12}.

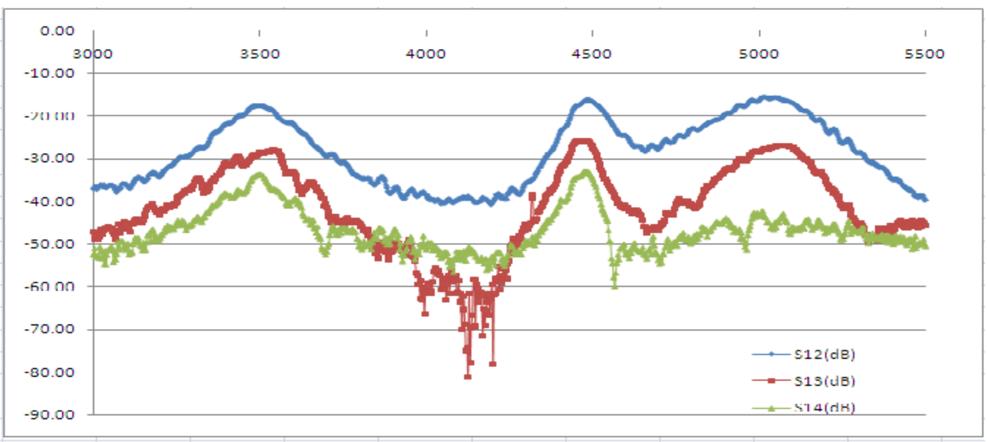
138mm



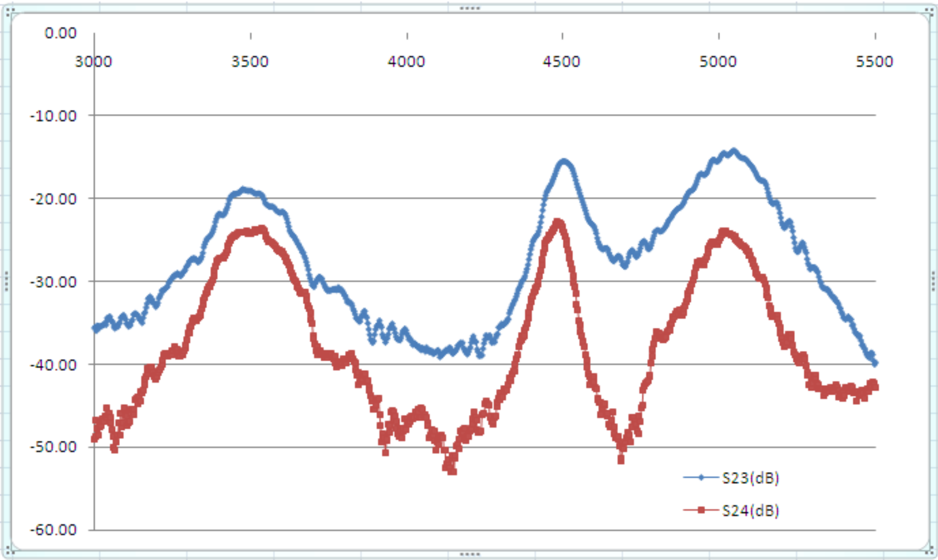
(a)



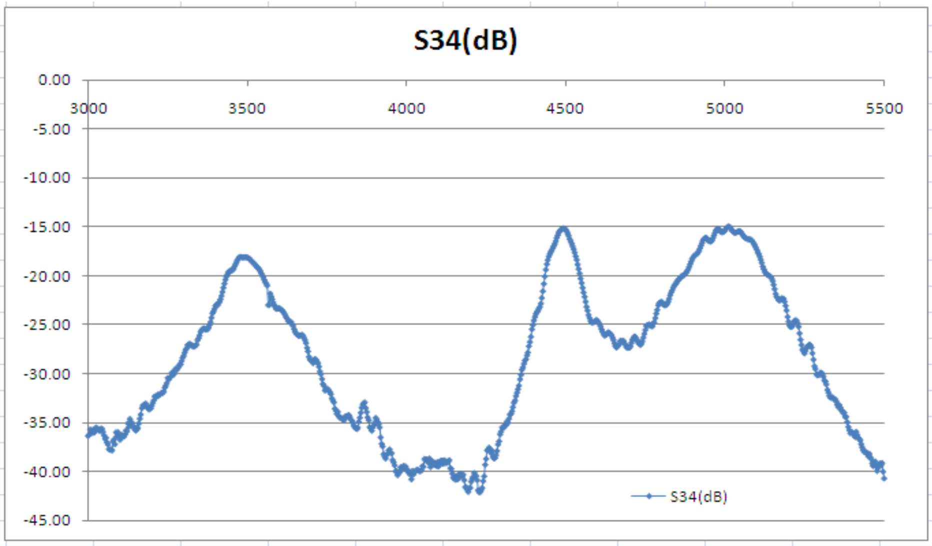
(b)



(c)



(d)



(e)

Figure (17)

(a) *shows the compact fabricated 1x4 linear sub-array.* ***(b)*** *shows the measured reflection coefficients* S_{11}, S_{22}, S_{33} *and* S_{44}. ***(c)*** *shows the measured coupling coefficients* S_{12}, S_{13} *and* S_{14}. ***(d)*** *shows the measured coupling coefficients* S_{23} *and* S_{24}. ***(e)*** *shows the measured coupling coefficients* S_{34}.

4- Conclusion:

A compact dual-band microstrip patch array antenna that is suitable for the MIMO 4G LTE and WLAN has been developed. Single element, prototype is fabricated and measured. 1x2 and 1x4 linear sub-arrays are designed, fabricated and measured. Good agreement between the measured and simulated results are achieved. The achieved results satisfy the requirements of both the MIMO 4G LTE and WLAN antenna systems.

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