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A single layer multi-resonant 1×4 series fed high gain microstrip patch array antenna for L-Band and C-Band applications

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Abstract: This paper describes a design of 1×4 series fed Microstrip Patch Antenna Array for multi-resonance applications such as GPS devices, WCDMA (1910–2190 MHz) and WLAN. This antenna array consists of patch elements using a single layer RT/Duroid 5880 substrate with transformer coupled impedance matching network, which provides high gain of 9.583dB and efficiency 96.08%. This antenna array has good performance in terms of antenna gain, directivity, return losses ,VSWR, Characteristics impedance, liner polarization, Band width and efficiency over the frequency range for L band C band applications. WLAN working at IEEE 802.11a employ 5.15-5.35 GHz for lower WLAN and 5.725-5.825GHz for higher band WLAN.

Index Terms: RMPA, High gain, Multiband antennas, Method of moment ADS-2009, Impedance matching, WLAN.

1: Introduction

Micro-strip patch antenna (MPAs) has attractive and widespread features due to its low profile, small size, light weight, low cost as well as to the fact these are very simple to design, suited to planer and non-planer surfaces. It is mechanically robust, easily integrated with circuits, and allow multi-frequency operation to be achieved [1].
However their further use in specific systems is limited of their relatively narrow bandwidth. The principle of wide bandwidth or bandwidth enhancement of MPAs may be achieved by several efficient approaches as : Increasing the substrate thickness ,Optimizing impedance matching ,Reduce substrate effective permittivity , Incorporating multiple resonance. The miniaturization of conventional MPA size [1] has been accomplished by using various form such as using high permittivity substrate, shorting ports and modifying basic patch shape. MPAs required to be extremely small and compact size that is basic need of mobile cellular handsets, card-less phones and Bluetooth devices. In this paper, a line fed rectangular patch is developed to has resonant frequency for 5.15-5.35GHz and 5.725-5.825 GHz for lower and higher band WLAN with edge fed is connected to the radiating patch. This fed is also easy to match.

2.1: IEEE802.11a

Wi-Fi system using 802.11a specification operates in Unlicensed National Information Infrastructure (UNII) band, which enables system using this exacting network to operate not only at higher speeds but also at higher power .The 802.11aoperate the UNII band at 5Ghz.It is designed to provide data rate of up to 54 Mbps [13].
Design for an antenna (usually, linearly polarized) operating at DCS-1800 (1710–1880 MHz), IMT-2000 at (1885–2200MHz) , global positioning system (GPS) at (1570–1580 MHz) receiver WLAN-IEEE 802.11b (2400–2483 MHz) bands.

2.3: Microstrip Lines

A microstrip line consists of a single ground plane and a thin strip conductor on a low loss dielectric substrate [1] above the ground plate. Due to the absence of the top ground plate and the dielectric substrate above the strip, the electric field lines remain partially in the air and partially in the lower dielectric substrate. This makes the mode of propagation not pure TEM but that is quasi-TEM. Due to the open structure and any presence in discontinuity, the microstrip line radiates electromagnetic energy. The use of thin and high dielectric materials reduces the radiation loss of the open structure where the fields are mostly confined inside the dielectric.

Any transmission line system which is filled with a uniform dielectric can support a single well defined mode of propagation at least over a specific range of frequencies (TEM for coaxial lines TE or TM for wave guides.) Transmission lines which do not have such a uniform dielectric filling cannot support a single mode of propagation. Microstrip falls [7,8] in this category. Here the bulk of energy is transmitted along the microstrip with a field distribution which quite closely resembles TEM and is usually referred to as Quasi – TEM.

3.0: Design Methodology

The basic microstrip transmission line methodology (formulas) and line calculation analyze from ADS, used for the designing of MPAA . The microstrip design consists of finding the values of width (w) and length (l) corresponding to the characteristic impendence (Z_o) defined at the design stage of the network. A substrate of permittivity (ϵr) and thickness (h) is chosen [1,10,12]. The effective microstrip permittivity (ϵ_{eff}) is unique to a fixed dielectric transmission line system and provides a useful link between various wave lengths impedances and velocities. The microstrip in general, will have a finite strip thickness't which influences the field distribution for moderate power applications. The thickness of the conducting strip is quite significant when considering conductor losses [8]. But at smaller values of w /h or greater values of t / h the significance increases.

Line Calculation

Line calculation for Patch in terms of length L, Width W, Height H, and characteristics impedance Z_0 at centre frequency 5.4GHz can be calculated by following calculation.
The initial design was done by hand to create a rough model in which to begin simulations. The equations are as listed below and sourced by:

$$\varepsilon_{eff} = (\varepsilon r+1)/2 + (\varepsilon r-1)/2[1+12(h/W))^{-1/2} \quad (1)$$

$$L=0.814\, h\, (\varepsilon_{eff} + 0.3)(W/h + 0.264) /\{ (\varepsilon_{eff} - 0.258)(W/h + 0.8)\} \quad (2)$$

$$W= 0.5\lambda 0/ \sqrt{(\varepsilon_{reff}+1)/2} \quad (3)$$

Characteristics impedance Z_0 are as:

When $W/H \geq 1$

$$Z_0= 120\pi/\sqrt{(\varepsilon_{reff}}[(W/H)+1.393+2/3\ln\{(W/H)+1.444\}]$$

Due to fringing fields, the change in dimensions of length is given by:

$$\Delta L = \frac{0.412h\, [(\varepsilon_{reff}+0.3)*\{(W/H)+ 0.264\}]}{[(\varepsilon_{reff}-0.258)*\{(W/H)+ 0.8\}]} \quad (4)$$

Effective length $L_{eff} = L+ 2\Delta L$

3.1: Radiation Mechanism

The radiation pattern and the input impedance are determined by solving Maxwell's equations for a given antenna structure .Depending upon the solution technique taken, either an integral or differential form of Maxwell's equations in frequencies domain, or time domain is selected to prescribe the problem. Sometimes, a combination of equations forms or domain is used to describe complex antenna problems. These equations are solved using various numerical methods available. Such as , the integral form of Maxwell's which are solved using the Method of moments (Mom)[7] and other popular techniques include the finite element method and finite –difference time-domain method (FDTD) [8,9].

3.2: Antenna array structure:

The layout of optimized array has been designed by using thick of 1.6524 mm RT/Duroid substrate. The geometry of proposed antenna 1×4 array shown in figure ….. Its characteristic parameters length L, width W, and thickness h to meet the design requirements of antenna array, various analytical approaches may be used . The calculation are used based on transmission line model [3,6,11].

Resonating frequency $(f_r)_{010}$,Dominant mode, L>W when No fringing field.

$$(f_r)_{101} = 1/\ 2L(\mu_0 \varepsilon_0 \varepsilon_r)^{1/2}$$

Resonating frequency $(f_r)_{010}$,Dominant mode, L>W with fringing field.

$$(f_r)_{101} = 1/\ 2L_{eff}(\mu_0 \varepsilon_0 \varepsilon_{r\ eff})^{1/2}$$

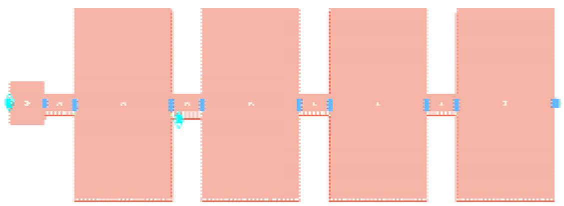


Figure:1 layout of array

3.3: Array Realized Gain

The realized gain of an antenna array includes the losses associated with the impedance mismatches between array antenna element and the source. The realized gain is defined as: [6]

$$G_R(\Theta, \phi) = 4\pi(\Theta, \phi)/Pav \qquad 5$$

Where P_{av} is the maximum available power from the source network. The maximum available power from the source are determined from the power incident on a network that is conjugate matched to the source network.

4.0: Simulation and Results Analysis

Principle of operation of ADS momentum based on Mom Method of moment .Simulation of s –parameter and by clicking radiation pattern in 2-D &3-D radiation patterns has been obtained .This gives all antenna parameter such as Radiation pattern, Gain, Directivity, Radiate power, Effective angle , maximum intensity etc.

4.1: Fundamental Specification of Patch Antenna

S11 Parameters

As we have used only one probe feed in this design, so find only input reflection coefficients or the S11 parameter for the patch.

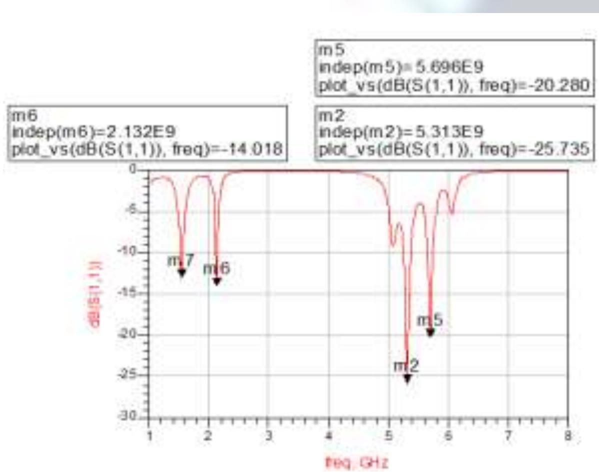


Figure 2: S-parameter

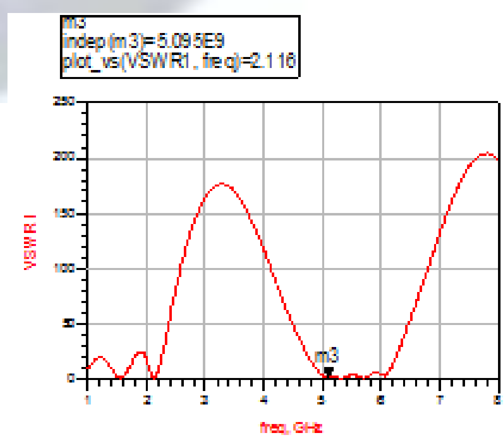


Figure 3: VSWR

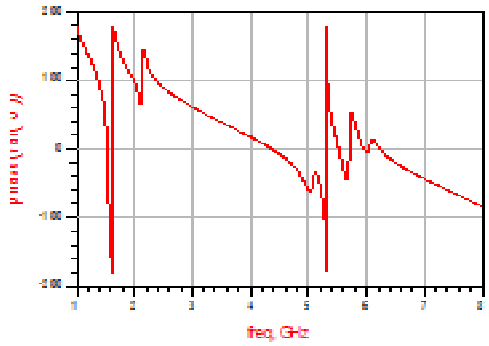


Figure 4: phase plot

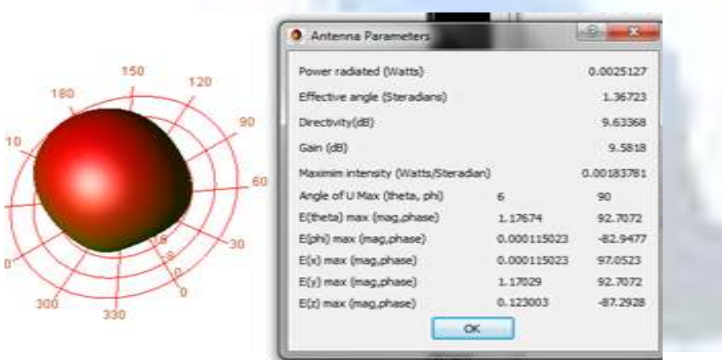
The simulation results of the ADS Momentum are shown in Fig , the designed antenna array giving resonates at the desired frequency which is 5.313 GHz and offering multi-resonant peak at frequency at 1.65GHz,2.132GHz, 5.313GHz and 5.696GHz . At the resonant frequency the input reflection coefficient has the minimum magnitude which is about -25.735 dB. The input reflection coefficient is shown in figure on the Smith chart where the marker clearly indicates that the microstrip array antenna resonates at 5.4 GHz having the minimum impedance over the straight resistance line at the resonating frequency. The graphs in these three figures verify the performance of the designed antenna to a great extent.

4.2: Gain, Directivity and Bandwidth

The rectangular patch excited in its fundamental mode has a maximum directivity in the direction perpendicular to the patch (broadside). The peak Gain **9.581 dB** and Directivity **9.6336dB** are obtained by electric field radiation pattern of array in 3-D analysis of ADS software. And the maximum -10dB bandwidth of **671MHz** has been achieved in simulation of S_{11} parameter for frequency band 4.918-5.589 GHz shown in figure 9.

$BW = \{(FH - FL) \times 100\}/F0$ is **12.4259%**

$BW = (VSWR - 1)/ Q . (VSWR) - 1/2$ Q is quality factor of patch.



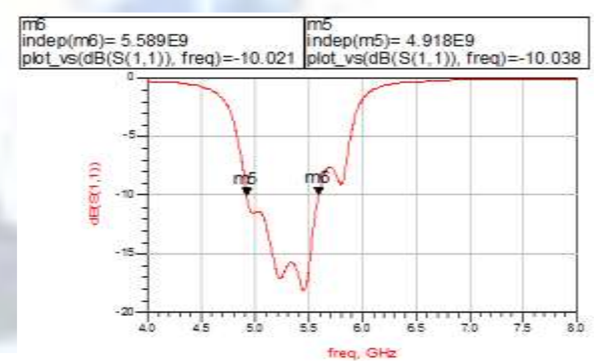


Figure : 5 Antenna parameter and radiation pattern in 3-D

Figure:6 Impedance Band Width

Efficiency

The efficiency of the antenna array is shown by 2-D analysis of ADS in the figure 10. The efficiency of antenna array is far better than the efficiency of single patch antenna. The efficiency of the1×4 array antenna is 96.03 % while the efficiency of two array patch antenna was 77.63% shows an accurate three dimensional graph of the radiation pattern of the microstrip patch array antenna. The antenna is radiating broadside i.e. Perpendicular to the axis of the patch. The main beam is sharp in between 90º and 270º. This graph shows that the design is working well and that it has achieved the desired results. A more advanced 3D curve is obtained from the ADS Momentum using a feature called the Electro Magnetic Design Solver showing a different presentation method of the 3D curves. The Graph obtained by EMDS is shown in figure for two array.

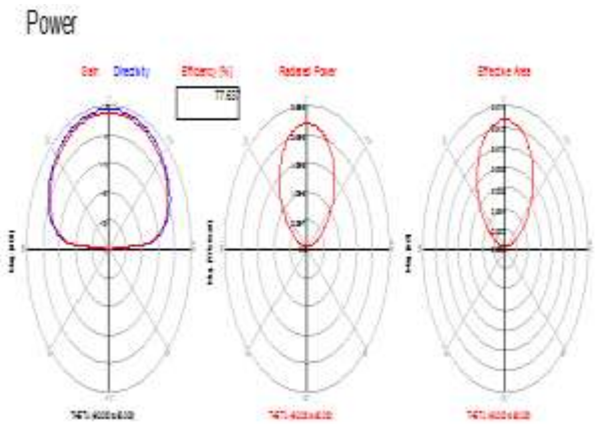


Figure 7: Power analysis for two array

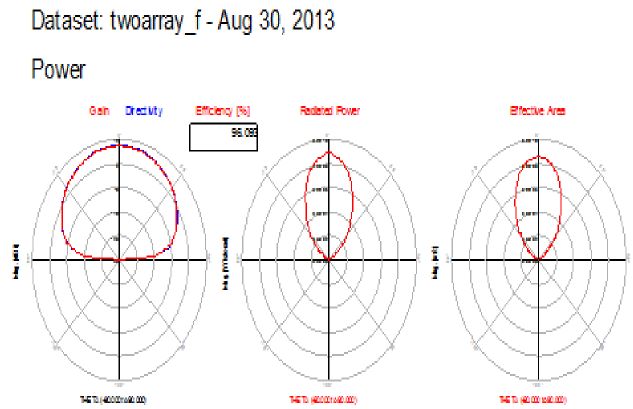


Figure 8: Power analysis for four array

5.0 Conclusion

All the simulation results shows that the RMPA array performs better than the single patch antenna. This four array design offering multi resonant, high efficiency, approximate three time improved gain and Bandwidth as compare to previous antenna [1]. The radiation pattern of the micro-strip array antenna is far better than the single rectangular patch. The main beam is in the broadside direction between 90º and 270º with nulls at 0º and 180º. All these simulations lead to the conclusion that the number of patches in an array is directly proportional to the efficiency, directivity and gain of the antenna.

References

[1]. Brajlata Chauhan, Sandeep Vijay and S.C. Gupta "Comparative analysis of Microstrip Patch Antenna using different substrates and observe effect of changing parameter at 5.4 GHz" Word conference CACCS-13, ISBN-978-90-78677-66-6, ISSN-1951-6851 in Atlantis press collaborated with Springer.

[2]. A.B. Mutiara, R.Refianti, Rachmansyah **"**Design of micro strip antenna for wireless Communication at 2.4 GHz" * Journal of Theoretical and Applied Information Technology Vol. 33 Gunadarma university, November 2011.

[3]. D. Nashaat, H. A. Elsadek, E. Abdallah, H. Elhenawy and M. F. Iskander, "Ultra-Wide Bandwidth 2 × 2 Microstrip Patch Array Antenna by Using Electromagnetic Band- Gap Structure (EBG)," IEEE Transactions on Antennas Propagate, Vol. 59, No. 5, , pp. 1528-1538, 2011.

[4]. N. J. Kolias, R. C. Compton, J. P. Fitch and D. M. Pozar, Antenna, CRC Press, 2000.

[5]. P. Yang, F. Yang, Z. P. Nie , H. J. Zhou, B. Li, and X. F. Tang "Robust Beam-former Using Manifold Separation Technique for Semispherical Conformal Array" IEEE Antennas And Wireless Propagation Letters, Vol. 10, 2011 1035

[6]. R. Iwata and S. Chen**,** "Mutual Coupling Effects in Microstrip Patch Phased Array Antenna," IEEE Antennas and Propagation Society International Symposium, pp. 1028- 1031, New York, August 2002.

[7]. R. F. Harrington, Field Computation by Moment Methods. Piscataway, NJ: IEEE Press, 1993.

[8]. A. Chatterjee, L. C. Kempel, and J. L. Volakis, Finite Element Method for Electromagnetic: Antennas, Microwave Circuits, and Scattering Applications. Piscataway, NJ: IEEE Press, 1998.

[9]. A. Taove, Computational Electrodynamics: The Finite-Difference Time-Domain Method, 2nd ed. Boston, MA: Artech House, 2000.

[10]. G.P. Gauthier, A. Courtay and G.M. Rebeiz, "Microstrip Antennas on Synthesized Low Dielectric-constant Substrates," IEEE AP- 45, p. 1310, August 1997.

[11]. R. F. Harrington, Field computation by Moment Methods, Maxillan, New York, 1968. [15] T. F. Lai, W. N. Mahadi and N. Soin, "Circular Patch Microstrip Array Antenna for KU band," World Academy of Science, Engineering and Technology. Vol. 48, pp. 298-302, 2008.

[12]. Clint, S. P. E. and Myer, J. (2004): 3G Wireless with Wi-MAX and Wi-Fi: 802.16 and 802.11. United States of America: Mc Grow Hill Companies.

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