JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Design and Simulation of a Dual-Band Antenna Array for Ultra-Wideband (UWB) Wireless Communication

Priyanka Raghuvanshi

Dept. of Electronics and Communication, UIT-RGPV, Bhopal, India

Anubhuti Khare

Dept. of Electronics and Communication Engineering, UIT-RGPV, Bhopal, India

Abstract : A coplanar waveguide (CPW)-fed microstrip dual-band antenna array exists as the primary focus of this paper due to its optimization for UWB wireless communication. The designed antenna functions at 4.6 GHz while providing a bandwidth range of 0.6 GHz and operates at 10.2 GHz supporting a bandwidth of 0.4 GHz. The antenna uses a microstrip transmission line for feeding purposes because it enables optimal VSWR performance while supporting efficient wireless communication operations. The designed antenna reaches 6 dB gain through 86% efficiency and 95% radiation efficiency. Analyses of the radiation pattern together with input impedance and current distribution and gain were conducted through IE3Dv14.65 Zeland Software. Keywords: CPW, ultra-wideband, VSWR, radiation pattern, input impedance, current distribution.

Introduction: UWB technology allows secure high-bandwidth and low-power wireless transmissions through short distances. UWB technology emerged from its radar imaging origins to find new applications in precision tracking and wireless communication as well as sensing systems. UWB technology received approval from the Federal Communications Commission (FCC) during 2002 which then led to extensive research about commercial applications. UWB system antennas require specific design features including a wide bandwidth and compact dimensions coupled with ability to radiate omnidirectionally or directionally and deliver high efficiency. The allocated spectrum for UWB communication spans from 3.1–10.6 GHz which overlaps with wireless technologies like WLAN, WiMAX along with satellite communications. UWB antennas transmit electromagnetic pulses rather than carrier frequencies because of which they simplify transmitter and receiver system hardware. The growing need for peer-to-peer IoT device communication makes UWB technology an appropriate solution for applications that need fast data transport. An antenna design is presented to support wireless and satellite communication bands which include GSM AWS WCDMA UMTS ISM Wi-Fi and onboard aircraft internet-based AMSS application.

II. Antenna Design Considerations

Table 1: Antenna Parameters

Parameter	Value
Substrate Thickness	40 mils
Dielectric Constant	4.4
Patch Length (L)	700 mils
Patch Width (W)	400 mils
Inset Width (S)	50 mils
Inset Depth (D)	400 mils
Strip Width (T)	40 mils
Feed Line Length (F)	385 mils

A. VSWR Calculation

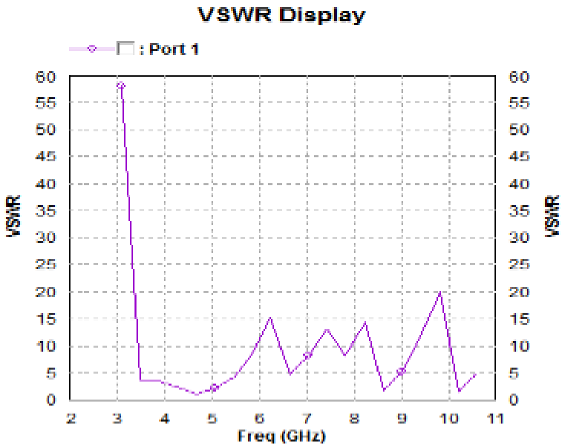
Voltage standing wave ratio (VSWR) is determined by the reflection coefficient (Γ), representing impedance mismatches in transmission lines. The relationship between maximum and minimum voltages along the line defines VSWR as:

$$\Gamma = \frac{V_r}{V_f}.$$

$$V_{\max} = V_f + V_r = V_f + \rho V_f = V_f(1+\rho).$$

$$VSWR = \frac{V_{\max}}{V_{\min}} = \frac{1+\rho}{1-\rho}.$$

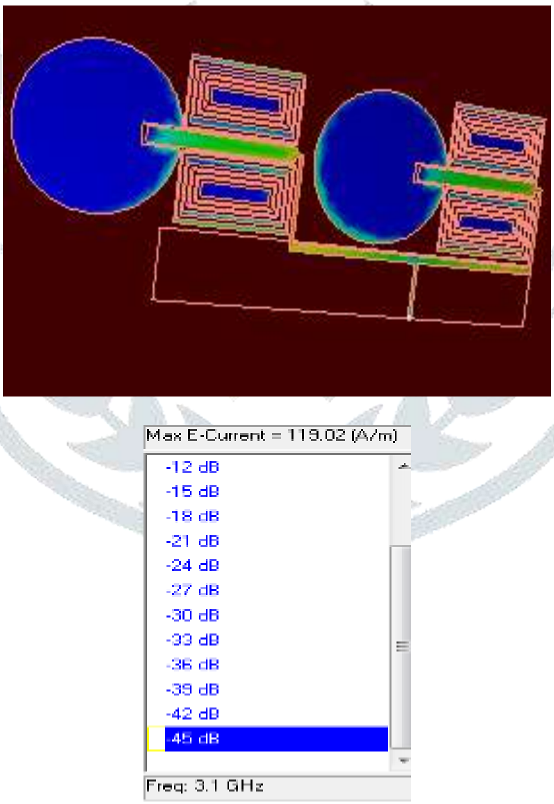
$$V_{\min} = V_f - V_r = V_f - \rho V_f = V_f(1-\rho).$$



Since |Γ| lies within the range [0,1], the VSWR value remains ≥1, ensuring efficient power transfer.

B. Current Distribution

Current distribution is analyzed by segmenting the antenna conductors and determining the moment contribution of each segment. The moment is calculated based on current magnitude and segment vector orientation. Matching conditions at segment boundaries ensure accurate current distribution estimation.



C. Radiation Pattern

Radiation patterns describe the directional distribution of radiated power. The transmitted power density is given by:

$$W(\theta, \Phi) = \frac{G(\theta, \Phi)}{4\pi r^2} P_t$$

$$P_r = A(\theta, \Phi) W$$

where is the transmitted power. The received power, influenced by the antenna's effective aperture , is given by:

$$P_r = A\frac{G}{4\pi r^2}P_t$$

$$P_{1r} = A_1(\theta,\Phi)\frac{G_2}{4\pi r^2}P_{2t}$$

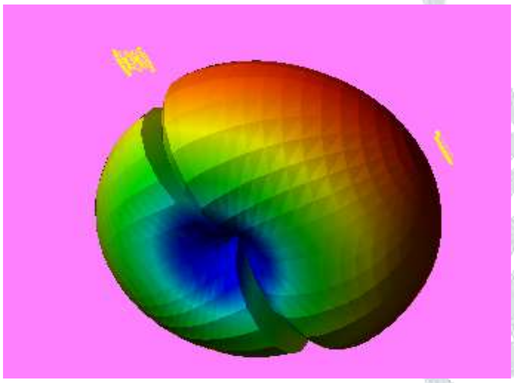
$$P_{2r} = A_2\frac{G_1(\theta,\Phi)}{4\pi r^2}P_{1t}$$

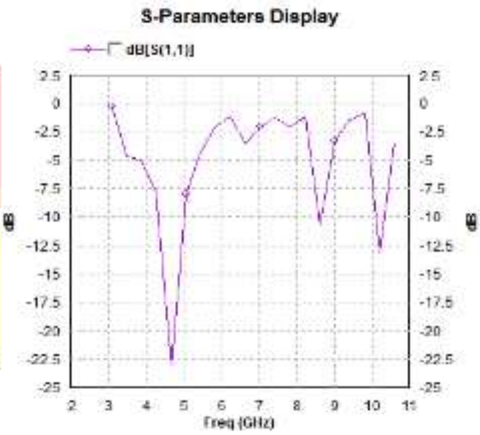
$$P_r = \frac{\lambda^2 G_r G_t}{(4\pi r)^2}P_t$$

These parameters determine the overall performance of the antenna in various communication scenarios.

III. Simulated Results

Antenna array pattern S-parameter display



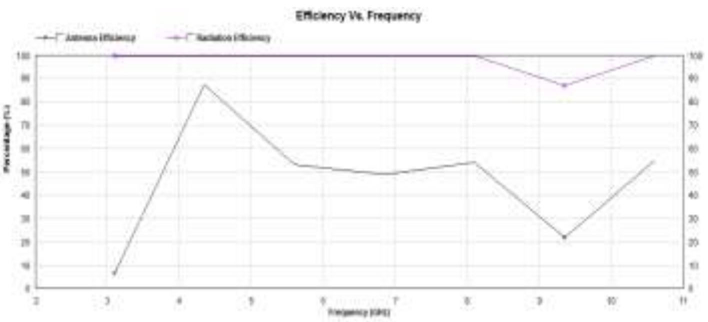


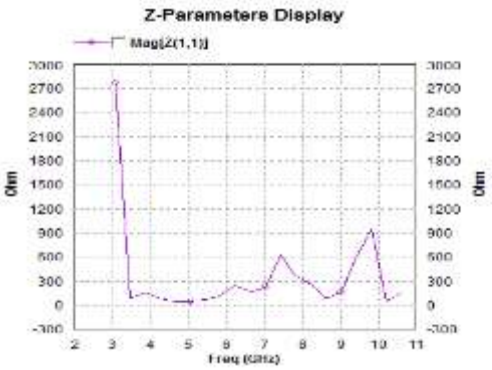
Efficiency Vs

Frequency Z – Parameter

Efficiency Vs Frequency Z – Parameter

Efficiency Vs Frequency





Simulations were performed using Zeland IE3Dv14.65 software to evaluate radiation patterns, S-parameters, efficiency, and Z-parameters.

The antenna exhibits a gain of 6 dB with high efficiency (86%) at the target frequency range. VSWR remains within acceptable limits (>1), ensuring minimal signal loss. Simulated return loss (S11) closely correlates with measured values, validated using an HP8510C vector network analyzer. The correlation coefficient between simulated and measured results is 0.98, with a mean square error of 0.022.

IV. Conclusion

The proposed antenna demonstrates strong suitability for downlink applications within the 4.3 GHz – 4.9 GHz frequency range, achieving the desired gain and efficiency A compact wideband microstrip antenna was successfully designed and simulated. Simulation results confirm that the antenna meets performance expectations, making it an ideal candidate for wireless communication applications.

5. REFERENCES

[1] HUNG, K.-J., LIN, Y.-CH. Open-slot loaded monopole antennas for WLAN and UWB applications. In IEEE Antennas and Propagation Society International Symposium. Albuquerque (USA), 2006, p. 4653 - 4656.
[2] ABBOSH, A. Planar ultra wideband antennas with rejected sub bands. In IEEE Proceedings of Asia-Pacific Microwave Conference. Bangkok (Thailand), 2007.
[3] YIN, K., XU, J. Compact ultra-wideband monopole antenna with band-stop characteristic. In International Conference on Microwave and Millimetre Wave Technology, vol. 3. Nanjing (China), 2008, p. 1174 - 1176.
[4]. Yoon, J. K., D. H. Kim, and C. D. Park, \Implementation of UWB antenna with band pass filter using Microstrip-to-CPW transition matching," Asia Pacific Microwave Conference 2009, 2553-2556.
[5]. Schantz, H. G., G. Wolence, and E. M. Myszka, \Frequency notched UWB antennas," IEEE Conf. on Ultra Wideband Systems and Technologies, P. 214-218, 2003.
[6]. C. Deng and Y. J. Xie. Dual band-notched design of rectangular Monopole antenna for uwb applications. Progress In Electromagnetic Research C, Vol. 14, 213-225, 2010.
[7]. Myung Ki Kim, Kwonil Kim, Young Hoon Suh, and Ikmo Park, "A T-Shaped Microstrip-Line-Fed Wide Slot Antenna." IEEE conference on ultra wideband systems and technologies, 7803-6369 2000.
[8]. Adel M. Abdin, "Radiation characteristics of a wideband triangular antenna for wireless communications", PIERS Proceedings, Beijing, China, March 23-27, 2009.
[9]. H.S. Tsai and R.A. York, "Applications of Planar Multiple-Slot Antennas for Impedance Control, and Analysis using FDTD with Beranger's PML method.