# Design and Implementation of Quasi Landstorfer Antenna for Wireless Communication

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**Abstract** - *In this project printed Quasi Landstorfer antenna is designed, simulated and fabricated. Printed antennas are drawing a lot of attention due to their small size, ease of fabrication and light weight. The proposed antenna utilizes parasitic radiators to realize a higher gain. The Quasi-Landstorfer antenna presented in this project is smaller in size when compared to the previous Landstorfer antenna and provides higher gain than that of the other antennas. Also it has truncated ground plane as reflector when it is compared to Yagi-Uda antenna which is the reason for high gain. Finite Element Method based software i.e. High Frequency Structure Simulator (HFSS) has been used to simulate the antenna and the simulated results are shown that the directivity of Quasi Landstorfer antenna is greater than Yagi-Uda and Quasi Yagi-Uda antenna. From the simulation results of the antenna, The Quasi Landstorfer antenna is measured at a resonant frequency of 2.45GHz with a return loss of -20dB and the directivity of the antenna is measured to be 6.6dBi. Also the voltage standing wave ratio (VSWR) shows that impedance of antenna and transmission line is well matched due to this mismatch loss will be reduced and hence the maximum power transfer from input side to output side of the antenna. The antenna is fabricated on FR-4 epoxy substrate material of dielectric constant 4.4 with thickness 1.57mm and testing of fabricated antenna is conducted using antenna test bench setup.*

*Key Words: HFSS, FEM, Yagi-uda antenna, Quasi - Landstorfer antenna.*

## 1. Introduction

Wireless communications have been developed widely and rapidly in the modern world especially during the last two decades. The future development of the personal communication devices will aim to provide image, speech and data communications at any time, and anywhere around the world. This indicates that the future communication terminal antennas must meet the requirements of these printed antennas which employed in the Ultra-High Frequency (UHF) band and above, which leads to small antenna size[1]-[4]. Modern wireless systems have been deployed in many areas including personal communications, sensor systems, entertainment, security and the automobile industry. These applications require printed antennas that are small in size, light weight and cost-effective [5]. Recently, researchers have shown that various forms of the printed Yagi-Uda antenna can be used successfully in wireless systems[15]. The planar Quasi-Yagi antenna that uses the ground plane as a reflector was a significant development from these efforts. The use of the ground plane eliminates the need of a dipole as a reflector and thus reduces the overall size. However, the size reduction of the overall structure comes at the cost of gain. Another type of modified Yagi-Uda antenna is the Landstorfer antenna that has a higher gain than the traditional Yagi-Uda antenna. In the Landstorfer antenna configuration, the antenna consists of dipole elements that are electrically large[12]. These elements are designed in a sweeping manner to reduce the overall size and because of the electrical length of the each dipole this antenna has a sizable gain. This design has been shown to have a high gain and is very useful for many wireless applications.

Fig. 1.1 shows the current distribution on a dipole for different lengths. The directivity of an antenna with a length, L is maximum for $L=\lambda_0/2$, where $\lambda_0$ is the free-space wavelength at the resonant frequency. The reason is that the phases of the currents add to each other for $L=\lambda_0/2$. However, in Figs. 1.1b-1.1d, the phases of the currents are not the same and therefore, the directivity is not a maximum. The phase differences can be compensated for by different path lengths using the appropriate shape of the linear antenna[6].

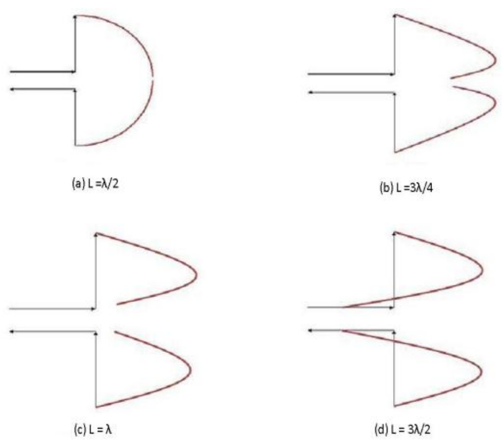



Fig. 1.1 Current distribution on various center-fed dipoles

In Fig. 1.2a, the current distribution on a $3\lambda_0/2$ dipole is shown. The center $\lambda_0/2$ portion of the $3\lambda_0/2$ dipole is then segmented into a $\lambda_0/4$ stub as shown in Fig. 1.2b.

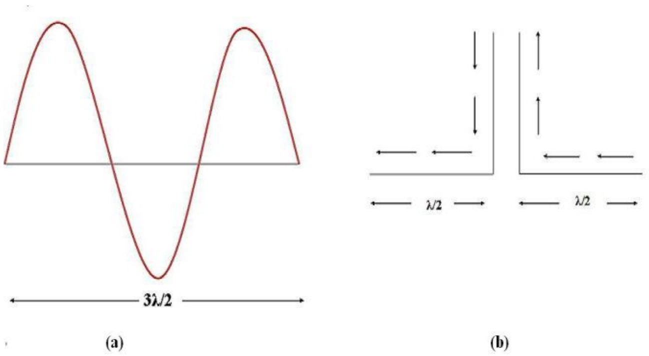



**Fig.1.2 (a) Current distribution on $3\lambda_0/2$ dipole (b) Current distribution on $3\lambda_0/2$ dipole with center $\lambda_0/2$** portion folded.

By doing this, the phases of the currents cancel each other on the stub whereas the phases of the current add to each other in the linear portion. Therefore, the antenna behaves as an $1\lambda_0$ in phase dipole antenna.

In the Quasi-Yagi antenna, the driver element was used to generate the $TE_0$ mode surface wave power on the metal layer to obtain the end fire radiation pattern. On the bottom layer, the $TE_0$ mode was at cut-off and therefore, the ground plane was used as the reflector for the generated $TE_0$ mode on the top layer. The $TE_0$ mode on the top layer was also used to couple the driver and the director elements. However, the $TE_0$ mode surface wave power was generated using a thick substrate with a high dielectric constant. In the proposed Quasi-Landstorfer antenna, no surface wave power was generated to contribute to the radiation pattern. The proposed Quasi-Landstorfer antenna is designed to operate at 2.45 GHz therefore, the Quasi-Landstorfer antenna can realize better radiation efficiency. In the proposed Quasi-Landstorfer antenna in the driver element of the antenna is fed by a microstrip-to-coplanar strip line transmission line. The balun for this antenna serves as a transition for a microstrip line and a Co-Planar Strip-line (CPS).The microstrip lines at the input port as well as the two split arms to the CPS are all assumed to be 50Ω. The balun employs a quarter-wavelength long, 34.5Ω impedance transformer, followed by a symmetric T junction for signal dividing or combining[3].

In this communication, a compact printed Quasi-Landstorfer antenna is presented. The Quasi Landstorfer antenna consists of a driver, a director, a reflector, and a microstrip balun. The balun acts as an unbalanced to balanced transformer from the feed co-axial line to the driven element[2]. The length of the driver element is $\lambda_0/2$, where $\lambda_0$ is the free-space wavelength at the resonant frequency. The layout of this new design is shown in Fig. 2.1 The reflector element was removed from the planar Landstorfer antenna design and the ground plane was redesigned to perform the role of the reflector and allow for a much simpler feed-network[13].

## 2. Layout and design of the antenna

The overall design in Fig. 2.1 comprises of a printed transmission line that feeds the antenna, a driven element, a director element and a ground plane. The top layer consists of the transmission line and the radiating elements while the bottom layer consists of the ground plane. The two arms of the microstrip line form a balun to transition power from the microstrip line to the coplanar stripline (CPS) at the edge of the ground plane. The radiating elements consist of two sweeping printed conductors, of which the larger element is the driven element fed by the CPS and the shorter element is the director.

It has been shown that by choosing the length of the driver to be $L=3\lambda_0/2$, where $\lambda_0$ is the free-space wavelength at resonance and modifying the shape to a more swept form, the overall gain of the driver element can be increased[14].

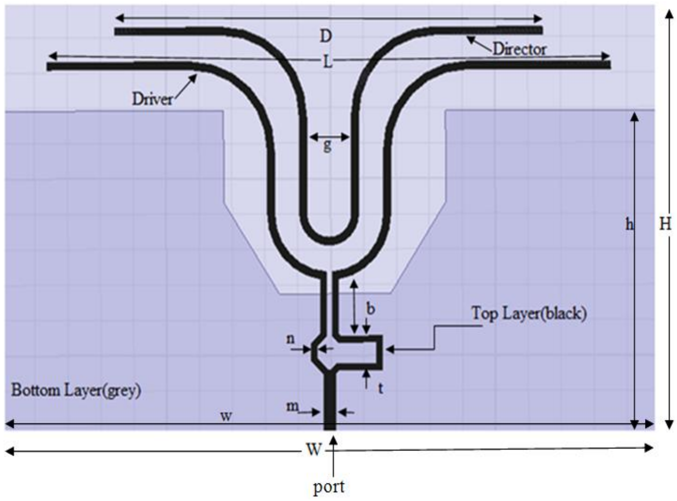



Fig. 2.1 The layout of the proposed Quasi-Landstorfer antenna.

The director or parasitic element guides electromagnetic energy in the y-direction and is used for matching. The ground plane is truncated in parallel to the driven element to behave as a reflector in the y-direction. Moreover, the truncated ground plane also serves as the ground for the microstrip feed line of the antenna. The design of the Quasi-Landstorfer antenna was simulated in High Frequency Structure Simulator (HFSS), which is based on the Finite Element Method [8]. The size and the spacing of the director elements are considered to be the most critical elements for the design of the Yagi-Uda antenna.
The dimensions of the elements are frequency dependent. Here the general rules for length are:

Reflector length : 0.495×wavelength.
Dipole length : 0.473×wavelength.
Director length : 0.440×wavelength.

Getting right length is the part of tuning, Spacing between the elements is the other part.
Reflector to Dipole spacing : 0.125×Wavelength.
Dipole to Director spacing : 0.125×Wavelength.
Design frequency : 2.45GHz, $\lambda=c/f$

The antenna was designed to operate in the 2.45GHz (S-band) frequency on a 1.57 mm thick FR4 epoxy substrate ($\varepsilon_r$=4.4)[3]. The substrate dimensions of the antenna are 99.5mm ×61.5mm × 1.57mm and other design dimensions of the antenna are shown in fallowing table 2.1 (unit: mm):b=8,g=6.75.

Table 2.1 Quasi Landstorfer antenna dimensions

| Parameter | Measurement in millimeter(mm) |
|---|---|
| L (length of director) | 65 |
| D(length of director) | 86.73 |
| h(height of ground plane) | 46.125 |
| w (width of ground plane) | 99.5 |
| Substrate | 99.5×61.5×1.57 |
| m(width of port) | 1.8 |
| t(thickness of balun) | 4.7 |
| n(width of one arm of balun) | 0.9 |
| Input Impedance | 50Ω |
| Conducting material | copper |

## 3. Simulated antenna results

The design of the Quasi-Landstorfer antenna is simulated in High Frequency Structure Simulator (HFSS), which is based on the Finite Element Method. To describe the performance of an antenna, definitions of various parameters are necessary. Some of the parameters are interrelated and not all of them need be specified for complete description of the antenna performance.

### 3.1 S-Parameters

As shown in fig. 3.1 this antenna shows -20dB return loss at frequency band of 2.5GHz to 2.6GHz. At the resonant frequencies antenna radiates with maximum power. Also it gives -29dB return loss at frequency 2.55GHz [11].

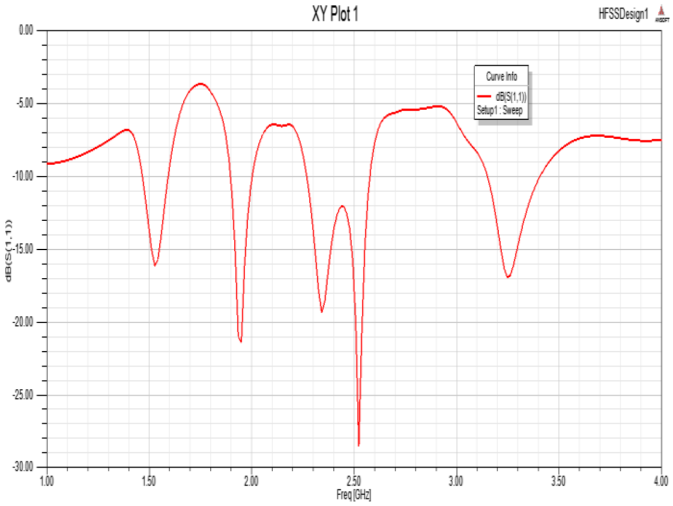



Fig. 3.1 $S_{11}$ vs Frequency

### 3.2 Radiation Pattern

Radiation is maximum when broadside, or perpendicular to a wire, so a vertical whip is ideal for communication in any direction except straight up. The radiation "pattern", perpendicular to the whip, can be described as omnidirectional. There is a "null" or signal minimum, at the end of the whip. With a less than ideal antenna, such as a bent or tilted whip, this null may move and partly disappear [10]. It is important to know the radiation pattern of the antenna, in order to insure that a null is not present in the desired direction of communication.

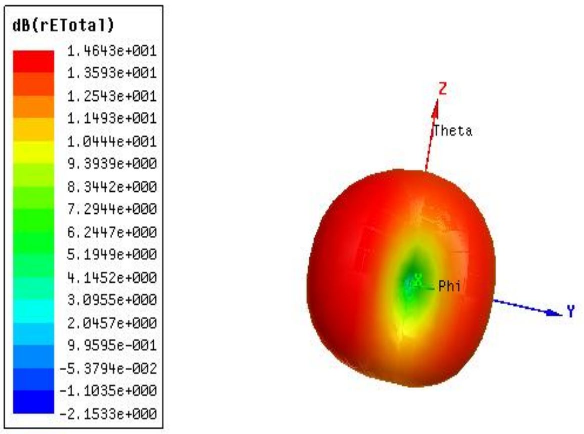



Fig. 3.2 Radiation Pattern

### 3.3 Smith Chart

Impedance matching at the design frequencies of 2.45GHz is 1.34. To match an antenna, the impedance locus needs to be shifted as near as possible to the centre of the smith chart (matching point) as shown in Fig. 3.3. As can be observed impedance matching point is very close to the centre of the smith chart [10].

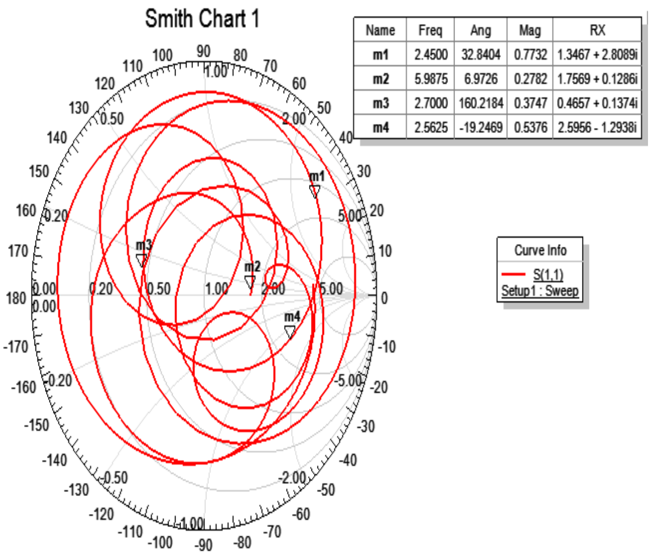
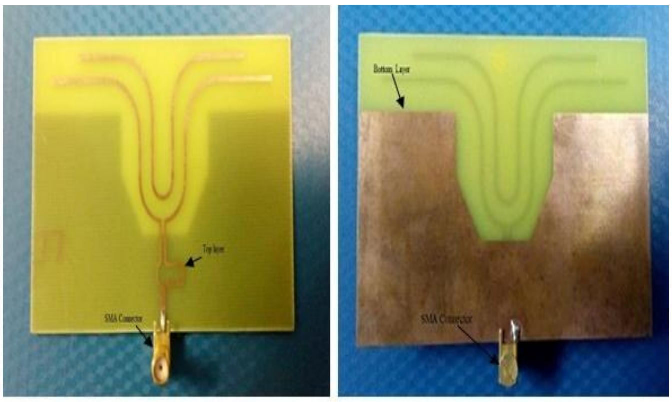



Fig. 3.3 Smith Chart

## 4. Fabricated Antenna Result

The Quasi Landstorfer antenna is designed on a FR4 epoxy substrate with $\varepsilon_r$=4.4 and thickness of 1.57 mm. The substrate dimensions of the antenna are 99.5mm×61.5 mm×1.57mm. A picture of the manufactured prototype antenna is shown in Fig. 4.1 The antenna was manufactured on a substrate with dimensions of 99.5mm×61.5mm×1.57mm.



(a) (b)

Fig. 4.1(a)Top layer and (b) Bottom layer of Quasi Landstorfer Antenna

The testing of fabricated antenna is conducting using antenna test bench setup as shown in Fig. 4.2 the fabricated antenna is fixed on the receiving side using tripod stand and power supply for the transmitting antenna is provided using signal generator.

Fig. 4.2 Antenna Test Bench Setup

The reciving antenna is Quasi Landstorfer antenna used as receiving antenna which in turn is connected to VSWR meter for measuring the power level(in dB) at 1.5m distance between transmitting and receiving antenna and different angles of receiving antenna as shown in following Table 4.1.

Table 4.1 Power Levels(in dB) Of Antenna At Different Angles.

| Angle | Power Receved By Quasi Landstorfer Antenna(dB) |
|---|---|
| $0^0$ | 39.9 |
| $45^0$ | 38.5 |
| $90^0$ | 38.4 |
| $135^0$ | 37.5 |
| $180^0$ | 25 |
| $225^0$ | 38.3 |
| $270^0$ | 38.3 |
| $315^0$ | 39.8 |
| $360^0$ | 40 |

Based on Table 4.1 the polar plot of Quasi Landstorfer antenna is as shown in Fig. 4.2. So from the polar plot it is clear that the Quasi landstorfer antenna is more directional as compared to Yagi-Uda antena and Quasi Yagi-Uda antenna.

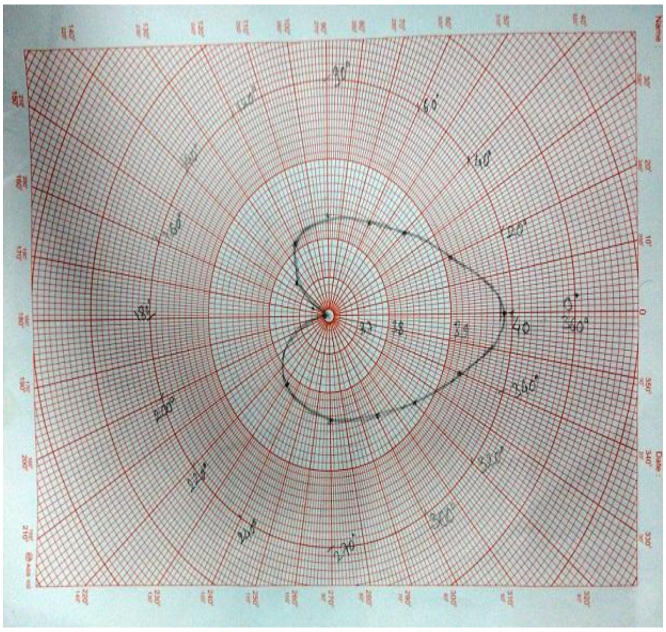


Fig. 4.2 Polar Plot Of Quasi Landstorfer Antenna

## 5. CONCLUSION

The design of a printed Quasi Landstorfer antenna has been presented. From the simulation results of these antennas, the Quasi Landstorfer antennas have a return loss of -20dB at 2.45 GHz. Also the voltage standing wave ratio (VSWR) shows that impedance of antenna and transmission line is well matched due to this mismatch loss will be reduced and hence the maximum power transfer from input side to output side of the antenna. Moreover, the size of the Quasi Landstorfer antenna is less than that of the Landstorfer antenna. The antenna also exhibits a symmetric radiation pattern in the end-fire direction. The directivity of the antenna was measured to be 6.6dBi which is good. From the result of fabricated antenna it is clear that the Quasi landstorfer antenna is more directional. So due to the compact size and moderate gain, the Quasi Landstorfer antenna can be widely used in WLAN applications, such as wireless communications, phased arrays, and millimeter wave applications.

## REFERENCES

[1] Phillip R. Grajek, Bernhard Schoenlinner, Student Member, IEEE, and Gabriel M. Rebeiz, Fellow, IEEE,"A 24-GHz High-Gain Yagi–Uda Antenna Array" in IEEE Transactions On Antennas And Propagation, Vol. 52, No. 5, May 2004.

[2] S.S.Khade, S.L.Badjate, PhD," Yagi Uda Antenna with Integrated Balun for WLAN Application", in International Journal of Computer Applications (0975–8887)International Conference on Reliability, Infocom Technologies and Optimization, 2013.

[3] O.Shoewu, L. A Akinyemi, N. T. Makanjuola “Design, Development and Simulation of a 2.4 GHz Yagi Uda Antenna ” International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org Volume 2 Issue 5 ǁ May. 2013 ǁ PP.31-37.

[4] William R. Deal, Member, IEEE, Noriaki Kaneda, Student Member, IEEE, James Sor, Yongxi Qian, Member, IEEE, “A New Quasi-Yagi Antenna for Planar Active Antenna Arrays” IEEE Transactions On Microwave Theory And Techniques, Vol. 48, No. 6, June 2000.

[5] Angus C. K. Mak, Corbett R. Rowell, and Ross D. Murch “Low Cost Reconfigurable Landstorfer Planar Antenna Array” IEEE Transactions On Antennas And Propagation, Vol. 57, No. 10, October 2009.

[6] Gulshan Sharma, Vijay Sharma and P.K. Singhal," Performance Investigation Of Yagi-Uda Antenna Using Different Shapes Of Antenna Element At 2 Ghz " in International Journal of Advance Research, IJOAR .org Volume 1, Issue 3, March 2013, Online: ISSN 2320-9100.

[7] Derek Gray, Jun Wei Lu, and David V. Thiel, "Electronically Steerable Yagi-Uda Microstrip Patch Antenna Array" in IEEE Transactions On Antennas And Propagation, Vol. 46, No. 5, May 1998.

[8] Software simulation using ANSYS HFSSv13 V-15.

[9] C.-C. Hsu, K.-H. Lin, and H.-L. Su, “Implementation of broadband isolator using meta material-inspired resonators and a T-shaped branch for MIMO antennas,” IEEE Trans. Antennas Propag., vol. 59, no. 10, pp. 3936–3939, Oct. 2011.

[10] Warren L. Stutzman, Gary A.Thiele, Antenna Theory And Design, Second Edition.

[11] Venkata Kishore.K, Nalini.K, B.T.P.Madhav, B.V.Raj Gopala Rao, Surendra Kumar.B, Naga Harsha Vardhan.K, "Design and Analysis of 3-Element yagi-uda Antenna for Wind Profiling Radar" in B T P Madhav et al, International Journal of Computer Science & Communication Networks, Vol 1(3), 242-246.

[12] Neelakantam V. Venkatarayalu and Tapabrata Ray,"Optimum Design of Yagi–Uda Antennas Using Computational Intelligence"in IEEE Transactions On Antennas And Propagation, Vol. 52, No. 7, July 2004.

[13] Yoshihiko Kuwahara,"Multiobjective Optimization Design of Yagi–Uda Antenna"in IEEE Transactions On Antennas And Propagation, Vol. 53, No. 6, June 2005.

[14] Ankit Agnihotri, Akshay Prabhu, Dheerendra Mishra, "Improvement in Radiation Pattern Of Yagi-Uda Antenna" in International Journal Of Engineering And Science Vol.2, Issue 12 (May 2013), Pp 26-35.

[15] A.Kasinathan,Dr.V.Jayaraj,M.Pachiyaannan,"E-Shape Microstrip Patch Antenna Design for Wireless Applications" in IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 3, May 2014.

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