# Design and Analysis of Yagi-Uda Antenna for WLAN Applications

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***Abstract*—The antenna is supplied by a balanced microstrip-slotline plus it makes a good utilization of space in order to decrease the feeding network area as well as the size of antenna. Based on the simulation results using the CST Microwave Studio software, the broadband characteristics and directional radiation properties of the antenna are explained. The operating bandwidth is 1.8 GHz–3.5GHz with reflection coefficient less than −10 dB. Compared by the antenna unit, the gain of the antenna array has enlarged by 2 dB. Thus, the proposed antenna has features of compact structure, relatively small size, along with wideband and it can be broadly used in PCS/UMTS/WLAN/WiMAX fields.**

***Index Terms*—Yagi-Uda Antenna; Microstrip; WLAN; WiMAX.**

## I. INTRODUCTION

The extensive and intensive expansion of wireless communication systems has directed to a raising request for antennas that can be printed on a substrate. And printed antenna has broad applications due to light weight, low profile, small volume, easiness to fuse with communication system, and other system.

In 1998, printed quasi-Yagi-Uda antenna was early projected by Qian et. al [1], and it is still the main concern in today, following a line of investigation actions. This quasi-Yagi-Uda antenna synchronizes the outstanding radiation fixtures of the Yagi-Uda antenna with the adaptability of the microstrip method. The impartial to unstable alteration design establishes the broadband fixtures of Yagi-Uda antenna. Microstrip-to-coplanar-strip (MS-to-CPS) conversion is designed in [1], and it reaches 17% relative bandwidth. Furthermore, a coplanar waveguide-coplanar strip (CPW-to-CPS) conversion is proposed in [2], which can stimulate the odd-mode electric areas at the CPS line although the CPW feeding line. And at the same time, the antenna can operate at various frequency points. The odd-mode at the CPS line be capable of two energized by delivering 180° phase delay [3]. These days, the feeding structure of the Yagi-Uda antenna is also straightforwardly determined by a microstrip line or a simple CPW without any changeover structure [4, 5]. For the above research, a regular character, that is a huge ground plates, are employed as reflectors. As a result, these antennas usually have big size and are unbeneficial for antenna efficiency as well as array composing. If the feeding structure, excluding the large ground plate, can be designed, the size and difficulty can be deeply condensed [6].

A simple and compressed printed Yagi-Uda antenna supplied by impartial microstrip-slotline and its array are exposed based on [13, 14]. Balanced microstrip line imitates traditional ground plate that will be the reflector of the Yagi-Uda antenna. The features of compact size and broad band are obtained. The stable to unstable alteration is designed all the way through a quasi-microstrip structure. The last projected Yagi-Uda antenna unit operates at 1.8 GHz–3.5 GHz through reflection coefficient less than −10 dB. The ratio bandwidth is 1.94 : 1, plus stable gain in band can be attain 4.5–6.8 dBi. Next, a two-element Yagi-Uda antenna array with 28.7% relative bandwidth plus 8.5 dBi gain (maximum) is accessible. It can cover up WLAN range as well as has feasible use in broadband mobile applications.

## II. ANTENNA CONCEPT

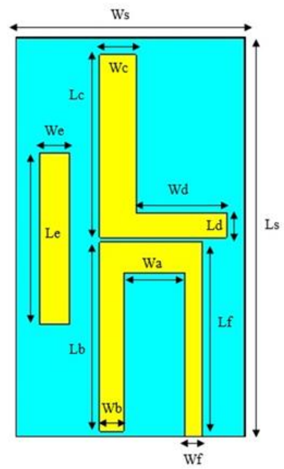


Figure 1: Front view of structure Yagi-Uda antenna

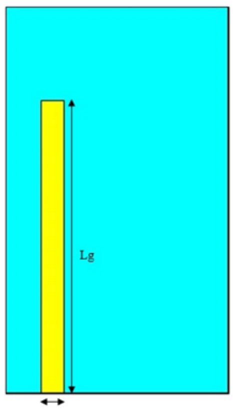


Figure 2: Back view of structure Yagi-Uda antenna

Table 1
The Parameter for Every Element in The Ultra-Wideband Antenna Design.

| Description | Symbols | Dimension (mm) FR4 |
|---|---|---|
| Substrate length | Ls | 66 |
| Substrate width | Ws | 38 |
| Feedline length | Lf | 32.4 |
| Feedline width | Wf | 3 |
| Dipole 1 length | Lb | 31 |
| Dipole 1 width | Wb | 4 |
| Dipole 2 length | Lc | 30 |
| Dipole 2 width | Wc | 6 |
| Parasitic element length | Le | 28 |
| Parasitic element width | We | 5 |
| Patch a width | Wa | 10 |
| Patch d length | Ld | 4 |
| Patch d width | Wd | 15 |
| Gap | g | 0.8 |

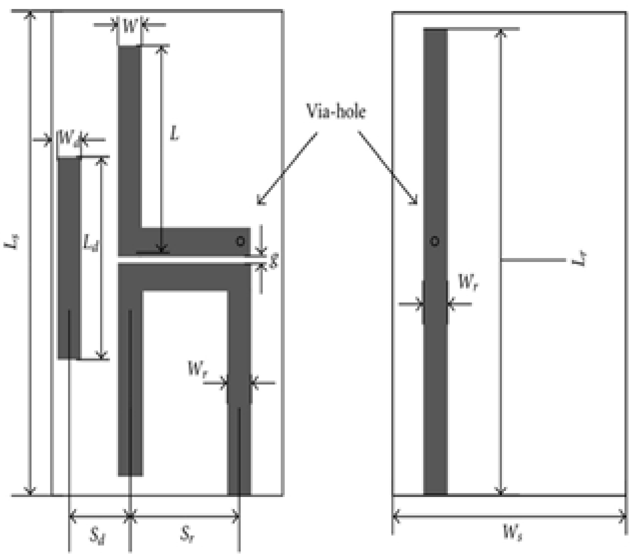


Figure 3: Original design [13]

Figure 3 show the original Design and Analysis of Printed Yagi-Uda antenna which operate bandwidth is 1.8 GHz–3.5GHz with reflection coefficient less than −10 dB.

## III. RESULT AND DISCUSSION

In parameter study, the parameters that have been chosen as the result are:

i. Return Loss
ii. Bandwidth
iii. Realization Gain
iv. Total efficiency
v. Directivity

The value of length that have been sweep are:

i. Gap between dipole of antenna, g
ii. Length of patch d, Ld
iii. Length of patch e, Le
iv. Length of slot ground, Lg
v. Width of ground, Wg

The main purpose of this parameter study is to identify whether it has any effect on return loss, gain, directivity and efficiency.

From the result that has been stated, we will discuss about the parameter that change when we change the value of the length. In Table 2, we increased the length of gap between dipole of antenna. Therefore, the return loss is increased until 0.7 mm. In term of gain, efficiency and directivity, the value is increasing as well and the gap is also increasing. By increasing the gap, it would decrease the return loss until -50.503021 dB at length of 0.7 mm but at that point, it start to increase at 0.8mm.

Table 2
The Simulation of Parameter Sweep of Gap between Dipole of Antenna

| Parameter value (mm) | Frequency (GHz) | Return loss (dB) | Efficiency (dB) | Gain (dB) | Directi -vity (dBi) |
|---|---|---|---|---|---|
| 0.5 | 2.458 | -46.50473 | -1.536 | 1.857 | 3.392 |
| 0.6 | 2.464 | -46.965126 | -1.523 | 2.311 | 3.834 |
| 0.7 | 2.468 | -50.503021 | -1.521 | 2.730 | 4.251 |
| 0.8 | 2.47 | -48.329884 | -1.504 | 3.105 | 4.608 |
| 0.9 | 2.47 | -18.018896 | -1.607 | 2.713 | 4.319 |
| 1.0 | 2.47 | -16.637062 | -1.576 | 3.012 | 4.588 |
| 1.1 | 2.806 | -17.514767 | -1.587 | 3.317 | 4.904 |

In Table 3, we increased the length of patch d, Ld. Thus, the return loss is decrease until -66.81456 dB at 3.9 mm. When we analyzed the gain and the efficiency, the value is increasing as well and the gap is also increasing but not for the directivity. The value of directivity is inconsistent.

Table 3
The Simulation of Parameter Sweep of Length of Patch d

| Parameter value (mm) | Frequency (GHz) | Return loss (dB) | Efficiency (dB) | Gain (dB) | Directi -vity (dBi) |
|---|---|---|---|---|---|
| 3.7 | 2.444 | -39.17395 | -1.511 | 2.996 | 4.507 |
| 3.8 | 2.456 | -54.947708 | -1.533 | 3.066 | 4.600 |
| 3.9 | 2.464 | -66.81456 | -1.499 | 3.028 | 4.528 |
| 4.0 | 2.472 | -54.624039 | -1.504 | 3.105 | 4.608 |
| 4.1 | 2.482 | -43.508106 | -1.509 | 3.178 | 4.687 |
| 4.2 | 2.486 | -30.437057 | -1.487 | 3.276 | 4.762 |
| 4.3 | 2.49 | -30.364582 | -1.443 | 3.223 | 4.666 |

In Table 4, we increased the length of patch e, Le. From the result, the return loss is increasing but inconsistent. The value is increasing as well as the of length of patch e, Le for gain, efficiency and directivity is also increasing. By increasing the length, it would decrease the return loss until -54.624039 dB at the length of 28 mm but then it starts to increase at 29 mm.

Table 4
The Simulation of Parameter Sweep of Length of Patch e

| Parameter value (mm) | Frequen-cy (GHz) | Return loss (dB) | Efficiency (dB) | Gain (dB) | Directi-vity (dBi) |
|---|---|---|---|---|---|
| 25 | 2.466 | -2608757 | -1.356 | 2.049 | 3.406 |
| 26 | 2.466 | -26.744347 | -1.506 | 2.852 | 4.357 |
| 27 | 2.468 | -28.858156 | -1.485 | 2.975 | 4.459 |
| 28 | 2.472 | -54.624039 | -1.500 | 3.094 | 4.594 |
| 29 | 2.474 | -38.376389 | -1.463 | 3.207 | 4.669 |
| 30 | 2.47 | -34.924362 | -1.442 | 3.447 | 4.889 |
| 31 | 2.452 | -29.22241 | -1.448 | 3.679 | 5.127 |

In Table 5, we performed the parameter sweep of length of slot ground, Lg. We raise the length of slot ground, Lg from 50mm-56mm. From the result stated, the return loss is enlarged until -22.215109 dB. For directivity, the value is increasing when the length is rising. For efficiency, it decreases until 54mm, then from 55mm, the efficiency is increasing. With the gap increased, it would decrease the return loss until -50.503021 dB at length of 0.7 mm but start to increase at 0.8 mm.

Table 5
The Simulation of Parameter Sweep of Length of Slot Ground

| Parameter value (mm) | Frequency (GHz) | Return loss (dB) | Efficiency (dB) | Gain (dB) | Directi-vity (dBi) |
|---|---|---|---|---|---|
| 50 | 2.474 | -45.101196 | -1.487 | 3.049 | 4.536 |
| 51 | 2.412 | -29.553946 | -1.488 | 2.948 | 4.436 |
| 52 | 2.35 | -24.738461 | -1.517 | 2.920 | 4.437 |
| 53 | 2.294 | -22.632259 | -1.542 | 2.916 | 4.458 |
| 54 | 2.22 | -21.615929 | -1.556 | 3.101 | 4.567 |
| 55 | 2.164 | -22.215109 | -1.492 | 3.390 | 4.882 |
| 56 | 2.112 | -24.161488 | -1.350 | 3.694 | 5.043 |

In Table 6, we increased the width of ground of antenna. As a result, the return loss is decreased. For parameter like gain, efficiency and directivity, the value is increasing but it is inconsistent. By increasing the width of ground, it would decrease the return loss until -54.624039 dB at the length of 4.0mm.

Table 6
The Simulation of Parameter Sweep of Width of Ground

| Parameter value (mm) | Frequency (GHz) | Return loss (dB) | Efficiency (dB) | Gain (dB) | Directi-vity (dBi) |
|---|---|---|---|---|---|
| 3.4 | 2.49 | -19.875271 | -1.457 | 3.035 | 4.492 |
| 3.5 | 2.494 | -20.262962 | -1.717 | 3.208 | 4.926 |
| 3.6 | 2.496 | -20.763695 | -1.437 | 3.003 | 4.441 |
| 3.7 | 2.498 | -21.209898 | -1.422 | 2.986 | 4.409 |
| 3.8 | 2.502 | -21.764566 | -1.408 | 2.963 | 4.371 |
| 3.9 | 2.472 | -44.509007 | -1.493 | 3.060 | 4.553 |
| 4.0 | 2.472 | -54.624039 | -1.490 | 3.060 | 4.550 |

### A. *Parameter sweep of Yagi-Uda antenna on S-parameter*

*i. 1st Parameter – Length of Parasitic Element, Le*

Figure 4 shows the effect on return loss of the antenna when the Length of Parasitic Element, Le is sweep in the range of frequency from 25-31 GHz.

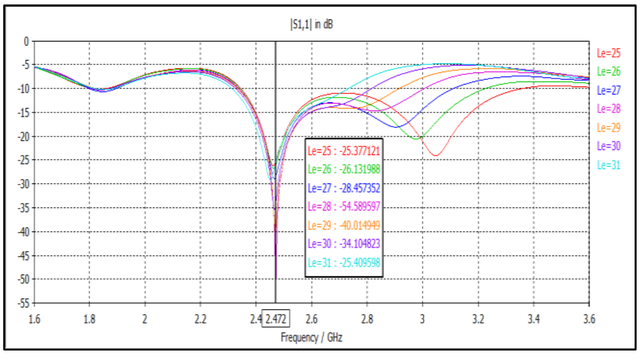


Figure 4: Return loss of Length of Parasitic Element, Le

*ii. 2nd Parameter – ground*

Figure 5 shows the effect on return loss of the antenna when the L ground, g Le is sweep in the range of frequency from 0.5-1.1 GHz.

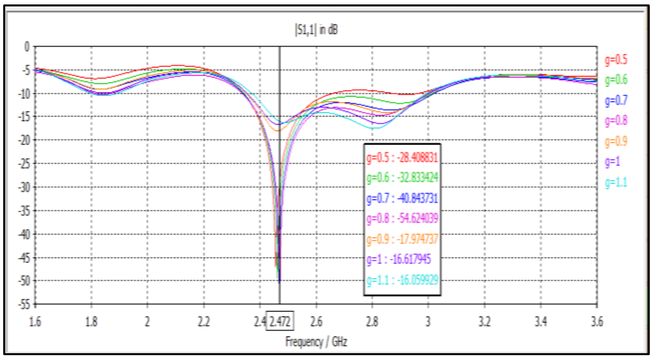


Figure 5: Return loss of ground, g

*iii. 3rd parameter-length of patch d*

Figure 6 shows the effect on return loss of the antenna when the length of patch d, Ld is sweep in the range of frequency from 3.7-4.3 GHz.

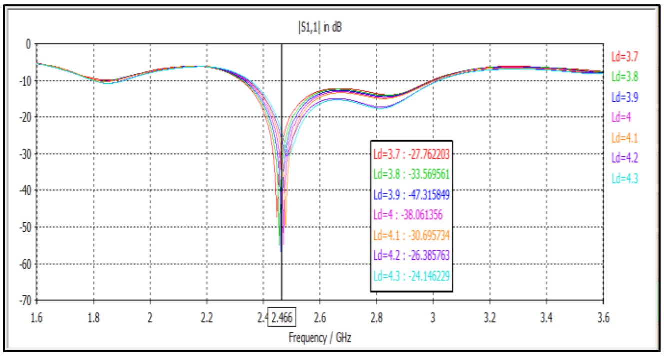


Figure 6: Return loss of length of patch d, Ld

*iv. 4th parameter-length of slot ground*

Figure 7 shows the effect on return loss of the antenna when the length of slot ground, Lg is sweep in the range of frequency from 50-56 GHz.

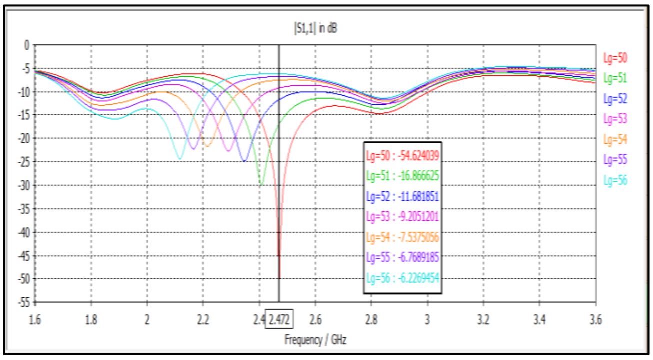


Figure 7: Return loss of length of slot ground, Lg

*v. 5th parameter-width of ground*

Figure 8 shows the effect on return loss of the antenna when the width of ground, Wgis sweep in the range of frequency from 3.4-4.0 GHz

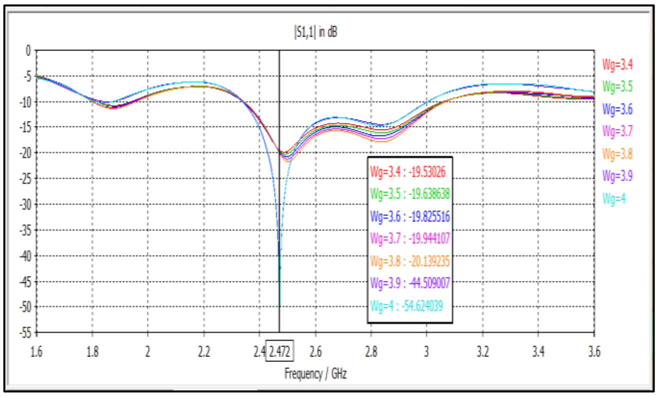


Figure 8: Return loss of width of ground, Wg

## IV. Conclusion

It can be concluded that, the design structure, material and its parameter are explained as well as the antenna parameter was discussed and analyzed. The antenna mentioned in this paper can be printed on low-loss dielectric substrate with higher relative permittivity. Affected by dielectric, the antenna size will be smaller and the antenna will be simply included in microwave circuit. As a result, this antenna can be widely functional in many areas or fields like PCS/UMTS/WLAN/WiMAX.

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