The study of the wideband planar sleeve antenna

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Abstract. In this paper, the wideband planar sleeve antenna with two sleeves on the upper side and two sleeves on the bottom side are analyzed numerically. In the previous study, the wideband planar sleeve antenna is used at frequency 3.5 GHz. The purpose of this research is addressed to analyze the wideband planar sleeve antenna in the range frequency of 400–4000 MHz by using WIPL-D EM Simulator by adjusting the antenna parameter. The antenna upper sleeve, lower sleeve, the length of the antenna and the gap between the lower and upper sleeves are adjusted. The result shows that the wideband planar sleeve antenna is achieved. When the length of the upper sleeve is increased, the antenna will work at lower frequency but the return loss slightly reduced, the same effect occurred by increasing the lower sleeve size, but it doesn’t affect at the lower frequency. When the antenna length is increased, the return loss of the antenna is reduced. Furthermore, the distance between the lower and upper sleeve affects the return loss characteristic. This is indicated that by adjusting the length of the antenna parameter, the antenna is applicable for many systems, such as television system and the ISM system.

1. Introduction
Planar sleeve antenna has been used for multi-frequency band in the communication system [1]. On this research, the planar sleeve antenna is analyzed and used as a wideband antenna. The sleeve antenna is essentially a coaxial transmission line fed to a half-wave dipole antenna [2]. The planar sleeve antenna consists of two tubular sleeves and the antenna monopole is modified and added by upper sleeves [3]. The study is to analyse the characteristic of the wideband planar sleeve antenna using WIPL-D EM simulator [4]. This planar sleeve antenna has the characteristic of wideband return loss antenna around the resonant frequencies [5]. In the previous study, the wideband planar sleeve antenna is used at 3.5 GHz, 4.0 GHz and 4.5 GHz, and can be concluded that the characteristic can be improved as wideband antenna [6]. In this research, the antenna is analyzed at the range frequency of 400 MHz – 4000 MHz. The antenna upper sleeve, lower sleeve, the length of the antenna and the distance between lower and upper sleeves are adjusted.

2. Antenna design
The structure of the wideband planar sleeve antenna shows in Figure 1. On this research, the antenna material is using single-sided printed circuit board R-1781 (Matsushita) [7]. The planar sleeve antenna is, in fact, a sleeve antenna conventional that cut in half and improved by adding some modification. A
conventional sleeve antenna is an omnidirectional antenna [8]. Many communication systems often required an antenna that has an omnidirectional radiation pattern [9] and planar sleeve antenna is the suitable choice for that communication system because the pattern characteristic of the antenna is omnidirectional.

This planar sleeve antenna has two sleeves. The lower sleeve works like the sleeve on the conventional sleeve antenna attached on the surface of the coaxial transmission line [6]. The upper sleeve is attached at the edge of the inner conductor of the transmission line.

![Figure 1. Structure of wideband planar sleeve antenna.](image)

The length of the planar sleeve antenna (B) is 60 mm. The width of the central conductors (W1) and side conductors (W2) are 4.5 mm and 6 mm, respectively. The lower sleeve length, L1 are 20.3 mm and L2 are 19.13 mm. The upper sleeves length, U1 are 62.3 mm and U2 are 61.13 mm. The gap width between sleeves g is 0.2 mm. The thickness and the relative permittivity of the dielectric plate are 1 mm and $\varepsilon=4.5$, respectively. In the calculation process, WIPL-D EM Simulator is used.

3. Results and discussion

The antenna upper sleeve (U), lower sleeve (L), the length of the antenna (B) and the distance or the gap between the lower and upper (d) sleeves are adjusted. The calculated frequency and return loss result from the simulation of adjusted size is obtained and analyzed.

Table 1 shows return loss bandwidth and the resonant frequency of the planar sleeve antenna for different size of the upper sleeve. When the length of the upper sleeve is increased, the antenna resonant frequencies are not changed much, and the return loss slightly improved. As we can see on the table, the antenna gets best return loss when the length of the upper sleeves are 80.3 mm and 19.16 mm and get lowest return loss when the length of the upper sleeves are 62.3 mm and 61.16 mm.

Table 2 shows return loss bandwidth and the resonant frequency of planar sleeve antenna for different size of lower sleeve, it shows that when increasing the lower sleeve size, the second antenna resonant frequency is reduced but the others resonant are not much affected. And also, the return loss is getting...
better in the second resonant frequency, but others resonant return loss is not much affected. Except when the lower sleeve size is more than 32.3 mm and 31.16 mm, all the return loss becomes worse.

Table 3 and Table 4 shows return loss bandwidth and the resonant frequency of planar sleeve antenna for different size of the length of the antenna and sleeves gap, respectively. When the antenna length is increased, the return loss of the antenna is reduced. Furthermore, the gap between the lower and upper sleeve size affects the return loss characteristic. For a good result, the return loss should be less than -10 dB [10]. From the result, the wideband planar sleeve antenna has good return loss characteristic and have resonant frequencies around 0.801 GHz, 3.125 GHz, and 3.550 GHz. The resonant frequencies on the previous research are at 3.5 GHz and 3.8 GHz [6]. on this research the antenna resonant frequencies is from 0.8 GHz to 3.550 GHz, so the resonant frequencies are improved and wideband planar sleeve antenna is achieved.

**Table 1.** Return Loss bandwidth of planar sleeve antenna for different size of upper sleeve.

| B   | L1  | L2  | U1  | U2  | d   | Resonant Frequency | Return Loss |
|-----|-----|-----|-----|-----|-----|-------------------|-------------|
|     |     |     |     |     |     |                   |             |
| 60  | 20.3| 19.16| 62.3| 61.16| 2.4| 801 MHz| 3343 MHz | 3900 MHz| -21 | -12 | -23 |
| 60  | 20.3| 19.16| 68.3| 67.16| 2.4| 856 MHz| 3273 MHz | 4210 MHz| -21 | -15 | -15 |
| 60  | 20.3| 19.16| 74.3| 73.16| 2.4| 829 MHz| 3207 MHz | 3746 MHz| -27 | -21 | -19 |
| 60  | 20.3| 19.16| 80.3| 79.16| 2.4| 801 MHz| 3125 MHz | 3550 MHz| -35 | -28 | -71 |

**Table 2.** Return Loss bandwidth of planar sleeve antenna for different size of lower sleeve.

| B   | L1  | L2  | U1  | U2  | d   | Resonant Frequency | Return Loss |
|-----|-----|-----|-----|-----|-----|-------------------|-------------|
|     |     |     |     |     |     |                   |             |
| 60  | 20.3| 19.16| 80.3| 79.16| 2.4| 801 MHz| 3125 MHz | 3550 MHz| -35 | -28 | -71 |
| 60  | 26.3| 25.16| 80.3| 79.16| 2.4| 775 MHz| 2880 MHz | 3610 MHz| -26 | -32 | -42 |
| 60  | 32.3| 31.16| 80.3| 79.16| 2.4| 745 MHz| 2585 MHz | 3480 MHz| -21 | -65 | -29 |
| 60  | 38.3| 37.16| 80.3| 79.16| 2.4| 730 MHz| 2380 MHz | 3350 MHz| -17 | -16 | -29 |

**Table 3.** Return Loss bandwidth of planar sleeve antenna for different size of antenna length.

| B   | L1  | L2  | U1  | U2  | d   | Resonant Frequency | Return Loss |
|-----|-----|-----|-----|-----|-----|-------------------|-------------|
|     |     |     |     |     |     |                   |             |
| 40  | 20.3| 19.16| 80.3| 79.16| 2.4| 900 MHz| 3160 MHz | 4248 MHz| -35 | -20 | -22 |
| 60  | 20.3| 19.16| 80.3| 79.16| 2.4| 801 MHz| 3125 MHz | 3550 MHz| -35 | -28 | -71 |
| 100 | 20.3| 19.16| 80.3| 79.16| 2.4| 630 MHz| 2870 MHz | 3620 MHz| -14 | -15 | -39 |

**Table 4.** Return Loss bandwidth of planar sleeve antenna for different size of sleeve gap.

| B   | L1  | L2  | U1  | U2  | d   | Resonant Frequency | Return Loss |
|-----|-----|-----|-----|-----|-----|-------------------|-------------|
|     |     |     |     |     |     |                   |             |
| 60  | 20.3| 19.16| 80.3| 79.16| 0.8| 830 MHz| 3150 MHz | 3720 MHz| -25 | -14 | -15 |
| 60  | 20.3| 19.16| 80.3| 79.16| 1.6| 808 MHz| 3127 MHz | 3650 MHz| -28 | -19 | -22 |
| 60  | 20.3| 19.16| 80.3| 79.16| 2.4| 801 MHz| 3125 MHz | 3550 MHz| -35 | -28 | -71 |
| 60  | 20.3| 19.16| 80.3| 79.16| 3.2| 792 MHz| 3110 MHz | 3510 MHz| -59 | -35 | -24 |

Figure 2 shows the comparison of S-parameter (S11) of the planar sleeve antenna for different size of lower sleeve, it shows that by adjusting the lower sleeve size, the resonant frequency that has frequency more than 2.4 GHz becomes lower and the return loss is better. Figure 3 shows the comparison of S-parameter (S11) of the planar sleeve antenna for different size of upper sleeve, it shows that by adjusting the upper sleeves size is just slightly change the graph. Figure 4 shows the comparison of S-parameter
(S11) of the planar sleeve antenna for different size of the length of the antenna (B) and it shows that by adjusting the length, it moves the resonant frequency to become smaller, but if the length is too long, the return loss becomes too much and it is not good enough for the antenna. And Figure 5 shows the comparison of S-parameter (S11) for different size of the gap between the sleeves (d), it shows that by adjusting the gap, the resonant frequency is unchanged but the return loss is greatly improved. So, it shows that the return loss characteristic of the wideband planar sleeve antenna is achieved and the return loss can be adjusted by adjusting the antenna parameter.

Figure 2. Comparison of return loss bandwidth with different lower sleeve size (L).

Figure 3. Comparison of return loss bandwidth with different upper sleeve size (U).

Figure 4. Comparison of return loss bandwidth with different length of the antenna (B).

Figure 5. Comparison of return loss bandwidth with different size of sleeve gap (d).

Figure 6 shows the electric field radiation patterns of the planar sleeve antenna in the z-x plane, it shows eight shaped pattern on resonant frequency 0.8 GHz and the shape changed on the other resonant frequency. However, it got higher gain on the higher resonant frequency. And Figure 7 shows the electric field radiation patterns of the planar sleeve antenna in the x-y plane, it shows omnidirectional pattern on all the resonant frequency. So the planar sleeve antenna has good radiation pattern with the eight-shaped pattern on the z-x plane, and the omnidirectional pattern on the x-y plane [11].
Figure 6. Electric field radiation patterns in the x-z plane.

Figure 7. Electric field radiation patterns in the x-y plane.

4. Conclusion
The proposed wideband planar sleeve antenna has been analyzed numerically by using WIPL-D EM simulator. From the result show that by adjusting the length of the antenna parameter, the antenna is having good return loss characteristic and good radiation pattern. That result shows that the wideband planar sleeve antenna is achieved. That is mean the proposed antenna is applicable for many systems, such as the television system and the ISM system.

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