Design and Development of a Conformal Printed sleeve dipole antenna operating in 800MHz to 3000MHz

P. Bhavya¹, K. Lakshmi Narayana¹ and K.H. Takeshore²

¹Department of Electronics and Communication Engineering, Sir C. R. Reddy College of Engineering, Eluru − 534007, West Godavari District, Andhra Pradesh India; bhavyapagadala@gmail.com
²Defence Electronics Research Laboratories, Hyderabad − 500 005, India; takeshore@gmail.com

Abstract
In this paper, a conformal loaded printed sleeve dipole antenna operating in 800MHz to 3000MHz frequency band is designed and presented with measured results. The wide band characteristics are achieved using sleeve configuration along with capacitive loading. The proposed antenna has VSWR ≤ 3:1 with good radiation efficiency and omni-directionality. The proposed antenna is designed in CST Microwave Studio™ and fabricated using photolithography technique. As the antennas is printed on 10 mils thick RT Duroid 5880™ substrate. The antenna is flexible and can be conformed to given cylindrical shaped platform. The proposed conformal antenna finds wide applications in avionics and wireless communication systems.

Keywords: Conformal, Printed Dipole, Sleeve

1. Introduction
The recent advances in information technology and wireless communications has created many opportunities for enhancing the performance of existing signal transmission and processing systems and has provided a strong motivation for developing novel devices and systems. Wireless devices require integration of antenna units with the rest of electronic components. Monopole or dipole¹ is a good choice for broadcasting applications because of their Omni directional radiation pattern. Printed dipole antennas are mostly preferred than printed monopole antennas because they don’t require ground plane. Printed antennas² are the best choice for the RF engineers because of its low profile, low cost, ease of fabrication and compatibility with the microwave integrated circuit technology. The conventional wire monopole / dipole antennas are narrowband antenna with bandwidth of the order of 5-10% of its centre frequency. There are various techniques to improve the antenna impedance bandwidth. In this paper, bandwidth enhancement techniques for a conventional narrowband printed dipole antennas is presented.

In this proposed antenna, a printed sleeve configuration is chosen along with printed dipole to improve its impedance bandwidth greater than 3:1. Conformal antennas are the emerging trends in radio communication and avionics due to its integrity with the desired structure or platform. The air drag experienced by such antenna mounted on any high speed platform will be lesser and the camouflage properties are also improved. A flexible substrate with lower dielectric constant is chosen in order to make the antenna conformable to given platform.

2. Design Approach
The CST design model of conformal printed sleeve dipole antenna along with the sleeve configuration is shown in Figure1.
By reducing wavelength to diameter ratio of printed dipole or in other words thickening the radiating elements, the impedance bandwidth can be improved up to certain extent. Further thickening will result in distortion in radiation patterns. R, L, C loading techniques or impedance matching circuits introduces losses in the antenna system, thereby lowering the efficiency of the antenna. This may not be acceptable in application where the overall system performance critically depends on the efficiency of the antenna.

In this proposed antenna, a fat antenna configuration along with sleeve and capacitive loading concept is used in order to improve impedance bandwidth. The antenna is fat as length to diameter ratio is 4. Rectangular strips on both the arms of the dipole act as capacitive loading thereby reducing the antenna size and at the same time improving impedance bandwidth.

Moreover, using printed sleeves on both the sides of the dipole, the virtual feed point of the antenna is shifted from the physical feed point thereby changing the current distribution along the antenna which results better impedance matching. The antenna is printed on RT Duroid 5880\textsuperscript{TM} with dielectric constant, $\varepsilon_r=2.2$ and 10mil thick.

The proposed antenna is designed in CST Microwave Studio\textsuperscript{TM} and its geometrical configurations along with physical dimensions are shown in Figure 2.

The length and width of printed dipole are $0.31\lambda \times 0.19\lambda$ at lowest frequency of operation (i.e., $800\text{MHz}$).

After the antenna dimensions are optimized in CST Microwave Studio, it is printed on RT Duroid 5880 substrate using photo lithography technique. Figure 3 shows the photograph of the fabricated antenna.

The antenna is fed coaxially using flexible coaxial cable (diameter = 0.141\textsuperscript{in}) between the two dipole arms. Since the dipole is balance and the coaxial cable is unbalance, a balun is required. A choke type broadband ferrite
balun is used in order to suppress the undesired current flowing on the outer surface of the coaxial cable.

**Figure 4.** Conformal antenna with different curvatures.

Finally, in order to study the characteristics of the conformal antenna, the proposed antenna is made to conform to various curvatures as shown in Figure 4. The smallest curvature ranging from 52mm diameter up to 1000mm is taken in simulation studies.

### 3. Results and Discussion

The simulation studies are carried out for various antenna configurations as shown in Figure 5.

Figure 5(a) shows the CST model of Fat dipole antenna. From Figure 5(b), it is seen that the fat dipole antenna is resonating at 1 GHz and 2.8 GHz respectively. The VSWR is high at lower frequencies as well as in mid frequencies. Figure 5(c) shows the CST model of Fat dipole antenna with rectangular strips on both the dipole arms. The lower frequencies are better matched even though the middle frequencies shows higher VSWR.

![Fat dipole antenna](image)

**Figure 5 (a).** Fat dipole antenna.

![VSWR of fat dipole antenna](image)

**Figure 5 (b).** VSWR of fat dipole antenna.

Figure 5(e) shows the CST model of Fat dipole antenna with printed sleeves. Here the middle frequencies are better matched and the lower frequency band shows higher VSWR. Finally, the sleeves along with the strips are introduced together with fat dipole antenna as shown in Figure 5(g). With this configuration the simulated VSWR is better matched over the entire band (0.8-3GHz) as shown in Figure 5(h).

![Fat dipole antenna with sleeves](image)

**Figure 5 (e).** Fat dipole antenna with sleeves.

![VSWR of Fat dipole antenna with sleeves](image)

**Figure 5 (f).** VSWR of Fat dipole antenna with sleeves.
The radiation pattern characteristics were measured in the rectangular anechoic chamber using PNA based antenna pattern recording system. Figure 7 shows the measured radiation patterns of wideband printed dipole antenna in three cut planes.

Figure 6 shows the simulated radiation patterns of the Printed dipole antenna in three cut plane. It consists of two elevation plane patterns and one azimuth plane pattern. It shows good elevation coverage and omni-directionality over the frequency band.

After fabrication of the antenna, the VSWR was measured using Agilent ENA series Vector Network Analyzer (VNA) E5071C and was found to be less than 3:1 throughout the desired frequency band. Figure 8 shows the comparison of simulated and measured VSWR.

Figure 6. Simulated radiation patterns of proposed printed dipole antenna.

Figure 7(a). Measured e-plane in ZX plane

Figure 8. Simulated and measured VSWR results of proposed antenna.
The characteristics of conformal printed dipole antenna is also studied. Figure 9(a) shows the CST model of conformal printed dipole antenna with curvature diameter of 52mm. Three different curvature i.e., 52mm, 125mm and 500mm are used in simulation studies. Figure 9(b) shows the VSWR comparison of conformal antennas with different curvatures. The measured VSWR of conformal antenna with curvature of 52mm and 125mm are shown in Figure 10.

Figure 9(a). Conformal printed dipole antenna

Figure 9(b). Simulated VSWR of conformal printed dipole antenna with various curvatures.

Figure 10. Measured VSWR of conformal printed dipole antenna.

From the above VSWR figures it is seen that there is not much changes in VSWR even though there is drastic changes in curvature. And the simulated results are in good agreement with the measured results.

Figure 11. Measured gain plot of the proposed antenna.

The gain of conventional tune dipole antenna is 2.15dbi, however the proposed antenna is wideband thus the gain varies from 0.4dbi to 2.26dbi over the design frequency bands as shown in Figure 11.

Figure 12 shows the simulated Elevation and azimuth plane radiation patterns of the conformal antennas with different curvatures at 0.8 GHz and 3.0 GHz respectively.

Figure 12(a). E plane radiation patterns at 0.8 GHz.

The distortion in radiation patterns due to change in antenna curvatures can be seen from the above polar plots. As the frequency increases the distortion increases and they are more profound at 3 GHz. Moreover, the larger the curvature diameter the lesser in patterns distortion levels. The antenna curvature diameter of 125 mm and above shows lesser patterns distortion both in elevation and azimuth planes.
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4. Conclusions

In this paper, sleeve configuration is used in order to achieve the desired bandwidth and a conformal printed sleeve dipole antenna is designed and its results are verified. The antenna due to its conformal nature, compactness and light weight serves its applications in radio communications, avionics, and spectrum monitoring and military system. It also finds applications in wireless communications systems like GSM, PCS, Bluetooth and WLAN which operating frequencies lies within 0.8GHz to 3GHz.

5. References

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