Bluetooth Wireless Technology Low Profile Printed Antenna

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Abstract- Bluetooth wireless technology provides short-range wireless voice and data communication in the Industrial, Scientific and Medical (ISM) band of radio spectrum. This paper describes several half wave printed dipole antennas with offset feed operating at Bluetooth frequency of 2.45 GHz. Two variation of feeding techniques have been employed, namely the side feed and direct feed. Direct feed techniques were incorporated in some structures in order to reduce antennas size. A corresponding rectangular patch antenna operating at the same frequency is also designed for comparison purposes. Numerical simulations have been carried out on the designed structures using Micropatch and Sonnetlite softwares. The antennas have been fabricated on GML laminates and tested. Measured one port results showed that all the antennas are well-matched at their corresponding frequency of operation. The co-polarisation radiation patterns exhibit broad beamwidths.

Keywords
Low profile, Bluetooth antenna, printed microstrip dipole.

I. INTRODUCTION

A class of antennas that has gained considerable popularity in recent years is the printed antenna. This is primarily due to the desirable features exhibited by these antennas such as lightweight and low volume, low cost, ease of construction, conformability and ease of integration with printed circuits [1].

The term Bluetooth refers to an open specification for a technology to enable short-range wireless voice and data communications. This technology operates within a chosen 2.4 GHz frequency spectrum that is unlicensed throughout the world [2]. One of the key design points in implementing Bluetooth wireless technology into a system is the selection of an appropriate antenna. Generally, the larger antennas perform better than the smaller ones but the smaller devices are easier to hide within a portable product. The antenna needed for the device terminal is a linearly polarized, omnidirectional antenna having VSWR of less than 2:1 [3].

II. DESIGN DESCRIPTION

The geometry of the designed microstrip dipole with offset feed antenna is illustrated in Fig.1. The antenna is printed on a GML substrate of 1.524 mm and 0.508 mm thick dielectric (relative permittivity, ε_r = 3.05, loss tangent = 0.003), clad in 0.035 mm thick copper electro-deposited on both sides and the surface roughness is 0.003 [4].

The printed dipole is the printed form of the cylindrical dipole. Hence, the dimensions of the dipole patch which are designated by its width, a, and length, b, can be given by [5]

$$a = \frac{a_c}{0.25} \tag{1}$$

where $a_c = \frac{D}{2}$, $D = \frac{L}{10}$, $L = \frac{\lambda_g}{2}$

a_c is the radius of the cylindrical dipole,
D is the diameter of the cylindrical dipole,
L is the length of the cylindrical dipole and
λ_g is the guide wavelength .

The length b can be calculated using the formulation

$$b = \frac{c}{2f_r\sqrt{\varepsilon_e}} - 2\Delta\ell \tag{2}$$

where
$\Delta\ell$ is the line extension,
ε_e is the effective dielectric constant,
c is velocity of light and
f_r is frequency response.

The designed antennas are numerically simulated. Hardware implementations are then carried out. The fabricated antenna prototypes are tested for their one and two port characteristics. Analysis are then made.

III. NUMERICAL SIMULATIONS

MICROPATCH 2.0 [6] software is able to design the required printed antenna, by first specifying one the antenna dimension. Input parameters required are operating frequency, type of feed structure, loss tangent (tan δ), dielectric constant (ε_r), height of substrate (h), thickness of conductor (t) and conductivity of conductor (σ). The software is able to simulate the performance of the antenna, in terms of one and two port characteristics.

In Micropatch 2.0, RPDesign is used to achieve the optimum rectangular patch dimension while RPAnalyse is used to analyse the rectangular patch structure. Results computed from RPDesign are fed into RPAnalyse for the simulation of the far field radiation patterns. Other parameters simulated are antenna efficiency, directivity, voltage standing ratio (VSWR), input impedance (Z_{in}) and reflection coefficient.

Sonnet Lite software is used for simulating the designed antennas obtained through calculation. Results obtained are return loss, input impedance, VSWR, current distribution [7].

IV. EXPERIMENTAL INVESTIGATIONS

Each antenna prototype is tested at an operating frequency of 1.5 GHz, which is a scaled down factor of 1.6. This is due to the limitation of the Antenna Lab measurement set-up frequency range; i.e., 1.2 GHz to 1.6 GHz.

One and two-port measurements are successfully carried out. The measurement results include return loss, frequency response and far field radiation pattern. Some of the measured results are compared with theory. The far field radiation patterns, operating bandwidth, return loss, input impedance and gain are measured and compared with numerical simulation results of the basic rectangular radiating structure.

V. DISCUSSIONS

The physical size of the fabricated antenna has the dimensions a = 8.784 mm and b = 37.029 mm. Referring to Fig 1, the feeding line is located at 16.7243 mm from the left edge. The line is 19.9178 mm long and 3.78 mm wide. A 50 ohm SMA connector is connected at the end of the feed line.

From the mesurements carried out, the antenna is reasonably well matched to its input at the corresponding frequency of operation. The return loss response of the structure is shown in Fig. 2. The corresponding return loss is –19.00 dB.

The simulated return loss obtained from Sonnet Lite are differs from that of Micropatch 2.0 and experiments as shown in Table 1. This maybe due to the memory limitation of Sonnet Lite, which causes the layout of the antenna to be slightly different from its original designed size.

At the reference level of VSWR = 2, the reflection bandwidth is 0.94 %. The VSWR of 1.294 showed a good match input impedance.

Table 2 shows the simulated and experimental results of the operating bandwidth. Considering the Bluetooth frequency band requirement of approximately 4 % bandwidth [8], the simulated results agree well with the exception of the experimental results. However, bandwidth improvement techniques can be employed for future work.

The measures co-polarisation E-plane radiation pattern is given in Fig. 3. It indicates a wide beamwidth of almost 100^0. The corresponding cross polarisation pattern is shown in Fig 4. The pattern is lower than co polarisation as expected.

The current distribution is as in Fig 5. The distribution across the mid-section exhibits half wave sinusoidal curve. Fig. 6 shows the frequency response, which peaks to –10 dB at the frequency of operation.

VI. CONCLUSION

The principles of the Offset Feed Microstrip Dipole antenna have been investigated. The antenna has been tested at the operating frequency of 1.5 GHz, which has been scaled down by a factor of 1.6 from 2.4 GHz due to limitation of Antenna Lab system. However, the properties of the antenna remains unchanged since the material used is the same. The only change is the antenna size and antenna size is inversely proportional to the operating frequency.

VII. REFERENCES

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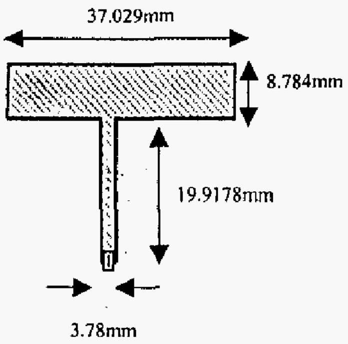

Figure 1: The geometry of microstrip dipole with offset feed antenna.

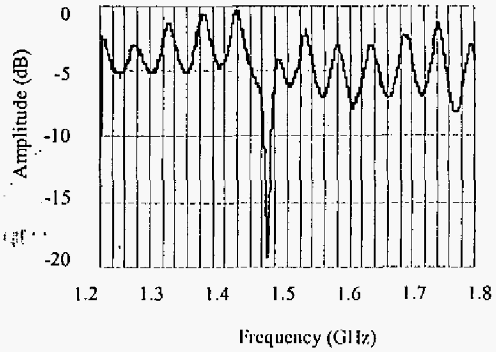

Figure 2: Return loss (S_{11})

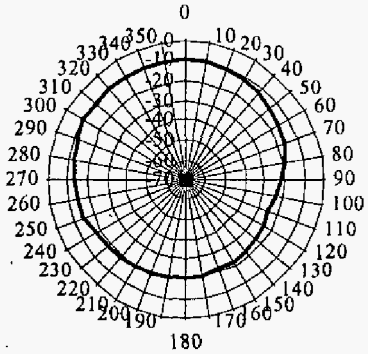

Figure 3: Co-polarisation E-plane radiation pattern

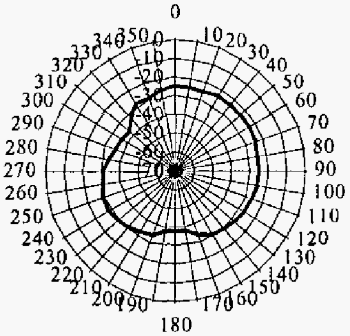

Figure 4: Cross-polarisation E-plane radiation pattern

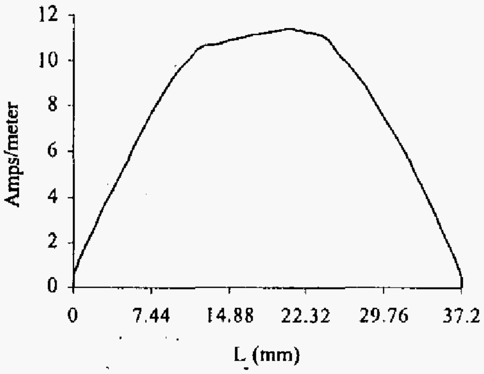

Figure 5: Current distributions

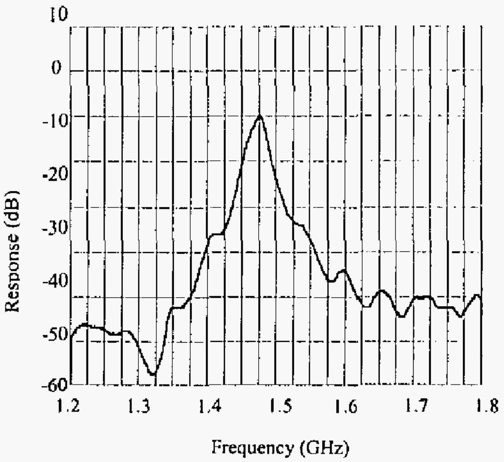

Figure 6: Frequency response

Table 1: Measured and numerically simulated return losses.

Methods	$\|S_{11}\|$, dB
Sonnet Lite	-5.57
Micropatch 2.0	-55.41
Experiments	-19.00

Table 2: Operational Bandwidths

Methods	BW, %
Sonnet Lite	Not available
Micropatch 2.0	5.3
Experiments	0.94