Broadband Printed-Circuit Elliptical Dipole Antenna Covering 750 MHz-6.0 GHz

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***Abstract*—The printed-circuit board (PCB) elliptical antenna with useful bandwidth covering from 750 MHz to 6.0 GHz is suitable for mobile, Bluetooth, wireless local area network (WLAN), the worldwide interoperability for microwave access (WiMax), and other wireless system applications. We present a low profile, PCB elliptical antenna design capable of achieving the above specified bandwidth. Swept frequency return loss, impedance and radiation patterns of this antenna have been measured. Design criteria for this elliptical dipole antenna are also investigated.**

Keywords—Elliptical antenna, printed circuit board (PCB), ultra wideband (UWB), wireless local area network (WLAN), the worldwide interoperability for microwave access (WiMax).

I. INTRODUCTION

THE use of a single broadband antenna with an operating spectrum which covers a wide range of frequencies is very desirable for future and present wireless communications. The proposed elliptical broadband antenna presently can cover wireless data networking frequencies from 750 MHz to 6.0 GHz. Included in this range of frequencies is 824 MHz-5.90 GHz Mobile Communication, 2.4-5.875 GHz Information Enterprise, 2.4-5.9 GHz Network Enterprise, 2.4-2.7 GHz WiMax, and 2.4-2.7 GHz WLAN 802.11b/g. Also included are frequency bands 4.9-5.9 GHz WiMax and 4.9-5.9 GHz WLAN 802.11a and 802.11h.

Square planar monopoles [1]-[2] have been designed in 790 MHz to 6.00 GHz band with a measured swept frequency return loss of -8 dB. A UWB square planar metal monopole antenna [3] with a trident-shaped feeding stripe can provide a -10 dB return loss, when operating in the frequency band of 1.376 to 11.448 GHz. This monopole antenna consists of a planar antenna 40mm x 40 mm perpendicularly placed on top of a ground plane. To achieve suitable (-10 dB return loss and omni-directional pattern) performance across the band, a 150 mm x 150 mm ground plane is needed. The design of square planar monopole antennas with various feeding methods had been investigated [4]. Still, sizeable ground plane is needed for the monopole design to operate, especially in the 800 MHz frequency range.

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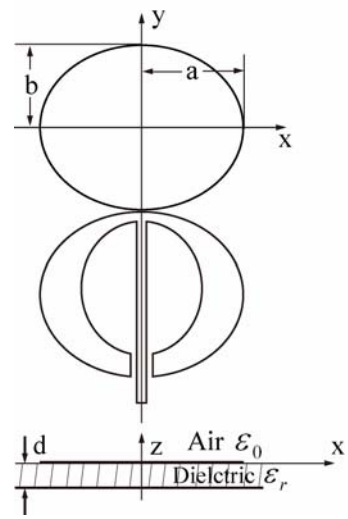

Fig. 1. Geometry of an elliptical printed-circuit dipole antenna

The printed-circuit dipole antenna has proven to be an efficient radiator with a smaller footprint (without ground plane) than a monopole design. Several methods have been proposed to study the impedance of elliptical printed-circuit antennas [5]-[7]. A printed crescent patch antenna [8] and a bottom fed elliptic antenna [9] were investigated experimentally to provide broadband performance with linear polarization without added complexities inherent in the feed circuit.

In this paper, experiments are carried out to investigate the design of an elliptical wideband antenna extending the low end of the operating frequency into the MHz range. Swept frequency impedance and radiation patterns of this particular antenna are measured and investigated.

II. EXPERIMENTAL IMPEDANCE MEASUREMENTS

The geometry of a printed-circuit elliptical dipole antenna is shown in Fig. 1. In its simplest configuration, the antenna dipole with the upper and lower radiation elements having an elliptical shape is designed to produce a broad-beamwidth and broad bandwidth with linear polarization. In the lower elliptic radiator, a portion of the area is cut off in the shape of an ellipse

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to accommodate the 50 ohm micro stripe feed line. This 50 ohms feed line extends into the dipole center or the attached point of the two adjacent elliptical radiators. It was found that the current on the radiator at all frequencies is largely concentrated on the peripheral edge with very low current density approaching inward towards the center. For elliptic dipoles, one can effectively picture that numerous semi-elliptic thin-line dipoles of varying lengths are effectively formed to excite multi-linear modes hence resulting in a very wide bandwidth.

To achieve the broadband properties, A dipole with elliptic radiators with major diameter $2a$ = 80 mm and minor diameter $2b$ = 65 mm were etched on FR4 PCB with a thickness d = 0.762 mm and dielectric constant of 4.2. With overall FR4 PCB size of 90 mm x 150 mm, this elliptic dipole provides suitable impedance properties and nearly omni-directional patterns from the lower 750 MHz to 6 GHz range.

The swept frequency return loss of this elliptic dipole is first measured using a network analyzer. From Fig. 2, in the 750 MHz to 6 GHz range (bandwidth ratio 8:1), the return loss is generally better than -10 dB. Next, Fig. 3 presents the swept frequency measurement of the elliptic dipole in Smith chart format. Further, a plot of the real and imaginary parts of the input impedance against frequency is given in Fig. 4. From this figure, we can actually see multiple resonance peaks indicating that the radiator effectively consists of multi-elliptically-shaped thin-line dipoles of various lengths exciting many linear modes thus resulting in a very broad bandwidth with linear polarization.

It is well-known that the minor diameter of an elliptic dipole determines the resonant frequency. With the minor diameter $2b$ of the above elliptic dipole fixed at 65 mm, the starting resonant frequencies (defined here as the starting frequency with return loss better than -10 dB) is observed at about 750 MHz. The starting resonant frequency of this elliptic dipole can be estimated at the frequency that the minor ellipse diameter is about 0.333 times the guided wavelength. The broadband impedance properties of the dipole can also be pictured in Fig. 3 and Fig. 4 in the swept frequency Smith chart format. From 750 MHz to 6GHz, the measured elliptic dipole impedance is always in the vicinity of 50 ohms.

It is observed that as the radiator shape becomes less elliptical, the number of effective semi-elliptical-shaped thin-line dipoles of various lengths appears to decrease resulting in a narrower bandwidth. This particular elliptic dipole is designed at an ellipse minor to major diameter ratio of 0.813. We have also fabricated elliptic dipoles with reduced minor to major diameter ratios of 0.800 and 0.750 and found that the impedance performance starts to fail.

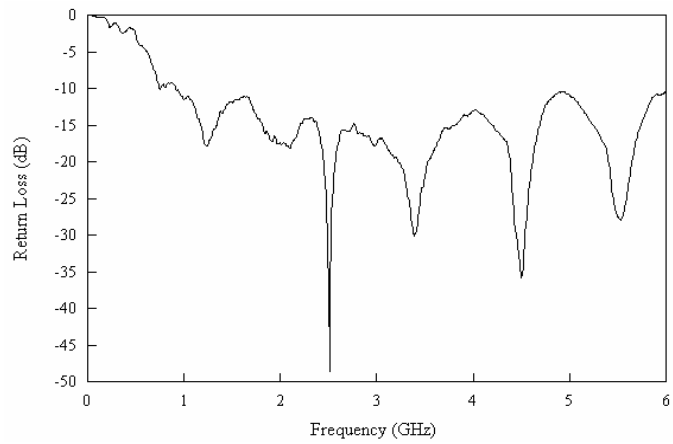

Fig. 2. Measured return loss of the (*90 mm x 150 mm*) elliptic dipole

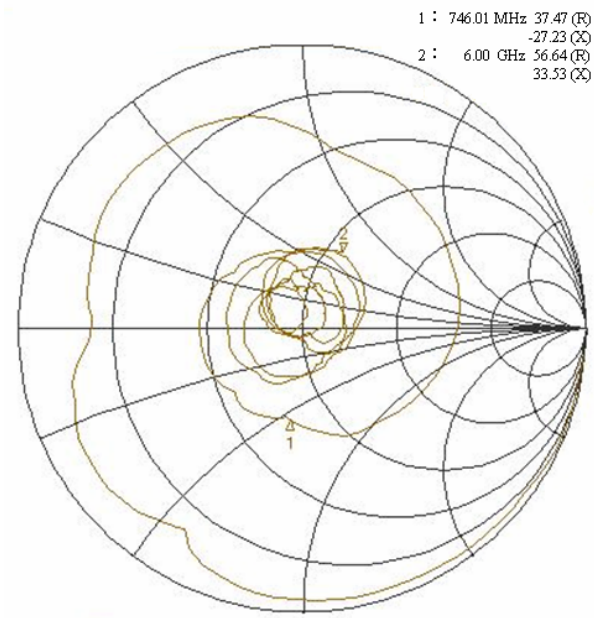

Fig. 3. Smith chart display of the (*90 mm x 150 mm*) elliptic dipole

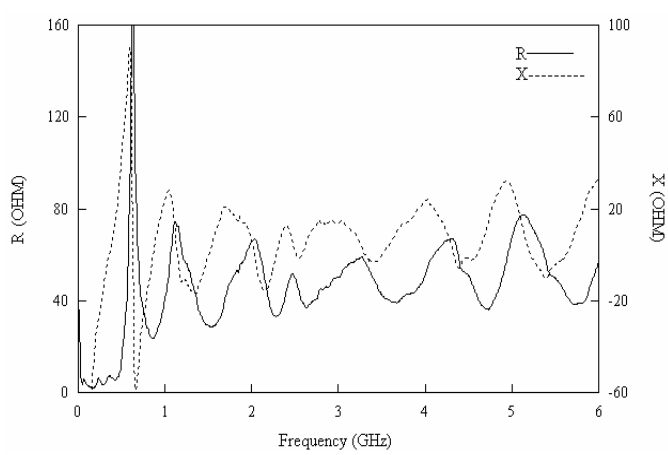

Fig. 4. Impedance versus frequency of the (*90 mm x 150 mm*) elliptic dipole

III. RADIATION PATTERNS

The third part of our experiments involved investigating the radiation patterns of the elliptic dipole. Radiation patterns on the x-y, y-z, and x-z planes of the elliptic dipole antenna (90mm x 150 mm) at 1.0, 3.5, and 6.0 GHz were measured in an anechoic chamber and are shown in Fig. 5, Fig. 6, and Fig. 7 respectively. Results indicate reasonable omni-directional radiation patterns on all the three planes. Consistency of the patterns, similar to a typical dipole radiation pattern, can be observed across the frequency band.

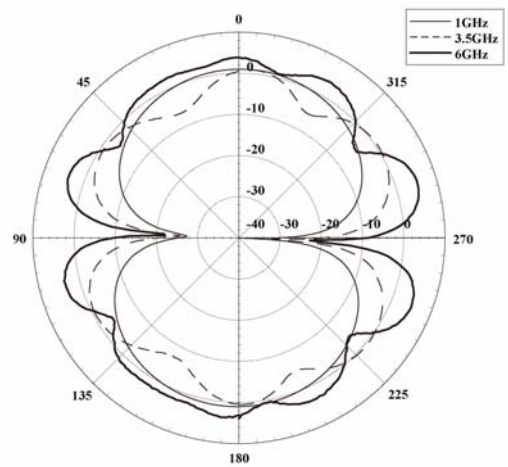

Fig. 5. Measured radiation pattern on x-y plane of the elliptic dipole

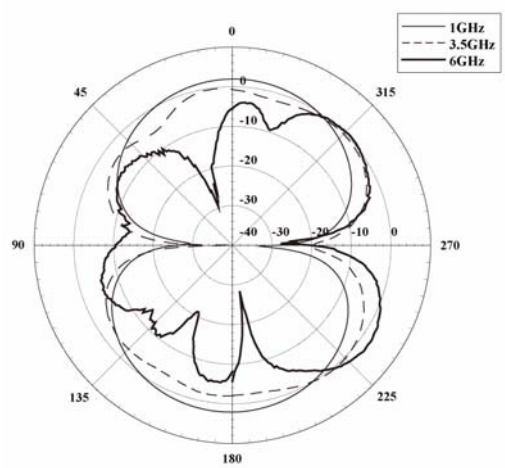

Fig. 6. Measured radiation pattern on y-z plane of the elliptic dipole

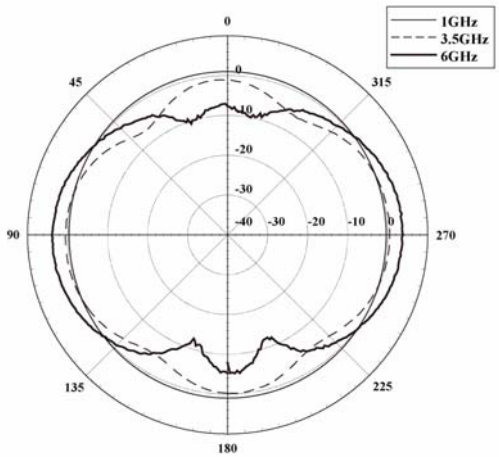

Fig.7. Measured radiation pattern on x-z plane of the elliptic dipole

IV CONCLUSION

We have shown that, with a proper choice of minor and major diameters, a printed-circuit elliptic dipole antenna using a simple single-feed network can provide a useful operating bandwidth from 750 MHz to 6 GHz. The swept frequency return loss, impendence and radiation patterns have been investigated. By properly choosing the minor diameter for the dipole made of FR4 PCB of about 0.333 times the guided wavelength, the starting operating frequency can be easily located for the system design.

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