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DESIGN OF A DUAL MONOPOLE ANTENNA WITH WIDEBAND FREQUENCY

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Abstract—In this article, a design for wideband dual-frequency folded dual monopole antenna is presented. By the proper choice of the dimensions of the Y-shape patch and the gap distance for the feeding structure, an additional resonant mode and wide impedance matching can be realized. Both simulated and experimental results, such as antenna impedance bandwidth, antenna radiation characteristic, and antenna gain have been presented and discussed. The lower impedance bandwidth covers from 8.78 GHz to 9.05 GHz, and the upper impedance bandwidth covers from 11.64 GHz to 12.01 GHz.

1. INTRODUCTION

In recent year, wireless communications have gained a wider and wider popularity. Presently, the trend is that of providing a wireless link to every kind of electronic device in parts of our daily lives. In this framework, personal digital assistants (PDAs), notebooks, mobile phone are becoming constitutive elements of new generation networks [1–5].

In order to afford efficient of mobility, the wireless communication devices are required becoming smaller [6–8]. Antennas, which play an important role in wireless communication, are also increasingly required to become smaller, lightweight and conformal to the structure of the mobile terminal, while maintaining the high gain characteristics. In particular, it is important mentioning that the strongest limitation in antenna design for smaller wireless systems is the radiating element size [9–12].

Many antennas have been designed for wireless application, but the resulting size of the final layout often comes out to be too bulky to be integrated in any part of the mobile terminal [13–15]. Moreover, by using small antenna the quality factor of undersized antennas increases due to the proximity of a grounding surface and the high electric current density, reducing the antenna's bandwidth. Meanwhile, an increase in the electric current density causes the impedance to rise, increasing Joule losses, and thereby decreasing the antenna's gain [16–19]. However, existing dual monopole antennas generate a mutual inductance, typical of a radiator with a monopole structure [20–26]. This has a negative influence on the radiation efficiency of the antenna, as it increases the reactance [27–31].

In this article, a simple antenna design in that dual monopole structure was folded at each end, so as to change the reactance value caused by the coupling between lines. Therefore, the antenna overall performance can be increase. Besides that, to fulfill mobility efficiency, cost effective, and allow large number of production, a planar printed structure in the form of microstrip antenna is employed. Detail of the investigations based on experiments and simulations of the proposed antenna are described.

2. ANTENNA DESIGN

The geometrical configuration of the proposed wideband dual-frequency folded dual monopole antenna is shown in Figure 1. For the design studied here, the radiation element, and the feeding line are printed on the same side of a microstrip patch substrate of thickness 0.813 mm (h) with a dielectric constant $\varepsilon = 3.38$ while the other side is ground plane of the antenna.

The transmission line, which consists of a signal strip thickness of W_f and a gap distance of g between the single strip and the coplanar ground plane, is use to feeding the antenna. Two equal finite ground planes, each with dimensions of length, L_g and width, W_g, are situated symmetrically on each side of the antenna feed line. The basic of the antenna structure is a patch element with a Y-shape patch element with varying the L_1, L_2, W_1, and W_2 length in order to get the optimum outputs. In this study, the dual-frequency wide impedance matching capability is provided by the use of the electromagnetic coupling effect of the ground planes to both feed line and the Y-shape patch. By properly selecting the antenna's geometric parameters numerically and experimentally, the optimum wideband dual-frequency antenna characteristic can be obtained while maintaining the antenna in smaller size.

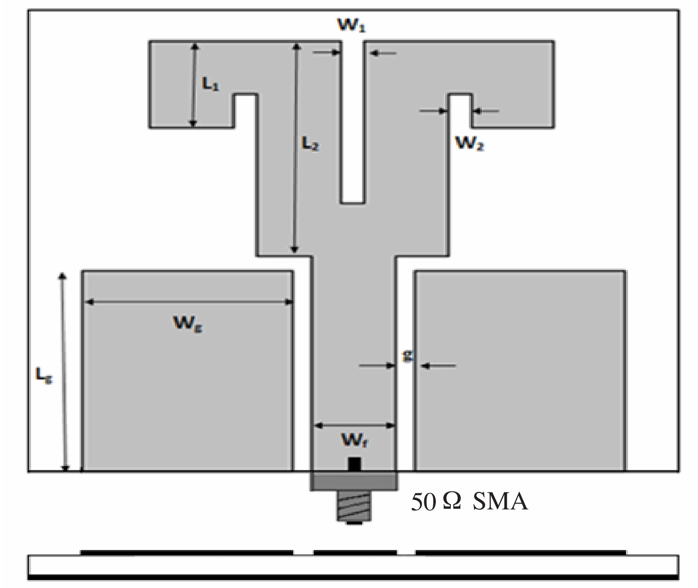

Figure 1. Geometry of proposed folded dual monopole antenna [6].

The geometric parameters were adjusted carefully and, finally, the antenna dimensions were obtained as shown in Table 1. Thus, the proposed antenna can be fabricated, and the experimental results of the antenna input impedance and radiation characteristics are presented and discussed. The wideband dual-frequency folded dual monopole antenna is shown in Figure 2.

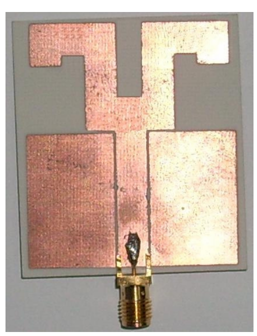

Figure 2. The fabricated wideband dual-frequency folded dual monopole antenna.

Table 1. Antenna dimensions.

Parameter	Length (mm)
L_1	8.00
L_2	20.00
L_g	23.50
W_1	4.00
W_2	4.00
W_f	6.00
W_g	20
g	0.355

3. RESULTS AND DISCUSSION

Figure 3 shows the simulated and measured return loss against frequency for the proposed wideband dual-frequency folded dual monopole antenna. It is clearly seen that simulated two resonant frequencies at 8.92 GHz and 11.82 GHz are excited with good impedance matching. The measured lower resonant mode achieves a −10 dB impedance bandwidth of ranging from 8.78 GHz to 9.05 GHz with respect to the center frequency at 8.92 GHz, and the measured upper resonant impedance bandwidth ranges from 11.64 GHz to

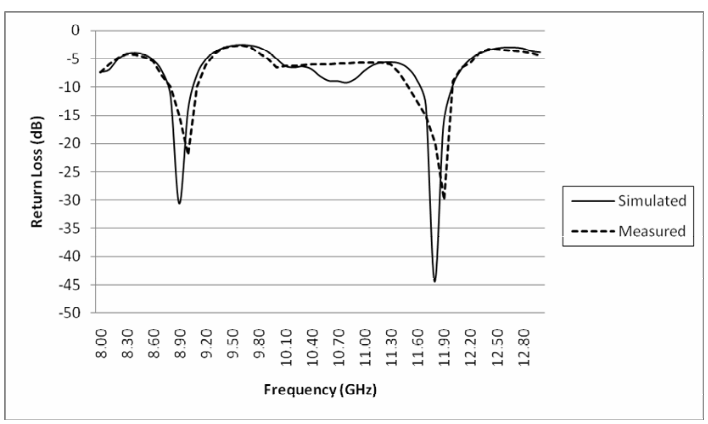

Figure 3. Simulated and measured return loss for the proposed dual monopole antenna.

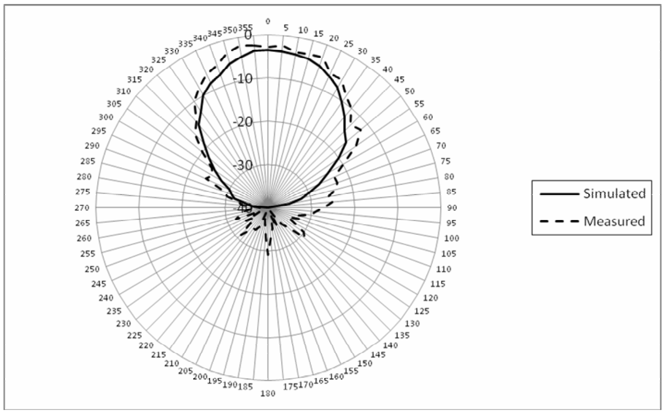

Figure 4. Simulated and measured horizontal (E_ϕ) polarization pattern at 8.92 GHz for antenna studied in Figure 2.

12.01 GHz with respect to the center frequency at 11.82 GHz. If compare the simulation result and the measured data, a good agreement is seen over the whole operating band. The discrepancies between the simulated and measured return loss may due to the fabricated deviations during the fabrication process in the laboratory. Besides that, measurement of the return loss is not done in the free space where there is no other interruption that will absorb the signal been transmitted.

The far-field radiation patterns for the proposed wideband dual-frequency folded dual monopole antenna are also examined. From Figure 4 until Figure 8, shows the comparison between the simulated and measured radiation pattern including the horizontal (E_ϕ) and vertical (E_θ) polarization pattern for the antenna at lower band of 8.92 GHz and upper band 11.83 GHz.

Due to the much symmetry in structure of the proposed wideband dual-frequency folded dual monopole antenna, rather all symmetrical radiation are seen in the horizontal and vertical planes as depicted in the plot. Typically, the radiation under the ground plane should be zero as same with the simulation radiation pattern. This is because the ground plane of the microstrip patch antenna serves as a reflector for all the radio frequency. This means, all the transmitted signal will be reflected back to the source. There are several factors that can cause the radiation under the ground plane. One of the main factor is the entities such as metallic device in the laboratory act as reflectors as they reflected the transmit signal to the patch antenna. Moreover, the SMA connector which is solder on the patch dielectric

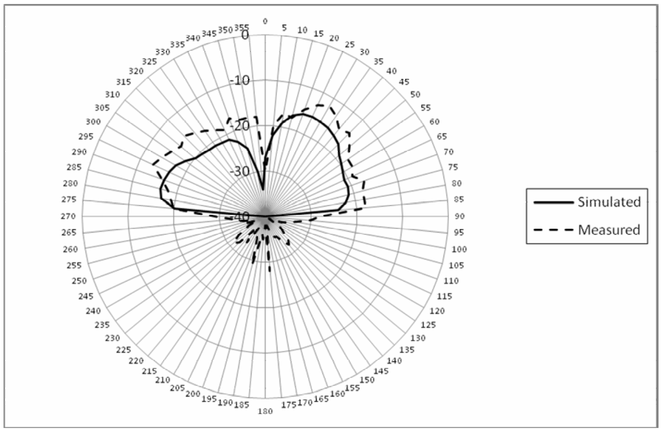

Figure 5. Simulated and measured vertical (E_θ) polarization pattern at 8.92 GHz for antenna studied in Figure 2.

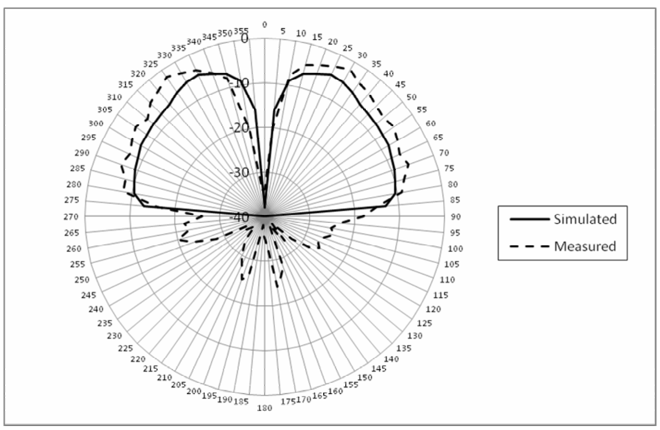

Figure 6. Simulated and measured horizontal (E_ϕ) polarization pattern at 11.83 GHz for antenna studied in Figure 2.

substrate, connectors and adapters used for connecting different types of transmission lines and power splitters can also causes the inaccuracy of the result.

Finally, the simulated and measured antenna gain for the lower and upper band is obtained and discussed. From simulation, the proposed wideband dual-frequency folded dual monopole antenna's gain for lower band is 9.465 dBi and is 9.996 dBi for the upper band resonant frequency. However, the measured antenna's gain for the

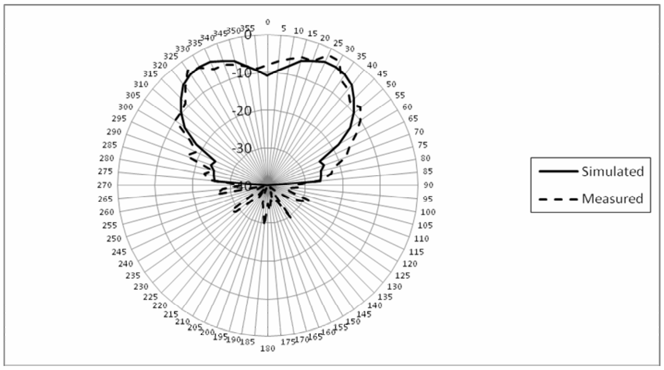

Figure 7. Simulated and measured vertical (E_θ) polarization pattern at 11.83 GHz for antenna studied in Figure 2.

lower band is 6.353 dBi and 7.021 dBi for the upper band resonant frequency. The measured gain is calculated from the Friss equation [5], which is shown in equation (1).

$$P_r = P_t \cdot G_t \cdot G_r \cdot \left(\frac{\lambda}{4\pi R}\right)^2 \tag{1}$$

Where,

P_r = the received power (Watts)
P_t = the transmit power (Watts)
G_t = the gain of the transmitter
G_r = the gain of the receiver
λ = the wavelength of the proposed antenna (meters)
R = distance between transmitter and the receiver (meters)

From the results of the simulated gain and measured gain, can be note that the offset between the simulation and measurement result is quite high. This may caused by the fabrication quality on the microstrip patch substrate during the prototype process in the laboratory. Loss in the SMA connector that connected to the coaxial cable and the proposed folded dual monopole antenna also can cause the inaccuracy in the measurement result.

4. CONCLUSION

A novel design of wideband dual-frequency folded dual monopole antenna which is constructed by two monopole structure with both ends are folded is proposed. The measured results such as return loss, radiation pattern, and the gain of the proposed antenna is obtained and compared with the simulation results and the overall performance of the antenna still can be considered in good condition. The proposed folded dual monopole antenna has a very simple structure, which makes the design simpler and fabrications easier, and is very suitable for applications in the access points of wireless communications.

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