

## A Compact CPW-Fed Curved Meander Line Monopole Antenna (MLMA) for GSM Application

Nor Afifah Borhan, Noor Asniza Murad\*

Communication Department Engineering, Faculty of Electrical Engineering, University of Technology  
Malaysia, 81310 UTM Johor Bahru, Johor

\*Corresponding author, e-mail: asniza@fke.utm.my

### Abstract

Monopole antenna is widely used in many communication systems especially in broadcasting where omnidirectional pattern allow the 360-degree coverage. However, at low frequency the conventional design may require miniaturization to fit in versatile spaces. Thus, this paper discusses a low cost, compact CPW-fed curved meander line monopole antenna (MLMA) designed to operate at 0.9 GHz GSM band. The overall dimension is 25mm x 80mm. The antenna is well matched at required GSM band with the bandwidth from 0.88 GHz to 0.93 GHz. Comparison between the conventional MLMA and curved (MLMA) is made in term of return loss and gain. It was found that the curved MLMA has a better gain compared to the conventional MLMA which is 1.472 dB.

**Keywords:** GSM, Meander Line Antenna, Compact Antenna, Monopole Antenna

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### 1. Introduction

The rapid growth of wireless communication has led to more versatile, compact and lightweight devices. To meet the miniaturization of these modern communication equipments, the design of a compact antenna is definitely crucial. Compact portable devices became an interest in many applications. Monopole antenna have been found extensively in mobile communication application due to its simple structure, omnidirectional radiation, low profile and low manufacturing cost. Eventhough the conventional monopole antenna is already small, further size reduction is needed to satisfy the space limitation of the hand held and portable terminal.

Omnidirectional antennas are usually used in point to multipoint communication system. The antenna can achieve 360 degrees omnidirectional homogenous radiation in horizontal plane while having relatively narrow beam in vertical plane. It has been used in broadcast system such as GSM, WiFi, and WiMAX. The radiation power is distributed evenly to cover 360 degrees coverage. Thus, the gain is eventually low. The gains of the antenna need to be improved in order to enhance the reception and increase the communication distance.

A numbers of researchers have proposed omnidirectional antennas with high gain. For instance, coaxial collinear antenna adopting multiple coaxial radiators were discussed in [1-2]. The gain was increased but the bandwidth is relatively narrow. Printed dipole array antenna is another technique discussed in [3]. The antenna was fed by a balanced microstrip line. The close arrangement of the array elements make it able to radiate in omnidirectional pattern. Another kind of antenna is a CPW cross-fed proposed in [4]. It has been improved with broadband radiant load in [5]. The antenna possess up to 8dBi gain.

At frequency that below than 1 GHz, meander line antenna is a smart choice in designing a compact antenna for GSM. Besides that, it is proved that the meandering technique may improve the gain of the antenna by optimizing the height of the meander line [6]. The effects of horizontal, vertical and conductor length of the meander line antenna is studied in [7] and it shows that the meander line antenna may have an omnidirectional radiation.

In this paper, a CPW-fed curved meander line monopole antenna (MLMA) for GSM operations at 0.9 GHz is proposed. The antenna is printable on a single metal layer meander line technique for size reduction purpose is discussed.

### 2. Curved Meander Line Monopole Antenna

Figure 1 shows the geometry of the proposed curved meander line monopole antenna for GSM application. The antenna is designed on Fr4 substrate with thickness 1.6mm, copper thickness 0.035mm and relative permittivity of 4.3 and simulated using Computer Simulation Technology (CST) 2014. A 50 Ω CPW transmission line is used to excite the antenna. The CPW-fed technique has several advantages include a simple, easy to fabricate by using a single metallization layer on a substrate and comprehensive radiation. The feed of the antenna is fixed at 3.2mm and step impedance technique is applied so the feed is matched to the meander line monopole. The total dimension of the antenna is 25mm x 80 mm which equivalent to  $0.075\lambda \times 0.247\lambda$ . Table 1 shows dimension of the antenna parameters.

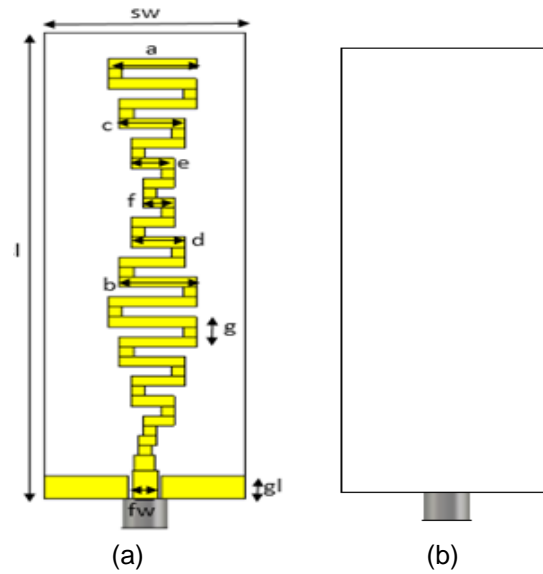


Figure1. Geometry of the proposed antenna (a). Front view (b). Back view

Table 1. Antenna Parameters Dimension

Parameters	<i>s/l</i>	<i>sw</i>	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>E</i>	<i>f</i>	<i>g</i>	<i>fw</i>	<i>gl</i>
Dimension(mm)	80	25	10.95	10	9.55	8.15	6.75	5.35	3.95	3.2	4

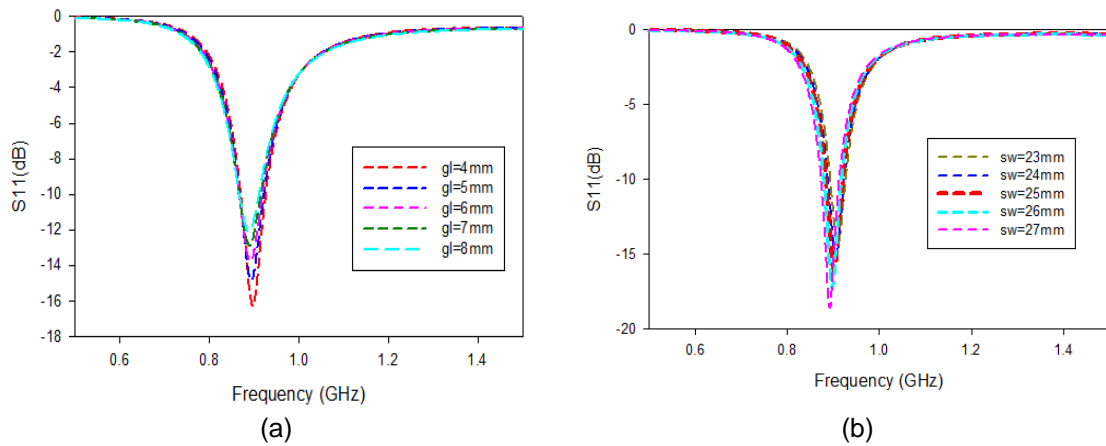


Figure 2. Parametric studies of: (a) CPW length, (b) Substrate width

Parametric studies had been done to optimize the antenna dimension. Parameters that were taking into consideration are the length of the CPW,  $g_l$  and substrate width,  $sw$ . From Figure 2(a), as the length of the CPW gets longer, the return loss of the antenna gets higher. It is due to the coupling effect of the feed of the antenna and the CPW. Figure 2(b) shows the effect of varying the substrate width of the antenna. Although it does not give much significant difference, it's still important for the minituarization purpose.

### 3. Results and Discussions

As seen from Figure 3, two different structures of meander line monopole antenna (MLMA). Figure 3(a) is the conventional MLMA while Figure 3(b) is the curved MLMA. Both conventional and curved MLMA has equal total dimension but the total electrical length is slightly different as the electrical length of conventional MLMA is 212.16mm and the electrical length of curved MLMA is 236.25mm. Besides that, the number of turns of meander line also same which is 18 turns. This results to the same return loss -16.12dB at GSM frequency 0.9 GHz as shown in Figure 4. Both antennas posses same bandwidth from 0.88 GHz to 0.93 GHz. However, the maximum width of the meander line is different. Meander width for the conventional MLMA is 5.77mm and maximum meander width of the curved MLMA is 10.95mm. Maximum width of both antennas is varied using a multiplier,  $m$ . As value of  $m$  is increased, the width of the meander line also increases. For both conventional and curved MLMA, value of the multiplier is optimized and set to 2.0.

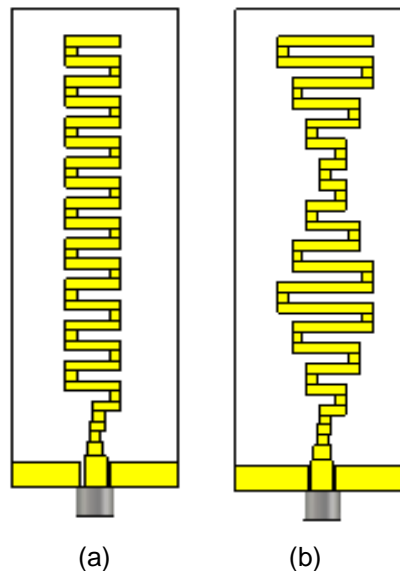


Figure 3. (a) Conventional MLMA; (b) Curved MLMA

The radiation pattern of both conventional MLMA and curved MLMA is shown in Figure 5. Both antennas have an omnidirection radiation that makes it suitable to be used for GSM application. However, there is significant difference on the gain of the antennas. The gain of conventional MLMA and curved MLMA is 0.0418dB and 1.472 dB respectively. Eventhough the gain of the curved MLMA is not very high, it is proved that this technique of meandering can improve the gain of the antenna compared to the conventional antenna. Figure 6 shows the comparison between conventional and curved MLMA on the gain of the antenna as the multiplier,  $m$  is varied. As the multiplier are increases, the electrical length also increases. Therefore, the coupling effect between every turn of the meander line is more thus reducing the gain of the antenna. Figure 7 shows the surface current of the curved MLMA. The current is distributed fairly through every turn of the meander line.

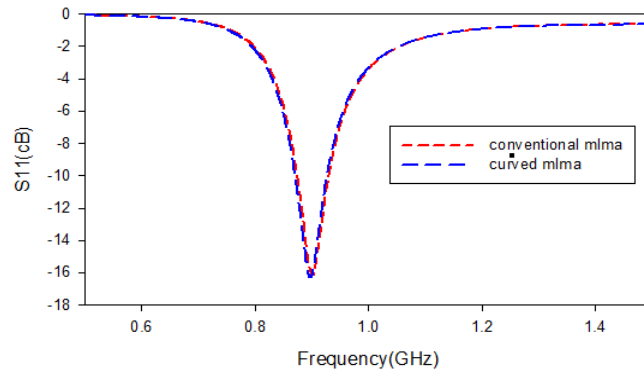


Figure 4. Return loss of the antennas

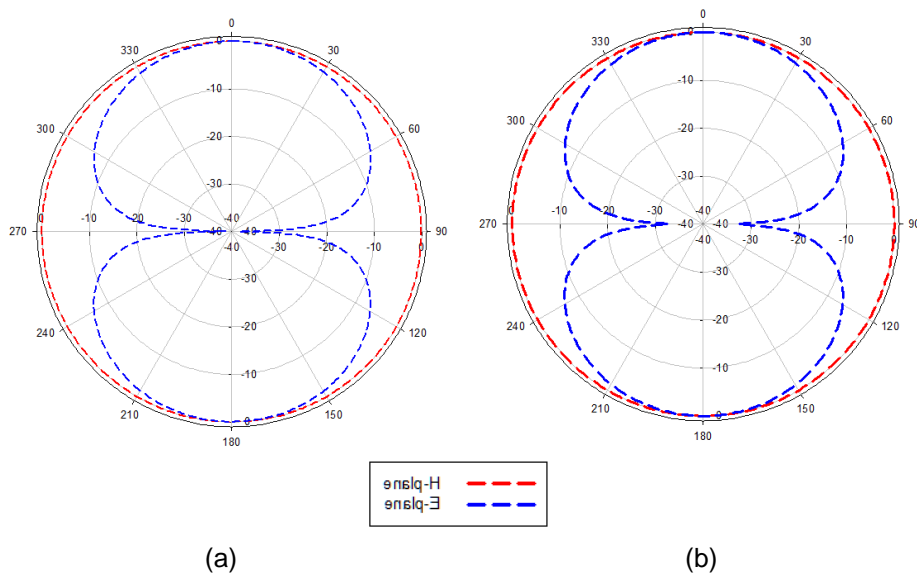


Figure 5. Radiation pattern of the antennas (a) Conventional MLMA; (b) Curved MLMA

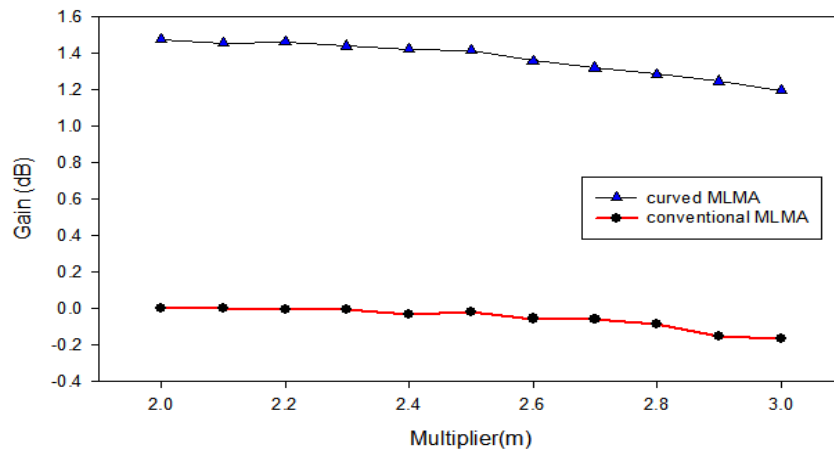


Figure 6. Gain of the conventional MLMA and curved MLMA

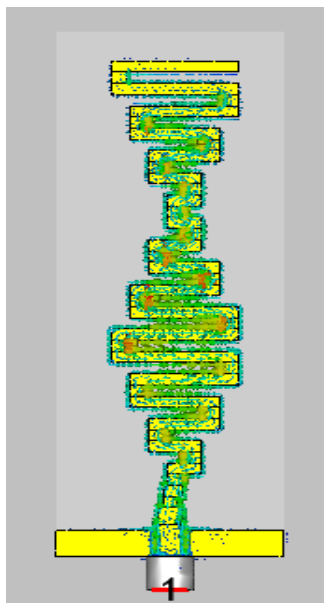


Figure 7. Curved MLMA surface current

#### 4. Conclusion

A curved MLMA with omnidirectional radiation and improved gain is discussed. The antenna operates at 0.9 GHz GSM band with bandwidth from 0.88GHz to 0.93 GHz. The total dimension of the antenna is 25mm x 80mm which is smaller compared to its total wavelength. The gain is 1.472 dB with omnidirectional pattern satisfy the need of GSM application.

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