Designing CPW Fed Meander Line Antenna and Its Impedance Matching Circuit for L-Band Applications

Alireza Sharifi
Faculty of Engineering, University of Zanjan, Zanjan, Iran
([1] arsharifi@znu.ac.ir)

***Abstract*— In this paper the band width of a small CPW fed meander line antenna and the matching circuit which is composed of LC lumped elements is increased in the L-band. The antenna structure for operating at center frequency , 1.5 GHz, with 300 MHz bandwidth is designed and simulated in the HFSS full-wave software at first. Then using MWO software a proper matching circuit is designed to increase the reflection coefficient band width of the proposed antenna in the frequency range 1-2 GHz. The obtained reflection coefficient of the designed structure by this method has become better than -8 dB in the assumed frequency range while the antenna radiation pattern remains almost unchanged.**

***Keywords*— Coplanar Waveguide (CPW); Meander Line Antenna (MLA); Radiation Pattern; Impedance Matching**

I. Introduction

Antenna is an indispensible part in communication systems. In mobile communication systems, using small and light weight antennas is preferred. Meandering is a method to decrease the antenna dimensions. Printed circuit meandering antennas have been found useful in mono band and multi band WLAN applications [1],[2]. These antennas were used in RFID circuits too [3]. They can be fed by microstrip transmission lines or by coplanar waveguides [4] and etc. Feeding the meander line antennas by CPWs has advantages over feeding them with microstrip transmission lines. In CPWs the radiation losses and dispersion effects are less than microstrips. They are more compatible with SMD elements. In implementing lumped elements circuit networks with CPWs, the need for constructing via holes is eliminated. In [4] closed form relations are presented to describe the characteristics of CPWs.

The main problem with meander line antennas is their limited bandwidth. As far as author knows, these antennas have not been designed and optimized in the L- band yet. The L-band is dedicated to special applications like satellite navigation, amateur radio, aircraft surveillance and so on. In this paper several techniques which involve altering the feed line and matching circuit are used to solve this problem. In the second part of the paper, the structure and geometric dimensions of the designed antenna is demonstrated and in the third part, a matching circuit using lumped elements, is presented to increase the bandwidth of the antenna reflection coefficient.

II. Geometric Structure and Antenna Radiation Pattern

Figure 1, shows the geometric dimensions of the designed CPW fed meander line antenna. This antenna is implemented on RT/duroid 5880 substrate with relative dielectric constant 2.2 and thickness 15 mil = 0.381 mm. The design frequency is assumed in the L-band (1-2 GHz). Table 1 contains the physical dimensions of the designed antenna. The input impedance of printed meander line antenna is about 100 ohms at the center frequency, so to match this impedance to the 50 ohms impedance of the feed input, two series CPW transmission lines are used. The first transmission line has the characteristic impedance about 66 ohms and electrical length about 20 degrees at the center frequency. the second transmission line has characteristic impedance and electrical length of about 86 ohms and 20 degrees respectively. To further impedance matching, a small printed line with length L3 and width W3 connects the CPWs to the meander line antenna. Figure 2, shows the simulation of antenna in HFSS software [5]. Figure 3 presents the reflection coefficient of the proposed antenna in the frequency range 0-3 GHz, obtained by HFSS software. It can be observed that the antenna dimensions are designed so that the reflection coefficient at the center frequency is reduced to about -22 dB. At least, 300 MHz of 10 dB bandwidth is obtained. Figure 4 presents the smith chart of the designed antenna reflection coefficient and Figure 5 shows the antenna radiation pattern at 1.5 GHz. It can be seen from this figure that the antenna patterns in the xz plane and yz plane approximately equal to the pattern of a half wavelength dipole antenna [6]. Figures 6(a), 6(b) and 6(c) show the antenna radiation patterns in $xz(\varphi=0)$ and $yz(\varphi=90^\circ)$ planes, respectively at 2 GHz, 1.5 GHz and 1 GHz. It is deduced that the antenna radiation pattern in the design frequency band almost remains equal. Figure 7 shows the antenna surface current distribution at 1.5 GHz. It is clear from this figure that like half wavelength dipole antenna, the current amplitude has its maximum at antenna input and faces to its minimum at the antenna end. Figure 8, shows the normalized directivity of the designed antenna at 1.5

GHz at xz plane. this figure shows that the half power beam width (HPBW) of the proposed antenna is approximately 60 degrees and is decreased in comparison to half wavelength dipole antenna, with HPBW equal to 78 degrees. The overall antenna dimensions with respect to half wavelength dipole antenna is decreased but the electrical characteristics remain almost the same.

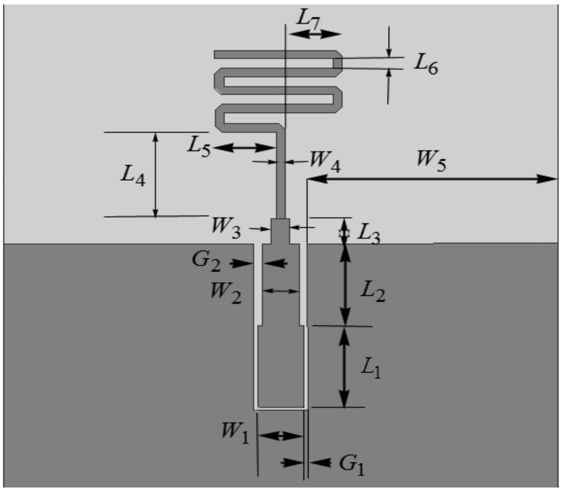


Fig. 1. Geometric dimensions of the proposed L-Band CPW fed meander line antenna.

TABLE I. PHYSICAL DIMENSIONS OF THE DESIGNED ANTENNA PRESENTED IN FIGURE 1.

$L_1 = 10\ (mm)$	$L_2 = 10\ (mm)$	$L_3 = 3\ (mm)$	$L_4 = 12.8\ (mm)$
$L_5 = 6.6\ (mm)$	$L_6 = 1\ (mm)$	$L_7 = 6.6\ (mm)$	
$W_1 = 5\ (mm)$	$W_2 = 4\ (mm)$	$W_3 = 2\ (mm)$	$W_4 = 0.7\ (mm)$
$W_5 = 27.1\ (mm)$	$G_1 = 0.4\ (mm)$	$G_2 = 0.9\ (mm)$	

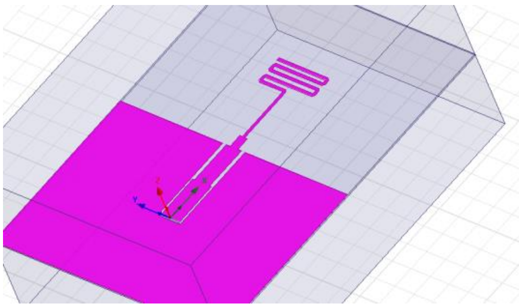


Fig. 2. Schematic of the antenna in HFSS software.

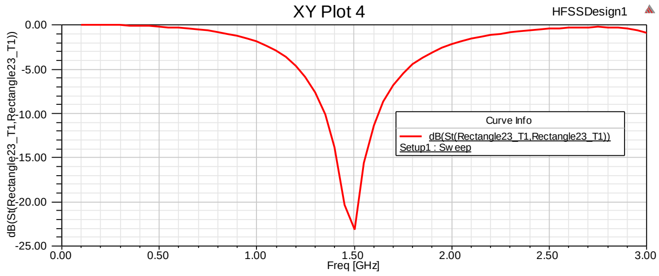


Fig. 3. The reflection coefficient of the proposed antenna in dB, in the frequency range 0-3 GHz, obtained by HFSS software.

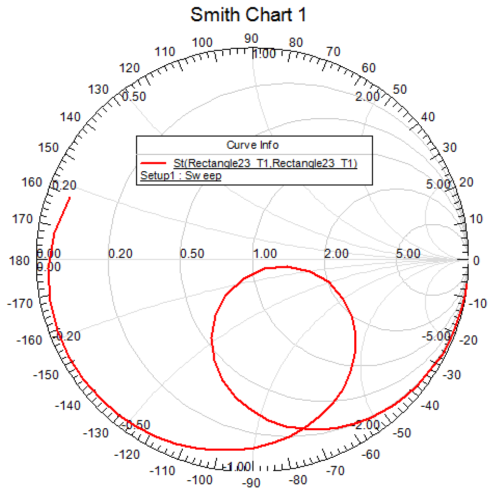


Fig. 4. The smith chart of the reflection coefficient for the designed antenna.

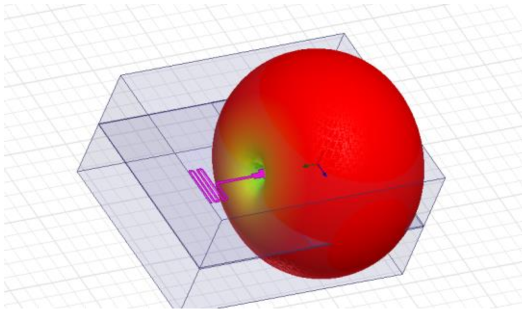
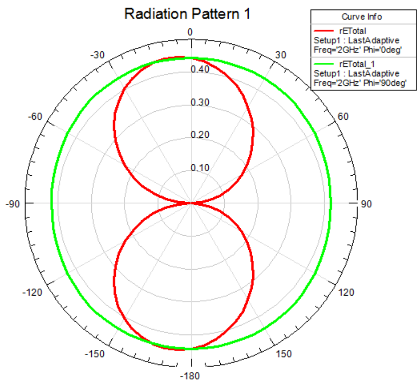
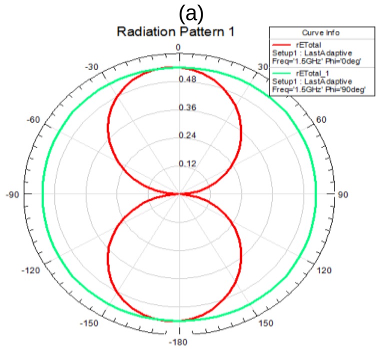


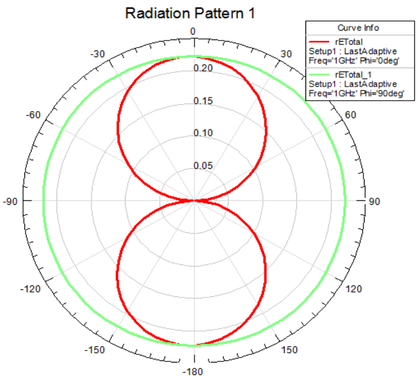
Fig. 5. The antenna radiation pattern at 1.5 GHz.



(a)



(b)



(c)

Fig. 6. The antenna radiation patterns in $xz(\varphi = 0)$ and $yz(\varphi = 90^{\circ})$ planes (a) at 2 GHz, (b) at 1.5 GHz and (c) at 1 GHz.

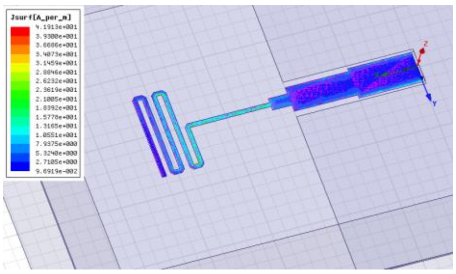


Fig. 7. Surface current distribution of the antenna at 1.5 GHz.

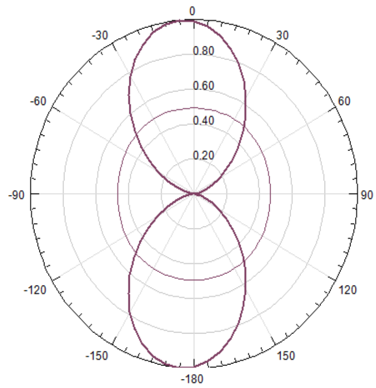


Fig. 8. Normalized directivity of the designed antenna at 1.5 GHz in xz plane.

III. Optimum Desifn of Matching Circuit for Increasing the Antenna Bandwidth

Figure 9 shows the proposed matching circuit using lumped elements to increase the antenna bandwidth in the range 1-2 GHz. This circuit is simulated in MWO software [7]. To obtain the optimum values of the elements in this circuit, the scattering matrix of the meander line antenna, illustrated in Figure 1, that was calculated by HFSS software in previous section, is imported to MWO software as a single port block and it is considered as the load of the matching circuit, as is observed from Figure 9. assuming that the input impedance in Figure 9 be 50 ohms, using different optimization techniques in MWO software, the optimum values of the circuit element are calculated and after rounding off the element values, they are written in Table 2. In optimization it is assumed that the goal function be as follows,

$$20\log|S_{11}| < -10\ (dB) \qquad 1GHz \le f \le 2GHz \qquad (1)$$

In MWO software, using "Direction set method" algorithm, the optimum values are obtained and the frequency response of the reflection coefficient from the input port, is seen from Figure 10. As it can be observed, the amount of reflection coefficient in the frequency range is less than -8 dB which is sufficient for the currently presented application. Figure 11 presents the smith chart of the proposed network in Figure 9, in the frequency range 0.1-3 GHz.

The designed element values in Table 2 are practically implementable by small SMD elements on CPW transmission lines in the antenna input. To improve the frequency response of Figure 10, similar networks like the network presented in Figure 9 may be employed with higher number of elements.

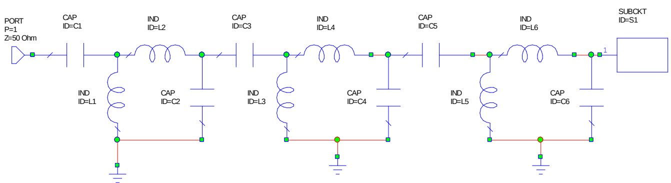


Fig. 9. The proposed matching circuit to increase the antenna reflection coefficient bandwidth.

TABLE II. OPTIMUM VALUES OF THE MATCHING NETWORK PRESENTED IN FIGURE 9, OBTAINED BY MWO SOFTWARE.

C1=726 nF	L1=458 nH
L2=1 nH	C2=3 pF
C3=409 nF	L3=401 nH
L4=2 nH	C4=1 pF
C5=409 nF	L5=3 nH
L6=3 nH	C6=1.2 pF

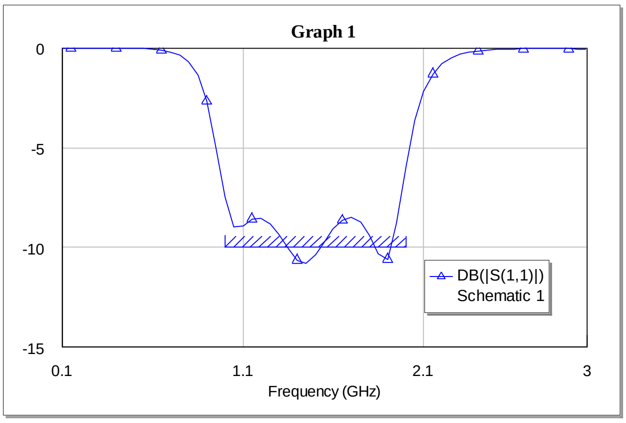


Fig. 10. The frequency response of the reflection coefficient from the input port of the network in Figure 9 in the frequency range 0.1-3 GHz.

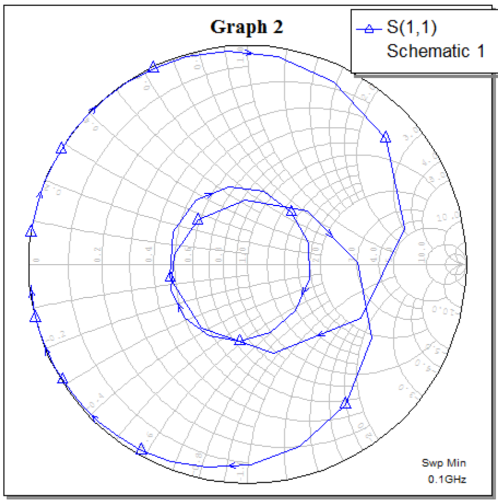


Fig. 11. Smith chart of the frequency response of the reflection coefficient from the input port of the network in Figure 9 in the frequency range 0.1-3 GHz.

CONCLUSION

In this paper, the structure of printed CPW fed meander line antenna is designed and simulated in L-band. The antenna resonances at 1.5 GHz, and its 10 dB bandwidth is 300 MHz. The antenna pattern in the frequency range 1-2 GHz remains almost unchanged. Its half power beam width almost equals to that of a half wavelength dipole antenna. In order to increase the input reflection coefficient band width of the antenna, a matching network constructed from lumped elements is employed in which the reflection coefficient remains less than -8 dB in the entire frequency range of the design.

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