# Printed–Circuit Dipole Antenna for Personal Communication Network Handset

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Abstract

This paper presents a shortened antenna designed for the personal communication network (PCN) handset operating at center frequency $f_0$ = 880 MHz. The shortened dipole antenna using meander line is printed on Duroid 6010 with dielectric constant $\epsilon_r = 10.5$ and thickness = 25 mils. A shortening ratio (SR) of 45.9 % is achieved experimentally for the printed–circuit dipole antenna (PCDA) of 9.2–cm length with respect to the $\lambda_0/2$ dipole antenna. Owing to the planar, light–weight, thin, and small characteristics the PCDA using meander line is well suited for the signal transmission and reception of the PCN handset in which the PCDA can be built in, and the antenna diversity schemes for reducing the fading effect may be utilized.

## I. Introduction

The purpose of this paper is to present a planar, light–weight, thin, and small PCDA to be used in the PCN handsets operating around 880 MHz [1]. When the antenna satisfies all these characteristics, it can be built in for convenient usage. In addition, fading reduction is also a major concern. As we know, the signal transmitted through the random environments suffers multipath–reflection, scattering, and diffraction effects, all of which cause standing wave patterns, and hence serious fading phenomonon [2]. So, it can also be utilized to reduce the fading effect using different antenna diversity schemes [3].

At first, the microstrip antennas [4] were condidered , but its radiation efficiency and VSWR bandwidth are very limited, e.g., the 2:1 VSWR bandwidth is less than 2 % for substrate thickness less than 0.01 $\lambda_0$ [5], which is not sufficient for PCN communication system. Owing to this reason, the meander dipole antennas were resorted to. The meander dipole antennas studied in [6] may lead to about 30 % shortening ratio (SR) with respect to the $\lambda_0/2$ dipole antenna, but it has less mechanical rigidity. In this paper we reserve the substrate with the flat meander dipole antenna printed on it, but with the ground conductor etched off, which is shown in Fig. 1. The flat meander dipole antenna is designed to have the omnidirectional radiation pattern of the $\lambda_0/2$ dipole antenna, and to achieve the shortening purpose as well. As to the substrate, it can let the antenna printed on it for easy manufacturing, offer some shortening effect, and also to enhance the mechanical rigidity.

In the following section, different structrures of PCDAs are considered and measured, including the meander dipole antenna.

## II. Experiments

In this section the $\lambda_0/2$ dipole antenna and four PCDAs operating at center frequency $f_0$ = 880 MHz are made. For the sakes of rigidity, symmetry, and simplicity, the split–coax balun [7] is used to balance the current distribution of each PCDA fed by the coaxial cable, which is shown in Fig. 1(a). And the SR is defined as [16]

$$SR = ( \lambda_0/2 - L ) / ( \lambda_0/2 ) \qquad (1)$$

where $\lambda_0$ = 34.09 cm.

Duroid 6010 with $\epsilon_r = 10.5$, and thickness = 0.064 cm (25 mils) is used for all the four PCDAs as shown in Fig. 1(b)–(e), and all the widths are chosen to be 1 cm for convenience, which is much less than $\lambda_0$, and hence is not critical in the radiation characteristics of the dipole antenna.

In Fig. 1(b) the dipole antenna is printed on the Duroid substrate with the ground conductor etched off, and is used to see the shortening effect of the substrate. Although its $\epsilon_r$ is equal to 10.5, yet the thickness is very much less than $\lambda_0$. So the SR is expected to be small. In order to achieve a larger SR, a strip of 4–mm width and of the same length as the dipole antenna is added to the opposite side of the previous PCDA, which is shown in Fig. 1(c). A larger SR is expected to obtain because the strip will induce some opposite charges to that of the PCDA, and hence a a larger SR may be achieved. Due to the microstrip–like structure, its radiation efficiency and VSWR bandwidth are not expected to be satisfactory. From this observation the printed–circuit meander dipole antenna is resorted to then, which is shown in Fig. 1(d). The period of the meander line is chosen to 1 cm for convenient patterning work. As studied in [6], a large SR may be obtained without sacrificing the radiation efficiency at the center frequency, but some cross polarization may be generated. Gereration of cross polarization is not a problem for PCN handset usage, because depolarization occurs in the received signal during propagation through the random terrains [2]. Quite on the contrary, the cross polarization component helps receive more signal power. Lastly, the meander dipole antenna is sandwiched with two Duroid substrates to offer a further shortening effect, and as well as to achieve protecting purpose, which is shown in Fig. 1(e).

Using HP8510 network analyzer the $|S_{11}|$ values for the five dipole antennas are measured, and shown in Fig. 2 to Fig. 6 respectively. From the measured $|S_{11}|$ we see that both the length (L) and the 2:1 VSWR bandwidth of the $\lambda_0/2$ dipole antenna are the largest. In order to give convenient comparison, the length, shortening ratio, absolute and percent 2:1 VSWR bandwidths of each dipole antenna are listed in Table 1. For antenna (a) is the $\lambda_0/2$ dipole antenna so the SR box is not filled. But owing to the use of the split–coax balun, the length of antenna (a) deviates a little from $\lambda_0/2$. In addition, the boxes of the 2:1 VSWR and percent bandwidths for antenna (c) are empty because none of its $|S_{11}|$ value satisfies the 2:1 VSWR requirement.

Observing Fig. 2 to Fig. 6, and Table 1 as well, the largest SR obtained is found with antenna (e) , and has the value of 45.9 % without sacrificing the radiation efficiency at $f_0$. Although the length of antenna (e) is the smallest – 9.2 cm which may be short enough for PCN handset usage, yet its 44–MHz bandwidth of 2:1 VSWR is the smallest, too. If 44 MHz is not sufficient for PCN communication system, then antenna (d) is recommended, because its 2:1 VSWR bandwidth has 20 MHz more ,and yet its length is just 2 cm longer.

III. Conclusion

A meander–line PCDA with 45.9 % SR and 5% bandwidth of 2:1 VSWR has been designed for PCN handset usage operating at $f_0 = 880$ MHz. Owing to its planar, light–weight, thin, and small characteristics, the PCDA using meander line is well suited for the signal transmission and reception of the PCN handset, in which the PCDA can be built in, and the antenna diversity schemes may be used for fading reduction.

Refferences

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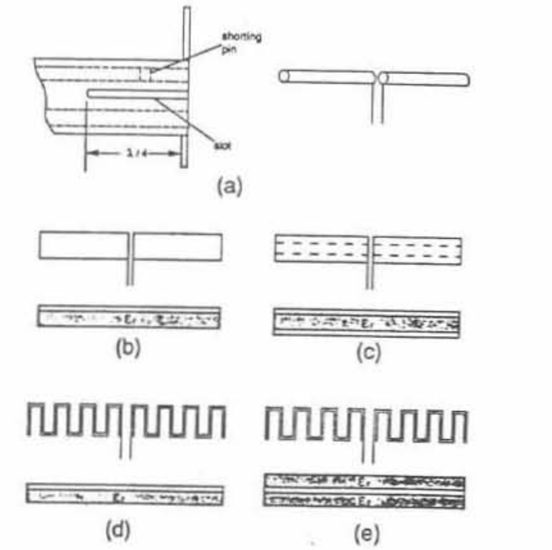


Fig. 1 Plots of the split–coax balun, the $\lambda_0/2$ dipole antenna, and the four PCDAs of various patterns.

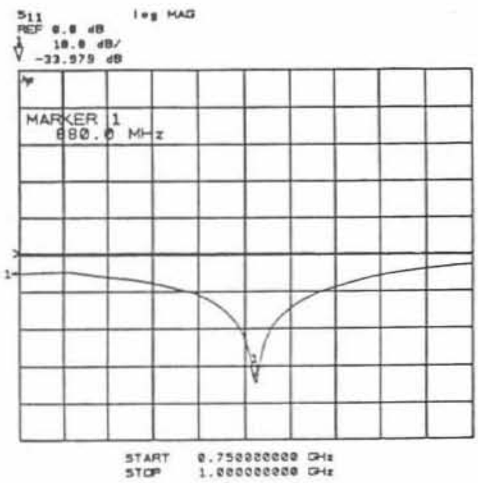


Fig. 2 $|S_{11}|$ for the dipole antenna of Fig. 1(a).

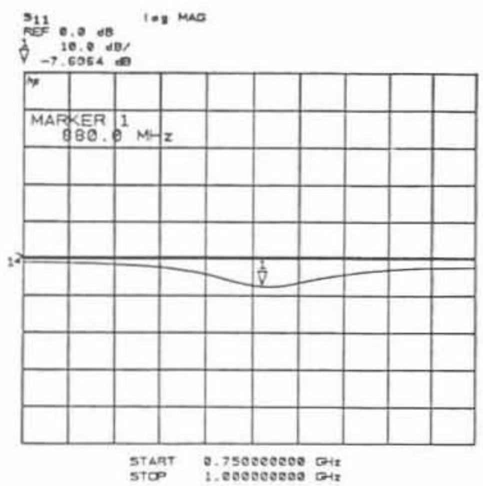


Fig. 3 $|S_{11}|$ for the dipole antenna of Fig. 1(b).

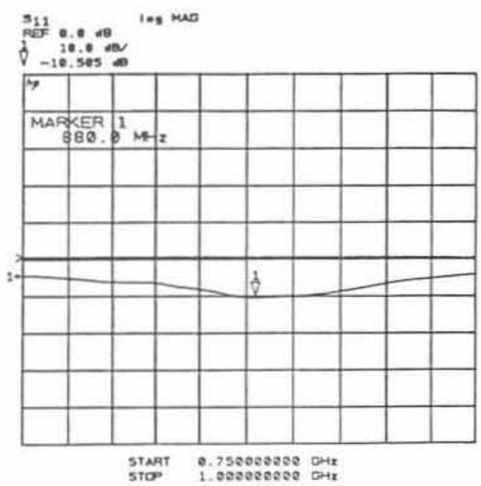


Fig. 4 $|S_{11}|$ for the dipole antenna of Fig. 1(c).

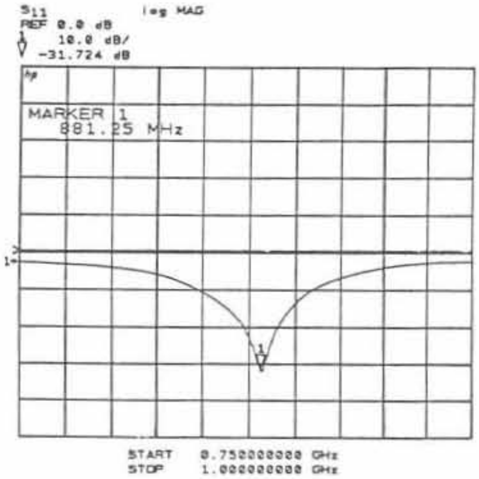


Fig. 5 $|S_{11}|$ for the dipole antenna of Fig. 1(d).

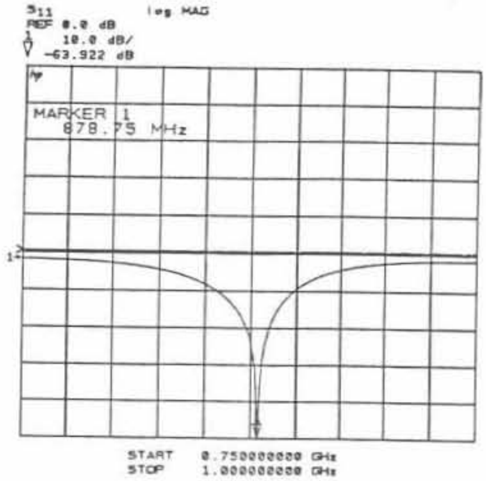


Fig. 6 $|S_{11}|$ for the dipole antenna of Fig. 1(e).

| $f_0$ = 880 MHz, $\lambda_0$=34.09 cm | | | | |
|---|---|---|---|---|
| antenna | L | SR | 2:1 VSWR BW | % BW |
| (a) | 17.4cm | ----- | 85MHz | 9.7% |
| (b) | 16.2cm | 4.7% | 46MHz | 5.2% |
| (c) | 11.2cm | 34.1% | ----- | ----- |
| (d) | 11.2cm | 34.1% | 64MHz | 7.3% |
| (e) | 9.2cm | 45.9% | 44MHz | 5.0% |

Table 1 The measured length, shortening ratio, 2:1 VSWR and percent bandwidths of each dipole antenna in Fig. 1.