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## BROADBAND DUAL-PLATE MONOPOLE ANTENNAS

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### INTRODUCTION

Planar monopole antennas employing square and other geometries have been demonstrated to have large impedance bandwidth [1-8]. A square monopole has a typical impedance bandwidth ratio (IBR) of 1:2.4 [2]. The ratio can be improved by employing a short circuit at an edge of the planar monopole [4]. A typical value of 1:4 may be achieved [2]. The introduction of short circuit also reduces the lower end matching frequency (LEMF). Significant improvement in bandwidth can also be achieved by trimming the square monopole plate, which results in an increase in the higher end matching frequency (HEMF). It has been shown by Ammann [5] that the LEMF is determined by the length of the square plate. At this frequency the length of the plate is approximately 1/5 of the wavelength. This is relatively large. It is therefore necessary to reduce the LEMF so as to improve the bandwidth at the lower end of the frequency or reduce the antenna size for a given LEMF. Dual-plate monopole antennas are thus proposed in this paper to improve the impedance performance. The investigation of the dual plate antennas and variations are described below. The experimental results of return loss of these antennas are compared with those of single plate monopoles. The radiation patterns of a dual plate antenna at various frequencies are also presented.

### SINGLE- AND DUAL- PLATE MONOPOLE ANTENNAS

The structures of the single- and dual- plate monopole antennas on a ground plane of 15cm x 15cm used for experimental studies are shown in Table 1. They include single-plate and dual plate monopole antennas without and with short circuits and/or edge trimming. Each antenna is assigned a code, with S in the first letter denoting single plate, S in the second letter indicating a short-circuited edge, D denoting dual-plate, and T indicating edge trimming. For comparison, the dimensions of the plates are kept the same, i.e. 25mm x 25mm, for all single- and dual- plate antennas. The length of the feed probe may change slightly between antennas as it is chosen for an 'optimal' performance for each antenna.

### EXPERIMENTAL RESULTS

Figure 1 shows the measured return loss response of the single plate antenna "S". The frequency range of 10dB return loss is from 2.26GHz to 5.23GHz, giving an IBR of 1:2.3. The return loss response of the shorted single plate antenna "SS" is also shown in Fig.1 for comparison. By shorting the plate at the edge, the LEMG is reduced to 1.86GHz, but the HEMF is almost unchanged. By trimming the lower edges of the plate with  $\alpha=30^\circ$ , the HEMF can be increased beyond 20GHz, as shown in Fig.2 for antenna "ST". The use of a shorting pin at the edge can again reduce the LEMF. The return loss of the antenna "SST" is also shown in Fig.2.

Figure 3 shows the measured return loss response of the dual-plate antenna "D". The frequency range of 10dB return loss is from 2.14GHz to 4.04GHz, giving an IBR of 1:1.9. The bandwidth is smaller than the single plate antenna "S", but the LEMF is slightly lower. The LEMF can be further reduced by introducing a shorting pin at one of the edges, creating the structure of antenna "DS". The return loss of antenna "DS" is compared in Fig.3. The LEMF of the "DS" antenna is 1.55GHz. In comparison with single plate antennas, the LEMF of the shorted dual-plate antenna is lowered by 17%. But the HEMF is also lowered, by 14%. By trimming the lower edges of the plates with  $\alpha=45^\circ$ , the HEMF can be increased beyond 20GHz, as shown in Fig.4 for antenna "DT". The use of a shorting pin at the edge again reduces the LEMF, as shown in Fig.4 for antenna "DST". The HEMF is however also lowered.

Both the single plate and the dual-plate types of antennas have frequency-dependent radiation patterns over the 10dB return loss bandwidth. The measured radiation patterns of the "DT" antenna at various frequencies are shown in Fig.5. The antenna radiates like a wire monopole at lower frequencies. However, the patterns, particularly the E-plane patterns, change significantly at higher frequencies.

### DISCUSSION AND CONCLUSIONS

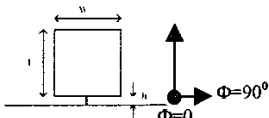
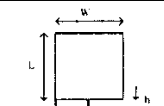
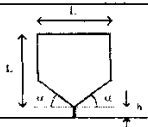
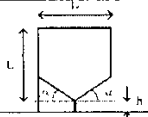
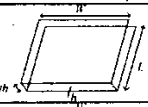
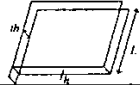
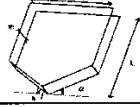

In this paper, dual-plate monopole antennas without and with a shorting pin and/or edge trimming have been studied. The experimental results of return loss

have been presented, and compared with single plate monopole antennas. It has been shown that the lower end matching frequency can be lowered by 17% by using dual plates. The higher end matching frequency can be improved by edge trimming. Despite of their frequency-dependent radiation patterns, these planar monopoles with a BWR of 1:7 or above can serve as a wideband antenna for a range of portable wireless terminals.

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Table 1: Structures and impedance bandwidth

Structure	Antenna Code & Dimensions in mm	-10dB Impedance Bandwidth, Range in GHz or Ratio
	<b>S</b> $L = W = 25; h = 1.5$	IBW = [ 2.26; 5.23 ], or [ 1, 2.3 ]
	<b>SS</b> $L = W = 25; h = 0.6$	IBW = [ 1.86; 5.20 ] or [ 1, 2.8 ]
	<b>ST</b> $L = 25; h = 1.5; \alpha = 30^\circ$	IBW = [ 2.26; >20 ] or [ 1, >8.8 ]
	<b>SST</b> $L = 25; h = 0.6; \alpha = 10^\circ$	IBW = [ 1.84; >20 ] or [ 1, 10.8 ]
	<b>D</b> $L = W = 25; h = 2.9; th = 4$	IBW = [ 2.14; 4.04 ] or [ 1, 1.9 ]
	<b>DS</b> $L = W = 25; h = 2.1; th = 4$	IBW = [ 1.55; 4.45 ] or [ 1, 2.9 ]
	<b>DT</b> $L=W = 25; h = 2; th=6.5; \alpha=45^\circ$	IBW = [ 1.89; >20 ] or [ 1, >10.6 ]
	<b>DST</b> $L = W = 25; h = 2; th = 5; \alpha = 30^\circ$	IBW = [ 1.59; 11.06 ] or [ 1, 7 ]

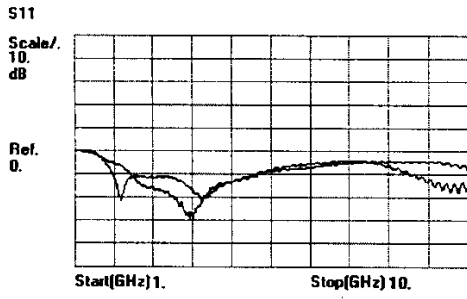


Fig.1 Return loss of antennas "S" and "SS"

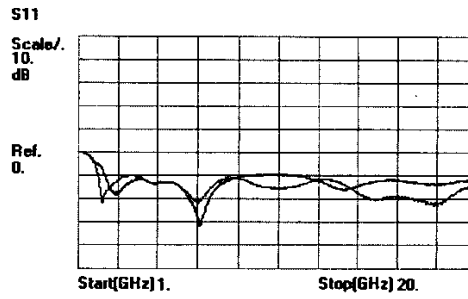


Fig.2 Return loss of antennas "ST" and "SST"

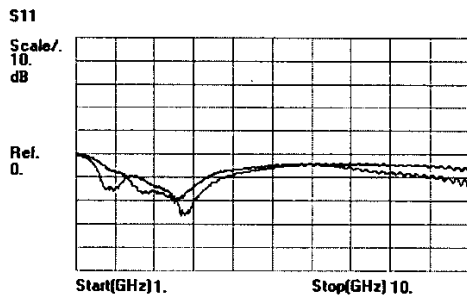


Fig.3 Return loss of antennas "D" and "DS"

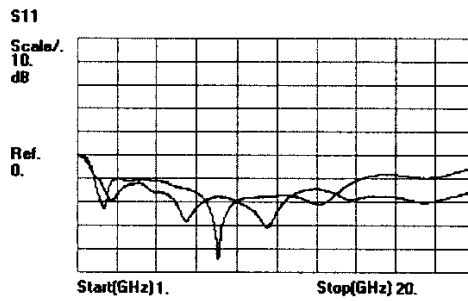


Fig.4 Return loss of antennas "DT" and "DST"

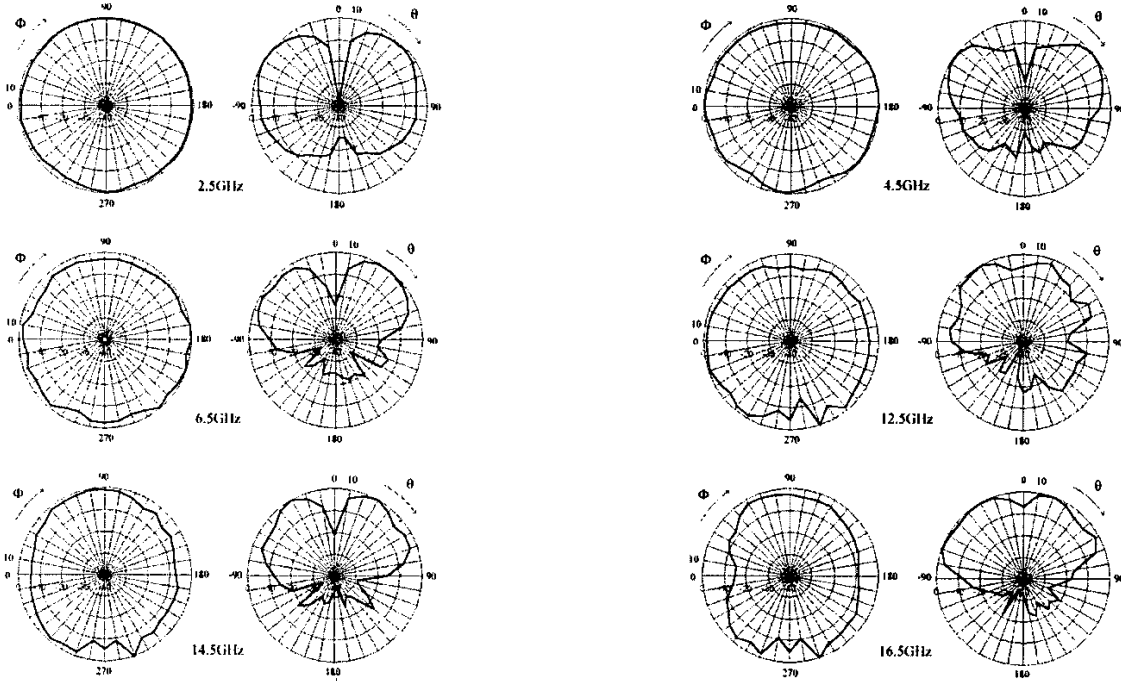


Fig.5 H-plane ( $\theta=90^\circ, \Phi$ ) patterns (left) and E-plane ( $\theta, \Phi=0^\circ$ ) patterns (right) of the "DT" antenna at various frequencies.