

Fig. 2 Photograph of fabricated prototypes

3 Numerical and experimental results of the antenna

The dimensional parameters of the antenna are studied numerically with the aid of Zeland’s IE3D, which is a MoM-based simulator. In the numerical simulation, only one parameter varied every time. The effect of adjusting s on the return loss is given in Fig. 3. It is observed that the return loss was sensitive to the value of s . When s is 1 mm, the return loss becomes lower than -10 dB from 2.9 to 11 GHz. The second parameter studied here is W_2 , which is the width of the polygon slot as $s = 1$ mm. The effect of changing W_2 on the return loss is plotted in Fig. 4. It is seen that the return loss

at high frequency band is much more sensitive to W_2 than that at low frequency band. When W_2 is 22 mm, the return loss is lower than -10 dB from 2.9 to 11 GHz.

Based on the numerical results discussed above, the dimensional parameters are determinate with $W_2 = 22$ mm, $s = 1$ mm. Some prototypes are fabricated and measured. The input performance of the antenna is simulated with Zeland’s IE3D and measured with a HP8720ET vector network analyzer (VNA). The simulated and measured return losses of the proposed antenna are plotted and compared with each other in Fig. 5.

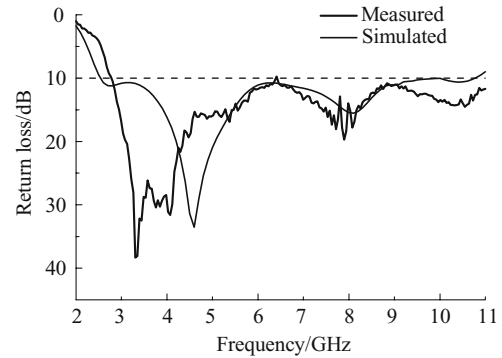


Fig. 5 Simulated and measured return losses of the proposed antenna ($s = 1$ mm, $W_2 = 22$ mm)

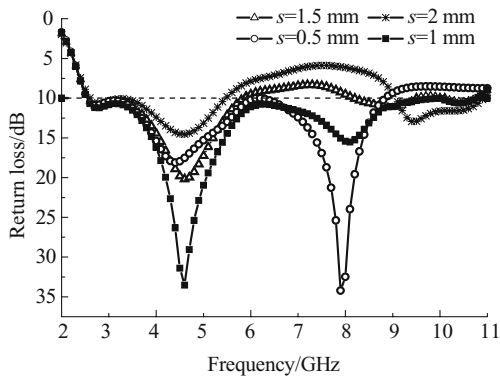


Fig. 3 Effect of s on its return loss ($W_2 = 22$ mm)

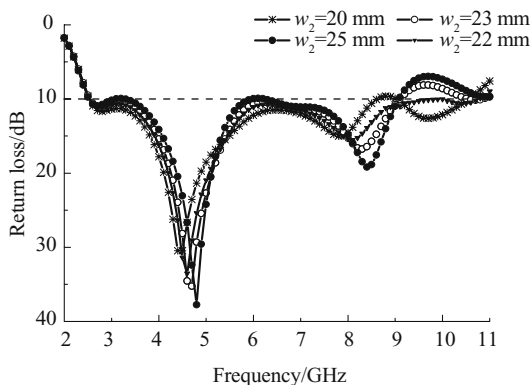


Fig. 4 Effect of W_2 on its return loss ($s = 1$ mm)

It is observed that the two results are well consistent with each other. It is also seen that the impedance bandwidth for return loss below -10 dB is from 2.9 to 11 GHz, which is more than 3.7:1. In order to investigate the radiation performance, the radiation patterns of the proposed antenna were measured in a chamber. The measured E-plane ($y-z$ plane) and H-plane ($x-z$ plane) radiation patterns at three different frequencies, 3.0, 6.0 and 9.0 GHz, are given in Fig. 6 respectively.

It is seen that the H-plane radiation patterns are relative omni-directional over the entire frequency range. Furthermore, antenna gain at $+z$ direction was also measured in a chamber, as given in Fig. 7. It is also seen that gain flatness with the maximum variation of about 1.7 dB can be achieved over the entire frequency range. The measured antenna gain is between 3 to 4.7 dB. Therefore, the antenna gain is relative constant. It may be determined that the gain bandwidth is the same as its impedance bandwidth and radiation pattern bandwidth. Thus the antenna can be determined to be an ultra-wideband antenna.

Sub-nanosecond pulses are used in UWB communication system. The transmitting/receiving antenna system can be considered as a two-port network. It is clearly that within the UWB band the magnitude of the transfer function should be invariable or flat and the phase of the transfer function should be linear. The transmission performances were measured in the chamber. A transmitting/receiving antenna system is

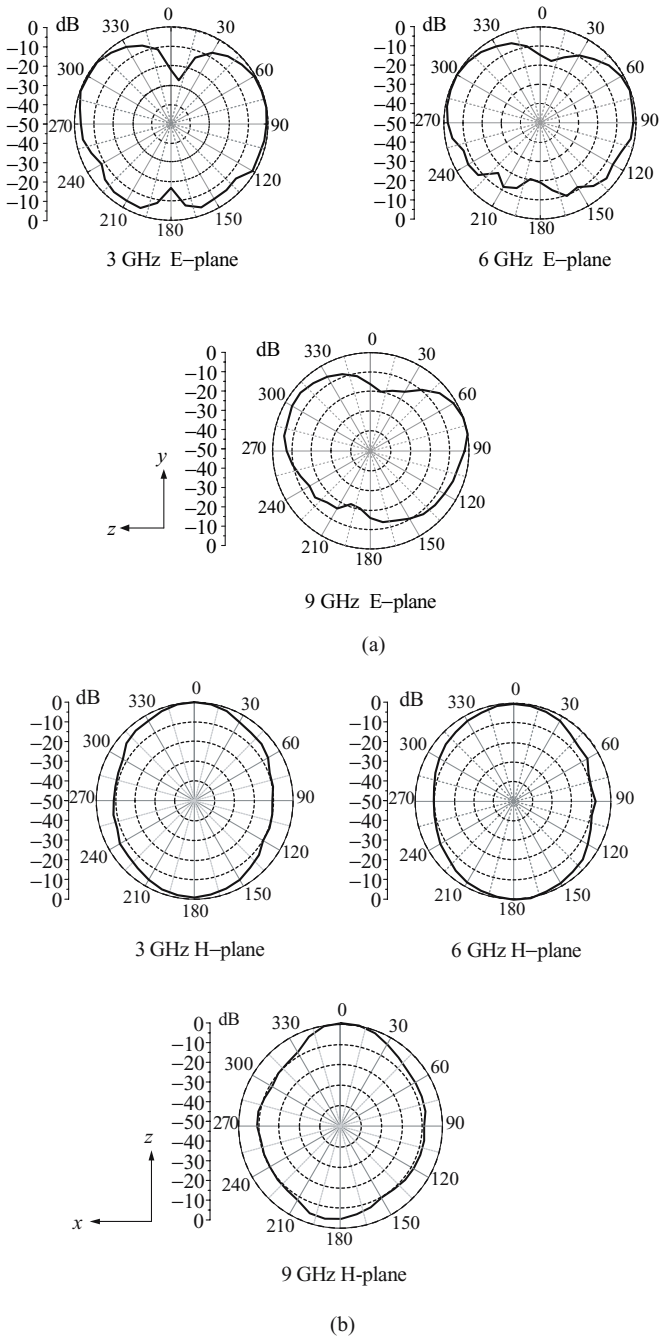


Fig. 6 Measured radiation patterns of the proposed antenna (a) E-plane; (b) H-plane

formed by two antennas. The distance between the antennas is 40 cm. The measured results are shown in Fig. 8. It is observed that the phase of the system is linear and the magnitude is flat.

4 Time domain analysis

The pulse signal fidelity of the proposed antenna must be considered in the carrier-free UWB radio systems against conventional antenna. The antenna was numerically

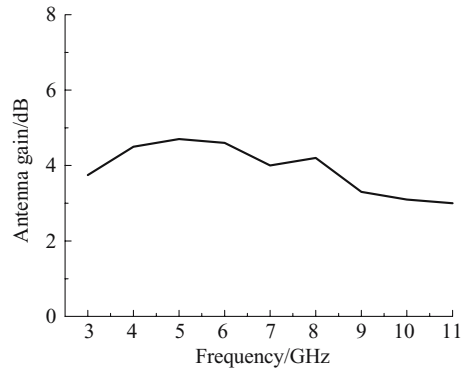


Fig. 7 Measured gain of the proposed antenna

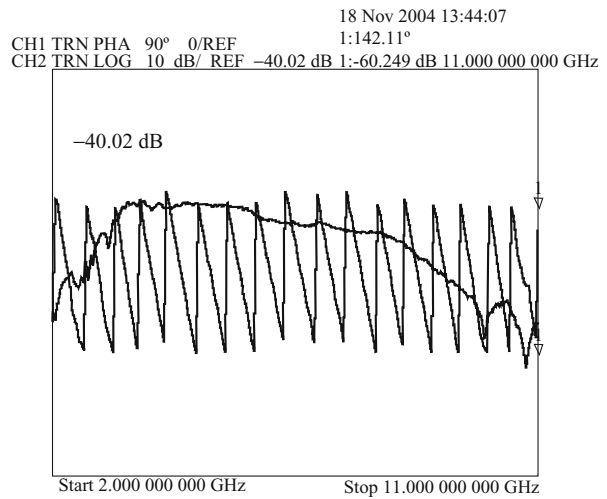


Fig. 8 Transmission performance between two antennas

simulated via utilizing FDTD method. The input pulse signal is a Gaussian pulse as

$$E(t) = \exp\left(-\frac{4\pi(t-t_0)^2}{\tau^2}\right) \tag{1}$$

where $t = 17.5$ ns, $\tau = 1.5$ ns. The waveform is shown in Fig. 9.

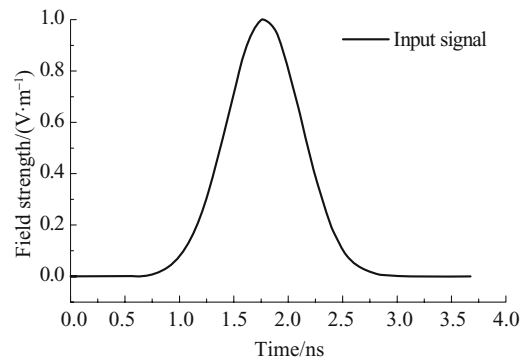


Fig. 9 Waveform of Gaussian pulse

Let $\Phi = 0^\circ$ in $+z$ direction, and the radiate pulses at $\Phi = 0^\circ, 45^\circ, 90^\circ$ are calculated respectively. Figure 10 demonstrates the results. The magnitude at the $+z$ direction is largest while the magnitude of the side is the lowest. The waveform of the pulse has a little distortion due to the deferential and reflection of the antenna even though the proposed antenna has a good pulse signal fidelity.

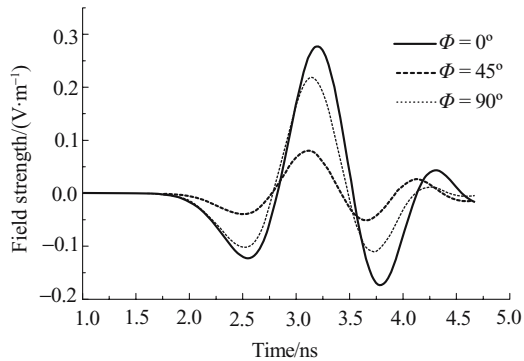


Fig. 10 Radiate pulse at $\Phi = 0^\circ, 45^\circ, 90^\circ$

5 Conclusion

In this paper, a novel, small, and compact planar antenna for UWB applications is proposed. The antenna is an extension of microstrip slot antenna technology. To achieve ultra-wideband characteristics, a tapered microstrip fork-shaped stub has been employed. A symmetric polygon wide slot has been placed on the antenna ground. The design was investigated numerically to obtain proper dimensions for the antenna and a prototype was accordingly constructed. The return loss, pattern, and gain of the prototype antenna have been measured. The transient pulse signal fidelity has also been investigated by FDTD method. The above results show that the proposed antenna has good UWB performance of over 3.7:1. Relative unidirectional radiation patterns and flat gain can be obtained over the entire bandwidth. Good pulse signal

fidelity is achieved. Experimental results demonstrate that the proposed antenna design has promising characteristics for UWB applications.

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