BroadSpec UWB Antenna

TDSR UWB Radios

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320-0385F
December 2024

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1 Summary

TDSR BroadSpec is a planar elliptical dipole UltraWideband (UWB) antenna. Its primary use is with the members of the P400 series of UWB modules. As of this date, the P400 family includes the P400, P410, P412, and P440. Members of this series are also referred to as P4xx platforms. The BroadSpec has a standard SMA connector that allows it to be connected to either port of a P4xx.

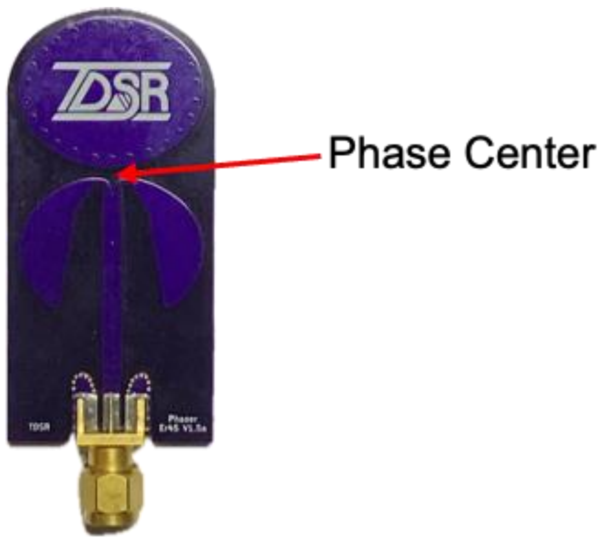

Fig. 1: BroadSpec antenna with phase center indicated

2 Performance Specification

Radiated Waveform:	500 ps Monocycle: 1 Ns waveform
Pattern:	Omni in azimuth to +/- 1.5dB
Polarization:	Vertical
VSWR:	~ 1.75:1
S11:	~12 dB
Gain:	Nominally ~3dBi (see Section 4)
Phase Response:	Linear
Efficiency:	Nominally ~90%

3 Mechanical Specification

Width:	1.15” (2.92 cm)
Height:	2.4” (6.1 cm)
Thickness:	0.065” (0.165 cm)

When mounted vertically on a SMA connector, the tip of the antenna will be within +/-1.5 mm from true vertical.

4 Range Measurement Applications

When using the BroadSpec antenna for Two-Way Time-of-Flight (TW-TOF) distance measurement, all range measurements are taken from the phase center of one antenna to the phase center of the second antenna. Note that there is only one phase center and the location is indicated in **Figure 1**. Ranges measured from the phase center of one antenna to the side opposite the phase center will be longer by 1.5 mm. This reflects the fact that the RF is passing through the antenna to reach the phase center.

5 Antenna Beam Patterns

Figure 2 below shows the antenna azimuth beam pattern. 0 and 180 degrees are perpendicular to the flat face of the antenna ("boresight") while 90 and 270 degrees are at the edges of the antenna. Note that when two radios at the same elevation are rotated so the flat sides of the antennas face one another, radio performance will be approximately 6 dB higher than when the antennas are edge-on.

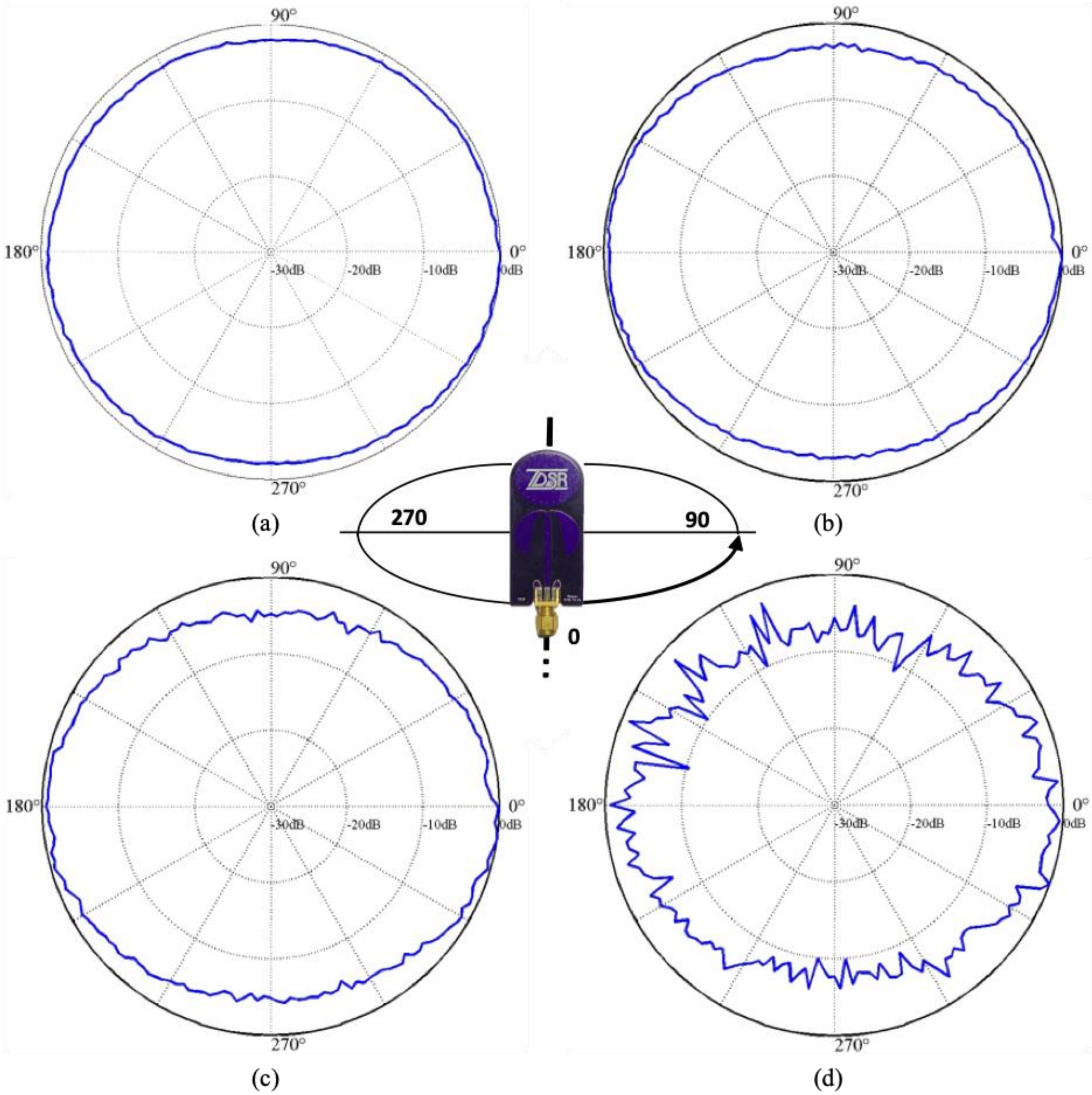

Fig. 2: Azimuth Beam Pattern for (a) 3 GHz, (b) 4 GHz, (c) 5 GHz, and (d) 6 GHz

Figure 3 illustrates the elevation beam pattern. Note that the peak of the antenna gain is elevated approximately 20 degrees and is 2 dB higher than the gain at 0 degrees. Therefore, two radios at the same physical elevation (altitude) can achieve a 4 dB increase in performance if the antennas are tilted 20 degrees towards each other.

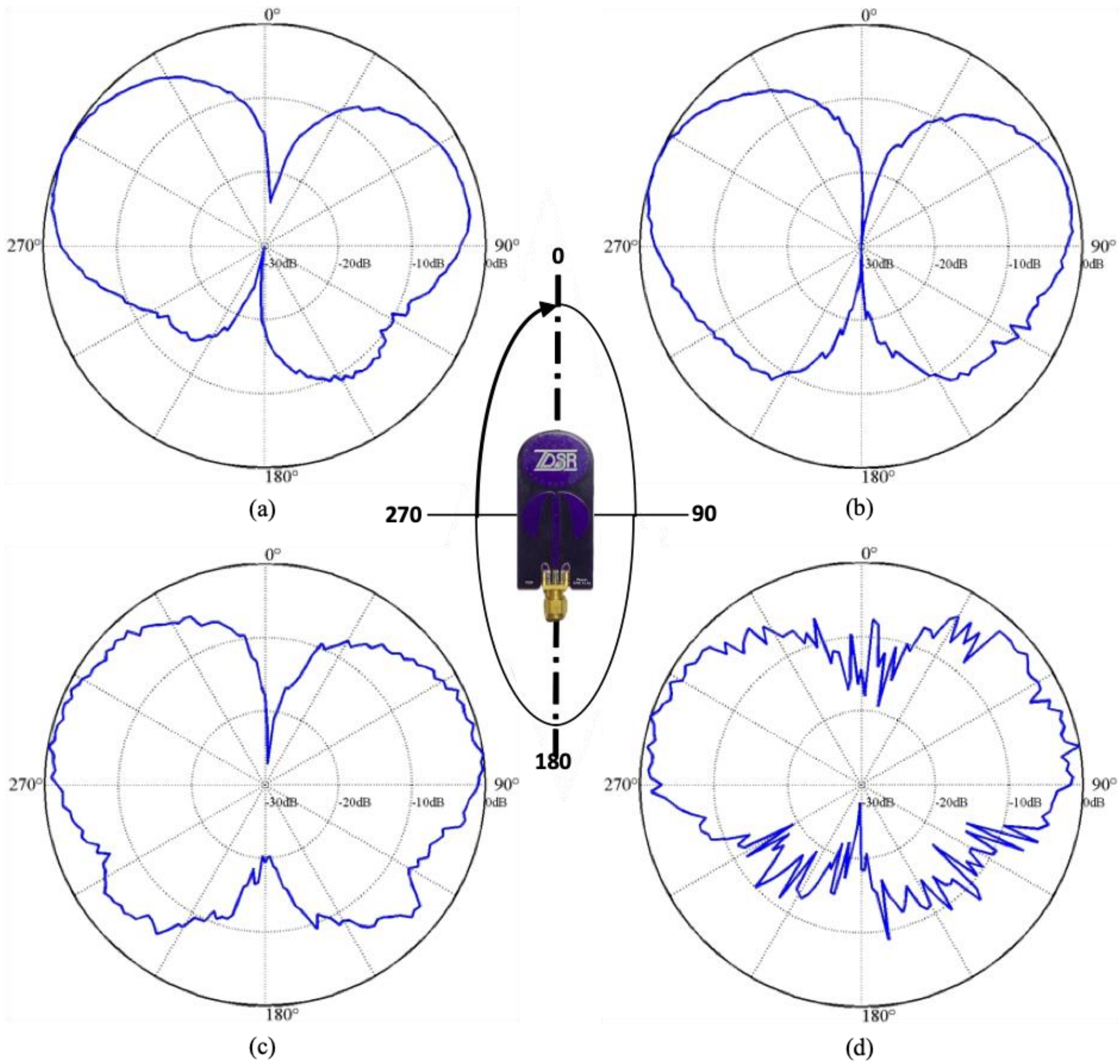

Fig. 3: Elevation Beam Pattern for (a) 3 GHz, (b) 4 GHz, (c) 5 GHz, and (d) 6 GHz

6 Adding a Planar Back-Reflector

Augmenting the BroadSpec UWB antenna element with a flat planar back-reflector is a relatively straightforward method of providing directionality and gain. This document discusses the key parameters for accomplishing this.

The three primary parameters as depicted in **Figure 1** are *d* (the separation distance), *w* (the width of the reflector), and *h* (the height of the reflector).

Optimal dimensions are fundamentally related to a single frequency of the radio. Since UWB occupies a wide band of frequencies, we make a reasonable compromise and design the reflector based on the center frequency f_c, related to the center wavelength λ_c by $\lambda_c = c/f_c$, where c is the speed of RF. For example we will use $f_c = 4$ GHz, resulting in $\lambda_c = 75$ mm (3 in.). Thus, in theory this structure will provide enhancement at 4 GHz and attenuate or distort other in-band frequencies. In practice it works well, providing gain and directionality for frequencies between 3 and 5 GHz.

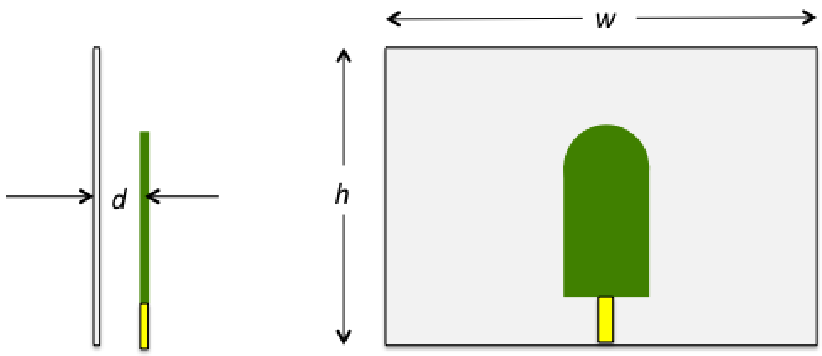

Fig. 1: Separation distance *d*, back-reflector width *w*, and height *h*

A well-designed and well-implemented reflector can provide bore-sight (maximum) gain of around 5 dB* (180%) with an azimuth (horizontal) pattern around 100°. Compromises for size are possible with trade-offs in gain, pattern, and signal distortion, which can induce range error in a two-way ranging (TWR) system.

Dimensions *d, w*, and *h*

The separation distance (d) between the antenna element and the back-reflection plane should be by approximately $\frac{1}{4}\lambda_c$ ~= 19 mm = 0.7 in.) This will enhance frequencies close to 4 GHz.

The width (w) of the reflection plane should, in theory, be at least 15 cm (6 in.), providing a full wavelength of surface area margin on each side of the antenna element in the azimuth (horizontal) plane. Even wider back-reflectors will provide even better performance at wide angles, but in practice anything wider than 20 cm (9 in.) produces rapidly diminishing returns.

The reflector height (h) isn't as critical due to the dipole nature of the element. However, the reflector should have at least $\frac{1}{4}\lambda_c = 19$ mm = 0.7 in. of top and bottom margin, especially if the reflected antenna can tilt forward/back or the relative elevation angle of the other radio(s) can be large (more than +/-45°.) In this case a wider top/bottom margin is recommended. **Note:** one can always tilt this back-reflected antenna forward or back slightly if the other side is always below or above this antenna's horizontal plane.

Compromises and Trade-offs

Separation distances *d* less than 19 mm (0.7 in.) will induce preference for higher frequency components. Lower frequencies naturally travel farther and penetrate materials better, while higher frequencies contribute to improved ranging accuracy. In practice, variations of *d* by a couple of millimeters (more or less) make little difference unless the performance requirement is biased towards either maximum operating range or maximum ranging accuracy.

Specifically, *d* distances smaller than 13 mm (0.5 in) will produce poor results. Special antenna designs (filling the gap with other dielectrics besides "air") are required to close this gap. Separation distances *d* by multiples of $\frac{1}{2}\lambda_c$ (3.7 cm, 1.5 in., 7.5 cm, 3 in.) will likewise attenuate and distort the signal producing undesirable results.

As the width *w* of the back reflector is decreased from 15 cm (6 in.), the wide-angle signal begins to distort, decreasing the azimuth pattern. Likewise, the elevation pattern decreases with the back reflector height *h*.

*Increasing transmission gain can cause the radio emissions to exceed regulatory limits. The transmit gain of the radio can be reduced to compensate. However, the receive gain is maintained.