

# Guidelines for Augmenting the Broadspec Antenna with a Planar Back-Reflector

PulsON<sup>®</sup> 300 and 400 Series

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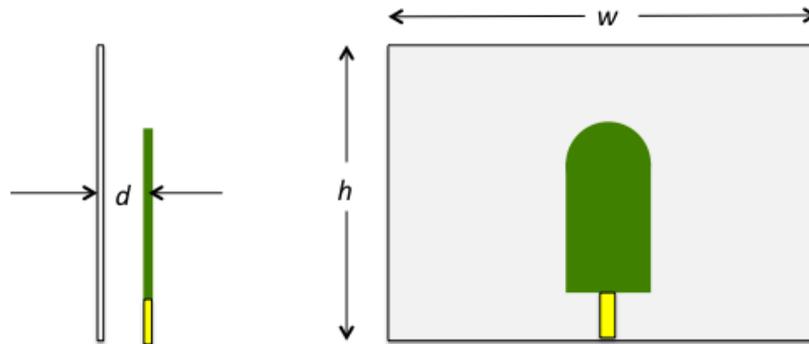
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## Overview

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  $\lambda_c$  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  $100^\circ$ . 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  $\frac{1}{4}\lambda_c \approx 19$  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  $\pm 45^\circ$ .) 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 cm (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.