AN-011 Cosine Error Adjustment

When measuring the speed of an object with radar, an adjustment needs to be made based on the angle the object in motion is traveling relative to the radar. This is known as the Cosine Error and is straight forward to correct for the true speed of the object if the angle is known.

Figure 1 provides an easy way to understand the cosine error. If the line of sight that the RADAR makes with the object in motion is an angle θ, then the measured speed is different from the actual speed by a factor cosine θ. Knowing this angle, the actual speed can be easily calculated.

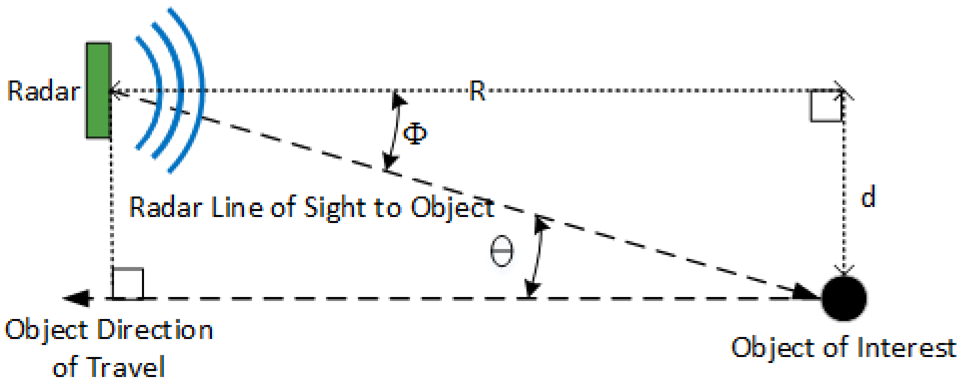

Figure 1. Cosine Error

The math for the correction is:

$$v_M = v_A cos\theta \qquad \textit{Equation 1}$$

If v_M is the measured speed, the actual speed, v_A, is a higher value that has been reduced by the cosine of the angle θ. For all the angles of θ from 0 to 90°, the cosine provides numbers from 1 to 0. Therefore, the actual speed v_A will be a number larger than the measured speed, v_M. The larger the angle θ, the higher the actual speed v_A will be.

Alternatively, rearranging to solve for v_A, you get:

$$v_A = \frac{v_M}{cos\theta} \qquad \textit{Equation 2}$$

Here it's easier to see that v_A will be greater than v_M with the adjustment by the inverse of cosine θ. Since cosine θ is always a number between 1 and 0, it will be a multiplier over v_M.

As an example, let's say you're measuring the speed of a car and you read the measured speed v_M to be 25 mph. The car is 15m away at an angle of 30°. Using equation 2 $v_M = v_A cos\theta($

Equation 1gives you the actual speed v_A to be 28.9 mph.

If the angle to the object is not known but the range R and distance d are, the correction can still be calculated. The range to the object is not the line of sight distance but the range of the object if it were slid across and directly in front of the radar module as shown in Figure 1. Likewise, the distance d is the separation distance between the path of the object and the line 90° from the radar module. Knowing these two values, the adjustment to speed is:

$$v_A = v_M \frac{R}{\sqrt{R^2 + d^2}} \qquad \textit{Equation 3}$$

The angle θ is related to the range and distance by:

$$\Phi = tan^{-1} \frac{d}{R} \qquad \textit{Equation 4}$$

where the angles θ and Φ are equivalent.

A simple lookup table is provided below for various speed and angle combinations.

Table 1. Actual Speed Look Up Table

	Measured Speed (mph)						
Angle	**10**	**20**	**30**	**40**	**50**	**60**	**70**
0°	10.0	20.0	30.0	40.0	50.0	60.0	70.0
10°	10.2	20.3	30.5	40.6	50.8	60.9	71.1
20°	10.6	21.3	31.9	42.6	53.2	63.9	74.5
30°	11.5	23.1	34.6	46.2	57.7	69.3	80.8
40°	13.1	26.1	39.2	52.2	65.3	78.3	91.4
50°	15.6	31.1	46.7	62.2	77.8	93.3	108.9
60°	20.0	40.0	60.0	80.0	100.0	120.0	140.0

Revision History

Version	Date	Description
A	Apr. 20, 2017	Initial release.