

Application Note 1001

Using Non-Contact Speed Sensing to Measure Vehicle Ground Speed

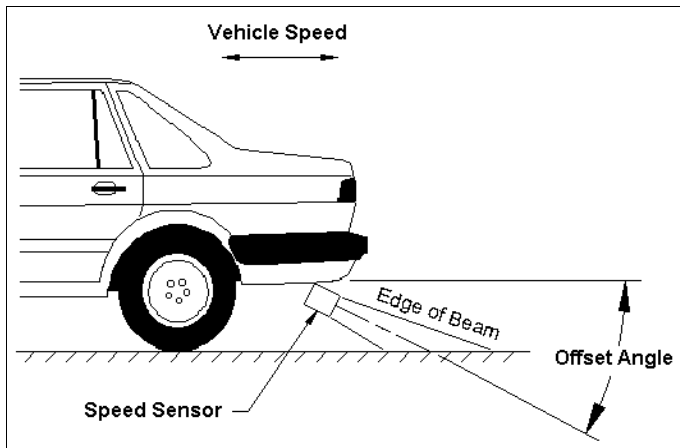


Figure 1 - Measuring Vehicle Ground Speed (not to scale)

Measuring vehicle ground speed is a straight-forward application of the non-contact speed sensor. As shown in Figure One, the sensor can be mounted on a vehicle, pointed at the ground and used to measure the speed of the vehicle relative to the ground. The sensor may be pointed either forward or backward.

An advantage of using a non-contact speed sensor over other methods such as measuring wheel rotation is that the speed measurement is not affected by factors like wheel slip, allowing a better measurement of true ground speed.

In one such measurement, the sensor was mounted pointing backward on a vehicle. The sensor was about one foot above the ground and was inclined downward from the horizontal by 30° (offset angle shown in Figure One). The sensor output was read by a counter channel on a GMH Engineering DataBRICK data acquisition system, which also applied a scale factor and corrected¹ for offset angle to produce the plot shown in Figure Two.

The data in Figure Two clearly show such features as gear shifting, acceleration, coasting and braking. In this test, the vehicle was driven over an asphalt surface, but the sensor may be used on other surfaces such as concrete, gravel or dirt.

Offset Angle

The offset angle shown in Figure One is the *nominal* offset angle. This is the angle between the center axis of the radar beam and the horizontal in the vertical plane. Because of factors involving geometry and relative strengths of the return signal from areas on the ground ahead of and behind the center axis of the radar beam, the *effective* offset angle will differ from the nominal and requires a correction.

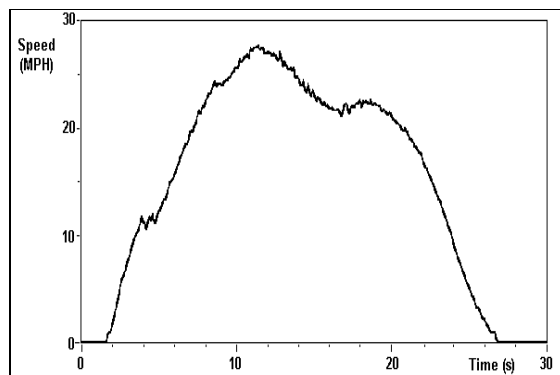


Figure 2 - Vehicle Ground Speed (Miles per Hour)

Table One shows the results of testing conducted to determine effective offset angles using the speed sensor on vehicles driven over asphalt. To use the table, replace the *nominal* offset angle actually used by the corresponding *effective* offset angle when correcting for offset angle¹. For convenience, the cosine of the *effective* offset angle is also given in the table.

The particular choice of nominal offset angle involves a tradeoff between several factors. Placing the sensor at a steeper angle increases signal strength and reduces the field of view of the sensor so that it does not see non-targets, such as other vehicles. On the other hand, a steeper angle also increases sensitivity of the sensor to vertical motions and may introduce more variation in the vehicle ground speed measurement because of pitching of the vehicle on its suspension. For most applications involved in road testing, GMH Engineering uses a 30° nominal offset angle.

The accuracy of the speed measurement using this method of offset angle correction depends on the accuracy to which the offset angle is known. For instance, with a 30° offset angle, a 1° uncertainty in offset angle can cause a 1-2% uncertainty in the speed measurement. If greater accuracy is required the sensor can be calibrated by other methods, such as a distance comparison achieved by recording the number of pulses received from the sensor while the vehicle travels over a fixed distance.

Table One - Effective Offset Angles On Asphalt

Nominal Offset Angle (degrees)	Effective Offset Angle (degrees)	Cosine Effective Offset Angle	Nominal Offset Angle (degrees)	Effective Offset Angle (degrees)	Cosine Effective Offset Angle
20	24.12	0.9127	33	34.47	0.8245
21	24.82	0.9076	34	35.34	0.8157
22	25.54	0.9023	35	36.22	0.8068
23	26.28	0.8966	36	37.11	0.7975
24	27.04	0.8907	37	38.00	0.7880
25	27.82	0.8844	38	38.90	0.7782
26	28.61	0.8779	39	39.80	0.7682
27	29.41	0.8711	40	40.71	0.7580
28	30.23	0.8640	41	41.63	0.7475
29	31.05	0.8567	42	42.54	0.7368
30	31.89	0.8490	43	43.47	0.7258
31	32.74	0.8411	44	44.39	0.7146
32	33.60	0.8329	45	45.32	0.7031

Other Considerations

The sensor should be aligned parallel to the direction of vehicle travel so that there is no horizontal offset angle. It is also important to consider factors such as suspension pitching, vibration, dust or water spray when choosing a mounting location for the sensor. For example, a forward-pointing sensor may be indicated for applications where dust or water spray is expected at the rear of the vehicle which might interfere with the radar beam. The sensor should be mounted on a rigid location located away from engine vibration. Some suspension pitching is evident in Figure Two, where the vehicle under test was, in fact, driven over bumps and had a stiff suspension. These effects could be removed, if desired, by post-processing to smooth the data. If these factors are taken into consideration measurements of vehicle ground speed can be made for a wide variety of applications.

Contact Us

GMH Engineering personnel are available to discuss applications using non-contact speed sensing. If you have questions, please contact us at (801) 225-8970 or info@gmheng.com.

¹ see *Application Note 1000 Fundamentals of Non-Contact Speed Measurement Using Doppler Radar*

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