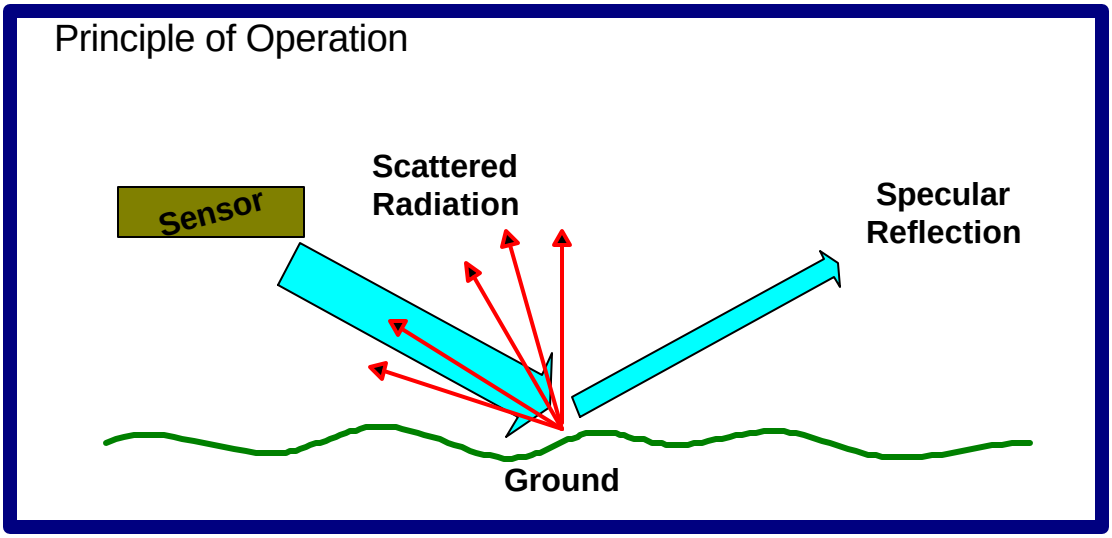
Theory of Operation for the Doppler Effect Speed Sensor (DESS)

Phoenix International®
1441 44th Street NW
Fargo, North Dakota 58102

Doppler Effect Speed Sensor uses a concentrated millimeterwave radar signal and the Doppler shift principal to provide a measure of true ground speed of vehicles used in agricultural and forestry operations.

The speed sensor relies on the radiation transmitted from the sensor being scattered by the ground and re-entering the sensor. If the sensor is moving, the scattered radiation appears to have a slightly different wavelength than the transmitted radiation. The difference in the two wavelengths is the Doppler signal.

An ideal speed sensor would indicate a vehicle's true ground speed instantaneously on any surface. It should perform under any acceleration/deceleration event as well as under steady state conditions. In reality, it is difficult for any one sensor to perform flawlessly under all conditions.



Doppler effect speed sensors are ideal for stubble fields, plowed fields, and gravel roads which give a large amount of scattered radiation, but are less reliable on smooth surfaces such as on concrete or blacktop roads which have a larger amount of specular reflection. This is particularly true if the smooth surface is wet. Doppler effect speed sensors do not work if the incident surface is standing water.

Sensor speed is a sum of all movement for which $\underline{r} \cdot \underline{v}$ is non zero. Where $\underline{r}$ is the vector indicating the column of microwave radiation incident on the ground, and v is the vector describing the velocity. For example if the sensor moves vertically ($\underline{v}_v$) as well as horizontally ($\underline{v}_h$), the speed indicated will be the magnitude of the vector $\underline{r}/|\underline{r}| \cdot \underline{v}_h + \underline{r}/|\underline{r}| \cdot \underline{v}_v$.

The Doppler effect speed sensor outputs 100 pulses/meter. A pulse is defined from rising edge to rising edge of the output pulse stream. The output pulses run from 0 – 12 VDC and are approximately square.

The speed sensor is relatively insensitive to vehicle vibration at zero speed. Because the sensor is designed to detect movement, motion in the horizontal direction (vibration) can lead to the sensor giving a false speed signal even at zero speed. This effect has been minimized through design and sophisticated algorithms that are constantly executed by the on-board digital signal processor (DSP).

The sensor detects changes in vehicle speed. Both acceleration from rest (or deceleration to rest) and acceleration/deceleration while in motion.

Installation:

The ground speed sensor is designed for mounting from 30 cm to 120-cm vertical height above the ground and at 35 degrees from horizontal. The sensor is designed to face the rear of the vehicle.

The sensor can be mounted directly to the tractor without need for rubber mounting feet. The line of sight of the sensor shall not be blocked by any moving parts such as tires, treads, 3-point hitch.

The following is an abbreviated version of the sensor specifications.

Velocity Range	0.3 to 64 km/h
Accuracy	< ± 3% 0.3-3 km/h < ± 1% 3-64 km/h
Electrical Supply	150 mA @ 12 V DC +9 to 16V DC input voltage range
Output Frequency	27.78 Hz/kph (100 pulses/meter) @ 35° mounting angle
Step Response	≤ 200 millisecond delay
Start/Stop Delay	≤ 25 cm
Microwave Frequency	24.125 GHz (standard) 24.300 GHz (UK) Tolerance ± 25 MHz
Microwave Power	5 mW, (nominal at the transceiver)