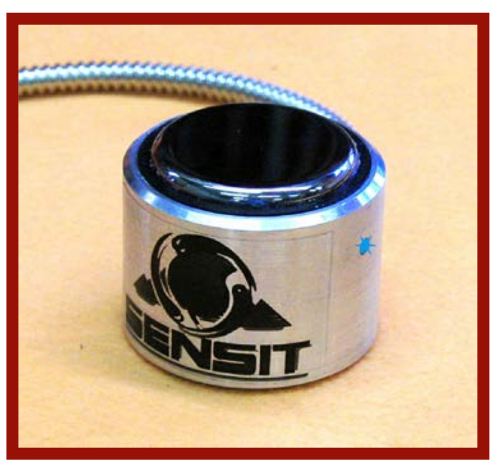
TM-FP5-RevC

MOVEMENT DETECTOR

Technical Manual - Model FP5-RevC



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Processing Sensit Field Data - Introduction

The Sensit movement sensor does not need to be maintained and can operate at a solar powered remote erosion monitoring station. Operating power is 6 -> 24V DC @ 8.6ma. The data provides accurate immediate response to just about any particle movement. It should be noted that the extreme sensitivity will produce a response to rain. It may be desirable to place a second movement sensor located at some height above the saltation layer (~ 1-> 2 meters).

Model FP5-RevC (picture)

WebSite: 4Gb Memory Stick: 

About the new Model FP5-RevC

The flat plate (FP) sensor provides the same PC pulsed output as previous Sensit models H11B & H11C except this sensor's pulse width is a precision 1mS and is not temperature sensitive. It also has a blue LED that flashes with every impact. The LED is visible via a small hole in the side of the sensor case. The LED provides several valuable functions.

Model FP5-RevC

- **4Gb Memory Stick Technical Data Source**: A 4Gb memory stick is included with every order containing a directory of each sensor model produced. Currently; \H11-LIN and \FP5-RevC. All images, technical documents and information contained on this memory device are provided for royalty-free copy and redistribution of Sensit product information.
- **Data output – individual particle impact response**: The sensitivity of the model FP5-RevC is extremely high. Unlike the Model H11-LIN horizontal mass flux sensor, this sensor responds to downward energy impacting the sensor at approximately 9 degrees incident to the surface.
- **LED indicator**: A blue LED located on the side of the sensor produces one flash for each impact detected. This is a valuable visual aid when performing drop calibrations and as an indicator that the sensor is working properly during field installation.
- **Extreme sensitivity:** The sensitivity of this sensor is very high making it difficult to determine its threshold of detection. Glass spheres of 600 and 1000 micron diameters are supplied with each sensor for testing purposes. You may simply pinch a few beads between your fingers and release them above the sensor. See how close to the surface you have to get to reach detection threshold. With my fingers, I can't release the spheres low enough.
- **Gold plated circuit board:** The PCB is gold plated to insure a good ground connection between the circuit and the crystal assembly. A soldered ground wire is also employed.
- **Superior seal:** The polished stainless steel crystal assembly mounts into the base via a captive rubber seal very tightly and is sealed with silicone RTV. It is not impossible to take apart without destroying the sensor.
- **Lower power:** The new sensor draws a constant 8.6ma from any voltage source (battery) between 6 VDC and 20VDC.
- **Output response:** A precision digital monostable multivibrator creates the output pulse of 1.00mS. The pulse width does not change with temperature as the analog RC components of old style multivibrator. The output is one positive 5 volt TTL/CMOS pulse for every impact.
- **No multiple counts:** Large energy impacts do not produce multiple counts in the PC output data. Due to the advanced signal processing, multiple pulses out for one impact do not occur. It should be noted that it is so sensitive that the sensor will produce output pulses as a single particle bounces across the surface.
- **Rodent proof cable shielding:** The cable is shielded with stainless steel flex-conduit.
- **Extreme signal dynamic range:** The dynamic range of impact energy is $> 10^6$.
- **Wind diffuser:** Disrupts the wind flow around the sensor to thwart scouring.

Sensor specifications

• Base diameter: 1.995”	height: 1.5”
• Crystal diameter	40mm (1.575”)
• Crystal surface	stainless steel
• Cable outer diameter: 7mm	length: 6 meters, stainless steel flex conduit.
• Power requirement*	6VDC to 20VDC @ 8.6ma
• Mounting post: dia:1/4”	length: 9”
• Data output	TTL/CMOS compatible pulse, width: 1.00mS
• Signal dynamic range	greater then 10^6
• Wind diffuser	dia: 9” thk: 1/16” material: ABS

Model FP5-RevC Wiring Color Code

Output:

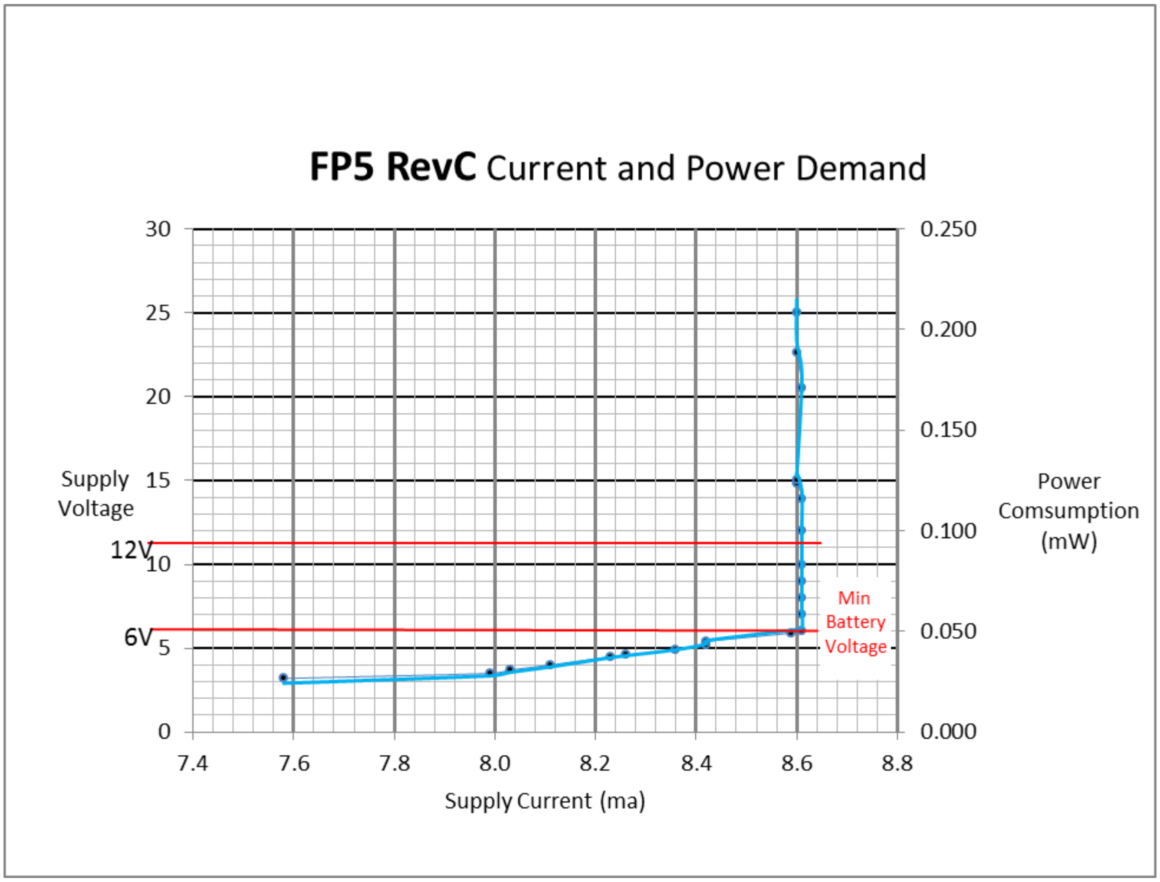
- **Green**: Particle count (PC) data output is a CMOS/TTL compatible pulse indicating one particle impact,

Inputs:

- **Red:** +12VDC **Power requirement:** +12VDC @ 8.6 ma
- **Black:** Common

* Battery voltage (red: +12VDC, black: common): This sensor operates over the battery voltage range of 6VDC to 20VDC. The current draw remains a constant 8.6 ma over this voltage range. Keep in mind that power dissipated in the sensor is equal to the battery voltage times the battery current. This sensor has not been tested for thermal damage at high battery voltages i.e., greater than 16VDC. Example: 20VDC @ 8.6ma equals an internal power dissipation of 0.258 watts or ~1/4 watt. This is ~¼ watt should low enough to maintain a safe level of heat within the sensor. However, if the sensor is embedded in the surface of a hot desert surface, the temperature increase could be damaging. Sensit’s advice is to stay with a standard 12VDC battery for its source of power which produces a safe internal power dissipation of 1/10th watt.

Graph: Current draw vs. supply voltage.



Mounting configurations

The sensor comes with several hardware pieces to facilitate various mounting options. There is a ¼"-20TPI threaded hole in the bottom of the sensor housing. This is the standard mounting hole for most cameras.

<u>Post Dia:¼" Len: 9" w/ nut for tightening.</u>

Supplied with the sensor is a stainless steel post 9" in length and ¼" diameter. When screwed into the bottom of the sensor the post provides a stable mount to keep the sensor vertical if scouring takes place.

 SS post.

Stainless steel wing nuts

One of these can be used in conjunction with the threaded studs to fasten the sensor to a plate.

 SS wing nuts

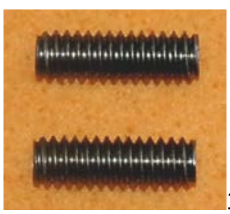
Stainless steel ¼"-20 TPI machine bolts.

One of these can be used in conjunction with the threaded studs to fasten the sensor to a plate.

SS bolts w/washers

Threaded studs ¼"-20 TPI

Used with above nuts and bolts. Also, threaded into the bottom of the sensor allow the sensor to be screwed into a board or the end of a rod as a monopod. Even a broom stick will work.

1/4"-20 studs

Standard camera tripod mounting

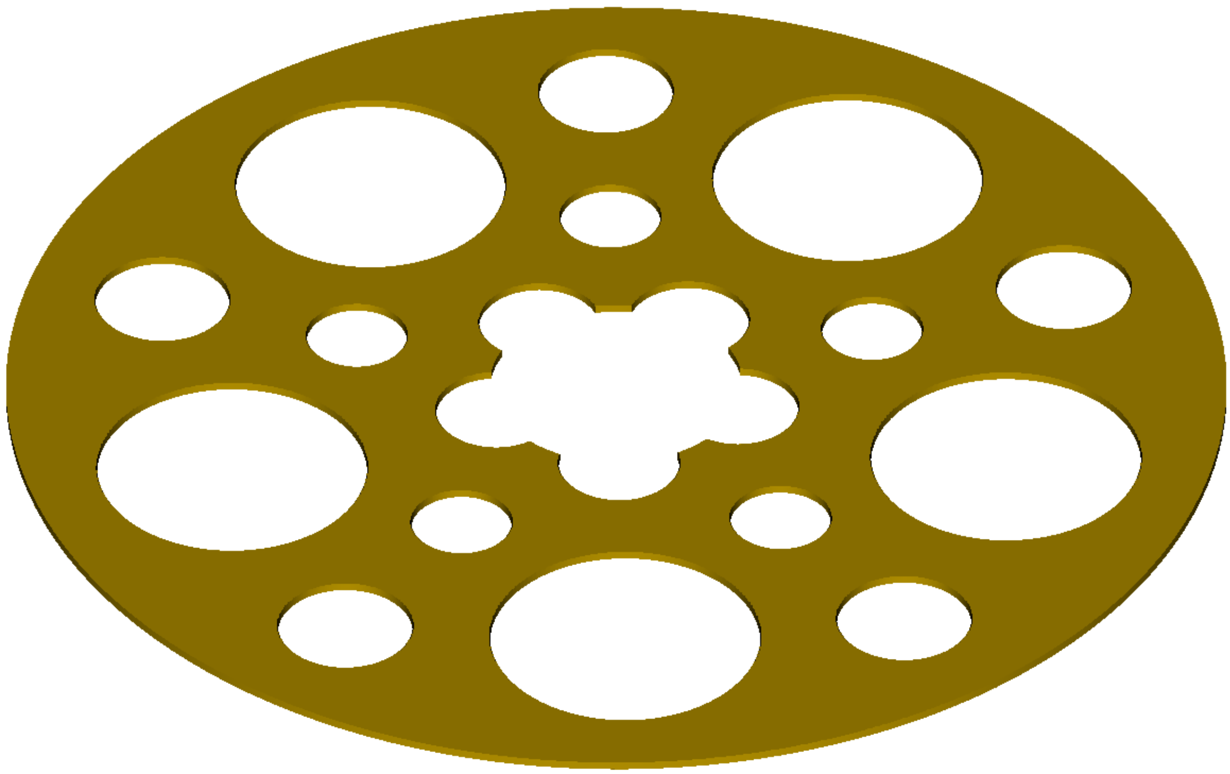
The ¼"-20 TPI threaded hole in the bottom of the sensor is compatable with all camera tripods using the standard ¼"-20 screw mount.

Anti-Scouring plate

Plastic wind diffuser THK: 0.063” DIA: 9.0” MATL: ABS COLOR: Orange

Snaps onto sensor housing near top into 0.065” channel.



Response (sensitivity)

The sensitivity of the FP5-RevC has been designed to be extremely high. In the past sensitivity necessary to achieve a satisfactory response from extremely low energy impacts to very high energy impacts was not technically feasible do to complexity and high current requirements.

Sensit has taken advantage of super sensitive and stable electronics in a very small package coupled with a very sensitive and durable sensing crystal assembly. The achieved sensitivity is too high for use in the standard Sensit model H11-LIN because it may respond to noise in the wind.

For use in the flat plate sensor the extreme sensitivity is necessary. First of all, particle will be impacting the surface at approximately 9 degrees. The impact energy transferred to the crystal is therefore typically 15.6% of that transferred at an impact angle of 90 degrees for a particle of identical mass and velocity.

Fortunately for the flat plate sensor, its active sensor surface is parallel to the direction of the wind. The sensor should only experience wind effects of turbulence and not direct wind pressure as the model H11-LIN encounters.

Response (many uses)

The high sensitivity of the flat plated sensor makes it a valuable rain sensor. It will not respond to light drizzle but most rain will trigger a response. This ability is useful if you are encountering suspicious data from the model H11-LIN horizontal sensor. If the flat plate model FP5-RevC is mounted above the saltation level, it can serve as a data flag for invalid “rain” impacting energy on the model H11-LIN sensor. This can be very valuable if you are looking for low wind speed impacts on the H11-LIN sensor to determine threshold of movement by eliminating rain impacts. The FP5-RevC can be buried and still produce data (pulses) responding to movement at the surface above the sensor. For example; if the sensor is buried perhaps 10 to 30 cm (or more, this has not been tested) below a sand surface, it will respond to pressure on the surface such as an animal crossing. Note: This sensor is NOT to be used to trigger and other devices and will not be sold for any illegal use.

Threshold velocity

is an important term in wind erosion equations. This value represents the amount of wind energy necessary to cause movement on the surface. Even though it is ultimately wind energy that ultimately moves particles, the most common reference use to express this value is U* (Ustar). U* the slope of a line of a graph of log(U*) vs. Z_0 (height above the surface).
U* requires the use of anemometers placed and three different heights, preferably logarithmically spaced which will cause the spacing between the three wind data points vs. height to be roughly equally spaced on the graph. This is much better for calculating the slope of the line (U*).

Prior to the advent of the horizontal mass flux sensor affectionately called the “Sensit”, it was not possible to determine threshold velocity from field data. The original “Sensit” model H11-LIN is used extensively for determination of “threshold” of movement however its particle impact data represents impacts from particles at the height of the sensor’s active crystal sensing surface.

The new “Flat Plate” sensor model FP5-RevC responds to particle movement on the surface. According to Dr. John Stout (USDA-ARS, Lubbock Tx), the increase in movement threshold accuracy due to measurement at the surface is roughly 20 to 40% better than threshold determined from H11-LIN sensor data..

Threshold changes dramatically with changing soil conditions. A small amount of precipitation prior to an event or an established crust can have an extreme effect on threshold velocity. Surface characteristics during an event which effect threshold. High resolution (short sampling interval) data is necessary to observe changes in threshold throughout an event.

Figure 3 shows high-resolution **Sensit data taken at Owens Dry Lake**, Keeler, and California. Sensit data provides detail and threshold determination.

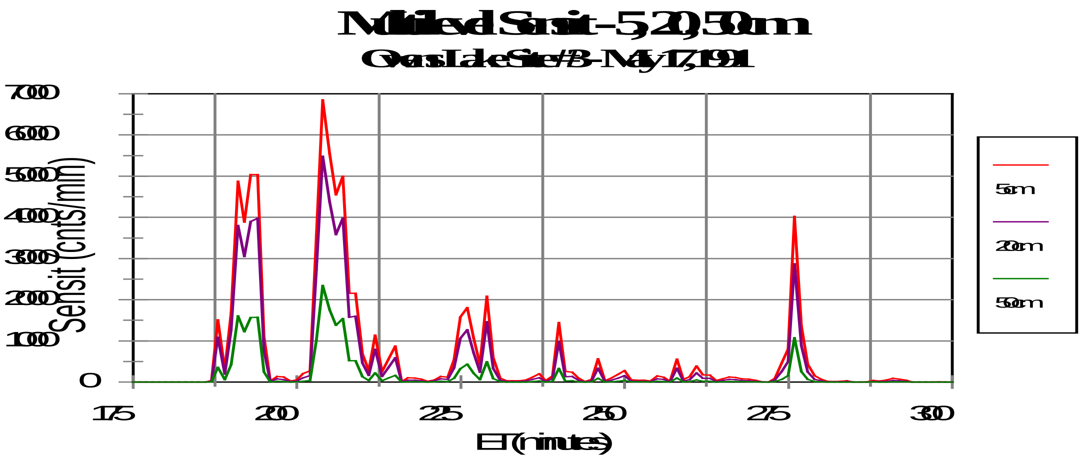


Figure 3 - Response (Sensit {H11-LIN]-5cm-20cm-50cm)

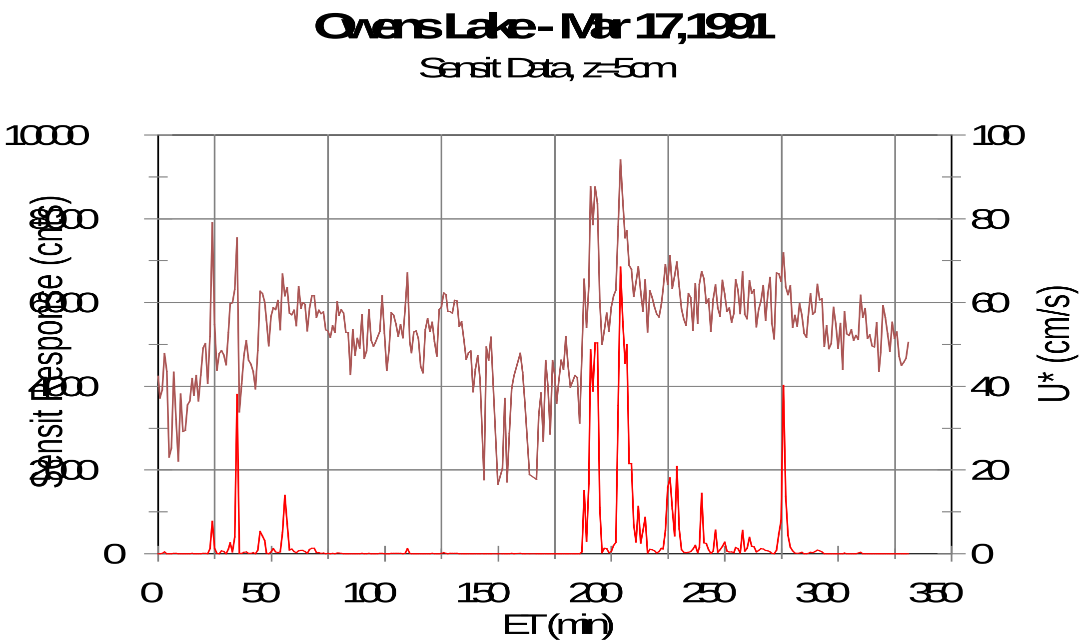


Figure 4 - Response (Sensit [H11-LIN], U*)

Threshold velocity can be determined when the shear stress[1] of the wind (U*) is compared to the Sensit’s' response (model H11-LIN) data as shown in Figure 4. The importance of the threshold velocity parameter is a starting point or baseline of wind erosion. Energy from saltating particles can destroy a surface which in turn makes more material available for saltation. Threshold can start out high due to an established surface, decrease and end up high again as the loose material portion of the surface is removed.

The Sensit does not respond to suspended fine dust[2]. It responds to saltating[3] particles. It is important to note that fine dust[4] adheres to large particles vary tightly through valence bonding.

Background (Model FP5-RevC vertical impact counter)

After the highly successful development and sales of the Model H11-LIN horizontal mass flux sensor commonly known as the “Sensit” for thirty years, Sensit is proud to announce this new Flat Plate Sensor Model FP5-RevC.

The new flat plate sensor represents a substantial improvement toward the accuracy of particle impact energy when used to establish the threshold of parameter necessary for wind erosion equations and various other uses such as sensing rain.

The new technology used in this sensor became available recently allowing the design of this idea threshold of movement sensor.

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[1] Shear stress (U*): Briefly, the slope of a line represents ratio of wind speed to the log of height. General equation (simplified): U* = 0.4*((u2-u1)/ln(z2/z1)].

[2] Fine dust: Referred to here as particles of less than 75 microns in diameter which tend to stay in suspended in air with little turbulent energy.

[3] Saltation: A term originally coined by Gilbert, G.K. (1914). U.S. Geological Survey, Prof. Paper 86 to describe the motion of sand under water. Derived from the Greek word saltair meaning to dance, also commonly used to describe non-suspended sand motion in air once above the surface.

Dropping Glass Spheres Testing

The glass spheres used to test the Model H11-LIN horizontal mass flux sensor are 600 micron and 1000 microns diameter. A sample bottle of each are supplied with the FP5-RevC movement sensor for studying the response. These diameters may seem large to many researcher especially those of the “old school” erosion scientific society. There is a reason for using these sphere diameters. When dropped on to a surface the particle velocity can be considered the particle mass times the gravitational constant. The gravitational constant can be used as the particle velocity while the particle is considered to be in the Stokes region. The Stokes region is the condition where the particle is experiencing virtually no drag, therefore not a factor in velocity determination.

The same impacting kinetic energy can be achieved by using large spheres at low velocity vs. small spheres at higher velocities. Using this method, the dropping particle velocities can remain in the Stokes region (negligible drag) where the gravitational constant can be used as particle velocity. Please keep in mind the maximum release heights of these particles is quite small, approximately 3 cm for the 600 micron and 10 cm for the 1000 micron glass spheres. One could ignore this constraint and use higher velocities resulting from release at higher heights without very much error if kept within reason.

Kinetic energy (units of Dyne-cm) is term used to put a value of the detection threshold for Sensit erosion sensors. This is because kinetic energy encompasses both mass and velocity which are the primary components of consideration regarding glass spheres at some falling velocity onto the sensors active surface.

The following is an example of the impacting energy calculation used for the two primary sizes of glass spheres used for this detectivity determination. The values shown are typical for the standard Sensit Model H11-LIN sensor. The Flat Plate Model FP5-RevC detectivity threshold is smaller but I have not had time to investigate this thoroughly. Typical values for these values will be placed here when available.

Glass sphere impact energy calculation

The highlighted terms indicate the values used in each example. The light yellow values are the results. NOTE: These values were typical values experimentally found using a Sensit Model H11-LIN sensor where the choice of two different gain settings is available. The Flat Plate sensor has only one gain setting: maximum.

Threshold	Dia	~Height[cm]	~[Dyne-cm]
1X	1000u	0.1	2.57
10X	600u	0.2	1.85

Detection Threshold Calculations

Glass sphere Dia: 600u

600 microns		0.009424778	Mass (gm/cm^3)
1000 microns		0.026179939	Mass (gm/cm^3)

KINETIC ENERGY = POTENTIAL ENERGY (PE) if falling in the Stokes region (no drag)

1/2 m v^2	m h g	mass x height x acc. gravity	
9.42E-03	mass (gm)		
0.2	height (cm)		
980	acceleration of gravity cm/s^2		

the force required to accelerate a mass of one gram at a rate of one centimeter per second squared

PE = m dZ g = mass x height x acc.grav.

1.85	**Dyne cm or ergs**	**(new SI) = 1g * cm/s^2**
1.84726E-05	Newton	(old cgs) = 1 kg * M/s^2
1.84726E-07	Joule	Joule = Dyne cm * 10^-7

Glass sphere Dia: 1000u			-
600 microns	0.009424778	Mass (gm/cm^3)	
1000 microns	0.026179939	Mass (gm/cm^3)	
KINETIC ENERGY = POTENTIAL ENERGY (PE) if falling in the Stokes region (no drag)			
1/2 m v^2	m h g	mass x height x acc. gravity	
2.62E-02	mass (gm)		
0.1	height (cm)		
980	acceleration of gravity cm/s^2		
the force required to accelerate a mass of one gram at a rate of one centimeter per second squared			
PE = m dZ g = mass x height x acc.grav.			
2.57	**Dyne cm or ergs**		**(new SI) = 1g * cm/s^2**
2.56563E-05	Newton		(old cgs) = 1 kg * M/s^2
2.56563E-07	Joule		Joule = Dyne cm * 10^-7

I apologize for any confusion you may have had regarding the use of the word “threshold” with reference to wind, particle movement and sensor detectivity collectively.

I am sure it can be confusing, especially for those researchers of languages other than English.

Sensor – Theory of operation

The sensor's man-made crystal produces an electric charge when physically deformed. This charge is the analog signal used by the sensors circuitry. When this charge exceed an internally set threshold (here's that word threshold again!), a 1.00mS wide positive polarity TTL/CMOS compatible digital output pulse is generated representing a single impact.

The charge portion of the **energy within the crystal** can be roughly expressed as:

$$Q = C * V$$

where:

Q	charge in coulombs.
C	capacitance in farads.
V	the voltage developed across the crystal.

conversely:

$$Q = I * t$$

where:

I	current developed over time (t)

The circuit converts this charge into a voltage representation of the charge. The signal voltage is then compared to an internal threshold voltage called the signal's threshold voltage reference. When the signal exceeds this internal threshold voltage a 1.00mS output pulse is generated. The output circuit is capable of driving a 20ma load with this pulse but a 470 ohm resistor has been placed in series with the output to limit damaging current should the sensor be miss-wired.

At this time the sensor does not produce a kinetic energy output like the horizontal mass flux sensor Model H11-LIN. The response does not represent any horizontal momentum energy. The sensor is responding to the impact energy from downward momentum of descending particles. And only a small portion of it at that. A kinetic energy output would have no valid data component regarding any inferred quantity of movement. Furthermore, the impact angle of 9 degrees incident assures that only a small portion of the downward momentum is lost. The after-impact particles momentum is substantial because it contains most of the original horizontal velocity energy and most of the downward velocity component. This sensor is simply a very sensitive activity detector.

Instrument Calibration Constants

The threshold of detectivity is the only calibration constant applicable for the Model FP5-RevC flat plate sensor. This constant is established as indicated above and carries units of Dyne-cm.

I hope this paper is of some help with understanding Sensit data and the use of this sensor to provide quality erosion data for your project. The design features of this sensor can be attributed to valuable feedback from users like you. All comments are welcome, especially any negative comments as these drive design toward perfection.

Please inquire to: sensit@polarcomm.com

Model FP5-RevC Flat Plate sensor printed circuit board

Please enjoy taking data with the newest addition to a growing family of erosion sensors from Sensit Company. I know it seems there are only two models but there are more that I decided not to commercially produce for various reasons such as too difficult to manufacture or too complicated and prone to increased MTBF (mean time between failure). Sensit is proud of the long standing record failures being a rare occurrence. And, failures have usually been due to lightening or some other external activity like Marines running over them with military jeeps.

Revisions:

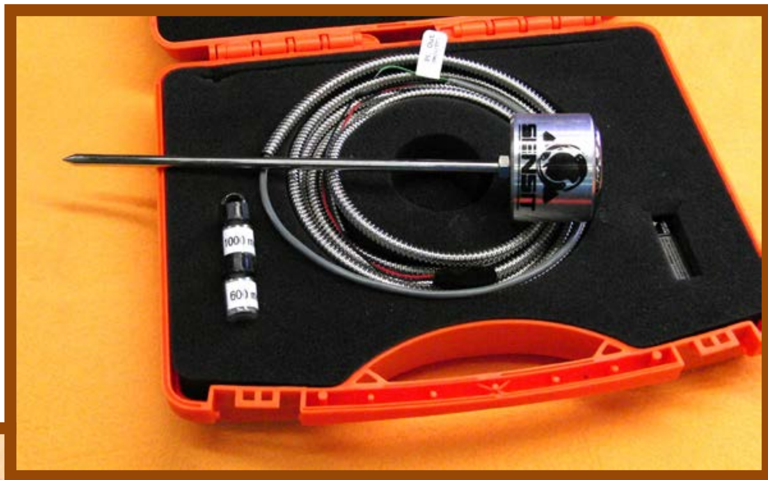
02jan2013: Manual - All occurrences of "30" regarding battery voltage has been changed to 20VDC for a better safety margin.

02jan2013: Manual - Corrected the crystal diameter: Crystal diameter 40mm (1.575").

02jan2013: Manual - Added battery voltage vs. current draw and power consumption.

Future spin-offs

A rain sensor is planned to be produced as a spin-off of this design. There are two possible models of rain sensor; one simply detects rain impacts as this model detects particle impacts. Another model will have a kinetic energy output for uses such as spore dispersion (Dr. Larry Madden, Ohio State Univ.) and soil crust destruction. The strength if you will of a surface crust is largely a function of water effects on very small particles and sometimes chemical adhesions like calcium sulfate $CaSO_4$ (gypsum). Rain energy can destroy this crust strength often referred to as the modulus of rupture.

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