USER MANUAL

FOR

FIBEROPTIC

DISPLACEMENT SENSOR

with Analog Output

TYPE RC

REFLECTANCE COMPENSATED

PHILTEC®

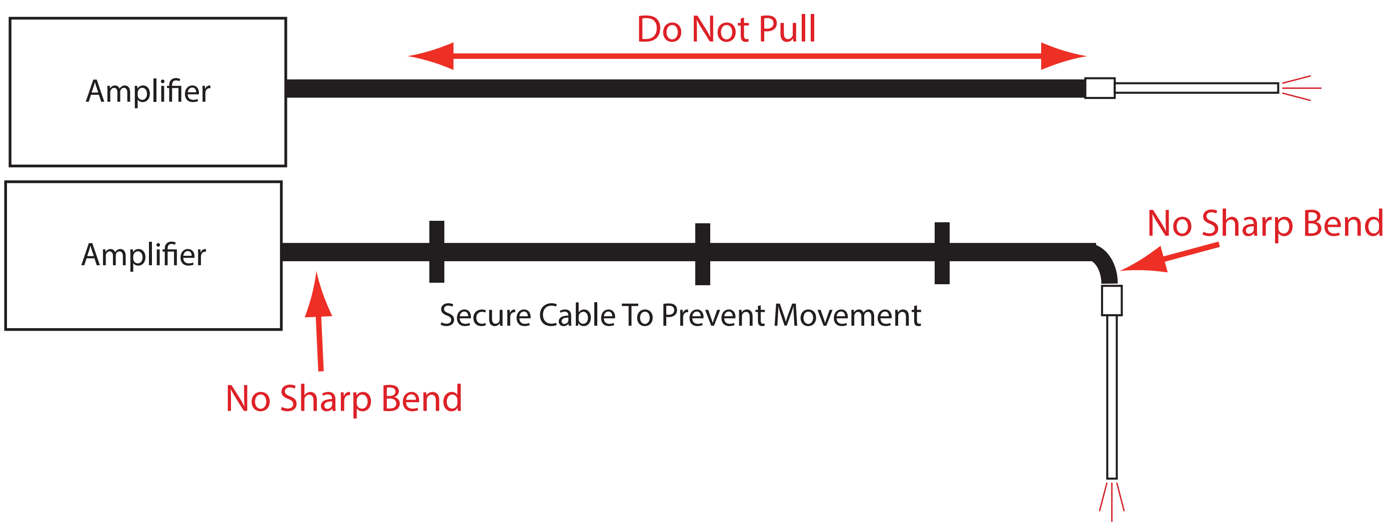
www.philtec.com

Fiberoptic Sensors for the Measurement of Distance, Displacement and Vibration

CAUTIONS :

1. Sensor tips and fiber optic cables are provided in a variety of sizes and materials, some of which are extremely rugged and others which are very fragile. It is important to handle sensor tips and cables with care, as they are not subject to warranty replacement if broken.

2. Always ensure that the sensor tip, target area and optical path are clear and clean. Accurate motion amplitude measurements are dependent upon the precise reflection of rays of light from target surfaces. Lint, dirt, debris and very rough surface textures can diffract and reflect light rays in unpredictable directions, thereby compromising the achievable accuracy of these devices. Sensor tips can be cleaned with alcohol and a soft cloth or tissue.

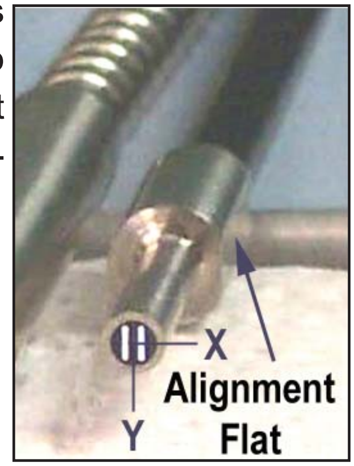


SENSOR OPERATING PROCEDURE

INPUT/OUTPUT CONNECTIONS

1) Connect a positive voltage DC power source +12 Volts with at least 150 ma capacity to the contacts marked +DC and GND (Ground).
2) Connect any suitable voltage readout device to the terminal marked OUT.
Standard units provide 0 - 5 volt output with DC - 20 KHz bandwidth.

SENSOR ALIGNMENT and TIP FIXTURING



1) **ALIGN THE SENSOR TIP.** RC sensors have adjacent fiber bundles in the face of the sensor. An alignment flat on the casing aids with tip alignment. The flat is ground parallel to the split between the adjacent fiberoptic bundles. Depending upon the application, there may be a preferred orientation for best performance. For example:

- If the target is cylindrical, it is usually best to mount the sensor with the Y axis perpendicular to the cylindrical axis
- If there is lateral motion, it may be preferrable for the direction of motion to be perpendicular to the Y axis
- The sensor is 10 times more sensitive to tilt about the Y axis than the X axis. If tilt is directional, orient the sensor so that the target pivots about the sensor's X axis.
- If targets are discontinuous, voltage spiking at the leading and trailing edges of the parts will occur when the direction of travel is perpendicular to the Y axis. The voltage spiking is eliminated when the direction of parts travel is parallel to the Y axis.
- For smooth and continuous flat surfaces, sensor tip orientation is not important.

2) **MOUNT THE SENSOR**, so that the tip is perpendicular to the target surface.

NOTE: The collar and tip may not be exactly parallel to each other. For best accuracy, clamp to the probe tip and not to the collar.

The flat is ground on the collar parallel to the split between
the adjacent fiberoptic bundles as shown here

SENSOR ELECTRONICS ADJUSTMENTS

Each new measurement application requires the consideration of:

- Sensor Signal-to-Noise Ratio (SNR)
- The reflective nature of the target surface

HOW TO CHECK SNR

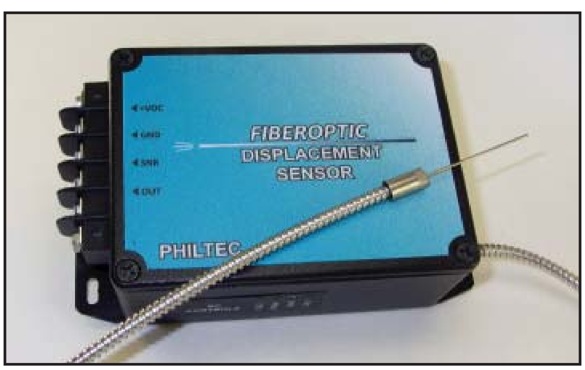
SNR should be checked and optimized each time the sensor is being set up for a new measurement.

How To Properly Set The SNR Level

SNR is a measure of the analog signal strength passing thru the amplifier.
To check the SNR level, hold the sensor perpendicular to a target and move it thru the sensor's range of operation while noting the highest voltage level measured on the SNR output.
With the sensor gap held at the position where the highest SNR level is reached, adjust the SNR control until the SNR voltage reads about 3.5 volts.

NOTES

- SNR level should be set between the values 2 - 5 volts to achieve the best resolution and accuracy.
- SNR levels above 5.0 volts should be avoided to prevent clipping of the signal.
- SNR levels below 0.5 volts must be avoided. A minimum level of 0.5 is required for reflectance compensation to work.
- SNR amplitude is proportional to the reflectivity of the target surface.



REFLECTANCE COMPENSATION

Reflectance Compensated Fiberoptics eliminate sensitivity to target reflectance variations. There are many applications where distance to a target must be measured in the presence of changing reflectivity. For example:

Shaft runout

- In-process dimensional control
- Z coordinate measurement with X & Y travel
- Part-to-part inspection

THE RC PRINCIPLE

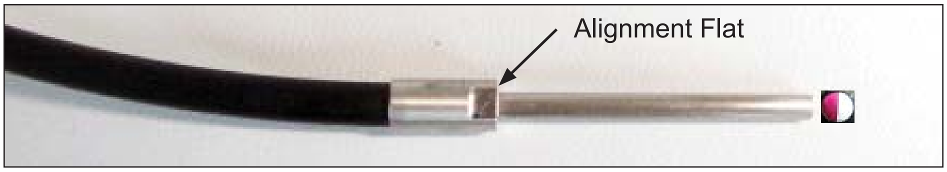
RC sensors have side-by-side fiber bundles where light is transmitted to a target from just one side. The transmit fibers (shown in red) are randomly mixed with receive fibers. A second group of receive fibers (shown as white) are adjacent to the transmitters. The Random and Adjacent light signals are processed ratiometrically to provide the distance measurement which is independent of target reflectance variations; i.e., ***reflectance compensated.***

RC sensors perform static as well as dynamic measurements with equally excellent results. Transverse motion is not required for reflectance compensation to work.

WHEN DOES REFLECTANCE COMPENSATION WORK?

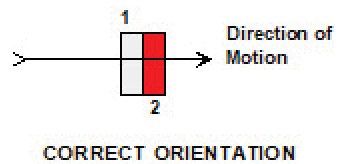
The RC sensor works very accurately with target surfaces that appear uniformly reflective to the unaided eye, which means the reflectance variations under the small area covered by the fiber optic sensor are negligible. The target could be very shiny, or it could be all dark, and that is OK. It is not so good when the area is a mix of light and dark spots or highlights. If reflective highlights and less reflective areas within the small spot size of the sensor can be observed with the naked eye, the sensor's performance will be affected by them.

RC SENSOR TIP ORIENTATION NOTES



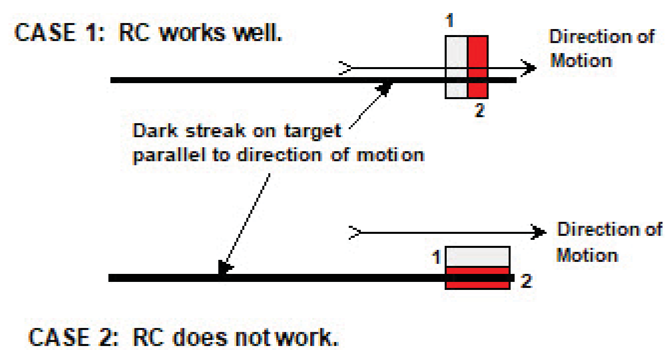
An alignment flat found on the probe collar can be used as an aide to get proper alignment. The flat is ground parallel to the split between the adjacent fiber bundles.

UNIFORMLY REFLECTIVE TARGETS



If there is no lateral motion, no tip alignment is required. With lateral motion, the sensor should be oriented as shown here. With this orientation, reflectance compensation is most accurate.

VARIABLE REFLECTANCE TARGETS



LATERAL MOTION

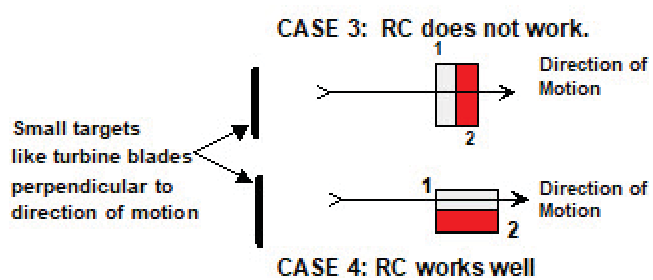
CASE 1:

Scoring, streaks or bands on the target that have different reflectance than the rest of the surface will not have a major effect on sensor performance *if they are parallel to the direction of target motion*.

CASE 2:

Sensor area 1 "sees" a different reflectance level than sensor area 2, and reflectance compensation does not work accurately.

TURBINE BLADES (THIN TARGETS)



CASE 3:

Sensor areas 1 and 2 “see” the leading and trailing edges at different times, thereby causing voltage spikes in the sensor output.

CASE 4:

Voltage spikes are avoided by orienting the sensor so the part edges are perpendicular to the direction of motion.

LARGE ROTATING TARGETS

CASE 5:

With large diameter rotors and discs, the radius of curvature is much greater than the diameter of the fiber optic probe and calibrations to a flat target will be accurate.

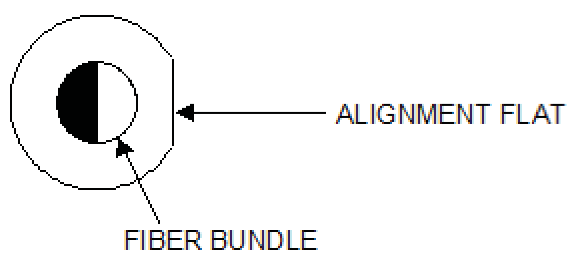
- Preferred orientation is same as Case 1.

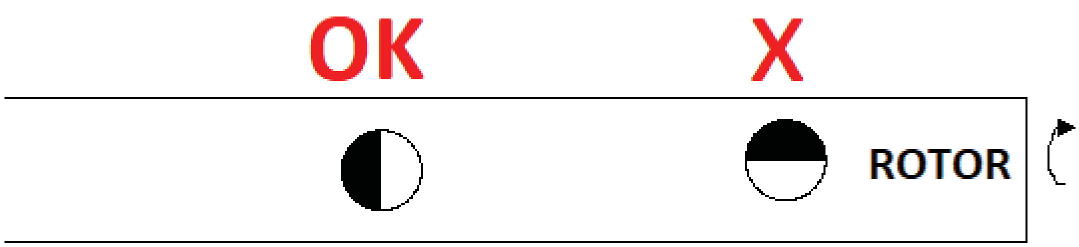
SMALL ROTATING TARGETS

CASE 6:

With small diameter rotors, the radius of curvature is small and the sensor output can be altered. It is best to mount the sensor with the alignment flat perpendicular to the cylindrical axis as shown below. The sensor should not be mounted with the flat parallel to the shaft axis.

The standard factory calibration to a flat target will not apply accurately. A calibration to a target having the same diameter as the small rotor should be used.





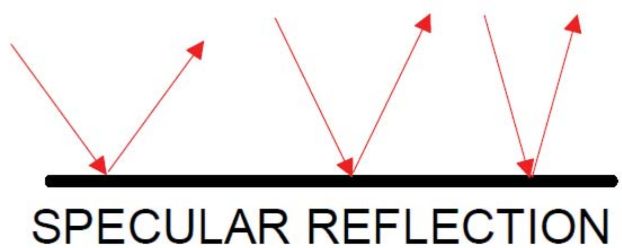
REFLECTIVE NATURE OF THE TARGET SURFACE

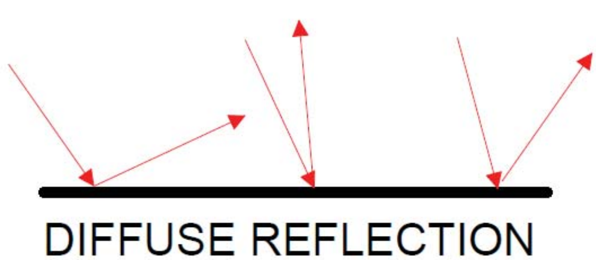
Specular Targets...A mirror surface calibration should be used when making measurements to mirrored surfaces.

A factory supplied calibration chart shows the sensor's voltage relationship with distance to the target surface, where the target surface is a front surface aluminized mirror. The RC sensor as delivered from the factory can be used - without adjustment - for any target surface is very smooth, highly polished, mirrored, glossy or very shiny; i.e., specular.

Diffuse Targets... A diffuse surface calibration should be used when making measurements to diffuse surfaces. A diffuse surface looks dull rather than shiny.

With diffuse surfaces, reflected light rays travel randomly varying path lengths back into the sensor tip. Reflectance compensation does not correct for this random scattering of light rays. The response of an RC sensor to a diffuse reflector can be as much as 15% in error unless it is recalibrated or reset to the diffuse reflector. See Philtec Application Note "Reflectance Compensated (RC) Sensors" of Nov 2017.



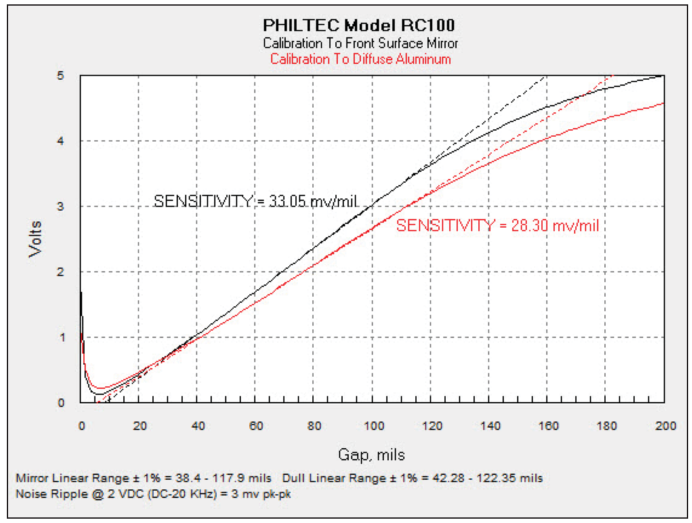


FACTORY CALIBRATIONS

Two calibrations are provided:

- Front Surface Mirror Sensitivity with linear range
- Diffuse Dull Aluminum Sensitivity with linear range

The XY calibration data points are made available upon request.



ADJUSTING THE AMPLIFIER FOR CUSTOM TARGETS

A control labelled **CAL 1** is located on the side of the amplifier. The CAL 1 control is used to set the DC voltage output to full scale (5.000 volts) when the sensor gap is set to full scale. This control is set during factory calibration with a specular target surface such that the sensor output reads precisely 5.000 volts at the maximum gap for that sensor.

Maximum Operating Gaps For RC Sensors

MODEL	RC19	RC20	RC25	RC32	RC60	RC62	RC63	RC90	RC100	RC171	RC190	RC290
mils	30	65	30	80	125	80	160	350	200	500	1000	1600
mm	0.76	1.65	0.76	2.0	3.2	2.0	4.0	9.0	5.1	12.7	25.4	40.6

PROCEDURE

1) SET THE SENSOR GAP... With a custom target surface, while maintaining perpendicularity to the target, set the maximum sensor gap for your model according to the table above.

2) RESET THE CAL 1 CONTROL...Remove the black cover from the Cal 1 control and adjust the Cal 1 control until the DC output volts reads precisely 5.000 volts at that maximum gap.

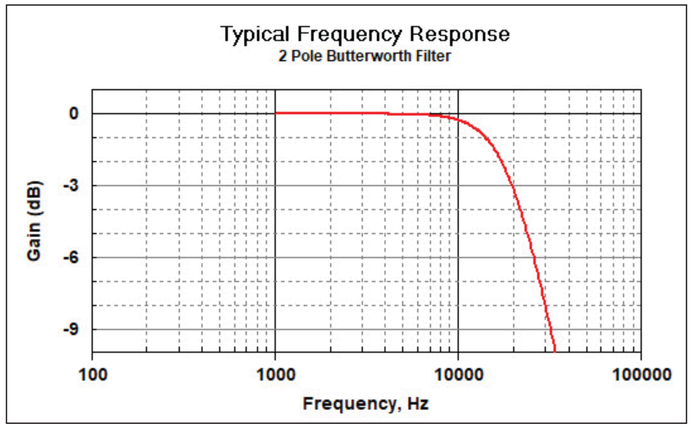
Note:
Adjusting this control voids the factory calibration setting.

THE SENSOR IS NOW RESET FOR MEASUREMENTS TO CUSTOM TARGETS

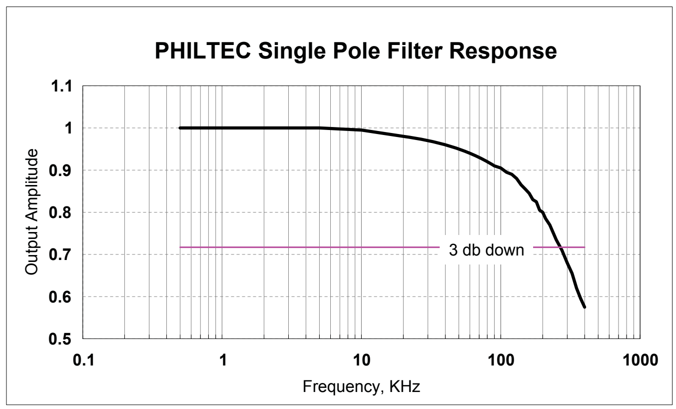
FREQUENCY RESPONSE

The standard 20 KHz RC sensor has a 2-pole butterworth frequency rolloff. The chart shows the typical response. With the 3 db down point set at 20 KHz, the output is flat out to approximately 6 KHz.

- With a high frequency amplifier, the 3 db down point is set at 200 KHz.
- With a low frequency amplifier, the 3 db down point is set at 100 Hz



NOTE: Any high frequency amplifier exceeding 200 KHz as well as the Options +H and +L will have a one-pole filter response as shown below.

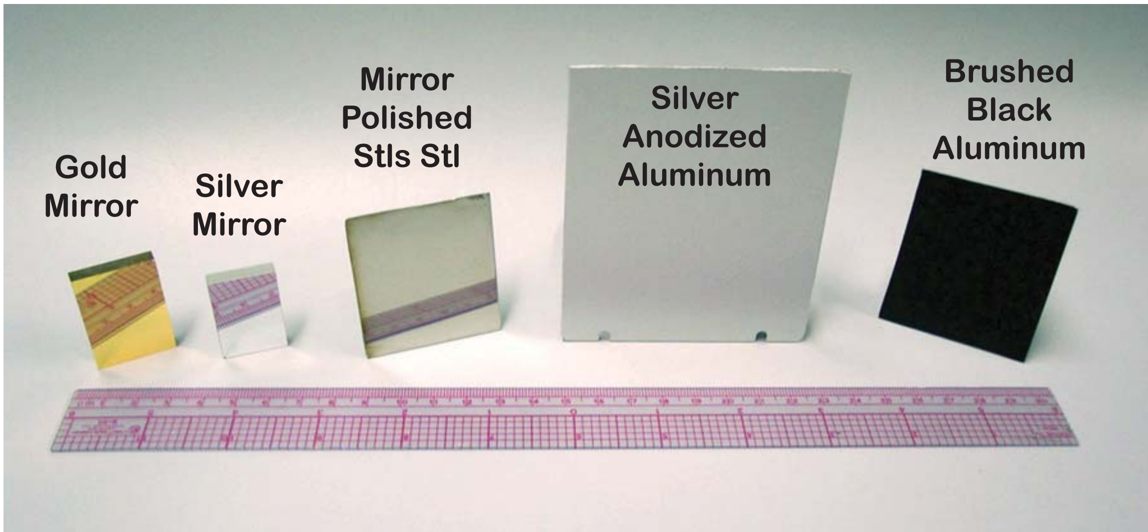


WARRANTY

Fiber Optic Displacement Sensors are warranted by Philtec, Inc. against defects in material and workmanship for 12 months from the date of shipment from the factory. Damage to the fiber bundle or sensor tip from rough handling is not covered under this warranty.

Philtec Application Note Vol. 6, No. 25
Nov 2017

Reflectance Compensated (RC) Sensors



The Problem

The output signal from an intensity-based reflective optical displacement sensor (*Philtec D Type*) varies proportionately with the reflectivity of the target surface as well as with distance: i.e., the shinier the target, the higher the signal. This limits successful distance measuring applications to targets having a single axis reciprocating or vibratory motion (reflectivity is unchanging).

The Solution

PHILTEC developed the ***Reflectance Compensated*** fiberoptic sensor to overcome those limitations of reflectance dependent sensors, by providing a sensor whose output signal is blind to reflectance variations. The RC type sensor is a more general purpose optical sensor that can make accurate distance measurements to rotating or translating targets as well as measure part-to-part size variations in production parts.

RC Sensors

Light is transmitted to the target thru one side of adjacent fiberoptic bundles. The reflected light is captured in two separate fiber bundles which follow independent paths back to the electronics. A ratiometric calculation provides the distance measurement which is independent of target reflectivity variations; i.e., **reflectance compensated.**

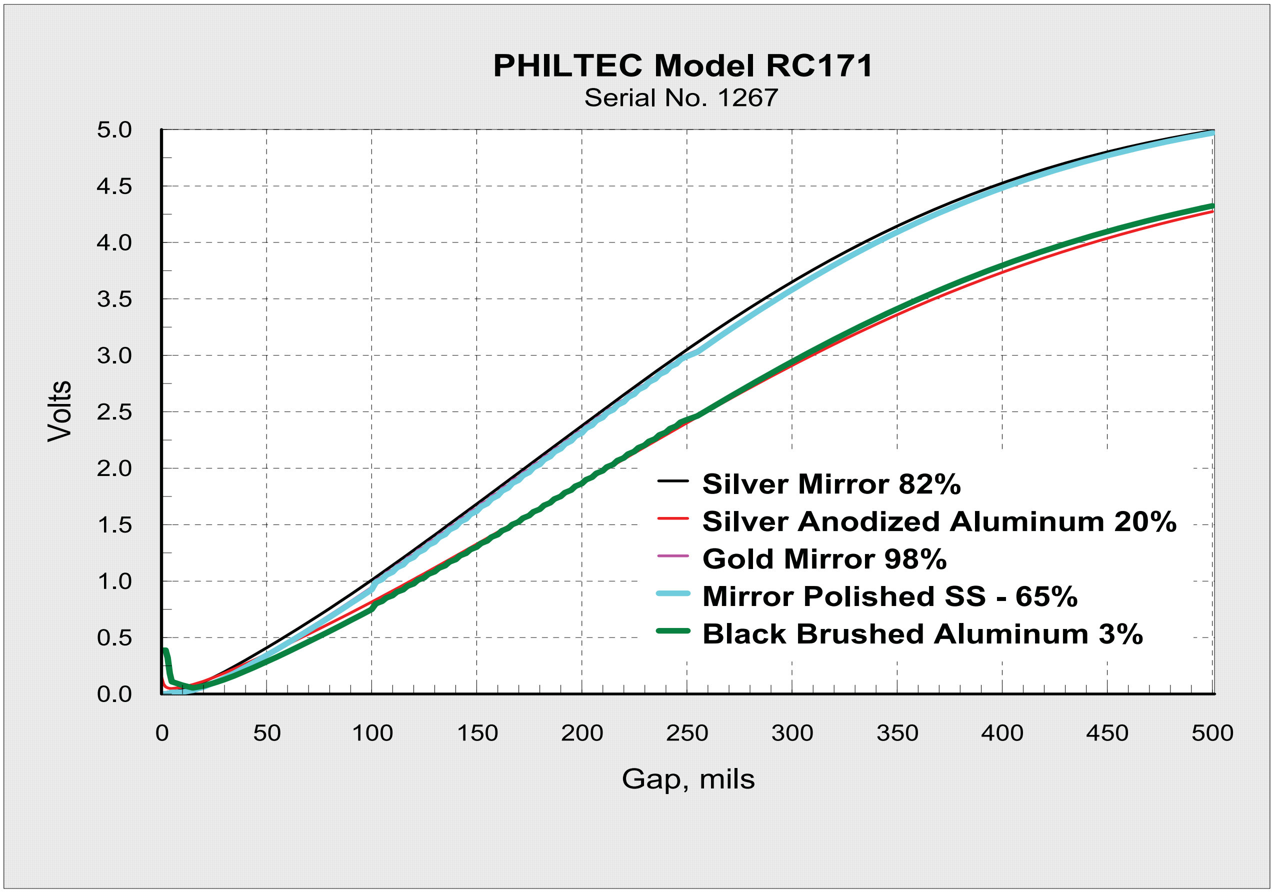
MIRROR vs. DULL SURFACE RESPONSES

Specular (Mirrored) Targets

All targets with mirror smooth surface finish generate identical output responses. This is illustrated in the chart below where the gold, silver and stainless steel mirrors generate identical outputs even though their surface reflectances vary from 65 to 98%.

Diffuse (Dull) Targets

Dull or matte finish targets will generate output curves less steep than specular targets. While being different than the mirror targets, they are essentially identical between them. This is illustrated in the chart below where the silver anodized aluminum and black brushed aluminum generate identical outputs even though their surfaces vary from 20% to 3% reflectance.



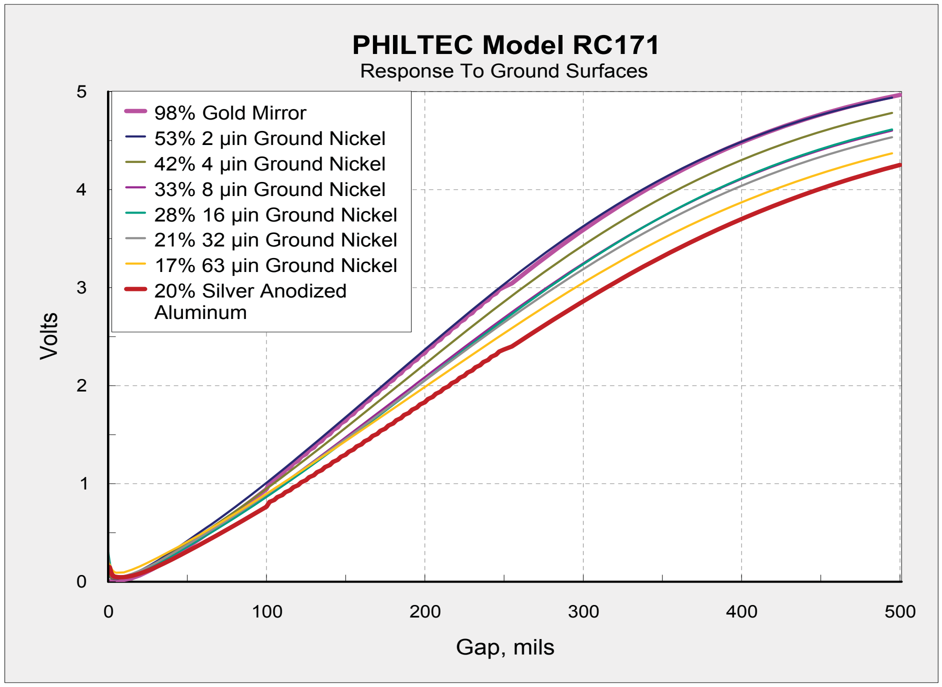
This chart illustrates that reflectance compensation works over a very wide range of target reflectances, nearly 100::1. These data also demonstrate that reflectance compensation does not correct for the differences between specular and diffuse reflectors. Specular (smooth and shiny) targets generate about 15% higher sensitivity than diffuse reflective targets...and therefore, different calibrations are required for different surface roughnesses (but not for different materials).

Machined Surfaces

Machined surfaces span the range from diffuse to specular. Rough machined surfaces are diffuse reflectors. Ground finishes can be in between totally diffuse and specular. This is illustrated in the chart here: a 2 microinch ground finish acts essentially as a mirrored surface; a 63 microinch ground surface is essentially a diffuse reflector. For best results, it is always good practice to calibrate a sensor to the same ground surface to be measured.

Reflectance of the ground surfaces are provided here.

Differences between the ground surfaces are <u>proportional to the surface roughness</u>, not to the reflectance of those surfaces.



Custom Calibrations

The factory supplies calibrations to mirrored and dull targets. To make accurate measurements to custom targets other than mirrored or totally diffuse:

a) calibrate the sensor to the target material, or

b) rescale the sensor output to the target material.

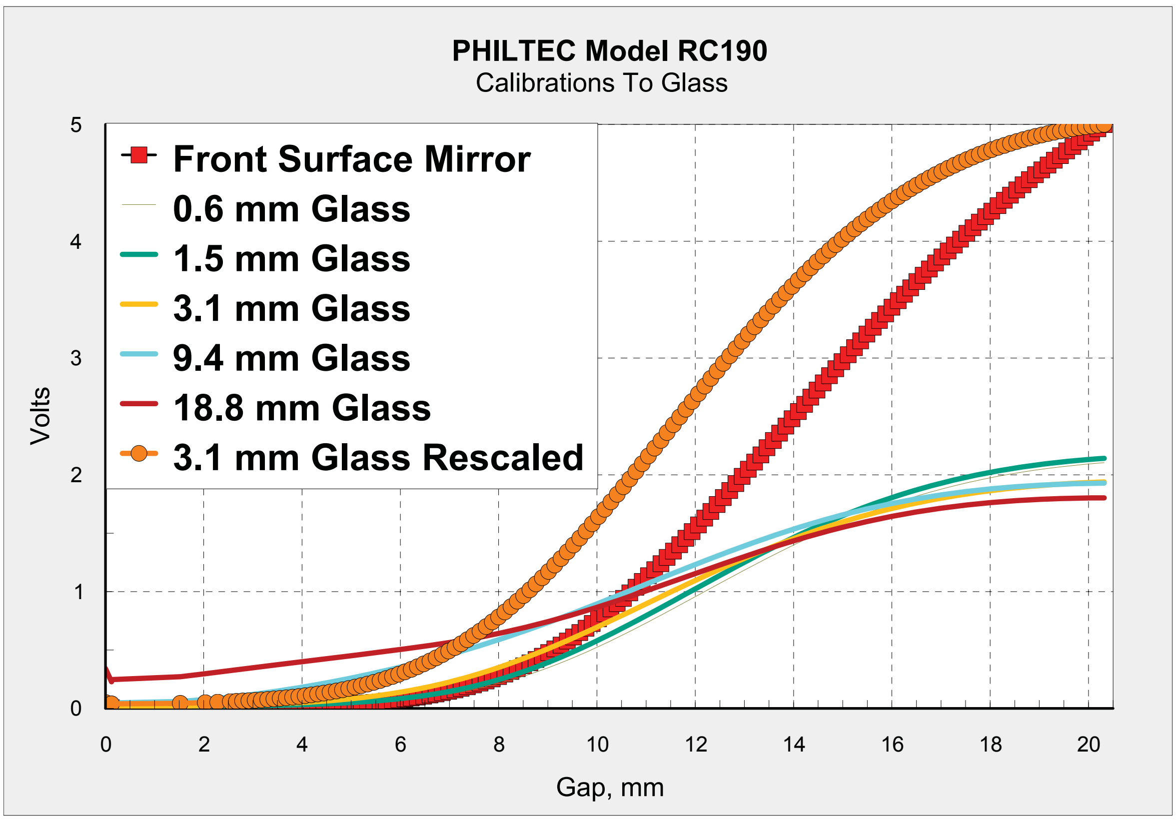
<u>Analog Sensors</u>: A Gain Control is provided for rescaling the analog sensor output. The procedure is simple. Gap the sensor to full scale, such as 500 mils for the model RC171 shown above. Using the Gain Control, bring the output voltage to read precisely 5.0 volts.

<u>Digital Sensors</u>: DMS units have 24 storage registers for calibration data. The factory supplies new DMS units with a mirror calibration in register #1 and a diffuse target calibration in register #2. DMS Control Software lets the user scale either cal table and store the results in another register.

Transparent Materials

Transparent materials require calibrations to the material with the same thickness, as some light will reflect off the front surface and some light will reflect off the back surface and return to the sensor. In the examples shown below, a model RC190 was first set up and calibrated to a front surface mirror. Then, it was used without adjustments, and calibrated to 5 different thicknesses of glass. The output voltage reached only 2 volts at 20 mm with glass.

Finally, a repeat calibration was performed using the 3.1 mm thick glass, where the sensor was rescaled to 5 volts using the Gain Control. The resulting slope sensitivity of the sensor was equal to that using a front surface mirror.



APPLICATIONS FOR RC SENSORS

Automated Parts Inspection Bearing/Rotor Dynamics Commutator Profile Hard Drive Assembly Deformation Studies	Distance To Glass Distance To Paper Dynamic Expansion Hard Disc Thickness Precision Grinding	Process Control Rotor Runout Shaft Orbits Structural Deformation Surface Finish	Turbine Blade Growth Ultrasonic Vibration Ultra-High Vacuum Vibration Studies