Reflective Assemblies

Application Bulletin 247

Design considerations for single-sided sensing applications

A reflective sensor provides a major mounting advantage to the designer because only one side of a sensing surface is required. However, there are a number of design variables that need to be considered to assure detection of the object or target. They include the type or size of the reflective surface, the distance to the reflective surface, variation of surface reflectivity, sensor variation and contrast ratio. There are two types of reflective sensors that Optek manufacturers, focused and unfocused. For this discussion, a reflective sensor consists of an emitter and detector in the single housing.

Reflective Sensor Types

FOCUSED REFLECTIVE ASSEMBLY: Sometimes referred to as 'arrowhead' sensors because of their shape, the discrete components are positioned within the sensor such that the optical axes converge at a specified distance. Their components generally each have a lens, because the tighter the beam angle of the emitter and detector, the better they are focused, hence the more accurate an object can be sensed. In this device type, the on-state collector current, Ic(on), peaks when a the reflective surface is typically placed from 0.100" to .300" (2.5 mm to 7.5 mm), [see graphs page 2] but longer distances can be designed as well for up to 30+" (760 mm).


From left: OPB700, OPB703WA (leaded version available), OPB708 and OPB740WZ.

Because the emitted light pattern follows a diverging pattern, rather than a straight line through its centerline, and the detector views a converging pattern, rather than a straight line through its optical centerline, the maximum or peak Ic(on) occurs at ~75% of the distance to the intersection of the optical centerlines of the LED and photodetector. In other words, if the components' optical centerlines are focused to a reflective surface at a distance of 0.200" (5.0 mm) from the housing, the approximate peak of Ic(on) would be at 0.150" (3.8 mm). This type of sensor is best for detecting polished or highly smooth shiny surfaces. Examples of this type of sensor are Optek's OPB700, 701 series, OPB703, 704 series and OPB708, 709, 740-745 series.

UNFOCUSED REFLECTIVE ASSEMBLY: Their components, generally without lenses are positioned within the sensor such that their optical axes are parallel. In this device type, the on-state collector current, Ic (on), peaks when a the reflective surface is typically placed .050" to 0.080" (1.25 mm to 2.0 mm), (see graphs page 2) from the component face of the sensor. Distances up to over 1.5" (38mm) can be designed for. These leaded and surface mount sensors were designed for use on PC boards. This type of sensor is best for detecting in the presence of rough or matte finishes. Examples of this type of sensor are Optek's OPB606 - 608 series, OPB706 - 707 series, OPB711 & 712, and OPB710 and OPB730. Surface mount as assemblies include the OPB609 series and OPR5005.


From left: OPB606, OPB706, OPB711, OPB710, OPB609, and OPR5005.

CONTRAST RATIO

One of the most important considerations when using a reflective sensor is the Contrast Ratio (CR). The Contrast Ratio is defined as the ratio of the received signal strength in the presence and absence of the target object. This can also be defined as the ratio of two objects that are trying to be distinguished apart from one another. This ratio should be a minimum of 3:1.

CR = Ic(on) with Target / Ic(on) w/o Target

From this chart it appears that a 3:1 Contrast Ratio is easy to attain but, that doesn't always happen because there are other factors that must be considered.

Contrast Ratio to Kodak 90% white paper	FOCUSED Reflective Assemblies				UNFOCUSED Reflective Assemblies			
	OPB700	d=.200"	OPB742	d=.150"	OPB706	d=.050"	OPB711	d=.080"
Surface Material | Output	µA		µA		µA		µA	
Kodak 90% diffuse neutral white paper	115	Contrast Ratio	420	Contrast Ratio	1950	Contrast Ratio	1430	Contrast Ratio
No reflective surface	0.2	479	1.6	271	0.8	2597	4.3	331
Flat black matte paint (3M #101-C10)	1.6	72	6.4	66	21	93	31	46

Table 1 - Contrast Ratio

General Note
TT Electronics reserves the right to make changes in product specification without notice or liability. All information is subject to TT Electronics' own data and is considered accurate at time of going to print.

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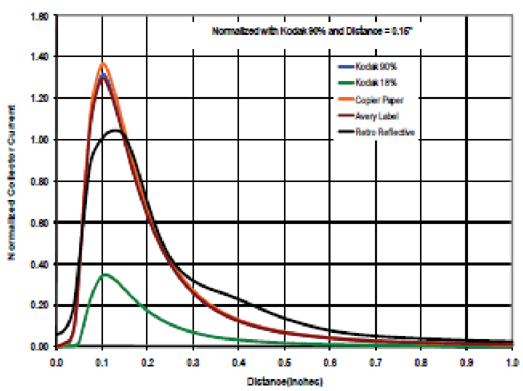
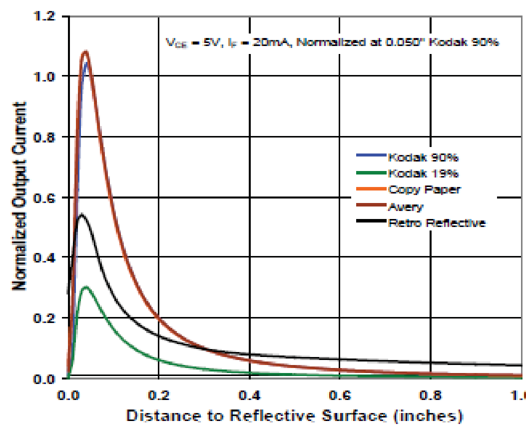
OUTPUT VS. TARGET DISTANCE

It is important that the sensing distance to the target be matched to the specific reflective sensor so other mechanical and electrical variations cause minimal output [Ic(on)] variation. To find the best range for a specific reflective sensor, refer to its Normalized Collector Current vs. Distance to a Reflective Surface graph located in the datasheet and choose the endpoints of the most linear region of the curve and those endpoints will correspond to a distance shown on the x-axis of the graph. For the OPB700 that linear region falls from about .100” to .300”, which becomes the optimal detecting distance range. Note as the distance to the reflecting surface increases the normalized output has decrease into a region where the distance has very little impact on the output. This is not a good region to operate the sensor because not only is the output low but the CR may not be acceptable even versus a non-reflective or no reflective surface. In this region it may be difficult to distinguish between the two surfaces or targets.

But this characteristic can also be taken advantage of. For gear tooth sensing applications, the distance naturally varies from the peak of the tooth to the valley between the teeth providing a significant output difference if the tooth is designed correctly to reflect at the tip of the tooth. Similarly, designed properly, a slot in a target will attain a good CR. (The designer should make sure that there is not another reflective surface behind the gap that could cause a reflective path that would diminish the CR.)



Graph of OPB700 Focused Normalized Collector Current vs. Distance to a Reflective Surface.



Graph of OPB706 Unfocused Normalized Collector Current vs. Distance Reflective Surface.

OUTPUT VS. SURFACE TYPE

The output from the reflective sensor can vary by surface type. It would be a mistake to assume that these reflective sensors sense infrared the same way the human eye sees visible light. To a reflective sensor different color surfaces can have similar reflective properties, thereby becoming indistinguishable.

Several observations can be made from the table.
1. A shiny metallic surfaces reflect best for focused sensors.
2. Flat black matte paint and dull black tape are excellent non-reflecting surfaces, nearly equivalent to the absence of a reflective surface and will give an excellent contrast ration with most any surface.
3. Color and texture of a plastic tape yield very little difference to the IR reflective sensor.
Note: Aging of the reflecting surface and foreign debris can diminish the sensor’s desired output , thereby affecting the CR.

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TARGET SIZE

The designer will want to know how to determine the smallest size or pitch that the sensor can detect. An optimized size is one which will yield no increase in Ic(on) when its size is increased and conversely will yield a decrease in Ic(on) as the size of the reflective surface is decreased.

SENSOR VARIATION

The output, Ic(on) of all sensors vary within their production population, so minimum and maximum values as shown in the datasheets may need to be comprehended as well as their variations over the operating temperature range.

SUMMARY

The information presented should allow the engineer / designer to understand the two types of reflective sensors and the basic variables that exist in reflective sensor applications. An understanding should allow the choosing of the best reflective assembly type for the application and a successful implementation.

Sensor Output Ic(on)	FOCUSED Reflective Assemblies				UNFOCUSED Reflective Assemblies			
	PT	PD	PT	PD	PT	PD	PT	PD
	OPB700	OPB701	OPB742	OPB745	OPB706	OPB707	OPB711	OPB712
reflective distance	d=.200"	d=.200	d=.150"	d=.150"	d=.050"	d=.050"	d=.080"	d=.080"
Surface Material | Output	µA	µA	µA	µA	µA	µA	µA	µA
Aluminum Foil Tape	689	33390	6160	41180	1000	54250	1220	29930
Kodak 90% diffuse neutral white paper	115	5420	420	3720	1950	53990	1430	31630
No reflective surface	0.2	9.2	1.6	1.1	0.8	0.5	4.3	0.2
Flat black matte paint (3M #101-C10)	1.6	34.6	6.4	22.4	21	3400	31	1160
Dull black #M Tape #476	1.4	36.1	6.8	24.8	0.2	4250	34	1400
White bond paper	85	4330	320	2920	860	52330	1050	28700
Clear smooth finish plastic tape	123	7920	728	5040	964	52990	1360	31330
Clear matte finish plastic tape	90	4850	351	2750	913	47570	1230	31400
Blue smooth finish plastic tape	118	7330	648	4850	985	52260	1300	31100
Blue matte finish plastic tape	100	5760	439	3290	961	52270	1280	30800
Red smooth finish plastic tape	116	7010	614	4620	996	52810	1310	31500
Red matte finish plastic tape	106	6080	471	3600	972	52520	1380	31200
PT - Phototransistor Output PD - Photodarlington Output								

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