SenseTek Proximity Sensor Mechanical Design Guide

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Contents

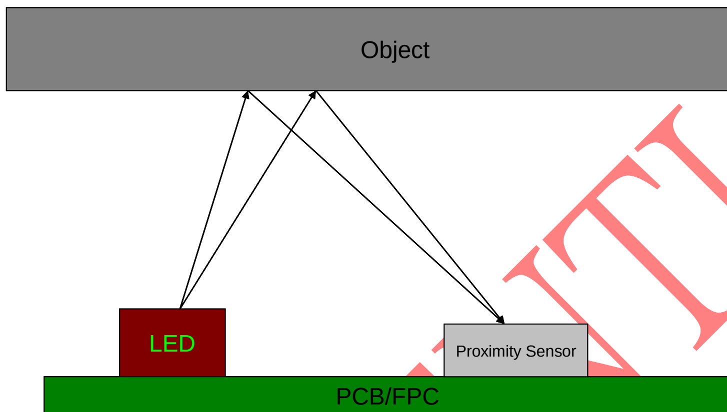
Change Log

Date	Version	Change log	Sponsor	Remark
7/30/2011	0.8	Preliminary Release	Patrick Chang	
8/19/2011	0.9	Add FOV in reference deisgn	Patrick Chang	

1. Basic Design Concept and Description of Technical Expression

1.1. Principle of optical proximity sensor

The proximity detecting system includes two main components, one emitter and one receiver.
The proximity sensor IC (receiver) will driver LED (emitter) to emit IR-light and receive the signal returned (reflected) from the object. Sensor will get larger signal while objector being closer.



In almost all cases, the receiver will get both two kinds of lights, signal reflected from the object and noise from the ambient light. In order to cancel the background noise, the proximity sensor uses time-differential-elimination to archive.

Reading 1 = Signal (reflected from object) + Background Noise (Ambient Light)
Reading 2 = Background Nose (Ambient Light)

PS Output = Reading 1 – Reading 2 = Signal (if background noise 1 = background noise 2)

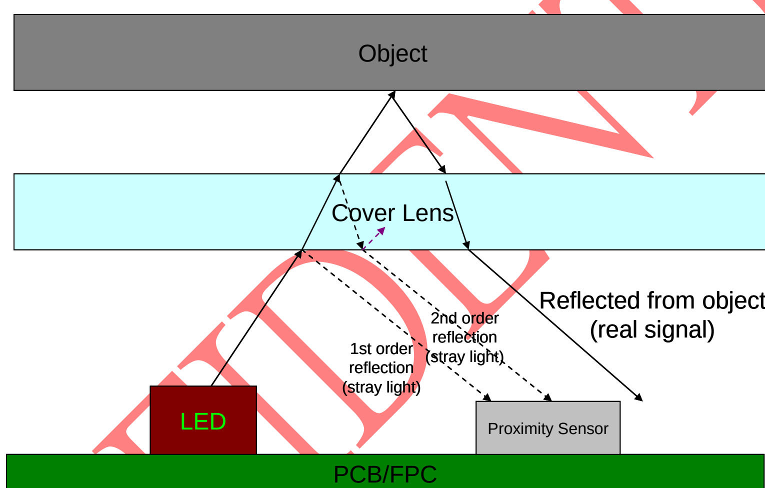
LED's pulse width was set to be 100 ~ 500 us usually. In those conditions, we could ignore the variation of background ambient light expect high frequency light. (High frequency light is much lower than ambient light and signal, so we can also ignore it.)

1.2. Stray light

When proximity sensor receives lights emitted by LED, the sensor will treat those lights as signal whether they are reflected from object or the other thing. In almost all phones, there are the cover lens, housing and the other mechanical parts above proximity sensor. And all those parts reflect lights emitted from LED. We call those NOISE lights STARY LIGHT.

1.2.1. Stray light from cover lens

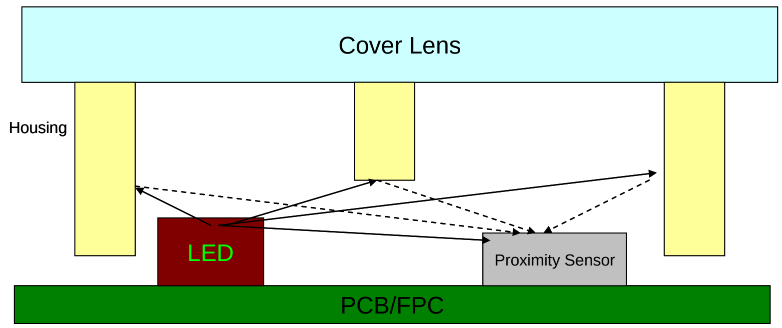
Cover lens will reflect rays even if it is transparent. Those reflections we call FRESNEL REFLECTION LOSS. (See Wiki Fresnel Reflection Loss)



For typical usage, material of cover lens is plastic or glass (refractive index = 1.4 ~ 1.6). Reflection coefficient R is around 4% (1^{st} reflection + 2^{nd} reflection ~ 8%)

1.2.2. Internal stray light

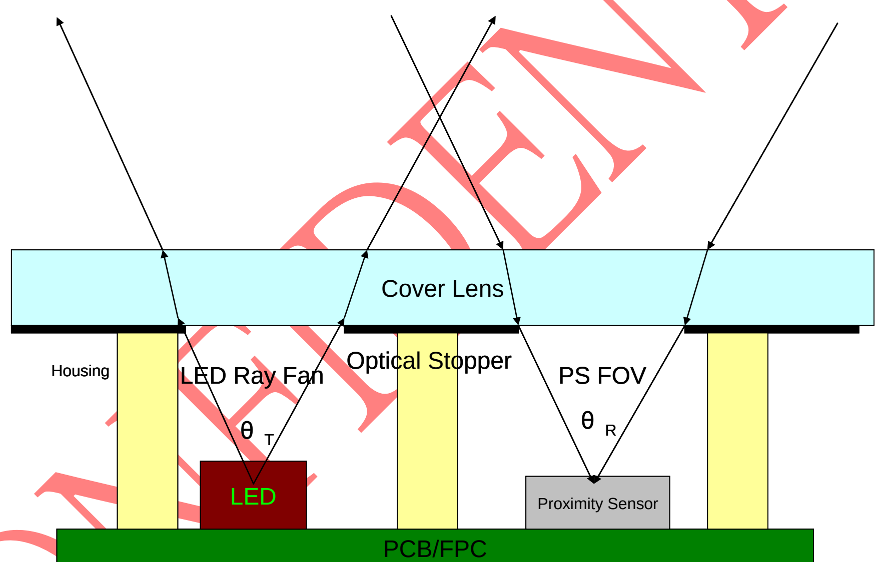
Proximity sensor receives lights that emitted from LED directly. Besides, the sensor also receives lights reflected from the housing / other mechanical parts.



To avoid internal stray light, we recommend using black or deep color mechanical parts rather than white ones.

1.3. Field of View (FOV) and Divergent Angle

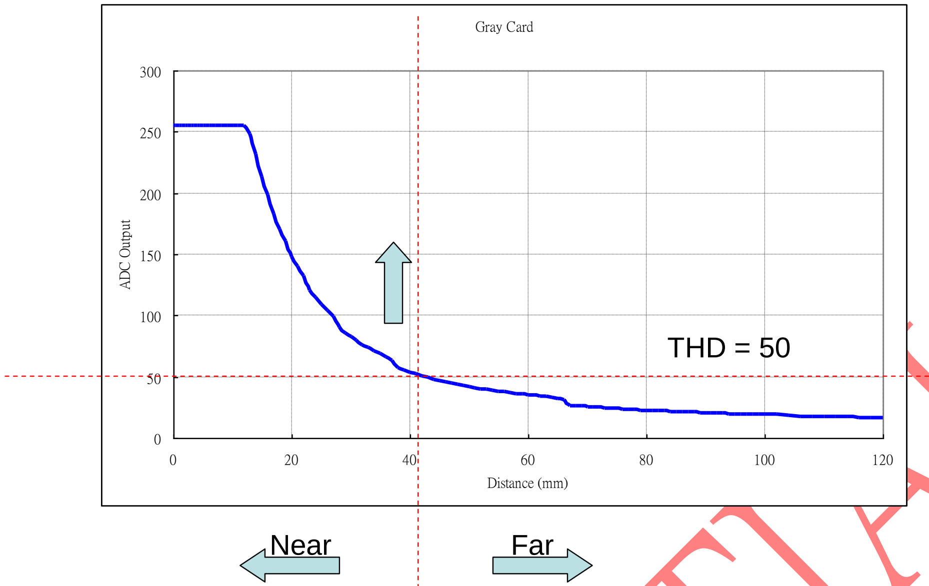
View angle θ_R is the angle of view describes the angular extent that ambient lights illuminate the sensor. Larger FOV is better. For more details, see the FOV report of bare die in the datasheet.



LED divergent angle θ_T is the maxima angle of emission lights. Fine tune FOV and divergent angle to reach the performance you want.

1.4. Detectable Range and Hysteresis

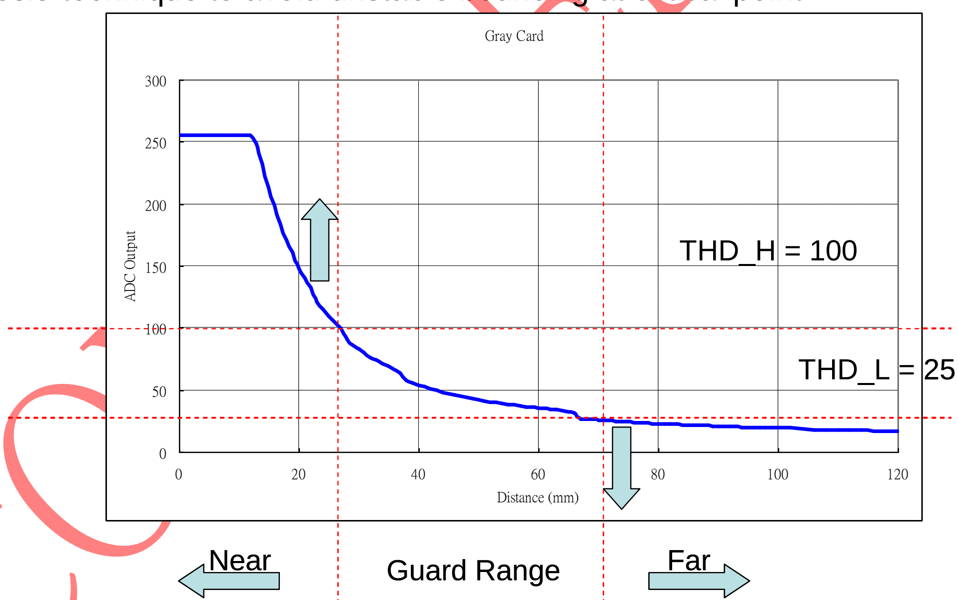
We would use the signal amplitude to determine that object is near or far. The distance which signal is significant is called detectable distance or working distance.



In the illustrator: THD = 50 ➔ if signal >= 50, near (~40 mm)
if signal < 50 , far

1.4.1. Hysteresis

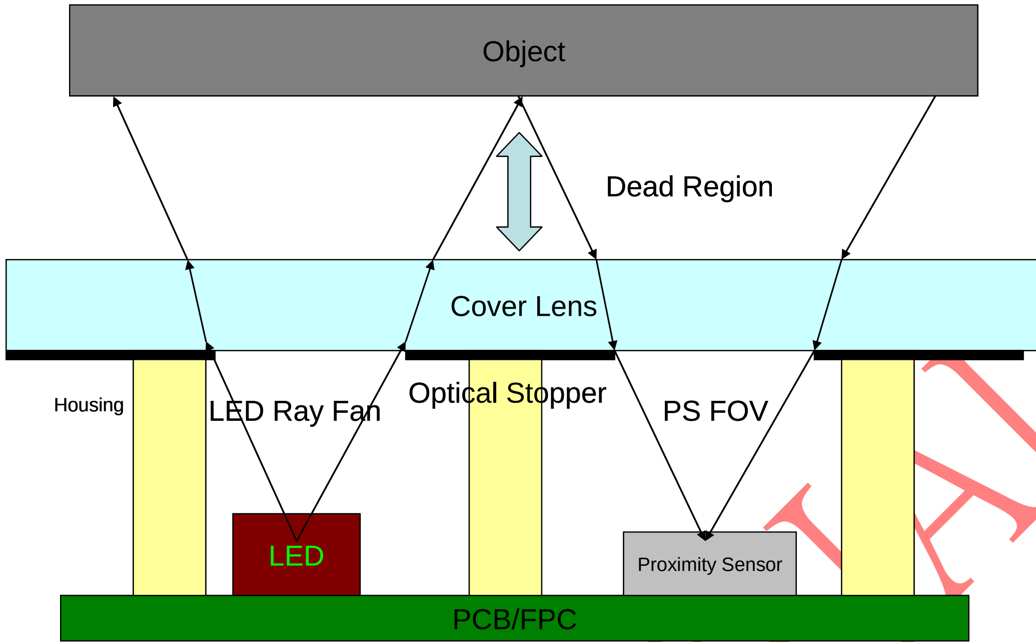
Use hysteresis-technique to avoid unstable bouncing at critical point.



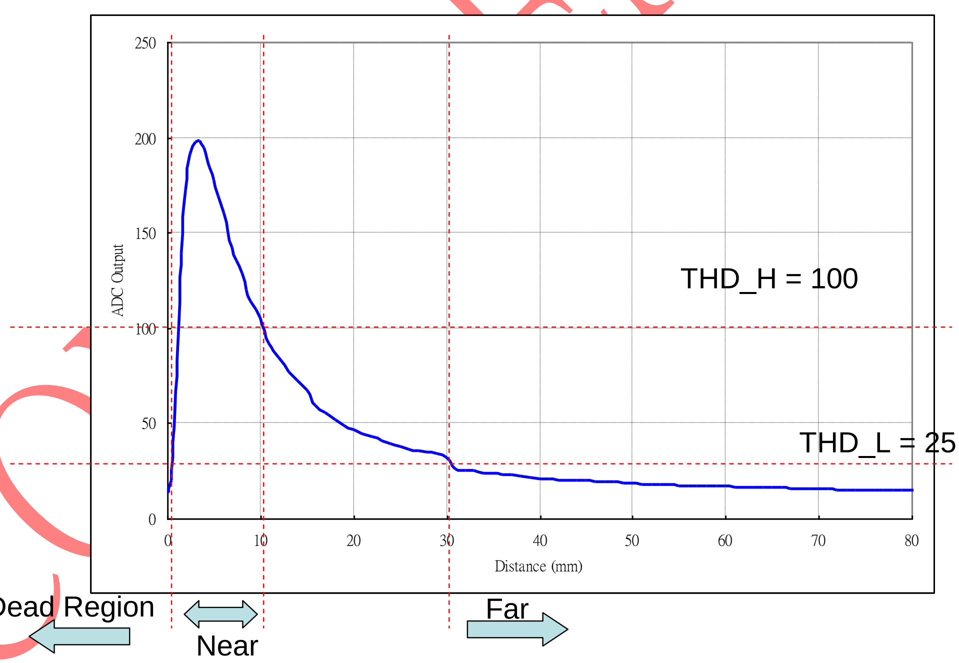
In the illustrator: THD_H = 100, THD_L = 25 ➔ if signal >= 100, near (~23 mm)
if signal <25 , far
if 100 > signal >= 25, last state

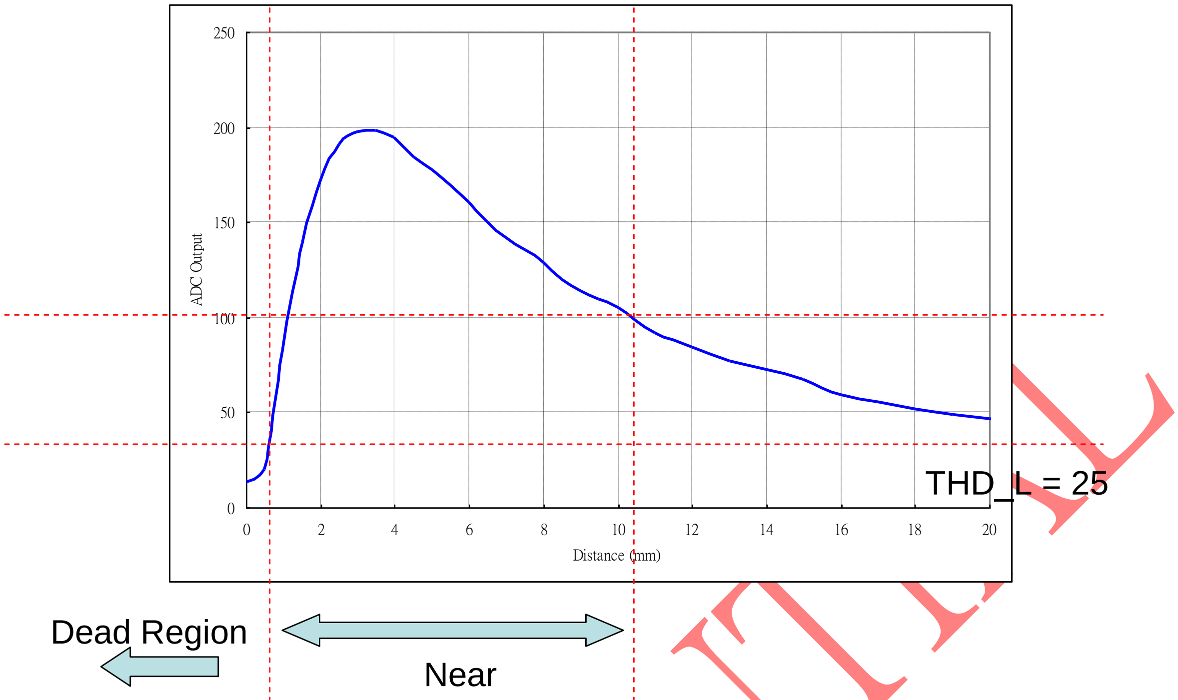
1.4.2. Dead Region

As we known, there are some mechanical parts to eliminate the stray light. But those parts also eliminate signal reflected from the detecting object when the detecting object is too close to the cover lens. In the extreme conditions, there is no possible path for light's propagation.



PS wouldn't receive any 1st reflecting rays in dead region. The dead region means region between intersection plane and cover lens plane

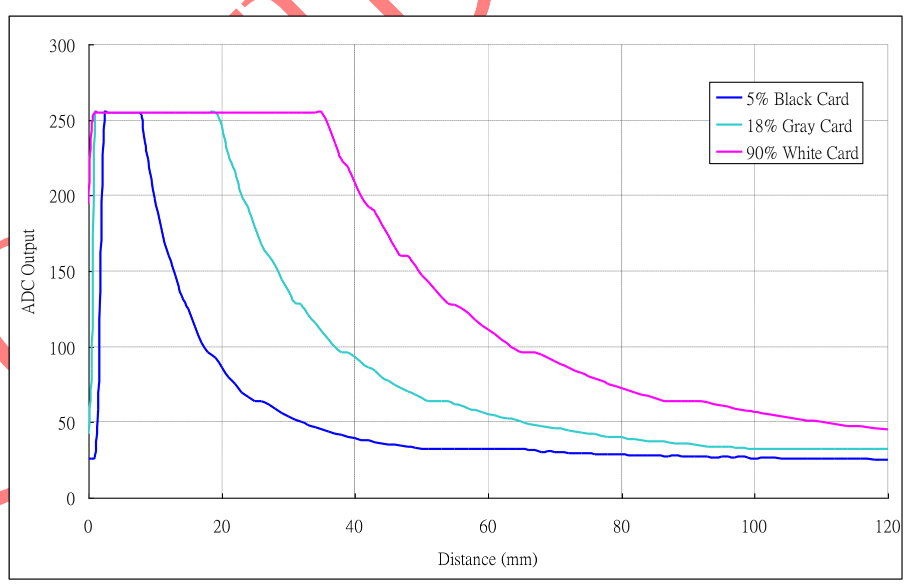




Use hysteresis-technique could tighten dead region but still can't solve this problem completely. Fine-tune mechanical parts' layout could solve this problem.

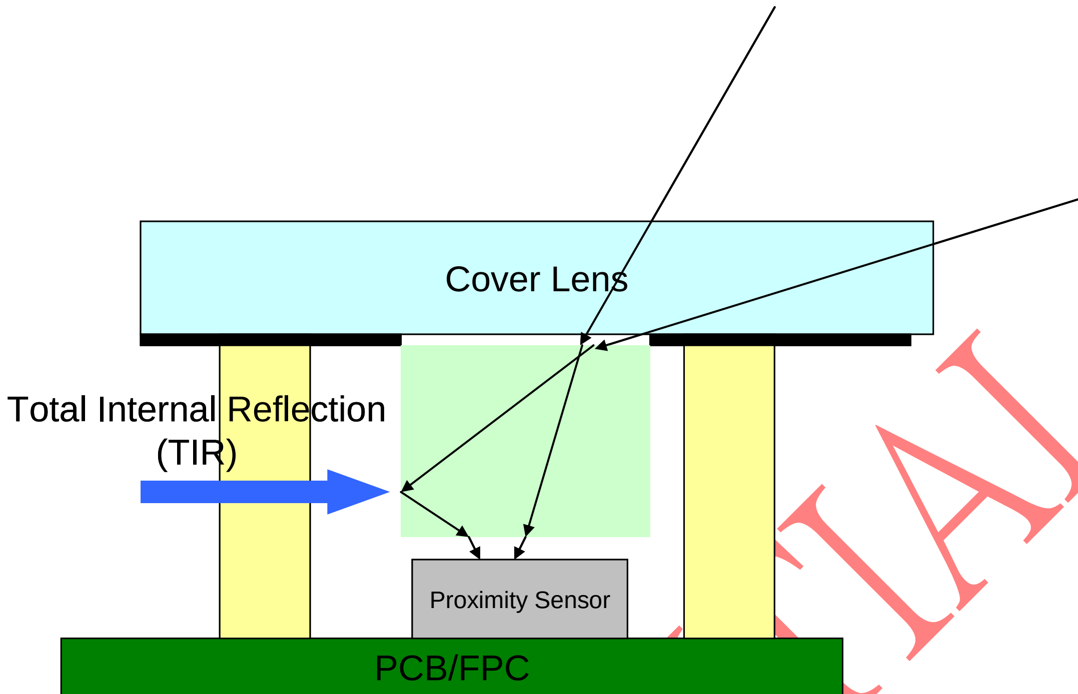
1.5. Color Dependent Signal

Proximity sensor get different signal with different color objects.

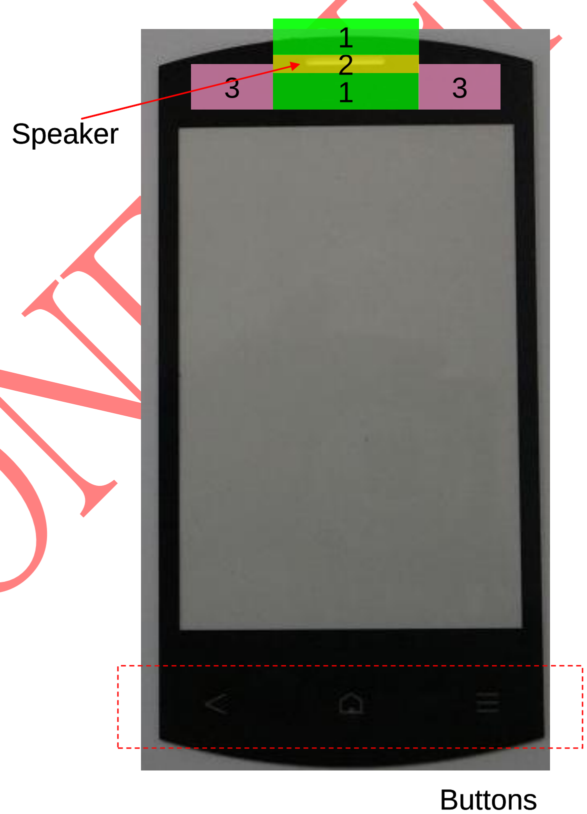


1.6. Light Pipe

Light pipe is a simple and good design to increase FOV. The structure of light pipe is quiet simple, just a rod. For more details, see the chapter of design of light pipe.



1.7. The recommended position of final product



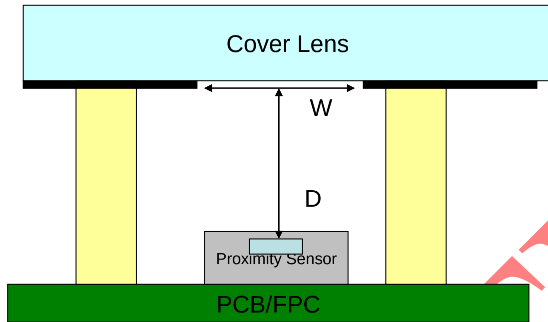
Recommended Position (Priority):
1st Position: upper or lower than the speaker region.
2nd Position: under the speaker mesh.
3rd Position: left or right to center.

1.8. Width to depth ratio (WDR)

For lower cost design, we would not use any light pipe but we still want larger FOV.

WDR ≡ W/D, W= Open window diameter, D = Distance from open window to photo-diode in PS

We strongly recommend WDR > 2.0

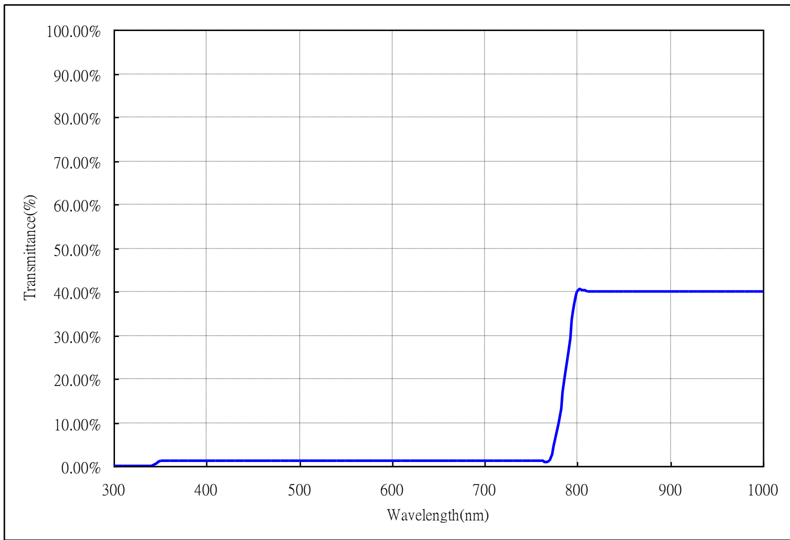


WDR	FOV (deg)	WDR	FOV (deg)
0.5	28.1	1.6	77.3
0.6	33.4	1.8	84.0
0.7	38.6	2.0	90.0
0.8	43.6	2.2	95.5
0.9	48.5	2.4	100.4
1.0	53.1	2.6	104.9
1.2	61.9	2.8	108.9
1.4	70.0	3.0	112.6

1.9. The recommended material for optical window/light pipe

For optical window, we recommend using "glass" with a black coating that transmittance > 1.25% (400~700nm), >40% (750~950nm). Besides, we also recommend using transparent plastic (e.g. polycarbonate) with black coating and the transmittance still is above than 1.25% during 400~700nm and 40% during 750 ~ 950nm.

For light pipe, we recommend using transparent plastic and its optical refractive index should be above than 1.4. The net transmittance over the total thickness of the rod and optical window should also be above 1.25% during 400~700nm and 40% during 750~950nm.



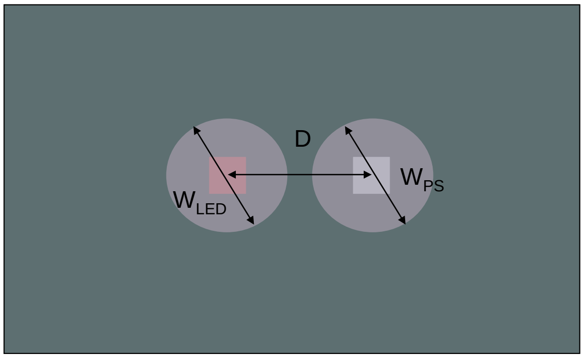
Wavelength Section (nm)	300 ~ 400	400 ~ 450	450 ~ 600	600 ~ 780	780 ~ 800	800 ~ 950	>950
Transmittance Requirement (%)	Don't care	approximate to section 450 ~ 600	>1.25%	<= section 450 ~ 600	Don't care	>40%	>20%

1.10. Ambient Light Sensor Performance

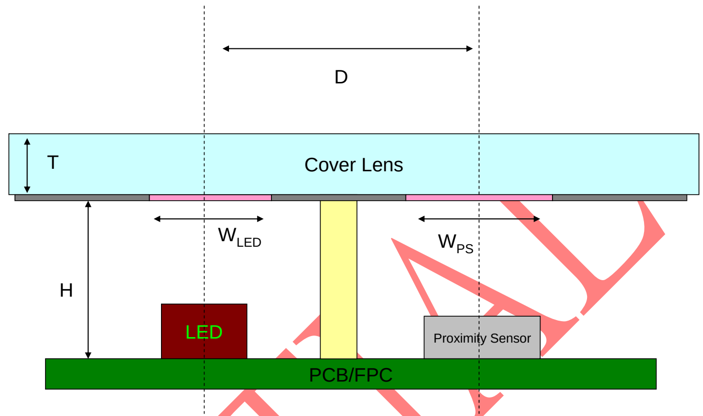
Sensetek provides both 2 in 1 (PS+ALS) and 3 in 1 (PS+ALS+LED) solutions to customers. Don’t forget to fine-tune ALS performance when you design mechanics for PS. To enhance ALS performance, you would increase FOV of sensor. Recommended FOV is larger than 90°. (>120° is better)

2. *Reference Design*

2.1. Reference Design for 2 in 1 Sensor + LED



Top View



Side View

W_{LED} : Diameter of LED Open Window
W_{PS} : Diameter of Proximity Sensor Open Window
D : LED Center to Proximity Sensor Center
H : PCB Top to Touch Panel Bottom
T : Cover Lens Thickness

2.1.1. STK3158 + STK3101/3128

Refractive Index = 1.5 @ Wavelength = 850nm					
Glass Thickness (mm)	H (mm)	WLED(mm)	WPS(mm)	D(mm)	Sensor FOV (˚)
0.7	2	3	3	4.05	100
	2.5	3	3	3.85	81
	3	3.2	3.2	3.95	70
	3.5	3.5	3.5	4.25	65
	4	4	4	4.75	63
0.8	2	3	3	4.15	100
	2.5	3	3	3.95	81
	3	3.2	3.2	4.05	70
	3.5	3.5	3.5	4.35	65
	4	4	4	4.85	63
0.9	2	3	3	4.25	100
	2.5	3	3	4.05	81
	3	3.2	3.2	4.15	70
	3.5	3.5	3.5	4.4	65
	4	4	4	4.85	63
1.0	2	3	3	4.4	100
	2.5	3	3	4.2	81

	3	3.2	3.2	4.3	70
	3.5	3.5	3.5	4.45	65
	4	4	4	4.95	63
1.1	2	3	3	4.5	100
	2.5	3	3	4.3	81
	3	3.2	3.2	4.3	70
	3.5	3.5	3.5	4.5	65
	4	4	4	5	63
1.2	2	3	3	4.6	100
	2.5	3	3	4.35	81
	3	3.2	3.2	4.4	70
	3.5	3.5	3.5	4.6	65
	4	4	4	5.05	63

3. Automatic Backlight/Brightness Control Setting

For more brilliant display (max > 400 nits), we recommend using power saving profile. You could always adjust those settings according your requirement.

3.1. Brightness setting for power saving profile

Ambient light level (lux)	Suggested screen brightness (%)	Android Lookup Table (Code)	Suggested screen brightness (nits, or candelas per square meter)					
			Max 250 nits	Max 300 nits	Max 350nits	Max 400nits	Max 450 nits	Max 500 nits
10	30	77	75.0	90	105.0	120.0	135.0	150.0
40	42	107	105.0	126	147.0	168.0	189.0	210.0
65	55	140	137.5	165	192.5	220.0	247.5	275.0
145	60	153	150.0	180	210.0	240.0	270.0	300.0
300	65	166	162.5	195	227.5	260.0	292.5	325.0
550	75	191	187.5	225	262.5	300.0	337.5	375.0
930	80	204	200.0	240	280.0	320.0	360.0	400.0
1,250	90	230	225.0	270	315.0	360.0	405.0	450.0
1,700	100	255	250.0	300	350.0	400.0	450.0	500.0

3.2. Brightness setting for balance profile

Ambient light level (lux)	Suggested screen brightness (%)	Android Lookup Table (Code)	Suggested screen brightness (nits, or candelas per square meter)					
			Max 250 nits	Max 300 nits	Max 350nits	Max 400nits	Max 450 nits	Max 500 nits
10	42	107	104.9	125.9	146.9	167.8	188.8	209.8
40	53	135	132.4	158.8	185.3	211.8	238.2	264.7
65	71	181	177.5	212.9	248.4	283.9	319.4	354.9
145	76	194	190.2	228.2	266.3	304.3	342.4	380.4
300	85	217	212.7	255.3	297.8	340.4	382.9	425.5
550	93	237	232.4	278.8	325.3	371.8	418.2	464.7
930	98	250	245.1	294.1	343.1	392.2	441.2	490.2
1,250	100	255	250.0	300	350.0	400.0	450.0	500.0
1,700	100+	255	250.0	300	350.0	400.0	450.0	500.0

3.3. Brightness setting for brilliant profile

Ambient light level (lux)	Suggested screen brightness (%)	Android Lookup Table (Code)	Suggested screen brightness (nits, or candelas per square meter)					
			Max 250 nits	Max 300 nits	Max 350nits	Max 400nits	Max 450 nits	Max 500 nits
10	50	128	125.0	150.0	175.0	200.0	225.0	250.0
40	58	148	145.0	174.0	203.0	232.0	261.0	290.0
65	75	191	187.5	225.0	262.5	300.0	337.5	375.0
145	80	204	200.0	240.0	280.0	320.0	360.0	400.0
300	90	230	225.0	270.0	315.0	360.0	405.0	450.0
550	95	242	237.5	285.0	332.5	380.0	427.5	475.0
930	100	255	250.0	300.0	350.0	400.0	450.0	500.0
1,250	100	255	250.0	300.0	350.0	400.0	450.0	500.0
1,700	100	255	250.0	300.0	350.0	400.0	450.0	500.0