NOA3301

Digital Proximity Sensor with Ambient Light Sensor and Interrupt

Description

The NOA3301 combines an advanced digital proximity sensor and LED driver with an ambient light sensor (ALS) and tri-mode I^2C interface with interrupt capability in an integrated monolithic device. Multiple power management features and very low active sensing power consumption directly address the power requirements of battery operated mobile phones and mobile internet devices.

The proximity sensor measures reflected light intensity with a high degree of precision and excellent ambient light rejection. The NOA3301 enables a proximity sensor system with a 32:1 programmable LED drive current range and a 30 dB overall proximity detection threshold range. The photopic light response, dark current compensation and high sensitivity of the ambient light sensor eliminates inaccurate light level detection, insuring proper backlight control even in the presence of dark cover glass.

The NOA3301 is ideal for improving the user experience by enhancing the screen interface with the ability to measure distance for near/far detection in real time and the ability to respond to ambient lighting conditions to control display backlight intensity.

Features

- Proximity Sensor, LED driver and ALS in One Device
- Very Low Power Consumption
  - ♦ Stand-by Current 5 mA (monitoring I^2C interface only, V_{DD} = 3 V)
  - ♦ ALS Operational Current 50 mA
  - ♦ Proximity Sensing Average Operational Current 100 mA
  - ♦ Average LED Sink Current 75 mA

Proximity Sensing♦

Additional Features

- Programmable interrupt function including independent upper and lower threshold detection or threshold based hysteresis for proximity and or ALS
- Proximity persistence feature reduces interrupts by providing hysteresis to filter fast transients such as camera flash
- Automatic power down after single measurement or continuous measurements with programmable interval time for both ALS and PS function
- Wide operating voltage range (2.3 V to 3.6 V)
- Wide operating temperature range (-40°C to 80°

Table 2. ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input power supply	VDD	4.0	V
Input voltage range	V_{in}	- 0.3 to VDD + 0.2	V
Output voltage range	V_{out}	- 0.3 to VDD + 0.2	V
Maximum Junction Temperature	$T_{J(max)}$	100	°C
Storage Temperature	T_{STG}	- 40 to 80	°C
ESD Capability, Human Body Model (Note 1)	ESD_{HBM}	2	kV
ESD Capability, Charged Device Model (Note 1)	ESD_{CDM}	500	V
ESD Capability, Machine Model (Note 1)	ESD_{MM}	200	V
Moisture Sensitivity Level	MSL	3	-
Lead Temperature Soldering (Note 2)	T_{SLD}	260	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the

Table 4. ELECTRICAL CHARACTERISTICS (Unless otherwise specified, these specifications apply over 2.3 V < VDD < 3.3 V, 1.7 V < VDD_I2C < 1.9 V, -40°C < T_A < 80°C, 10 pF < Cb < 100 pF) (See Note 4) (continued)

Parameter	Symbol	Min	Typ	Max	Unit
Capacitive load for each bus line (including all parasitic capacitance) (Note 6)	C_b	10		100	pF
Noise margin at the low level (for each connected device - including hysteresis)	V_{nL}	0.1 VDD		-	V
Noise margin at the high level (for each connected device - including hysteresis)	V_{nH}	0.2 VDD		-	V

4. Refer to Figure 2 and Figure 3 for more information on AC characteristics.
5. The rise time and fall time are dependent on both the bus capacitance (Cb) and the bus pull-up resistor $R_{p.}$ Max and min pull-up resistor values are determined as follows: $R_{p(max)} = t_{r\ (max)}/(0.8473 \times Cb)$ and $R_{p(min)} = (Vdd\_I2C – V_{ol(max)})/I_{ol}$.
6. Cb = capacitance of one bus line, maximum value of which including all parasitic capacitances should be less than 100 pF. Bus capacitance up to 400 pF is supported, but at relaxed timing.

Table 5. OPTICAL CHARACTERISTICS (Unless otherwise specified, these specifications are for VDD = 3.3 V, T_A = 25°C)

Parameter	Symbol	Min	Typ	Max	Unit
AMBIENT LIGHT SENSOR					
Spectral response, peak (Note 7)	p		560		nm
Spectral response, low -3 dB	c_low		510		nm
Spectral response, high -3 dB	c_high		610		nm
Dynamic range	DR_{ALS}	0.05		52k	lux
Maximum Illumination (ALS operational but saturated)	E_{v_Max}				

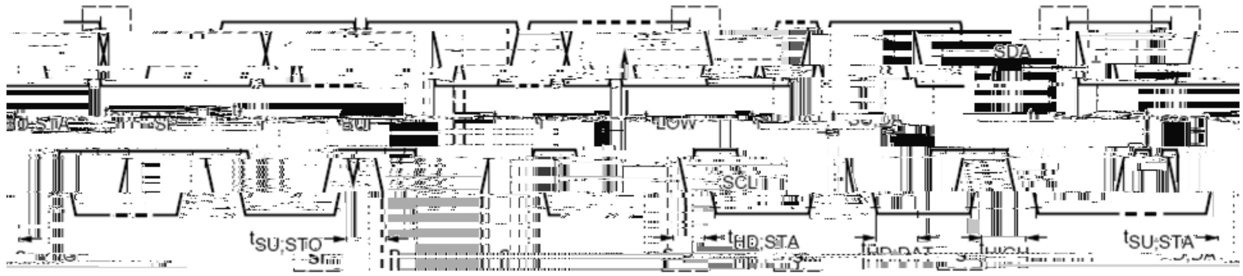


Figure 2. AC Characteristics, Standard and Fast Modes

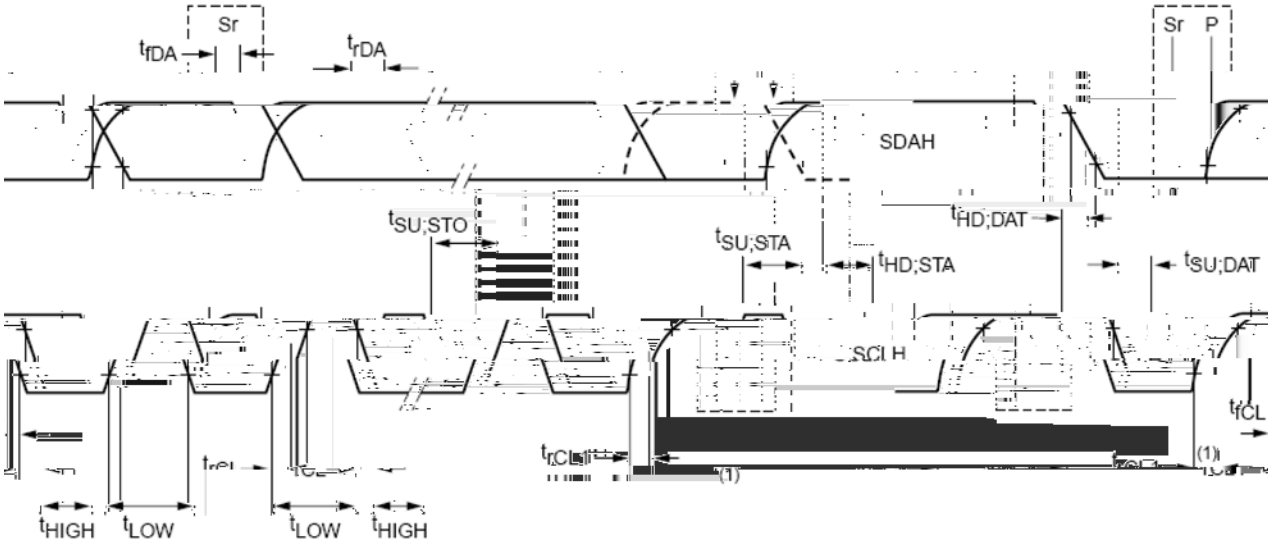


Figure 3. AC Characteristics, High Speed Mode

TYPICAL CHARACTERISTICS

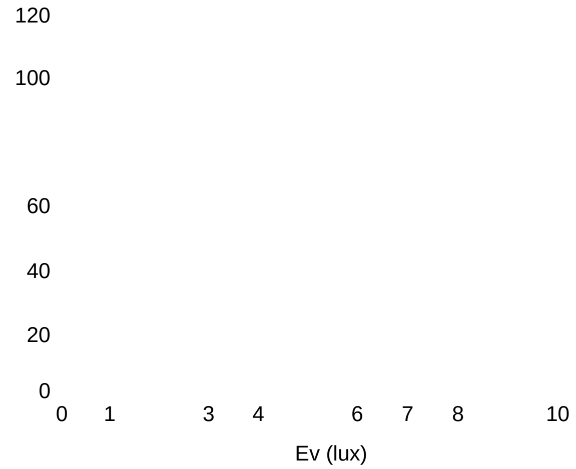


Figure 10. ALS Linearity 0-10 lux

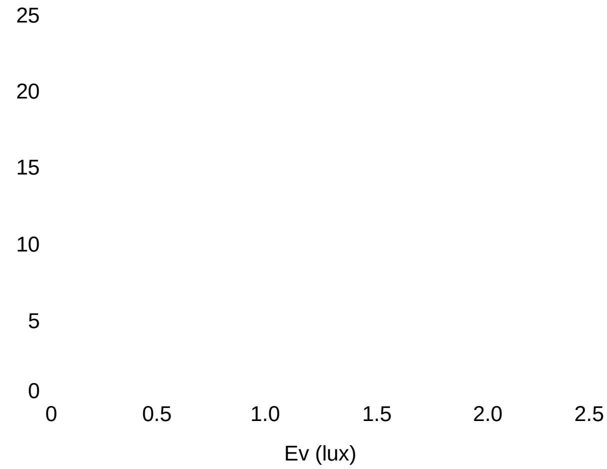


Figure 11. ALS Linearity 0-2 lux

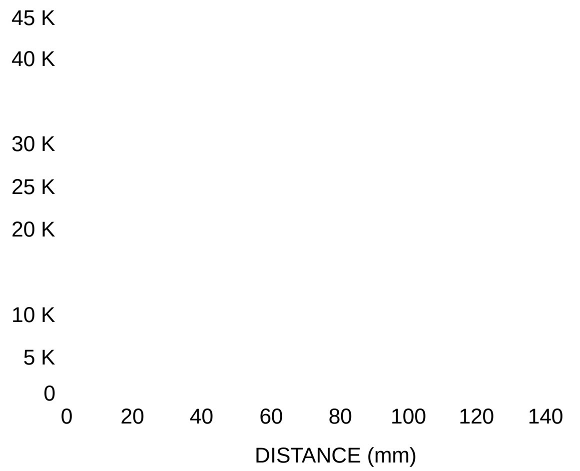


Figure 12. PS Response vs. Distance and LED Current (1200 ms Integration Time, Grey Reflector (RGB = 162, 162, 160))

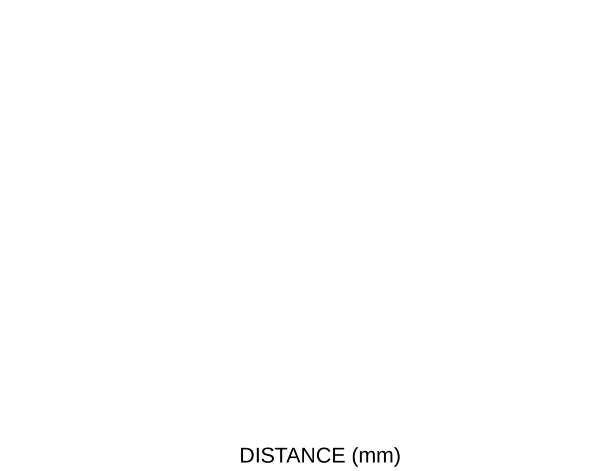


Figure 13. PS Response vs. Distance and LED Current (300 ms Integration Time, White Reflector (RGB = 220, 224, 223))

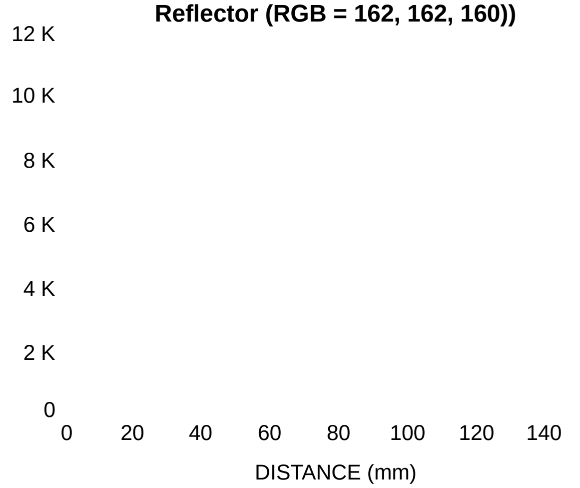


Figure 14. PS Response vs. Distance and LED Current (300 ms Integration Time, Grey Reflector (RGB = 162, 162, 160))

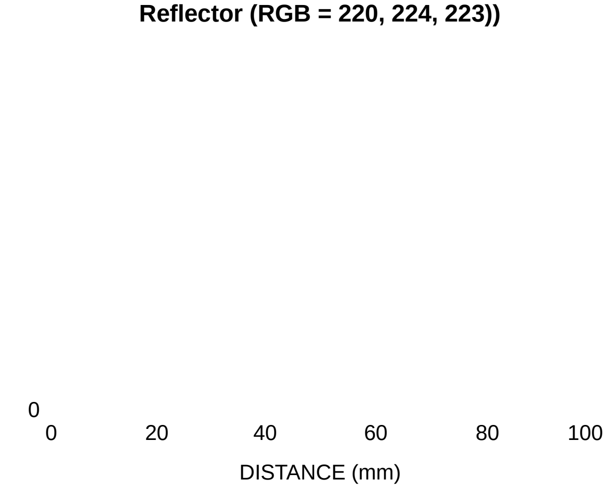


Figure 15. PS Response vs. Distance and LED Current (300 ms Integration Time, Black Reflector (RGB = 16, 16, 15))

DESCRIPTION OF OPERATION

Proximity Sensor Architecture

NOA3301 combines an advanced digital proximity sensor, LED driver, ambient light sensor and a tri-mode I^2C interface as shown in Figure 1. The LED driver draws a modulated current through the external IR LED to

NOA3301 Data Registers

NOA3301 operation is observed and controlled by internal data registers read from and written to via the external I^2C interface. Registers are listed in Table 6. Default values are set on initial power up or via a software reset command (register 0x01).

The I^2C slave address of the NOA3301 is 0x37.

Table 6. NOA3301 DATA REGISTERS

Address	Type	Name	Description
0x00	R	PART_ID	NOA3301 part number and revision IDs
0x01	RW	RESET	Software reset control
0x02	RW	INT_CONFIG	Interrupt pin functional control settings
0x0F	RW	PS_LED_CURRENT	PS LED pulse current (5, 10, …, 160 mA)
0x10	RW	PS_TH_UP_MSB	PS Interrupt upper threshold, most significant bits
0x11	RW	PS_TH_UP_LSB	PS Interrupt upper threshold, least significant bits
0x12	RW	PS_TH_LO_MSB	PS Interrupt lower threshold, most significant bits
0x13	RW	PS_TH_LO_LSB	PS Interrupt lower threshold, least significant bits
0x14	RW	PS_FILTER_CONFIG	PS Filter configuration
0x15	RW	PS_CONFIG	PS Integration time configuration
0x16	RW	PS_INTERVAL	PS Interval time configuration
0x17	RW	PS_CONTROL	PS Operation mode control
0x20	RW	ALS_TH_UP_MSB	ALS Interrupt upper threshold, most significant bits
0x21	RW	ALS_TH_UP_LSB	ALS Interrupt upper threshold, least significant bits
0x22	RW	ALS_TH_LO_MSB	ALS Interrupt lower threshold, most significant bits
0x23	RW	ALS_TH_LO_LSB	ALS Interrupt lower threshold, least significant bits
0x24	RW	RESERVED	Reserved
0x25	RW	ALS_CONFIG	ALS Integration time configuration
0x26	RW	ALS_INTERVAL	ALS Interval time configuration
0x27	RW	ALS_CONTROL	ALS Operation mode control
0x40	R	INTERRUPT	Interrupt status
0x41	R	PS_DATA_MSB	PS measurement data, most significant bits
0x42	R	PS_DATA_LSB	PS measurement data, least significant bits
0x43	R	ALS_DATA_MSB	ALS measurement data, most significant bits
0x44	R	ALS_DATA_LSB	ALS measurement data, least significant bits

RESET Register (0x01)

Software reset is controlled by this register. Setting this register followed by an I2C_STOP sequence will immediately reset the NOA3301 to the default startup standby state. Triggering the software reset has virtually the same effect as cycling the power supply tripping the internal Power on Reset (POR) circuitry.

Table 8. RESET REGISTER (0x01)

Bit	7	6	5	4	3	2	1	0
Field	NA							SW_reset

Field	Bit	Default	Description
NA	7:1	XXXXXXX	Don’t care
SW_reset	0	0	Software reset to startup state

INT_CONFIG Register (0x02)

INT_CONFIG register controls the external interrupt pin function.

Table 9. INT_CONFIG REGISTER (0x02)

Bit	7	6	5	4	3	2	1	0
Field	NA						auto_clear	polarity

Field	Bit	Default	Description	
NA	7:2	XXXXXX	Don’t care	
auto_clear	1	1	0	When an interrupt is triggered, the interrupt pin remains asserted until cleared by an I

Table 11. PS_TH_UP REGISTERS (0x10 – 0x11)

Bit	7	6	5	4	3	2	1	0
Field	PS_TH_UP_MSB(0x10), PS_TH_UP_LSB(0x11)							

Field	Bit	Default	Description
PS_TH_UP_MSB	7:0	0xFF	Upper threshold for proximity detection, MSB
PS_TH_UP_LSB	7:0	0xFF	Upper threshold for proximity detection, LSB

Table 12. PS_TH_LO REGISTERS (0x12 – 0x13)

Bit	7	6	5	4	3	2	1	0
Field	PS_TH_LO_MSB(0x12), PS_TH_LO_LSB(0x13)							

Field	Bit	Default	Description
PS_TH_LO_MSB	7:0	0x00	Lower threshold for proximity detection, MSB
PS_TH_LO_LSB	7:0	0x00	Lower threshold for proximity detection, LSB

PS_FILTER_CONFIG Register (0x14)

PS_FILTER_CONFIG register provides a hardware mechanism to filter out single event occurrences or similar anomalies from causing unwanted interrupts. Two 4 bit registers (M and N) can be set with values such that M out of N measurements must exceed threshold settings in order to set an interrupt. The default setting of 1 out of 1 effectively turns the filter off and any single measurement exceeding thresholds can trigger an interrupt. (Note a setting of 0 is interpreted the same as a 1).

Table 13. PS_FILTER_CONFIG REGISTER (0x14)

Bit	7	6	5	4	3	2	1	0
Field	filter_N				filter_M			

Field	Bit	Default	Description
filter_N	7:4	0001	Filter N
filter_M	3:0	0001	Filter M

PS_CONFIG Register (0x15)

Proximity measurement sensitivity is controlled by specifying the integration time. The integration time sets the

Table 18. ALS_TH_LO REGISTERS (0x22 – 0x23)

Bit	7	6	5	4	3	2	1	0
Field	ALS_TH_LO_MSB(0x22), ALS_TH_LO_LSB(0x23)							

Field	Bit

each measurement. In both cases the quiescent current is less than the IDD_{STBY} parameter. These automatic power management features eliminate the need for power down pins or special power down instructions.

For accurate measurements at low light levels (below approximately 3 lux) ALS readings must be taken at least once per second and the first measurement after a reset (software reset or power cycling) should be ignored.

Table 21. ALS_CONTROL REGISTER (0x27)

Bit	7	6	5	4	3	2	1	0
Field	NA							

ALS_DATA Registers (0x43 – 0x44)

The ALS_DATA registers store results from completed ALS measurements. When an I^2C read operation begins, the current ALS_DATA registers are locked until the operation is complete (I2C_STOP received) to prevent possible data corruption from a concurrent measurement cycle.

Table 24. ALS_DATA REGISTERS (0x43 – 0x44)

Bit	7	6	5	4	3	2	1	0
Field	ALS_DATA_MSB(0x43), ALS_DATA_LSB(0x44)							

Field	Bit	Default	Description
ALS_DATA_MSB	7:0	0x00	ALS measurement data, MSB
ALS_DATA_LSB	7:0	0x00	ALS measurement data, LSB

Ambient Light Sensor Operation

The ALS configuration is accomplished by writing the desired configuration values to registers 0x02 and 0x20 through 0x27. Writing to configuration registers can be done with either individual I^{2}C byte-write commands or with one or more I^{2}C block write commands. Block write commands specify the first register address and then write multiple bytes of data in sequence. The NOA3301 automatically increments the register address as it acknowledges each byte transfer.

ALS measurement is initiated by writing appropriate values to the CONTROL register (0x27). Sending an I2C_STOP sequence at the end of the write signals the internal state machines to wake up and begin the next measurement cycle. Figures 25 and 26 illustrate the activity of key signals during an ambient light sensor measurement cycle. The cycle begins by starting the precision oscillator and powering up the ambient light sensor. Next, the ambient light measurement is made for the specified integration time and the result is stored in the 16 bit ALS Data register. If in One-shot mode, the ALS is powered down and awaits the next command. If in Repeat mode the ALS is powered down, the interval is timed out and the operation repeated. There are some special cases if the interval timer is set to less than the integration time. For continuous mode, the interval is set to 0 and the ALS makes continuous measurements with only a 5 ms delay between integration times and the ALS remains powered up. If the interval is set equal to or less than the integration time (but not to 0), there is a 10 ms time between integrations and the ALS remains powered up.

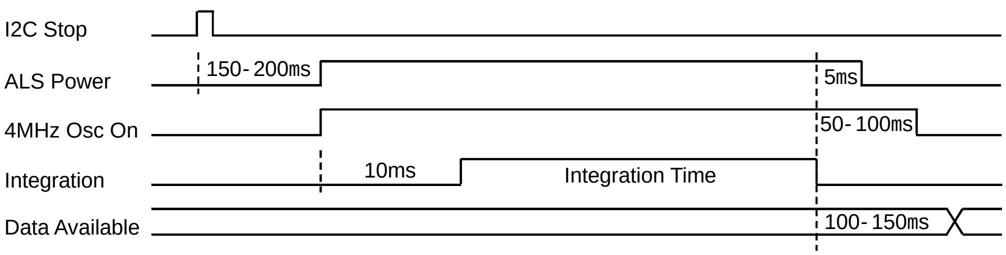
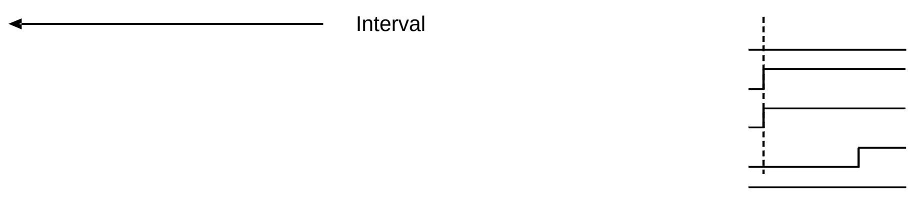


Figure 25. ALS One-Shot Timing



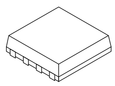
Example Programming Sequence

The following pseudo code configures the NOA3301 proximity sensor in repeat mode with 50 ms wait time between each measurement and then runs it in an interrupt driven mode. When the controller receives an interrupt, the interrupt determines if the interrupts was caused by the proximity sensor and if so, reads the PS_Data from the device, sets a flag and then waits for the main polling loop to respond to the proximity change.

```
external subroutine I2C_Read_Byte (I2C_Address, Data_Address);
external subroutine I2C_Read_Block (I2C_Address, Data_Start_Address, Count, Memory_Map);
external subroutine I2C_Write_Byte (I2C_Address, Data_Address, Data);
external subroutine I2C_Write_Block (I2C_Address, Data_Start_Address, Count, Memory_Map);
subroutine Initialize_PS () {
 MemBuf[0x02] = 0x02;   // INT_CONFIG assert interrupt until cleared
 MemBuf[0x0F] = 0x09;   // PS_LED_CURRENT 50mA
 MemBuf[0x10] = 0x8F;   // PS_TH_UP_MSB
 MemBuf[0x11] = 0xFF;   // PS_TH_UP_LSB
 MemBuf[0x12] = 0x70;   // PS_TH_LO_MSB
 MemBuf[0x13] = 0x00;   // PS_TH_LO_LSB
 MemBuf[0x14] = 0x11;   // PS_FILTER_CONFIG turn off filtering
 MemBuf[0x15] = 0x01;   // PS_CONFIG 300us integration time
 MemBuf[0x16] = 0x0A;   // PS_INTERVAL 50ms wait
 MemBuf[0x17] = 0x02;   // PS_CONTROL enable continuous PS measurements
 MemBuf[0x20] = 0xFF;   // ALS_TH_UP_MSB
 MemBuf[0x21] = 0xFF;   // ALS_TH_UP_LSB
 MemBuf[0x22] = 0x00;   // ALS_TH_LO_MSB
 MemBuf[0x23] = 0x00;   // ALS_TH_LO_LSB
 MemBuf[0x25] = 0x04;   // ALS_CONFIG 100ms integration time
 MemBuf[0x26] = 0x00;   // ALS_INTERVAL continuous measurement mode
 MemBuf[0x27] = 0x02;   // ALS_CONTROL enable continuous ALS measurements
 I2C_Write_Block (I2CAddr, 0x02, 37, MemBuf);
}
```

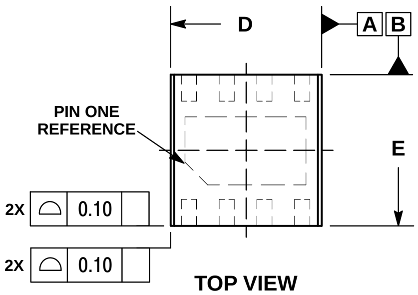
Physical Location of Photodiode Sensors

CUDFN8, 2x2, 0.5P
CASE 505AF−01
ISSUE O

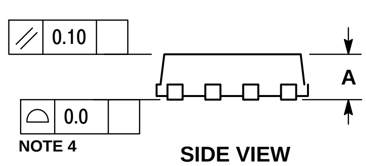


SCALE 4:1

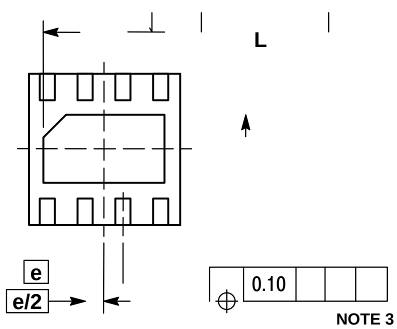
DATE 20 JAN 2011



TOP VIEW



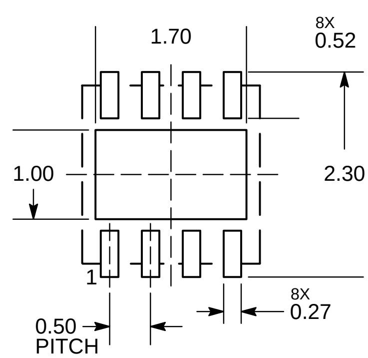
SIDE VIEW



1.
1 . , 1 .
2.
3.
0.10 0.20

DIM	MILLIMETERS MIN	MAX
A	0.	06
A1	0.00	0.0
A3	0.20	
b	0.1	0.2
D	2.00	
D2	1. 0	1. 0
E	2.00	
E2	0. 0	1.00
e	0. 0	
L	0.2	0.3
M	---	10°

RECOMMENDED



***For additional information on our Pb**−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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