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Description

The NOA2301W combines an advanced digital proximity sensor and LED driver coupled with a 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 NOA2301W enables a proximity sensor system with a 16:1 programmable LED drive current range and a 30 dB overall proximity detection range.

The NOA2301W 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.

Features

- Proximity Sensor and LED Driver in One Device
- Proximity Detection Distance Threshold I^2C Programmable with 12−bit Resolution and Eight Integration Time Ranges (16−bit effective resolution)
- Effective for Measuring Distances up to 200 mm and Beyond
- Excellent IR and Ambient Light Rejection including Sunlight (up to 50K lux) and CFL Interference
- Programmable LED Drive Current from 10 mA to 160 mA in 5 mA Steps, No External Resistor Required
- User Programmable LED Pulse Frequency
- Very Low Power Consumption
  - Stand−by current 2.8 μA (monitoring I^2C interface only, Vdd=3V)
  - Proximity sensing average operational current 100 μA
  - Average LED sink current 75 μA
- Programmable interrupt function including independent upper and lower threshold detection or threshold based hysteresis
- Level or Edge Triggered Interrupts
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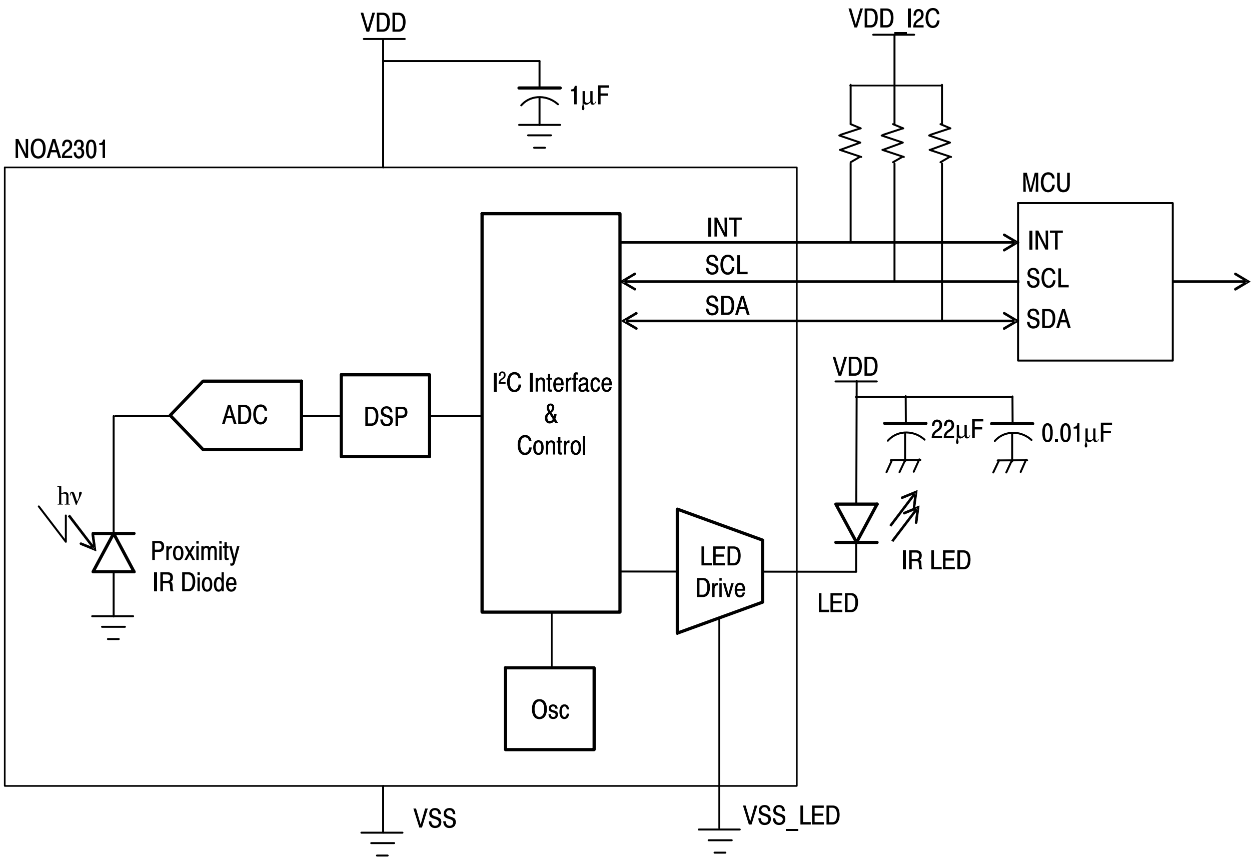


Figure 1. NOA2301W Application Block Diagram

Table 1. PAD FUNCTION DESCRIPTION

Pad	Pad Name	Description
1	VDD	Power pad
2	VSS	Ground pad
3	LED_GND	Ground pad for IR LED driver
4	LED	IR LED output pad
5	INT	Interrupt output pad, open−drain
6	SDA	Bi−directional data signal for communications with the I2C master
7	SCL	External I2C clock supplied by the I2C master

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

Table 4. ELECTRICAL CHARACTERISTICS (Unless otherwise specified, these specifications apply over 2.3 V < VDD < 3.6 V, 1.7 V < VDD_I2C < 1.9 V, −40°C < T_A < 80°C, 10 pF < Cb < 100 pF) (See Note 4)

Parameter	Symbol	Min	Typ	Max	Unit
Bus free time between STOP and START condition	t_{BUF_std}	4.7		–	μS
	t_{BUF_fast}	1.3		–	
	t_{BUF_hs}	0.160		–	
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.

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

Table 5. OPTICAL CHARACTERISTICS (Unless otherwise specified, these specifications are for VDD = 3.0 V, T_A = 25°C)(Note 7)

Parameter	Symbol	Min	Typ	Max	Unit
Detection range, Tint = 4800 μs, I_{LED} = 160 mA, 860 nm IR LED (OSRAM SFH4650), White Reflector (RGB = 220, 224, 223), LED Modulation Frequency = 308 kHz, Sample Delay = 250 ns, SNR = 7:1	$D_{PS\_4800\_WHITE\_MOD}$		200		mm
Detection range, Tint = 4800 μs, I_{LED} = 160 mA, 860 nm IR LED (OSRAM SFH4650), White Reflector (RGB = 220, 224, 223), SNR = 8:1	$D_{PS\_4800\_WHITE\_160}$		148		mm
Detection range, Tint = 4800 μs, I_{LED} = 25 mA, 860 nm IR LED (OSRAM SFH4650), White Reflector (RGB = 220, 224, 223), SNR = 8:1	$D_{PS\_4800\_WHITE\_25}$		66		mm
Detection range, Tint = 2400 μs, I_{LED} = 50 mA, 860 nm IR LED (OSRAM SFH4650), White Reflector (RGB = 220, 224, 223), SNR = 8:1	$D_{PS\_2400\_WHITE\_25}$		80		mm
Detection range, Tint = 1800 μs, I_{LED} = 75 mA, 860 nm IR LED (OSRAM SFH4650), White Reflector (RGB = 220, 224, 223), SNR = 8:1	$D_{PS\_1800\_WHITE\_75}$		88		mm
Detection range, Tint = 1200 μs, I_{LED} = 100 mA, 860 nm IR LED (OSRAM SFH4650), White Reflector (RGB = 220, 224, 223), SNR = 8:1	$D_{PS\_1200\_WHITE\_100}$		90		mm
Detection range, Tint = 600 μs, I_{LED} = 125 mA, 860 nm IR LED (OSRAM SFH4650), White Reflector (RGB = 220, 224, 223), SNR = 8:1	$D_{PS\_600\_WHITE\_125}$		88		mm
Detection range, Tint = 600 μs, I_{LED} = 100 mA, 860 nm IR LED (OSRAM SFH4650), White Reflector (RGB = 220, 224, 223), SNR = 8:1	DLED				

Table 5. OPTICAL CHARACTERISTICS (Unless otherwise specified, these specifications are for VDD = 3.0 V, T_A = 25°C)(Note 7)

Parameter	Symbol	Min	Typ	Max	Unit
Measurement resolution, Tint = 300 μs	MR_{300}		12		bits
Measurement resolution, Tint = 600 μs	MR_{600}		13		bits
Measurement resolution, Tint = 1200 μs	MR_{1200}		14		bits
Measurement resolution, Tint = 1800 μs	MR_{1800}		15		bits
Measurement resolution, Tint = 2400 μs	MR_{2400}		15		bits
Measurement resolution, Tint = 3600 μs	MR_{3600}		16		bits
Measurement resolution, Tint = 4800 μs	MR_{4800}		16		bits

7. Measurements performed with default modulation frequency and sample delay unless noted.

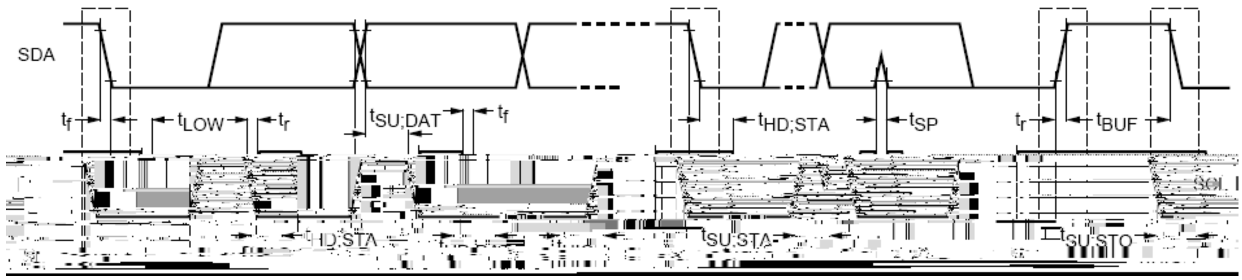


Figure 2. AC Characteristics, Standard and Fast Modes

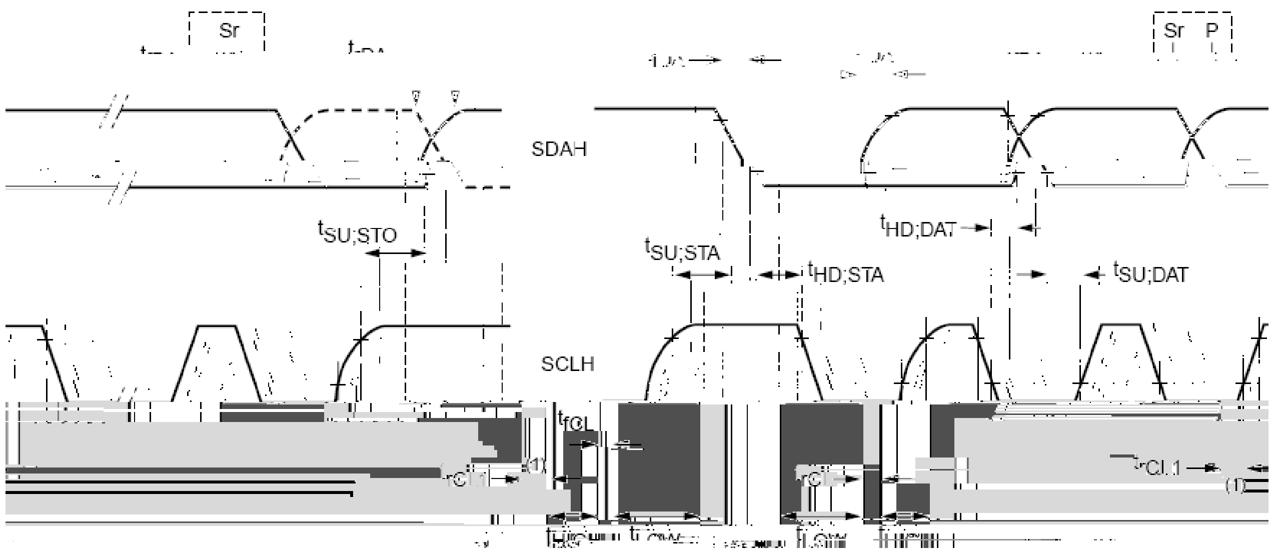


Figure 3. AC Characteristics, High Speed Mode

TYPICAL CHARACTERISTICS

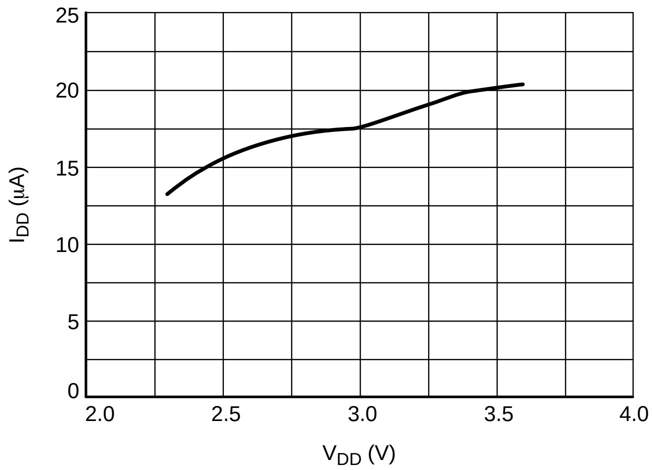


Figure 10. Supply Current vs. Supply Voltage TINT = 300 µs, TR = 100 ms

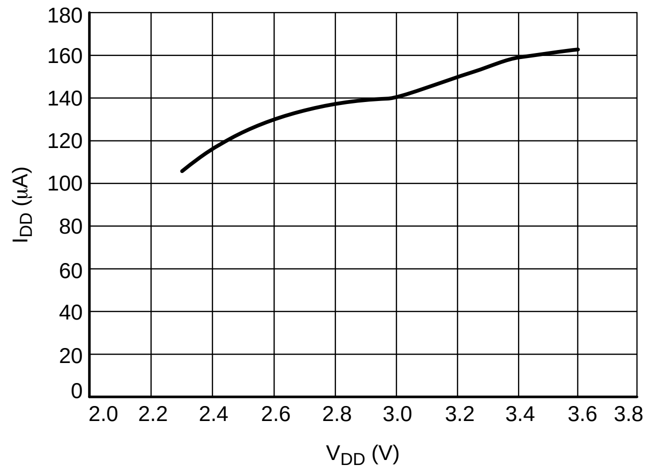


Figure 11. Supply Current vs. Supply Voltage TINT = 1200 µs, TR = 50 ms

Description of Operation

Proximity Sensor Architecture

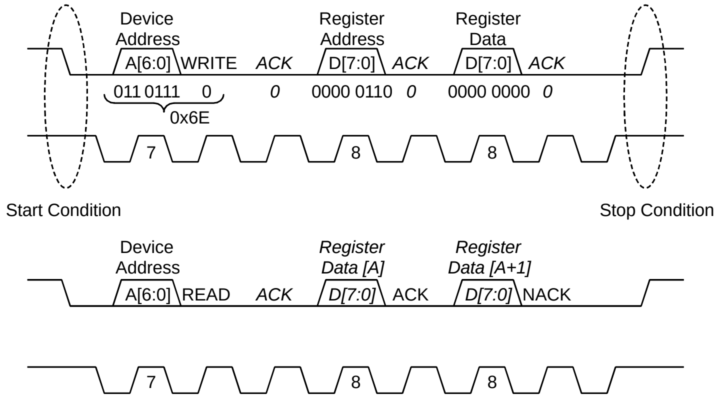
NOA2301W combines an advanced digital proximity sensor, LED driver and a tri−mode I^2C interface as shown in Figure 1. The LED driver draws a modulated current through the external IR LED to illuminate the target. The LED current is programmable over a wide range. The infrared light reflected from the target is detected by the proximity sensor photo diode. The proximity sensor employs a sensitive photo diode fabricated in ON Semiconductor's standard CMOS process technology. The modulated light received by the on−chip photodiode is converted to a digital signal using a variable slope integrating ADC with a default resolution (at 300 μs) of 12−bits, unsigned. The signal is processed to remove all unwanted signals resulting in a highly selective response to the generated light signal. The final value is stored in the PS_DATA register where it can be read by the I^2C interface.

Proximity Sensor LED Frequency and Delay Settings

The LED current modulation frequency is user selectable from approximately 128 KHz to 2 MHz using the PS_LED_FREQUENCY register. An internal precision 4 MHz oscillator provides the frequency reference. The 4 MHz clock is divided by the value in register 0x0D to determine the pulse rate. The default is 0x10 (16) which results in an LED pulse frequency of 250 KHz (4 μs period). Values below 200 KHz and above 1 MHz are not recommended.

Switching high LED currents can result in noise injected into the proximity sensor receiver causing inaccurate readings. The PS receiver has a user programmable delay from the LED edge to when the receiver samples the data (PS_SAMPLE_DELAY – register 0x0E). Longer delays may reduce the effect of switching noise but also reduce the sensitivity.

Since the value of the delay is dependent on the pulse frequency, its value must be carefully computed. The value obviously cannot exceed the LED pulse width or there would be no sampling of the data when the LED is illuminated. There is also a minimum step size of 125 ns.


Device Address
A[6:0]
WRITE
ACK
Register Address
D[7:0]
ACK
Register Data
D[7:0]
ACK
011 0111
0
0x6E
0
0000 0110
0
0000 0000
0
7
8
8
Start Condition
Stop Condition
Device Address
A[6:0]
READ
ACK
Register Data [A]
D[7:0]
ACK
Register Data [A+1]
D[7:0]
NACK
7
8
8

PART_ID Register (0x00)

The PART_ID register provides part and revision identification. These values are hard−wired at the factory and cannot be modified.

Table 8. PART_ID Register (0x00)

Bit	7	6	5	4	3	2	1	0
Field	Part number ID				Revision ID			

Field	Bit	Default	Description
Part number ID	7:4	0101	Part number identification
Revision ID	3:0	NA	Silicon revision number

PS_LED_FREQUENCY Register (0x0D)

The LED FREQUENCY register controls the frequency of the LED pulses. The LED modulation frequency is determined by dividing 4 MHz by the register value. Valid divisors are 2−31. The default value is 16 which results in an LED pulse frequency of 250 KHz (one pulse every 4 μs).

Table 11. PS_LED_FREQUENCY Register (0x0D)

Bit	7	6	5	4	3	2	1	0
Field	NA			LED_modulation frequency				

Field	Bit	Default	Description
NA	7:5	XXX	Don’t care
LED_modulation _frequency	4:0	10000	Defines the divider of the 4MHz clock to generate the LED pulses. Valid values are 2−31

PS_SAMPLE_DELAY Register (0x0E)

The PS_SAMPLE_DELAY register controls the time delay after an LED pulse edge before the resulting signal is sampled by

PS_TH Registers (0x10 – 0x13)

With hysteresis not enabled (see PS_CONFIG register), the PS_TH registers set the upper and lower interrupt thresholds of the proximity detection window. Interrupt functions compare these threshold values to data from the PS_DATA registers. Measured PS_DATA values outside this window will set an interrupt according to the INT_CONFIG register settings.

With hysteresis enabled, threshold settings take on a different meaning. If PS_hyst_trig is set, the PS_TH_UP register sets the upper threshold at which an interrupt will be set, while the PS_TH_LO register then sets the lower threshold hysteresis value where the interrupt would be cleared. Setting the PS_hyst_trig low reverses the function such that the PS_TH_LO register sets the lower threshold at which an interrupt will be set and the PS_TH_UP represents the hysteresis value at which the interrupt would be subsequently cleared. Hysteresis functions only apply in “auto_clear” INT_CONFIG mode.

The controller software must ensure the settings for LED current, sensitivity range, and integration time (LED pulses) are appropriate for selected thresholds. Setting thresholds to extremes (default) effectively disables interrupts.

Table 14. 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 15. 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

PS_CONTROL Register (0x17)

The PS_CONTROL register is used to control the functional mode and commencement of proximity sensor measurements. The proximity sensor can be operated in either a single shot mode or consecutive measurements taken at programmable intervals.

Both single shot and repeat modes consume a minimum of power by immediately turning off LED driver and sensor circuitry after 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.

Table 19. PS_CONTROL Register (0x17)

Bit	7	6	5	4	3	2	1	0
Field	NA						PS_Repeat	PS_OneShot

Field	Bit	Default	Description
NA	7:2	XXXXXX	Don’t care
PS_Repeat	1	0	Initiates new measurements at PS_Interval rates
PS_OneShot	0	0	Triggers proximity sensing measurement. In single shot mode this bit clears itself after cycle completion.

INTERRUPT Register (0x40)

The INTERRUPT register displays the status of the interrupt pin. If “auto_clear” is disabled (see INT_CONFIG register), reading this register also will clear the interrupt.

Table 20. INTERRUPT Register (0x40)

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

Proximity Sensor Operation

NOA2301W operation is divided into three phases: power up, configuration and operation. On power up the device initiates a reset which initializes the configuration registers to their default values and puts the device in the standby state. At any time, the host system may initiate a software reset by writing 0x01 to register 0x01. A software reset performs the same function as a power−on−reset.

The configuration phase may be skipped if the default register values are acceptable, but typically it is desirable to change some or all of the configuration register values. Configuration is accomplished by writing the desired configuration values to registers 0x02 through 0x17. Writing to configuration registers can be done with either individual I^2C byte−write commands or with one or more I^2C block write commands. Block write commands specify the first register address and then write multiple bytes of data in sequence. The NOA2301W automatically increments the register address as it acknowledges each byte transfer.

Proximity sensor measurement is initiated by writing appropriate values to the CONTROL register (0x17). 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. Figure 14 and Figure 15 illustrate the activity of key signals during a proximity sensor measurement cycle. The cycle begins by starting the precision oscillator and powering up the proximity sensor receiver. Next, the IR LED current is modulated according to the LED current setting at the chosen LED frequency and the values during both the on and off times of the LED are stored (illuminated and ambient values). Finally, the proximity reading is calculated by subtracting the ambient

Example Programming Sequence

The following pseudo code configures the NOA2301W 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] = 0x09;   // PS_CONFIG 300us integration time
 MemBuf[0x16] = 0x0A;   // PS_INTERVAL 50ms wait
 MemBuf[0x17] = 0x02;   // PS_CONTROL enable continuous PS measurements

 I2C_Write_Block (I2CAddr, 0x02, 37, MemBuf);
}

subroutine I2C_Interupt_Handler () {
 // Verify this is a PS interrupt
 INT = I2C_Read_Byte (I2CAddr, 0x40);
 if (INT == 0x11 || INT == 0x12) {
  // Retrieve and store the PS data
  PS_Data_MSB = I2C_Read_Byte (I2CAddr, 0x41);
  PS_Data_LSB = I2C_Read_Byte (I2CAddr, 0x42);
  NewPS = 0x01;
  }
 }

subroutine main_loop () {
 I2CAddr = 0x37;
 NewPS = 0x00;
 Initialize_PS ();
 loop {
  // Do some other polling operations
  if (NewPS == 0x01) {
   NewPS = 0x00;
   // Do some operations with PS_Data
   }
  }
 }
```

mitgesi-4y bm6.144pllneir pd,8.710TJ56e beS9ne f.8(s)-.0076 .0386 Tw[(s)7.5(023.9(mitupporcirc922(rh).1(e)sy3.429.3(s6.8( )ain 6.6(8t)57)-10.8(tfdf)5.4(/),8.713f)mr.11(e)f)]TJ23(ce)rpn b4-27. 6.6(8t.3((al d)