NOA2301

Digital Proximit Sensor with Interrupt

Description

The NOA2301 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 NOA2301 enables a proximity sensor system with a 16:1 programmable LED drive current range and a 30 dB overall proximity detection range.

The NOA2301 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
- 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
- Wide Operating Voltage Range (2.3 V to 3.6 V)
- Wide Operating Temperature Range (−40°C to 80°C)
- I^2C Serial Communication Port
  - Standard mode – 100 kHz
  - Fast mode – 400 kHz
  - High speed mode – 3.4 MHz

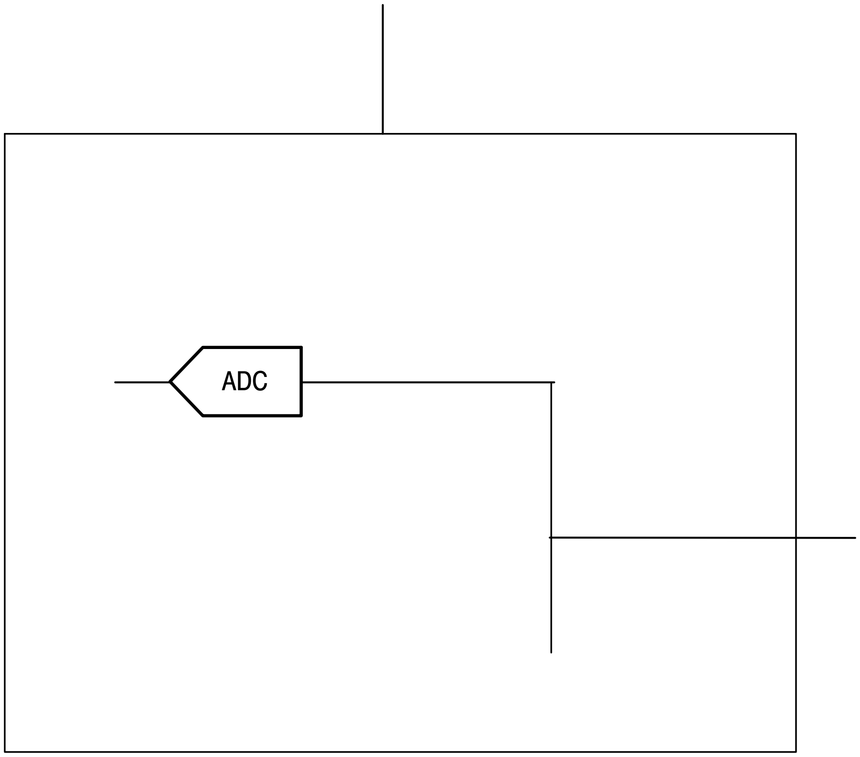


Figure 1. NOA2301 Application Block Diagram

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
Moisture Sensitivity Level	MSL	3	−
Lead Temperature Soldering (Note 2)	T_{SLD}	260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the

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

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.

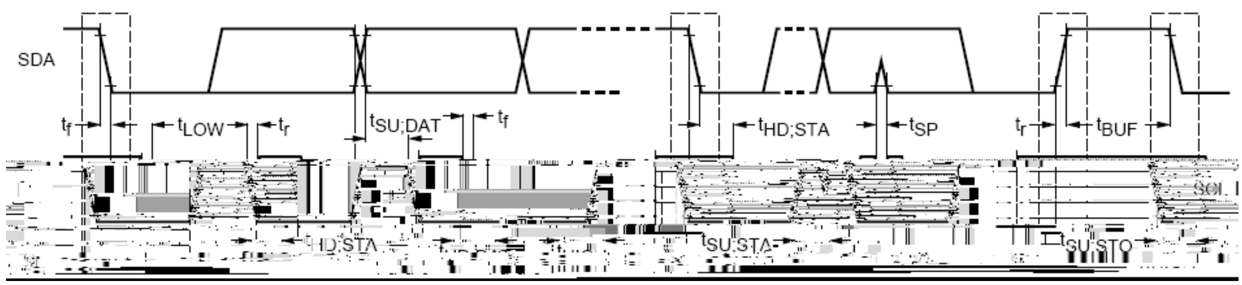


Figure 2. AC Characteristics, Standard and Fast Modes

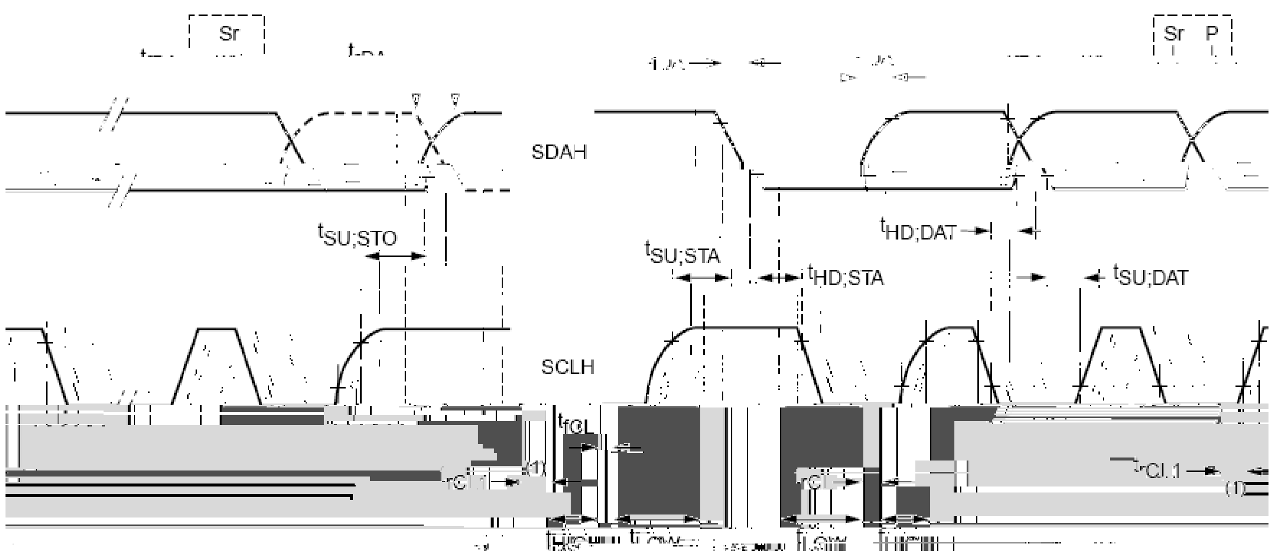


Figure 3. AC Characteristics, High Speed Mode

TYPICAL CHARACTERISTICS

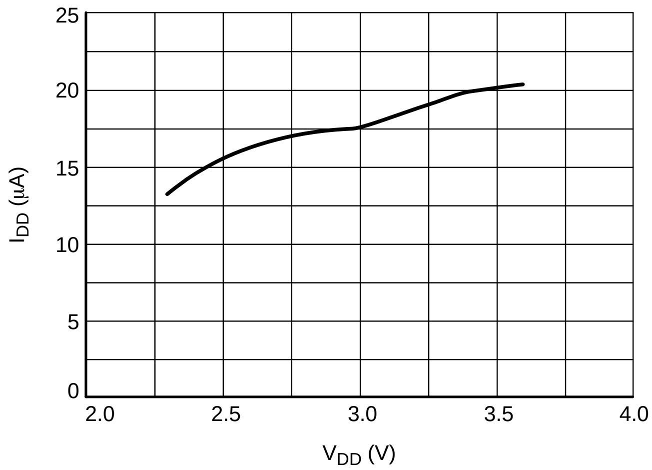


Figure 10. Supply Current vs. Supply Voltage TINT = 300 μs, TR = 100 ms

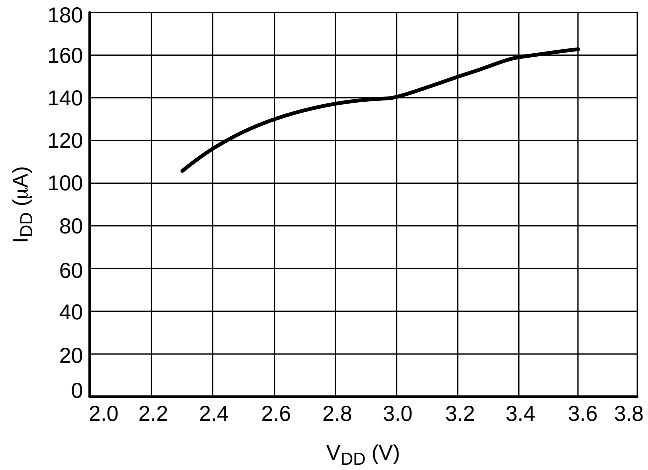


Figure 11. Supply Current vs. Supply Voltage TINT = 1200 μs, TR = 50 ms

Description of Operation

Proximity Sensor Architecture

NOA2301 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.

The delay values are programmed as follows:

0 or 1: No delay
2−31: Selects (N−1)*125 ns
N must be less than or equal to the
PS_LED_FREQUENCY Value
The default delay is 0x05 (500 ns)

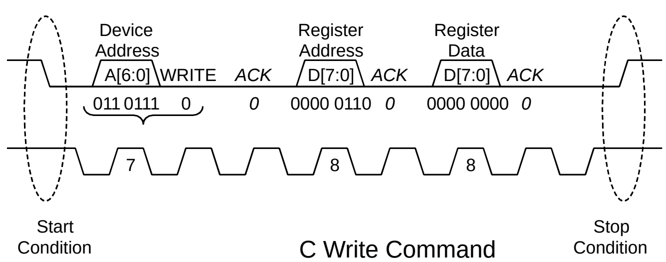
Table 6 shows some common LED pulse frequencies and sample delays and the resulting register values.

Table 6. COMMON LED PULSE FREQUENCY SETTINGS

LED Pulse Frequency (KHz)	Sample Delay (ns)	PS_LED_ FREQUENCY Register (0x0D) Value	PS_SAMPLE_ DELAY Register (0x0E) Value
200	250	0x14	0x03
200	500	0x14	0x05
200	750	0x14	0x07
250	250	0x10	0x03
250	500	0x10	0x05
500	250	0x08	0x03
500	500	0x08	0x05
1000	250	0x04	0x03

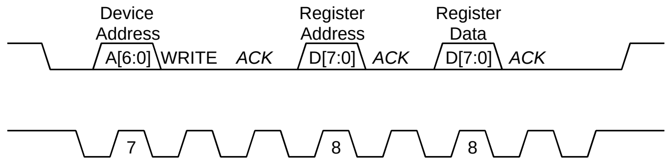
I^2C Interface

The NOA2301 acts as an I^2C slave device and supports single register and block register read and write operations. All data transactions on the bus are 8 bits long. Each data byte transmitted is followed by an acknowledge bit. Data is transmitted with the MSB first.



C Write Command

Figure 12 shows an I^2C write operation. Write transactions begin with the master sending an I^2C start sequence followed by the seven bit slave address (NOA2301 = 0x37) and the write(0) command bit. The NOA2301 will acknowledge this byte transfer with an appropriate ACK. Next the master will send the 8 bit register address to be written


Device
Address
A[6:0]
WRITE
ACK
Register
Address
D[7:0]
ACK
Register
Data
D[7:0]
ACK
7
8
8

PART_ID Register (0x00)

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 the proximity sensor. This can be used to reduce the effect of noise caused by the LED current switching. There is no delay for programmed values of 0x00 or 0x001. For other values the delay is (N−1)*125 ns, where N is the decimal value of the register. Default value is 0x05 (500 ns). N must be less than or equal to the value in register 0x0D (PS_LED_FREQUENCY). See the Description of Operation section for more information on programming this register.

Table 12. PS_SAMPLE_DELAY Register (0x0E)

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

Field	Bit	Default	Description
NA	7:5	XXX	Don't care
sample_delay	4:0	00101	Defines the delay from the LED pulse edge before the pulse is sampled

PS_LED_CURRENT Register (0x0F)

The LED_CURRENT register controls how much current the internal LED driver sinks through the IR LED during modulated illumination. The current sink range is 5 mA plus a binary weighted value of the LED_Current register times 5 mA, for an effective range of 10 mA to 160 mA in steps of 5 mA. The default setting is 50 mA. A register setting of 00 turns off the LED Driver.

Table 13. PS_LED_CURRENT Register (0x0F)

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

Field	Bit	Default	Description
NA	7:5	XXX	Don't care
LED_Current	4:0	01001	Defines current sink during LED modulation. Binary weighted value times 5 mA plus 5 mA

Proximity Sensor Operation

NOA2301 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

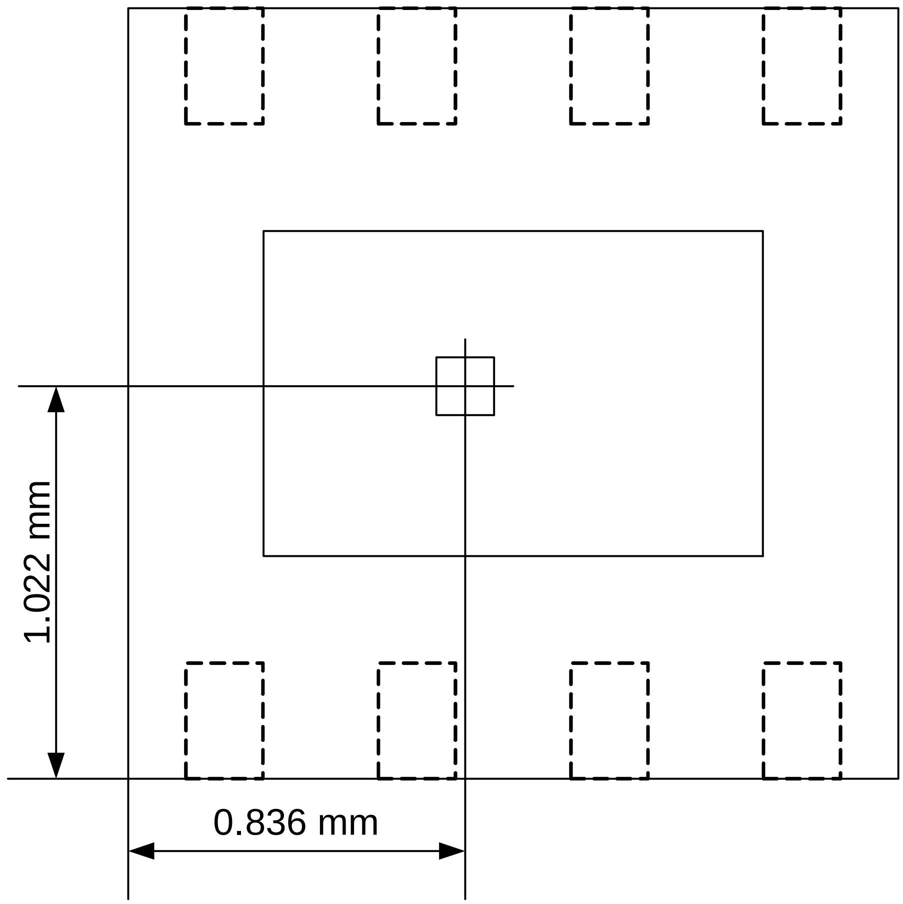
Example Programming Sequence

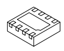
The following pseudo code configures the NOA2301 proximity sensor in repeat mode with 50 ms wait time between each measurement and then runs it in an interrupt driven mode. When the controller receives an interrupt, the interrupt determines if the interrupts was caused by the proximity sensor and if 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.

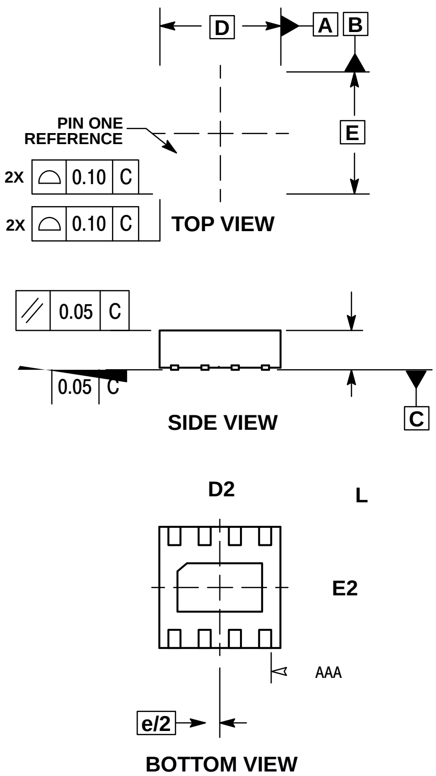
```
external subroutine I2C_Read_Byte (I2C_Address, Data_Address);
external subroutine I2C_Read_Block (I2C_Address, Data_Start_Address, Count, Memory_Map);
external subroutine I2C_Write_Byte (I2C_Address, Data_Address, Data);
external subroutine I2C_Write_Block (I2C_Address, Data_Start_Address, Count, 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
   }
  }
 }
```

Physical Location of Photodiode Sensor

The physical locations of the NOA2301 proximity sensor photodiode is shown in Figure 16 referenced to the lower left hand corner of the package.







NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

(*Note: Clear package, no marking is present)