

# NCS36000

## Passive Infrared (PIR) Detector Controller

The NCS36000 is a fully integrated mixed-signal CMOS device designed for low-cost passive infrared controlling applications. The device integrates two low-noise amplifiers and a LDO regulator to drive the sensor. The output of the amplifiers goes to a window comparator that uses internal voltage references from the regulator. The digital control circuit processes the output from the window comparator and provides the output to the OUT and LED pin.

### Features

- 3.0 – 5.75 V Operation
- –40 to 85°C
- 14 Pin SOIC Package
- Integrated 2-Stage Amplifier
- Internal LDO to Drive Sensor
- Internal Oscillator with External RC
- Single or Dual Pulse Detection
- Direct Drive of LED and OUT
- This is a Pb-Free Device

### Typical Applications

- Automatic Lighting (Residential and Commercial)
- Automation of Doors
- Motion Triggered Events (Animal photography)

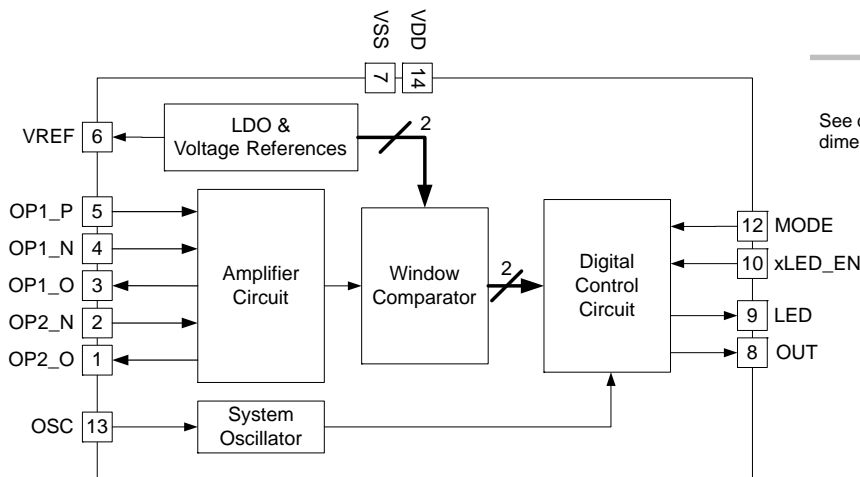


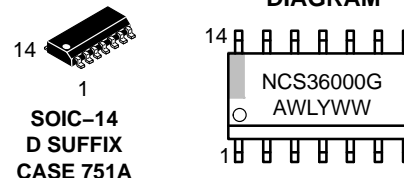
Figure 1. Simplified Block Diagram



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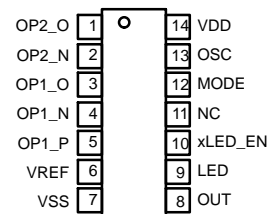
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### MARKING DIAGRAM



A = Assembly Location  
WL = Wafer Lot  
Y = Year  
WW = Work Week  
G = Pb-Free Package

### PIN CONNECTIONS



(Top View)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 7 of this data sheet.

## PIN FUNCTION DESCRIPTION

| Pin No. | Pin Name | Description                                    |
|---------|----------|--|
| 1       | OP2_O    | Output of second amplifier                     |
| 2       | OP2_N    | Inverting input of second amplifier            |
| 3       | OP1_O    | Output of first amplifier                      |
| 4       | OP1_N    | Inverting input of first amplifier             |
| 5       | OP1_P    | Non-inverting input of first amplifier         |
| 6       | VREF     | Regulated voltage reference to drive sensor    |
| 7       | VSS      | Analog ground reference.                       |
| 8       | OUT      | CMOS output (10 mA Max)                        |
| 9       | LED      | CMOS output to drive LED (10mA Max)            |
| 10      | xLED_EN  | Active low LED enable input                    |
| 11      | NC       | No Connect                                     |
| 12      | MODE     | Pin used to select pulse count mode            |
| 13      | OSC      | External oscillator to control clock frequency |
| 14      | VDD      | Analog power supply                            |

## ABSOLUTE MAXIMUM RATINGS

| Rating  | Symbol             | Value  | Unit |
|---|--------------------|--|------|
| Input Voltage Range (Note 1)  | $V_{in}$           | -0.3 to 6.0  | V    |
| Output Voltage Range  | $V_{out}$          | -0.3 to 6.0 V or ( $V_{in} + 0.3$ ),<br>whichever is lower | V    |
| Maximum Junction Temperature  | $T_{J(max)}$       | 140  | °C   |
| Storage Temperature Range   | $T_{STG}$          | -65 to 150   | °C   |
| ESD Capability, Human Body Model (Note 2)   | ESD <sub>HBM</sub> | 2  | kV   |
| ESD Capability, Machine Model (Note 2)  | ESD <sub>MM</sub>  | 200  | V    |
| Lead Temperature Soldering<br>Reflow (SMD Styles Only), Pb-Free Versions (Note 3) | $T_{SLD}$          | 260  | °C   |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
2. This device series incorporates ESD protection and is tested by the following methods:  
ESD Human Body Model tested per AEC-Q100-002 (EIA/JESD22-A114)  
ESD Machine Model tested per AEC-Q100-003 (EIA/JESD22-A115)  
Latchup Current Maximum Rating:  $\leq 150$  mA per JEDEC standard: JESD78
3. For information, please refer to our Soldering and Mounting Techniques Reference Manual, SOLDERRM/D

## THERMAL CHARACTERISTICS

| Rating  | Symbol                           | Value   | Unit |
|---|----------------------------------|---|------|
| Thermal Characteristics, DFN6, 3x3.3 mm (Note 4)<br>Thermal Resistance, Junction-to-Air (Note 5)<br>Thermal Reference, Junction-to-Lead2 (Note 5) | $R_{\theta JA}$<br>$R_{\psi JL}$ | Will be Completed once<br>package and power<br>consumption is finalized | °C/W |
| Thermal Characteristics, TSOP-5 (Note 4)<br>Thermal Resistance, Junction-to-Air (Note 5)  | $R_{\theta JA}$                  | See note above.   | °C/W |

4. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
5. Values based on copper area of 645 mm<sup>2</sup> (or 1 in<sup>2</sup>) of 1 oz copper thickness and FR4 PCB substrate.

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## OPERATING RANGES (Note 6)

| Rating                             |                               | Symbol          | Min                    | Typ             | Max                    | Unit |
|------------------------------------|-------------------------------|-----------------|------------------------|-----------------|------------------------|------|
| Analog Power Supply                |                               | V <sub>DD</sub> | 3.0                    | 5.0             | 5.75                   | V    |
| Analog Ground Reference            |                               | V <sub>SS</sub> |                        | 0.0             | 0.1                    | V    |
| Supply Current (Standby, No Loads) |                               | I <sub>DD</sub> |                        |                 | 170μ                   | A    |
| Digital Inputs (MODE)              |                               | V <sub>ih</sub> | 0.7 * V <sub>DD</sub>  | V <sub>DD</sub> | V <sub>DD</sub> + 0.3  | V    |
|                                    |                               | V <sub>il</sub> | V <sub>SS</sub>        |                 | V <sub>DD</sub> * 0.28 |      |
| Digital Output (OUT, LED)          | Push–Pull Output (10 mA Load) | V <sub>oh</sub> | 0.67 * V <sub>DD</sub> |                 | V <sub>DD</sub>        | V    |
|                                    |                               | V <sub>ol</sub> | V <sub>SS</sub>        |                 | V <sub>DD</sub> * 0.3  |      |
| OP1_P (Sensor Input) (Note 7)      |                               | AMP 1 IN        | 0.1                    |                 | V <sub>DD</sub> – 1.1  | V    |
| Ambient Temperature                |                               | T <sub>A</sub>  | –40                    |                 | 85                     | °C   |

6. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.

7. Guaranteed By Design (Non-tested parameter).

## ELECTRICAL CHARACTERISTICS $V_{in} = 1$ V, $C_{in} = 100$ nF, $C_{out} = 100$ nF, for typical values $T_A = 25^\circ\text{C}$ ; unless otherwise noted.

| Parameter | Test Conditions | Symbol | Min | Typ | Max | Unit |
|-----------|-----------------|--------|-----|-----|-----|------|
|-----------|-----------------|--------|-----|-----|-----|------|

### LDO Voltage Reference

|   |                            |       |       |     |       |               |
|---|----------------------------|-------|-------|-----|-------|---------------|
| Output Voltage  | $V_{DD} = 3.0$ V to 5.75 V | VREF  | 2.6   | 2.7 | 2.8   | V             |
| Supply Current  | $V_{DD} = 3.0$ V to 5.75V  | IREF  |       | 20  | 50    | $\mu\text{A}$ |
| Comparator High Trip Level                                    |                            | $V_h$ | 2.413 | 2.5 | 2.588 | V             |
| Comparator Low Trip Level                                     |                            | $V_l$ | 1.641 | 1.7 | 1.760 | V             |
| Reference voltage for non-inverting input of second amplifier |                            | $V_m$ | 2.007 | 2.1 | 2.174 | V             |

### System Oscillator

|                      |  |     |  |      |  |    |
|----------------------|--|-----|--|------|--|----|
| Oscillator Frequency | $V_{DD} = 5.0$ V<br>$R_3 = 220$ k $\Omega$<br>$C_2 = 100$ nF | OSC |  | 62.5 |  | Hz |
|----------------------|--|-----|--|------|--|----|

### Window Comparator

|                       |                 |  |  |  |  |  |
|-----------------------|-----------------|--|--|--|--|--|
| Lower Trip Threshold  | See $V_l$ above |  |  |  |  |  |
| Higher Trip Threshold | See $V_h$ above |  |  |  |  |  |

### Differential Amplifiers (Amplifier Circuit)

|                              |                           |            |     |    |                |               |
|------------------------------|---------------------------|------------|-----|----|----------------|---------------|
| DC Gain                      | $V_{DD} = 5.0$ V (Note 8) | $A_v$      | 80  |    |                | dB            |
| Common-mode Input Range      | $V_{DD} = 5.0$ V (Note 8) | CMIR       | 0.1 |    | $V_{DD} - 1.1$ | V             |
| Power Supply Rejection Ratio | $V_{DD} = 5.0$ V (Note 8) | PSRR       |     | 60 |                | dB            |
| Output Drive Current         | $V_{DD} = 5.0$ V (Note 8) | $I_{out1}$ |     |    | 25             | $\mu\text{A}$ |

### POR

|                     |  |           |      |  |      |   |
|---------------------|--|-----------|------|--|------|---|
| POR Release Voltage |  | $V_{POR}$ | 1.35 |  | 2.85 | V |
|---------------------|--|-----------|------|--|------|---|

8. Guaranteed By Design (Non-tested parameter).

## APPLICATIONS INFORMATION

### Oscillator

The oscillator uses an external resistor and capacitor to set the system clock frequency. Multiple clock frequencies can be selected using different combinations of resistors and capacitors. Figure 2 shows a simplifier block diagram for the system oscillator.

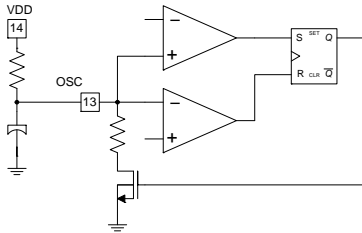


Figure 2. Block Diagram of System Oscillator Circuit

### LDO Regulator

The LDO regulator provides the reference voltage for the sensor and all other analog blocks within the system. The nominal voltage reference for the sensor is  $2.7\text{ V} \pm 5\%$ . An external capacitor is needed on the VREF pin to guarantee stability of the regulator.

### Differential Amplifiers

The two differential amplifiers can be configured as a bandpass filter to condition the PIR sensor signal for the post

digital signal processing. The cutoff frequencies and passband gain are set by the external components. See Figure 5.

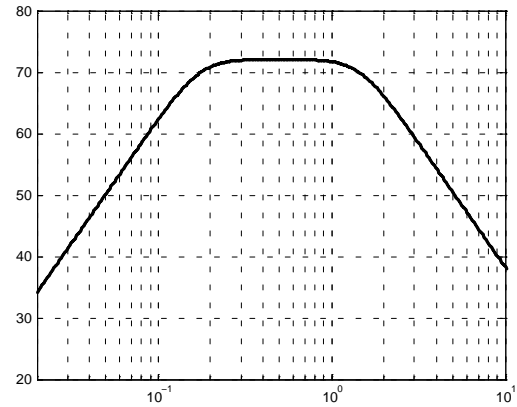


Figure 3. Plot Showing Typical Magnitude Response of Differential Amplifiers When Configured as a Bandpass Filter

### Window Comparator

The window comparator compares the voltage from the second differential amplifier to two reference voltages from the LDO regulator. COMP\_P triggers if OP2\_O is greater than the Vh voltage and COMP\_N triggers if OP2\_O is lower than the Vl voltage. See Figures 4 and 5.

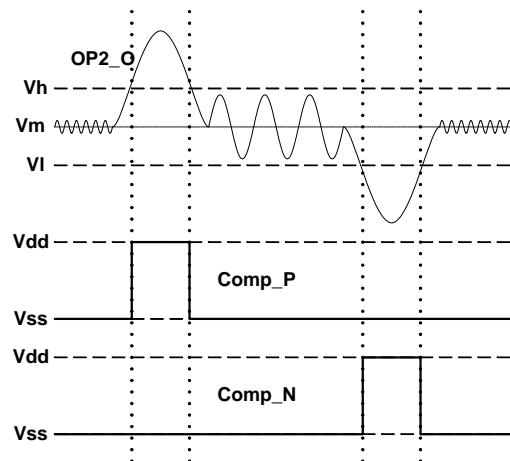


Figure 4. Plot Showing Functionality of Window Comparator for an Analog Input OP2\_O

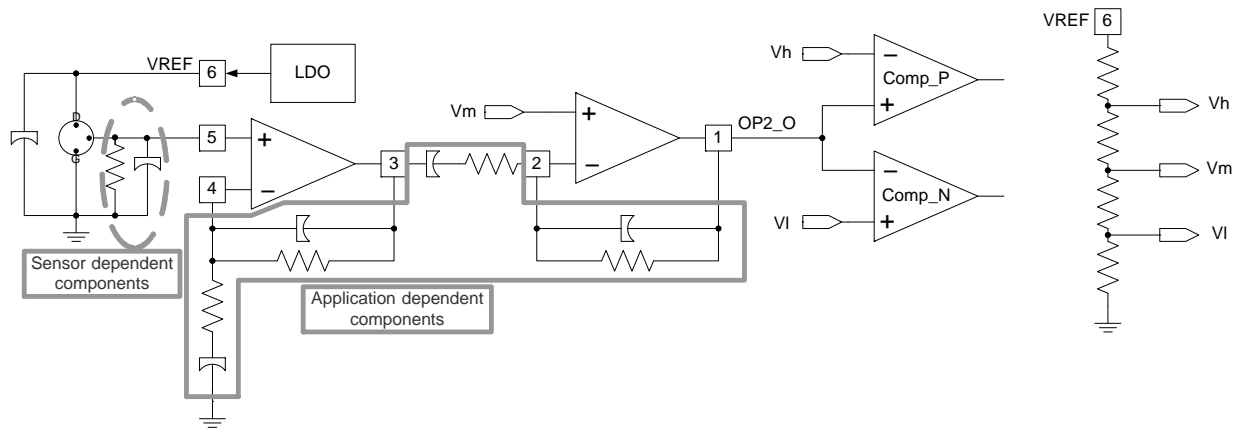


Figure 5. Figure Showing Simplified Block Diagram of Analog Conditioning Stages

#### Digital Signal Processing Block (all times assume a 62.5 Hz system oscillator frequency)

The digital signaling processing block performs three major functions.

The first function is that the device toggles LED during the start-up sequencing at approximately two hertz regardless of the state of the XLED\_EN pin. The startup sequence lasts for thirty seconds. During that time the OUT pin is held low regardless of the state of OP2\_O.

The second function of the digital signal processing block is to insure a certain glitch width is seen before OUT is toggled. The digital signal processing block is synchronous with the system oscillator frequency and therefore the deglitch time is related to when the comparators toggle within the oscillator period. A signal width less than two clock period is guaranteed to be deglitched as a zero. A signal width of greater than three clock cycles is guaranteed to be de-glitched. It should be noted that down-sampling can occur if sufficient anti-aliasing is not performed at the input of the circuit (OPI\_P) or if noise is injected into the amplifiers, an example would be a noisy power supply.

The third function of the digital signal processing block is to recognize different pulse signatures coming from the window comparator block. The device is equipped with two pulse recognition routines. Single pulse mode (MODE tied to VSS) will trigger the OUT pin if either comparator toggles and the deglitch time is of the appropriate length. (See Figure 6). Dual pulse mode (MODE tied to  $V_{DD}$ ) requires two pulses with each pulse coming from the opposite comparator to occur within a timeout window of five seconds (See Figure 7). If the adjacent pulses occur outside the timeout window then the digital processing block will restart the pulse recognition routine (Figure 8).

#### xLED\_EN Pin

The xLED\_EN pin enables the LED output driver when motion has been detected. If xLED\_EN is tied high the LED pin will not toggle after motion is detected. If the xLED\_EN is tied low the LED pin will toggle when motion is detected. During start-up the LED pin will toggle irrespective of how the xLED\_EN pin is tied. (See Figure 6).

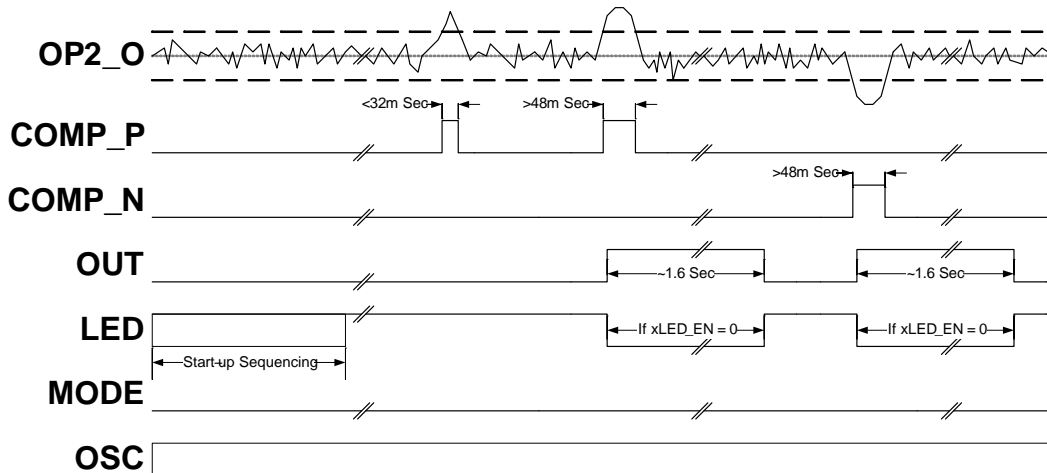


Figure 6. Timing Diagram for Single-Pulse Mode Detection

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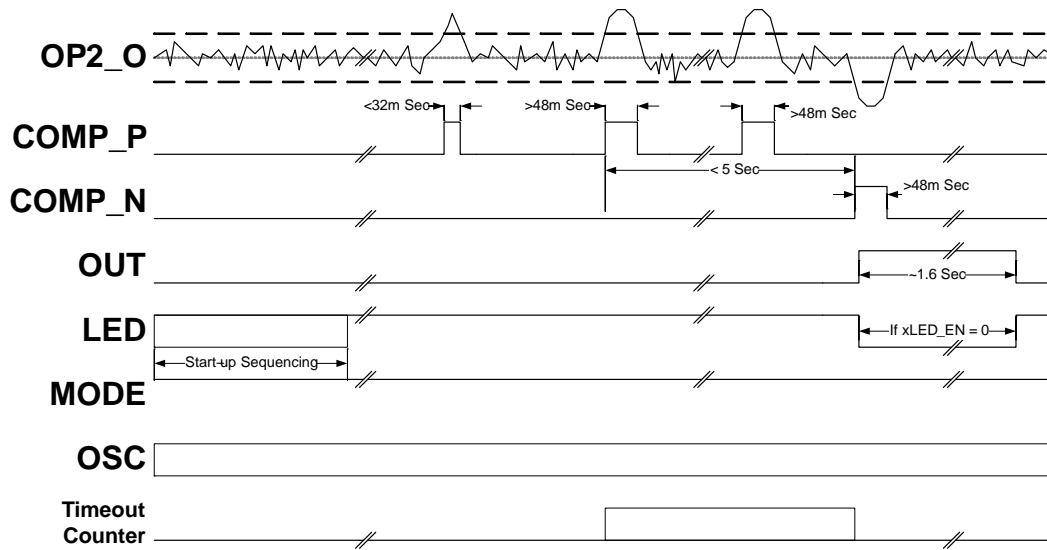


Figure 7. Timing Diagram for Dual-Pulse Mode Detection

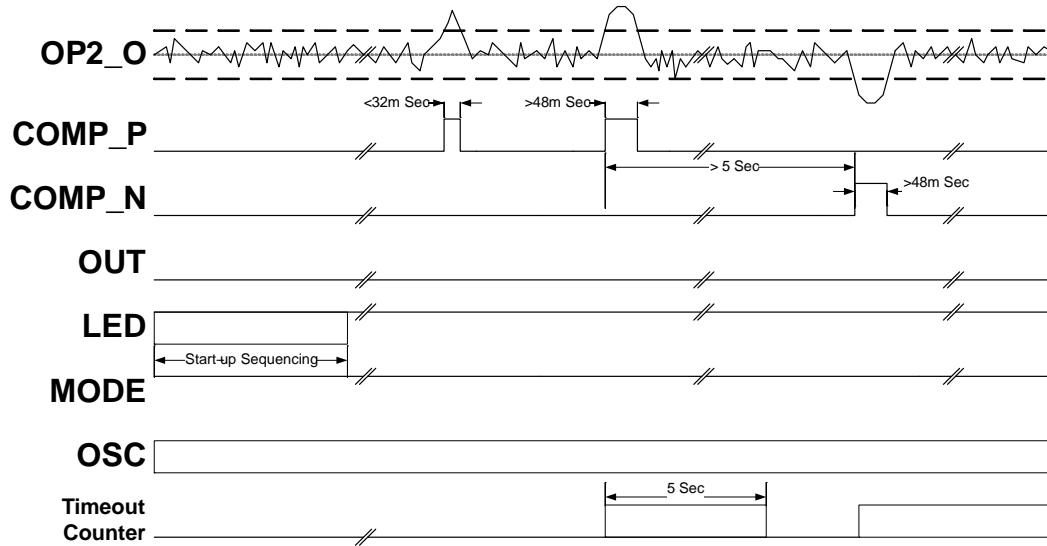
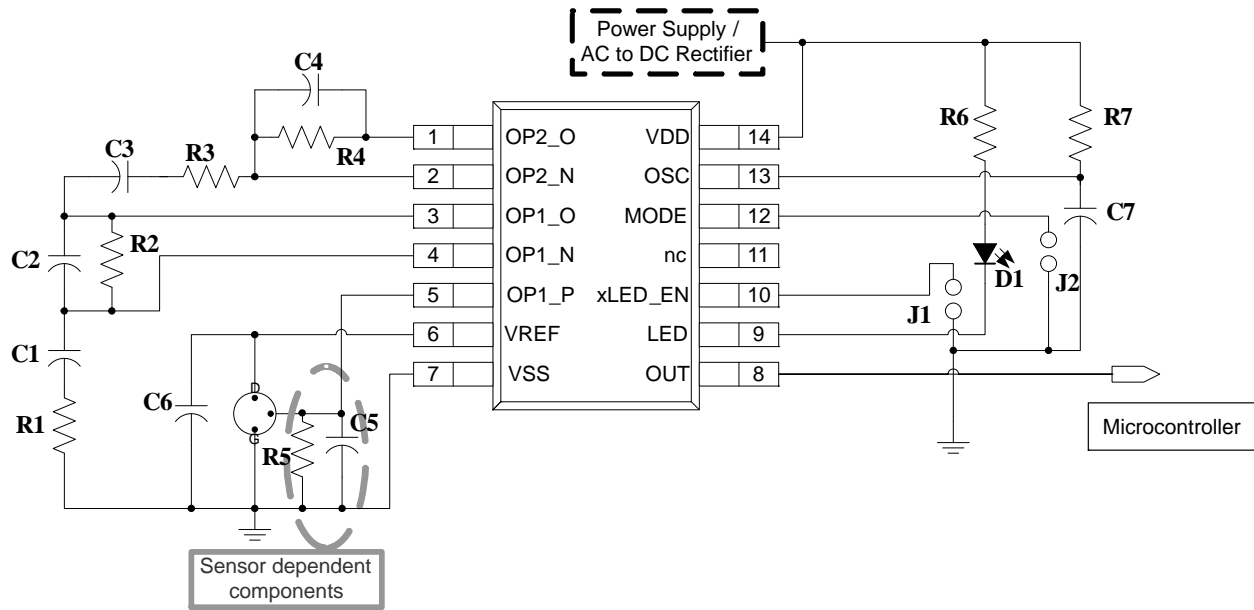


Figure 8. Timing Diagram for Two Pulses Outside Timeout Window

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**Figure 9. Typical Application Diagram Using NCS36000**

|             |             |                             |
|-------------|-------------|-----------------------------|
| R1 = 10 kΩ  | C1 = 33 μF  | J1 (Jumper for xLED_EN)     |
| R2 = 560 kΩ | C2 = 10 nF  | J2 (Jumper for Mode Select) |
| R3 = 10 kΩ  | C3 = 33 μF  | D1 (LED)                    |
| R4 = 560 kΩ | C4 = 10 nF  |                             |
| R5 = 43 kΩ  | C5 = 100 nF |                             |
| R6 = 1 kΩ   | C6 = 100 nF |                             |
| R7 = 220 kΩ | C7 = 100 nF |                             |

9. R1, C1, R2, C2, R3, C3, R4, C4 setup bandpass filter characteristics. With components as shown above the passband gain is approximately 70 dB with the 3 dB cutoff frequency of the filter at approximately 700 mHz and 20 Hz.
10. R4 can be replaced by a potentiometer to adjust sensitivity of system. Note dynamically changing R4 will also change the pole location for the second amplifier.
11. R5 and C5 are sensor dependant components and R6 may need to be adjusted to guarantee the AMP 1 IN parameter outlined within the Operating Ranges section of this document.
12. R7 and C7 may be adjusted to change the oscillator frequency. R7 may not be smaller than 50 kΩ.

## ORDERING INFORMATION

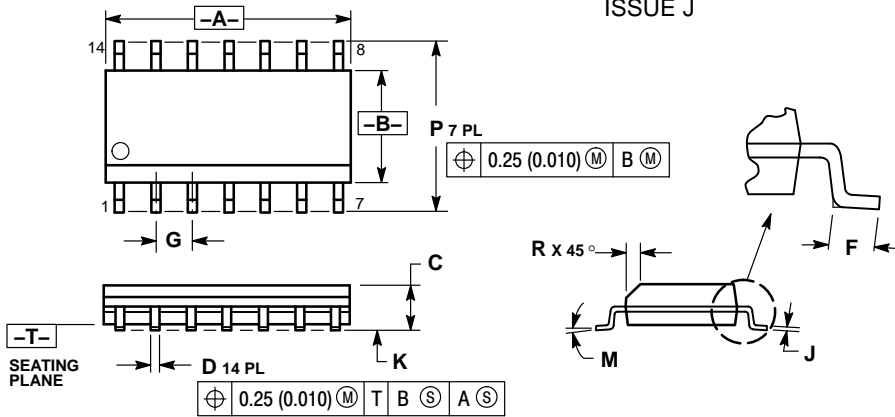
| Device      | Package              | Shipping <sup>†</sup> |
|-------------|----------------------|-----------------------|
| NCS36000DG  | SOIC-14<br>(Pb-Free) | 55 Units / Rail       |
| NCS36000DRG | SOIC-14<br>(Pb-Free) | 3000 / Tape & Reel    |

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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## PACKAGE DIMENSIONS

### SOIC-14 D SUFFIX CASE 751A-03 ISSUE J

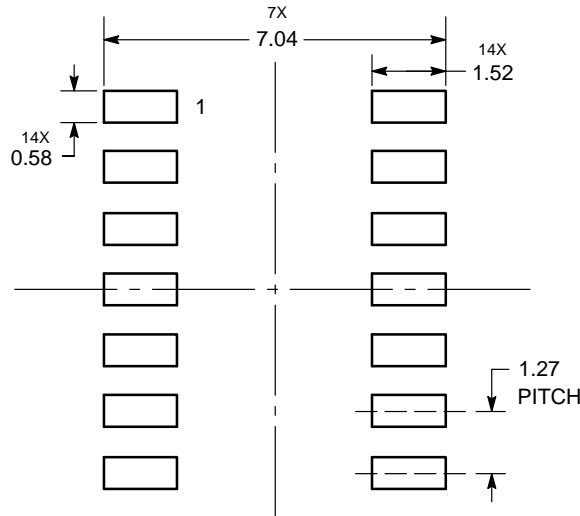


#### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

| DIM | MILLIMETERS |           | INCHES |       |
|-----|-------------|-----------|--------|-------|
|     | MIN         | MAX       | MIN    | MAX   |
| A   | 8.55        | 8.75      | 0.337  | 0.344 |
| B   | 3.80        | 4.00      | 0.150  | 0.157 |
| C   | 1.35        | 1.75      | 0.054  | 0.068 |
| D   | 0.35        | 0.49      | 0.014  | 0.019 |
| E   | 0.40        | 1.25      | 0.016  | 0.049 |
| F   | 1.27 BSC    | 0.050 BSC |        |       |
| G   | 0.19        | 0.25      | 0.008  | 0.009 |
| H   | 0.10        | 0.25      | 0.004  | 0.009 |
| I   | 0.10        | 0.25      | 0.004  | 0.009 |
| J   | 0°          | 7°        | 0°     | 7°    |
| K   | 5.80        | 6.20      | 0.228  | 0.244 |
| L   | 0.25        | 0.50      | 0.010  | 0.019 |

### SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

\*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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