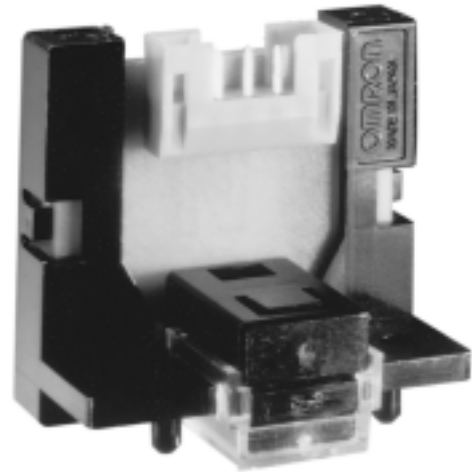# OMRON ®

Z4D-A01

New Micro-displacement Reflective Sensor Technology Detects Very Small Movement and Thickness of Objects

- Uses position sensing diode/LED to detect 10 μm movement

- Sensor output minimally affected by color and reflection of an object

- Requires 5VDC to give two analog outputs to the microprocessor with a 10-bit A/D converter

Ordering Information

Sensing method	Output configuration	Mating connector	**Part number**
Diffuse reflective type	Analog voltage output (2 signals)	AMP 173977-5 AMP 175778-5	**Z4D-A01**

Specifications

■ ABSOLUTE MAXIMUM RATINGS (T_A = 25°C (77°F))

Item	Symbol	Value	Unit	Remarks
Supply voltage	V_{cc}	7	VDC	-
LED emission control signal	V_a	7	VDC	Supply voltage for transistor base terminal
LED emission pulse	t_{FP}	100	ms	Duty cycle: 1% max.
Operating temperature	T_{opr}	-10 to +55	°C	(See Note.)
Operating relative humidity	RH_{opr}	25 to 85	%RH	(See Note.)
Storage temperature	T_{stg}	-25 to +65	°C	-
Storage relative humidity	RH_{stg}	25 to 85	%RH	-

Note: The product must be used in applications where neither freezing nor condensation takes place.

■ TYPICAL APPLICATION

Paper thickness detection for printers
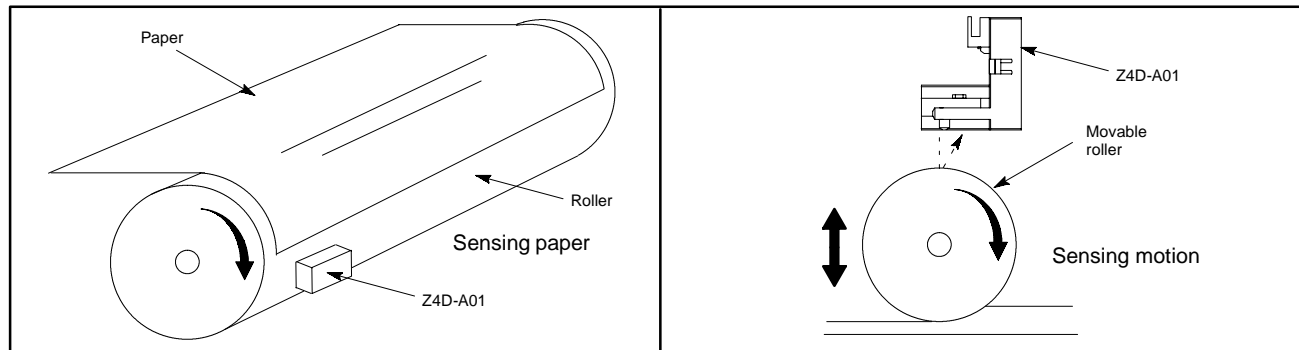
■ ELECTRICAL CHARACTERISTICS (T_A = -10 to +55°C (14 to +131°F))

Item	Limits	Remarks
Supply voltage	5 VDC ±10%	Ripple (p-p): 10mV p-p max.
Consumption current	200 mA max.	When LED is ON
	5 mA max.	When LED is OFF
V_1, V_2	3.9 V max.	Common to two signals (Notes 1 and 2)
Response time	100 μs max.	PSD rising time

Note: 1. When the measured surface of an object is a diffused surface (rough surface)
2. Please make impedance of signal input side a minimum of 10 kΩ

■ PERFORMANCE (T_A = -10 to +55°C (14 to +131°F), Cable length: 300 mm, AWG28 – See Note 1.)

Item	Values (See Note 2.)	Remarks
Operating distance	6.5 ±1 mm	From the reference mounting surface
Variation of sensitivity	±10%	(See Note 3.)
Resolution	±10 μm	(See Note 4.)
Operable ambient illumination	3000 lx max.	Under sunlight
	2000 lx max.	Under fluorescent lamp

Note: 1. As measured between sensor and microprocessor.
2. The values are measured with a white paper having a 90% reflection factor.
3. Defined as the variation of sensitivity between products. The variation is the change of the calculated analog output by distance (slope of the straight output line.) Refer to "Microprocessor Divided Output vs. Distance" graph in Engineering Data.
4. The resolution means the electrical noise width on the calculated analog output converted into distance when using a 10-bit or more A/D converter.

Engineering Data ────────────────────────────

Note: The operating conditions of the photomicrosensor must be within the absolute maximum rating ranges.

■ TEMPERATURE CHARACTERISTICS (TYPICAL)

Sensitivity Change Ratio (%) vs. Ambient Temperature (°C)
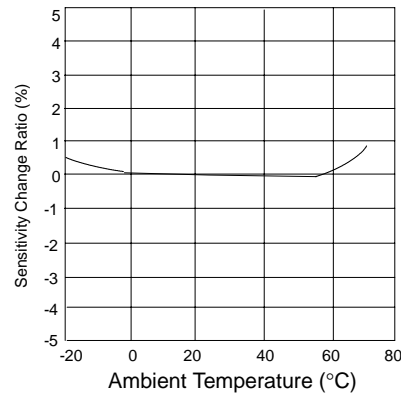
■ PULSED FORWARD CURRENT RATED CURVE

$$\text{Duty ratio (\%)} = \frac{t_{FP}}{T} \times 100$$

Pulse width (ms) vs. Duty ratio (%)
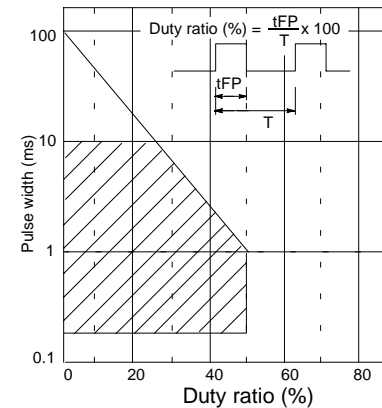
■ DEPENDENCY OF OBJECT ON REFLECTION FACTOR (TYPICAL)

Sensitivity Change Ratio (%) vs. Deflection Factor of Object (%)
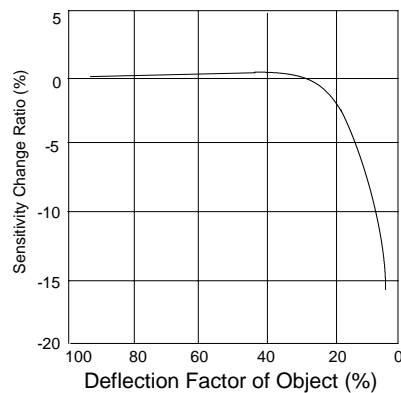
■ Z4D-A01 SENSOR OUTPUT VS. DISTANCE (TYPICAL)

Sensor output (V) vs. Distance from mounting reference plane (μm)

■ MICROPROCESSOR DIVIDED OUTPUT VS. DISTANCE (TYPICAL)

$$\frac{V_1 - V_2}{V_1 + V_2}$$
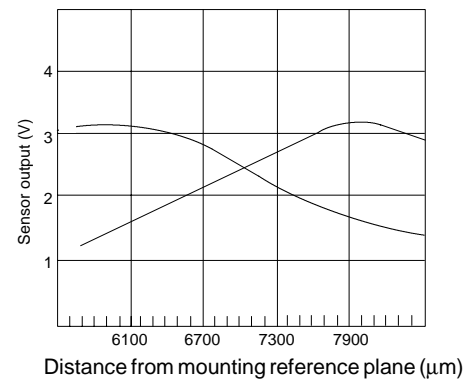
Divided output (V) vs. Distance from mounting reference plane (μm)
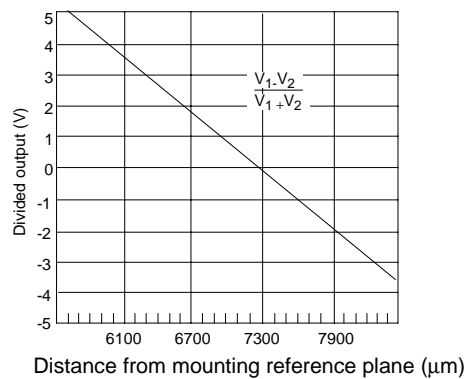
Operation

■ CIRCUIT DIAGRAM

Connector
Pin No.

Micro-displacement Sensor

Micro-processor (Reference)

PSD — Amplifier — ② V_1 — ○ — A/D — V_1+V_2

④ V_2 — ○ — A/D

$\dfrac{V_1 \cdot V_2}{V_1 + V_2}$ — Output

① 5 VDC

LED

Tr.

⑤ LED control signal — ○

③ GND

Object

■ TIMING CHART

LED lighting

LED control signal

V1ON   V1OFF

Read V_1

0.1 ms min.   0.1 ms min.

V2ON   V2OFF

Read V_2

Pulse width: t=6 ms max.

Period: T

1. PSD response time is 0.1 ms max. Set the delay time for reading the sensor output (V) to 0.1 ms or more.

2. To maximize LED life, set t=6 ms max., duty cycle (t/T) = 30% max.

Dimensions

Unit: mm (inch)

■ Z4D-A01

19 (0.75)
14.4 (0.57)
9.1 (0.36)
5.7 (0.22)
4.6 (0.18)
8.2 (0.32)
15.7 (0.62)
φ 2.3 (0.09)
2- M3
26 (1.02)
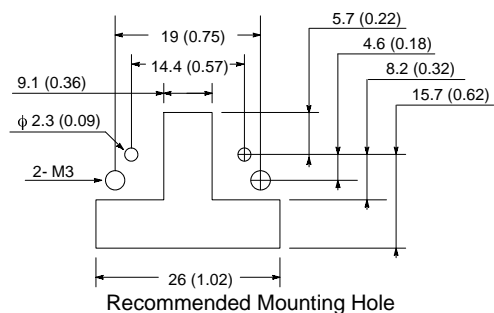
Recommended Mounting Hole

11.8 (0.46)
(5) (4) (3) (2) (1)

Mounting reference plane

1.8 (0.07)
2.4 (0.09)
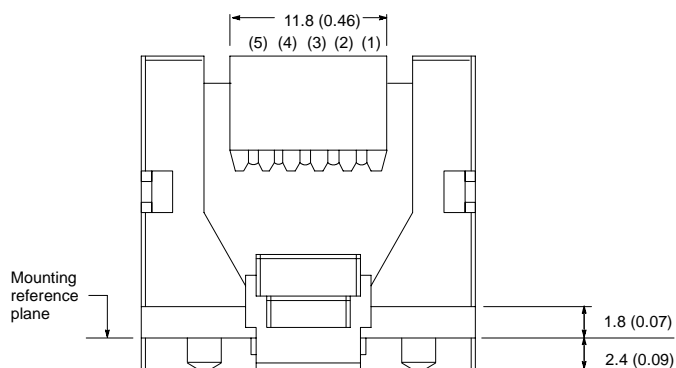
Top View

PIN No.	REMARKS
1.	5V DC
2.	Output V1
3.	GND
4.	Output V2
5.	LED Control Signal Input

Sensing window

19 (0.75)
14.4 (0.57)
8.4 (0.33)
3 (0.12)
φ 2 (0.08)
LED axis
4.6 (0.18)
6.3 (0.25)
13.6 (0.54)
Aperture center
4.2 (0.17)
φ 3.8 (0.15)
6.4 (0.25)
25.0 (0.98)

Front View

23.5 (0.93)
8.3 (0.33)
8.5 (0.33)
6.8 (0.26)
20 (0.79)
10.9 (0.43)
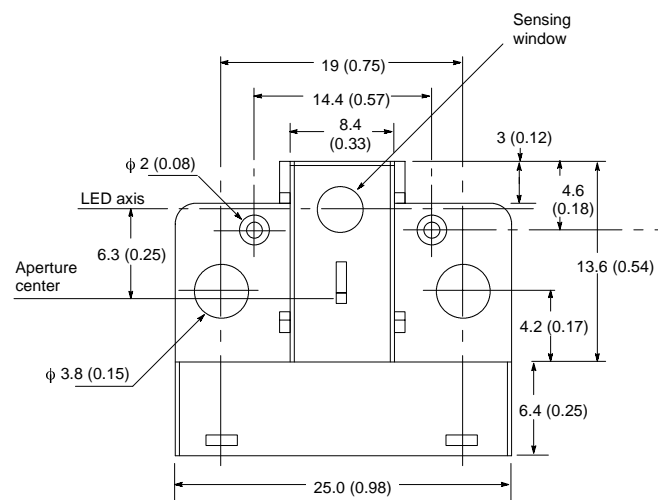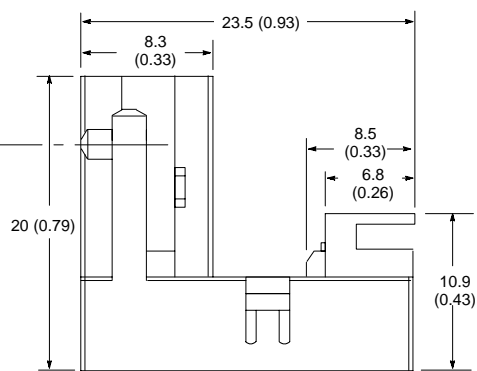
Side View

Technical Information ———————————

This product, developed for use in electronic equipment, is an optical displacement sensor that uses a position-sensitive detector (PSD). The following features are characteristic of the optical displacement sensor when directly connected to a microprocessor provided by the user:

1. The color or the reflection factor of a sensing object has little effect on the analog output.
2. The inclined face of a sensing object has little effect on the analog output.
3. Linear compensation is not required.

■ INTERNAL CONFIGURATION

$\triangle ABO \sim \triangle abO$

$\dfrac{\overline{AB}}{ab} = constant$

■ POSITION SENSITIVE DETECTOR (PSD)

$I_O = I_A + I_B$

$I_A = I_O * (L-x)/L, \quad I_B = I_O * x/L$

$I_A/I_B = (L-x)/x$
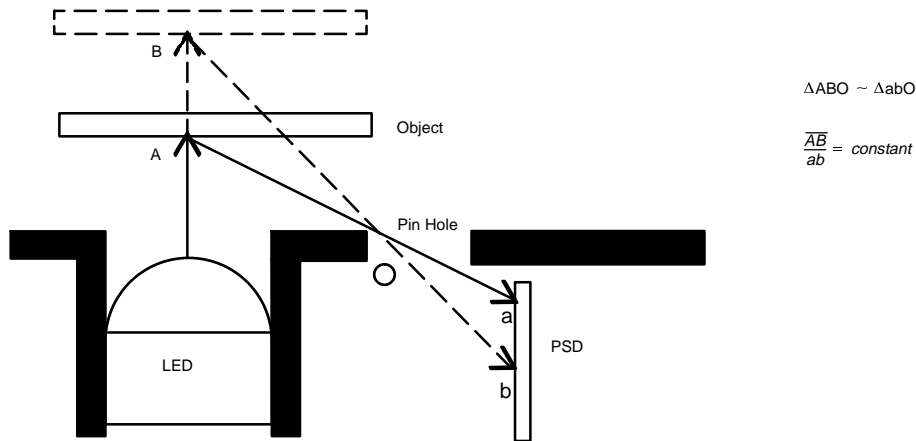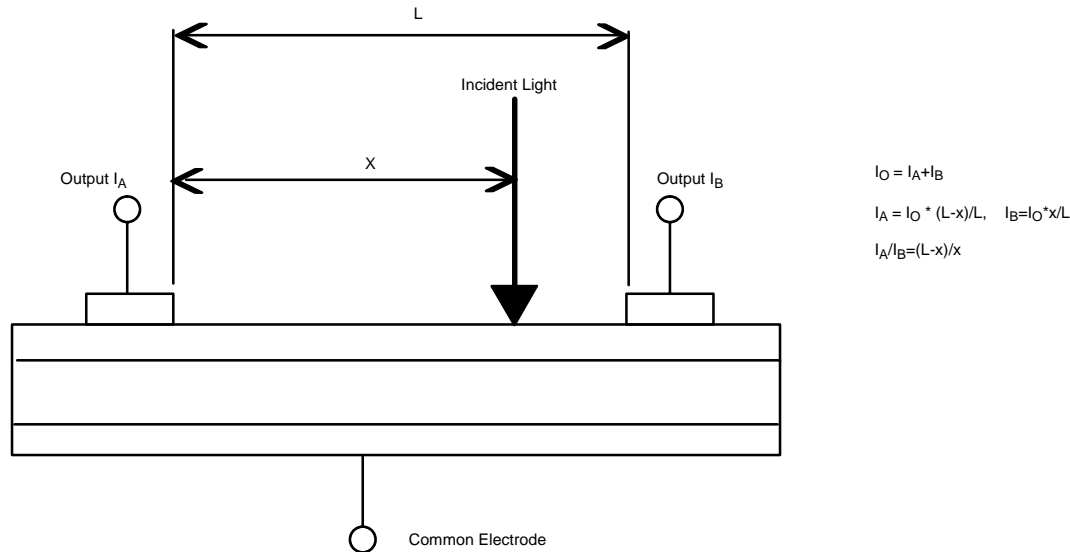
■ CONNECTIONS AND PRECAUTIONS

Connector Pin No.

PSD — Amplifier — ② V_1 — ○ — A/D — V_1+V_2 — $\dfrac{V_1-V_2}{V_1+V_2}$ — ○ Output

— ④ V_2 — ○ — A/D

① 5 VDC

LED

Tr. — ⑤ LED control signal — ○

Object — ③ GND

Micro-displacement Sensor   Micro-processor (Reference)
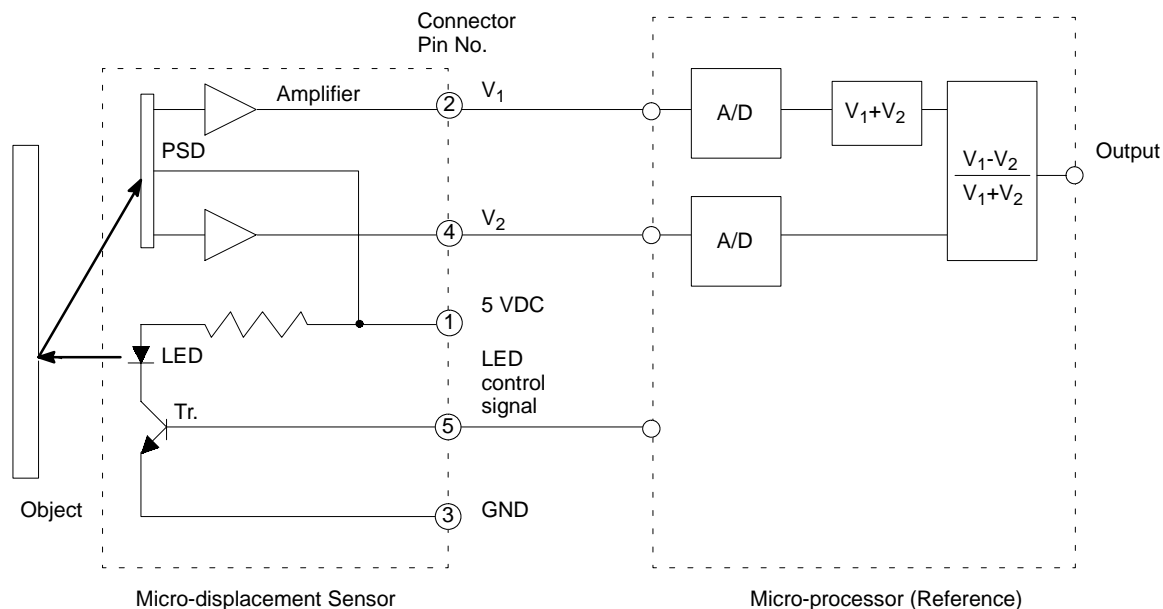
1. Connect each sensor output V1 and V2 directly to separate A/D converter ports. The sensor output is 3.9 volts or less. Therefore, set the input voltage for A/D converters to between 4 and 5 volts. A 10-bit A/D converter is recommended in order to attain a 10 μm resolution.

2. Use a 5 VDC power supply with a ripple of less than 10 mV p-p.

3. TTL with an output of 4V or more and a maximum current capacity or 10 mA can be used for the LED control signal.

4. In cases where the sensor is used near devices which generate noise, connect the ground terminals of the devices to the ground terminal of the Z4D-A01. If noise persists, use a low noise power supply (10 mV peak-to-peak) and the following noise filter circuit:

VCC — L —
C   C
GND

■ **FLOW CHART**

```
              ┌─────────────────────────────────┐
              │            START                │
              └─────────────────────────────────┘
                              ↓
      ┌──────────────────────────────────────────────┐
      │     │            Turn LED on              │   │
      │     └─────────────────────────────────────┘   │
      │                     ↓                          │
      │     ┌─────────────────────────────────────┐   │
      │     │   A/D conversion for V1: V1(ON)     │   │
      │     └─────────────────────────────────────┘   │
      │                     ↓                          │
      │     ┌─────────────────────────────────────┐   │
      │     │   A/D conversion for V2: V2(ON)     │   │
      │     └─────────────────────────────────────┘   │
      │                     ↓                          │
      │     ┌─────────────────────────────────────┐   │
      │     │          Turn LED off               │   │
      │     └─────────────────────────────────────┘   │
      │                     ↓                          │
      │     ┌─────────────────────────────────────┐   │
      │     │   A/D conversion for V1: V1(ON)     │   │
      │     └─────────────────────────────────────┘   │
      │                     ↓                          │
      │     ┌─────────────────────────────────────┐   │
      │     │   A/D conversion for V2: V2(ON)     │   │
      │     └─────────────────────────────────────┘   │
      │                     ↓                          │
      │     ┌─────────────────────────────────────┐   │
      │     │  V1 = V1(ON) – V1(OFF)              │----(1)
      │     └─────────────────────────────────────┘   │
      │                     ↓                          │
      │     ┌─────────────────────────────────────┐   │
      │     │  V1 = V2(ON) – V2(OFF)              │   │
      │     └─────────────────────────────────────┘   │
      │                     ↓                          │
      │     ┌─────────────────────────────────────┐   │
      │     │  Calculation: 2 * V2/(V1+V2)        │----(2)
      │     └─────────────────────────────────────┘   │
      │                     ↓                          │
      │     ┌─────────────────────────────────────┐   │
      └◄────│      Repeat calculation N times     │   
            └─────────────────────────────────────┘
                              ↓
            ┌─────────────────────────────────────┐
            │            Averaging                │----(3)
            └─────────────────────────────────────┘
                              ↓
            ┌─────────────────────────────────────┐
            │             Output                  │
            └─────────────────────────────────────┘
                              ↓
            ┌─────────────────────────────────────┐
            │             Finish                  │
            └─────────────────────────────────────┘
```
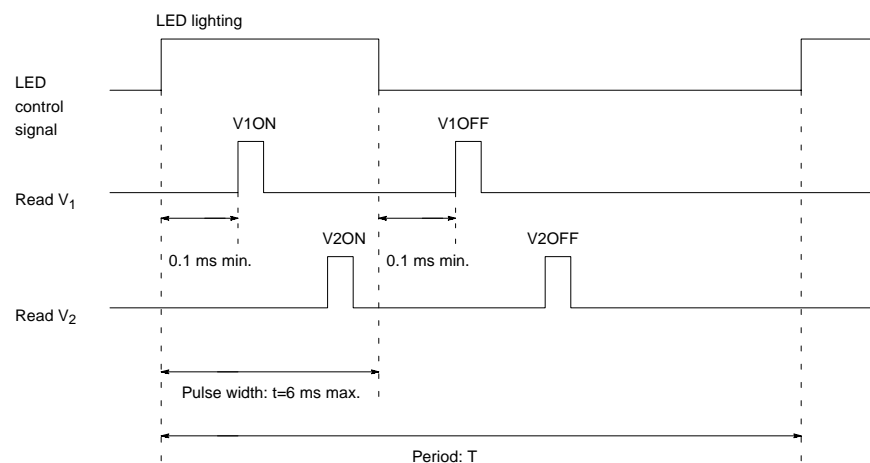
Equations from flow chart:

$$V1 = V1_{(ON)} - V1_{(OFF)} \quad ----(1)$$

$$V1 = V2_{(ON)} - V2_{(OFF)}$$

$$\text{Calculation: } 2 * V2/(V1+V2) \quad ----(2)$$
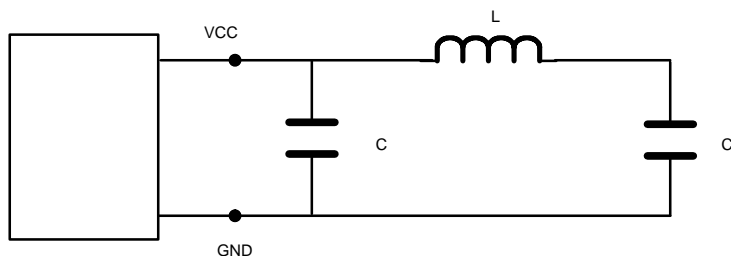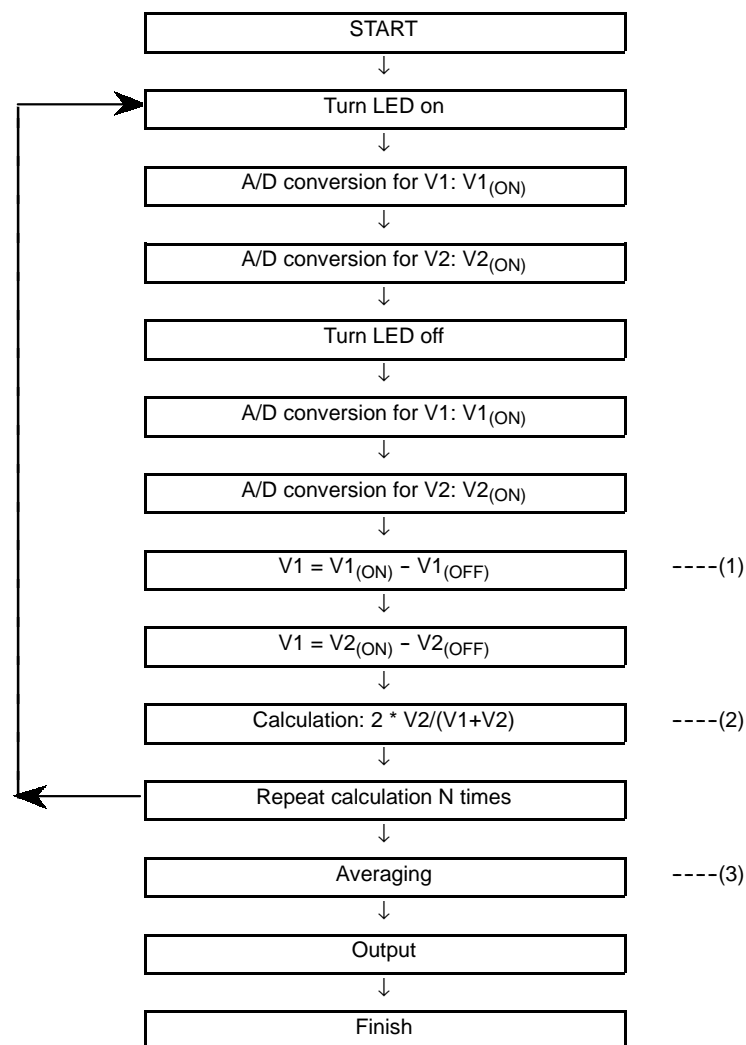
1. A PSD normally outputs two current signals. The internal circuit converts the current signals of the PSD to voltage signals at V1 and V2. The current signal from the PSD is amplified twice inversely using an Op amp. From the 5 VDC supply voltage restriction, the offset voltage for the Op amp is approximately 0.5 V. To obtain the true voltage signal from the PSD, subtract the offset voltage (V1OFF) from the output voltage (V1ON) with pulsed LED driving.

1st Amplification   2nd Amplification
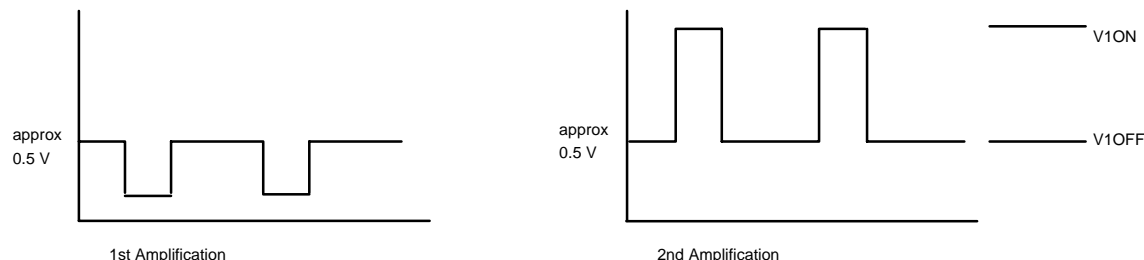
2. The graph of calculated output vs. distance can be defined by choosing either V1 or V2 as the numerator in the output equation. The equation will then be either $V1/(V1+V2)$ or $V2/(V1+V2)$. This will produce either a positive or negative slope, depending on whether V1 or V2 is chosen. Theoretically, $V2/(V1+V2)$ ranges from 0 to 1. When a 5 V full-scale A/D converter is used corresponding to this range, the sensitivity of the sensor is approximately 0.8 mV/μm. If required, the sensitivity can be doubled by multiplying the equation by two. This would change the theoretical range of $V2/(V1+V2)$ to 0 to 2. Considering the linear output range of this sensor (6.5 mm $\pm$ 1 mm at sensing distance), the applicable output ranges from 0.5 to 1.5 on this calculated value from the formula of $2*V2/(V1+V2)$. Subtracting the offset value of 0.5 from the calculated value provides a 0 to 1 range for the D/A converter input.

3. Repeating data measurements and averaging the data reduces measuring error. Measuring three or more times results in a more stable value.

LED lighting

LED
control
signal

V1ON

V1OFF

Read V$_1$

0.1 ms min.

V2ON

0.1 ms min.

V2OFF

Read V$_2$

Pulse width: t=6 ms max.

Period: T

1. PSD response time is 0.1 ms max.
Set the delay time for reading the sensor output (V) to 0.1 ms or more.

2. To maximize LED life, set t=6 ms max., duty cycle (t/T) = 30% max.

NOTE: DIMENSIONS SHOWN ARE IN MILLIMETERS. To convert millimeters to inches divide by 25.4.