LTR-301 Data Sheet (1.2)

LITEON

LITE-ON ELECTRONICS, INC.
Property of Lite-On Only

FEATURES
* WIDE RANGE OF COLLECTOR CURRENT
* LENSED FOR HIGH SENSITIVITY
* LOW COST PLASTIC SIDE LOOKING PACKAGE
* CLEAR TRANSPARENT COLOR PACKAGE

PACKAGE DIMENSIONS

NPN Transistor
Base controlled by light

CMPE 118/218 – Intro. to Mechatronics
### Absolute Maximum Ratings at TA = 25°C

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>MAXIMUM RATING</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Dissipation</td>
<td>100</td>
<td>mW</td>
</tr>
<tr>
<td>Collector-Emitter Voltage</td>
<td>30</td>
<td>V</td>
</tr>
<tr>
<td>Emitter-Collector Voltage</td>
<td>5</td>
<td>V</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>-40°C to +85°C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-55°C to +100°C</td>
<td></td>
</tr>
<tr>
<td>Lead Soldering Temperature</td>
<td>260°C for 5 Seconds</td>
<td></td>
</tr>
</tbody>
</table>

### Electrical Opto-Optical Characteristics at TA = 25°C

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNIT</th>
<th>TEST CONDITION</th>
<th>BIN NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector-Emitter Breakdown Voltage</td>
<td>( V_{BRECO} )</td>
<td>30</td>
<td></td>
<td></td>
<td>V</td>
<td>( I_C = 1mA ), ( E_{oo} = 0mW/cm^2 )</td>
<td></td>
</tr>
<tr>
<td>Emitter-Collector Breakdown Voltage</td>
<td>( V_{BRECO} )</td>
<td>5</td>
<td></td>
<td></td>
<td>V</td>
<td>( I_E = 100\mu A ), ( E_{oo} = 0mW/cm^2 )</td>
<td></td>
</tr>
<tr>
<td>Collector Emitter Saturation Voltage</td>
<td>( V_{CESAT} )</td>
<td>0.4</td>
<td></td>
<td></td>
<td>V</td>
<td>( V_{CC} = 5V ), ( I_C = 1mA ), ( R_L = 1K\Omega )</td>
<td></td>
</tr>
<tr>
<td>Rise Time</td>
<td>( T_r )</td>
<td>10</td>
<td></td>
<td></td>
<td>( \mu s )</td>
<td>( V_{CC} = 5V ), ( I_C = 1mA ), ( E_{oo} = 1mW/cm^2 )</td>
<td></td>
</tr>
<tr>
<td>Fall Time</td>
<td>( T_f )</td>
<td>15</td>
<td></td>
<td></td>
<td>( \mu s )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collector Dark Current</td>
<td>( I_{CEO} )</td>
<td>100</td>
<td></td>
<td></td>
<td>nA</td>
<td>( V_{CE} = 10V ), ( E_{oo} = 0mW/cm^2 )</td>
<td></td>
</tr>
<tr>
<td>On State Collector Current</td>
<td>( I_{C\text{(ON)}} )</td>
<td>0.20</td>
<td>0.60</td>
<td></td>
<td></td>
<td></td>
<td>BIN A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.40</td>
<td>1.08</td>
<td></td>
<td></td>
<td></td>
<td>BIN B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.04</td>
<td>1.80</td>
<td></td>
<td></td>
<td></td>
<td>BIN C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.20</td>
<td>2.40</td>
<td></td>
<td></td>
<td></td>
<td>BIN D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BIN E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BIN F</td>
</tr>
</tbody>
</table>
\[ V_{CT} = S - V_{AT} \]

Light ↑ \( \iff \) \( V_{AT} \downarrow \)
Phototransistors: How do you use them? (1.2)

How do choose R

10k

1k

10 mV

Too small

1V

2kV

Too big

NON-LINEAR RESPONSE
Phototransistors: How do you use them? (2.2)

(1) Linear w/ light
(2) Buffered input
Basic Sensors: Magnetic Field (1.4)

REED SWITCH

FRAGILE

Figure 1: Two-reed (top) and three-reed (bottom) reed switches
Basic Sensors: Magnetic Field (2.4)

Hall Effect Sensor
- Semiconductor device

Two flavors
- Switch (on/off)
- Analog 3-5x

Diagram:
- Magnetic Flux
- Hall Voltage
- Current
- Input Signal
- Sensor
- Output Signal
- HAL
- $V_{OUT}$
Basic Sensors: Magnetic Field (3.4)

Switch

Unipolar

Hysteresis

Analog

Output Voltage

\[ V_{OO} \]

\[ \Delta V_{out} \]

\[ \Delta B \]

Bipolar
Basic Sensors: Magnetic Field (4.4)

Rotation $\rightarrow$ Magnetic Field

Voltage $\rightarrow$ ECM

Rotation $\rightarrow$ modulated magnetic frequency $\rightarrow$ ECM
Measuring Position

Convert Motion to Voltage

Sonar ~ Ultrasonics

Time of Flight (TOF)

1 m/msec 2-3 m ~ 5 m.

~ $90

~ $4

TX

2 m
CIGN

SICK
~ $3k - $12k

RIGER
~ $120k

80 m ± 2mm

A
Optical Sensors for Position (1.2)

TCRT5000, TCRT5000L
Vishay Semiconductors

Reflective Optical Sensor with Transistor Output

FEATURES
- Package type: leaded
- Detector type: phototransistor
- Dimensions (L x W x H in mm): 10.2 x 5.8 x 7
- Peak operating distance: 2.5 mm
- Operating range within > 20% relative collector current: 0.2 mm to 15 mm
- Typical output current under test: I_C = 1 mA
- Daylight blocking filter
- Emitter wavelength: 950 nm
- Lead (Pb)-free soldering released
- Compliant to RoHS directive 2002/95/EC and in accordance to WEEE 2002/96/EC

DESCRIPTION
The TCRT5000 and TCRT5000L are reflective sensors which include an infrared emitter and phototransistor in a leaded package which blocks visible light. The package includes two mounting clips. TCRT5000L is the long lead version.

APPLICATIONS
- Position sensor for shaft encoder
- Detection of reflective material such as paper, IBM cards, magnetic tapes etc.
- Limit switch for mechanical motions in VCR
- General purpose - wherever the space is limited
Collector current vs. $V_{CE}$

Fig. 7 - Collector Emitter Saturation Voltage vs. Collector Current
Optical Sensors for Position (2.2)

Photo Interruptors

SLOTTED OPTICAL SWITCH

OPB860T11/OPB860T51/OPB860T55

PACKAGE DIMENSIONS

The OPB860T series of switches is designed to allow the user maximum flexibility in applications. Each switch consists of an infrared emitting diode facing an NPN phototransistor across a .125" (3.18mm) gap. A unique housing design provides a smooth external surface to prevent dust build-up while molded internal apertures give precise positioning and also provide protection from ambient light interference.

FEATURES
- Fully enclosed design allows dust protection.
- Lead spacing at .320".
- .060" and .010" aperture options.
- PCB mountable.
Encoders for Position Sensing (1.2)

ODOMETRY

ROTATION RATE

ABSOLUTE ENCODER

“GRAY”
10-12 bits
Encoders for Position Sensing (2.2)

Quantum Phase Encoders (QPE)

\[ A \wedge B \rightarrow \ldots \wedge 4 \]
Encoders: Where Do You Find Them?

Printers
Mouse - scroll wheel
Robotics - encoder

Austria Macdonin

$5
14 bit OPE
12 bit HSE
Basic Sensors: Temperature (1.2)

Thermistor

Temperature Sensing Resistor

Large SR for ΔT

Non-linear ~ 4th or 5th order polynomial

-40°C - 200°C
Basic Sensors: Temperature (2.2)

RTD - resistive thermal device (Platinum)
- High Temp range ~ 200°C - 600°C
- Very linear ~ 0.1% of full scale
- Extremely stable
- Expensive
- Not very sensitive ~ Small SR ~ 0.5
$15/\text{device}$

$k^2 = 0.99998$

$-0.00002$

**Thin Film Platinum RTD’s**

U.S. Sensor’s thin film platinum resistance temperature detectors (Pt-RTD) consist of a thin film platinum deposited on a ceramic substrate. Thin film Pt-RTD’s provide cost advantages when compared to wire wound Pt-RTD’s because of their lower material cost factor.

**Features**

- Glass coated platinum element
- Virtually linear relationship between temperature and resistance
- capable of withstanding temperatures ranging from -50°C to +500°C. Higher temperature ratings are available by special order.
- High reliability: Capable of withstanding extreme environmental conditions.
- Available in various probe configurations for specific applications.
- Excellent stability even at high temperatures.

**RTD vs. Temp**

$y = -0.0006x^2 + 3.8103x + 999.99$

$R^2 = 1$

**Specifications**

- Thermal time constant: 15 seconds max. (moving air)
- Dissipation constant: 2mW/°C (moving air)
- Maximum applied current: 1 mA
## Platinum RTD Datasheet

### RTD THIN PLATINUM

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Resistance Ohms @ 0°C</th>
<th>DIN 43760 Class</th>
<th>Resistance Tol ±% @ 0°C</th>
<th>Temp. Dev. ±°C @ 0°C</th>
<th>TCR ppm/°C</th>
<th>Dim &quot;W&quot; (±0.007)</th>
<th>Dim &quot;L&quot; (±0.008)</th>
<th>View R-T Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPG101A1</td>
<td>100</td>
<td>A</td>
<td>0.06</td>
<td>0.15</td>
<td>3850</td>
<td>0.067</td>
<td>0.110</td>
<td></td>
</tr>
<tr>
<td>PPG101B1</td>
<td>100</td>
<td>B</td>
<td>0.12</td>
<td>0.30</td>
<td>3850</td>
<td>0.067</td>
<td>0.110</td>
<td></td>
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<tr>
<td>PPG101C1</td>
<td>100</td>
<td>C</td>
<td>0.24</td>
<td>0.60</td>
<td>3850</td>
<td>0.067</td>
<td>0.110</td>
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<tr>
<td>PPG501A1</td>
<td>500</td>
<td>A</td>
<td>0.06</td>
<td>0.15</td>
<td>3850</td>
<td>0.079</td>
<td>0.118</td>
<td></td>
</tr>
<tr>
<td>PPG501B1</td>
<td>500</td>
<td>B</td>
<td>0.12</td>
<td>0.30</td>
<td>3850</td>
<td>0.079</td>
<td>0.118</td>
<td></td>
</tr>
<tr>
<td>PPG501C1</td>
<td>500</td>
<td>C</td>
<td>0.24</td>
<td>0.60</td>
<td>3850</td>
<td>0.079</td>
<td>0.118</td>
<td></td>
</tr>
<tr>
<td>PPG102A1</td>
<td>1000</td>
<td>A</td>
<td>0.06</td>
<td>0.15</td>
<td>3850</td>
<td>0.079</td>
<td>0.118</td>
<td></td>
</tr>
<tr>
<td>PPG102B1</td>
<td>1000</td>
<td>B</td>
<td>0.12</td>
<td>0.30</td>
<td>3850</td>
<td>0.079</td>
<td>0.118</td>
<td></td>
</tr>
<tr>
<td>PPG102C1</td>
<td>1000</td>
<td>C</td>
<td>0.24</td>
<td>0.60</td>
<td>3850</td>
<td>0.079</td>
<td>0.118</td>
<td></td>
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<tr>
<td>PPG102B2</td>
<td>1000</td>
<td>B</td>
<td>0.12</td>
<td>0.30</td>
<td>3750</td>
<td>0.079</td>
<td>0.118</td>
<td></td>
</tr>
<tr>
<td>PPG102C2</td>
<td>1000</td>
<td>C</td>
<td>0.24</td>
<td>0.60</td>
<td>3750</td>
<td>0.079</td>
<td>0.118</td>
<td></td>
</tr>
</tbody>
</table>

*Gabriel Hugh Elkaim*

*CMPE 118/218 – Intro. to Mechatronics*
Basic Sensors: Light (1.2)

Photo diode

Silicon Diode ~ 960 nm
Near IR

Fast ~ 5 ns
Communication/modulated

Much less sensitive to light

Fig. 5 RELATIVE SPECTRAL SENSITIVITY vs WAVELENGTH
Basic Sensors: Light \( (2.2) \)

- Very wide dynamic range
- No saturation
- Less useful than phototransistor

Fig. 6 PHOTOCURRENT VS IRRADIANCE \( \lambda = 940 \text{ nm} \)
Photodiode Datasheet (1.2)

**LITEON**

Black Plastic Photodiode
LTR-516AD/LTR-526AD/LTR-536AD/LTR-546AD

**Features**
- High photo sensitivity.
- Suitable for infrared radiation.
- Low junction capacitance.
- High cut-off frequency.
- Fast switching time.

**Description**
The LTR-516AD/LTR-526AD/LTR-536AD/LTR-546AD are special dark plastic package that cut the visible light and suitable for the detectors of infrared applications.

**Package Dimensions**
LTR-516AD
### Absolute Maximum Ratings at Ta=25 °C

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum Rating</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Dissipation</td>
<td>150</td>
<td>mW</td>
</tr>
<tr>
<td>Reverse Break Down Voltage</td>
<td>30</td>
<td>V</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>-55 °C to +100 °C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-55 °C to +100 °C</td>
<td></td>
</tr>
<tr>
<td>Lead Soldering Temperature (1.6mm (0.063 in.) from body)</td>
<td>260 °C for 5 Seconds</td>
<td></td>
</tr>
</tbody>
</table>

### Electrical Optical Characteristics at Ta=25 °C

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Test Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse Break Down Voltage</td>
<td>V(BR)</td>
<td>30</td>
<td></td>
<td></td>
<td>nA</td>
<td>Vr=10V Ee=0mW/cm²</td>
</tr>
<tr>
<td>Reverse Dark Current</td>
<td>I0(D)</td>
<td></td>
<td></td>
<td>30</td>
<td>nA</td>
<td></td>
</tr>
<tr>
<td>Open Circuit Voltage</td>
<td>V_oc</td>
<td>350</td>
<td></td>
<td></td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Rise Time</td>
<td>Tr</td>
<td>50</td>
<td></td>
<td></td>
<td>nsec</td>
<td>Vr=10V λ=940nm Ω=1K</td>
</tr>
<tr>
<td>Fall Time</td>
<td>Tr</td>
<td>50</td>
<td></td>
<td></td>
<td>nsec</td>
<td></td>
</tr>
<tr>
<td>Light Current</td>
<td>I_l</td>
<td>1.7</td>
<td></td>
<td>2</td>
<td>μA</td>
<td>Vr=10V Ee=0.5mW/cm²</td>
</tr>
<tr>
<td>Total Capacitance</td>
<td>C_t</td>
<td>25</td>
<td></td>
<td></td>
<td>pF</td>
<td></td>
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<tr>
<td>Wavelength of the Max Sensitivity</td>
<td>λ_SMAX</td>
<td>950</td>
<td></td>
<td></td>
<td>nm</td>
<td></td>
</tr>
</tbody>
</table>
Photodiodes: How Do You Use Them?

Diagram showing a light level curve with the relationship $\text{Leakage Current} \sim f(1, \frac{1}{x})$.
STRING POT

GPS

Position (≈ 3-5 m)
Velocity (≈ 1 m/sec)
Time (≈ 5 sec)
C/A code ≈ 10 meters
P/M code encrypted 2-3 m

0-3 ft

$2 - $300
Questions?