Enhanced Optical Position Detector

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Introduction
This document describes the Morse Code Buzzer Controller and how to assemble and install it.

Revision History
v0.1 12/19/17 SCN
v0.2 1/6/17 SCN – show Rev 2 board
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1 INTRODUCTION

This board is a variation on Geoff Bunza’s Differential Absolute Position Detector, described in his MRH blog post SMA-23.  http://model-railroad-hobbyist.com/node/26133

- The EOPD operates on 4-15 volts and draws about 3 mA,
- Any type of photo transistor can be used as a sensor, just be sure they are of the same type
- uses standard semiconductors available from Jameco and similar suppliers
- includes a fixed delay of about 1.5 seconds avoid false detection and non-detection
- Open collector active low output sinks up to 600mA at 40V (be sure to provide snubber diodes on inductive loads)

All components are through-hole technology for ease of assembly and repair.

All connection pads are standardized on .100” centers. This provides a wide range of interconnect options and components. Connection schemes include screw terminal blocks, header pin connectors (male and female), soldered right angle headers, and direct soldered wires.
2 IDENTIFICATION AND INFORMATION

2.1. BOARD IDENTIFICATION

Figure 1 - Rev 1.0 Board with no connector and no on-board reference detector

Figure 2 - Rev 2.0 Board with screw terminals and no on-board reference detector
Table 1- Bill of Materials Rev 2.0

<table>
<thead>
<tr>
<th>Qty</th>
<th>Value</th>
<th>Device</th>
<th>Package</th>
<th>Parts</th>
<th>Description</th>
<th>Vendor</th>
<th>Part</th>
</tr>
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<tr>
<td>1</td>
<td>1 uF</td>
<td>Tant CPOL-USE2.5-5</td>
<td>E2.5-5</td>
<td>C1</td>
<td>POLARIZED CAPACITOR, Tant</td>
<td>Jameco</td>
<td>1938421</td>
</tr>
<tr>
<td>4</td>
<td>10K</td>
<td>RESISTORPTH-1/4W</td>
<td>AXIAL-0.4</td>
<td>R1, R5, R6, R7</td>
<td>Resistor</td>
<td>Jameco</td>
<td>691104</td>
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<tr>
<td>1</td>
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<td>AXIAL-0.4</td>
<td>R3</td>
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<td>1</td>
<td>2N4401</td>
<td>2N3904-NPN-TO92-EB</td>
<td>TO92-EB</td>
<td>T2</td>
<td>NPN Transistor</td>
<td>Jameco</td>
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<td>2</td>
<td>Detectors</td>
<td>4 position Screw terminal</td>
<td>1X04_LOCK</td>
<td>JP1, JP2</td>
<td>4 position Screw terminal</td>
<td>electronic salon</td>
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<tr>
<td>1</td>
<td>LM2903N</td>
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<td>DIL08</td>
<td>IC1</td>
<td>COMPARATOR</td>
<td>Jameco</td>
<td>1922939</td>
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<tr>
<td>2</td>
<td>PT19</td>
<td>BPX81</td>
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<td>T1 (second one is kitted)</td>
<td>PHOTO TRANSISTOR</td>
<td>Digikey</td>
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<td>1</td>
<td>PCB</td>
<td>EOPD</td>
<td>PCB</td>
<td>board</td>
<td>EOPD</td>
<td>Seeed</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3 - Rev 2 Schematic

(Rev 1 is the same except for the blocking diode D1, which protects against reversing power to the circuit)
3 THEORY OF OPERATION (MOSTLY FROM GEOFF’S SMA-23)

The detector uses two small ambient light sensors based on a photo-transistor (a PT204 or BPX81 through-hole part). The ambient light hitting each sensor is compared. When the light level of the sensor between the rails falls below the light level of the nearby sensor, the output of the first Op Amp (LM2903) goes low (to ground).

Note well that the emitter resistors are different, to force the sensor “off” under clear ambient conditions. The light sensitivity of this detector is mostly in the same range visible to the human eye. This means the light in your layout room that the modeler sees is what is relevant. Geoff reports that he can lower the light level to be darker than what I would consider to be a “normal” comfort level for operation, and still have the detector working. Likewise, very bright light internal lighting works well too. However, absolutely no light means no detection. If you want to place the detector in a lightless tunnel or building, simply add a lighted LED or incandescent lamp nearby and you should enable correct operation. Remember both sensors need to see about the same unobstructed “ambient” light levels. If the sensor not between the rails sees a much lower light level, the sensor may never turn on. If the sensor not between the rails sees a much higher light level, the sensor may always be on.

The second segment of the Op Amp uses the delay circuit from Dr Chubb’s DCC-OD and is set by C1 and R4 to about 1.5 seconds. See “Options” if you prefer a different delay value. The output of the second segment (pin 7) is inverting and R7 (10K pull up) and base current limiting resistor R8 (1K) turn T2 on when the output is high.

Many first time DIYers are perplexed or even disturbed by the concept of active low open collectors. The idea that a low signal is “TRUE” is fundamentally upsetting to some people. However this arrangement generally provides greater current drive at lower cost as well offering the possibility of tying multiple outputs together in a “WIRE-OR” configuration. A good example is if you are using optical detectors for a short track section you may still want to use two close together to avoid the possibility of a train stopping with a gap between cars over the sensor. Just use two detectors and wire them both to your logic input (with a suitable pull up, say 4.7K). Either of the sensors showing occupied (the “OR”) will now give you a correct occupancy input.

Note I have freely taken from Geoff and Bruce’s work but they’re both in the public domain. Any errors or circuit problems that have crept in are solely my responsibility.
4 OPTIONS

3.1. TIMING VALUE R4

The factory value of 2M yields a turn on and off delay of about 1.5 seconds. This is a compromise value that prevents most false activations and dropouts. You can substitute resistors between 1M and 3M to get delays from about 0.75 to 3 seconds. If you need a value beyond .75 – 3 try using a different value for C1.

3.2. PHOTO TRANSISTOR

Geoff settled on the BPX81/ PT204 because it is relatively inexpensive and easily available but he states that almost any photo transistor will work, which has been our experience. Feel free to substitute if your favorite parts house doesn’t stock one of these and you want to minimize order minimums and shipping.

Pads are provided to mount the reference detector on board as T1. You can also connect the sensor externally on pins E1 and C1.

3.3. OUTPUT TRANSISTOR

I copied the output stage of Dr Bruce Chubb’s DCC-OD as that is a widely used current occupancy detector as most do-it-yourself model railroaders have some around. Bruce uses the 2N4401 (40V @ 600mA collector current) for an open collector output but any similar switching transistor will do. If you have 2N3904 or 2N2222(A) in your parts bin, they’ll work fine. Check specs if you need to drive a load at the margin and be sure to put snubber diodes across inductive loads!

3.4. CONNECTORS

- The input (sensor) connectors are on 0.100 centers (staggered slightly to hold the connectors in place during assembly). While our standard connector is the 0.100 screw terminal, you may substitute any other 0.100 connector you prefer. If you are ordering an assembled and tested unit from MRCS and you would prefer a different connector, please contact us at sales@modelrailroadcontrolsystems.com and indicate your preference and we’ll provide a quotation.
- Input power and output are on the right hand connector.
3.5 DETAILED ASSEMBLY

All of the components are through-hole technology with wire leads. A lead bender is a useful tool for forming the leads at 90 degrees for easy insertion into the pad holes. The general rule is install the lowest components first, working towards components that are higher off the board. Start by inserting the lower height components (resistors and diode). This enables you to support the low components as you solder them.

Resistors, Diodes

Install Resistors R1 through R8 and diode D1. Try to keep the gold tolerance band on the right side for easier reading of values.

Install diode D1, observe polarity.

IC LM2903

Install U1, notch pointing up

Tantalum Capacitor

Install C1, observe polarity

Onboard reference T1, if used

Output Transistor T2

Connectors JP1, JP2

Install JP1, JP2 using desired connector
5 TESTING

Testing your Enhanced Optical Position Detector is quick and simple:

1. Mount the board securely on standoffs
2. Apply positive voltage (5-15 VDC) between Vin (+) and one of the GND terminals on the right side of the board.
3. Connect an LED (observe polarity) in series with a suitable limiting resistor (RED Led, 330 Ohms at 5 Volts, 1,000 ohms at 12V, 1,200 ohms at 15V) between the Vin terminal and the out terminal.
4. Connect photo transistors (either install T1 on the board as reference or connect T1 across the E2/C2 connections) and the sense photo transistor across E1/C1 on the left side of the board. The Cs are the collectors (short lead, flag side in the clear part) and the emitters, Es are the long leads.
5. Momentarily obscure the sense proto transistor while leaving the reference photo transistor illuminated. After about 2 seconds the LED on the output will come on. Remove the obstruction and the output should turn off after another 1.5 seconds.
Figure 4 - Connections for Rev 1,2 Boards