Enhanced Optical Position Detector

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Introduction

This document describes the Enhance Optical Position Detector 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
v0.3	1/22/18 SCN – identify emitter, collector on Phototransistor, Rev0.3
v0.3	4/2/18 SCN – connections for “Da Fingah”
V.5	10/5/20 SCN – clean up, correct error on detector 1 and 2 functions
V.7	Updated Schematic and table to show typical test voltages
V 1.0	This is the “Production” document

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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 both the reference and track sensor 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 drop out
- Open collector active low output sinks up to 600mA at 40V (be sure to provide snubber diodes on inductive loads)
- Optionally uses "Da Fingah" a single piece detector with surface mounted detectors that slides under the rail between two ties and has an on-board reference detector.

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

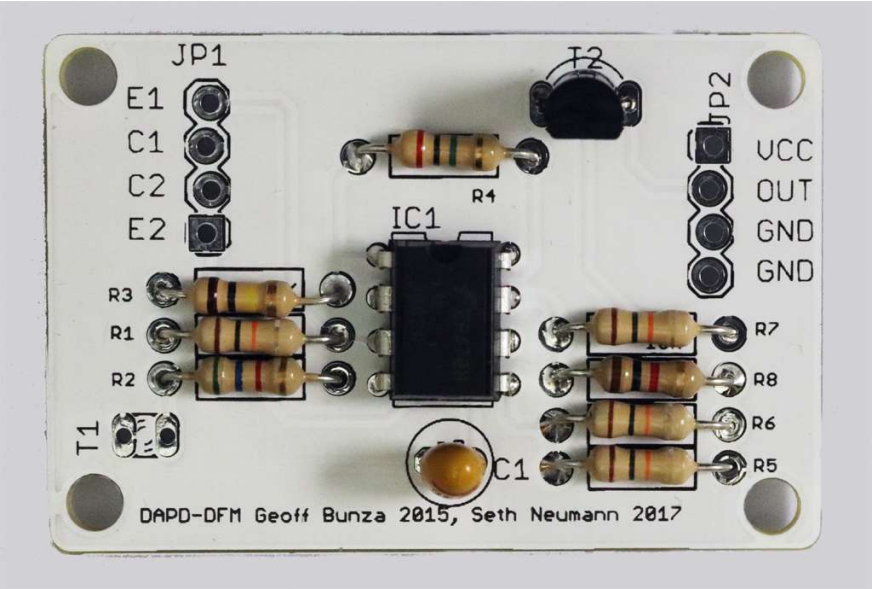

Figure 1 - Rev 1.0 Board with no connector and no on-board reference detector

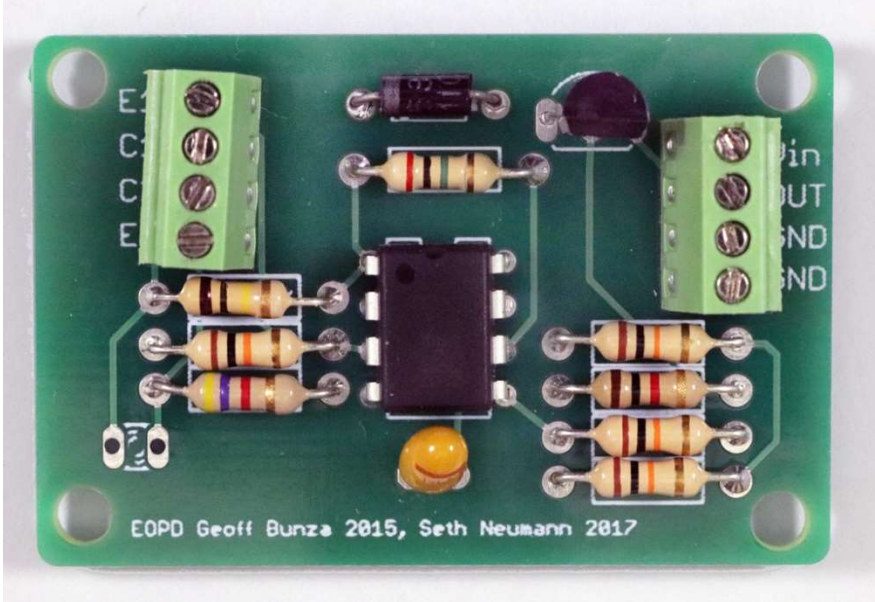

Figure 2 - Rev 2.0 Board with screw terminals and no on-board reference detector (note Rev 3 is identical except they are white and labels have been moved for better readability with screw connectors).

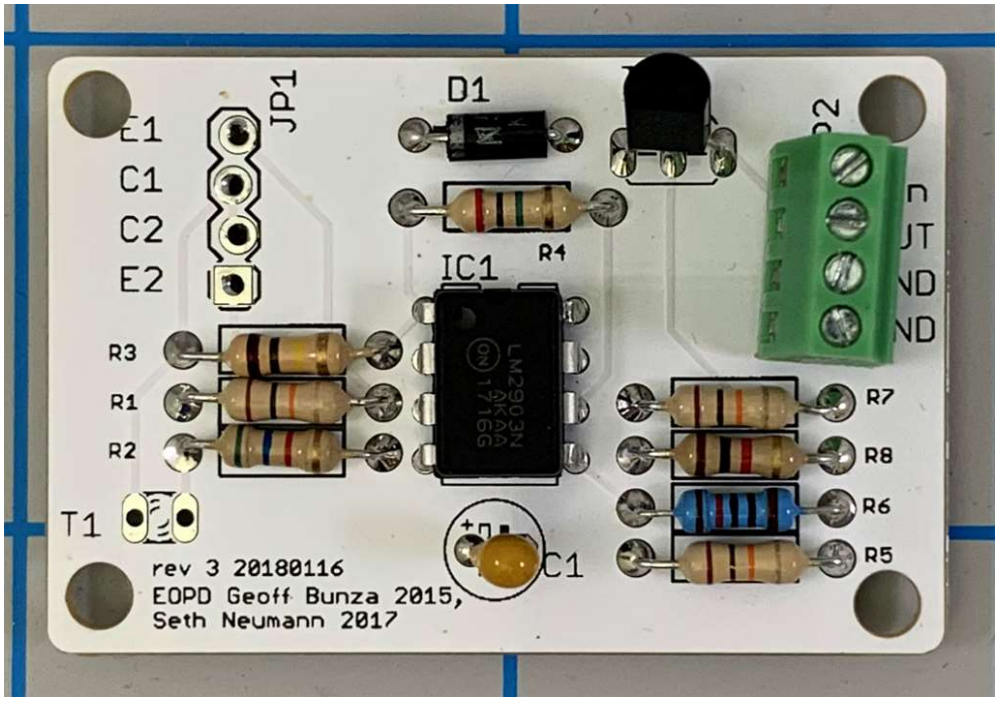

Figure 3 - Rev 3.0.4 EOPD board -

Cosmetic changes for better legibility. Rev 4 is the same but panelized, 6 up.

Qty	Value	Device	Package	Parts	Description
1	1 uF Tant	CPOL-USE2.5-5	E2,5-5	C1	POLARIZED CAPACITOR, Tant
1	1N5819	Schottky diode, 1A 40V	DO41	D1	Schottky diode, 1A 40V
4	10K	RESISTORPTH-1/4W	AXIAL-0.4	R1, R5, R6, R7	Resistor
1	100K	RESISTORPTH-1/4W	AXIAL-0.4	R3	Resistor
1	1K	RESISTORPTH-1/4W	AXIAL-0.4	R8	Resistor
1	2M	RESISTORPTH-1/4W	AXIAL-0.4	R4	Resistor
1	5.6K	RESISTORPTH-1/4W	AXIAL-0.4	R2	Resistor
1	1N5819	Diode Shottky 1N5819	AXIAL-0.3	D1	Diode Shottky 1N5819
1	2N4401	2N4401	TO92-EBC	T2	NPN Transistor
1	LM2903N	LM2903N	DIL08	IC1	COMPARATOR
1	PCB	EOPD	PCB	PCB	EOPD

Table 1- Bill of Materials Rev 2.0/3.0

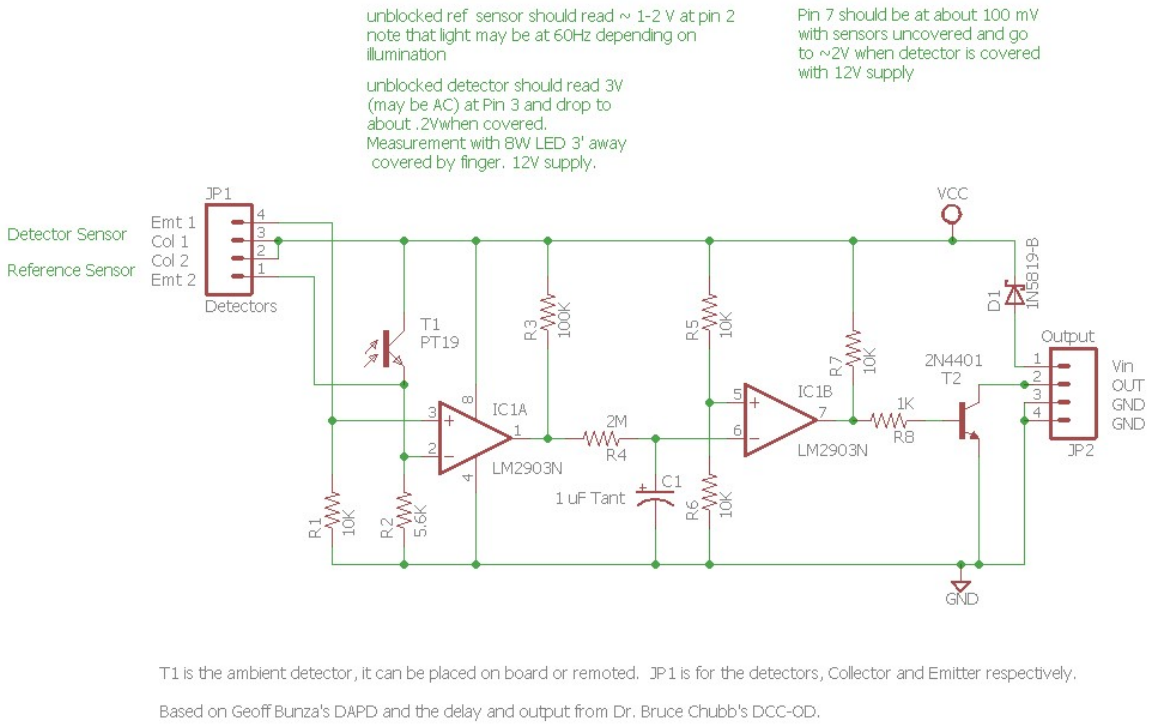

Figure 4 - Rev 2, 3 Schematic

(Rev 1 is the same except for the blocking diode D1, which protects against reversing power to the circuit)

Table of typical Occupancy Sensor uncovered /sensor covered voltages at pin 2,3 and 5,6 based on supply voltages of 5, 12 and 15V. Test conditions are 8W LED bulb 3' above work bench, covering and uncovering the sensor on "Da Fingah." Ranges refer to the 1VAC signal because the illumination is AC. This may vary depending on your set-up so these are starting values only.

Description	U1 Pin	5V	12V
Reference sensor	2	2V sine Wave with bottom at 2v	1-2V sine wave over 1V/1
Occupancy sensor	3	1V sine Wave with bottom at 1/0.3V	3/.2
Timer reference	5	2.5/2.5	6/6
Timer output	7	.1V/1.2V	.1/2

Table 2 - Voltages Uncovered (illuminated)/Covered

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* **does** mean *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 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 default value of 2M ohms 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 picked 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 E2 and C2. "Da Fingah" also connects to the detector pads using a 4 conductor 0.100 cable. Check orientation for correct operation (momentarily connecting Da Fingah upside down won't hurt it).

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 and 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.

- Power and output are on the right-hand connector.

3.5.**SENSORS**

- The EOPD is available with no sensors (provide your own), a pair of PT19s (package is like a 3mm LED) or with “Da Fingah” which has 2 surface mount sensors and slides between HO (and some N) scale ties.

Figure 5 - PT19 Sensors – note the “Flag” side, short lead is the collector.

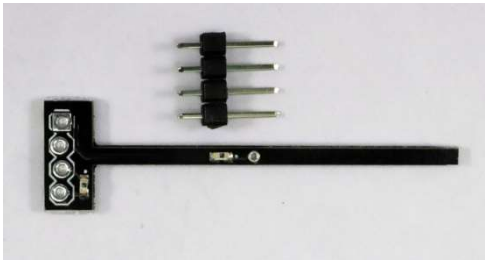

Figure 6 - "Da Fingah" with 0.100 header

3.6. DETAILED ASSEMBLY

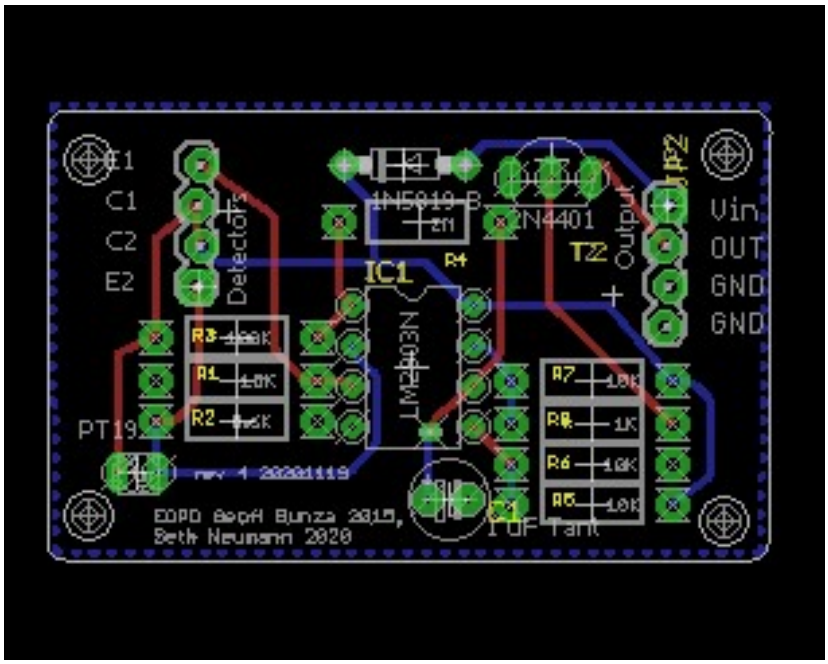

Figure 7 - EOPD Rev 3, 4 Parts Layout

All of the components are through-hole technology with wire leads. A lead bender is a useful tool is 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 cover 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.

6 INSTALLATION AND CONNECTIONS

Looking at the right-hand connector there are terminals (or header pins depending on how the EOPD was assembled) for Power (0-18V), an open collector, negative true (that it is, it goes to ground when it's detecting) output and 2 ground terminals, one for the power supply and another to connect to a common ground for the load.

The left-hand connector is for the remote sensors. If you've equipped your EOPD and Fingah with 0.100 headers an 0.100 4 conductor cable can make the connection. Try to keep the sensors within about 2 meters (6.5') of the EOPD as the input is high impedance and may pick up noise from DCC or lighting circuits. The output is low impedance and can run anywhere in the layout room on 24-gauge wire, be sure the EOPD and any layout control nodes are referenced to the same ground.