Build Your Own DCC Block Occupancy Detector

Introduction

While various types of detector can be used to determine whether a specific block is occupied by a locomotive or item of rolling stock, including magnetically operated switches or infrared beam detectors, the simplest device to use with a DCC system is an inductive detector which measures, and reacts to, the electrical current being taken from the section of track designated as a block.

A typical inductive detector is the NCE BD20 which, like all detectors of this type, is very simple to install and generally requires little (if any) adjustments –

Normally, DCC power will be supplied to a layout through a main two-wire bus connected to the Command Station Track output, with each track block then being connected to this main DCC bus via a pair of thinner-guage feeder wires. The BD20 block detector is not connected directly to the track but, instead, one of the block feeder wires (it does not matter which one) is looped two or three times through the hole in the BD20 current transformer (the large orange component) before being finally connected to the track.

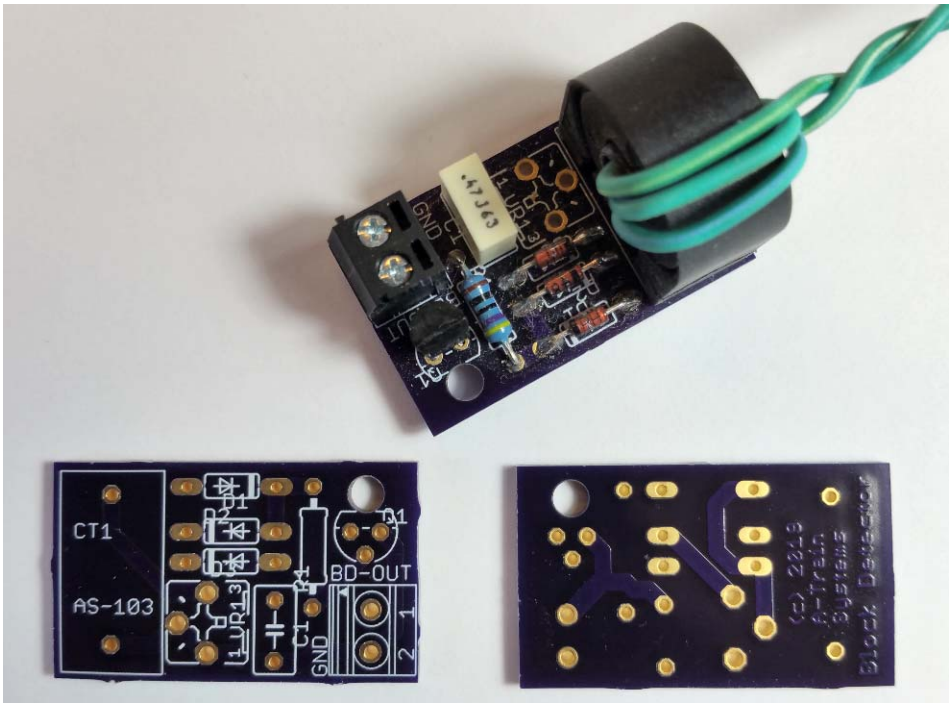
The LOGIC output from the BD20 terminal block is then connected to an input of an NCE Auxiliary Input Unit (AIU), with the GND terminal of the BD20 connected to the AIU common Ground connection.

When any current flows through the feeder wires to the track, as when a locomotive enters the block, this is detected by the BD20 circuitry which then effectively links the LOGIC output to ground (GND). This change is passed to the connected AIU input and, as well as illuminating the associated LED on the AIU, can subsequently be accessed by A-Track via a command sent through the NCE Command Station. A-Track can then show the block as occupied on the relevant Mimic Diagram panel.

The BD20 incorporates additional circuitry which, when connected to an external power supply (5 to 12 volts DC – ***not*** DCC), can be used to light an LED or drive a relay when block occupancy is detected.

If you do not require this additional BD20 functionality, then it is possible to build a basic occupancy detector yourself. The detection circuitry of this module is a cut down version of that in the BD20. Although A-Train Systems is happy to provide full details of this module and of the components required, including where you can obtain a ready-made printed-circuit board, it is unable to supply either kits of parts or assembled modules.

The assembled module and its printed-circuit board (PCB) are shown below –



Building the module requires some familiarity with electronic components, together with the ability to use a fine-tip soldering iron, but does not require any particular electronics expertise.

The PCB is available from OSH Park, a small company located in Lake Oswego, Oregon, via this link – DCC-BlockDetect Link. They will supply three PCBs for US$4.45 including free shipping to any destination worldwide.

If you then want to order a set of PCBs (in multiples of 3) click the button labelled **Actions**, followed by the **Order Board** option. Enter your e-mail address, name, and a password of your choice to establish an account with OSH Park, then follow their ordering process. You can pay either with a credit card or via PayPal. Your boards will be manufactured and delivered within two or three weeks depending on where you are in the world.

If you prefer to use an alternative PCB supplier then, instead of clicking Order Board, just click on **Download** to download a copy of the DCC-AIU Link PCB file in Eagle board (.brd) format which you can then send off to your preferred supplier.

Please note that neither A-Train Systems nor myself have any connection with OSH Park other than as a very satisfied customer of their services.

The parts required to build a single DCC Block Detect module are listed in the table below –

Part	Reference	Quantity	Value
Terminal Block, 3.5mm pitch, 2 Way	BD-OUT	1	
Capacitor, Polyester, 63Volt	C1	1	470nF (0.47uF)
Current Transformer (300 turns)	CT1	1	Talema AS103
			Murata 56300C
Diode	D1 – D3	3	1N4148
Transistor, General Purpose NPN	Q1	1	2N3904
Resistor, Metal Film, 0.25Watt	R1	1	470R (470 ohm)
Variable Resistor (Trim Pot)	VR1	1	5K Bourns 3306W-1-502

Notes :

1. The terminal block and the variable resistor are optional parts. You can solder wires direct to the PCB instead of using screw terminals, and the variable resistor is only required to reduce the sensitivity – a situation which is very unlikely to occur in normal usage.
2. Either of the options listed for the current transformer can be used (or any similar device with 300 turns), depending on which manufacturer's parts are available from your local supplier (or eBay).

Suggested suppliers for the parts listed above are Farnell or RS Components for users in the UK, or Newark for users in the USA (part of the same company as Farnell). RS Components also have a subsidiary in the USA. Mouser or Digikey are alternative sources in the USA, although their prices tend to be a little higher than Newark. Both Mouser and Digikey also have European-based operations, but still tend to have higher prices than Farnell.

The total cost of parts for a single DCC Block Detect module should be less than US$3.50 (UK£2.80), and even less if you omit the terminal block and variable resistor, plus the additional US$1.49 (UK£1.20) for the PCB.

You may be able to source equivalent parts locally at a lower cost, using the details available for each suggested part by clicking on the links below (assuming that you have sufficient electronics knowledge to understand the specifications). There is generally no problem buying components from established suppliers on eBay, for example, but beware of purchasing very low cost parts since these are often of low quality or may be manufacturers' substandard rejects.

Buying electronics components singly or in small quantities is much more expensive than buying in bulk (in quantities of 10 or more), so it is well worth considering carefully at the outset how many modules you might build, and then procuring all of the required components in a single purchase. This will also reduce any shipping charges.

The table below gives suggested part numbers for each DCC Block Detect component from each suggested supplier.

Click on the part number to view the relevant webpage with details of the part –

Part	Farnell	RS Cmp	Newark	Mouser	Digikey
Terminal Block, 2-Way	3882615	897-1332	68C9065	651-1985807	277-6043-ND
Capacitor, 470nF 63V	2429337	312-1481	18AC7609	80-R82DC3470AA60J	399-8901-ND
CTx, Talema AS103		399-7317			1295-1123-ND
CTx, Murata 56300C		106-8536	17M3817	580-56300C	811-3110-ND
Diode, 1N4148	2675146	843-1562	05AC0533	512-1N4148	1N4148FSCT-ND
Transistor, 2N3904	1700648	739-0442	83C3116	512-2N3904BU	2156-2N3904-ON-ND
Resistor, 470R 0.25W	9341951	165-0864	95W7764	279-LR1F470R	RNF14FTD470RCT-ND
Variable Resistor, 5K	108249	748-1355	09WX8749	858-36KR5KLF	3306W-502-ND

Once you have acquired your PCBs and a full kit of components, the next step is to start the assembly. If you do not have any experience of soldering electronic components then you should first have a look at one or two of the guides available on the Internet (such as at https://www.makerspaces.com/how-to-solder/) and some of the multitude of videos available on YouTube, although there is nothing to beat getting some copper stripboard from one of the component suppliers and practising soldering wires (and a few spare components) to it before tackling the real module PCB.

Use resin-cored solder in wire form only – never use solder with an acid flux (as sold for plumbing purposes) – and use a fine-tip soldering iron with a maximum power rating of 25 Watts. All joints should be made as quickly as possible to avoid damaging the PCB and components. The greatest enemy of electronics is heat.

Fit those components with least height to the PCB first, ie. the diodes and resistors, so that, when you turn the PCB over and lay it down to solder the component wires on the underside of the board, the components do not fall out of the holes. Ensure that the diodes are fitted the right way round, with the band or stripe at one end of the diode towards the centre of the PCB, as shown on the PCB markings. It does not matter which way round the resistor (or the capacitor at a later stage) is placed on the PCB.

A tip here is to solder just one wire from each component, then turn the PCB over and check that all components are still flush with the PCB. If not, make them so before soldering the remaining wire(s) of the component.

When you fit the transistor (as the next tallest components), ensure that the flat side of the package is towards the hole in the PCB, again as indicated by the board markings. Finally, fit the capacitor followed by the terminal block (if you decide to use one) and the current transformer. The recommendation is not to fit the variable resistor (and to buy no more than a few, if any) until checking how well the detector works on your layout.

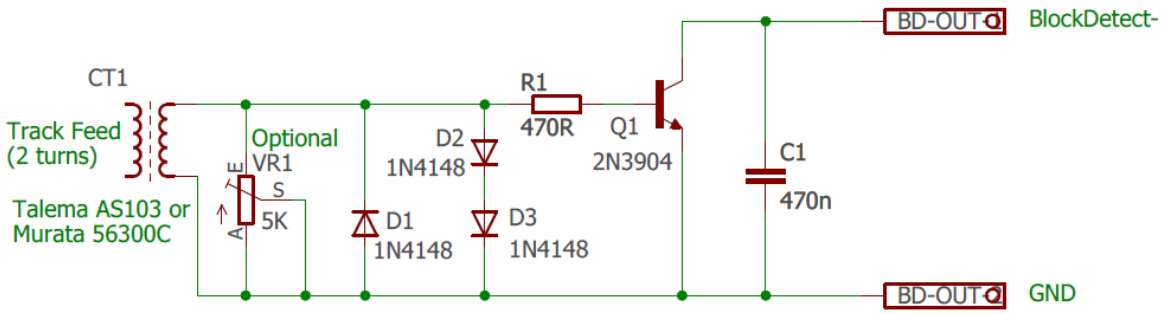
Carefully inspect the completed board to check that all of your soldered joints are bright and shiny, and that the solder has wicked through the PCB holes to the component side of the board. If you are uncertain of this then you can carefully apply your iron and a little extra solder to the joint again, but do not linger with the hot soldering iron. Check also that there are no solder

bridges between copper pads or component pins anywhere on either side of the PCB. Use of a x5 or x10 hand lens or jeweller's loupe is highly recommended for this inspection.

To test the DCC Block Detect module, pass one of the feeder wires to an isolated section of track through the hole in the current transformer to form two or three loops, as shown in the photograph earlier in this section, and connect the DCC Block Detect BD-OUT terminal to a spare input of an active AIU. Connect the GND terminal to the AIU common Ground terminal. Now connect your isolated section of track to the DCC supply and place one of your locomotives on the track – the AIU input LED should light to show that the block is occupied.

You can check the sensitivity of the DCC Block Detect module by getting a selection of resistors with values between 1K and 10K. Remove your locomotive from your section of track and instead connect one of the test resistors between the rails. With two loops of feeder wire through the current transformer, resistors up to around 4K7 should take sufficient current (3mA or more) from the DCC supply to trigger the module and light the AIU LED. Adding a third loop of feeder wire should improve the sensitivity to allow resistors up to around 6K8 (2mA current) to trigger block detection. Further information about the BD20 and how to use it (which applies equally to the DCC Block Detect module) can be obtained from the NCE website, and more general information about block detection can be found on Alan Gartner's Wiring for DCC website.

For anyone who is interested, the schematic for the DCC Block Detect module is shown below –



The loops of feeder wire through the current transformer CT1, when they are passing current to the track block, induce a voltage in the secondary of CT1. During the positive half-cycle of the DCC supply, this secondary voltage causes diodes D2 and D3 to conduct, raising the voltage at the junction of D2 and resistor R1 to around 1.4volts and switching transistor Q1 on. This brings the voltage at its collector, connected to the BlockDetect- output, close to Ground (GND). Capacitor C1 acts as a filter to remove any transient voltages from the BlockDetect- output. During the DCC negative half-cycle, D1 conducts and ensures that the base-emitter junction of transistor Q1 is not reverse-biased. Finally, the optional trimmer potentiometer VR1 can be fitted to bypass excess current from CT1 in cases where large currents are being taken from the track DCC supply, and the current induced through diodes D2 and D3 might be more than they can handle – this is unlikely for the large majority of layouts.

Please note that A-Train Systems cannot offer a repair service for faulty modules although, if you request support via the website, I will do my best to offer help and advice to sort things out.