Fibre Optic & Isolation Track Sensing

TX / RX & ISOLATION Modules

VERSION 5.2

Locomotive Detection for use with TGG Software

Version 1.6.Mod - October 2023

INDEX

Overview

Here are some Features of a Version 5.2 Detection System versus direct connection to an interface:

Significantly reduces under layout wiring with the use of inexpensive fibre optics – one plastic fibre optic cable eliminates up to 16 wires running between the BBI32 interface and a group of 8 track sensors.

Provides electrical isolation from DCC powered tracks in the event of accidental contact of a track sensor.

Modular so that it can be configured to meet a given layout's design

Eliminates any additional wiring between the modules and the BBI-32 interface.

Provides for easy connection of **various sensor types** - Hall Sensor, Reed sensor, IR sensors.

Improved electrical noise immunity by reducing sensor wire runs and through the use of low impedance sensor inputs.

Protects the TGG PC and BBI-32 interface from potential accidental damage. The only connection to the BBI-32 is via light inside an optical isolator.

It is **compact for under table mounting**. Low profile for tight under layout spaces.

Provides visual status LEDs that show sensor status, presence of power, and fibre optic link status at a glance - an aid in installation and troubleshooting.

Fibre Optic transmitters are track powered, eliminating the need for separate power wiring.

Sensor cables have quick disconnect and polarized connectors, further aiding installation and troubleshooting. No fiddling with screw or push on spring loaded terminals.

Motherboard and remote TX modules are **all fitted with self-resetting fuses.**

Modular design means that future modules could be designed (wireless, IR?) without the need for a redesign of the supporting components.

Inexpensive Fibre Optic Cable

This single small flexible plastic cable replaces up to 16 sensor wires that normally would have to run back under one’s layout to an interface. Being plastic it is immune to magnetically coupled electrical noise that typically radiates from DCC or point control wiring.

Fig 1 - 2.1mm plastic Fibre Optic cable

A simple utility knife can be employed to cut it to the required length – no polishing required.

Version 5.2 Installation

Bench Testing Motherboard

Any type of Version 5.X module can be plugged into any of the 4 available positions on the motherboard. The use of a motherboard eliminates the need for ANY additional wiring between the modules and the BBI-32 interface. The BBI-32 interface is mounted via socketed connectors to the motherboard. The motherboard also provides power for both the left and right side mounted modules.

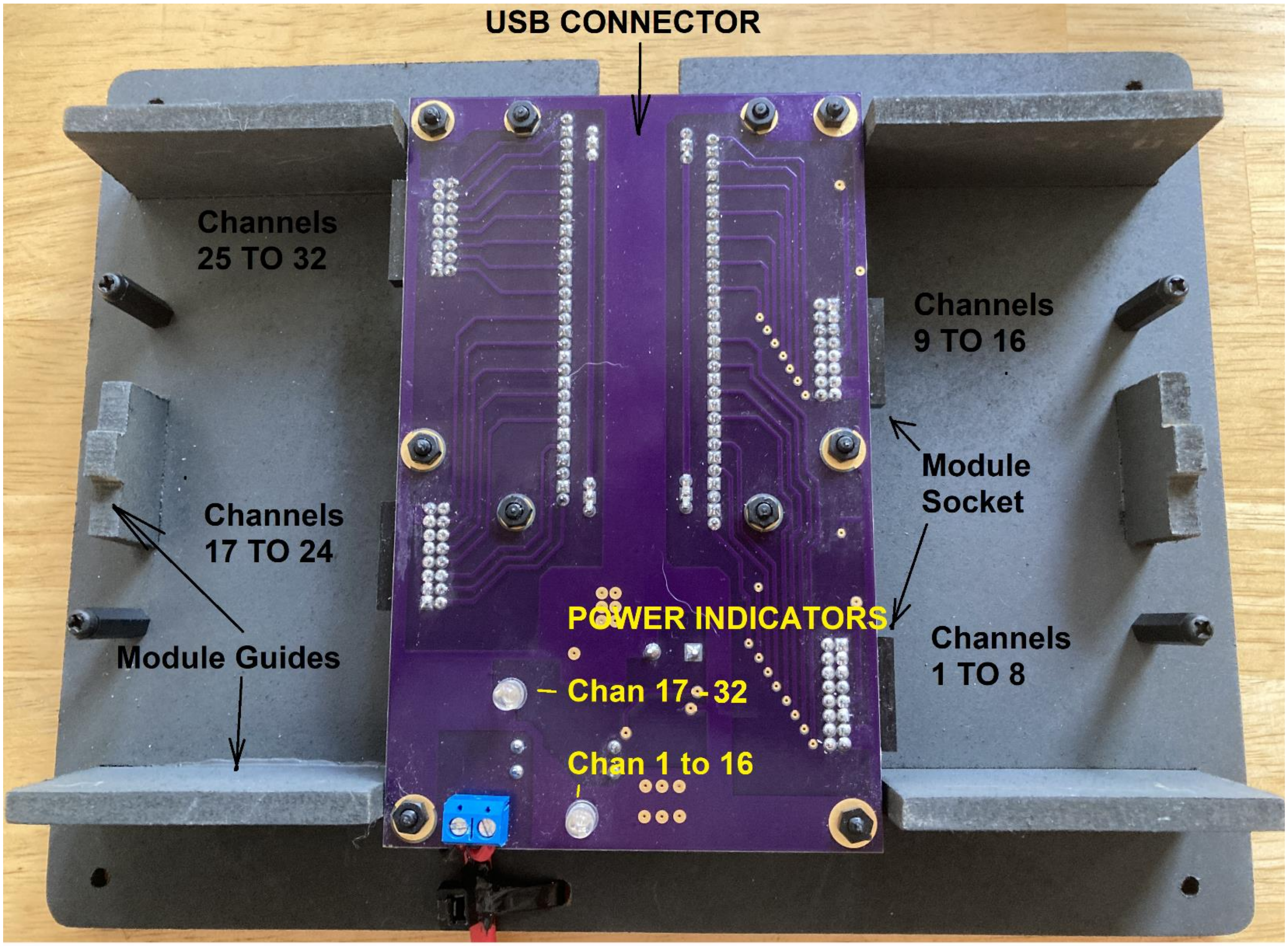


Fig 2 - Motherboard without any modules installed - Flat Pack Chassis shown

After unpacking the motherboard, do not install any modules, just leave the motherboard as shown in Figure 2.

Version 5.2 Installation

Bench Testing Motherboard

Connect a suitable PSU to the motherboard input power connector and apply power. The two blue LED's visible on the motherboard should turn on. Having checked the power up of the motherboard, unplug the PSU and allow the motherboard to turn off.

Adding Modules to the Motherboard

Unpack the supplied modules for your system.

Any Module type can be plugged into any of the four available sockets. **HOWEVER, DO NOT PLUG OR UNPLUG MODULES WITH POWER APPLIED TO THE MOTHERBOARD.** The blue LEDS on the motherboard indicate the presence of power for the modules.

Inspect the unpacked modules and inspect for any obvious shipping damage such as bent connector pins. Also identify the various module types.

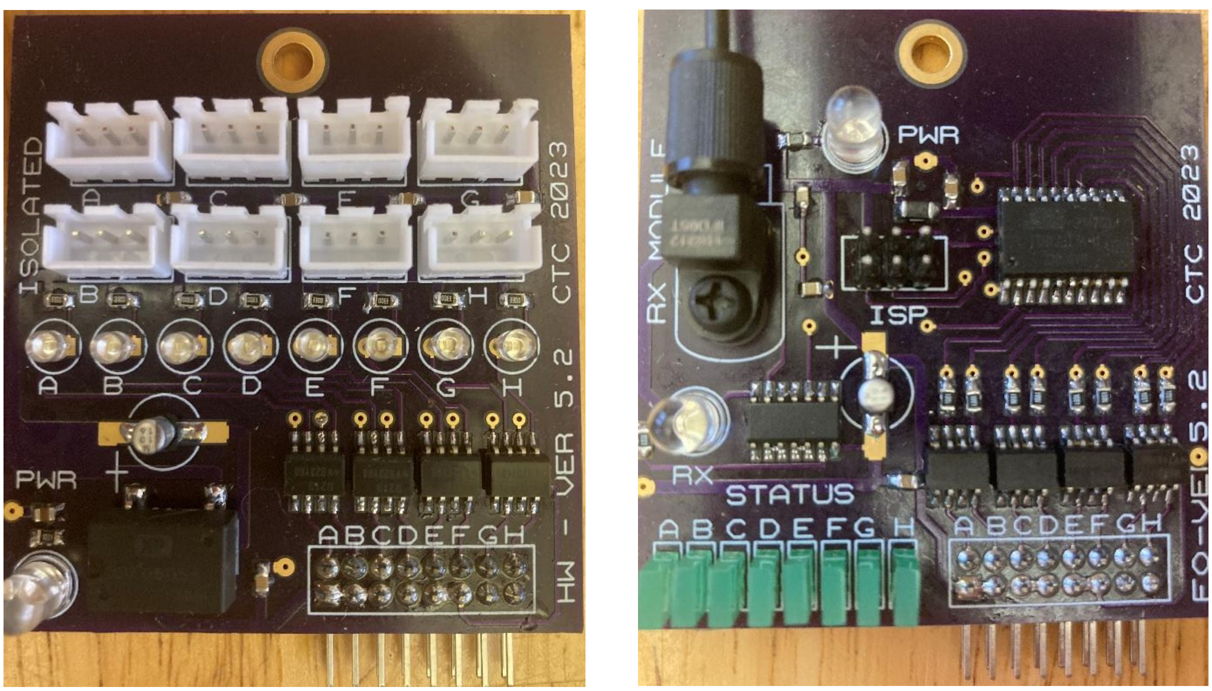


Fig 3 - Hardwired Module (left) and Fibre Optic RX Module (right)

Version 5.2 Installation Continued

Bench Testing Motherboard

Motherboard Power Supply

A Hornby P9100W AC Adapter can be supplied with the system if required. The P9100W PSU has a 6.3mm jack which may be difficult to procure. However, a Hornby HM7020 adapter cable will work to connect to the motherboard terminals.

The supplied motherboard 5.25 jack / socket is recommended for use with a 12v PSU. However any 12VDC PSU (minimum 300 mA) can be used with the motherboard. The remotely installed fibre optic connected TX modules are normally track powered.

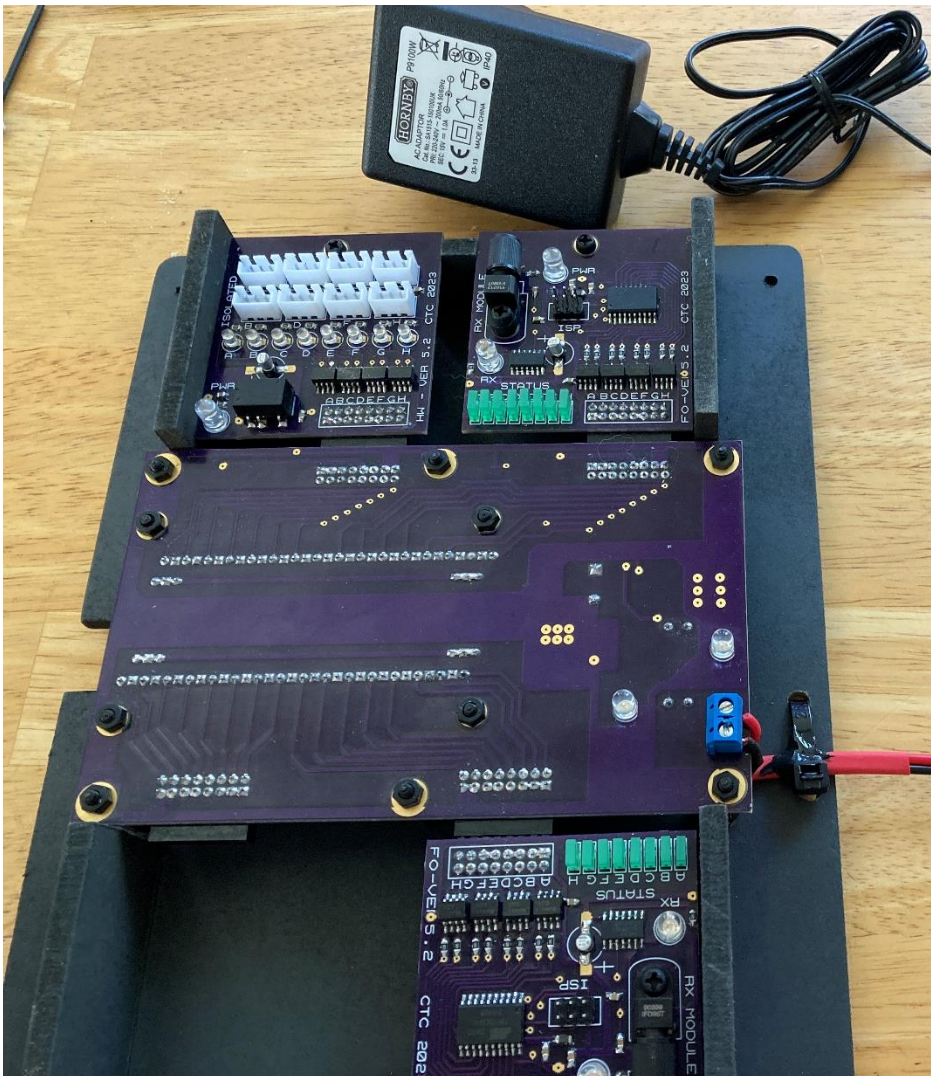


Fig 4 - AC Adapter and Motherboard with three modules installed

Version 5.2 Installation Continued

Adding Modules to the Motherboard

Installing Modules

Ensure that power is off when removing or restoring a module to the motherboard.

Be careful when inserting a module into the motherboard so as to not offset a row of connectors EITHER VERTICALLY OR LEFT TO RIGHT. Guides make it hard to offset a module either left or right, but a vertical offset is possible. See Photo.

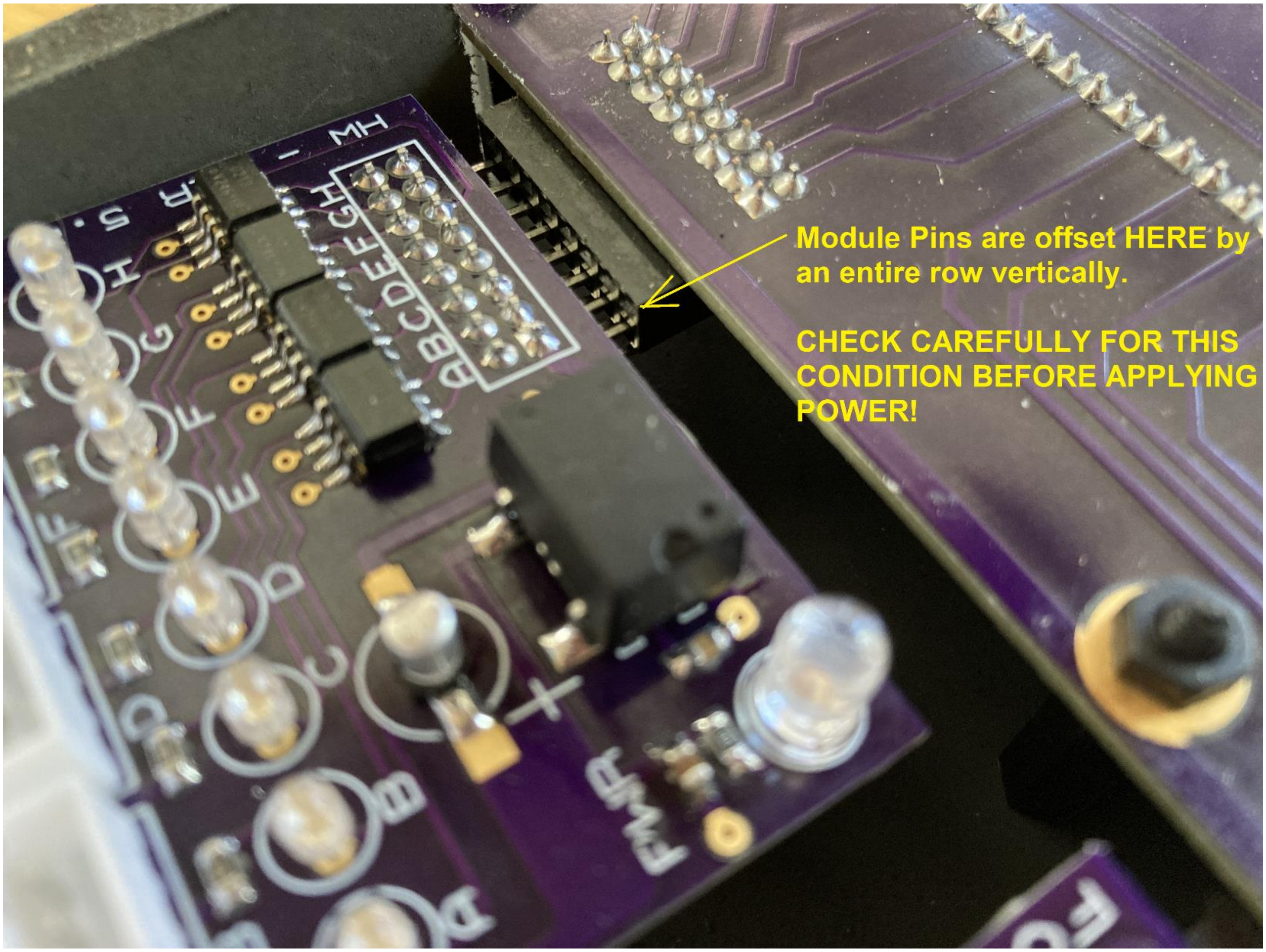


Fig 5 **– A miss-aligned module**

Version 5.2 Installation Continued

Adding Modules to the Motherboard

The modules plug into the motherboard via a 16 pin connector and are supported by a plastic standoff. Remove the plastic machine screw from the standoff. Insert the selected module into the 16 pin connector on the motherboard. Ensure that the module pins are not offset from the motherboard connector either vertically or horizontally. (See Fig 5 & 6)

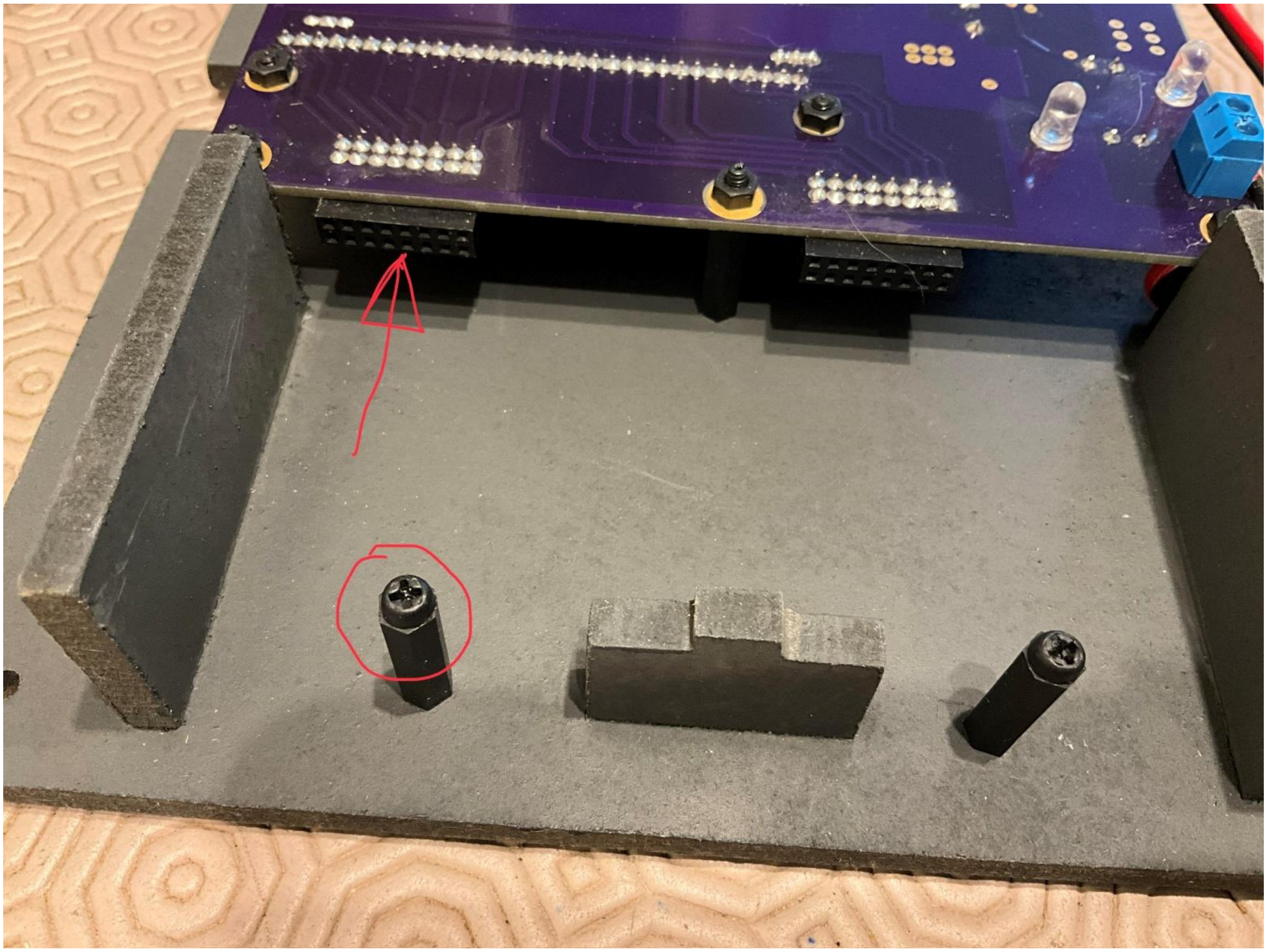


Fig 6 – Module standoff with screw and Motherboard connector

After installing the module, use the removed machine screw to secure it to the plastic standoff.

Version 5.2 Installation Continued

Adding Modules to the Motherboard

Depending on your layout size, one may have anywhere from one to four modules inserted into the motherboard. At this stage, a user should determine the best placement of the modules to suit their selected motherboard layout location relative to the track sensors.

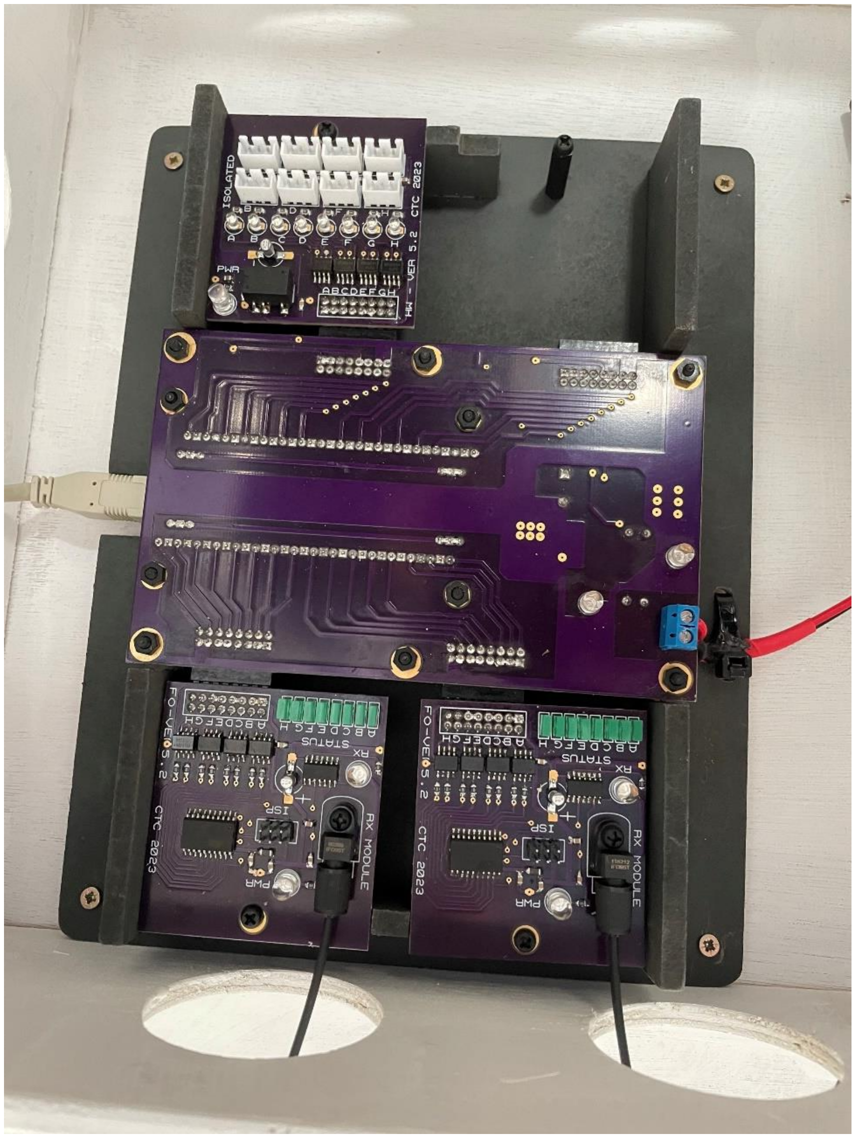


Fig 7 - Motherboard with 3 modules installed (two bottom modules are fibre optic / one top module is for isolated hardwired sensors)

Version 5.2 Installation Continued

Adding Modules to the Motherboard

Once modules have been installed and checked carefully for no offset, the power adapter may be plugged into the motherboard. Both Blue LED's on the motherboard should light, as well as blue LEDs on the installed modules.

Fibre Optic RX Module (FO RX)

This module is used for track sensors that are located at a distance from the motherboard.

At this point, with no optical transmitters connected to the fibre optic RX modules, all 8 rectangular channel LED's may or may not light – this is normal. The green RX LED will be off. With power applied to the motherboard the blue "PWR" LED on this module should be on.

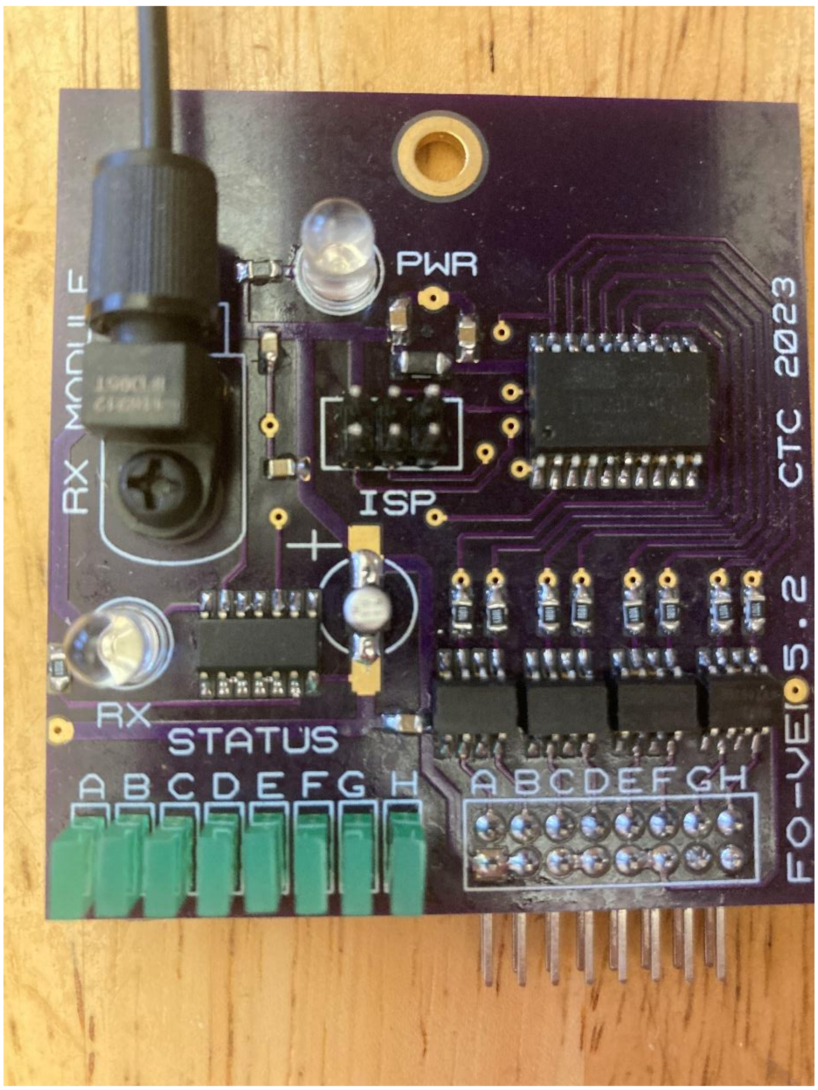


Fig 8 - Fibre Optic RX Module

Version 5.2 Installation Continued

Adding Modules to the Motherboard

Hard Wired Isolation Module (HW)

This module is used for sensors that are relatively close to the motherboard. Track sensors are hard wired to the individual white connectors labelled A thru H on the HW module. When installed into the motherboard and with power applied, the blue PWR LED should be on. Green sensor LED's labelled A thru H will be off.

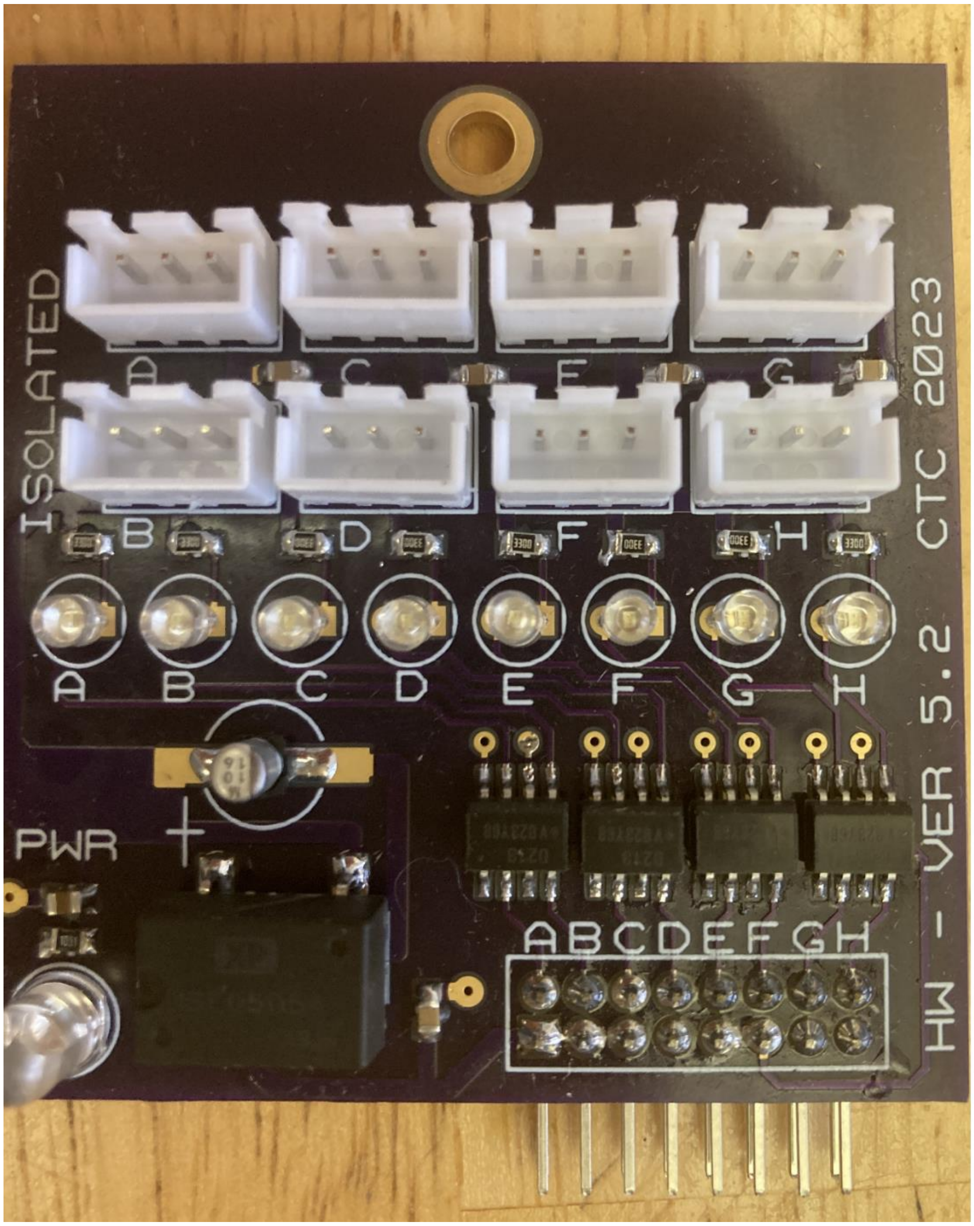


Fig 9 – Hardwired Isolation Module

Version 5.2 Installation Continued

Testing the Modules

Upon installation of your selected modules into the motherboard, and all power indications as expected, one can test the modules for correct operation.

Connecting test track sensors

For the HW module, connect one or both of the supplied Hall or Reed sensors wire / connectors to any of the three pin sockets. This can be done with the power on but better to start with the power off if you haven't done this before! **But, watch for the correct plug / socket orientation before trying to insert a sensor wire assembly.**

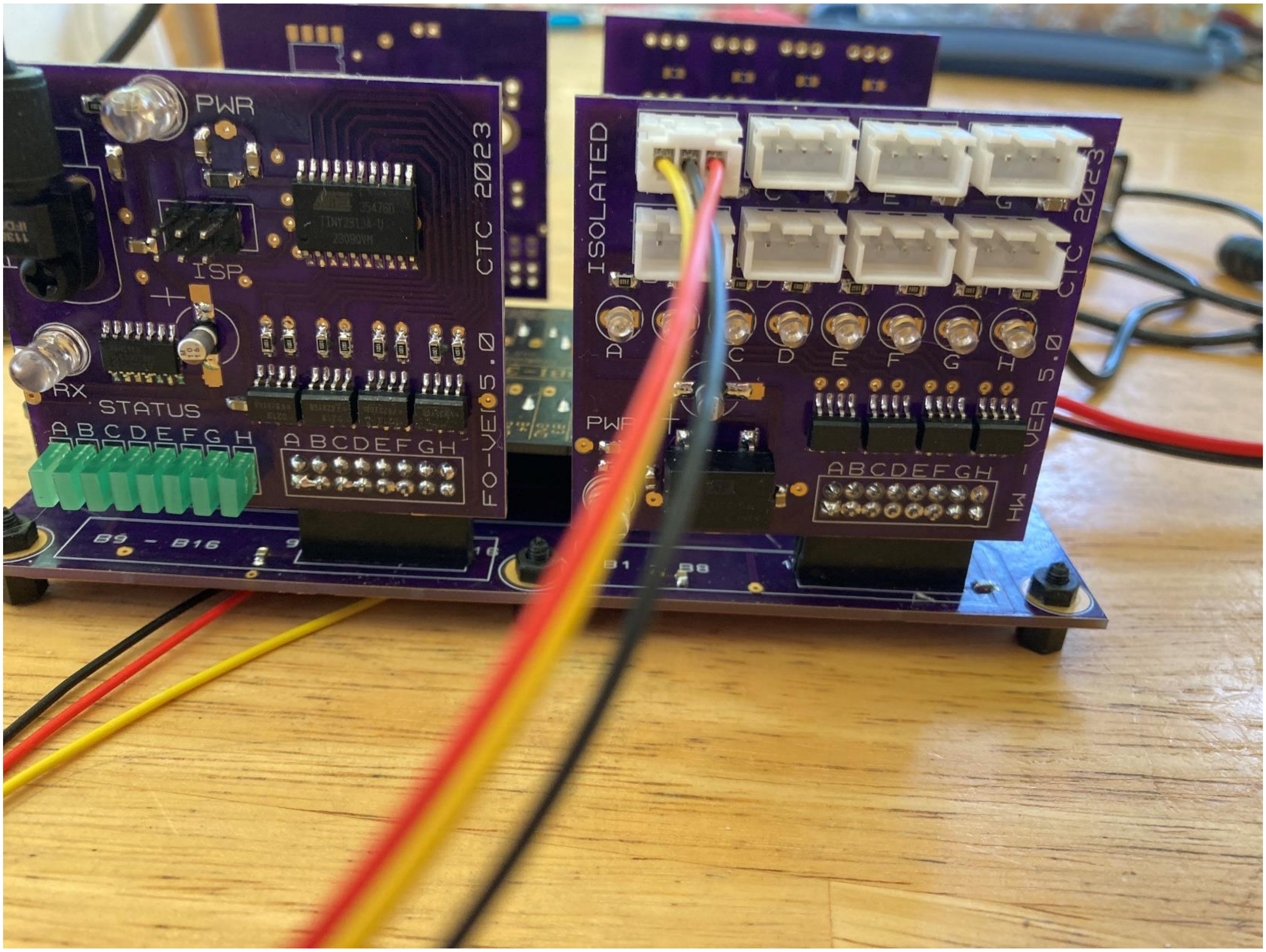


Fig 10 - Version 5 module vertical configuration shown.

Version 5.2 Installation Continued

Testing a Hard Wired Module

Bring a trigger magnet close to either one of the Hall or Reed switch track sensors that is connected to one of the Hardwired Module inputs. The corresponding small green status LED should turn on as the magnet is brought close to the sensor.

Fig 11 - Vertical Version 5 - HW module shown - triggered by magnet.

Use CAUTION when viewing the small green status lights as they are very bright!

Version 5.2 Installation Continued

TX Module testing and connection

Unpack one of the FO TX modules – either one can be used. The two white wires attached to the TRK-PWR terminals are for track power, but any 12 to 18 VDC can be applied to these modules for test purposes. These modules are NOT Polarity sensitive.

(One can connect this module – for test purposes only – to the low voltage motherboard adapter power wires attached to the blue power terminals located on the motherboard – See Figure 13.)

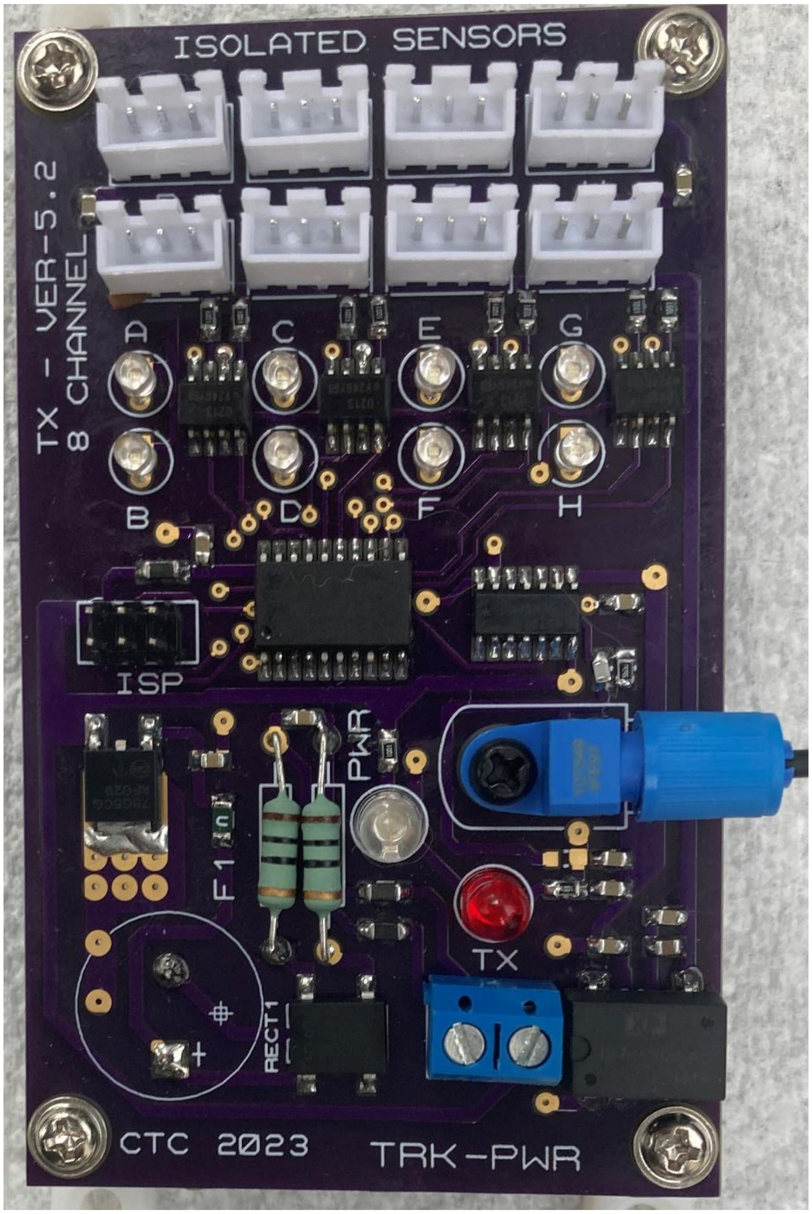


Fig 12 – Fibre Optic TX module

Version 5.2 Installation Continued

TX Module testing and connection

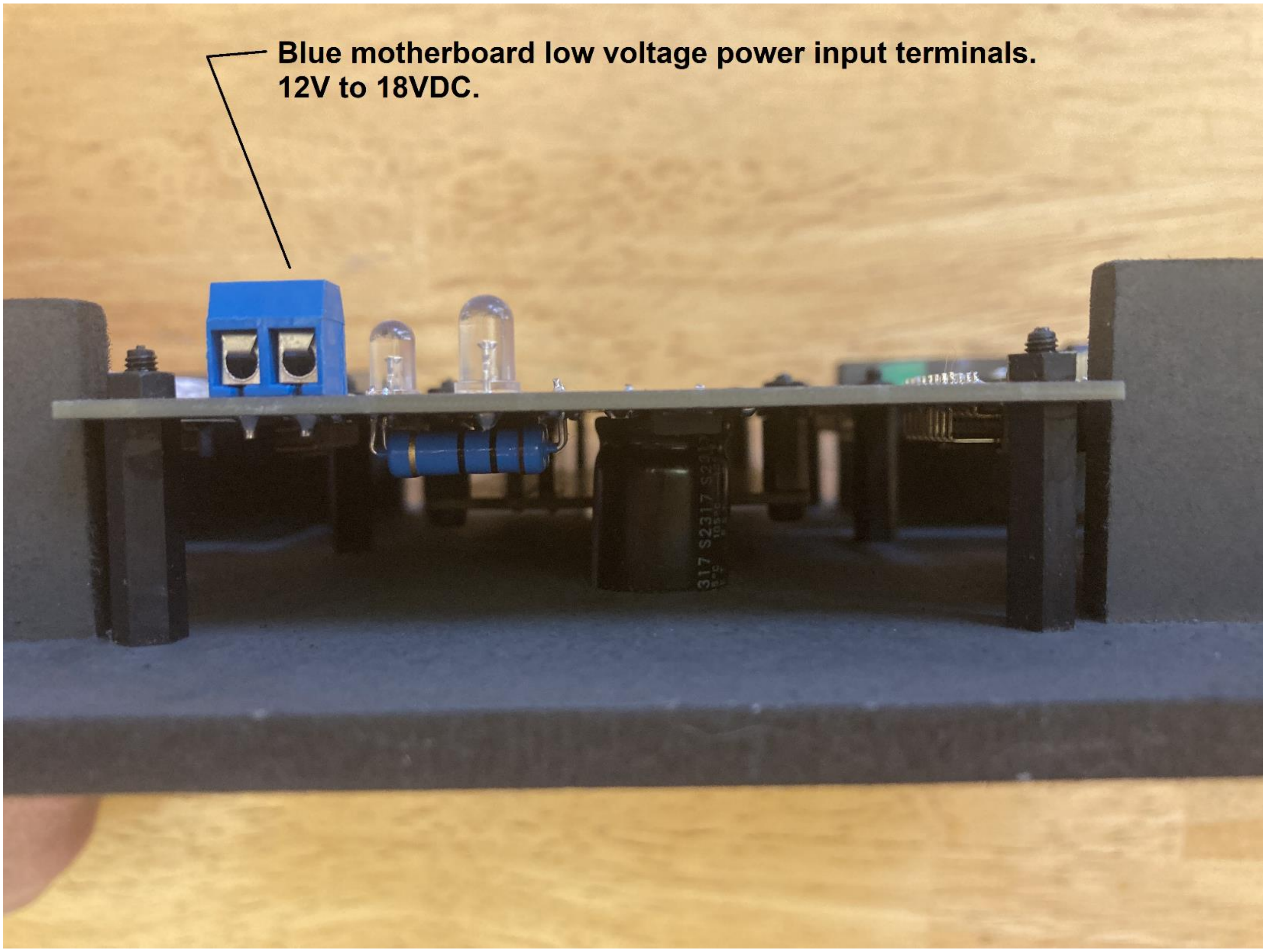


Fig 13 - Motherboard viewed from the side showing power input terminals.

Version 5.2 Installation Continued

TX Module testing and connection

Upon applying power to the FO TX module, both the blue PWR and red TX LED's should light. Loosen the knurled blue fibre optic connector and insert a short test section of plastic fibre optic cable into the connector. Lightly re-tighten the knurled connector. The open end of the fibre optic connector should glow red.

Fig 14 - Fibre Optic cable end attached to FO TX module.

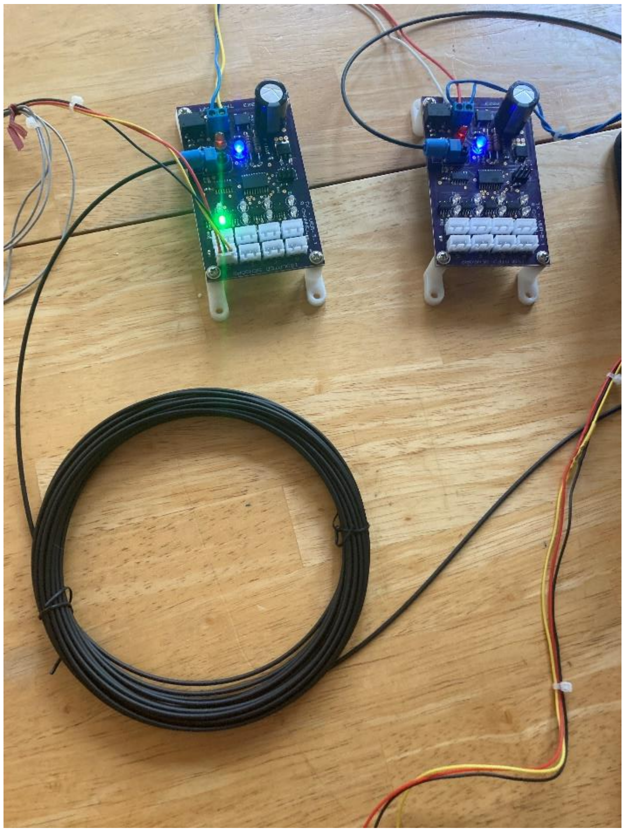


Fig 15 – Fibre Optic TX modules connected and powered on.

Version 5.2 Installation Continued

TX Module testing and connection

Insert the currently unconnected fibre optic cable into a FO RX module knurled connector (Black). If the motherboard and FO RX module are on, the green RX LED will light on the module**. There is ABSOLUTELY NO problem with either connecting / disconnecting the fibre optic with the power on.**

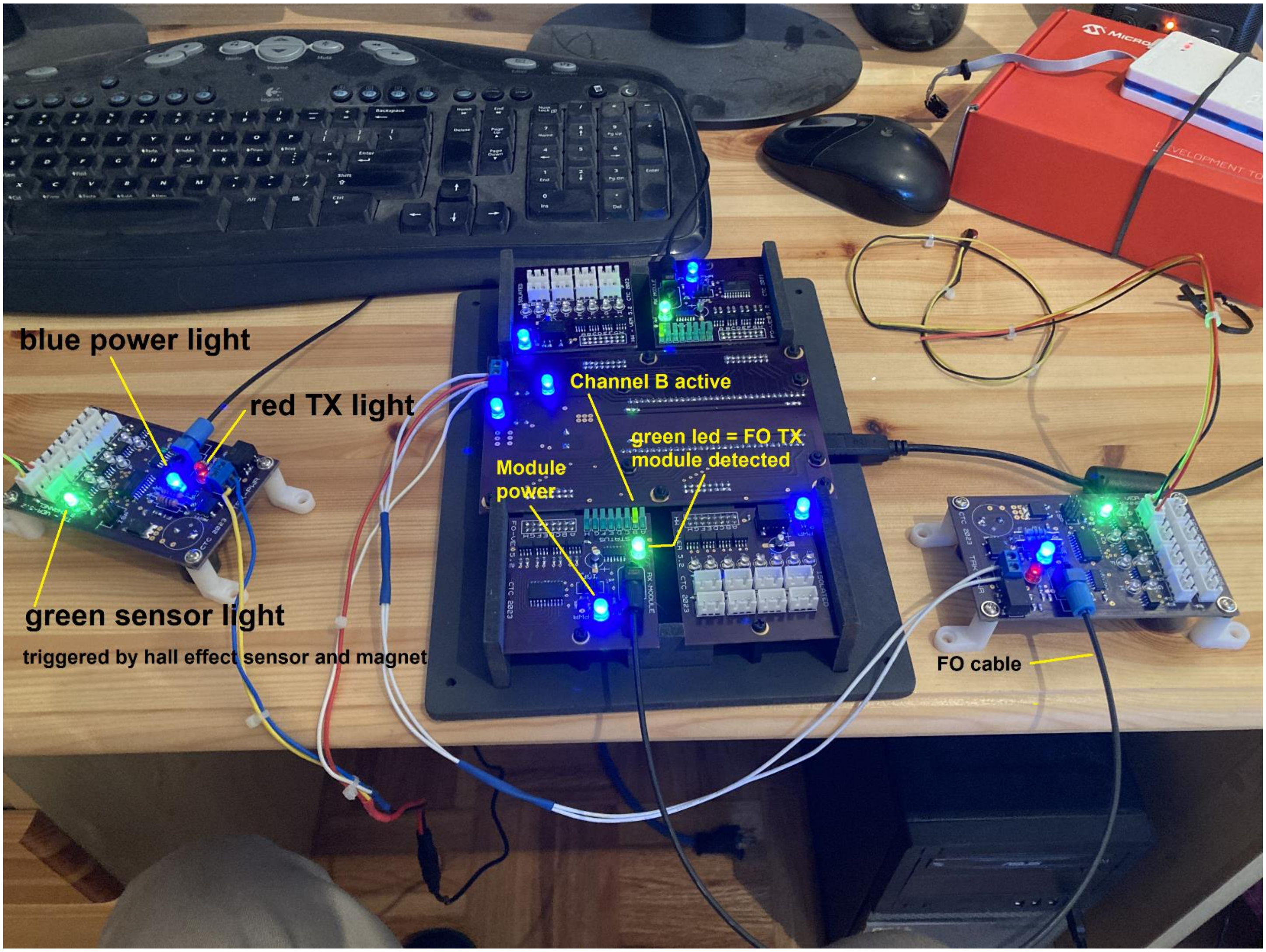


Fig 16 - ***Note for test purposes only*** – in the above photo, the right side FO TX module is connected by white wires to the low voltage motherboard input power terminals. Normally the FO TX modules are powered by the DCC track power.

Version 5.2 Installation Continued

TX Module testing and connection

With the FO TX module connected to the FO Rx module and powered on, connect either a Hall Sensor or Reed Switch sensor to one of the eight inputs on the TX module. Bring a magnet close to the sensor end. A small green status LED on the FO TX board should turn on indicating detection of the magnet. If the FO RX module status LEDs do not correctly follow the FO TX module LEDs, cycle the power off, wait 10 seconds, re-apply power.

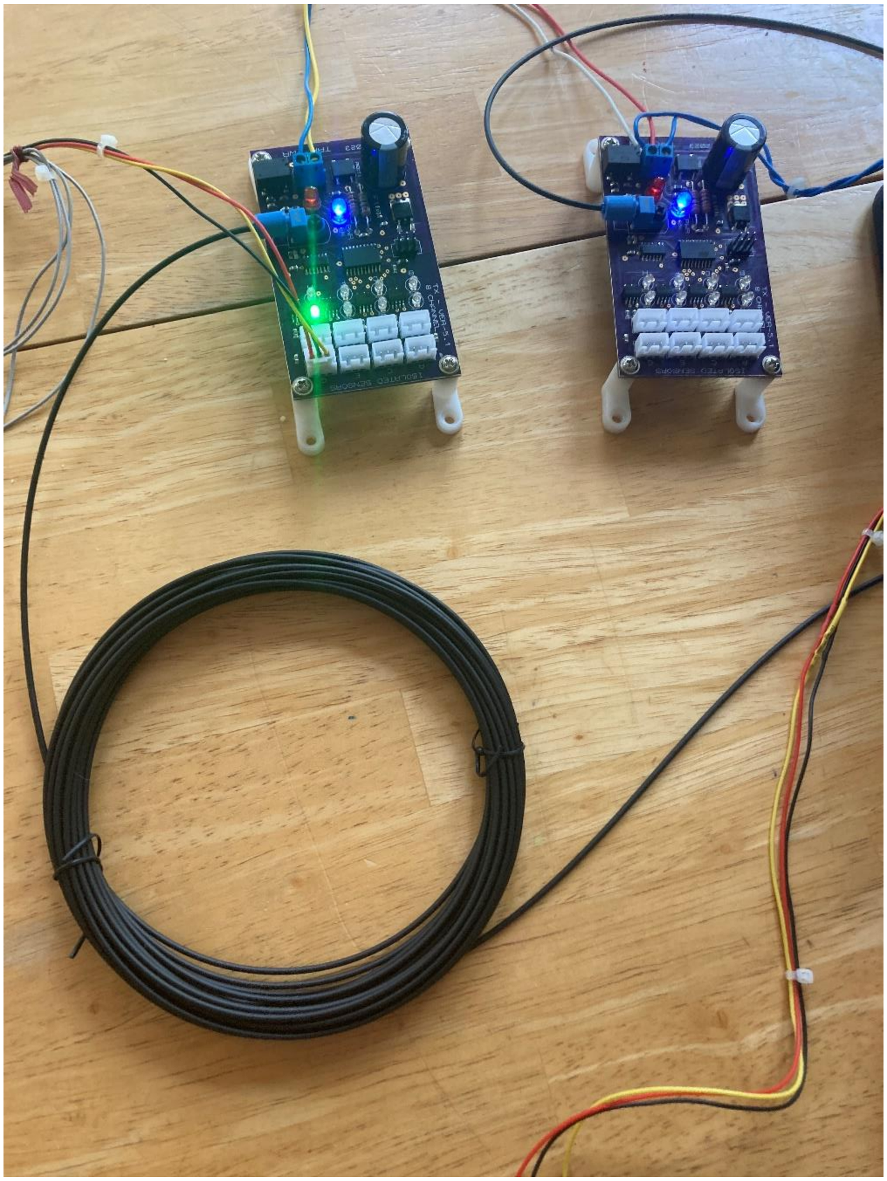


Fig 17 – Green Sensor status LED turned on (left FO TX module) indicating magnet detected

Version 5.2 Installation Continued

TX Module testing and connection

On the Fibre Optic receiver module, the corresponding rectangular green status LED should turn on, matching the FO TX status.

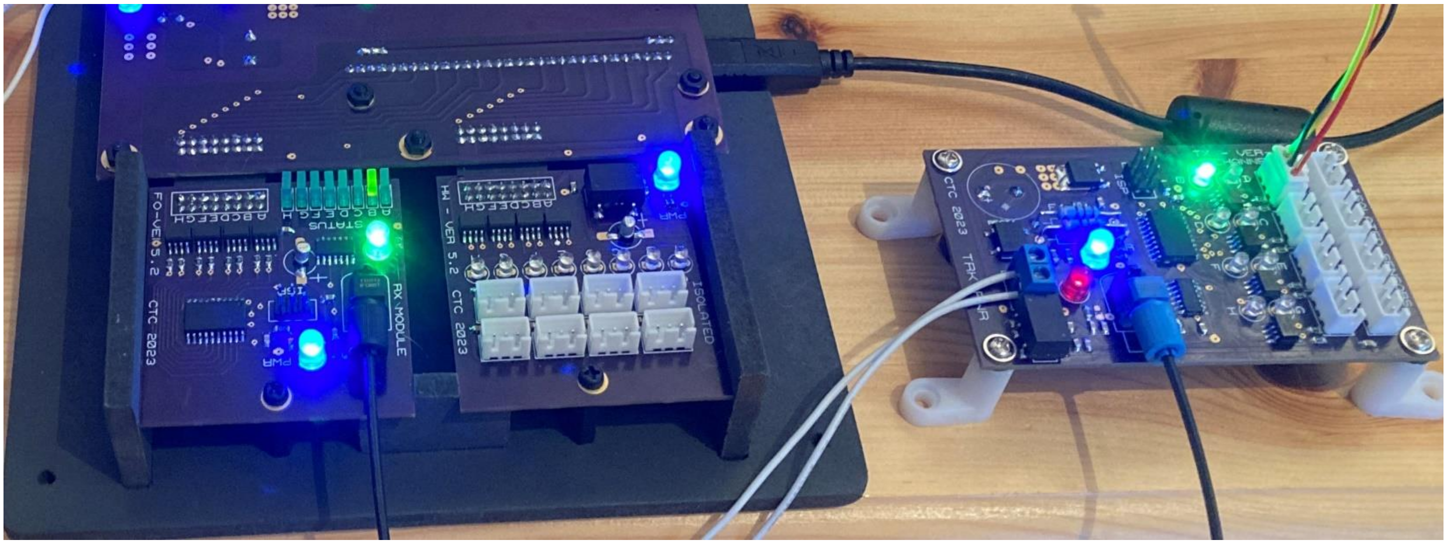


Fig 18A Flat Pack – Fibre Optic RX and TX status LEDs triggered by a magnet

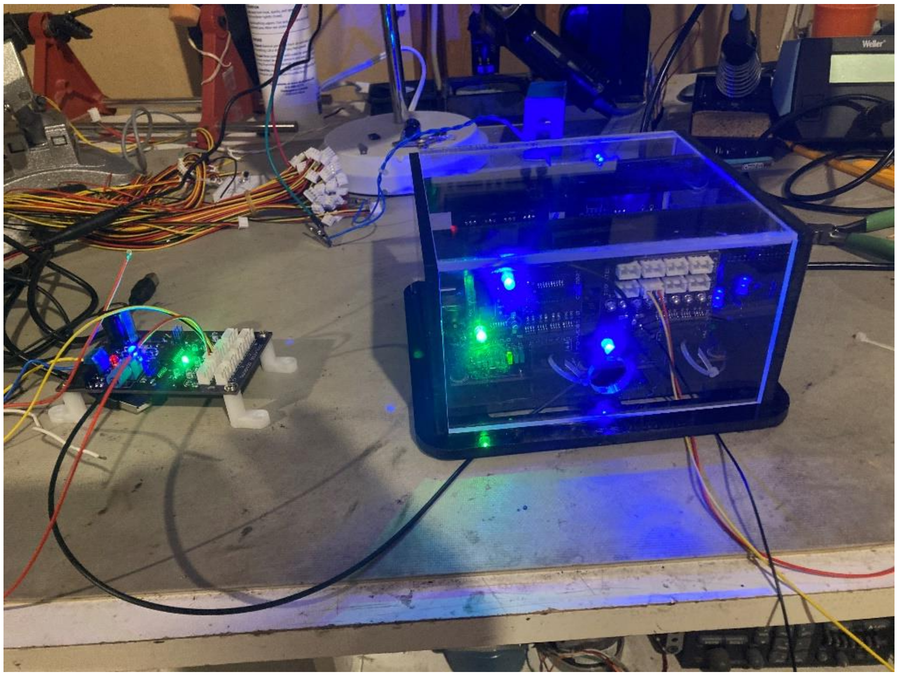


Fig 18B Vertical Pack shown

Version 5.2 Installation Continued

Turn off the power and disconnect the TX module white power wires from the motherboard if so previously connected. Disconnect the fibre optic cable.

Now that you have experienced how the various modules interconnect and operate, you are ready to consider where to place the motherboard chassis and fibre optic TX modules. Do this so as to keep the number of long sensor wires as short as is reasonably possible. Secure the motherboard chassis under your layout using the four mounting holes drilled in the chassis. The FO TX modules can be mounted by securing their four “L” shaped standoffs.

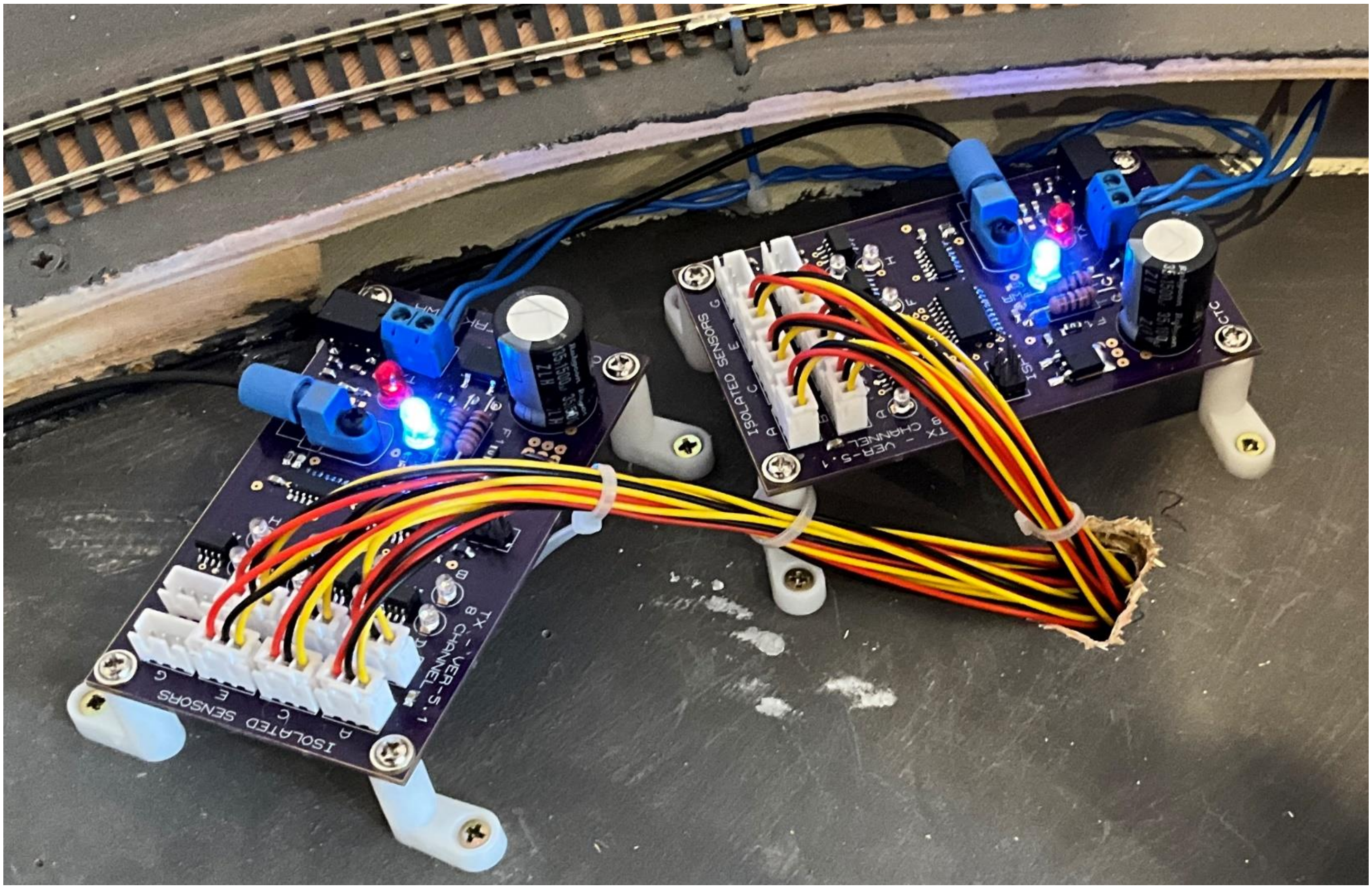


Fig 19 – Two remotely located Fibre Optic TX modules.

Version 5.2 Installation Continued

Use Caution running long sensor wires

When running track sensor wires under the layout, try not to run them in close proximity or parallel to either point control or DCC power lines. Of course this isn't always possible but the less sensor cables run next to electrically noisy power wires, the better!

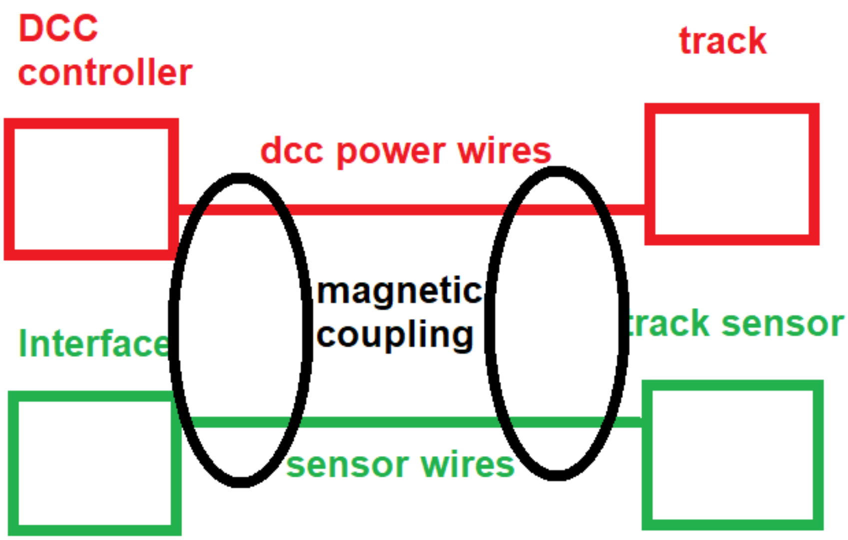


Fig 20 Undesired Inductive (magnetic) signal coupling

Figure 20 shows how magnetic fields from the DCC power lines could couple into the track sensor cables when the cables run parallel to each other. The signal induced into the sensor wires is made worse by the square wave nature of the DCC signals.

Mapping Sensors on your layout

It will help to keep track of both the sensor location and the input number that is assigned to it by the BBI-32 interface.

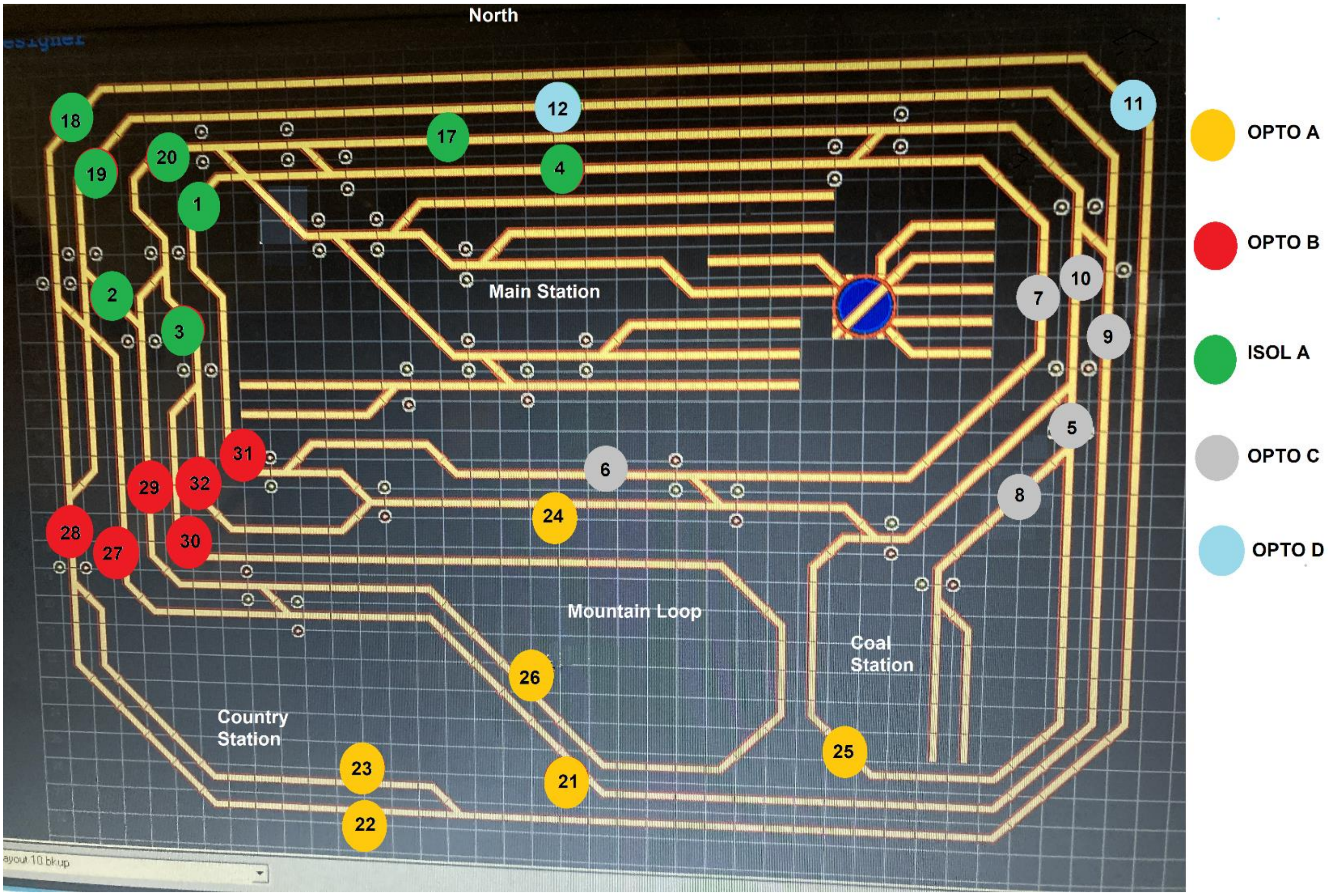


Fig 21 - Layout with sensor numbers mapped.

Using the TGG software the operator is able to assign “Block Names” to each sensor number. It is a relatively simple matter if a sensor needs to change location to unplug the sensor cable and then reconnected it to a different sensor socket. One can then update the TGG software’s block name and number.

Mapping Sensors on your layout

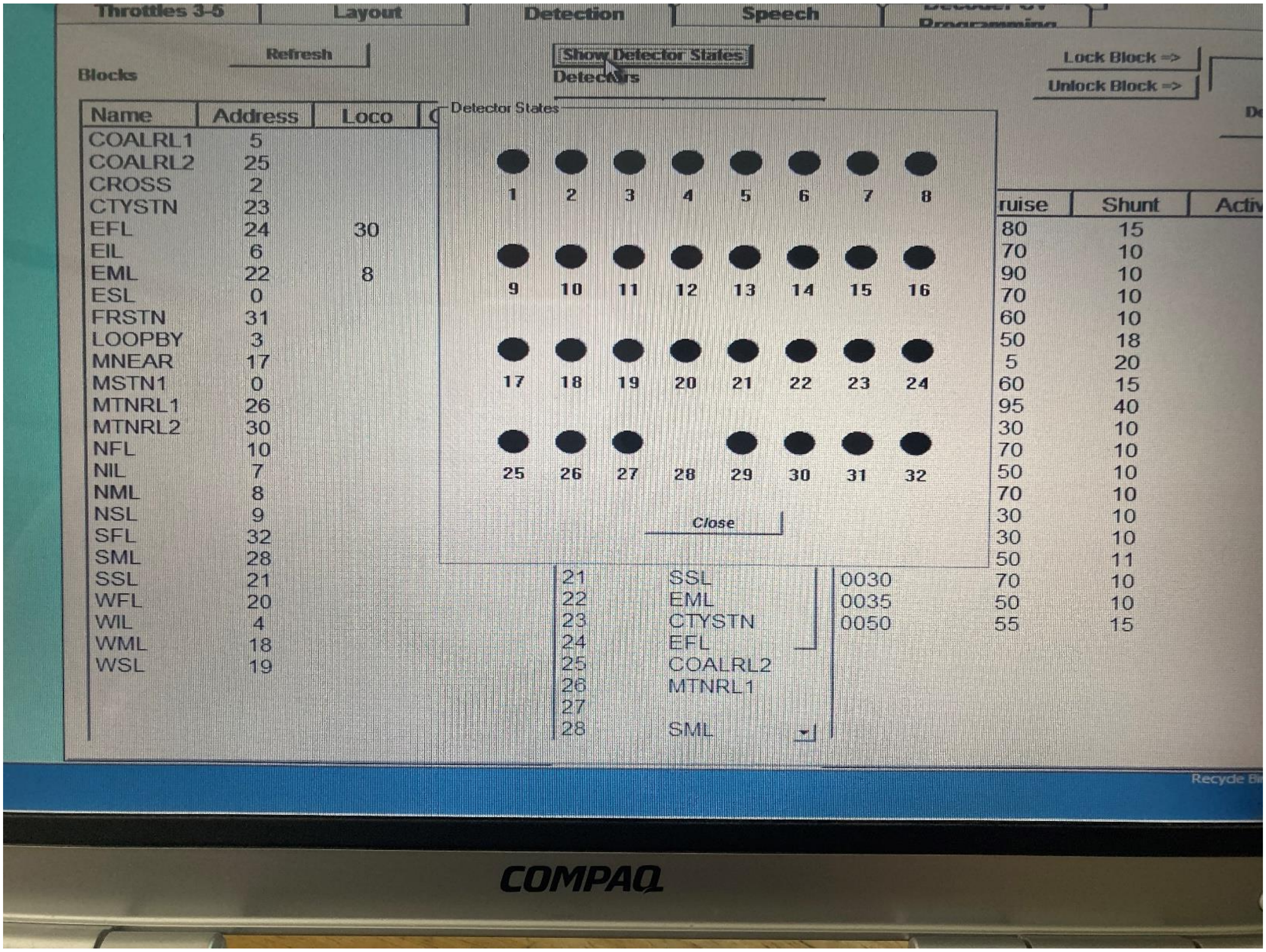
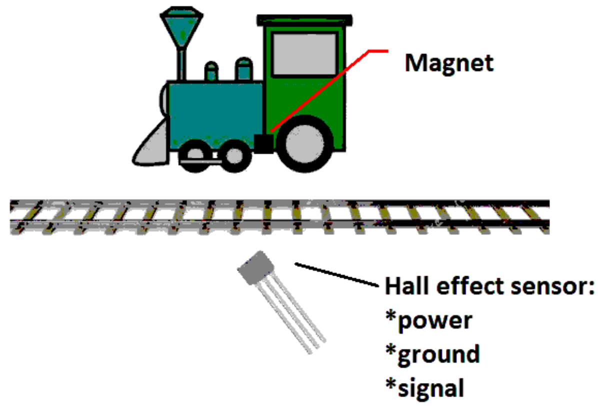


Fig 22 - Screen capture of TGG window showing Block Name on left matched to a sensor number. Sensor status is also displayed.

Hall Effect Sensor Fabrication



A Hall sensor used to detect locomotive magnet.

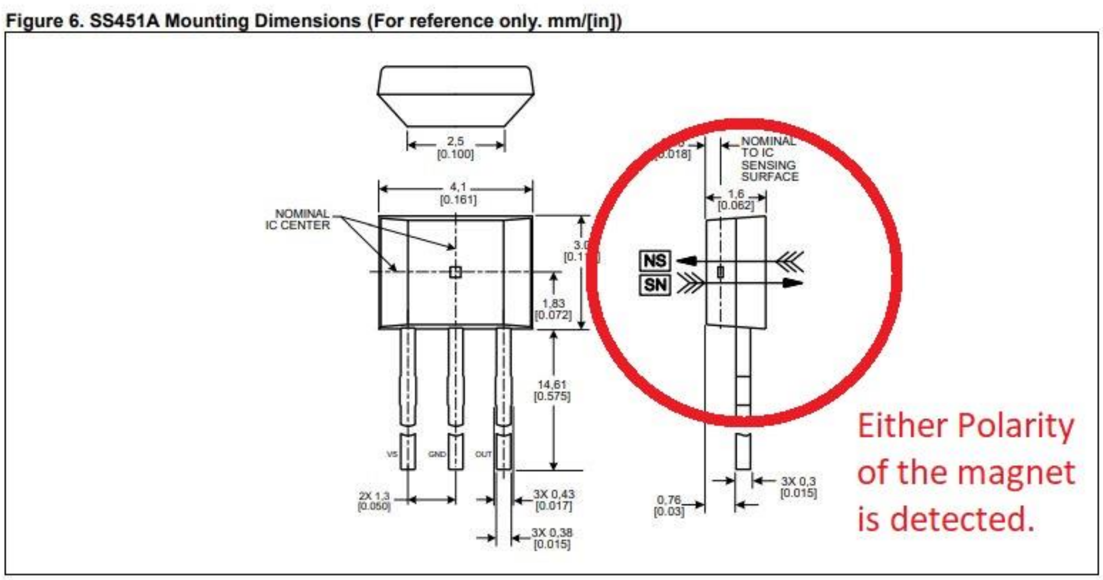


Fig 23 – The recommended Hall Sensors to use is a **SS451A** type. (Not all Hall sensors are the same when it comes to detection characteristics.)

Hall Effect Sensor Fabrication

By mounting a SS451A Hall device in a small vice one can solder sensor wires more easily.

Figure 6. SS451A Mounting Dimensions (For reference only. mm/[in])

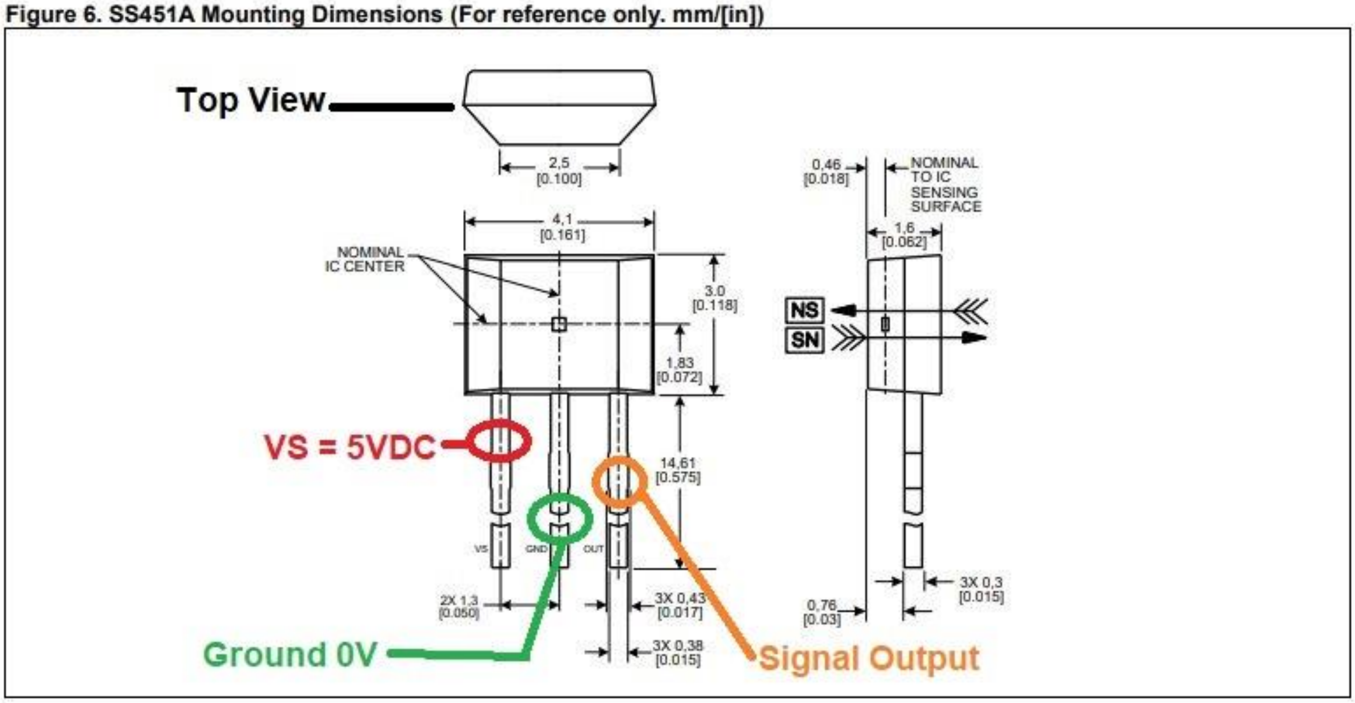


Fig 24 – Hall Effect wiring pinout identification.

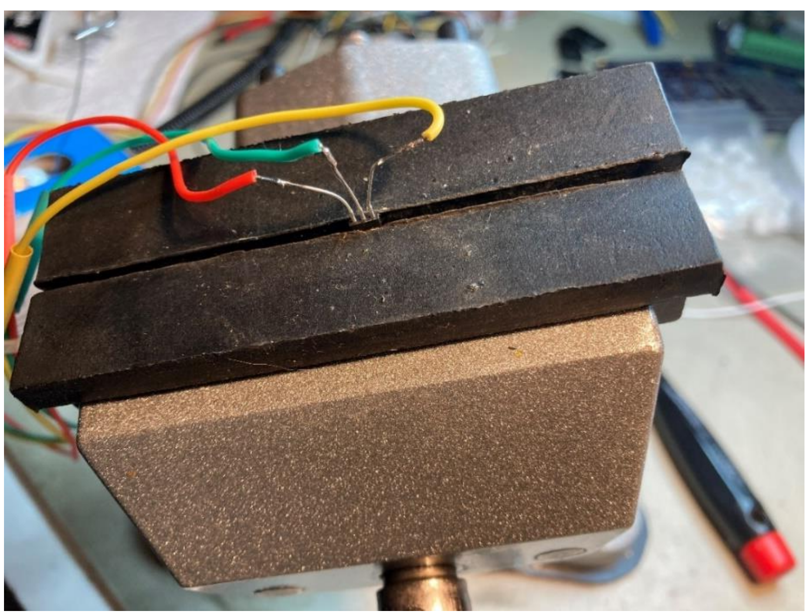


Fig 25 - SS451A Hall Effect Sensor with wires soldered. Don't forget to slide Heat shrink tubing on the wire FIRST.

Hall Effect Sensor Fabrication

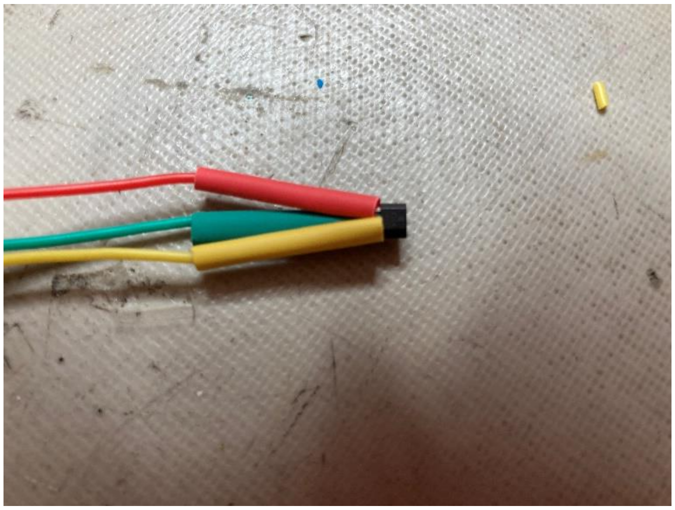


Fig 26 - **Red = +5V   Green = GND   Yellow = Signal**

Use the supplied pigtail wiring to splice to the connected Hall Sensor Device. If longer sensor wires are required (likely) then splice the pigtail wires to the added wire and then solder to the Hall Sensor Device.

Fig 27 – Supplied Sensor Pigtail connectors

JST 3 PIN 2.54mm pitch Type XH

Hall Effect Sensor Fabrication

A prefabricated Hall Effect sensor cable is provided for your use when setting up your system or for trouble shooting. This sensor cable can be used as a template when fabricating your own sensors.

Hall Sensor Orientation

One can choose either horizontal Hall Sensor placement or Vertical placement as the omnidirectional sensor's field of detection is on both faces of the detector. Horizontal placement will detect a magnet at a greater distance from the track but will generate a shorter detection pulse. However, TGG is able to detect very short pulses – I've had no problem detecting pulses as narrow as 10 msec. Normal train operation usually results in 50 to 100's of millisecond detection pulses. (See Figure 29)

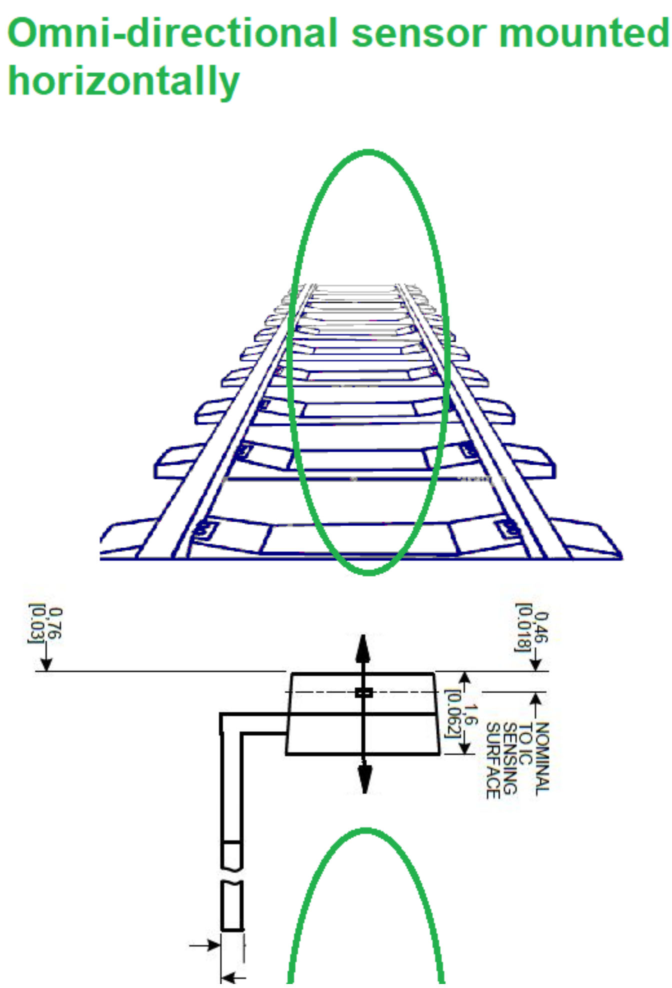


Fig 28

Hall Effect Sensor Fabrication

Hall Sensor Orientation

If one places the omnidirectional Hall Sensor vertically, the sensor and magnet are required to be closer to each other. This orientation however, does produce two longer detection pulses. The quick succession of two pulses doesn’t seem to negatively impact TGG’s operation. (See Figure 30)

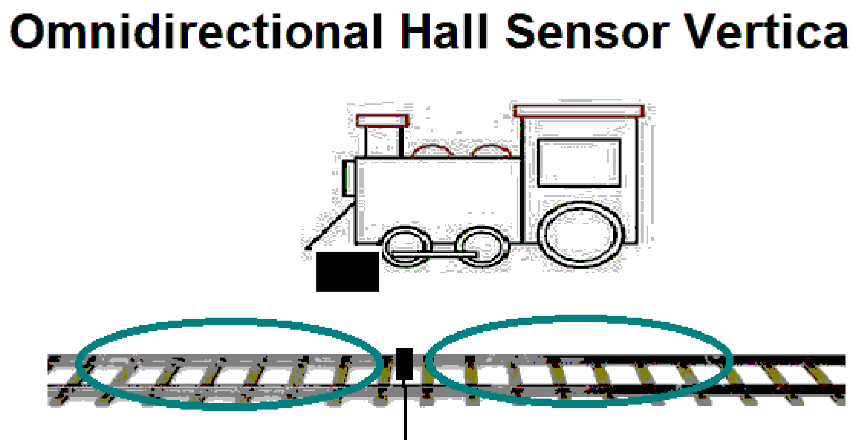
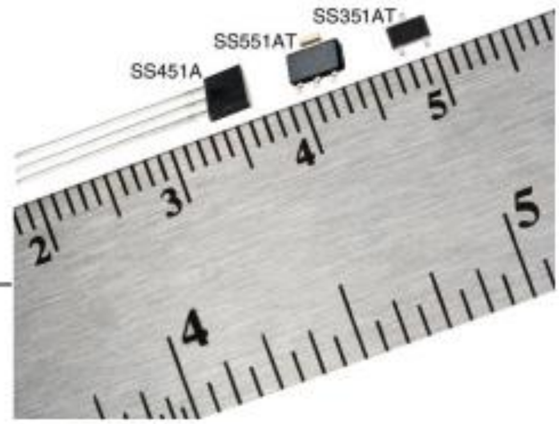


Fig 29

Fig 30 - Three track installed Hall Sensors peeking up between the sleepers.

Honeywell



SS351AT/SS451A/ SS551AT

Omnipolar Digital Hall-effect Sensor ICs

DESCRIPTION

The SS351AT, SS451A and SS551AT sensors are small, versatile digital Hall-effect devices that are operated by the magnetic field from a permanent magnet or an electromagnet. They are designed to respond to a either a North pole or a South pole.

These omnipolar sensors are sensitive and flexible devices designed to meet a wide range of potential applications. The SS351AT, SS451A and SS551AT have a typical operating point of 85 G at 25 °C [77 °F]. Because they can be operated by a North pole or a South pole, they do not require the magnet polarity to be identified, thus making the installation easier and potentially reducing the system cost.

These sensors are available in three package styles. The SS351AT is available in the subminiature SOT-23 surface mount package; the SS451A is available in the leaded, flat TO-92-style package, and the SS551AT is supplied in the SOT-89B surface-mount package. The SS351AT's small size requires less PC board space, allowing it to be used in smaller assemblies. Its 3 Vdc capability allows for use in low voltage applications, promoting energy efficiency.

The SS351AT is available on tape and reel (3000 units per reel); the SS451A is available in a bulk package (1000 units per bag), and the SS551AT is available on tape and reel (1000 units per reel).

FEATURES/BENEFITS

- Subminiature package size (SS351AT) supplied on tape and reel allows for a compact design with automated component placement, helping to reduce manufacturing costs
- Simple activation from a North pole or a South pole and sensitive magnetics make this omnipolar product suitable in a variety of potential motion control, lid closure detection, and displacement sensing applications
- Low voltage 3 Vdc capability helps reduce power consumption
- Built-in reverse polarity protection protects the device from potential damage during installation
- Thermally balanced integrated circuit provides for stable operation over a wide temperature range of -40° to 150 °C [-40 °F to 302 °F]
- RoHS-compliant materials meet Directive 2002/95/EC

POTENTIAL APPLICATIONS

Commercial:

- Speed and RPM (revolutions per minute) sensing in fitness equipment
- Magnetic encoder for building access
- Damper or valve position control in HVAC (heating, ventilation and air conditioning) equipment
- Flow rate sensing in appliances and water softeners
- Printer head position sensing

Industrial:

- Flow rate sensing in industrial processes
- Robotic control (cylinder position monitoring)
- Float-based fluid level sensing

Medical:

- Displacement sensor in hospital beds and medical equipment
- Medication bin monitor on portable drug carts

Fig 31 – The SS451A is the recommended Hall Effect Sensor

Reed Sensor Fabrication

Reed switches can also be employed with this system. However only two wires between the reed switch and any module input are required.

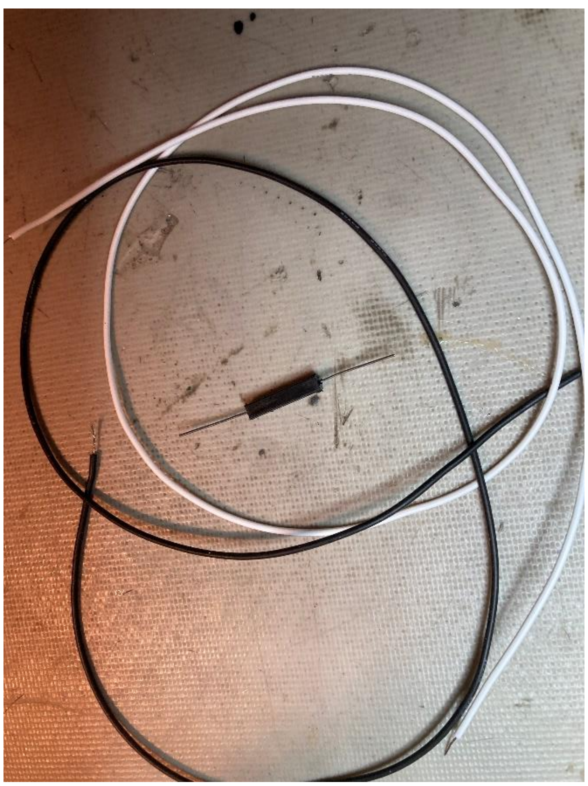
The supplied three pigtail wires are coloured red / black / yellow.

- Red = 5 Volts and is NOT used with a reed switch.
- Black = 0 Volts or common
- Yellow = detection signal

The RED wire end could be cut off, but this makes future use of the pigtail with either Hall or IR sensors not possible. It is suggested to cover the RED wire end with heat shrink if not used. Covering the +5V RED wire end, means that it is less likely to SHORT with another conductor.

A pre-fabricated reed switch sensor is provided for use when setting up your system or for trouble shooting. Use this sensor as a template when fabricating your own sensors.

Fabrication Sequence for a Reed Switch Sensor



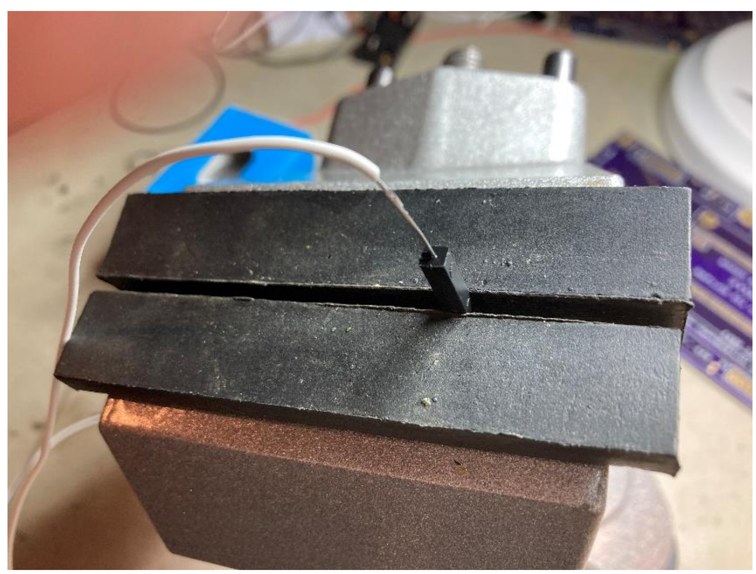


Fig 32 - Reed Switch with wires to be attached & using a small vice really helps

Fabrication Sequence for a Reed Switch Sensor

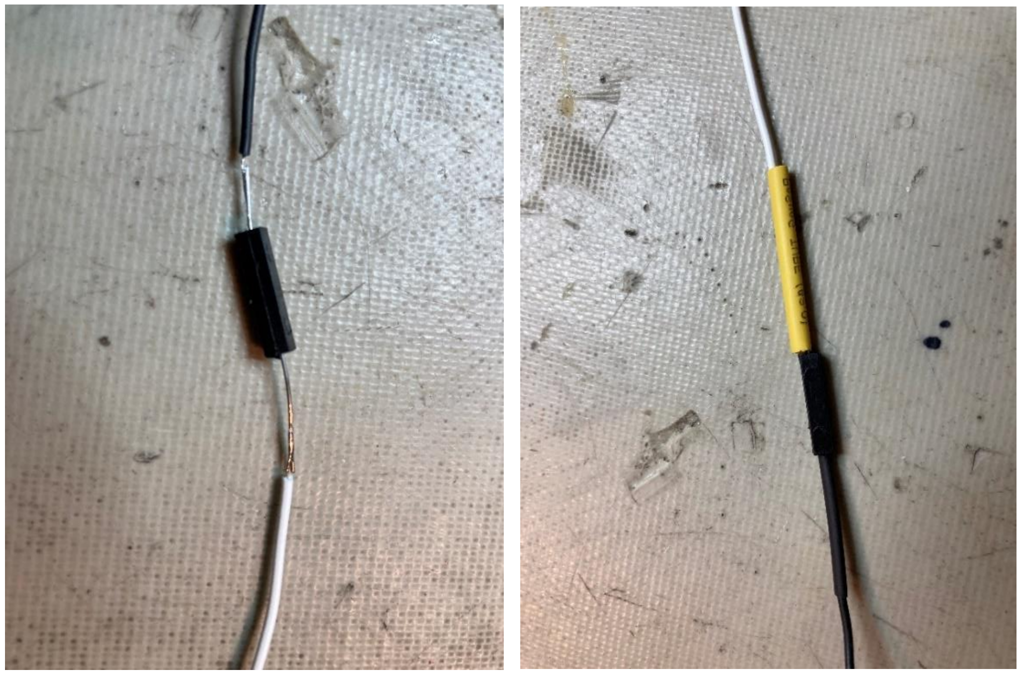


Fig 33 - Solder Sensor leads to both reed switch wires adding heat shrink sleeves.

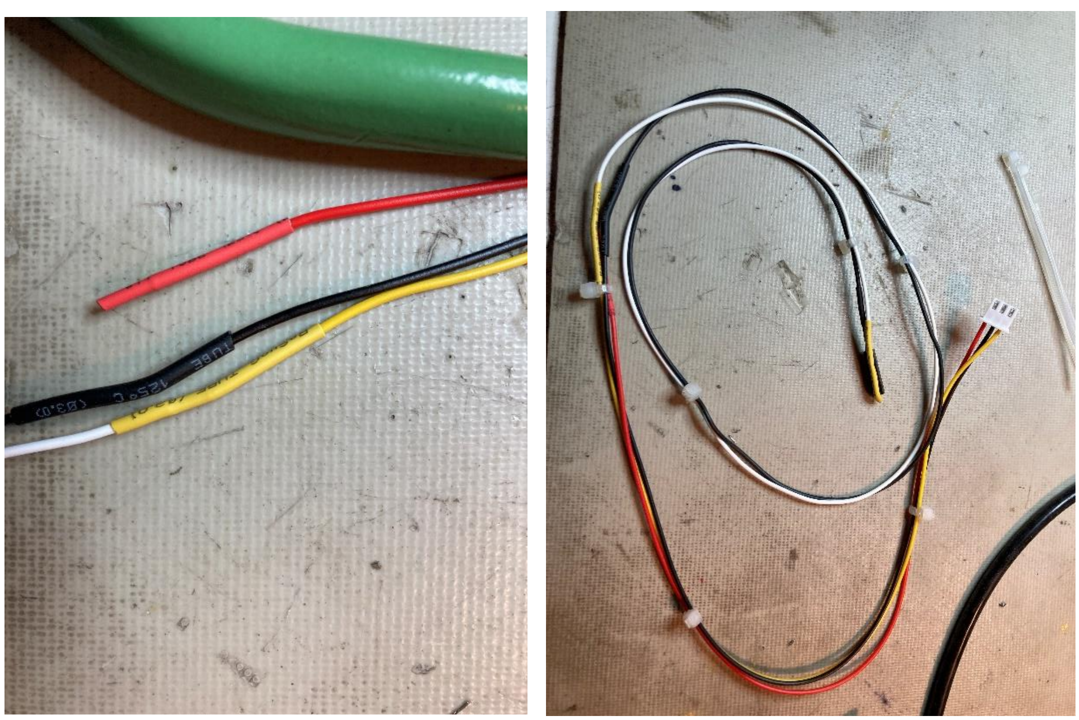


Fig 34 - Cover Red wire with heat shrink sleeve and adding tie wraps to sensor wires.

Once you have connected the wires to your reed switch, carefully fold back the wire along side the switch and sleeve it.

Fabrication Sequence for a Reed Switch Sensor

To provide additional protection to prevent one side of the reed switch from contacting a live DCC rail, add epoxy to the end of the reed switch.

Fig 35 – Adding Epoxy coating to the end of the reed switch.

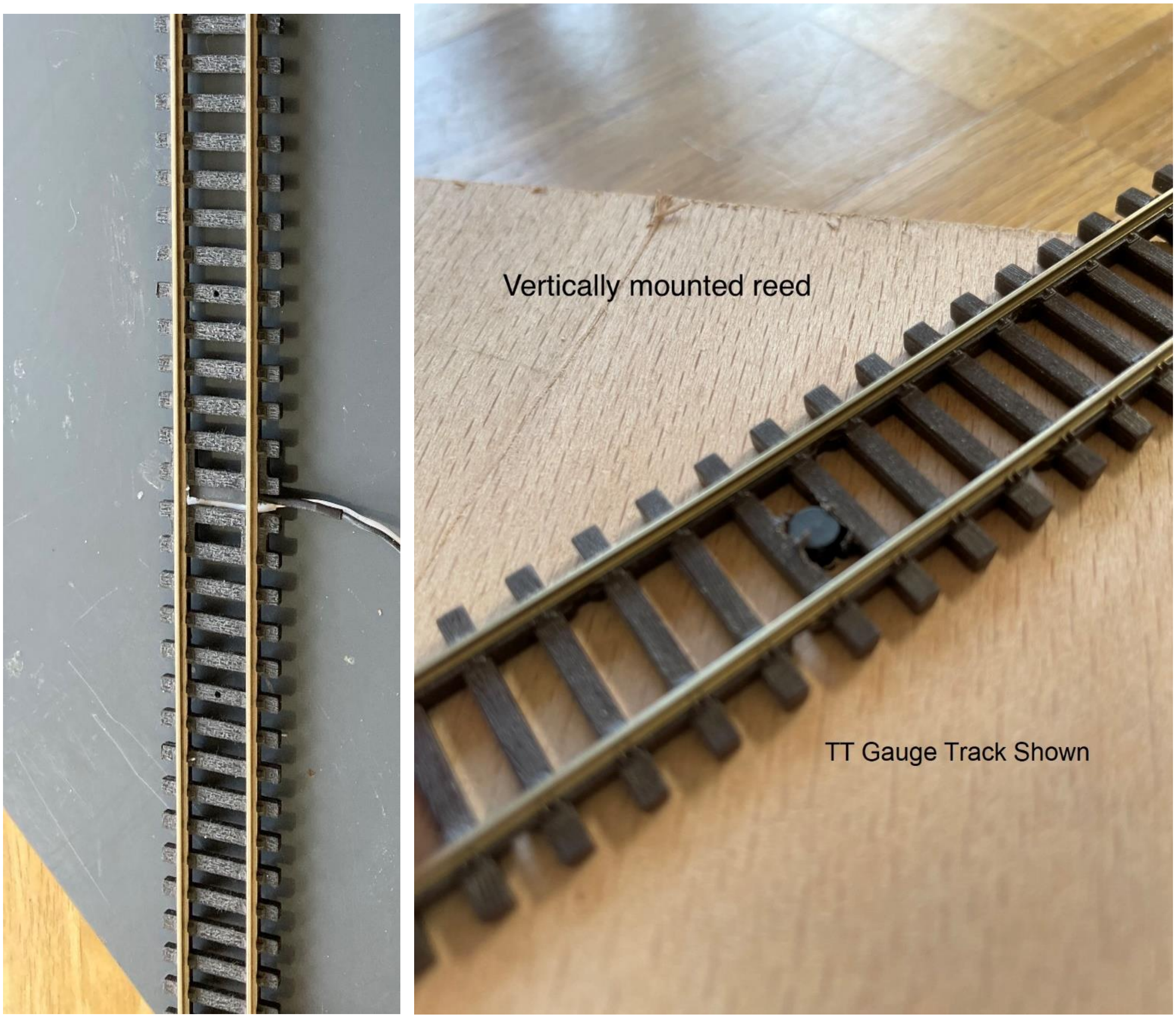


Fig 36A & 36B - Horizontal & Vertical mounted Reed Switches located between track sleepers.

Only two wires of the three wire pigtail are used with a reed switch. The red wire end is sleeved with heat shrink and not used. Use caution to ensure that either reed switch wire does not come in contact with the live DCC track rail.

Reed Sensor Fabrication

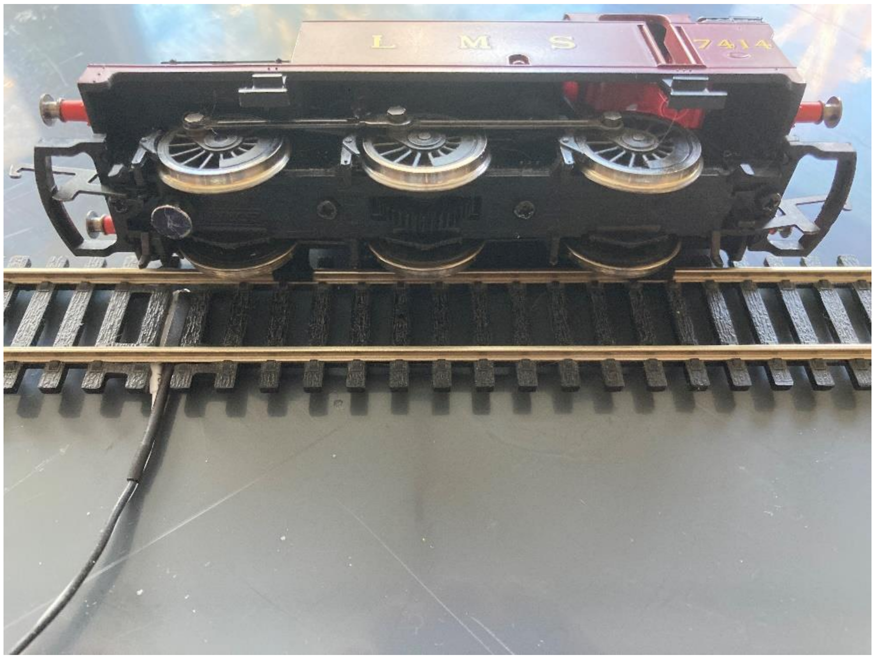


Fig 37 - A Horizontal Reed switch sensor and locomotive magnet.

Connect the reed switch sensor wires to the Yellow (Signal) and the Black (Common) wires of the supplied pigtail wire assembly.

Vertical reed switches are also available from various vendors and present a smaller profile.

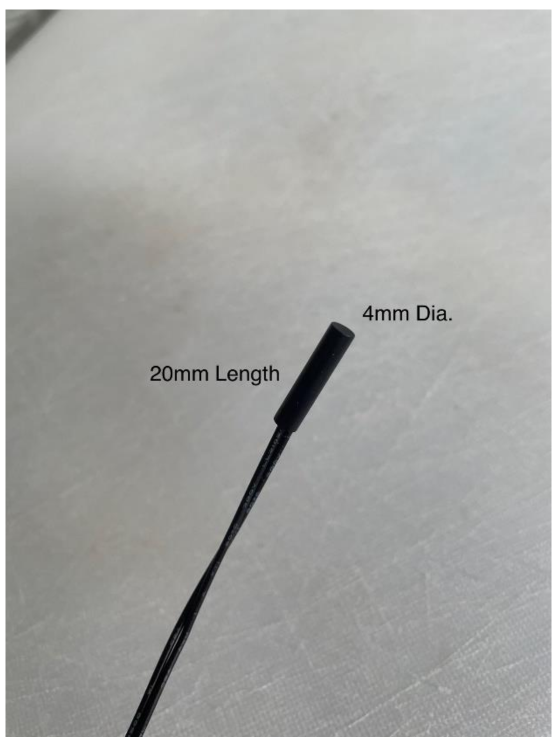


Fig 38 – Vertical Reed Switch - Use normally open switches.

Troubleshooting

If one or both BLUE Motherboard LEDs don't light –

Channels 1 to 16 are fused via a self-resetting fuse on the motherboard. Channels 17 to 32 are also fused with a self-resetting fuse. In the event of one or both of the blue LED power LED's not being lit when power is applied, immediately disconnect power. Allow at least 60 seconds or more to reset the fuses.

Remove the modules on the impacted side and restore power. If the LED's now all light on the motherboard when power is applied, further isolate the issue by only plugging in one module at a time.

Then disconnect sensor input wires one at a time to isolate a possible shorted or miss-wired sensor.

If the BLUE Fibre Optic TX module LED doesn't light –

Is the module connected to track power and is the track power on? Disconnect all the track sensor input wires. Does the blue power LED turn on now? Replace the sensor cables one at a time until the faulty sensor wire is identified.

If a module does not detect a magnet when brought near a sensor –

Try unplugging the sensor and plug it into a different detector channel. If this does not work, try using a different sensor. Use the status lights to observe for functionality.

WHY is Electrical Track Isolation Important?

TGG uses sensors placed around a layout that allows the TGG software to keep track of trains under its control. The TGG system allows for precise control of one's layout.

Currently up to 32 sensors can be detected by using a single USB based BBI-32 interface – 64 with two BBI-32's.

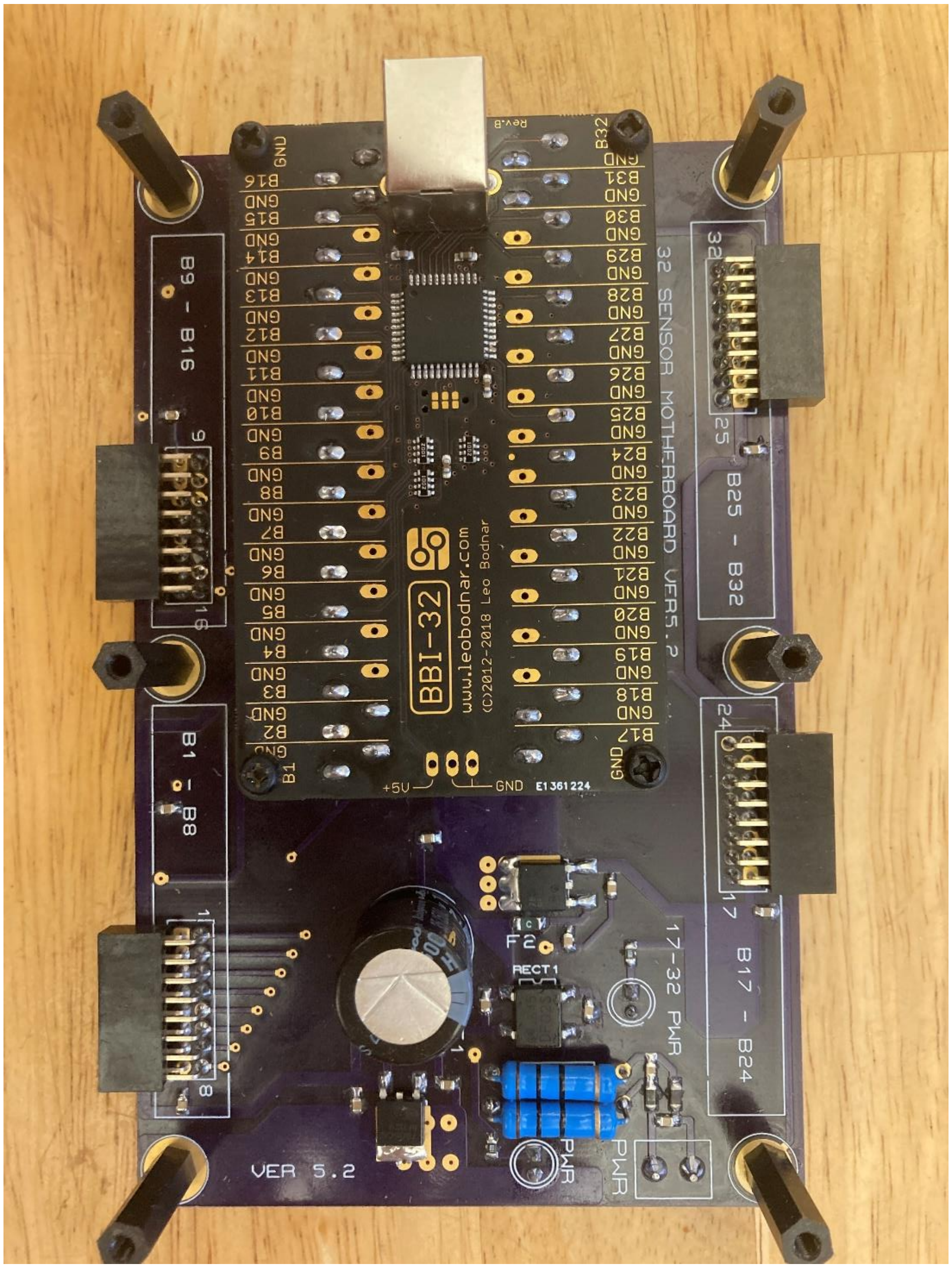


Fig 39 – BBI 32 interface mounted directly to motherboard.

Train Sensors

Train location can be sensed using many approaches, the most common is a simple reed switch placed somewhere on the track and triggered by a magnet on the locomotive.

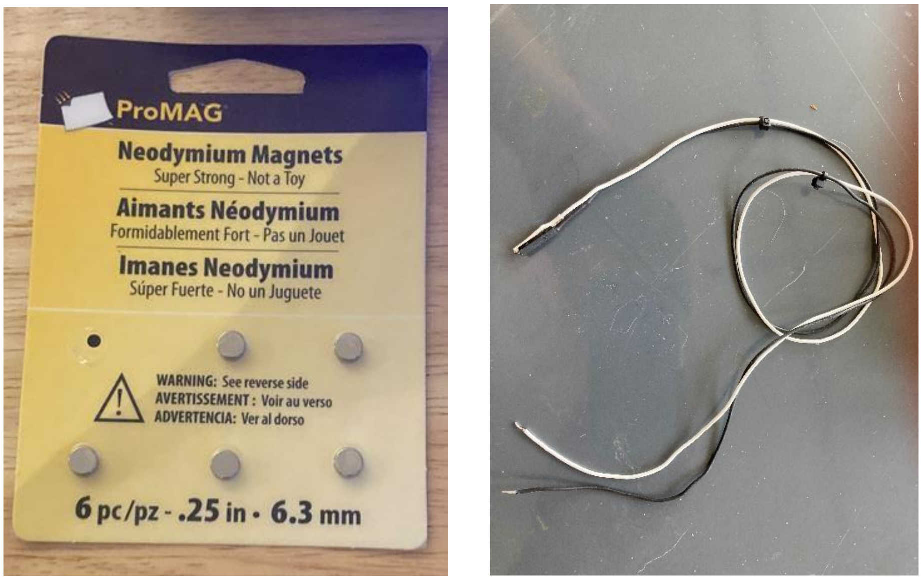


Fig 40 - Magnets and a Reed switch sensor

Other detection methods can use Hall Effect Sensors – which have the advantage of small size but require an operating voltage in addition to a common wire and a signal wire. So small, but slightly more complicated to use.

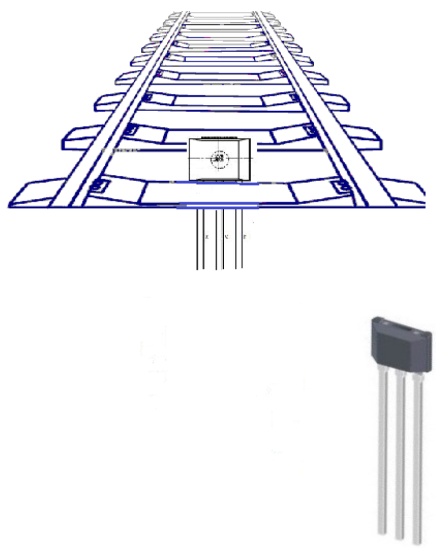


Fig 41 - Hall Effect Sensor and track

Another less common but interesting detection method uses an IR light source, an IR detector located under or beside the track. A reflector is placed on the locomotive to reflect the IR light and indicate the presence of a locomotive.

Fig 42 - IR light source and detector

The HAZARD

All of these train sensors are placed near, between, or beside the DCC powered track, where in lies the risk. If any of the sensor wires accidently come in contact with a live DCC rail, power from the track could flow unchecked into the BBI interface and even possibly up the USB cable into the supporting PC. In the event of DCC power being accidently applied to the BBI-32 permanent damage may occur to all the associated electronics.

So what does one do? Well firstly one must try and ensure that any bare sensor wire cannot come in contact with a DCC rail. But even when one is careful, things can happen on a layout – a derailment, placing landscaping might nudge a sensor, wiring gets accidently pulled……

Electrical Isolation

If the DCC powered track has no connection of any kind to the sensing system, then the accidental connection of one sensor wire could be ignored. One needs a complete circuit (two wires) for current to flow – so a single point contact might not be an issue.

Unfortunately the DCC system has another common contact point to the rest of the system. The DCC system “ground” or common is on the USB cable that connects to the DCC throttle controller, the PC and the BBI-32 interface. The USB cable serves in effect as a common connection. So an accidental sensor wire contact to a live track is probably bad news.

So what could be done to prevent or at least lessen the risk to one's layout electronics? There are fortunately a number of approaches to limit or isolate one's electronics from damage in the case of an accidental short to DCC powered track.

Optical Isolators

Fig 43 - A typical optical isolator

An optical isolator is exactly as its name implies – it isolates any electrical connection. In the previous picture of the isolator, there are two terminals on each side of this device. There is no electrical connection between the pins on the left side of the device to the pins on the right side. The only connection is a light beam inside the device and invisible outside of the device's package.

The isolator consists internally of an light emitting diode (LED) and usually a photo transistor or light detector of some type – hence the 4 terminals on the device.

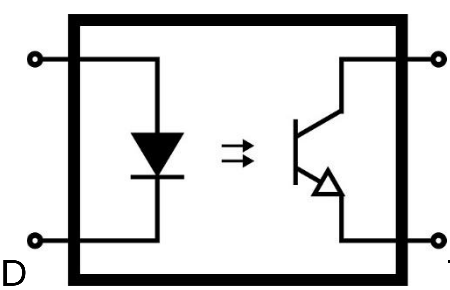


Fig 44 – Optical Isolator schematic

Think of the transistor as a simple switch – if the LED light is on, then transistor switch is closed / if the LED is off, the transistor switch is an open circuit.

The ONLY connection from one side of the device to the other is a light beam!

So perhaps a device like this could protect the BBI-32 and any downstream electronics from damage if a sensor wire comes in contact with the DCC powered track?

If one places an Optical-isolator between the track sensor and the BBI-32 **then the only connection between the track and the BBI-32 is effectively a light beam**. However, one other part of the puzzle is still missing. How does one power (see the "?" on diagram) the reed switch and the LED inside the Optical-isolator without defeating the isolation?

See the schematic diagram Figure 45 "Isolated Detection" on the next page…..

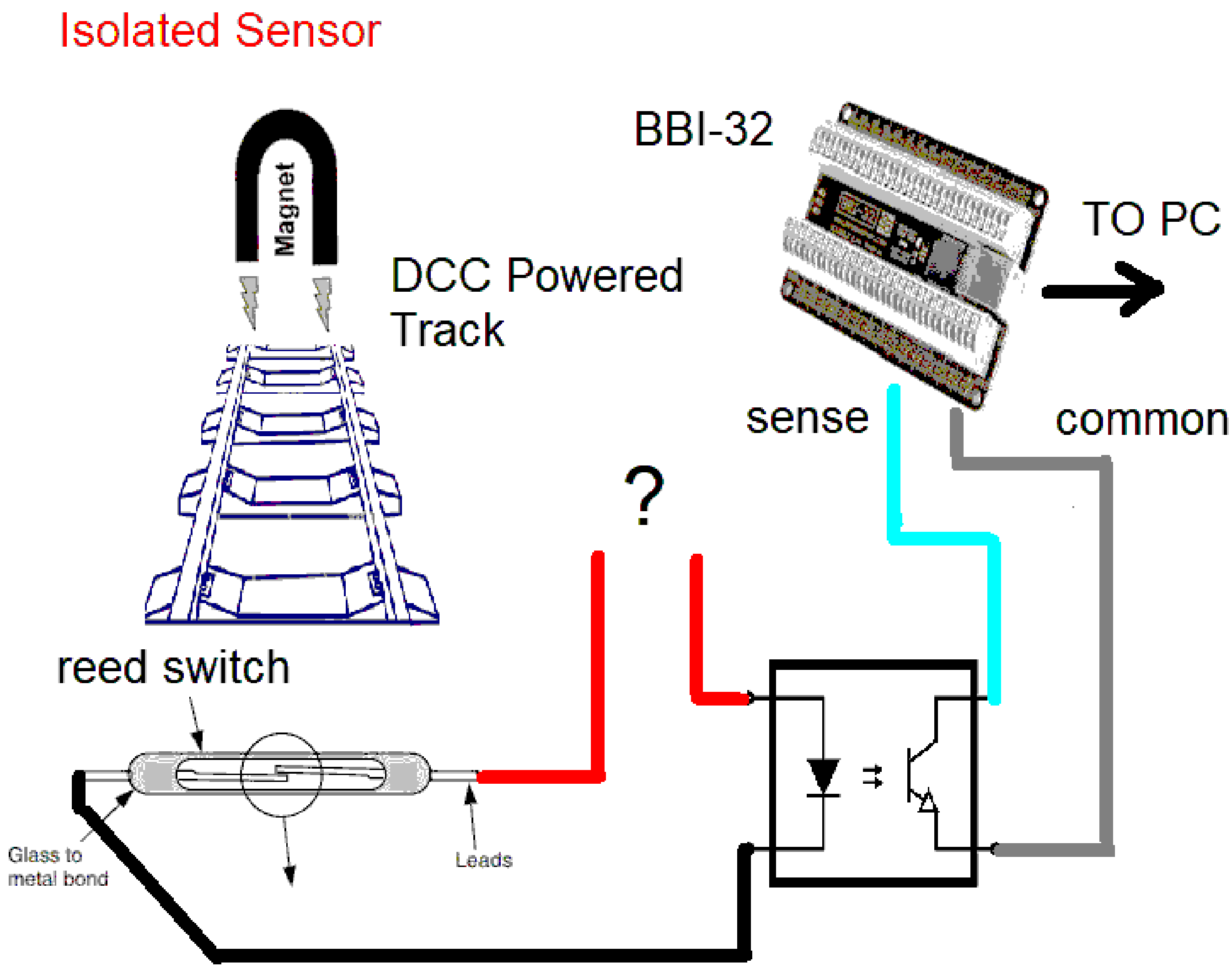


Fig 45 - Isolated Detection

Powering the reed switch and the LED will require another special device that can provide power without defeating the isolation that the Opto-isolator just provided. If one didn’t mind using a small AC wall adapter that provided a small DC voltage – say 5 volts or so, then that might be the way to go. But it would be nice if we could power our reed switch circuit perhaps from the track power itself?

To power the reed switch circuit from the track without defeating the optical isolation and still providing protection for the DCC throttle and the BBI-32 interface one needs to employ a device called a “DC to DC converter”. **Someone once said to me if you start with a DC voltage and you end up with a DC voltage – why does one need a “converter” to begin with? Good Question!**

Well another way to provide electrical isolation, other than using light is to use a magnetic field. If one places two coils of wound wire close to each other but not actually touching, one can magnetically transfer electrical power between the two coils but there is a catch – the magnetic field must be changing or the energy transfer stops.

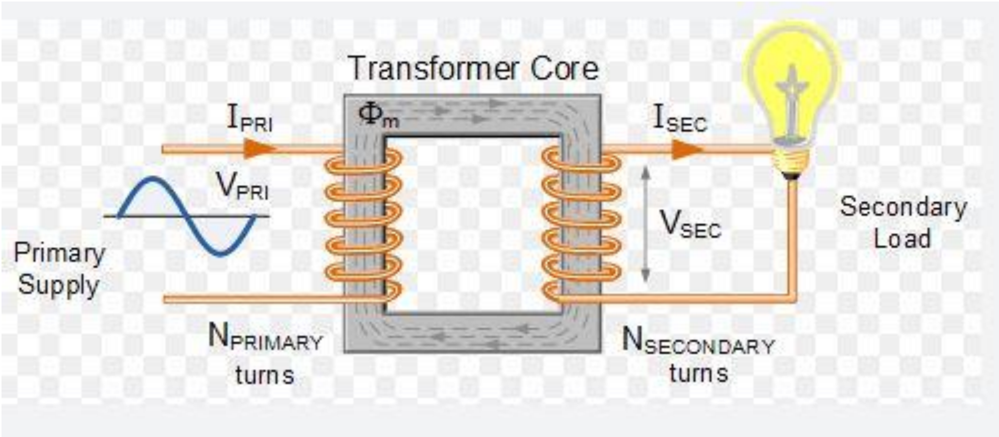


Figure 46 - Transformer isolation

Now in this diagram the electrical voltage applied to the transformer is sinusoidal because that's what mechanical generators produce and that's what comes out of the wall outlets in our homes. However with a DC to DC converter we are starting with a DC supply – not AC – so how does one employ a transformer? Well one can CHOP the incoming DC into pulses of DC and apply it to the winding of a transformer. It's not as efficient as a sinusoidal waveform but electrical energy will transfer between the two non-touching windings of wire. The pulses of energy magnetically coupled to the second coil of wire can then be easily converted back to a steady DC voltage (using a bridge rectifier and a filtering capacitor) and voila we have an isolated source of power that shares no common connection to any other wiring around it. A DC to DC converter.

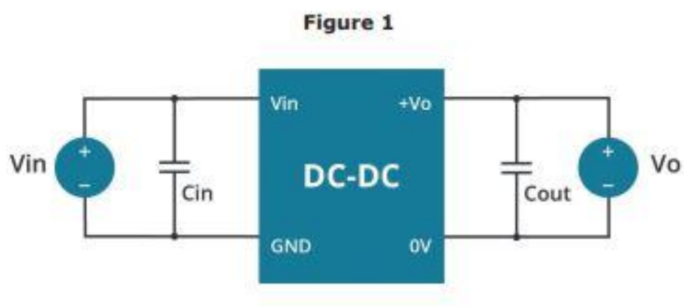


Fig 47 - A DC to DC converter

In real life these devices with all electronics and transformers built in can be very small,

Four wires – DC power in / Isolated DC power out

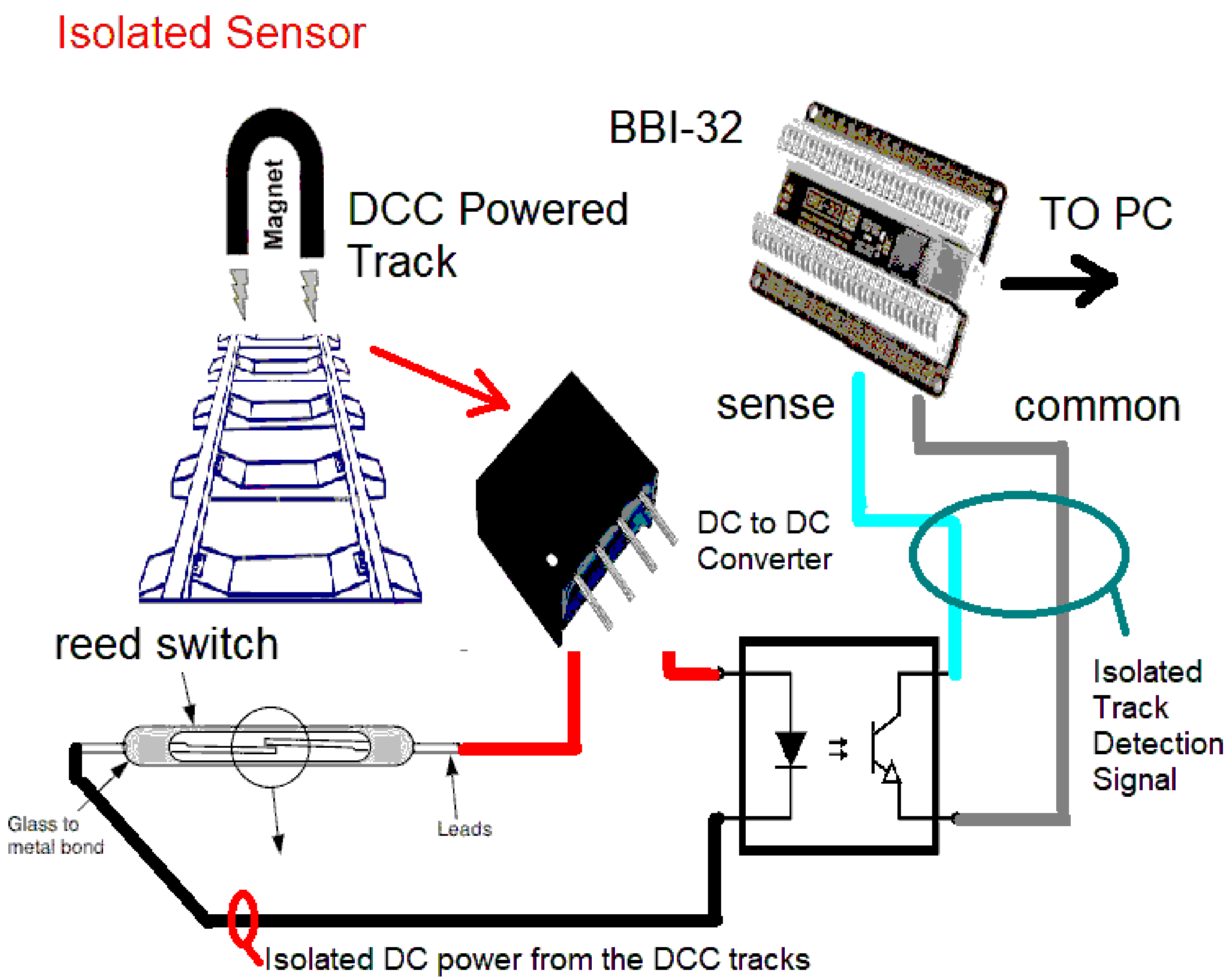


Fig 48 – employing the DC to DC converter

Now we have a sensor that doesn't share a common connection with the DCC track that it is actually powered by. The power is magnetically coupled. Short one end of a sensor to the track and nothing happens. You need two connections to make a circuit. The detection signal to the BBI-32 is optically connected.

Any electrical "chaos" STOPS at the Opto-coupler. No damage occurs to the BBI-32, the PC, or the DCC throttle Controller.

This is electrical isolation being used to protect the expensive electronics on one's layout. The isolation itself is of course not without some cost but its cost is relatively small compared to all the other electronics involved with your layout.

Version 5.2 Isolated Modules

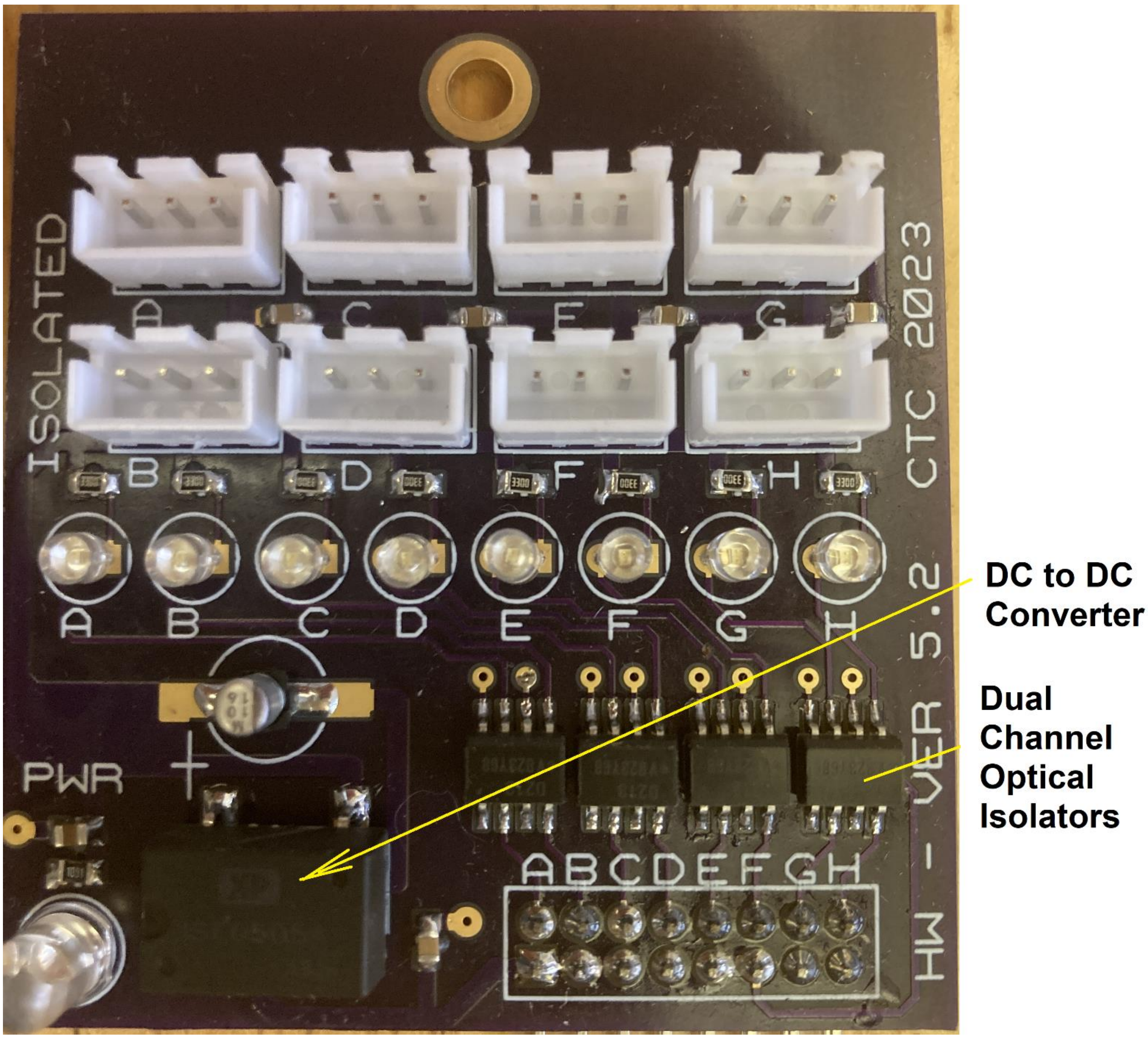


Fig 49 - Hard Wired Optical Isolator

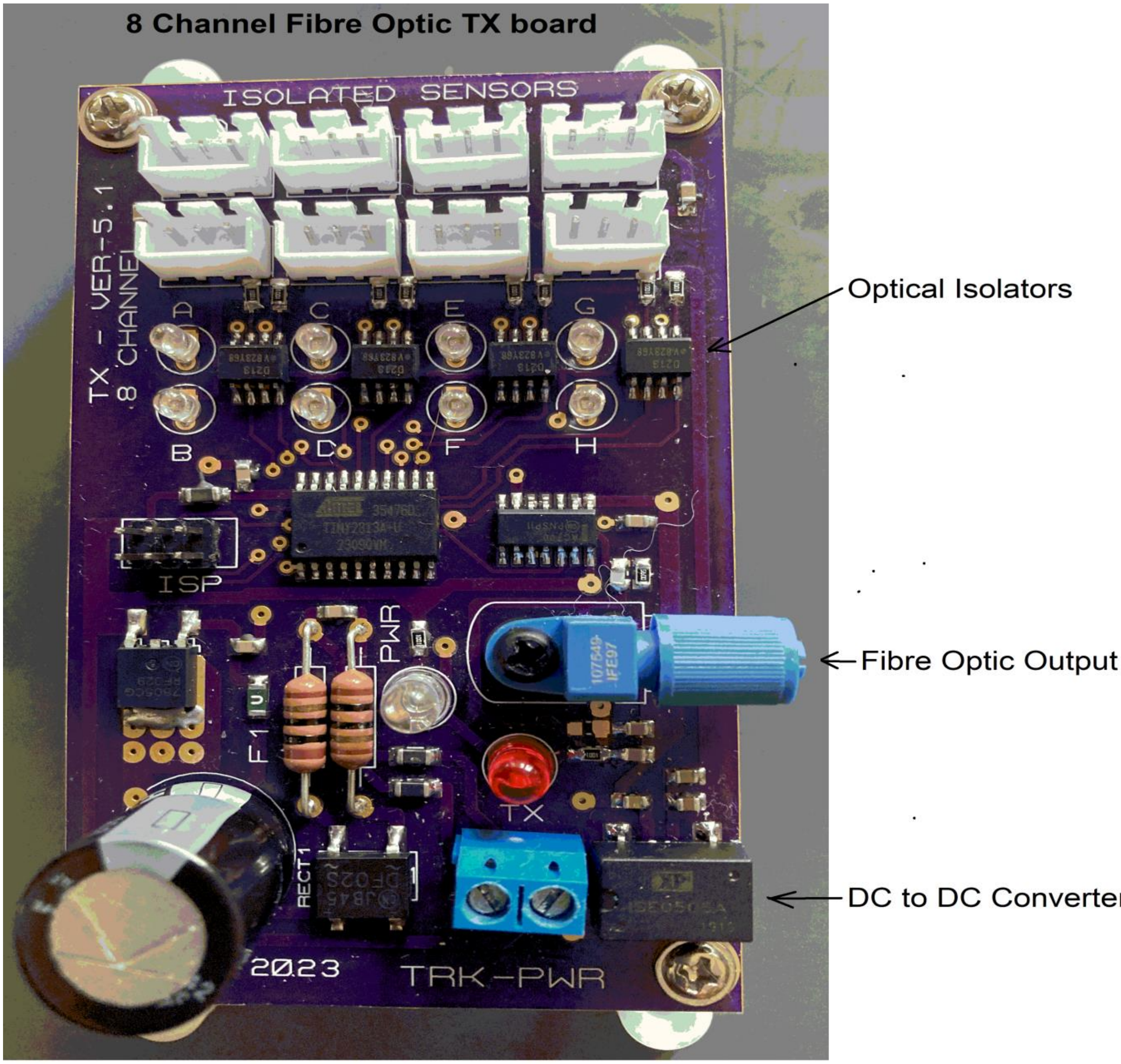


Fig 50 – An 8 Channel Fibre Optic TX Module

Track Sensors & Electrical Isolation

I haven't mentioned anything yet about the typical logic device's "input protection" which is incorporated into most logic devices. Logic devices today are vulnerable to static electric discharge when the device ("chip") is not actually installed on a circuit board. As a result the integrated circuit manufacturers build into logic devices – input protection. This is both a blessing and a curse as we shall soon see.

(I am grateful for an excellent technical article found on Digi-Key's website and from which I have drawn a number of diagrams. If one want's to review this article directly - https://www.digikey.ca/en/articles/protecting-inputs-in-digital-electronics)

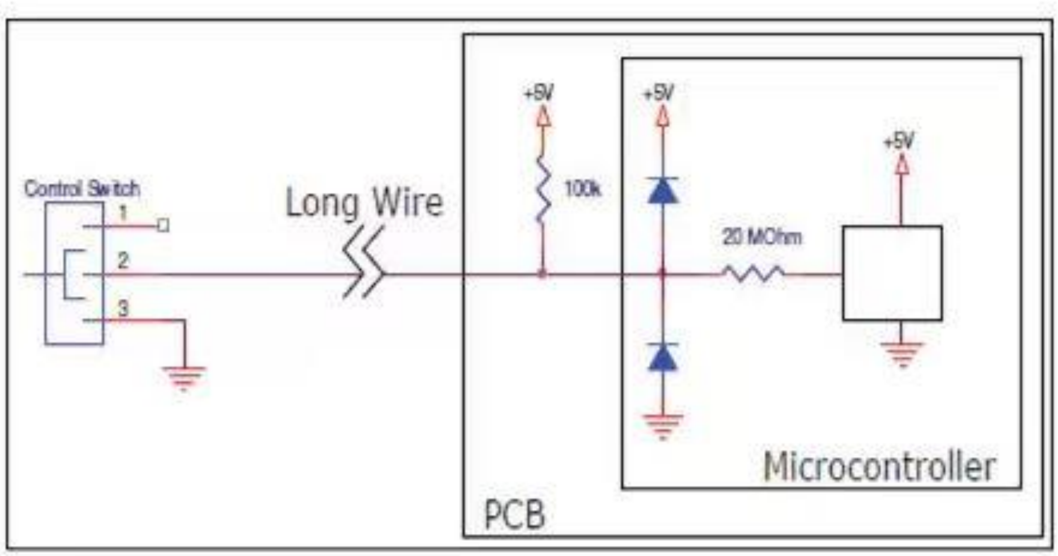


Fig 51 – switch attached to a long wire / Microcontroller = BBI-32

Think of the "control switch" shown in the above diagram as a track reed switch. And consider, the "Microcontroller" as the BBI-32 that we employ with our TGG controlled layout. All the circuitry inside the Microcontroller "box" is actually inside the "chip" or device itself. In the BBI-32, the 100K pullup resistor connected to +5V is also inside the BBI-32.

The "pullup" resistor pulls the switch sensor input line up to the +5V of the circuit's logic power supply. (Most but not all digital logic uses either +5V or 0V to represent a logic 1 or 0.)

When a magnet equipped locomotive crosses the track mounted reed switch, the switch closes and the wire is pulled from +5V to "ground" or 0V. The TGG software via the USB port is then signalled by the BBI-32 of the track sensor's change in status. TGG then "knows" where the locomotive is on the layout.

All pretty straight forward?

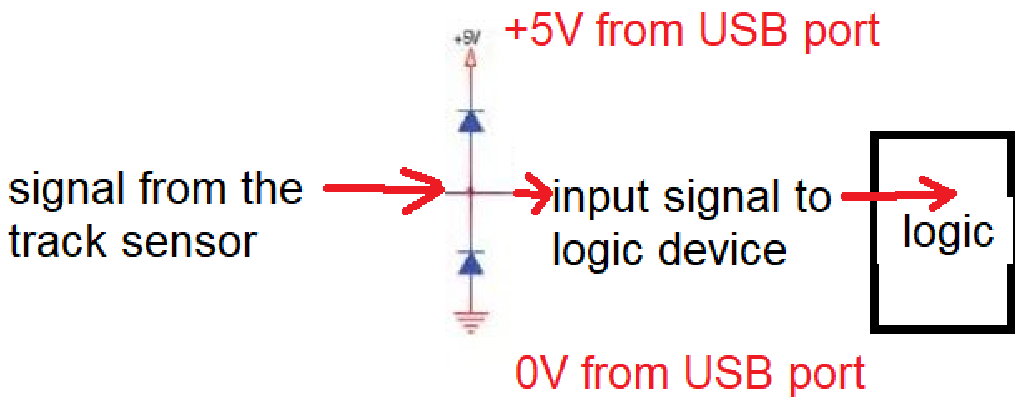


Fig 52 – typical logic device with internal input protection diodes

The two ‘bluish triangle symbols” inside the box labelled “Microcontroller” are protection diodes. These diodes prevent the input voltage on our BBI-32 input pin from going above 5V (5.6V to be precise) or below 0V (-0.6 to be more exact as silicon diodes require 0.6V to operate). If the input voltage does try to go above 5V the protection diode connected to 5V “dumps” the excessive voltage into the logic power supply. The logic power for the BBI-32 is supplied via the USB cable from the supporting USB connector on your expensive PC’s motherboard. The same is true if the input voltage drops below zero, the excessive negative voltage is again directed back into our expensive PC!

So where do these excessive positive or negative voltages come from?

Well, we’ve discussed the first source of dangerous voltages – the plus or minus 20 volt DCC signal travelling along the track sensor wires after the track sensor accidentally comes into contact with a DCC powered rail.

The DCC voltage is so much more than the normal 5V logic signal, that the protection diodes would fail (likely melt) and destroy the BBI-32 instantly. After the protection diodes fail the excessive DCC track voltage will likely travel up to the USB port, via the +5V or 0V power lines within the USB cable – is the PC motherboard far behind?

The second source of over or under voltage that may reach the BBI-32’s inputs is NOT from the DCC track itself, and can occur without any sensor accidently contacting the track! This source however has a lot less overall energy involved so the protection devices may survive and protect the BBI-32.

This second voltage threat is generated by the long sensor wires themselves!

When the track sensor is closed a small current flows through the long sense wires on the layout. However, when the train moves away from the sensor and the reed switch opens, the small magnetic field that had been generated around the track wire almost immediately collapses and induces an oscillating voltage in the sensor wire. (Pictures are again from the previously cited document.) In Figure 53 below, the voltage is going from 5V to 0V instead of 0V to 5V – but the effect is the virtually the same.

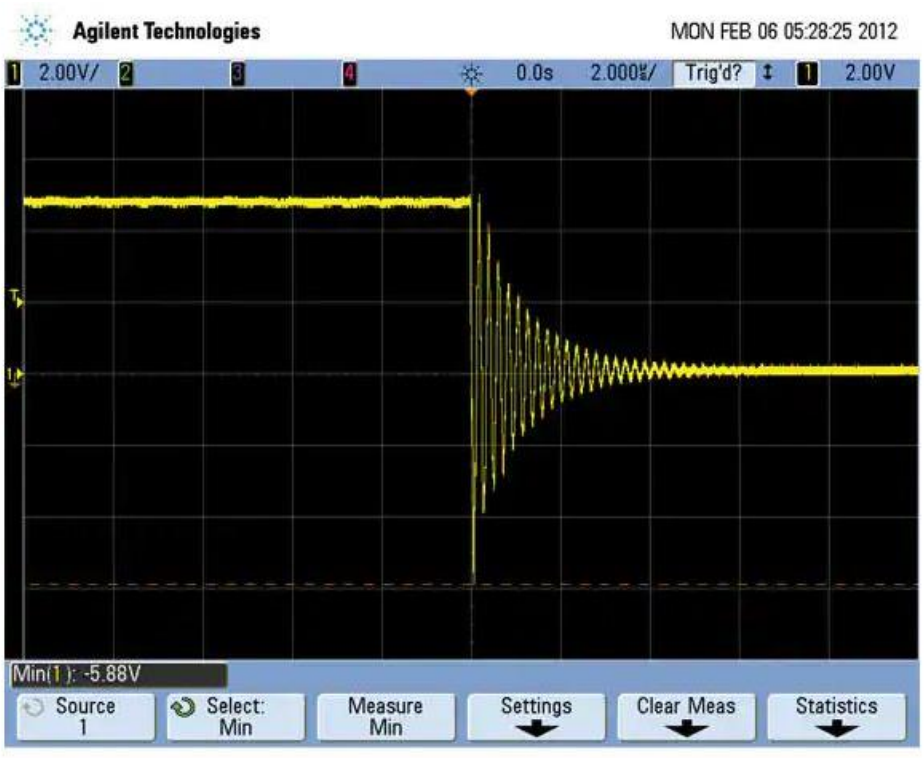


Figure 4: Switch from open to ground.

Fig 53 – Long sensor wire inductive "ringing"

This magnetically produced voltage can at times, be both several volts above and below the normal 5V and 0V logic levels. The protection diodes can in all likelihood absorb this energy by routing it into the PC's power supply. But the longer the wire, the more the energy.

So there are several things that one can do to help the logic devices protection diodes to survive and do their job of protecting the BBI-32.

- **As mentioned before, use optical-isolators and a DC to DC converter to prevent any direct connection from a DCC powered track reaching the BBI-32**
- **Use small capacitors to absorb the inductively induced voltage produced by long sense wires from reaching the BBI-32 or optical isolators.**
- **Keep the track sense wires as short as possible.**

The following page shows a diagram that illustrates a system to isolate and protect the TGG electronics.

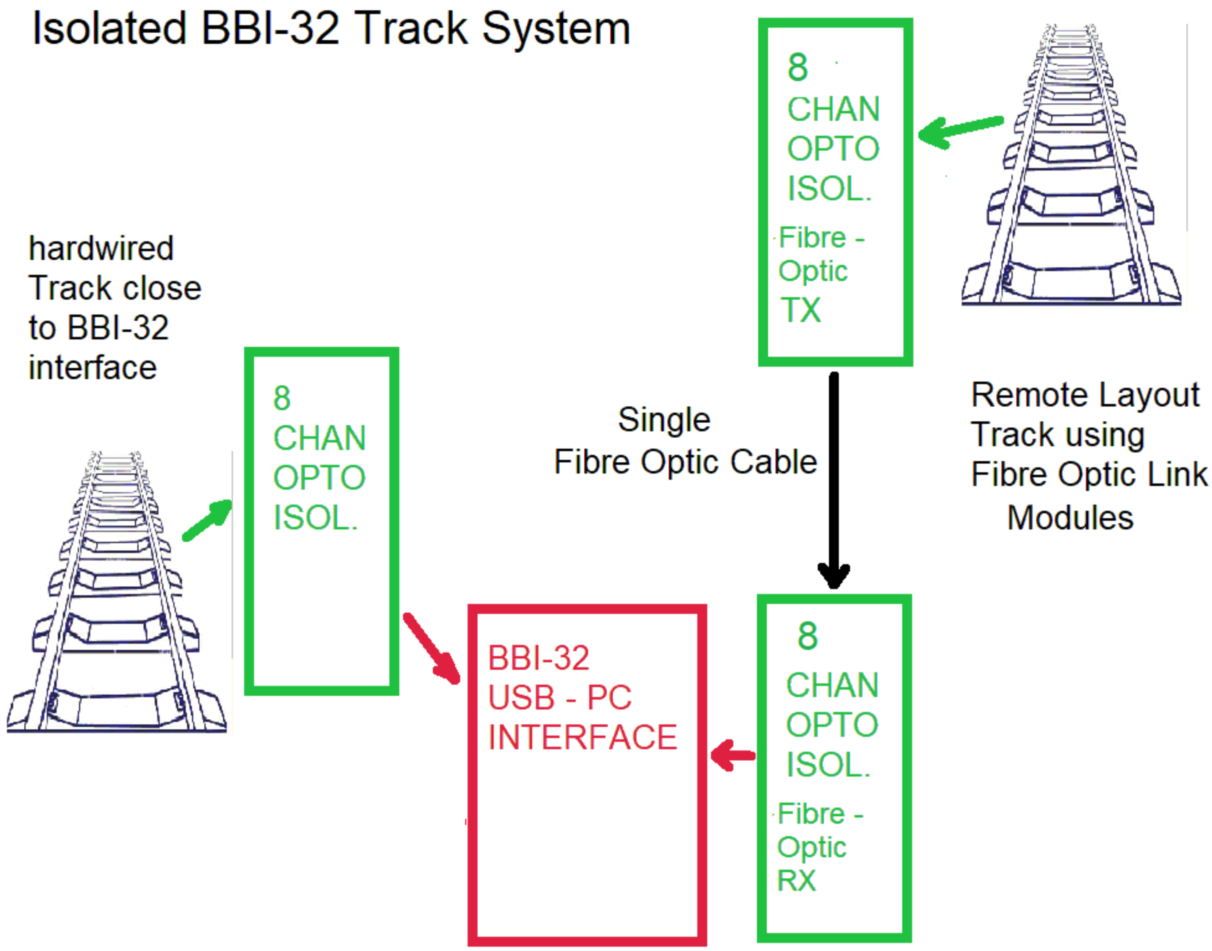


Fig 54 – Isolated BBI-32 Track detection system for use with TGG software.

Version History

Version 1

This was a first attempt at wireless detection using prefabricated RF modules for use with TGG software. The module provided for either Hall or Reed switch sensor inputs. The RF module had 6 channels. Unfortunately the module’s scan rate was slow, resulting in the occasional missed train – oops!

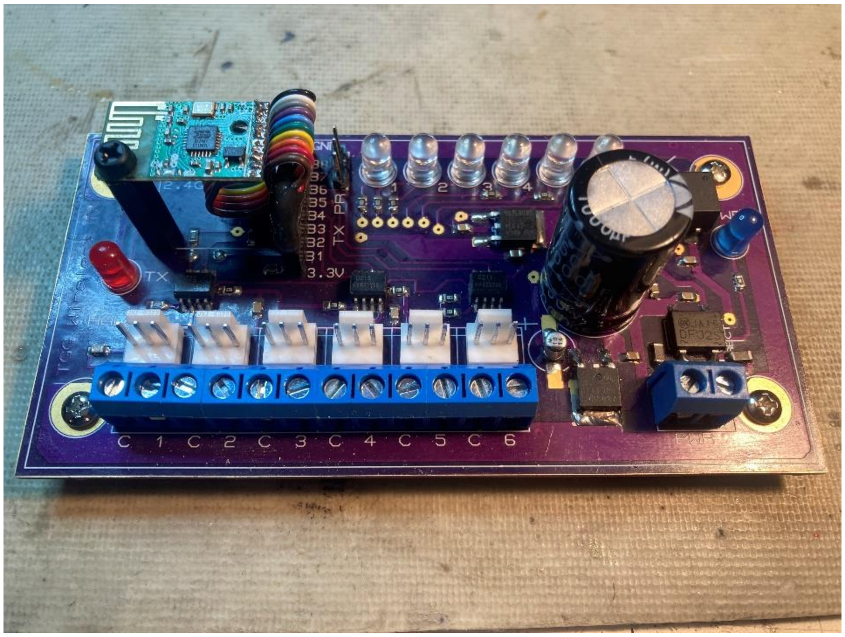


Fig 55 - Wireless Version 1 Module

Version 2

A small microprocessor was designed into the wireless module to improve the detection accuracy of the RF module. While this version was designed, it was never actually fabricated.

Version 2

Designed but Never Fabricated

Version History

Version 3

This was the first module type to employ fibre optics, however it still retained the original 6 channels from the previous RF module. This Version 3 TX module required two additional 1 watt resistors to be installed in the power lines when connected to the layout tracks. The Version 3 receiver also required improved electrical isolation when connected to the BBI-32. Note the similarity to the previous RF version.

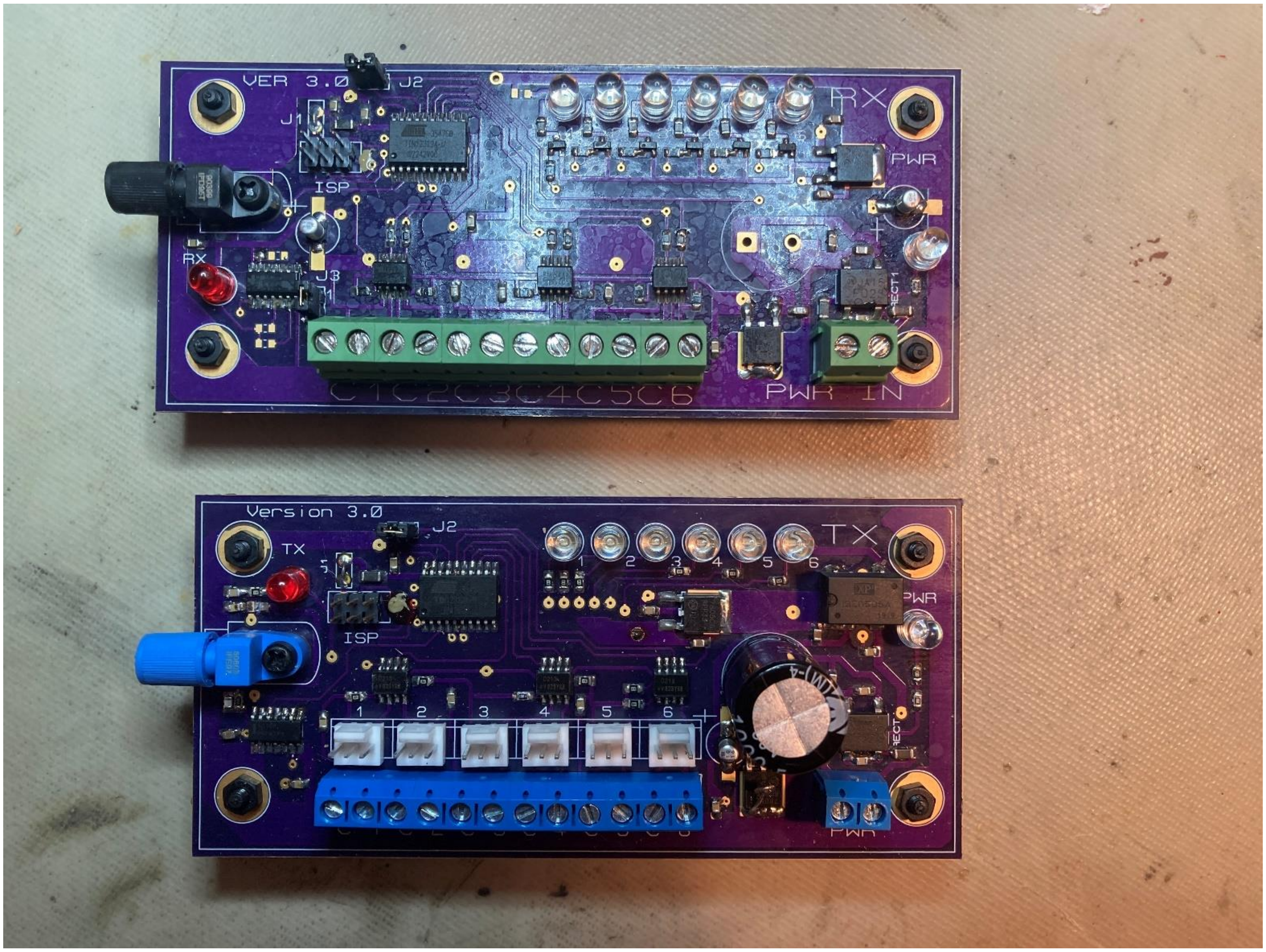


Fig 56 - Version 3 RX and TX modules

Version History

Version 4

This version incorporated the previously required 1 watt resistors into the printed circuit board, thus eliminating the need for externally added resistors when using track DCC power. Isolation was improved in the Version 4 RX module. In addition to the revised Fibre Optic modules, a Hardwired 8 channel isolation module was introduced.

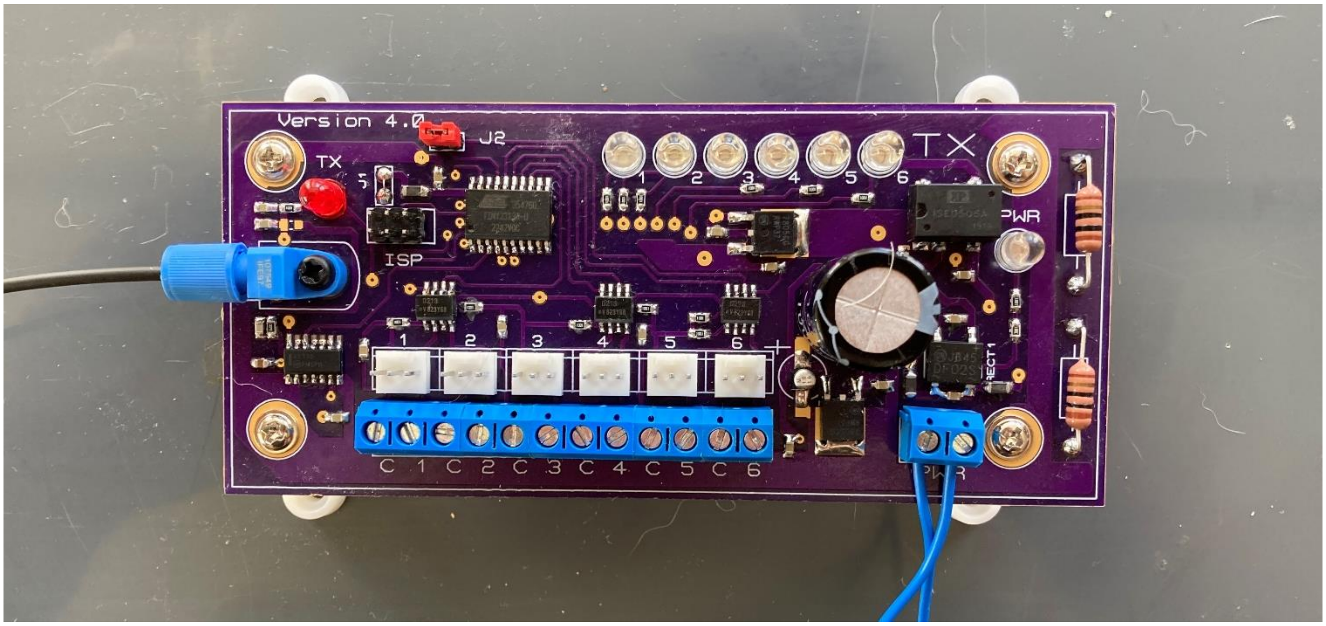


Fig 57 - A Version 4 Fibre Optic TX module with onboard 1 watt resistors.

Fig 58 - Introduced with Version 4 – A Hardwired Isolation Module

Version History

Version 4

Unfortunately, while virtually all the “bugs” were out of the Version 4 modules, all the modules still required additional wiring to connect to the BBI-32 interface. This was no small matter as shown. (See Fig 59.)

Furthermore, given the fibre optic modules continued limitation of 6 channels – more modules were required for a full 32 sensors system.

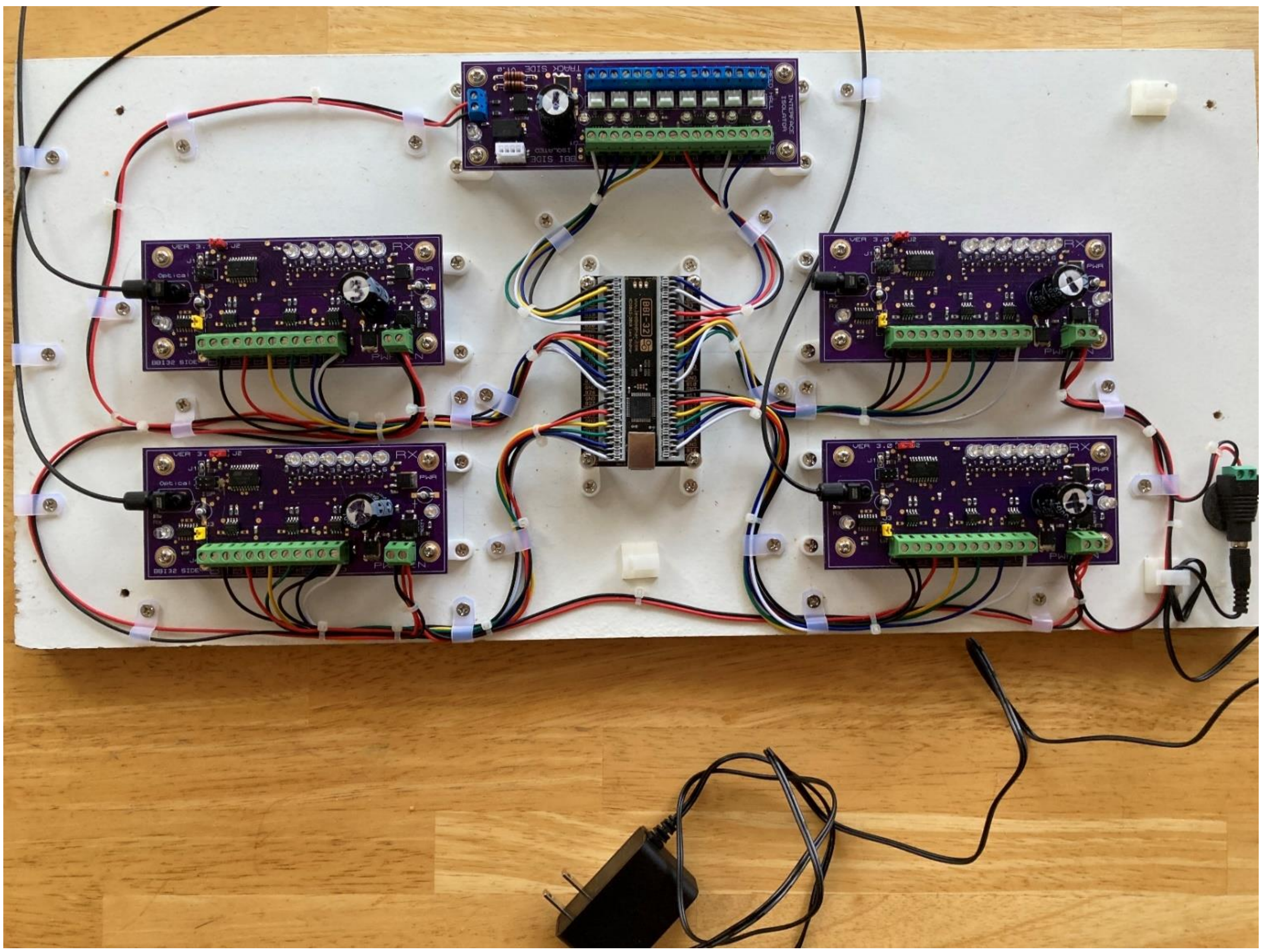


Fig 59 - Version 4 required a lot of wires and more modules!

Version History

Version 5

Version 5 took a modular approach, by being the first system to employ a motherboard. The result was a compact system that eliminated all the additional BBI-32 interface to module wiring as seen in Figure 59. It is now, as quick to install, as a single BBI-32 without isolation.

Version 5 comes in two formats – a flat pack or vertical format. Both formats feature the same modules – just the motherboard employs a different module connector – 90 degree versus straight connectors.

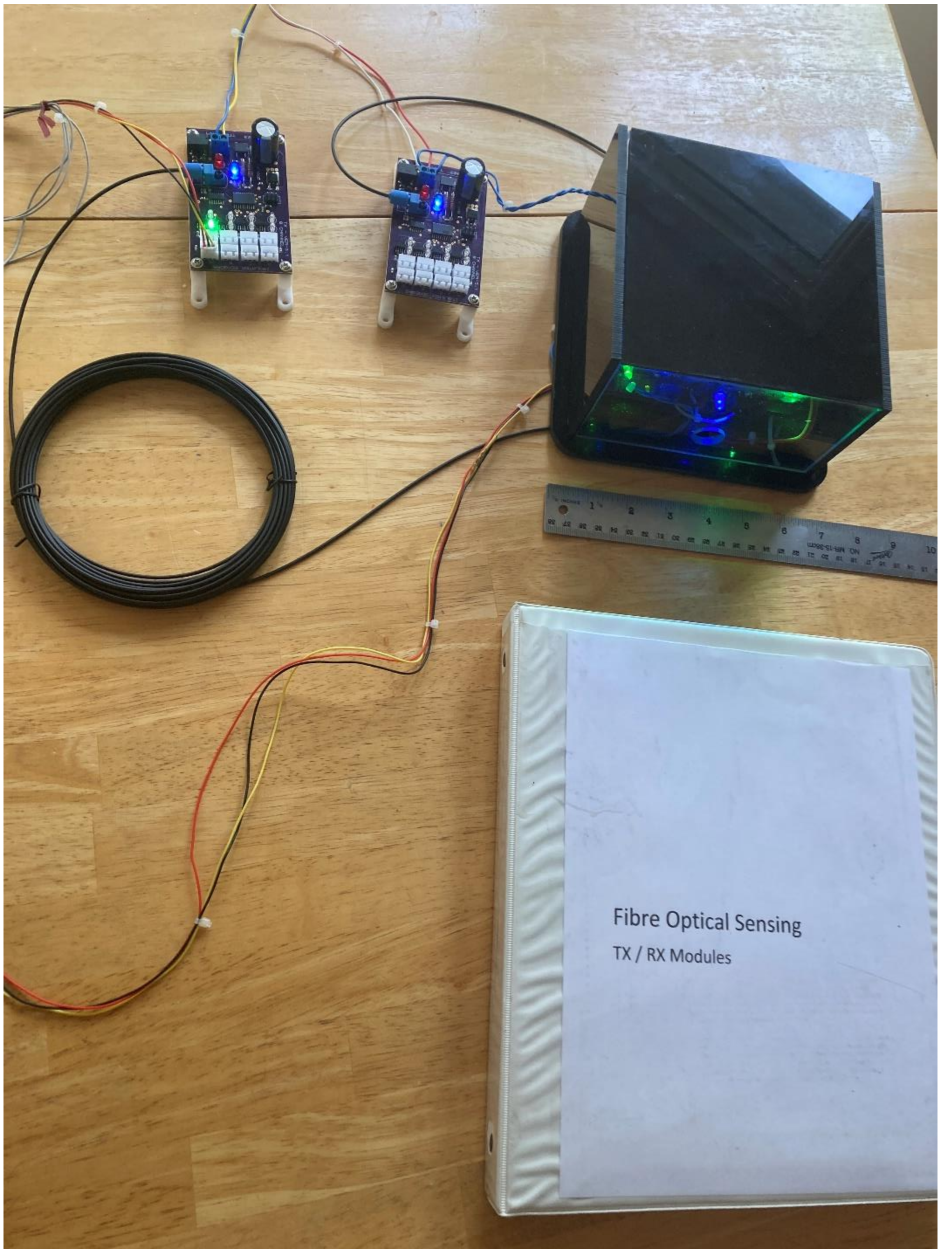


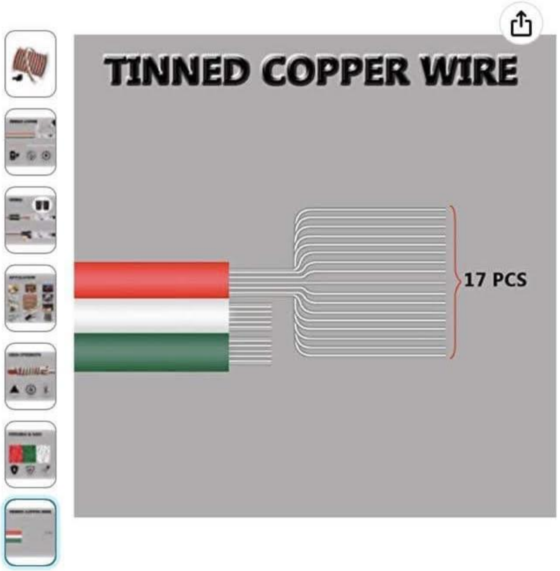
Fig 60 - Version 5 in a Vertical Format with two Fibre Optic TX modules

Version History

Version 5

Fig 61 - Version 5 in a “Flat Pack” format for easy under layout installation.

Appendix



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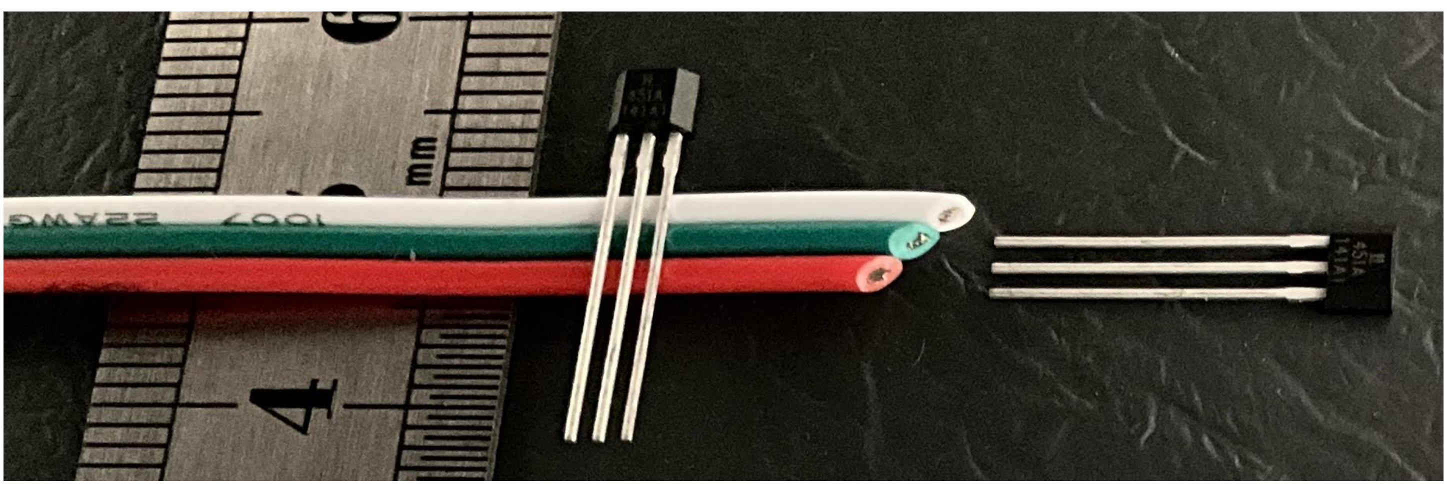
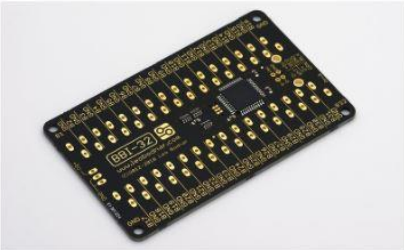


Fig 62 - Wire type & Source for Hall Effect sensors

Appendix Continued

BBI-32 Button Box Interface - No Connectors



Price: £22.50

1

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Product Description

A low profile version of the regular BBI-32. Exactly the same features but without the push in terminals or USB connector allowing you to solder your own USB connection to the labelled solder tabs. At under 3mm thickness and the exact dimensions of a standard credit card, there are great possibilities for mounting into tight spaces at a reduced cost.

This is a universal USB joystick interface board with solder tabs to connect buttons, rotary encoders and switches to a PC, Mac or Linux computer.

Build your own gaming device, whether it be a flight panel, button box, joystick, robot controls and more......the list is limited by your imagination.

Also suitable for converting gameport devices or connecting real life controls to turn them into a USB device suitable to be used by almost any simulation or game software without the need of installing any drivers.

Inputs

32 button / 16 rotary encoder / 11 BBI-32 rotary switch inputs

Dimensions

Length	3.370" / 85.60mm
Width	2.125" / 53.98mm
Height	0.15" / 2.90mm
Recommended Wire Size	24AWG to 20AWG
Mounting Screw Hole Size	M2.5 or #3-56 - DO NOT ENLARGE THE MOUNTING HOLES

Exactly the size of a standard credit card, and without the connectors will happily fit in your wallet (should you ever need it to!)

Fig 63 BBI–32 to be used with Version 5 System