# Layout Input Monitor – Version 2
# – an NCE Auxiliary Input Unit Lookalike

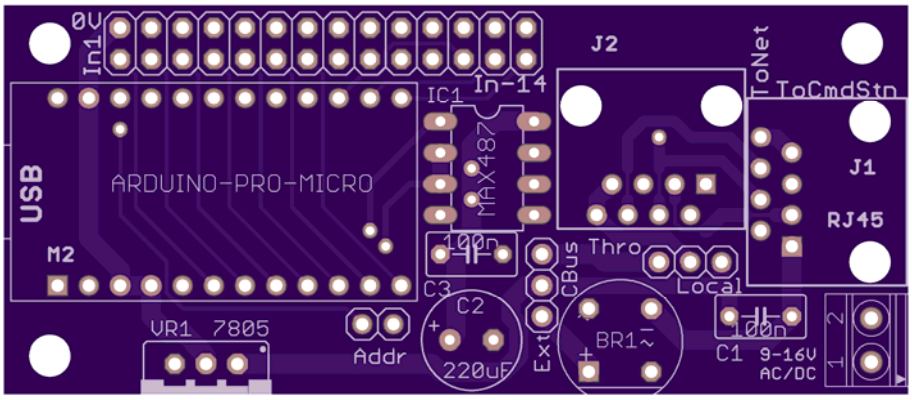
## Introduction

In the description of my Quad Servo Decoder-Monitor (QSDM), published in the June and July 2022 issues of Model Railroad Hobbyist, I suggested that you could simply build the Monitor half of the QSDM to give you a module which performed the same functions as an NCE Auxiliary Input Unit (AIU). Rather than use the larger (and more expensive) QSDM PCB a smaller PCB was also designed to hold just the Monitor section components.

However, this new module, named the Layout Input Monitor (LIM), still required an external power supply (9 – 16 Volts AC or DC) unlike the NCE AIU which is powered from the NCE Cab Bus (12 Volts DC). I therefore made a few modifications to the LIM PCB to allow it to be powered from either the NCE Cab Bus or from external power as before. If an external power supply is used, you can also configure the revised module (LIM-2) to provide 12 Volts DC to the downstream Cab Bus where this is needed to support the largest layouts.

The LIM-2 PCB to build the module is available as usual from OSH Park who will provide you with three boards at a cost of $18.10, which includes shipping to any destination worldwide. Just follow the link – oshpark.com/shared_projects/mgjhXEfO.

An outline of the LIM-2 board is shown in [1] below –




1. Layout-Input-Monitor-2 board

The LIM-2 module uses exactly the same components as the Monitor section of the QSDM – only the configuration of the two 3-pin headers has been changed. Hence, refer to the QSDM Part 1 document for a description of how the module is intended to operate, together with a full list of components plus links to recommended suppliers. The total cost of components for a LIM-2 module, including the PCB, should be under $20 – considerably less than the cost of an NCE AIU.

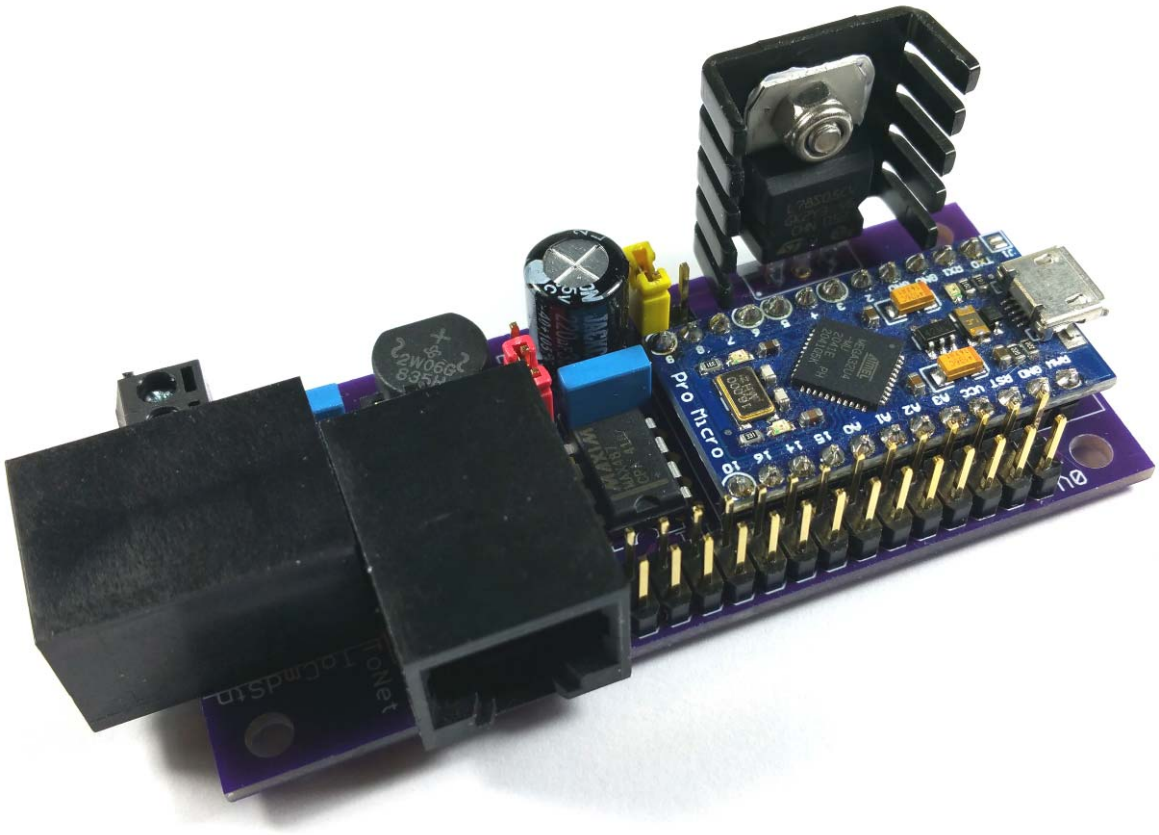
The QSDM Part 1 document also contains details of the Arduino software installation you need to provide in order to download the appropriate sketch (program) to the Pro-Micro module.

Each device connected to the NCE Cab Bus has to have a unique address, and the easiest way to set a Cab Bus address for your LIM-2 is to build a plug-in Set Address module, again as described

in the QSDM Part 1 document although, as will be explained later, it is possible to set the address by using a set of shorting links

Once you have acquired the LIM-2 (and Set Address) PCBs and the required components, assembly follows the same steps as described in the QSDM Part 2 document, arriving eventually at the fully assembled module shown in [2] below –




2. Layout Input Monitor 2 – fully assembled

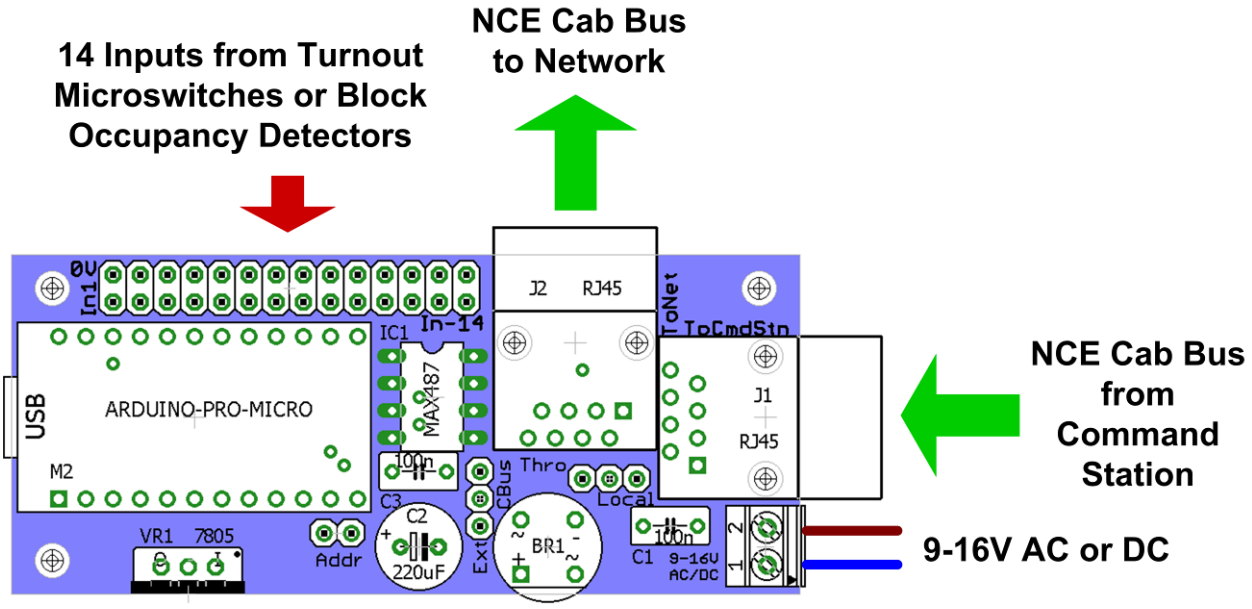
As you can see, the LIM-2 is based around an Arduino Pro-Micro module (a cutdown version of the Arduino Leonardo, but **not** to be confused with the Pro-Mini module which is based on a completely different processor). The Pro-Micro can use its serial port independently of the USB interface to transfer the state of up to 14 inputs (from turnout switches or block occupancy detectors) wired to the 14x2 pin header directly to the NCE Command Station's Cab Bus. The Cab Bus connection is implemented using cheap and available Ethernet Cat5/Cat6 cables with 8-way RJ45 connectors rather than the normal – and more expensive – NCE 6-way RJ12 cables.

Fairly obviously, control over the function of the LIM-2 is exercised through an attached computer application. You can use either the JMRI suite, which runs on a variety of computer systems, or my own A-Track application running on a Windows PC, both with a USB connection to either an NCE Interface Unit for Power Cab systems, or a USB-to-Serial converter for Power Pro systems. Note, however, that while JMRI works fine with a Power Pro command station, it appears to be unable to handle feedback from the LIM-2 (or from standard NCE AIUs) when using even the most up-to-date Power Cab system. I cannot claim to be any form of JMRI expert so, if anyone would like to tell me differently, I will be happy to be corrected.

## Connections

All of the connections to the LIM-2 are shown in diagram [3] below –




3. Quad Servo Decoder-Monitor – layout connections

In normal operation the LIM-2 is powered from the 12 VDC supply provided by the NCE Cab Bus through the RJ45 sockets. Alternatively, the module can be powered through an external supply of 9 to 16 volts AC or DC which can also be configured to provide a supply to the downstream NCE Cab Bus network. In the latter case, the external input needs to be at least 13.5 volts to compensate for the voltage drop through the bridge rectifier BR1 and provide a 12 volt supply to the Cab Bus.

The LIM-2 is connected to the Command Station Cab Bus via one of the 8-way RJ45 sockets (J1) using a standard Ethernet cable, and the Cab Bus is continued in daisy-chain fashion to the next LIM-2 (or AIU or other NCE device) from the second RJ45 socket (J2). Further details of the NCE Cab Bus network can be found in the QSDM Part 1 document.

Connections to the Cab Bus are only made after the LIM-2 software has been set up via the Arduino IDE, as described in the QSDM Part 2 document. The LIM-2 module can use the same sketch as the QSDM, although a customised version (with the module title changed) can be found in the Download section of the A-Train Systems website.

Once the software has been uploaded, you can then decide how to power the LIM-2, by setting a couple of jumper links, and prepare to give the LIM-2 a suitable Cab Bus address.

## Power Distribution

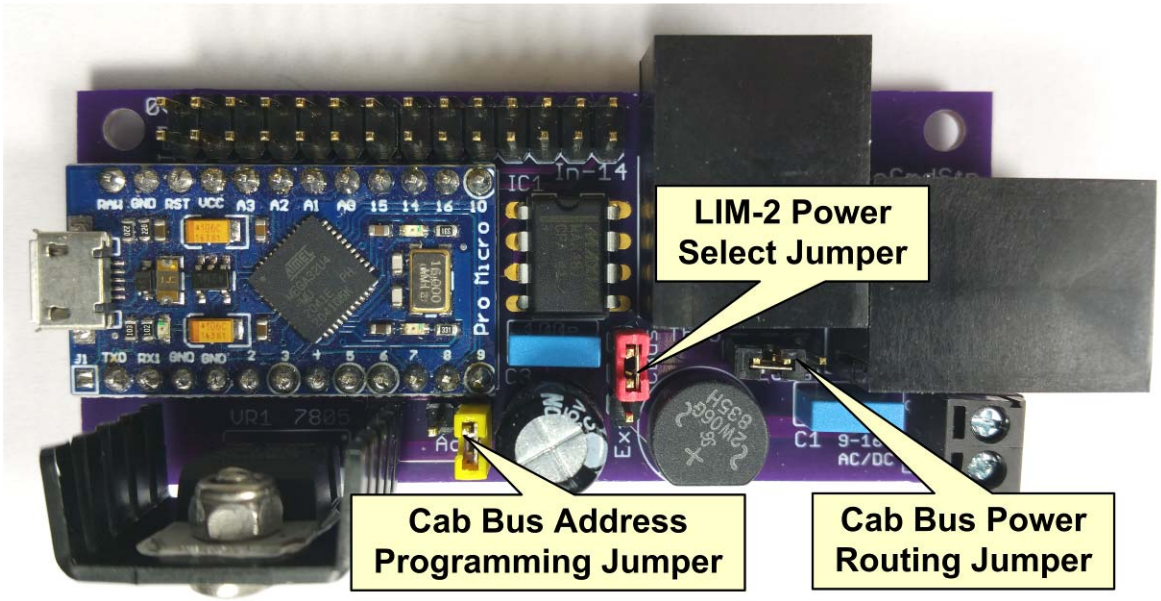
Jumper links on a pair of 3-pin headers are used to select how power is distributed to the LIM-2 and to the Cab Bus as shown in [4] below. The LIM-2 Power Select jumper (red) connects the LIM-2 to either the Cab Bus 12 VDC supply, in the position shown (Cbus), or to the external supply connected to the 2-way terminal block (Ext).

The Cab Bus Power Routing jumper (black) is normally fitted to the two leftmost pins of the header (Thro) to allow the 12 VDC supply carried by the Cab Bus to pass through the RJ-45 sockets. Fitting this jumper on the rightmost pair of pins (Local) allows the LIM-2 to supply power to the downstream section of the Cab Bus via the onboard bridge rectifier BR1. Such a connection

would only be necessary for a very large, extended layout and, as has been mentioned previously, would also require the LIM-2 to be powered from at least a 13.5 volt supply.

Note that you can use any colour of jumper that you like – I use different colours simply to help me identify which jumper is which –

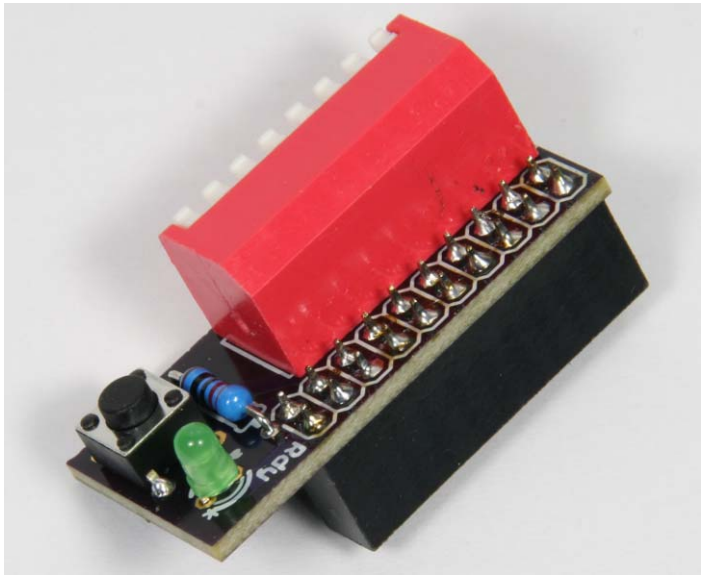



4. LIM-2 jumper link positions

The other jumper, Cab Bus Address Programming (yellow) is only fitted during input of the LIM-2 address, and will normally simply be 'parked' on one of the pair of header pins, as shown.

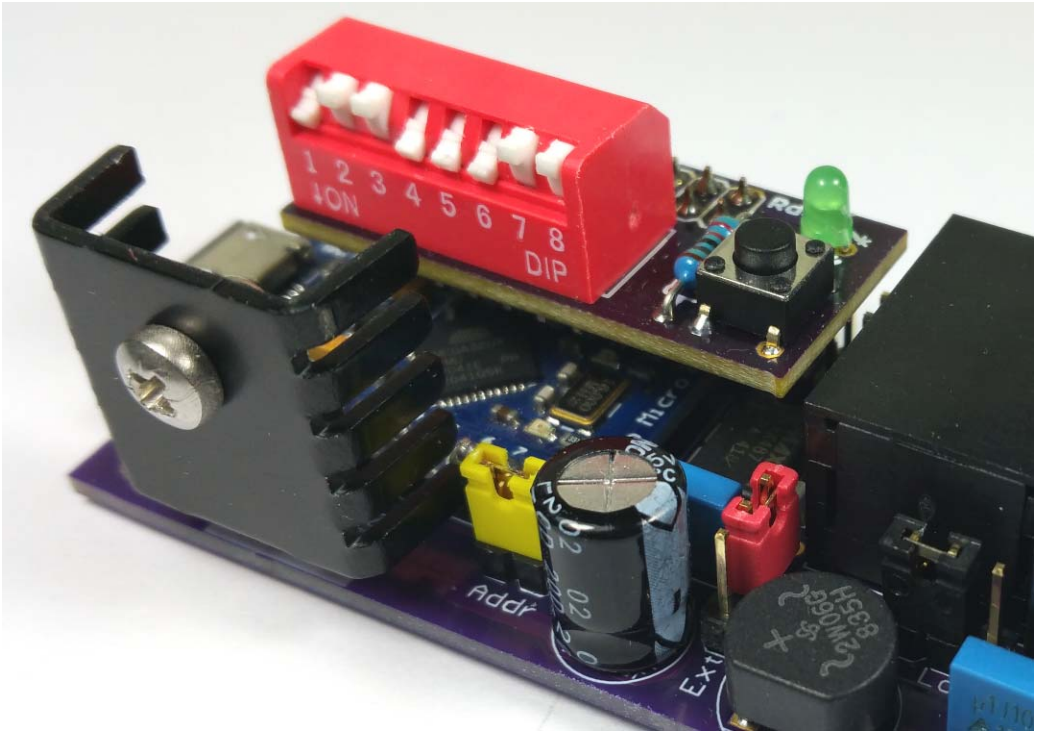
## Assigning a Cab Bus Address

In order to set the Cab Bus address the NCE AIU has a package (DIP) of eight dual-inline switches fitted to its PCB but, since the switches are only used very occasionally, and to keep the size of the LIM-2 as small as possible, the LIM-2 uses an additional small module, Set-Address, which is plugged in only when required, as shown in [4] and [5] below –



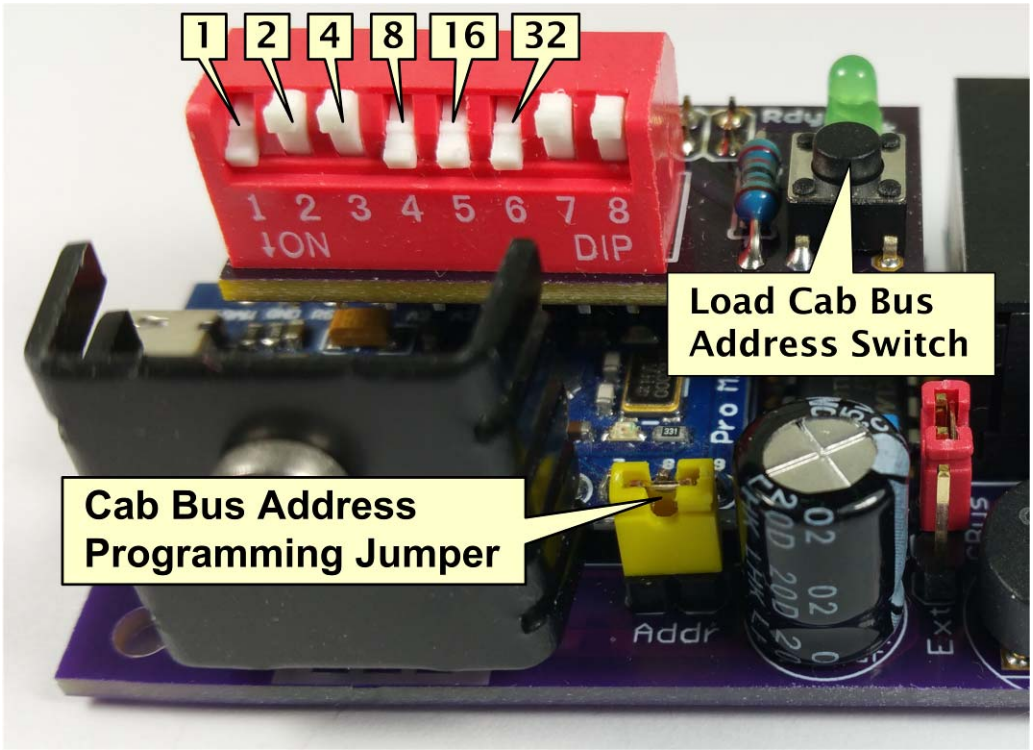
4. Plug-in module to set LIM-2 Address




5. Set-Address module plugged on to the LIM-2 14x2 header

The Set Address module is fitted with a 10x2 header plug which fits on to the first 10 pairs of pins of the LIM-2 14x2 header. The desired Cab Bus address for the LIM-2 is entered as a binary number using switches 1 to 6 (just like the NCE AIU) –




6. Setting the LIM-2 Cab Bus address

The switches are set ON or OFF with a small flat-blade screwdriver or similar tool, and are assigned the numerical values shown in [6] above. The Cab Bus address is selected by adding the values of switches 1 to 6 which are ON, so that the address set in [6] will be 57 (1+8+16+32). Switches 7 and 8 are used to control the way in which the optional Status View module operates, as described later in this document.

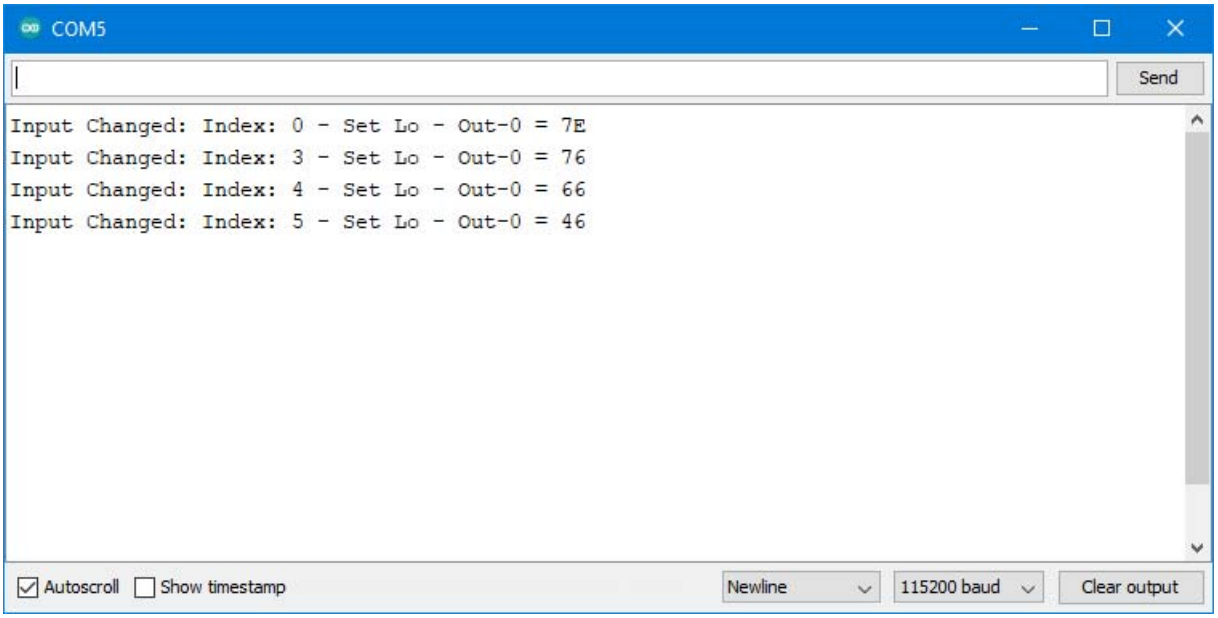
Using the NCE Power Pro, the Cab Bus address can have any value between 2 and 63, although NCE recommend that you use addresses from 41 and above. With the NCE Power Cab, only addresses 2 to 10 are available, with some restrictions (see the NCE website at ncedcc.zendesk.com/hc/en-us/articles/201802345-Cab-Ids-101 for more details).

For address programming, apply power to the LIM-2 by connecting the Pro-Micro to a USB port on your PC. It is not necessary (nor desirable) at this point to make any other connections to the LIM-2.

Open the Arduino sketch for the LIM-2 (LayoutInputMonitor_2-6.ino) and then start the Arduino Serial Monitor by clicking on its icon ( ) in the top-right corner of the Arduino window. The speed of the serial link should be set at 115200 baud, selected from the drop-down list located at the bottom-right corner of the Serial Monitor window.

Set the Set Address unit switches to the required Cab Bus address, then carefully plug the unit on to the first 10 pairs of the 14x2 pin header of the LIM-2, with the switch block overlapping the Arduino Pro-Micro, as shown in [5] and [6] –

The Serial Monitor window will display a few messages showing that the state of some of the LIM-2 Input pins has changed (depending on how the Set Address switches have been set) as shown in [14] –

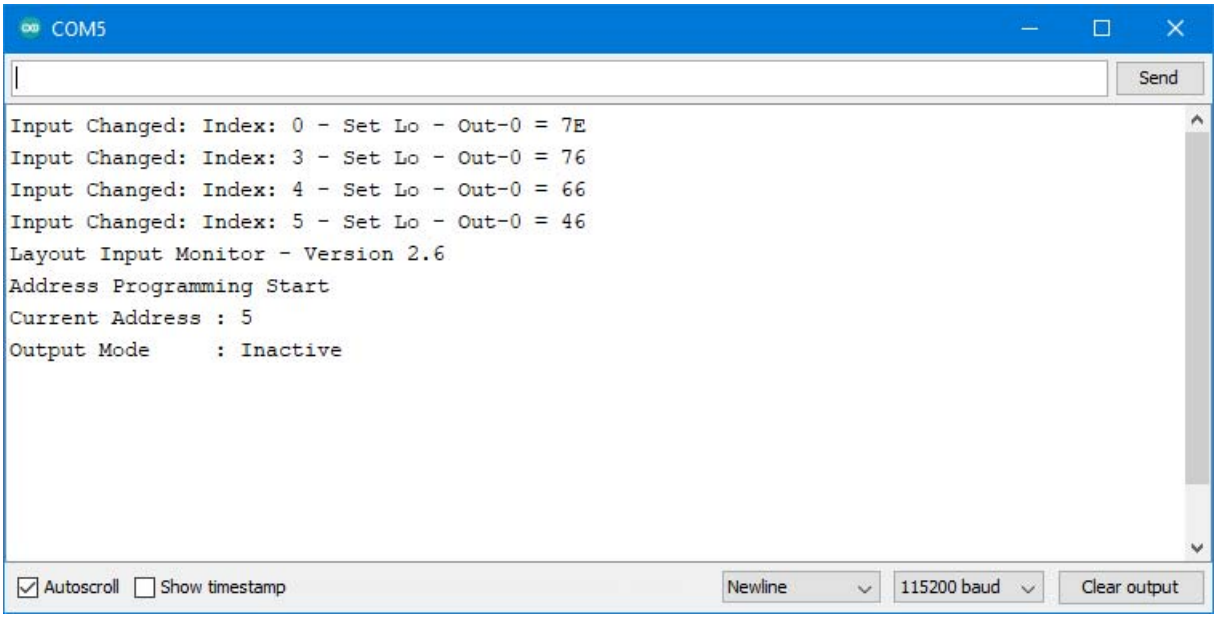



7. Serial Monitor window – initial state

Now, using a small pair of pliers (or your fingers if you are sufficiently dextrous) fit the jumper link to the 2-pin header next to the Pro-Micro (the yellow jumper labelled ‘Cab Bus Address Programming Jumper’ in [6]) – the jumper is normally ‘parked’ on one of the header pins.

This action should light the green LED on the Set Address unit and display a further message in the Serial Monitor window, as in [8] below, which shows you the currently-stored Address and Output Mode –

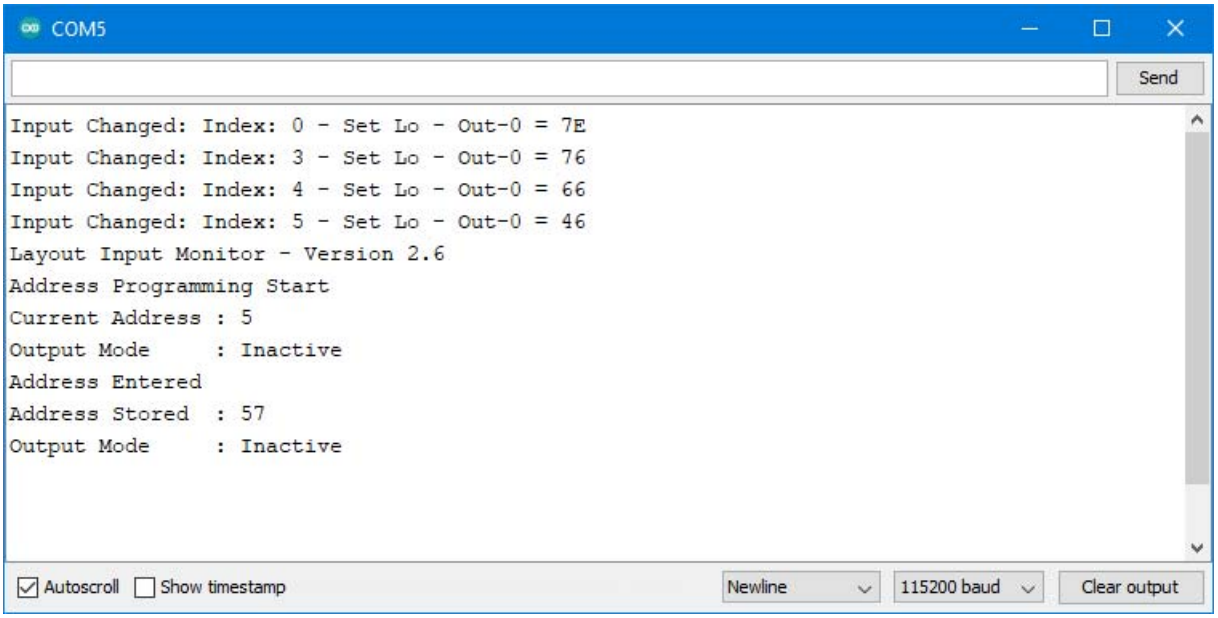
 




8. Serial Monitor window – programming started

Note that, if you do not manage to fit the jumper at the first attempt, so that it makes and breaks contact a couple of times, then you may see some further messages in the Serial Monitor window, indicating that Address Programming has been stopped and restarted.

This is not a problem – once the jumper is firmly in place, simply press the pushbutton on the Set Address unit. This will extinguish the LED and produce a set of messages in the Serial Monitor window, shown in [9], confirming that the Set Address (57 in this case) plus the Output Mode status (as set by switch 7 or 8) has been saved in the Pro-Micro memory (EEPROM). This means that these values will be retained even when the LIM-2 is powered off –




9. Serial Monitor window – address stored

You can now remove the Cab Bus Address Programming jumper and ‘park’ it on one of the 2-pin header pins for safekeeping. A final confirmation message ‘Address Programming Completed’ will be displayed in the Serial Monitor window, and you can unplug the Set Address unit from the

LIM-2. If the Serial Monitor window is still open you will see a few more Input Changed messages reporting the resultant changes in the Pro-Micro inputs – these can be ignored.

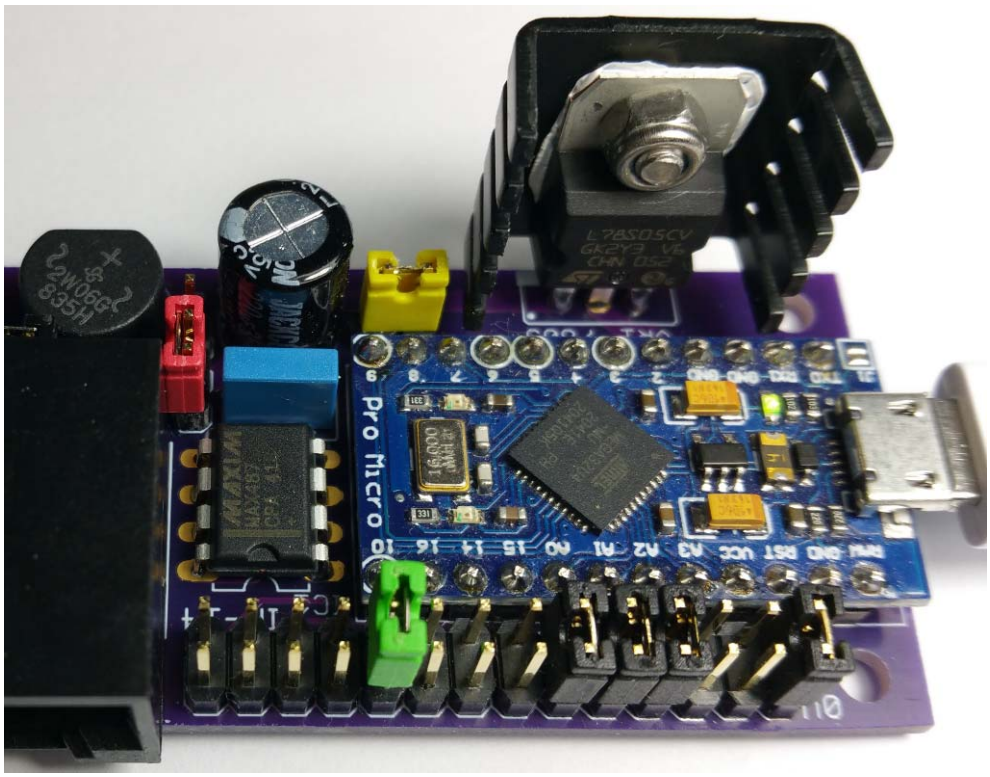
The USB connection to the Pro-Micro from your PC should now be removed, and the LIM-2 connected into its intended position in the layout control network, using standard Cat5/6 Ethernet cables (as shown in the example network [4] in the QSDM Part 1 document).

**Note :** It is **essential** that the LIM-2 is **powered off after programming** (and removal of the Set Monitor Address unit) – the newly entered values will not become effective until the QSDM is restarted.

Note also that, when setting up the address of the LIM-2, it is not actually essential to have the Arduino Serial Monitor window open – its only purpose is to provide confirmation that the switch settings have been accepted and the intended values have been saved to EEPROM – the Arduino IDE takes no part in the data entry operation.

## Assigning a Cab Bus Address without the Set Address Module

If you don't wish to build a Set Address module for the few times it is likely to be used, you can enter a Cab Bus address by using a set of jumper links. Fit a jumper link to each pair of pins on the LIM-2 14x2 header where one of the Set Address module switches would have been set ON, as shown in [10] below, where the address is set at 57 (1+8+16+32) as before, with jumpers on pairs 1, 4, 5 and 6, connect the LIM-2 to a USB port, then fit the Programming jumper (yellow) –




10. Setting LIM-2 Cab Bus address manually

Now place a further jumper (the green jumper in [10] above) on pair 10 of the LIM-2 14x2 header (next to the Pro-Micro corner pin) to input the set address to the LIM-2 EEPROM memory. As before, you can view all of these operations using the Arduino Serial Monitor window.

Finally, remove the yellow Cab Bus Address Programming jumper and 'park' it on one of the 2-pin header pins for safekeeping, disconnect the USB cable, and remove the remaining jumper links you fitted for programming.

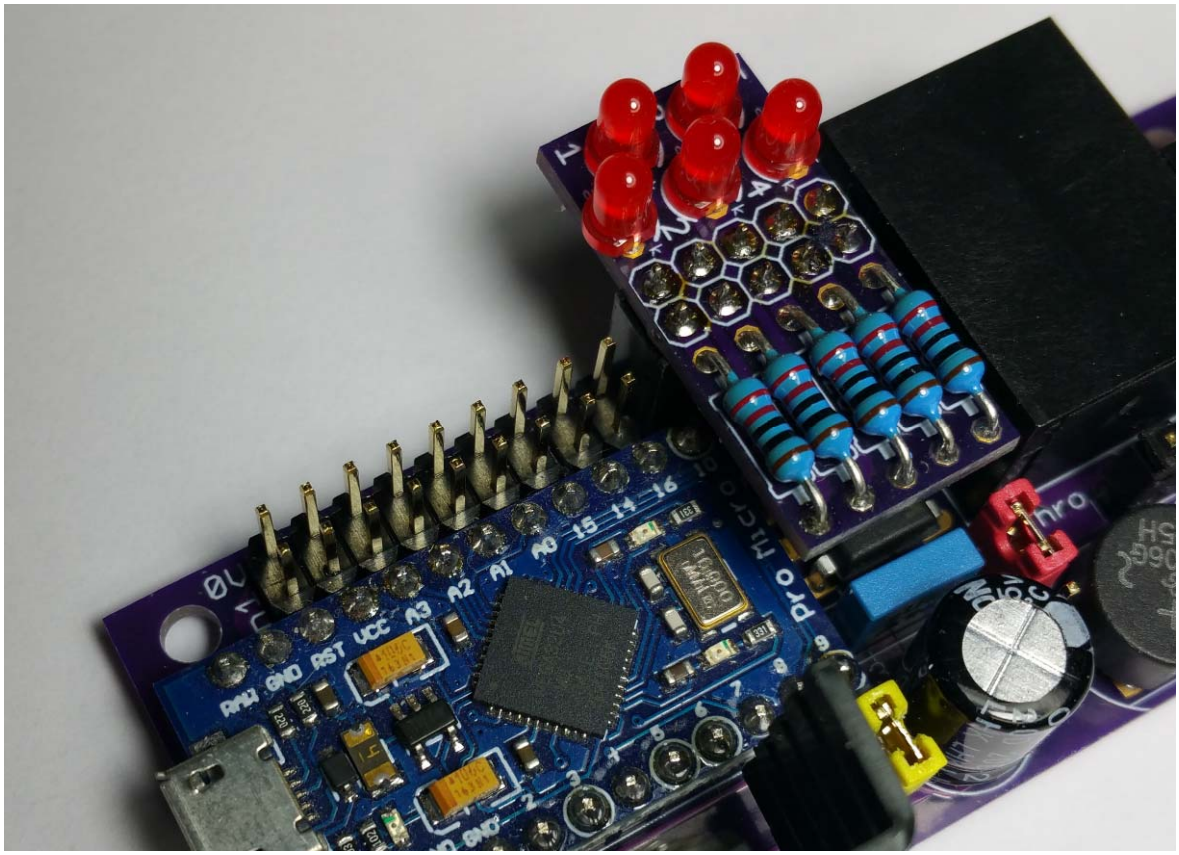
 

## Optional Status View Feature

Unlike the commercial NCE AIU, the LIM-2 does not have a set of 14 LEDs which clearly show the present state of the inputs to the device. Such LEDs are very helpful in providing an immediate check that the wiring from a particular layout element to the AIU input is correct.

Unfortunately, the Arduino Pro-Micro module used in the QSDM Monitor section does not have enough pins to drive an LED for each of its inputs, but its operation can be modified to provide a partial solution which can assist when initially setting up connections to the LIM-2 inputs.

The 5 pairs of pins of the QSDM 14x2 header nearest to the RJ-45 socket can be programmed as outputs which can each drive an LED, and a small module (Status View) with five LEDs can be plugged on to these pins, as shown in [11] below –




11. Status View module plugged on to the LIM-2 header pins

The option is controlled by the setting of switches 7 and 8 of the Set Address module when programming the Monitor Cab Bus address, to allow you to display the state of either the leftmost or the rightmost 5 pairs of header pins selected from the remaining 9 pairs.

Hence, assuming we have a sensor such as a microswitch on a turnout servo, or a block occupancy detector, connected to one of the selected group of header pins, the state of the sensor will be indicated immediately by whether the corresponding LED on the Status View module lights up or not (when power is applied to the LIM-2, of course).

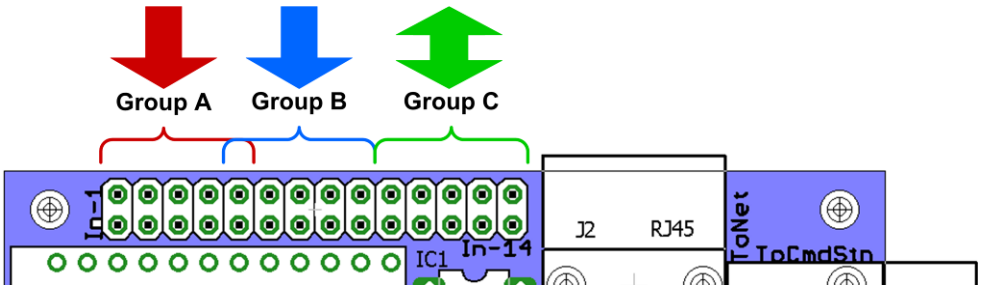
Once you are sure that all of your sensor connections are sound, you can simply unplug the Status View module, ready for use on the next QSDM.

Full details of the PCB and components required to build the Status View module can be found in the QSDM Part 1 document.

## Status View Module Setup

The 14 inputs (header pin pairs) to the LIM-2 have been divided into three groups, A, B and C, where Group A consists of inputs 1-5, Group B has inputs 5-9 (overlapping with Group A), and Group C has the remaining inputs 10-14, as shown in [12] below –

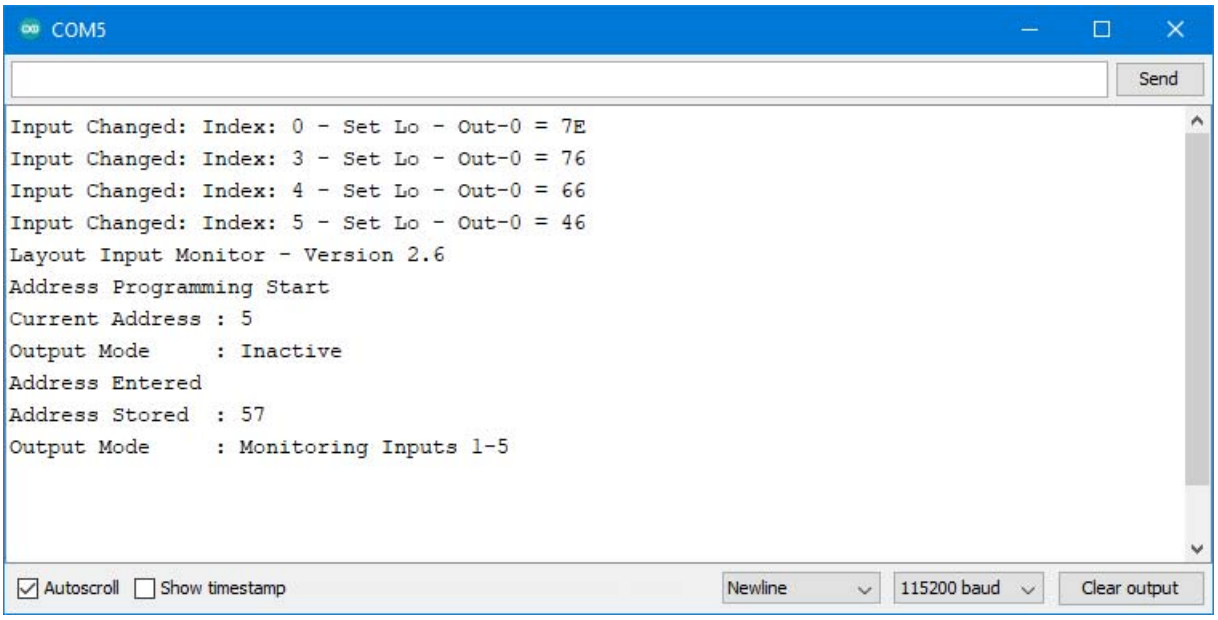



12. Grouping of LIM-2 header pins

During programming of the Cab Bus address, with the Set Address module plugged on to the LIM-2 14x2 pin header (or using a set of jumpers as shown earlier), you can set the pins of Group C as outputs (Output Mode) to drive the LEDs of the Status View module.

To enable the LEDs to display the states of the Group A inputs, set switch 8 ON or, to enable the display of the Group B input states, set switch 7 ON. Note that setting both Switches 7 and 8 ON will only enable display of the Group A input states. To disable Output Mode, and allow the Group C pins to be used as inputs, set both switches 7 and 8 to OFF.

If, for example, switch 8 was set to ON during the programming of the Cab Bus address to 57, as shown previously, the Arduino Serial Monitor will display the additional message shown in [18] below, to indicate that the Status View module, when plugged on to the Group C header pins, will display the state of the Group A pins –




13. Serial Monitor window – input monitoring enabled

Alternatively, if switch 7 is set On prior to programming (with switch 8 set Off, otherwise the setting of switch 7 will be ignored) the states of the Group B inner pins will be shown on the Status View module when it is plugged on to the Group C pins, ie. Output Mode will be shown as Monitoring Inputs 5-9.

Hence, assuming we have set switch 8 as part of Cab Bus address programming, when a sensor, such as a microswitch on a turnout servo, or a block occupancy detector, is connected to one of the LIM-2 Group A inputs, the state of the sensor will be indicated immediately by whether the LED attached to the corresponding Group C output lights up or not (when power is applied to the QSDM, of course).

Once you are sure that all of your sensor connections are sound, you can simply unplug the Status View module, ready for use during your next LIM-2 setup.

However, if you do then want to use the pins of Group C as inputs from other sensors, you will need to remove all of the current connections from the LIM-2 14x2 pin header – making a careful note of what they are and which way round they are connected. You can then reprogram the Cab Bus address into the LIM-2, with switches 7 and 8 set Off on the Set Address module. Finally, carefully reconnect the sensor inputs you removed, before adding additional sensors to the pins of Group C (now reset to be inputs).