Opus-Two Velocity Scanning Keyboard Module

This is a short introduction to the Opus-Two Hall Effect keyboard scanning module.

The above image shows 5 modules mounted to a Wurlitzer contact rail, ready for mounting in a keyboard.

The scan module is designed to sense key position & velocity using a series of sensor strips mounted under the keys. There is one sensor for each key. A small rare earth magnet is attached to the underside of each key using a small mounting bracket and attachment screw.

The sensor strip is designed to mount onto a 'contact rail'; usually of wood {non-conductive} similar to what would have been used for original contact block mounting.

The sensor strip should be positioned so that approx 0.150" clearance between magnet and respective sensor with a fully depressed key. The key up position is not very critical, sensing on magnet separation from sensor heights of approx 0.375" to 0.450 are acceptable. The magnet size {1/8" x 1/8" rod magnet} is selected so as to have proper magnetic strength so that positioning of key sensor is not very critical and that neighboring key magnets do not affect other key sensors. { A slightly larger magnet is to be used with the pedal keys – gives more allowance for larger note spacings and construction tolerances typically found in pedalboards.

The key sensors are fabricated in strips of 13 notes. The sensor strip is made so that one strip can have 4 sensors cut off making the total assembly for a 61 note keyboard 4 strips of 13 + 1 strip of 9.

The sensor strips plug into one another, head to tail and may be mounted on the contact rail using #4 x 3/8 sheet metal screws or similar wood screw.

Screw terminal strips are provided for power connections. A 3 pin wire header assembly connects the keyboard output to the Opus-Two Controller. Connections are provided to cascade keyboards from one to another.

The key sensing system is designed to scan all keys of a keyboard without needing any other input cards. For multiple manual console applications an efficient mechanism is provided to allow keyboards to be easily connected together in a cascade arrangement.

Since most modern console rebuilds also include combination action pistons or other control buttons, wiring positions have been allocated on the sensor strips to allow wiring of pistons to the scanning system. This avoids needing extra wiring or input cards for piston inputs. With 5 strips connected as above, a total of 29 piston inputs can be accommodated per keyboard manual.

The main purpose of the key scanning system is to detect key depressions. There are many variations on what can be reported.

Single touch key sensing is normal for pipe organ keyboards and is the 1^{st} series of output information derived by the scanning system.

Some pipe organ keyboards were fitted with extra depression springs and a second set of contacts to give a 'second touch'. If a keyboard has the second touch springs, the hall effect sensing system can be set up to give 2^{nd} touch contact key information {as well as 1^{st} touch info}.

It is often desired to have a velocity encoded keyboard {similar to a piano action, without the weighted key action} available to be used with a pipe organ keyboard. Such information is used with attached pianos and other synthesized instruments to get changes in volume and timbre of voices.

This key scanning system can generate velocity coding for the 1^{st} touch position. {Velocity encoding for 2^{nd} touch is possible, no current applications have been envisaged, to date.

All 3 codings {1st, 2^{nd} & velocity} are available for all modules. Specific installations will use one or more of these as needed.

The keyboard scanning system is normally calibrated during installation. This consists of using the Opus-Two menu system to send a control sequence to the keyboard, then moving the keys one by one to the various depressed points {1st touch & 2^{nd} touch bottom}. Internal software then computes necessary calibration parameters from that. These parameters can be slightly perturbed to change the way a keyboard 'feels' – e.g. to give a more or less aggressive velocity encoding, or to move the key trip point up or down to suit an individual performer.

The Opus-Two user configuration system will allow the derived information from the key scanning system to be utilized for stops and voices as needed.

A small pcb using the same sensor unit will be used for pedal keys and described in a later section of this document.

Detailed mounting diagrams will also be included. It is estimated that a typical keyboard installation & calibration could be done in approx 1 hr {during training & familiarization allow 2 to 3 hrs for 1^{st} couple of keyboards}.

Power Consumption:
A typical 61 note key assembly will need approx 350 ma at 12V to 15V.

Costs:
Key sensor systems are sold in sets of notes and come complete with magnets and magnet holders. { The rail to which the sensors mount is not included. }. Headers for small pitch IDC connectors are provided for pistons.

	Retail
61 note manual:	$750
32 note pedal :	$375

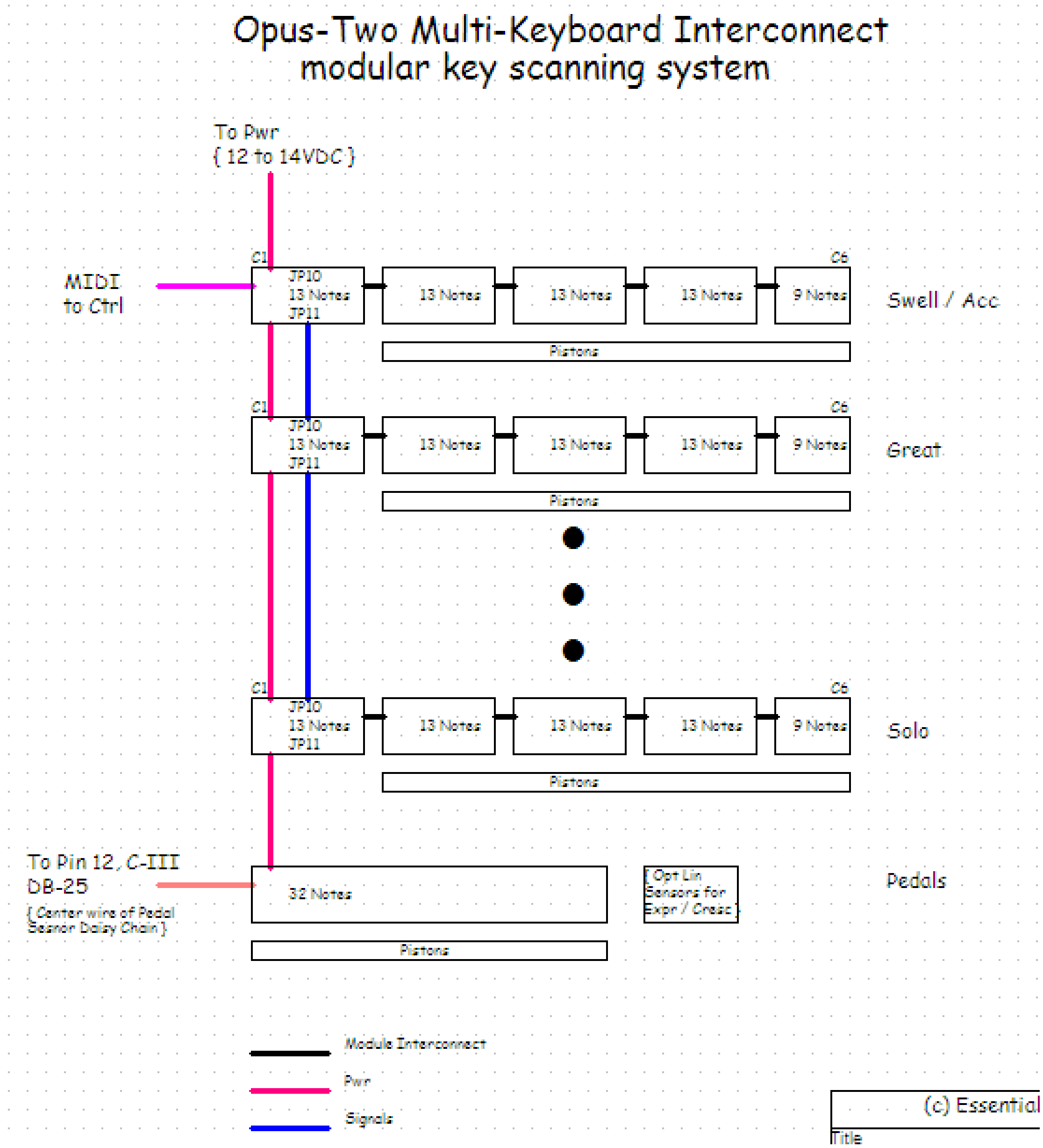
{ Pricing as of Feb 2006 }

Note that when using sensor sets, no extra input cards are needed for keys / pedals or pistons. In addition, the system can accommodate manual piston inputs, toe piston inputs and multiple analog expression / crescendo controls.

Availability
Velocity Key Sensors will be available from mid May 2006

Additional notes:

1. Since the scanning system utilizes a linear position sensor and contains a/d converters to read the sensors, it is possible to use the last 4 positions on any keyboard assembly to read other analog pots or analog information as may be found on some consoles. When used this way, the max # of pistons is reduced to 25.
2. As noted earlier, the key scanning systems do not need additional input cards. As such, some consoles may only require a Controller, key scan modules and SC units



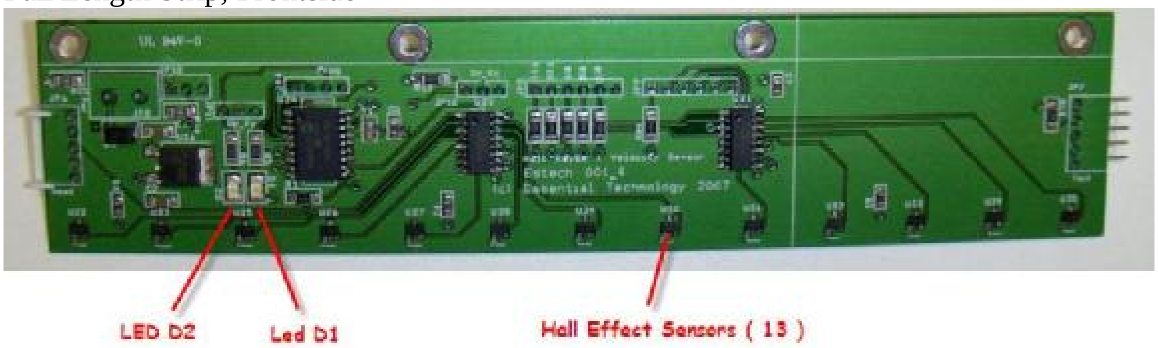
This block diagram shows how multiple sensor strips are connected for a multi-keyboard system.

{ in a future release of Keystrip firmware it will be possible to have the pedal sensors connect into one of the keystrips. This is planned for 2008 }.

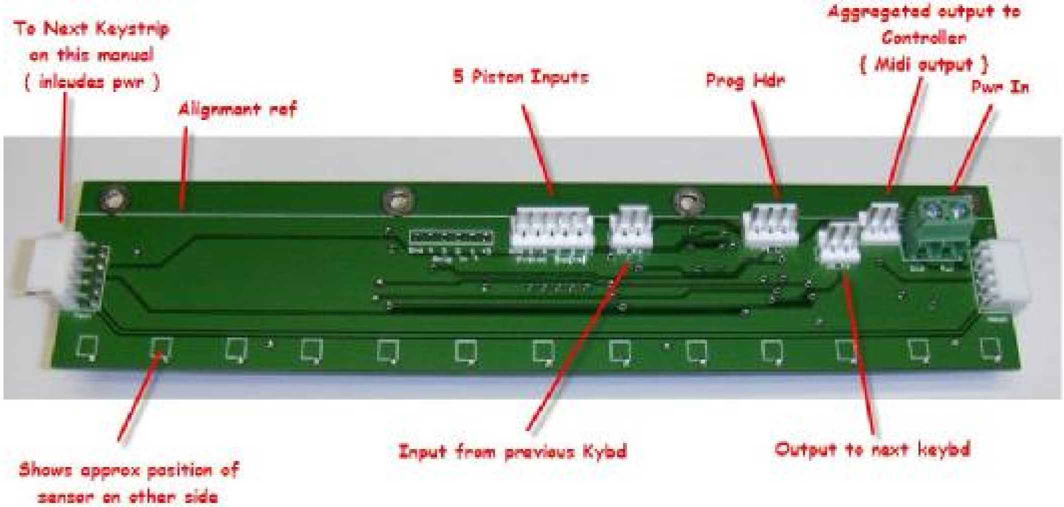
Connection Information

This information is based on the 001_4 version of the keystrip PCB. The 001_3 version is identical except for the JP12 connection to the controller and modified input header for analogue inputs on the ‘short’ version of the sensor strip. The same firmware is present in all modules.

Full Length Strip, Frontside



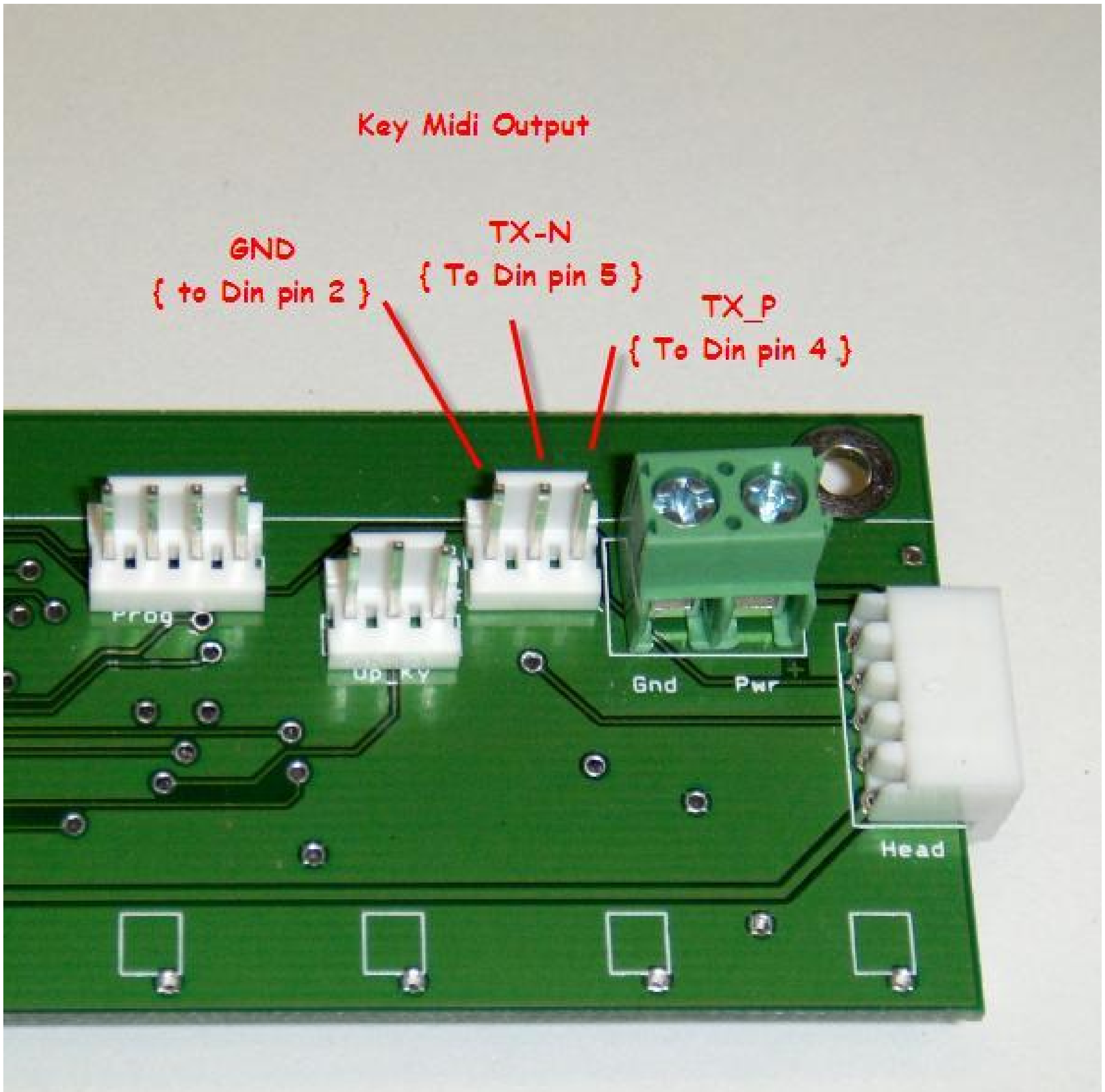
Full Length Strip, Backside



There are 5 keystrips used for each keyboard { normal 61 note kybd }. The strips plug together { 4 full length & 1 short }. For each keyset, 1 of the full length strips will have been provided with extra headers for power, Midi output and 3 pin headers for input / output to other keybds that may be present.

When multiple keyboards are present they are interconnected by the 3 wire input / output cables. This is a 3 wire cable with a 3 pin MTA-100 plug on each end { one to one wire ordering }.

From a keyboard ‘stack’, only 1 connection needs to be taken back to the Opus-Two controller. This signal is the Midi output and is a MIDI compatible signal. The Midi signals have resistors present before the header so none need to be included in the cable. The pin #’s on a standard MIDI 5 pin circular DIN connector are provided for reference.

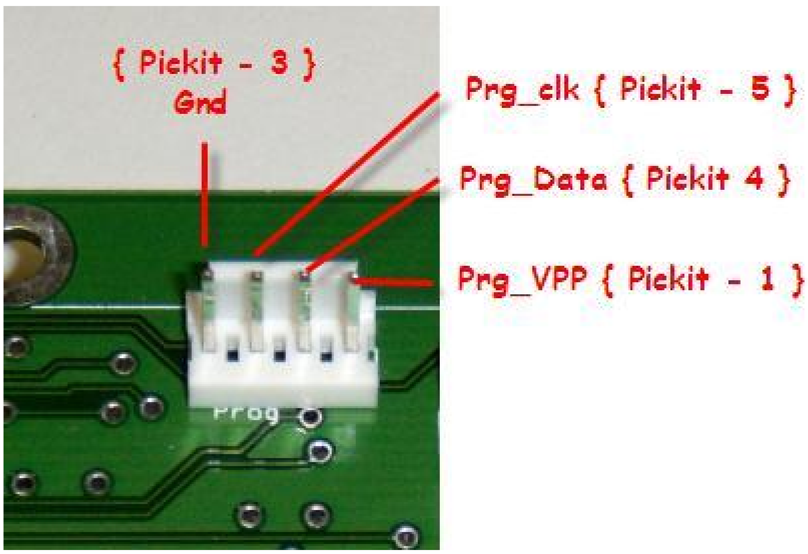


Programming Header

This 4 pin header is used to update the firmware or some settings of the keystrip EEPROM memory.

The new { 001_4 version & later } uses a 4 pin programming header to provide in-circuit programming access and a GND ref connection for the programmer. Earlier versions of the card used a 3 pin header. This meant that a GND connection during programming needed to be made, usually on the Piston header, not always the most convenient.

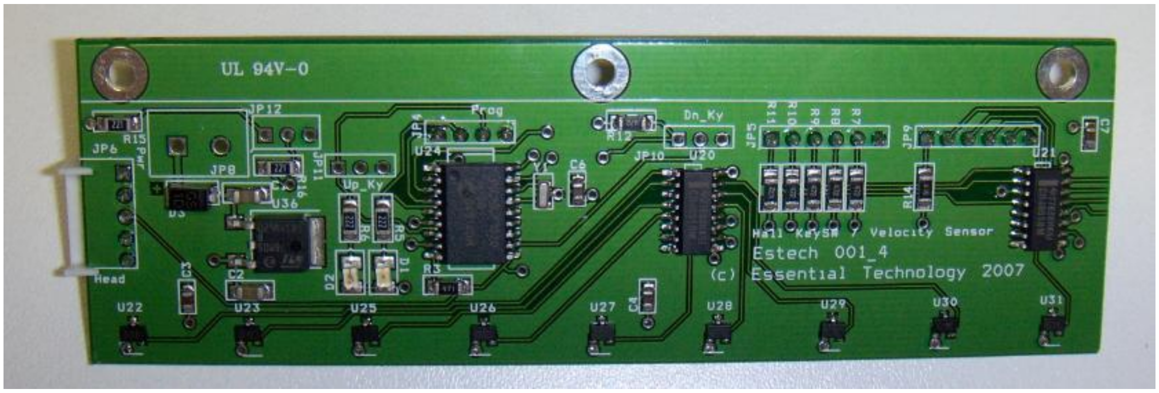
The programming pins are as follows:



Reference is made to the Pickit 2 programmer pinout, where pin 1 is the one identified with the white arrow on the case.

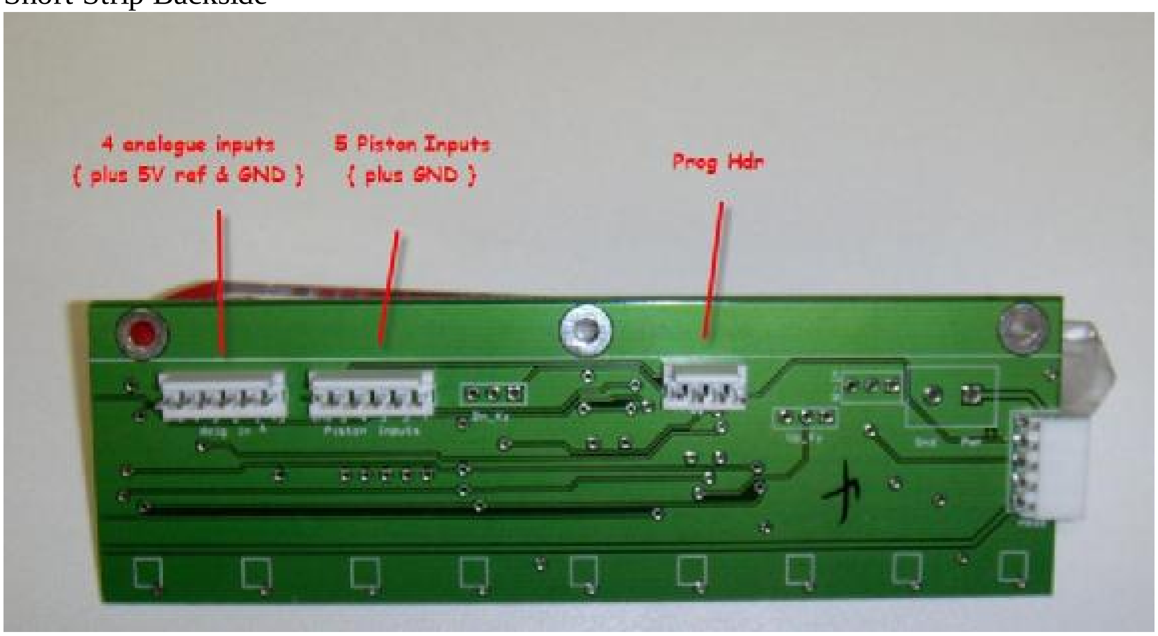
For earlier versions of the card, the 3 pin header is missing the GND connection, the other signals are in the same order with the same functions.

Short Strip, Frontside



This strip is made by cutting a full length strip along the line between U31 & U32 sensors. { Normally this is done at time of mfg, however a full length strip can always be converted if ever needed }. When the strip is cut short, 4 inputs are available for use as analogue inputs { for pots, etc }. A location has been provided for a 6 pin header. Connections are +5V Ref, Analogue inputs 1-4 and GND.

Short Strip Backside

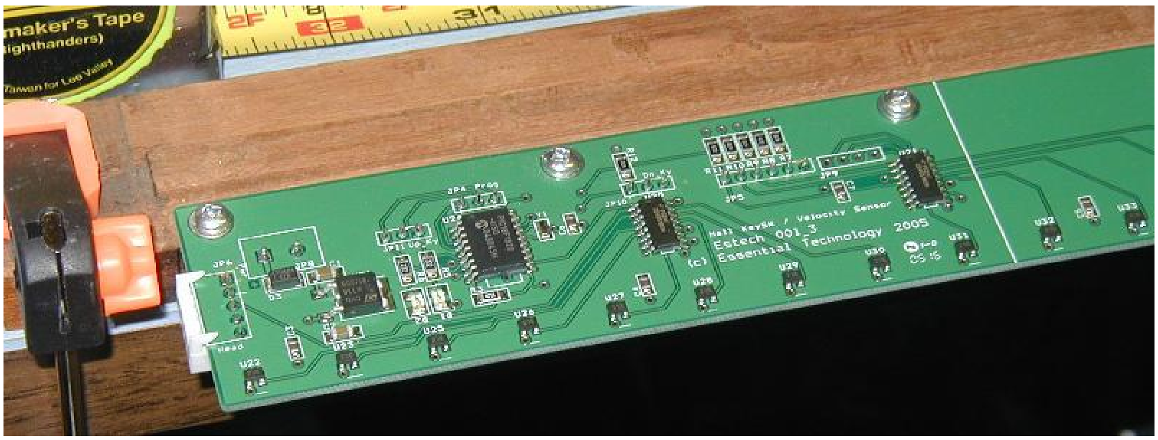


Each keystrip has a 6 pin header for up to 5 piston inputs. There is also a GND pin provided on this header. Piston inputs are normally switch closures to GND. The keystrip provides pull up resistors for each signal.

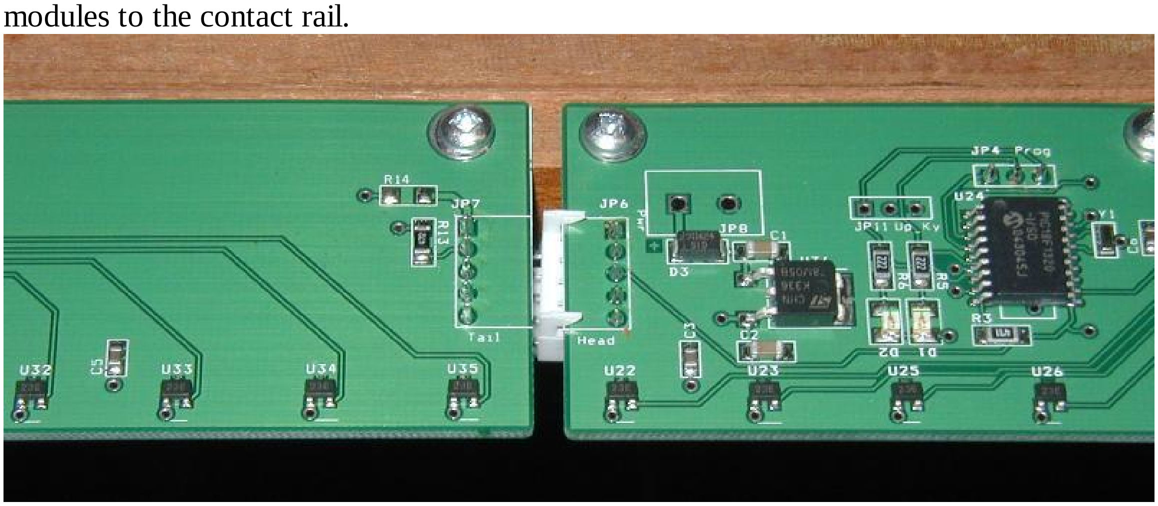
The Prog Hdr is used for updating the firmware of the keystrip. During operation there is normally no connection to this header.

Mounting Information

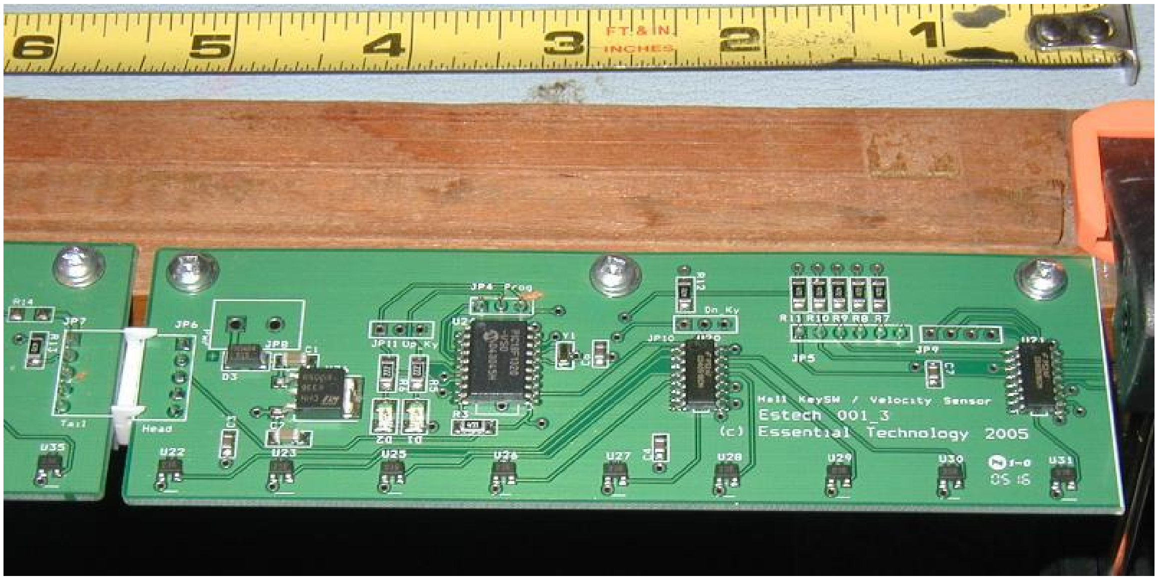
Here is a close-up of the bass end of the keyboard sensor. This side is the one that will go towards the magnet holders. Normally the magnet holders are attached to the underside of the keys and key movement will move the magnet towards the sensor. The individual sensors are the small block rectangles near the outer edge of the circuit card.



The units plug together. #4 x 3/8" sheet metal screws are used to attach the sensor modules to the contact rail.



The treble end of the scanner. The 5th board has been trimmed shorter to make a total of 61 sensors.



Everything on the sensor side of the circuit board is selected to be low profile so that there is no interference with the keys or the magnets. Normally there would be about 1/8” clearance between the top of the sensor and the magnet when the key is fully depressed. This measurement is only an approximate guide. Self-calibration of the individual keys after mounting will remove any variance

It is recommended that the spacing from the magnet to the top of the sensor be in the range of 0.125” to 0.150” { when key fully depressed }. Spacing less than 0.125 not recommended as the sensor output limits when magnet at approx 1/8” from sensor surface.

1. Determine the most suitable mounting site for the key sensor unit and the magnet. Usually this is on the bottom side of the key, near the key midpoint { often where original contact rail was mounted }. It may also be located at the rear of the key. The magnet may be mounted to the bottom of the key using a small magnet holder – a piece of wood with a 1/8 hole drilled in it for the magnet. Alternately a 1/8” hole can be drilled into the underside of the key. This holder is then screwed or glued to the bottom of the key. { A bit of hot melt glue will hold the magnet in place in the 1/8 hole }. At full key depression the magnet should be approx 0.125” to 0.150” from face of sensor. It is best to position the magnet / key sensor so that there is a min of 1/8” of magnet movement. The sensor will work correctly with any key movements in the range of 0.125” to 3/8”.

   Key sensors can also be mounted so that the magnet pulls away from the sensor as key is pressed. This is not recommended for keyboards that will use 2nd touch features. { When the magnet pulls away from the sensor strip, the critical 2nd touch decision points are made at the ‘small’ signal end of the magnetic response curve. This will result in poor 2nd touch response, so is not recommended }.

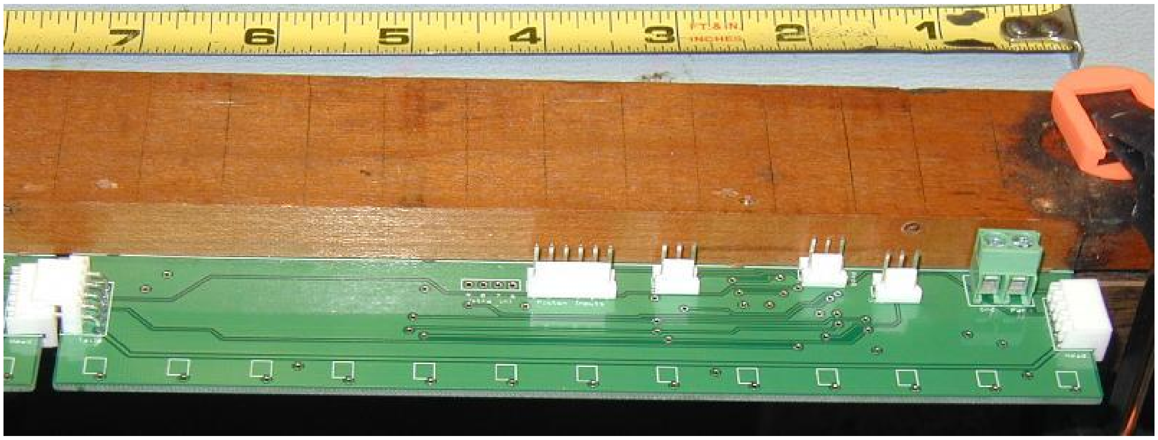
Key sensors can also be reversed in orientation, so that the short sensor goes at the bass end of the keyboard. This has been found useful when mounting sensor strips under some keyboards.

At the present time, it is not recommended to mount the sensor / magnet so that the magnet approaches the opposite side of the sensor { backside of the PCB }. { Future expanded mounting options may allow this when used with a larger magnet and revised spacing.

It is also recommended to obtain as much magnet movement as possible given the mechanical mounting constraints of typical keyboards. This is approximately the same location as where mechanical switch contacts were located on some keyboards. Other keyboards had the mechanical switches mounted outside the key area so a new location to mount the sensor strips would need to be found in the key area.

Typically the magnet would be located at approximately 5” from pivot point of the key. Distances of less than 4” are not recommended due to the reduced magnet movement available.

The other side of the sensor assembly is accessible after the sensor unit is mounted in the keyboard.



Here the module to module interconnect can be seen.

The green 2 terminal connector is for power & gnd connection to the keyboard sensor unit (5 modules = 1 keyboard unit }.

The small 3 pin terminals are used as follows:

The one on the right { JP11 } is the connection from this sensor strip towards the console controller { up-stream }.

The one on the left { JP10 } is the connection to the keyboards away from the console controller { down-stream }.

The center 3 pin connector { JP4 } is for programming of the unit. Normally the units are factory programmed but if necessary can be field programmed in place.

The 6 pin connector is used for connection to pistons that may be located on this keyboard assembly. There are 5 signals { with internal pull up resistors) + gnd. Five sensors strips per keyboard unit provide inputs for up to 25 pistons.

There are also 4 unused inputs available on the 5th sensor element { the one trimmed shorter } to make a final total of 29 inputs per keyboard assembly. These last 4 inputs are generally reserved for analog inputs { to be supported in 2007 }

The headers are oriented so that the wires may be dressed neatly along the contact rail without interfering with the keyboard underneath it.

Sensor Calibration

Each key sensor strip self-calibrates and continuously adapts as keys are played. When the sensor is initially 'erased' and programmed, the internal calibration table is re-built on power up.

In the 1st few seconds of operation after programming, the sensor strips 'learn' the 'off' position.

When keys are depressed to max depression, the sensor strip 'learns' where this point is. An algorithm operates to select the optimum 'trip' point for note on / note off based on the actual values for each key. { In later releases of the firmware it will be possible to vary this to make a 'heavy' or 'light' touch by adjusting threshold settings for 1st & 2nd touch positions }.

Other versions of firmware will generate velocity information as well as basic note on / off, and also do 2nd touch for keyboards equipped with 2nd touch springs.

In order that the key sensors 'adapt' to seasonal variations in the keyboards, small perturbations are made in the stored calibration values during power up. This allows approx 2% tolerancing for dimensional movement in the key units themselves. As the keys are played, new limits are determined and saved. Since the perturbation is applied as a ratio to both top & bottom limit values, no perceptible variation is observed as 1st notes are played on power-up, but this does give each key sensor a chance to better track the dimensional movements of the keyboards.

Typically the calibration is achieved in one or 2 key presses { from a fully erased table }. If stable key operation is not achieved, check the alignment and spacing of the magnet relative it's key sensor.

In some cases it may be more useful to re-initialize the sensor calibration, without re-programming the unit. This can be accomplished by connecting pins 4,5 & 6 together on the piston input header during power-up. Wait 2 seconds, then retrain the keys by operating individual notes.

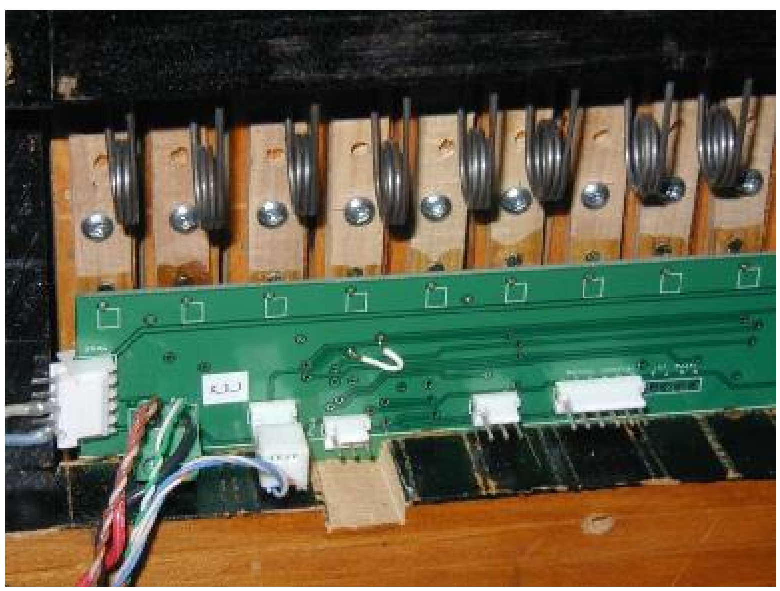
During note calibration it is better to play single notes at a time until each key learns its min and max values.

Additional sensor installation photos.

The following series of photos show some different ways that the sensors can be mounted.

Here the sensors have been mounted to the front keyboard support rail. The magnets are installed in small 1/8 x 1/8 holes drilled into the bottom of the keys.

{ For future orders, it will be possible to order the sensors with all components on one side so that there will be no exposed components on top side of card. The magnets will approach sensors through the backside of the bare circuit board }



1. An approach used on many keyboards.

Operational Connections

The 5 sensor strips for a given keyboard set plug into one another. Where multiple keyboards are used, the sensor strip sets { keyboards } are be connected together so that only a single connection back to the controller is used.

These connections are done with a 3 wire cable that connects from one keyboard to the next.

NB: These cables will come pre-made with sets of keyboard sensors.

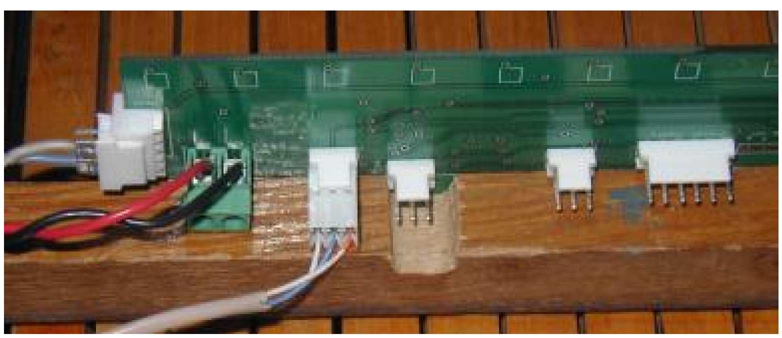
{ Starting with version 001_4 of the pcb a separate header for this connection is provided. This is more convenient to use. }

This photo shows the one end of the cable that connects the keyboard set to the controller. This cable can be plugged into any one of the available JP6 receptacles of a keyboard set. Only one of these connections needs to be made and it can be to any of the keyboards. **If access to the JP6 receptacle is cramped, the receptacle on the sensor strip can be carefully pried up so that it is vertical to the PCB.** Do not bend the receptacle back and forth repeatedly as this may break some internal connections.

The other end of this cable has a 5 pin MIDI connector on it and plugs into the MIDI in port of the console controller.

Showing the connections to the 1st keyboard of a set. The 'cascade' connection is also shown here, at one end.

The 'cascade' connection to a second keyboard. This unit is in fact the 'top' of the cascade, the other is the next 'dn' in the chain. There is no particular criteria for which should be selected as 'top' unit.



Extra Installation information & configuration detail.

The firmware for the key sensor system is delivered as a hex file. Early systems shipped will need to be updated in the field. This can be done with a notebook computer and an Asix Presto programmer.

The Asix Presto is not recommended any more due to the wider availability and ruggedness of the Pickit2 programmer. The operations of the two programmers are similar. { This section to be totally updated to reflect Pickit2 only in a future revision }

The Presto programmer comes with a standard 5' USB cable. In some circumstances a longer USB cable allows for easier work methods. A 10' USB cable can be used. These cables are available from many common computer supply or stationery stores.

Install Asix Presto on your notebook computer as per instructions that come with the unit. You should also be sure to get a later update of the Asix 'UP' software as the earlier releases of 'up' do not program the PIC1320

The Presto programmer has a small programming cable with discrete wires. This may be used or you may fabricate your own dedicated programming cable as shown in a later photo.

The Presto programming cable has several wires, you will use only 4, these are Yellow {P1) , Blue {P4) , White (P5) and Green (P6). The other wires will not be connected to anything during the configuration sequence for the sensor strips.

Be sure that you have a version of firmware for the sensor strips. The config sw is setup so that the same code file goes into each strip, however there are unique parameters that are set into the data memory for each unit during the programming.

The parameters set the note order of a sensor strip set { up or down } , the channels used for for notes, pistons and potentiometers. Each sensor strip in a set gets an address from 0 to 4. 0 is the end strip that has the extra screw terminal connector, 4 is the one that has been trimmed shorter than the others.

The data parameter bytes for each sensor strip are as follows:

0 – note channel { 0 to 15 },
    add 16 { 0x10 } if short sensor strip is at bass end of keyboard
    add 32 { 0x20 } if magnet pulls away from sensor as key is pressed
    add 64 { 0x40 } for 2nd touch contact reporting
        { 2nd touch info on note channel + 4 }
    Add 128 { 0x80 } for 1st touch velocity information
    Note: [0 = midi channel 1]

1 – piston channel, set to 7 unless otherwise instructed

2 – sensor strip address { 0 to 4 }

top 3 bits used to identify keyboard string. This is used to uniquely identify keyboard sets so that the pistons for a complete console { 3M }can occupy a single channel.
3 – analog potentiometer channel
4 – aging constant for calibration values
5 - # of keyboard sets connected together
6 – 1^{st} contact threshold { x / 256 }
7 – 2^{nd} contact threshold { x / 256 }
8 – hysteresis setting { default is 3, range of 0 to 3 recommended
9 – velocity calculation start threshold { x / 256 }

Suggested Standard 2 or 3 keyboard Data Parameter set.
Magnet moves towards sensor as key is pressed

Strip Number	Data Memory locations 0	1	2	3	4	5	
Swell / Acc							
1	0x00	0x07	0x00	0x09	0x00	0x03	-- bass end of keyboard
2	0x00	0x07	0x01	0x09	0x00	0x03	
3	0x00	0x07	0x02	0x09	0x00	0x03	
4	0x00	0x07	0x03	0x09	0x00	0x03	
5	0x00	0x07	0x04	0x09	0x00	0x03	-- treble end of keyboard
Great							
1	0x01	0x07	0x20	0x09	0x00	0x03	-- bass end of keyboard
2	0x01	0x07	0x21	0x09	0x00	0x03	
3	0x01	0x07	0x22	0x09	0x00	0x03	
4	0x01	0x07	0x23	0x09	0x00	0x03	
5	0x01	0x07	0x24	0x09	0x00	0x03	-- treble end of keyboard
Solo							
1	0x02	0x07	0x40	0x09	0x00	0x03	-- bass end of keyboard
2	0x02	0x07	0x41	0x09	0x00	0x03	
3	0x02	0x07	0x42	0x09	0x00	0x03	
4	0x02	0x07	0x43	0x09	0x00	0x03	
5	0x02	0x07	0x44	0x09	0x00	0x03	-- treble end of keyboard

Swell on Ch 1
Great on Ch 2
Solo on Ch 3
Pistons on Ch 8
Pots on ch 10

Suggested Standard 2 or 3 keyboard Data Parameter set { w 2nd touch on Acc / Great }
{ This is a typical 3M Wurlitzer, with two second touch keyboards }
Magnet moves towards sensor as key is pressed

Strip Nmbr	Data Memory locations 0	1	2	3	4	5	6	7	8
Acc									
1	0x40	0x07	0x00	0x0B	0x00	0x03	0x80	0xD8	0x02 -- bass end
2	0x40	0x07	0x01	0x0B	0x00	0x03	0x80	0xD0	0x02
3	0x40	0x07	0x02	0x0B	0x00	0x03	0x80	0xD0	0x02
4	0x40	0x07	0x03	0x0B	0x00	0x03	0x80	0xD0	0x02
5	0x40	0x07	0x04	0x0B	0x00	0x03	0x70	0xB8	0x02 -- treble end
Great									
1	0x41	0x07	0x20	0x0B	0x00	0x03	0x80	0xD0	0x02 -- bass end
2	0x41	0x07	0x21	0x0B	0x00	0x03	0x80	0xD0	0x02
3	0x41	0x07	0x22	0x0B	0x00	0x03	0x80	0xD0	0x02
4	0x41	0x07	0x23	0x0B	0x00	0x03	0x80	0xD0	0x02
5	0x41	0x07	0x24	0x0B	0x00	0x03	0x80	0xD0	0x02 -- treble end
Solo									
1	0x02	0x07	0x40	0x0B	0x03	0x03	0x8c	0xE8	0x03 -- bass end
2	0x02	0x07	0x41	0x0B	0x03	0x03	0x80	0xE8	0x03
3	0x02	0x07	0x42	0x0B	0x03	0x03	0x80	0xE8	0x03
4	0x02	0x07	0x43	0x0B	0x03	0x03	0x80	0xE8	0x03
5	0x02	0x07	0x44	0x0B	0x03	0x03	0x80	0xE8	0x03 -- treble end

Acc on Ch 1,
Acc_2nd on Ch 5
Great on Ch 2,
Gr_2nd on Ch 6
Solo on Ch 3
Pistons on Ch 8
Pots on ch 10

Key Strip Programming Update Procedure.

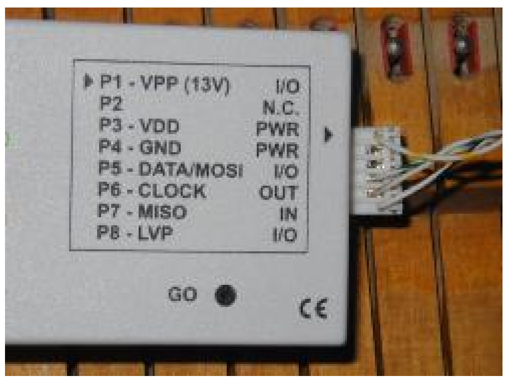
During program updates of the keyboard sensor strips, it is best to temporarily disconnect the connection from the keyboard sets to the controller. Programming activity could generate some invalid note information that could result in unplanned activity with the combination action system. It is sufficient to disconnect the one end only, at the controller MIDI in connection.

1. Activate Presto 'UP' software on the notebook PC
2. Select Device as PIC1320
3. Set Programmer power to be "internal' 5V for both option menus.
4. Load the hex file that has been sent for this update.
5. Power up the sensor strip or strip set. It is not necessary to remove the strips from a keyboard to program or configure, this can be done in-place,
6. Make connections to the sensor strip as follows, in this order.
    a. Blue wire to JP5.6 { You may need to pull off header for pistons temporarily = be sure to put it back after programming }. This is the pin that is towards the 4 pin blank extra inputs side.
    b. Yellow wire to JP4.1 { pin closest to "prog" text beside connector }
    c. White wire to JP4.2 { middle pin }
    d. Green wire to JP4.3

7. Select "Read Data Memory" to read the data eeprom contents into the programmer memory
8. Go into the EEPROM data screen and edit / verify the entries in locations 0 to 8 as indicated above, for the unit that is to be programmed.
9. If it is desired to erase the learned values for key min / max, change locations 0x10 to 0x4f to be 0xff. This initializes the min/max table.
10. Select "Erase All". A series of activities & results should be shown. No errors should appear. { Occasionally an error will be noted, check your connections as per step 6 & repeat }
11. Select "Program All". A series of activities & results should be shown No errors should appear.
12. Remove the 4 programming wires and repeat 5 and 7 to 9 for each sensor strip in a keyboard set.
13. Play all keys on the keyboard a couple of times { individually } to re-calibrate the min/max tables.
14. Keyboard operation can be checked by temporarily re-connecting the midi connection at the controller. It is probably best to check each keyboard as it is completed so as to check your work.

A dedicated programming cable can be made, however it is recommended that this option only be used if the cable that comes with the Asix programmer becomes damaged or lost.

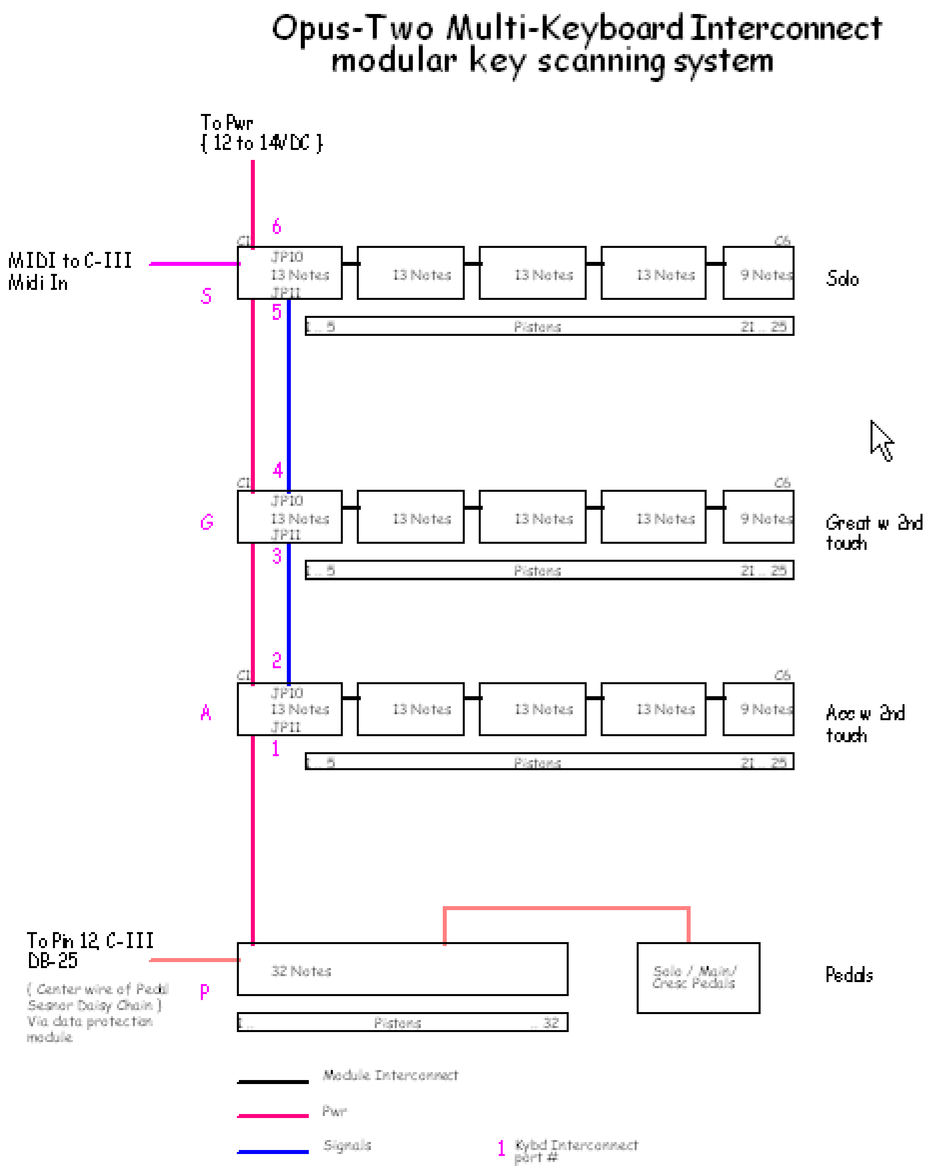
JP4 pin 1 is shown to the left in the photo.
JP5 pin 6 is on the right end of the 6 pin header in the photo.



Diagnosing Keyboard Behaviour + other notes & observations

This document is written as a quick guide to diagnosing strange Hall Effect Keyboard behaviour that may arise.

A typical 3M + pedal theater organ keyboard setup is illustrated below. { Except for the presence of 2nd touch, a similar arrangement would exist for a classic organ console }.



The keyboards and pedals are shown in approximate relative positions as they would be placed in the console.

Each keyboard can have up to 25 thumb pistons or switches connected to it.

Pedal Sensors

Each set of pedal sensors { usually 32 notes } can have up to 32 toe pistons or switches connected { 1 per sensor } and up to 6 analog inputs. The analog inputs can be wired to any of the pedal sensor units { 1 per sensor }. The exact positional location of each analog sensor is currently defined in the console configuration file. { With future console updates, the location will be defined via console display panel operations }

The note / toe / analog information from pedal sensor set is sent to the console controller { C-III } via a dedicated signal cable that connects to the DB-25 connector on the C-III at position 12.

Keyboard Sensor Units

A single keyboard system would only need a power connection and a midi data cable connection to the C-III controller. The midi data connection is taken from the ‘bass’ end keyboard sensor module. { In some installations, the set of keyboard modules has been reversed so that the module having 9 notes is at the bass end of the keyboard. The diagnostic procedures are the same, just substitute “treble end” for “bass end” where noted.

Each keyboard set must have a set of power connections to it to provide power for the logic and Hall Effect sensors. This power is brought into the key strip set for a keyboard on the module having a green 2 pin screw terminal connector. This unit will normally be placed at the bass end of the keyboard.

When extra keyboards are present in a system, they are interconnected in a simple manner. There is still only 1 midi data cable connection back to the C-III console controller. Extra keyboards are connected to the ‘master’ keyboard by means of 3 wire interconnect cables.

Any keyboard can become a ‘master’ keyboard and it’s not necessary that the master keyboard have the midi connection to the C-III controller.

Each bass end keyboard sensor strip has an ‘input’ chain port { JP11 } and an ‘output’ chaining port { JP10 } using 3 pin headers. The interconnection of these ports ties the keyboards together, provides a common signaling connection for midi data back to the C-III plus an inter-keyboard synchronization signal.

Given a set of 3 keyboards as in the above example:

1. The midi connection to the controller can be taken from S, G or A { the letters referring to the ‘bass’ end white receptacle located on the bottom end key strip for a keyboard.
2. For a 3 keyboard system 2 interconnect cables are used. They can be connected as shown in the above diagram, however there are actually 6 possible ways to connect the 3 keyboards together and they would all work equally well The only requirement is that an interconnect cable go from JP10 on one keyboard to JP11 on the ‘next’ keyboard. In any given set of keyboards there will always be 1 set with nothing connected to JP11 { making it the master } and nothing connected to JP10 on a different keyboard.
3. Any of the higher order note modules on any given keyboard will only have optional piston connections. All necessary internal signals for those connections are provided by the module to module interconnect system.

Fault Isolation

NB: Suggested recommendation: when doing these keyboard diagnostics with an attached PC, it is recommended that the chamber controllers / chamber blower not be turned on and that the independent power supply to the SC units be also shut off. This will avoid any loud or rude noises that may occur if some key modules are reset with some stops down and also avoids unnecessary cycling of SC power supply & SC units when repeatedly cycling power to the console controller for some tests. { if note sounds are needed / wanted for some tests, then a GM sound can be attached to the internal midi connection of the PC to generate 'piano like' sounds when keys pressed. Such audio tools are sometime good to use as it allows contact point & note value to be determined without looking at the PC screen . At other times, particularly if there are babbling notes, the PC audio can be too confusing, so just silence that part}.

To aid in the isolation, it is useful to connect a notebook or other PC having midi input capabilities. The midi input to the PC is taken from the Midi-Thru connection on the C-III controller in the console. { It is useful to use this connection for these tests as the particular configuration present in the controller might filter out some information that may be relevant to fault isolation }.

The PC should be running an application called MidiMon or Midi-Ox. { Either of these utilities is available for download from the Internet & each some with rudimentary installation instructions that will not be repeated here } Midimon was included with Opus-Two Utilities zip file.. Be sure that the PC application is correctly internally connected to the midi input. Usually this can be simply checked by pressing a few notes on one of the keyboards to see if new midi messages can be displayed on the PC screen.

If a keyboard system is giving 'hesitant' or repetitive notes, or possibly some non-functional notes, some relatively simple diagnostic procedures can isolate which keyboard set is giving the problem. Once the culprit and the mechanism are identified, corrective actions can be taken.

It's also useful to see if lazy or repetitive keys are specific to a single keyboard or region of a single keyboard. This can point to problems with one of the keyboard interconnect cables or how the cable is connected. { Intermittents or marginal connections in these cables can cause strange key behaviour symptoms }.

With no keys pressed on the console, observe if there are any 'babbling' midi messages. A 'babbling' message is defined as a repetitive note message { on / off or both }. If this is happening, 'freeze' the PC display and determine the message type { note on / off or 'other' } and what the midi channel is.

With the firmware present in current key modules, there should only be note on / note off messages present in a stream of information to the console { / PC display }. If any other types of messages are present, then there is a fault present on a module or in a cable. A later section will help with isolating this }.

If a ‘babbling’ message is observed on s single channel, possibly just a single note or closely spaced group of notes { i.e. 13 or 9 notes that might be present on a single module } then most likely a sensor module has lost or ‘reset’ it’s history table for some reason. Usually playing notes on that specific sensor module will allow the module to re-learn key min and max settings. If this does not work then it may be advisable to reset the history table in that sensor using a special ‘reset’ header connector during module power up.

The particular channel can be identified in the midi message stream and this will help identify the keyboard set that is giving the problem. Channels are typically assigned as follows:

Acc	0	{ 0x00 }
Acc2nd	4	{ 0x04 }
Great	1	{ 0x01 }
Great2nd	5	{ 0x05 }
Solo	2	{ 0x02 }
Pistons	7	{ 0x07 }

Occasionally it will be necessary to isolate a keyboard to do further fault diagnosis. This will require access to the interconnect cables and the MIDI to controller connection.

If keyboards are giving keying delays or repetitive notes and note babbling is not occurring, then the problem is usually a bad or marginal interconnect cable. Check the connections and the individual punch downs to see if a connection has come loose or broken. There are 3 wires in the interconnect cables between keyboards. One is a GND connection. The center one is the MIDI data signal and the 3^{rd} is a keybd to keybd communication signal.

If the GND is not well connected, one would probably get intermittent activity from a given keybd.
If the center or MIDI signal not connected, then one would get missing or intermittent note activity from a given keyboard.
If the 3^{rd} signal has problems then usually can get a) no notes, b) colliding notes when keys played on multiple manuals, c) excessive note delays or d) sporadic note reporting when keys played.

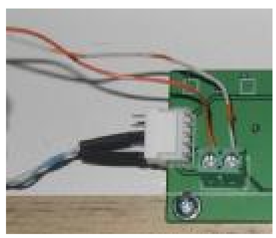
It is also useful to check that no pins are bent on the unused JP10 / JP11 connections.

In some cases lazy, delayed or repetitive note behaviour can be caused by a module to module connection that is marginal for various reasons 1) connector receptacle may have been ‘stressed’ during installation 2) unknown contamination or humidity effects on the module to module contact area.

Usually these problems are highlighted by working on a single keyboard at a time, gently pressing with fingers of one hand to slightly perturb board-to-board contact while playing notes with the other hand. If there are sudden 'bursts' of notes or improved key action when doing this, most likely have identified a potential marginal connection. Please be aware that if the sensor strip is 'pushed' towards the key magnets that there might be a burst of note activity as all the sensors sense magnet movements, When probing the key modules with fingers try to ensure that pressure is more side to side along the strip rather than pressure towards or from the key magnets.

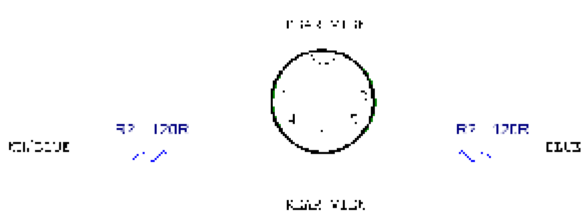
There are times that some further isolation needs to be done to check that single keyboards work fine by themselves. This can be done by moving the midi cable to the C-III to the appropriate key-strip set and temporarily disconnecting the kybd to kybd cables. This allows a single keyboard to be a single master. Then one can check for proper note operation on that keyboard, isolated from the others. { It may be more convenient to make up a separate midi keyboard cable for test use on the other 2 keyboards. } A photo of such a cable and its connections are shown below.

Power for this module in the photo is on the Orange / Orange white pair and is not needed if other power connections are present on the keyboard set being checked.



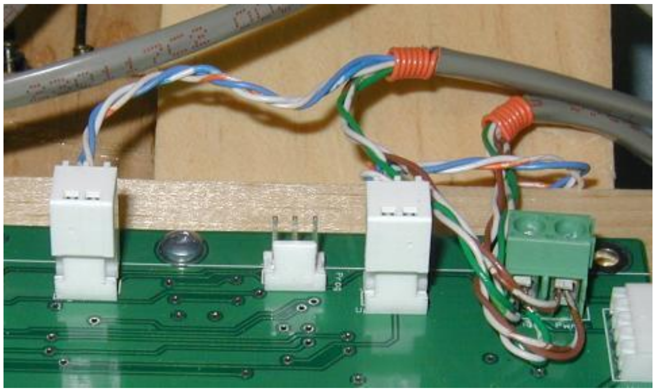
The blue/white wire connects to the center pin of the 5 pin header. The Blue { or blue/white } wire connects to the outside pin, towards the green screw terminal side.

The other end of the midi cable is a MIDI { 5 pin din } connector. Plug or socket may be used, depending on available needs / resources. The white / blue wire connects to pin 4 through a 120 ohm resistor. The blue { blue / white wire connects to pin 5 through a 120 ohm resistor. { This cable is identical to one that may have been made or used for the main keyboard to C-III midi connection. A second cable is used so as not to disturb the original one.



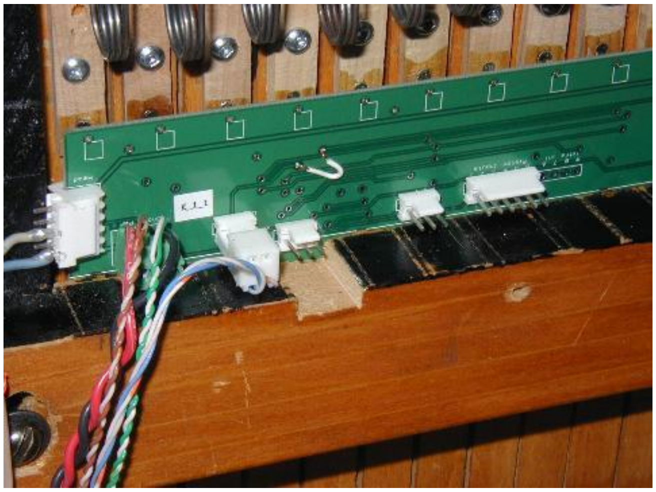
Misc Info & Photos

This photo shows an example of a kybd to kybd connections for the 'center' keyboard of a set. Both up and down cables are present, including power distribution.

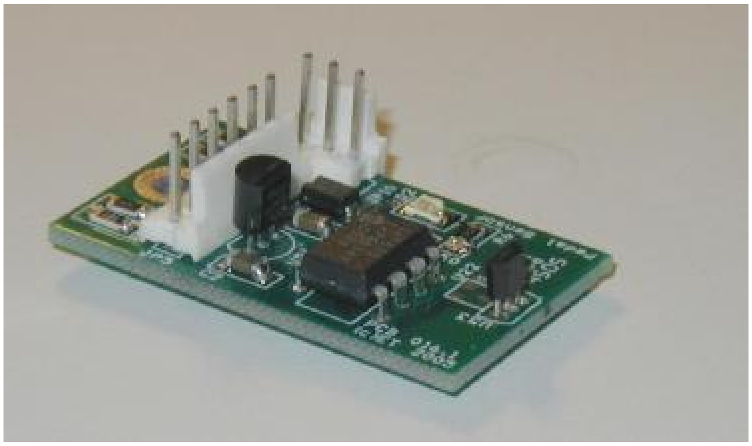


Note that there is no operational connection to be made to the "Prog" header.

Connections to the first or 'master' keyboard in a set. *{ Ignore the small white wire on the key strip in the photo. This is an early mod to the card that has been implemented differently on other production cards }*



Hall Effect Pedal Sensors



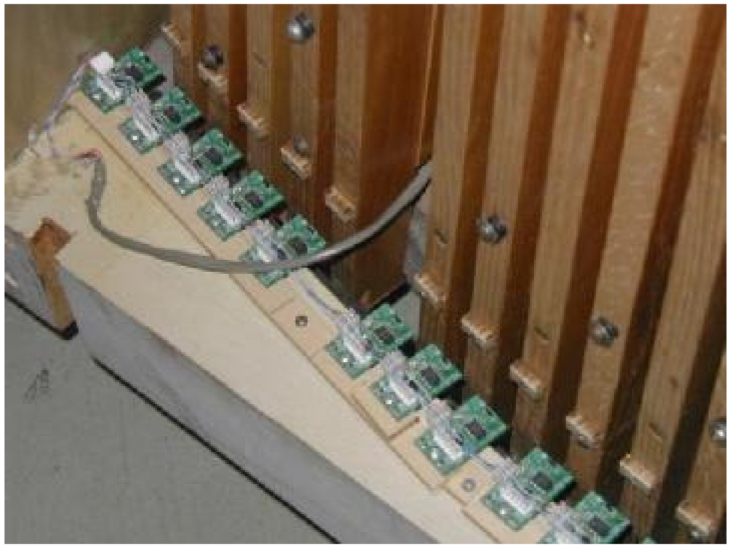
The Hall effect sensor for pedal notes is a single element that is daisy-chained together to make a keyboard set.

The unit is approx 0.7” wide and 1.3” long. The sensor is at the near end in the photo above. The magnet should approach the flat face of the sensor. The sensor assembly can be mounted at right angles to the key or parallel to the key { when mounted this way the sensor is pushed flat against the pcb }.

Normally, a larger 3/16” magnet is used so that the spacing from magnet to sensor can be greater { 3/16 to 1/8” when key fully depressed }. This allows for greater flexibility when mounting in pedal key assemblies.

This photo shows the daisy chain connector system for a pedal set of sensors.

The other 6 pin header is for use by toe pistons that may be closer to the pedal board to wire up. There are some contact points on this strip as well that can be used for pot inputs, useable for crescendo & expression.



Although the photo shows a daisy chain made from solid wire, it is recommended that 24 ga stranded wire be used due to the inherent vibration present in pedal board operations. Most pedal board kits will have 24ga wire supplied.

The pedal sensors may be positioned under the pedal keys anywhere from near the toe of the key to approximately 2/3 of way back to the heel of the note. In general, the more key travel range that is available is preferred, by very satisfactory operation can be achieved with approx 1/8” to 3/16” of magnet travel. As the key travel range is reduced there would be a preference to also have minimum magnet to sensor spacing be closer to 1/8”.

When a daisy chain cable has been put into position, it is useful to do a test to be sure that all punch-downs in the cable have been done properly. An open connection on any one of the 3 connections to each module can give a variety of problems. { A future expanded section will include info on what these effects may be }.

Pedal Sensor Test & Setup

The pedal sensor system can be set up as follows:

1. Determine the most suitable mounting site for the pedal sensor unit and the magnet. Usually this is on the bottom side of the key, near the key midpoint { often where original contact rail was mounted } or at the toe. The magnet may be mounted to the bottom of the key using a small magnet holder – a piece of wood with a 3/16 hole drilled in it for the magnet. This holder is then screwed or glued to the bottom of the key. { A bit of hot melt glue will hold the magnet in place in the 3/16 hole }. The sensor pcb is usually mounted in a vertical orientation, with the sensor { the small black device at U35 } positioned so that as the key is pressed the magnet approaches the flat face of the sensor unit. Be sure to leave room for the pedal daisy chain connector so that there is no interference with key movement or with the sides of the pedal board. **At full key depression the magnet should be approx 0.1" to 0.150" from face of sensor. Usually want to position pedal key sensor so that there is a min of 0.150" of magnet movement.** If the sensor is at the toe of the key, this movement is likely to be approx 0.6" to 0.8". The sensor will work correctly with any key movements in the range of 0.15" to 1".

2. Connect the pedal daisy chain cable to the pedal sensors. Connect the free end of the daisy chain cable to power and the C-III { Db-25 Pin 12 }

3. Apply power to the system { minimum of C-III, display and pedal sensors connected }

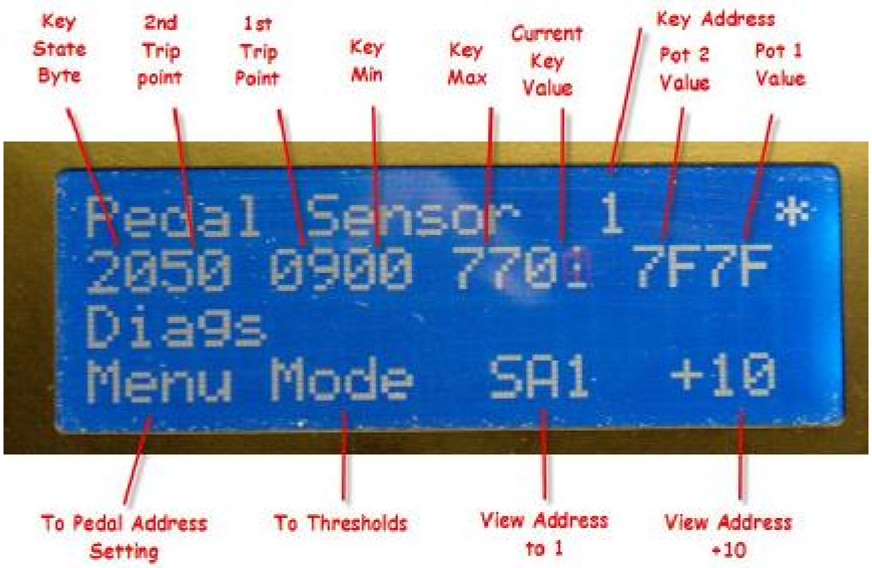
4. Access the Pedal Sensor Setup screen { "M3 + M4" display buttons, when in Cmn-mem display }. For these tests it may be helpful to have pedal board positioned so that the leds on each sensor are visible.

Pedal Sensor Display Menu:

The Pedal Sensor setup / diagnostics screen is used for basic test and initialization of the pedal sensors &/or pedal sensors used for analog inputs.

Pressing the Mode button cycles thru [Diags , Thresholds, Scrub, Address Setting]
Pressing Menu advances to Pedal Sensor Address Setting.
Pressing UP/DN changes the sensor being examined.
Pressing SA1 sets the examined sensor address to 1
Pressing +10 increments examined sensor address by 10.

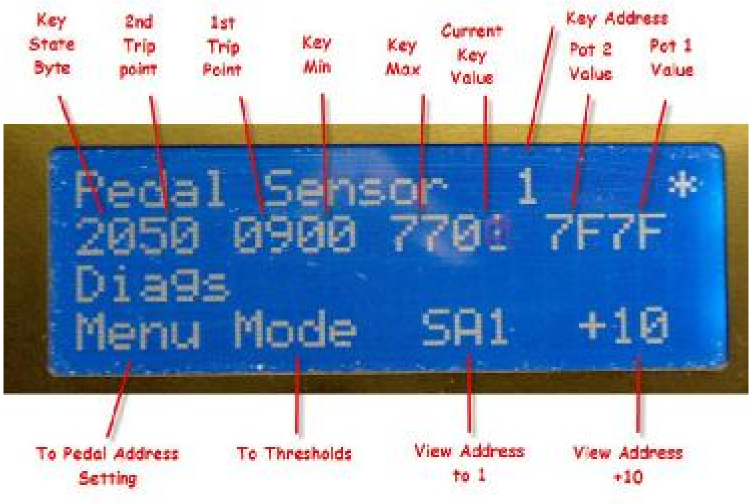
The Diag screen is a quick way to look at any given sensor to check operation.



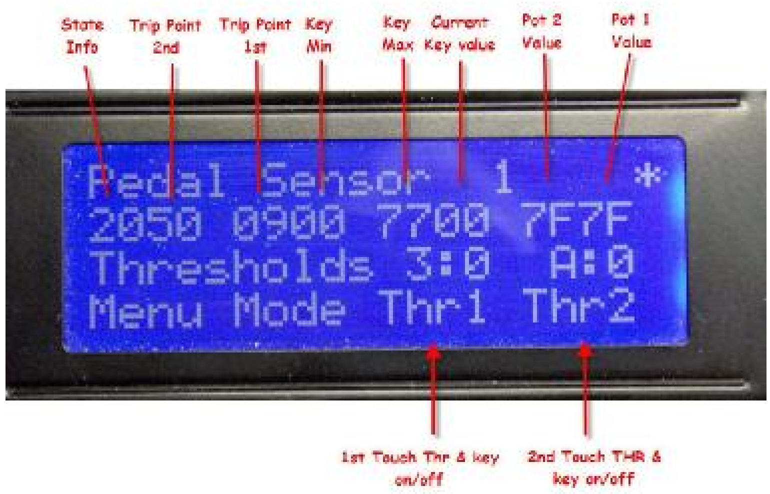
Each key sensor remembers the key min and max positions. It learns these from the operation of the individual notes.

Trip point thresholds are set from the display screen. These set the points at which the key sensor will report 1st touch and 2nd touch note contacts { 2nd touch normally only on theater organ pedal boards equipped with 2nd touch springs }. The thresholds, or decision points are set in the pedal sensor Thresholds screen.

Diags
The 1st is Diags, the address of the sensor being looked at is at the top, the next line is 8 data bytes from the sensor. The 3rd line is 1st & 2nd touch info for that sensor. As the magnet moves closer to the sensor you will see a value in line 2 change from 0 to 0x7F { approximately }. As the key passes trip points the 1st & 2nd touch note info will change. Pressing up / down change the sensor being looked at. The +10 key changes by +10 and SA1 sets the viewed sensor back to 1.

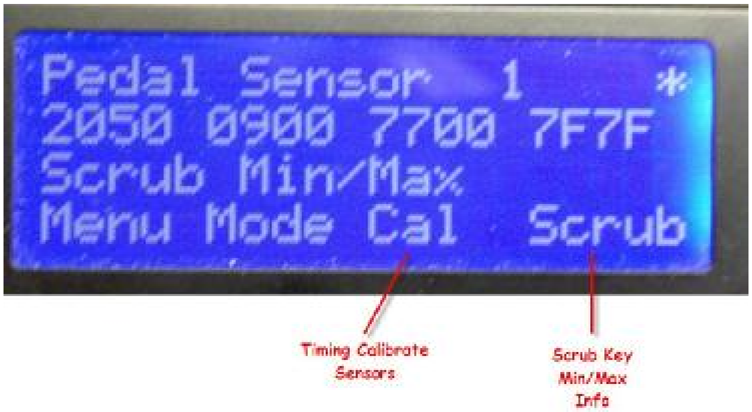


Thresholds
The 2nd mode screen is Thresholds. Here you set the 1st & second trip points. For now this is a global setting for all notes.



Scrub
the 2rd mode screen is Scrub min/max. This is used to erase the retained pedal note min / max tables. Only 1 button { scrub } needs to be pressed to actually erase the history table now. After you do this you need to play each note a few times.

You can cycle between the mode screens without doing anything to the sensors.



Pedal Address Setting

Pressing Clear starts the address setting sequence.

Pressing Set+ sets displayed address in selected sensor and increments address

Pedal Sensor Setup

Setup of a set of pedal sensors involves these operations

1. Scrub key min / max values & playing notes individually a few times to learn new min / max values. { A default set of thresholds is used after the scrub }
   This is operation is done in the Pedal Sensor Scrub screen.

   Navigate to this screen, press Scrub, then play each note a few times. As the note is engaged the led for that sensor will go on / off. When all keys are done the leds should all be off.

2. Setting individual sensor note addresses. Clear out any existing addresses and set new ones. Analog sensors can be included in this.

   Navigate to address setting screen. Press Clear. Each sensor should now be flashing { not necessarily synchronized }

   The display screen shows a Pedal Note 1 address. Fully depress the key that will be note 1 and press the Set+ key on the display. Release the display key and the note. The display will update to the next address and the led for the pedal sensor that has been just set will stop flashing. { That particular LED will now track pedal on/off movement instead of flashing. Repeat the process for the remainder of keys 2 – 32.

   Analog sensor addresses { 33 to 40 } can be set by moving expression magnet close to sensor or connecting pin 2 to pin 6 on the 6 pin header for that sensor.

   It should be mentioned that if enter address setting mode { with leds flashing } and leave this screen without setting any addresses or or completing address setting, any existing addresses in sensor units will not be changed.

3. Setting Key thresholds for 1st / 2nd touch trip points.

   Navigate to Pedal Sensor Thresholds screen

   Here you set the 1st & second trip points. For now this is a global setting for all notes. Set THR2 1st, then THR1.

   Press & hold THR2 along with up/dn to change the 2nd touch trip point. Range is 0 to F. A is probably a good start. If a single touch pedalboard, set this value to F.

   Press & hold THR1 along with up/dn to change the 1st trip point. The range is 0 to F, with 5 or 6 being a good 1st guess for 1st touch, 3 for second touch pedalboards.

4. Check individual sensors / keys for proper motion and note generation

This can be done in Diags screen or Thresholds screen. Up / DN changes the displayed sensor.

The data display line will show calculated trip points and current key and analog pot data.

5. Check analog sensor operations.

   The analog sensors are usually assigned addresses in range 33 to 40.

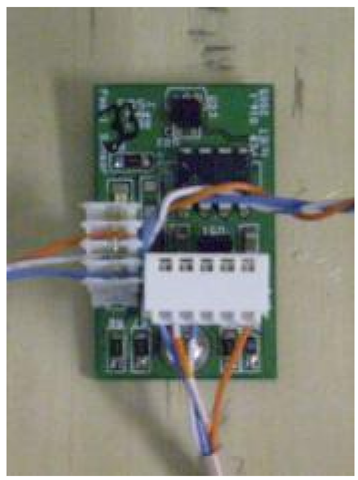
It should be noted that when the Pedal Diagnostic screen is active, normal pedal scanning an note reporting to other portions of and Opus-Two system is suspended.

Analog Inputs to Pedal Sensor Modules

The pedal sensor unit can also accept 2 analog inputs in addition to the regular use as a hall effect sensor.

If expression / crescendo pedals are attached to the pedal board, it is convenient for the analog inputs to be take to one or more sensors, 1-32. as may be required. Up to 6 analog inputs may be accommodated this way. Each pedal sensor can accommodate 0, 1 or 2 analog inputs. { If the pedal output option is used with the pedal sensor module, only 1 analog input can be used per sensor }.

If the expression / crescendo pedals are attached to the kneeboard of the console, it may be more convenient to have extra sensor units dedicated to these analog inputs separate from the pedal sensors. It may also happen that there are no pedal sensor units, only extra units for reading expression / crescendo analog inputs. In either case, the analog sensors share the same data line to the controller { landing on the C-III, pin 12 of the DB-25 }.



The photo shows a single pedal sensor. The 3 wire connection to the left is the power / comm. / Gnd connection to the controller.

The 4 pin connection at the bottom of the photo is the connection to one or two analog pots, linear or rotary style, as may be appropriate for the pedal mechanical arrangement.

For the connections to the left:
The orange wire is +12V.
The white/blue wire is the communication connection to the C-III, DB-25, pin 12. This connection may be shared with other pedal / analog sensor units { max of 36 }.
The blue wire is GND. This will be the logic GND or common of the C-III.

For the connections from the bottom of the sensor:
The orange wire { pin 1 } is +5V. This would connect to the 'top; ends of one or 2 analog pots used with this sensor

The Blue wire is { pin 6 } is GND. It would connect to the ‘bottom’ end of one or 2 analog pots used with this sensor.
The white/blue wire { pin 4 } is analog input 1. It would connect to the wiper of pot 1.
The white/orange wire { pin 5 } is analog input 2. It would connect to the wiper of pot 2.
For analog inputs connected to sensor units separate from the pedal keys, addresses of 33 to 36 will have been assigned to these units.

Unit 33 will have analog inputs 1 & 2
Unit 34 will have analog inputs 3 & 4
Unit 35 will have analog inputs 5 & 6
Unit 36 will have analog inputs 7 & 8

The analog inputs are assigned to the desired function in the main C-III configuration file.

Typical assignments are:

> Input 1: swell or main
> Input 2: choir or solo or crescendo
> Input 3: antiphonal or crescendo
> Input 4: crescendo

The configuration program will also arrange to trim out any DC offsets and apply scaling parameters to the analog input as may be needed for the application.