Hauptwerk Hardware

Motorized Stop Controller

Installation & User Manual

Release 1.1 – July 2022

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Introduction

What is it?

The Hauptwerk Hardware Motorized Stop Controller is a device that facilitates using motorized stops (sometimes called Moving, or powered) stops, within a Midi organ system. It controls the movement of the physical stops when one operates the stop via the organ software, i.e. turns a stop on or off via a touch screen, as well as operating the virtual stop within the organ software when one operates the physical stop. It is commonly installed between a computer running a Midi virtual organ or capture system and the physical stops of the console.

What does it do?

It communicates, via Midi, with the computer and generates and manages the timing of the pulses necessary to operate the coils within the physical stops. It works with all types of motorized stops, whether they be draw-stops or tab-stops. Because motorized stops always operate at a higher voltage and current than can be connected directly to a computer, this controller sits, electrically speaking, between the computer and the physical stops, allowing them to work seamlessly together.

Who is it for?

This Motorized stop controller has been designed for use by anyone who wants to use motorized stops or tabs with any type of Midi capable microprocessor controlled equipment, primarily in the realm of the digital electronic organ. Interfacing motorized stops to sensitive computer equipment is fraught with pitfalls! This stop controller has been designed to make it as risk free and easy as possible, whilst providing advanced features and communications, which both simplify installation and, any necessary troubleshooting, as well as ongoing maintenance. This controller is aimed at both the professional organ builder as well as the home enthusiast building a virtual organ system, although with the caveat that ***potential users MUST read and understand the information contained within this entire manual before attempting to connect or use this equipment. Failure to understand or follow this information is very likely to cause damage to either the stops, the computer or this interface. You have been warned.!***

Product Features.

- **USB MIDI interface as well as legacy MIDI 5 pin DIN built-in.**

- **Class compliant MIDI device – No additional MIDI drivers required.**

- **USB Communications port built in - allows for easy maintenance & troubleshooting.**

- **Powered by USB - No other power source required except the stop motors supply.**

- **Solder pads for easy & reliable connection.**

- **Calibrates pulse times (power) for each individual stop.**

- **Allows user to manually set pulse times (power) for individual stops.**

- **Compatible with all major manufacturers draw-knob and tab-stops**

- **Scans the stop switches and drives the coils (motors).**

- **Compatible with Hauptwerk, Grand Orgue and most other organ software.**

- **Compatible with our Midi Capture System.**

- **Drive up to 48 magnets (24 draw knobs or tabs).**

- **Notifies organ software if stop fails to move.**

- **Accommodates enough current for General Cancel of all stop motors simultaneously .**

Board dimensions (WxLxH): 177 x 177 x 25mm (7" x 7" x 1").

Principle of Operation.

How draw-stops work.

Scan the QR code below to watch my detailed video explaining how motorized stops work or just follow this link, https://www.youtube.com/watch?v=nmUad92PJcE

In order to understand how the controller works it is necessary to first take a quick look at what happens to make a draw-stop operate. Inside a moving stop, whether it be of the draw-stop type or the tab type there are four main parts. These are the armature, that's the part of the stop that actually moves, the coil that makes the armature move to the on position, the coil that makes the armature move to the off position and the contact that signals whether the stop is in the on or off position.

When the operator moves the stop to the on position the contact will close and when the stop is moved to the off position the contact will open, just like a regular switch.

If the stop is in the off position and power is applied to the coil that turns the stop on, the armature will move into the on position, and as a result of this movement the contact will close, thus signalling that the stop is now on. If the stop was already in the on position when power was applied to the aforementioned coil, the stop would not move but the coil would still be energised and using power.

The reverse happens if the stop is in the on position and power is applied to the coil that moves the armature to the off position.

When power is applied to the coil it will consume a significant amount of current, this will result in the coil heating up very quickly and it would soon burn out completely if power was not quickly removed. This is because it takes a relatively large amount of current to physically move the stop from one position to the other. Because the armature will move almost instantly once power is applied to the coil, we only need to apply that power for a very short time, typically less than ¼ of a second.

Since actual power, measured in Watts, is a product of work done in a specific period of time ,the result of a large current flowing in the coil *for a very short time* is manageable and the stop will operate reliably without any problems. It is therefore obvious that stop motors can only tolerate, being powered in short bursts.

The same can be said of the electronics that actually control the power to the stop coils. They can control high power pulses, but not continuous power.

Because the power supply apparatus that is used to move the draw-stops has to be able to provide enough power to potentially energise all the stops at once, say when a general cancel signal is received, it is easily capable of supplying enough current to cause significant damage if a stop coil was left energised due to a failure somewhere in the system.

How the Stop Controller works.

The job of the stop controller is to control the power to the stop coils and to communicate, via MIDI, with the computer. The controller scans all the stop switches to see which are on and which are off. Internally it remembers the status of each stop and then looks for any changes to their position as well as listening out for any incoming MIDI messages from the computer.

If a MIDI message arrives requesting a change of state for any particular stop, the controller first looks at the current state of that stop, and if it already matches the requested condition it will do nothing. However if the requested state is different to the current state it will send a pulse to the relevant coil to change the state of that stop. Once that has been done it will check that the stop has actually changed state. If it has then all is well and the controller goes back to its usual listening and scanning mode. If

for any reason the stop didn't move then the controller will send a MIDI message back to the requesting computer causing the computer to reset the stop to its previous condition. This is necessary in order to prevent physical stops becoming 'out of sync' with the ones on the computer screen.

As well as listening for incoming MIDI messages the controller continually scans the stops for any change of state. If it sees a stop has changed state it will update its internal state memory and then send a MIDI message to the computer saying that a particular stop has been operated. The computer will then change the state of that stop in the virtual organ software.

In More Detail

Mains Power In

Stops Power Supply
15 Volt 20 Amps

0v Gnd

+15v Out

Reed Switch

Off Coil

On Coil

OFF   ON

Stops +ve

REED

Connection for one stop Magnified

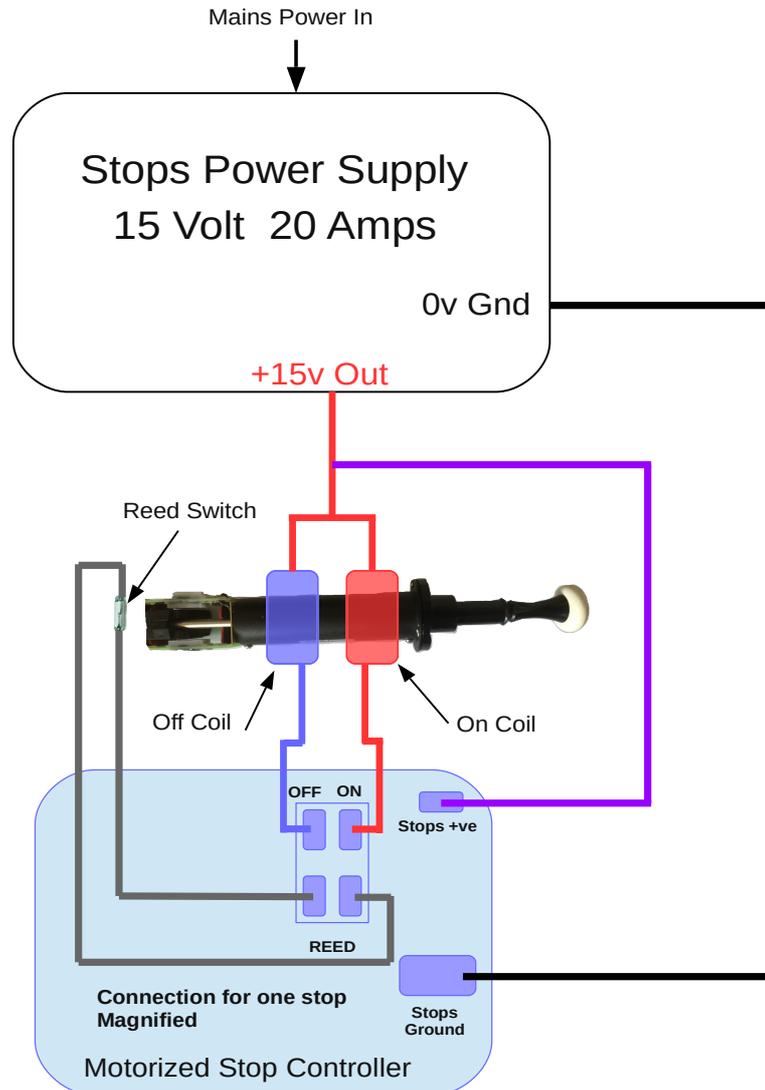**Stops Ground**

Motorized Stop Controller

Figure 1: Typical connection of a draw-stop

The stop controller has 24 sets of solder pads, one set for each stop that it can control. Each set has four solder pads. Two marked 'REED' and two others marked 'OFF' and 'ON' respectively. Looking at the diagram above you can see how each stop connects. A wire connects one side of both the ON and OFF coils to the +ve terminal of the power supply, this wire should be thick enough to handle the

maximum current when all stops are pulsed on, such as when a General Cancel is requested. 12 AWG or 2.0mm^2 is a good size. Then a single wire connects the other side of the coils to the ON solder pad and the OFF solder pad respectively on the controller board. Finally two wires are used to connect the reed switch* to the two pads marked REED on the controller board. It does not matter which end of the reed connects to each pad. Since this gives us a total of four wires per stop, wiring them can be achieved neatly by using 4 core cables. The type used for burglar alarms works well. By this method it is easy to make a neat job of the installation. Note that only the wire that connects the power supply to each of the stops needs to be heavy gauge, the rest of the wires can be much thinner as they only carry power from a single stop.

It is highly recommended that the controller board is mounted as close as possible to the actual stops. There are a number of reasons for this.

1. All cables have resistance and this causes a voltage drop along the length of the cable. Because these cables are carrying power required to physically move the stop it is wise to keep this resistance to a minimum. This is done by keeping the cables as short as practical.

2. The proximity within the cable of the power wires from the coils and the sensing wires from the reed can cause interference between each other in long cable runs. The shorter you can keep your cables the more reliable your finished installation will be. This is one of the reasons for keeping the number of stops per controller to 24. In larger instruments it is wise to have a separate controller installed in each stop jam.

3. The likelihood of the cables picking up any external electrical noise is greatly reduced when cables are kept short.

4. It results in a neater installation.

The wire that connects the Stops Ground solder pad to the 0v or Ground terminal of the power supply, shown in black on the diagram, also needs to be of the same heavy gauge as the supply wire to all the stops. This is because it too will need to carry a high current when all stops are powered, again 12 gauge or 2.0mm is a good size.

The wire, shown in violet on the diagram, is very important. I will explain why its needed below but if you want to skip the technical part just make absolutely certain that you connect this wire as shown in the diagram before powering on any stops. **Failure to connect this wire WILL irreparably damage the controller...!**

* Whilst draw-stops tend to use reed switches stop tabs usually use wire contacts.

Why the violet wire is so important.

The coils of the stops work by generating a magnetic field when power is applied to them. This magnetic field attracts the iron armature, that is the part of the stop that moves and has the knob attached to it. The ON coil is located at the front of the draw-stop unit and when energised it attracts the armature to it causing it to move towards the front of the stop unit and placing it in the on position. Likewise the OFF coil is placed at the back of the unit and pulls the armature back into the unit to put it in the off position.

When a coil is energised electric current flows through it and a steady magnetic field exists through and around the coil. When the power is removed from the coil the magnetic field quickly collapses and this is where it gets interesting. You probably know that moving a coil in a magnetic field causes the coil to 'generate' electricity. When the field collapses this has the same effect, and quite a strong voltage is 'generated' momentarily as the field decays. Although this only takes a fraction of a second it generates a real pulse of high voltage electricity, often in the order of a thousand volts or so. Since the component parts of the controller are only designed to work at up to 30v for the coil drivers and only 5v for the microprocessor and its supporting components, a pulse of many hundreds of volts tends to have the effect of immediately destroying these parts!

The coil drivers used in the controller have a built in protection circuit which protects both themselves and the rest of the controller against this high voltage pulse, **but this protection can not function without the connection shown in violet on the diagram.**
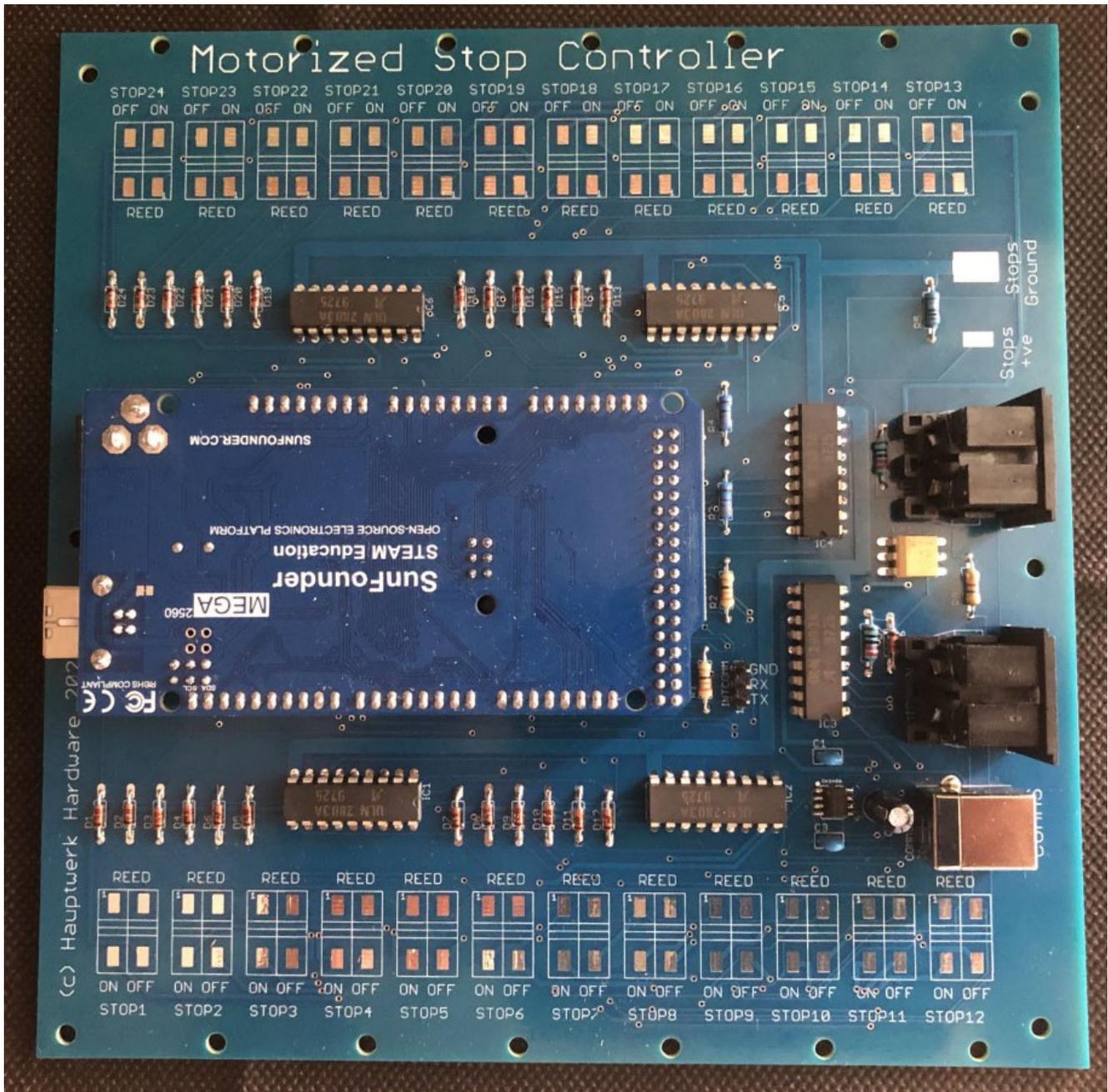
Installation and use.

Figure 1: Stop Controller Board

As discussed above the controller board has 24 sets solder pads, one set for each stop. These are arranged around the edge of the board so that they are easily accessible for soldering the cables to. You will notice that the 'REED' connections are placed on the inboard side of each pad set. This is so that all of the high voltage coil wires are kept as close to the edge of the board as possible and well away from the low voltage connections and components placed further within the boards perimeter.

The connections to each set of solder pads are made as per the previous section following the arrangement shown in figure 1. for each stop.

Any number of stops can be connected to the board from a single one up to the maximum of 24 and

once all the stops have been connected to the board we can look at the other connections. The 'Stops Ground' and 'Stops +ve' connections need to be connected as per figure 1.

That only leaves the plug in connections of two 5 pin DIN sockets and two USB sockets along with a row of 3 header pins labelled INTCOM. We will look at these connections separately.

The USB socket on the left of the board that is mounted on the sub-assembly is the main connection to the virtual organ computer and this carries both the power to supply the logic section of the controller along with the MIDI data to and from the computer. The controller is a Class Compliant Midi Device meaning that when connecting this USB connector to the computer, the computer will see the controller as a Midi device. In fact it will enumerate as a 'Motorized Stop Controller' and be available for use by any Midi capable software running on the computer.

The two 5 pin DIN sockets marked 'MIDI IN' & 'MIDI OUT' are for use with any computer system that does not have Midi over USB capability or for connecting to any other type of legacy Midi device.

The USB connector on the right of the board marked 'COMMS' allows for the connection of terminal emulation software such as 'PuTTY'. This is intended for configuring the controller and is left disconnected in normal everyday use. NOTE: This USB connection does NOT carry power. The controller can only be powered from the main USB connection.

The 'INTCON' headers are for internal use when using the controller in conjunction with our USB Capture System.

Configuration.

The Motorized Stop Controller is ready to use and will work just fine in it's default state as supplied from the factory, however there a number of things which can be changed via this interface. These are the controller address, automatic calibration of pulse timings for each stop as well as manual setting of pulse timing for any or all stops. Lets look at each of these in turn.

Controller Address.

This is set as 1 by default, which means that the controller will communicate on MIDI Channel 1 and use note on/off commands from 1 to 24. So, for example if you pull stop number 3 it will send a Midi note on for channel 3 over both the main USB Midi interface and also the 5 pin Midi interface simultaneously. You have the option to set the controller address to either 1, 2 or 3. Address 2 will use Midi channel 2 and Midi on/off notes 25 to 48, whilst address 3 will use Midi channel 3 and Midi on/off notes 49 to 72. If you have more than one controller in your system you do not need to change the address of either one as they will be seen by the computer as different Midi Devices and you can easily differentiate between devices when setting up the virtual organ software. The only time you would need to change the controller address would be when using it with our Midi Capture System. Instructions as to which address is required are included with the Capture System.

Viewing the Pulse Lengths

There is an option to view the pulse lengths so that you can see what the actual times are. This is useful because if any of the stops are markedly different to their fellows in the time they take to operate they may be closer to failure or require maintenance. The default value before calibration is 100mS for both off and on pulses for each stop.

Automatic Pulse Length Calibration.

Running the 'Calibration' program will cause the controller to actuate all the stops sequentially and measure the pulse length required for each stop. It does this five times and calculates the maximum time required to change each stop from off to on and back to off again. Once the values are calculated

they are stored in the controllers memory and used as reference values each time a stop is operated.

Setting Pulse Length Manually.

If there is a stop that is unreliable or slightly sticky you can manually set the pulse length to overcome this. You can choose to manually set the pulse length for any stop, both for the 'ON' and the 'OFF' operation phase. The maximum pulse length allowed is 700mS. **Be aware that this is a very long time** – usual times are less than 100mS. If you set a longer time for a stop, the controller will obviously use a lot more power because it will always power that stop for longer. If you were to set all stops to long pulse times your system would use a considerable amount of power, to the point where the controller, the stops themselves and probably the power supply unit would be likely to heat up. This would be bad. Stops are designed to be powered momentarily. The option to set pulse lengths manually is there for occasional use on one or two troublesome stops, you should use the Calibration function wherever possible. If you have a sluggish stop you should probably consider maintenance or replacement of that unit. Manual pulse length adjustment is meant as a temporary 'get out of jail' card.

How to connect the controller for configuration.

First make sure that all your stops are connected as described above and that the controller is connected to the computer by the main USB connection on the sub-assembly, also that the stops power supply is on and all the stops are in the off position.

Connect a second USB cable between the computer and the USB socket labelled 'COMMS' on the controller. The computer will see this connection as a COM port. In Windows look at the 'Device Manager' to see which com port number the computer has assigned to this connection.

Once you have ascertained which port number it is using open a terminal program such as 'PuTTY' and select 'Serial' from the available options, then select the 'Baud Rate' as 115000 and the 'Serial Line' as COMx, where x is the com port number described above. The other settings can be left in their default state. Press 'Open' to initiate the connection. This will open a window with a black blank screen.

Press 'Enter' on your keyboard and the controller's main menu will be displayed in the PuTTY window.
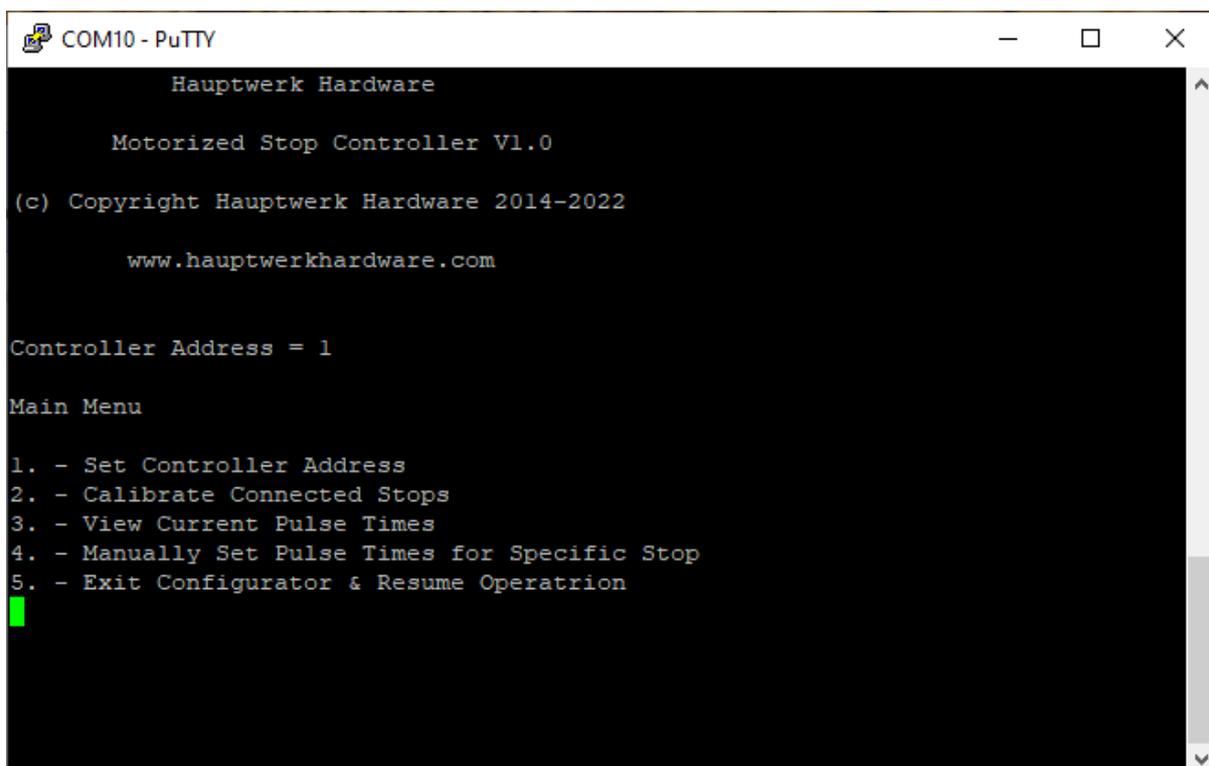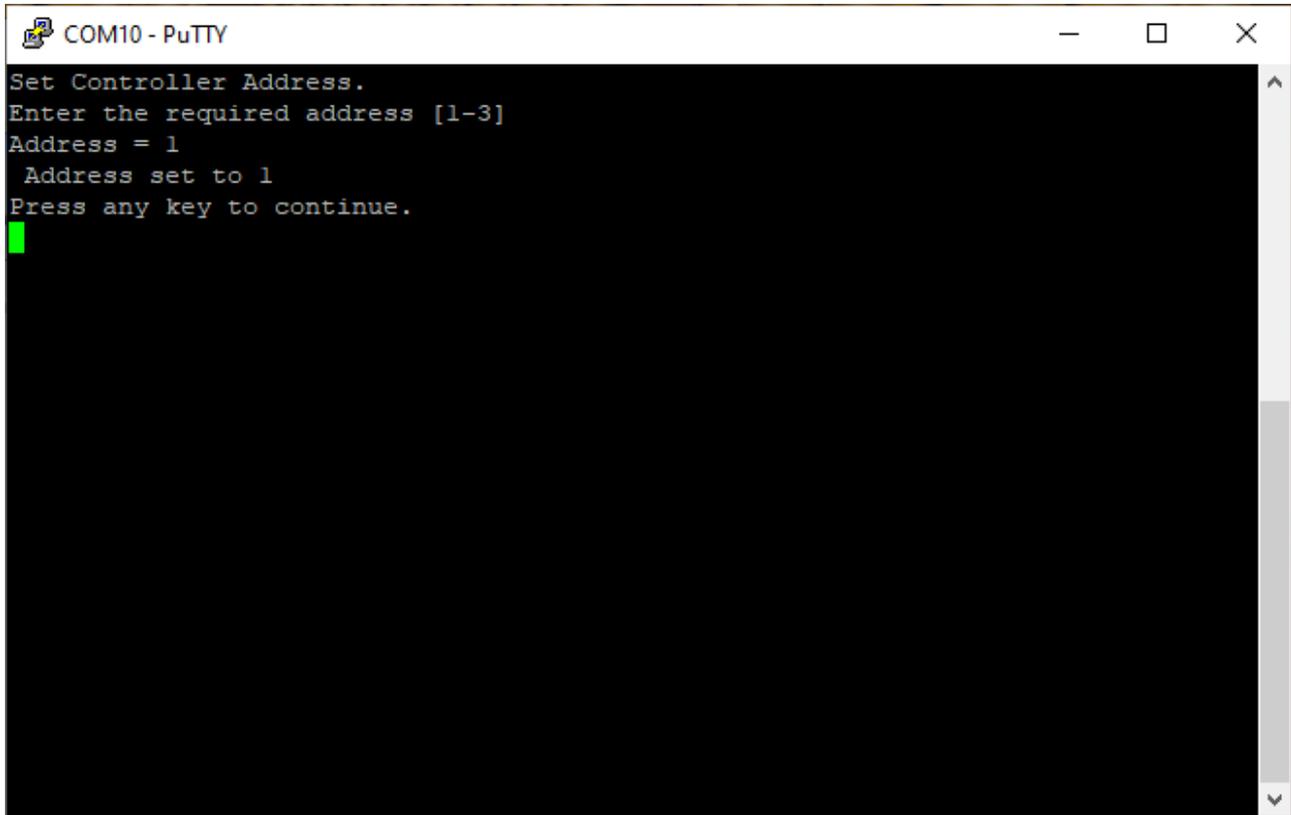

NOTE: Once you press Enter and have the main menu displayed the controller goes into program mode and will not respond to any stop movements or Midi commands until you select option 5 and press enter.

From this menu you can select the function you want to work with.

Option 1. Set Controller Address.

Pressing 1 and then Enter will take you to the Set Address screen where you can select from address 1 to 3. I selected 3. This screen is shown below.
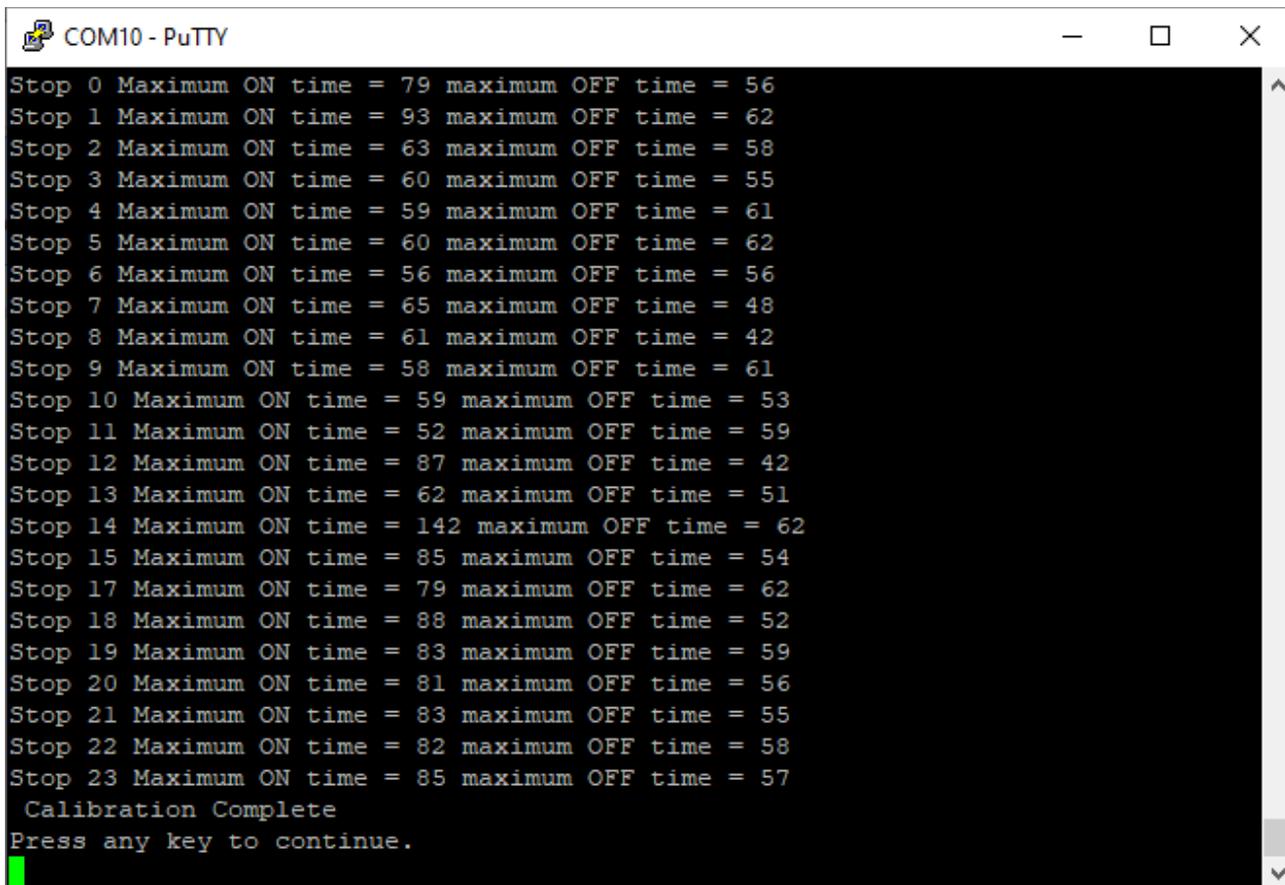

After you press a key you are taken back to the Main Menu Screen.

Option 2. Calibrate Connected Stops.

Pressing 2 will cause the controller to begin it's calibration routine. Make sure that the stops are connected and that the Stops Power Supply is turned on before selecting this option. As the calibration routine runs the stops will quickly move from off to on and back again. This will happen 5 times before the summary screen is shown as in the picture below.

After you press a key you are taken back to the Main Menu.

Option 3. View Current Pulse Times.

Pressing 3 followed by enter will display the stored pulse times for each stop, like in the picture below.
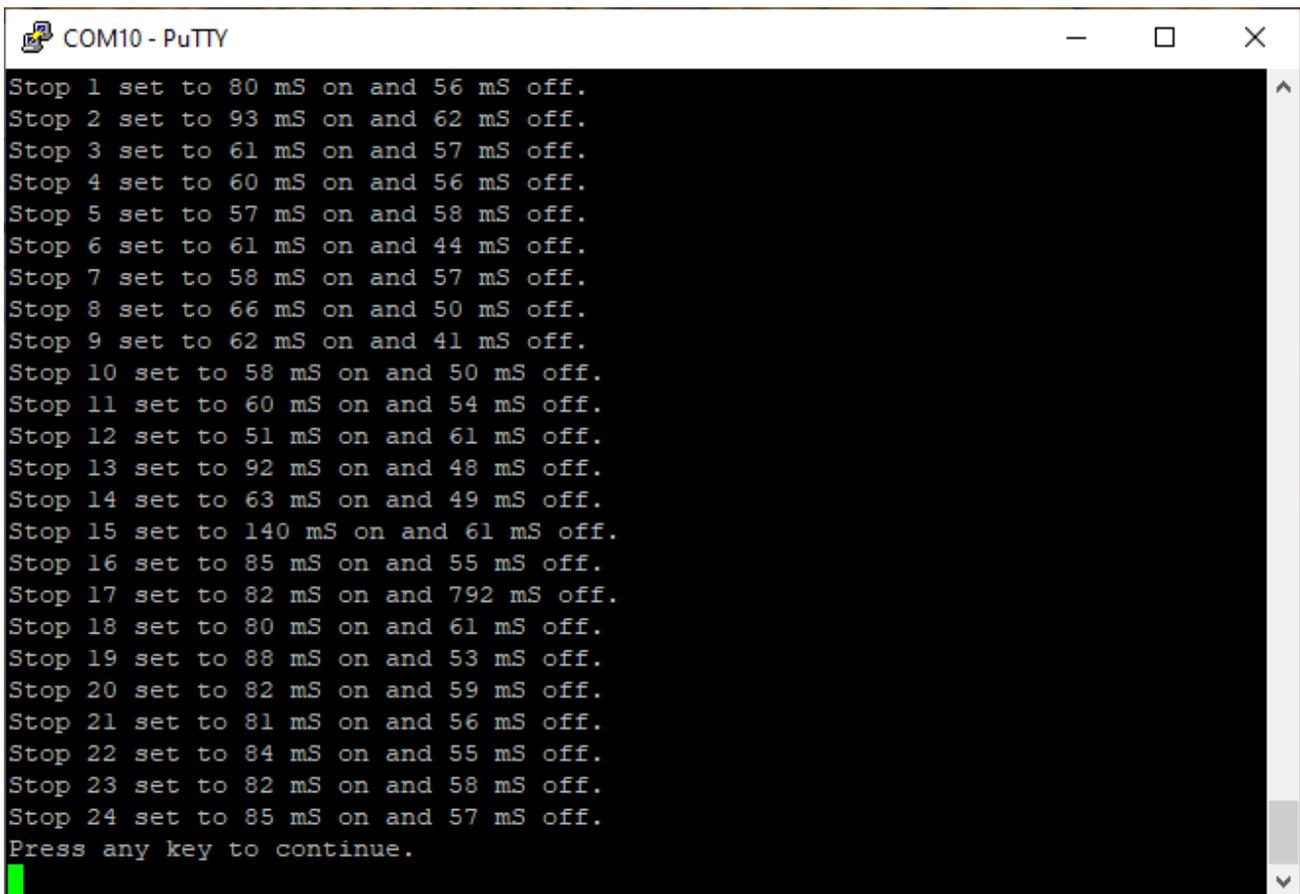
```
COM10 - PuTTY                                                    —    □    ✕

Stop 1 set to 80 mS on and 56 mS off.
Stop 2 set to 93 mS on and 62 mS off.
Stop 3 set to 61 mS on and 57 mS off.
Stop 4 set to 60 mS on and 56 mS off.
Stop 5 set to 57 mS on and 58 mS off.
Stop 6 set to 61 mS on and 44 mS off.
Stop 7 set to 58 mS on and 57 mS off.
Stop 8 set to 66 mS on and 50 mS off.
Stop 9 set to 62 mS on and 41 mS off.
Stop 10 set to 58 mS on and 50 mS off.
Stop 11 set to 60 mS on and 54 mS off.
Stop 12 set to 51 mS on and 61 mS off.
Stop 13 set to 92 mS on and 48 mS off.
Stop 14 set to 63 mS on and 49 mS off.
Stop 15 set to 140 mS on and 61 mS off.
Stop 16 set to 85 mS on and 55 mS off.
Stop 17 set to 82 mS on and 792 mS off.
Stop 18 set to 80 mS on and 61 mS off.
Stop 19 set to 88 mS on and 53 mS off.
Stop 20 set to 82 mS on and 59 mS off.
Stop 21 set to 81 mS on and 56 mS off.
Stop 22 set to 84 mS on and 55 mS off.
Stop 23 set to 82 mS on and 58 mS off.
Stop 24 set to 85 mS on and 57 mS off.
Press any key to continue.
```

Pressing any key at this point will take you back to the Main Menu.

Option 4. Manually set Pulse Times For Specific Stop.

Press 4 followed by Enter. This will take you to the next screen where you can choose which stop you want to set the pulse times for. Press the number of the desired stop followed by Enter.
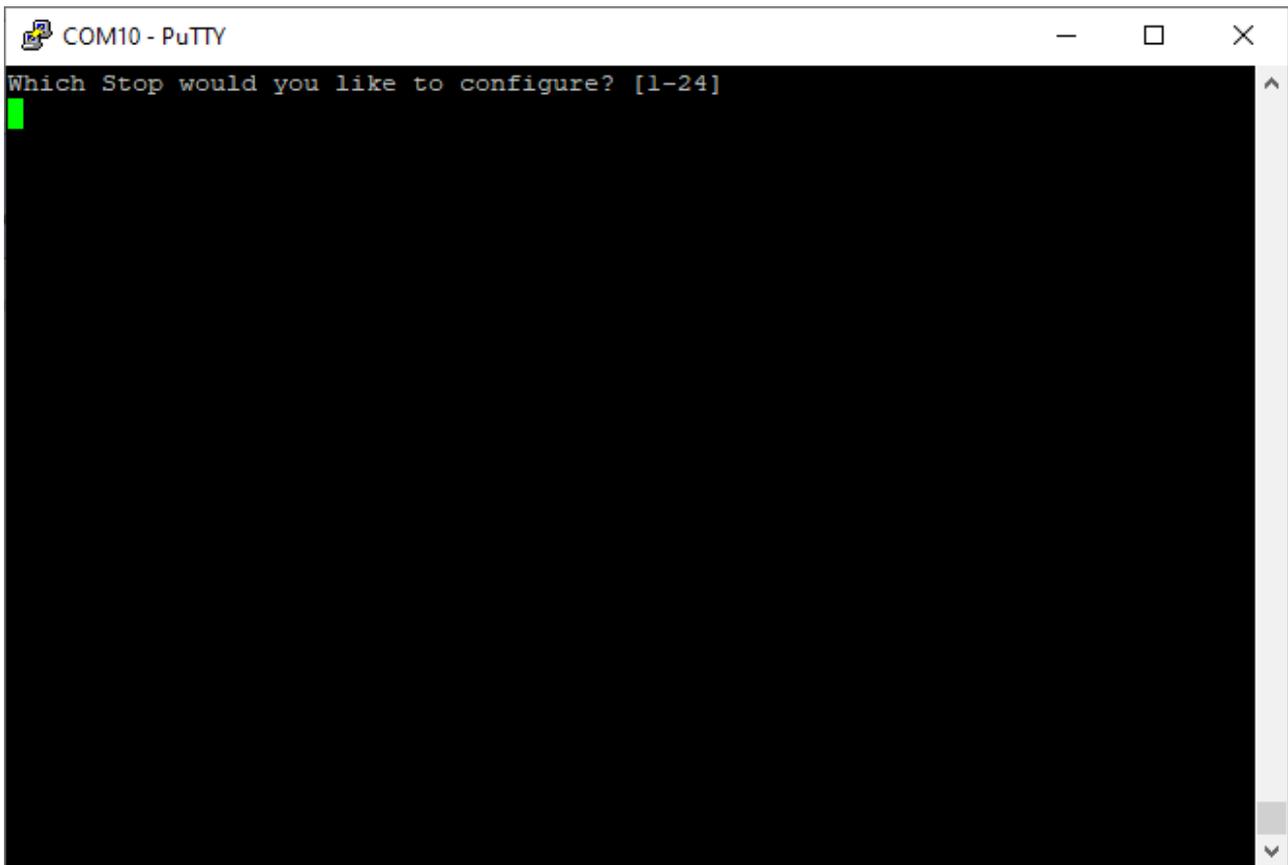
Follow the on-screen prompts to enter the desired times for both the On pulse and the Off pulse. You will then be taken to the next confirmation screen. This screen will display for a few seconds before taking you back to the Main Menu.
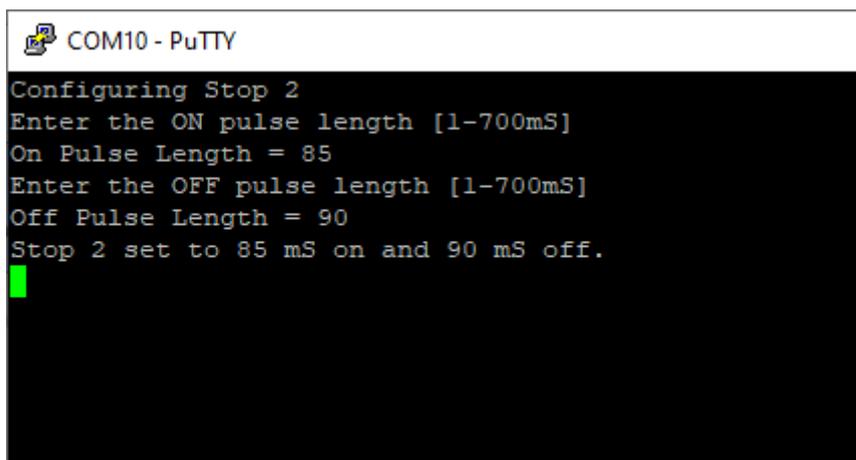
Option 5. Exit Configurator & Resume Operation

The final option in the Main Menu Exit Configurator & Resume Operation will switch the controller back into it's usual mode of operation.

```
COM10 - PuTTY                                      —    □    ✕

            Hauptwerk Hardware

        Motorized Stop Controller V1.0

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Controller Address = 1

Main Menu

1. - Set Controller Address
2. - Calibrate Connected Stops
3. - View Current Pulse Times
4. - Manually Set Pulse Times for Specific Stop
5. - Exit Configurator & Resume Operatrion
Done...
chan = 1 note = 3 on
chan = 1 note = 4 on
chan = 1 note = 7 on
chan = 1 note = 10 on
chan = 1 note = 11 on
chan = 1 note = 12 on
chan = 1 note = 17 on
```

Whilst in this mode the controller will display any commands it receives such as stop on & off commands caused by manual operation of the stops as well as received Midi commands followed by their consequential stop on or off operations as shown in the picture below.

This is useful for troubleshooting.

Once you have your stops and the controller mounted, configured and connected it's time to get the stops connected to Hauptwerk or whatever virtual organ software you use. We will look at how to do this in Hauptwerk and Grand Orgue. Taking Hauptwerk first, I will use the St Anne's organ as an example.

Configuring your stops in Hauptwerk.

For this example I am going to use the Trombone 16 from the Pedal Division. First right click the Trombone stop and you will be presented with a menu as shown in the picture above. Select the first option 'Auto-detect...' This will open a new dialogue box as in the next picture.
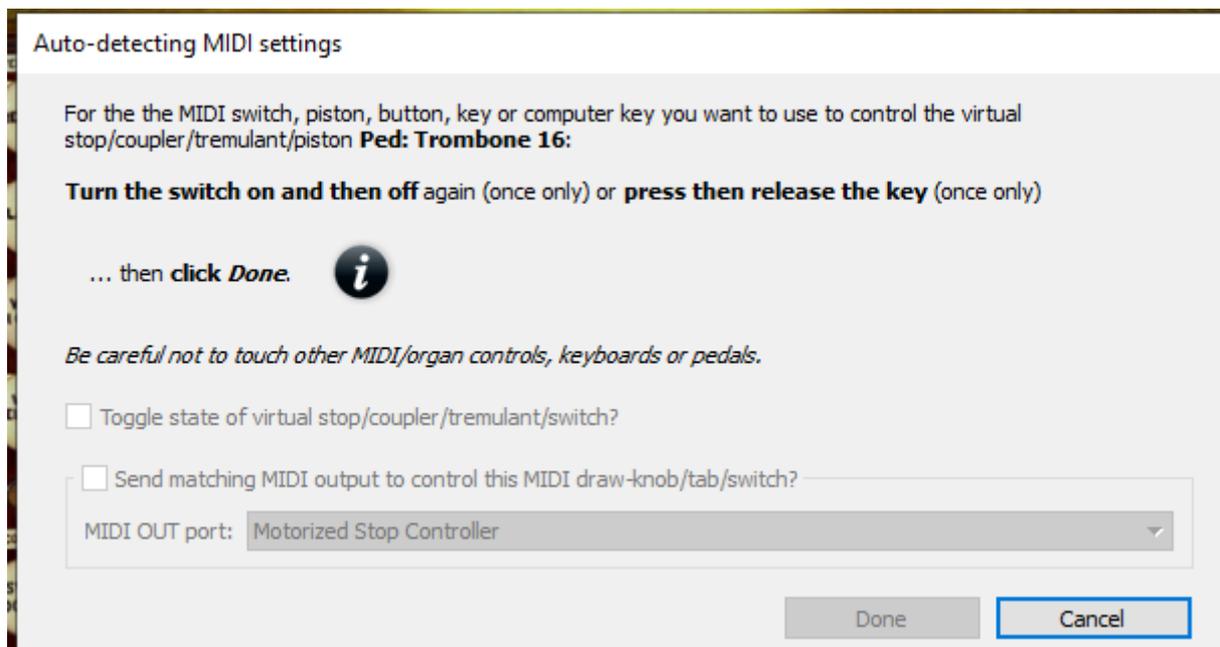
Once you see this box you will notice that the 'Done' option is greyed out, along with other options. This is because Hauptwerk is waiting for you to operate a stop. Put the stop into the on position and you will see that the 'Done' button becomes available, i.e. no longer greyed out. Now put the stop back into it's off position and you will see that all the options in the box are now active. Notice the last option 'Send matching MIDI output...' Make sure that this is ticked and select the 'MIDI OUT port' to be the Motorized Stop Controller. Once you have done this your screen should look like the next picture.

Click the 'Done' button and then, once again right click the Trombone stop. This time select the third option – 'Adjust MIDI/trigger settings manually for stop: ped:Trombone 16...'
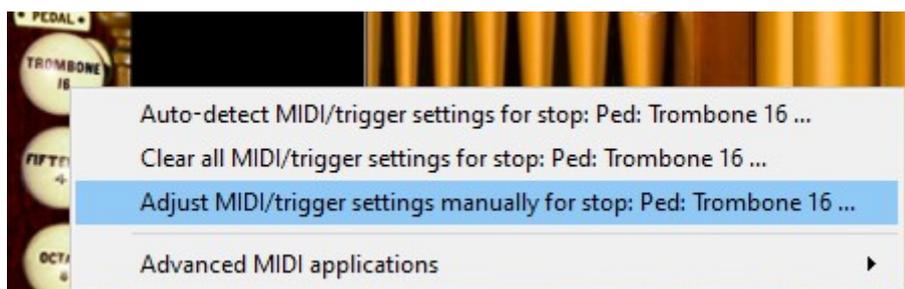
This will open a window like the one below. Only the right half of the window is shown in the picture simply for the sake of saving space and making the relevant part big enough to read. From this window you can see what settings Hauptwerk has chosen and make sure they look correct. There are two tabs at the top of the window. First check the info on the 'Primary input' tab. The important bits are: 'Input' should read 'Stop or hold-piston: MIDI note-on/off'. MIDI IN port: should read 'Motorized Stop Controller'.
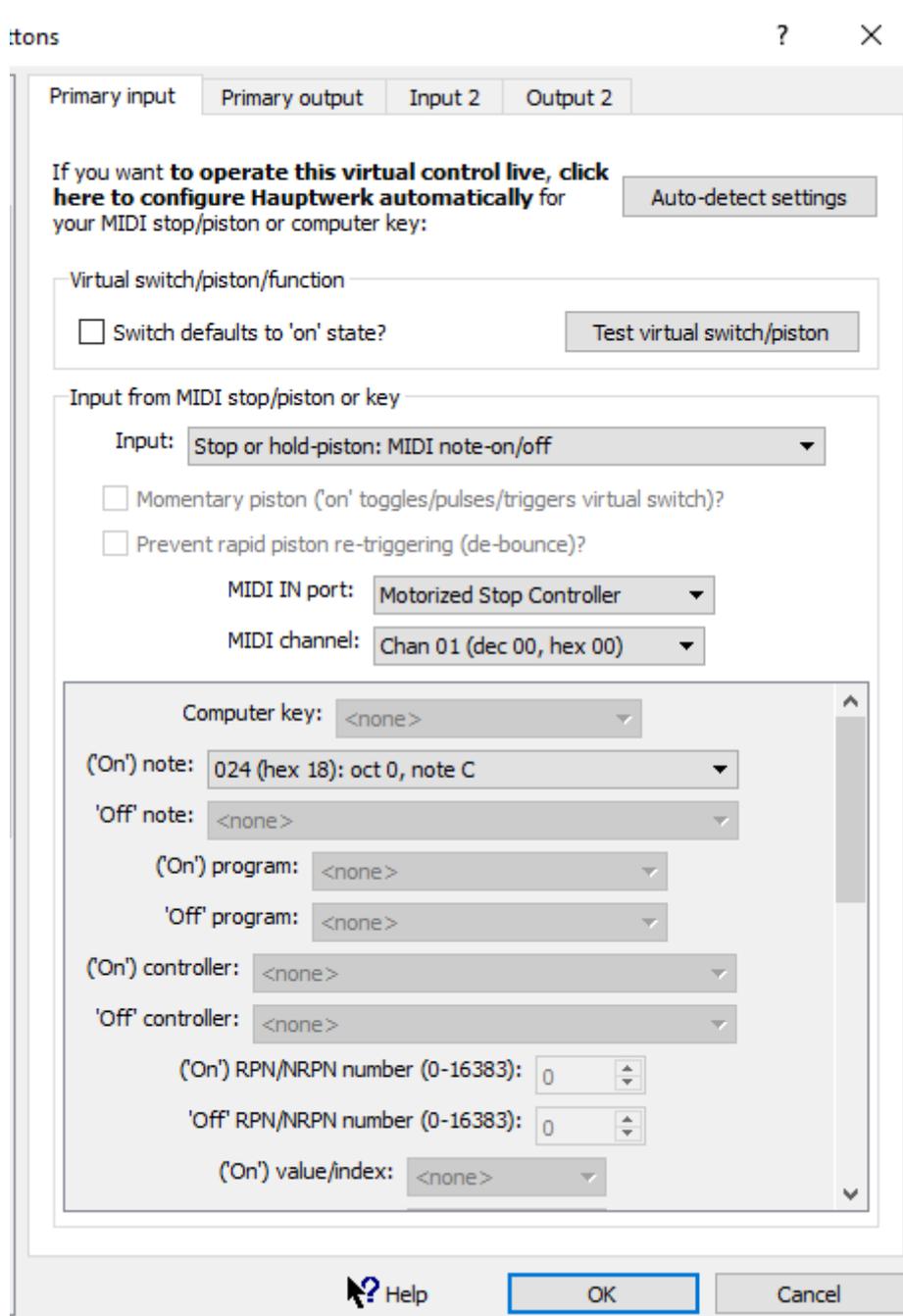
Once you have satisfied yourself that the information on the 'Primary input' tab is correct click the 'Primary output' tab. This will display a screen like the one in the next picture.
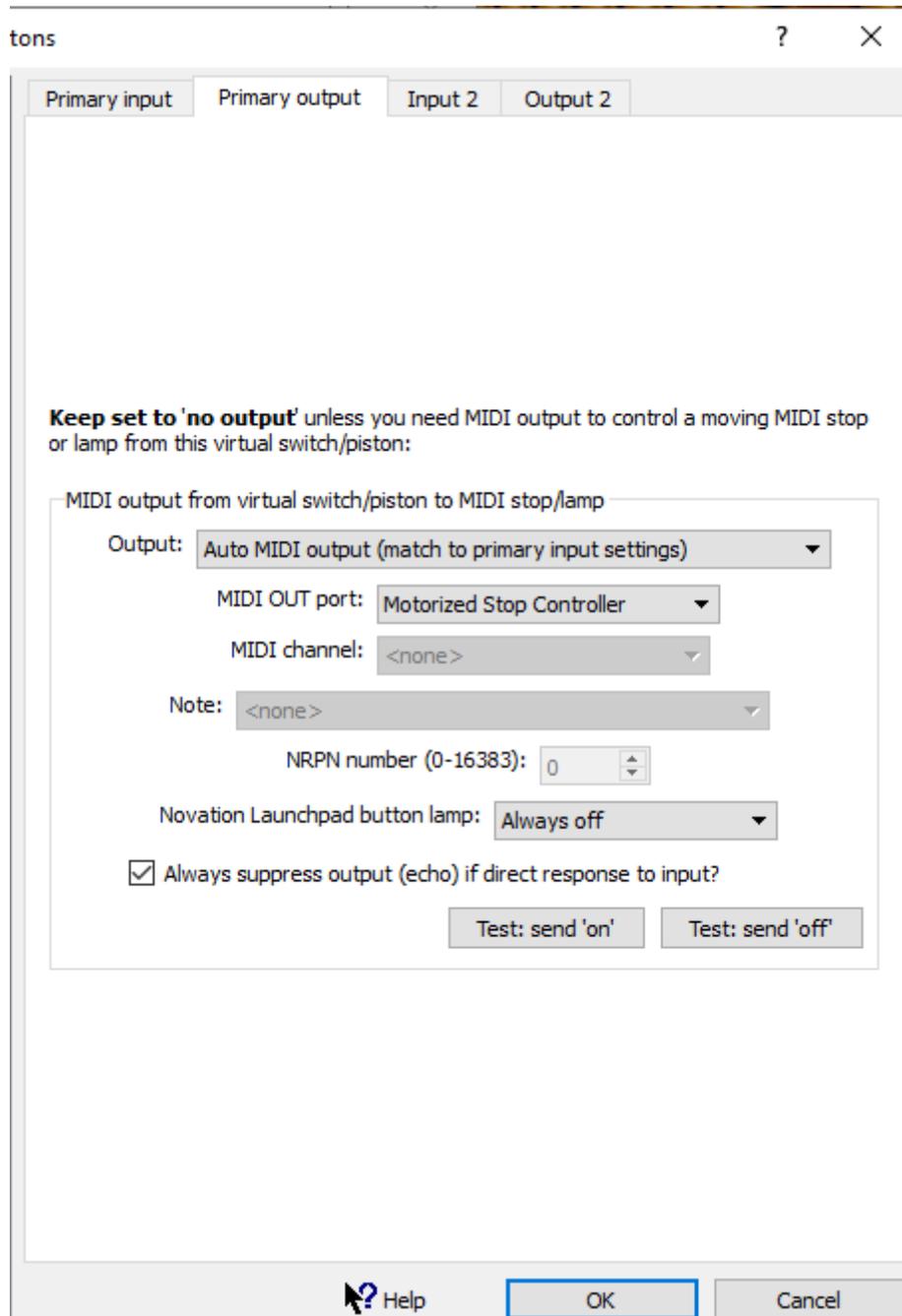
It is important to make sure that the box labelled 'Always suppress output (echo) if direct response to input?' is ticked. If this box is left unticked it can cause the stop to keep flipping between on and off in certain circumstances AND according to Murphy's law those circumstances will be during a recital!

Once all the adjustments have been made you can click the 'OK' button which will return you to the usual organ console view in Hauptwerk. At this point you should be able to operate the physical stop and see the virtual on screen stop change in sympathy with the real one. The reverse should also happen, operate the virtual on-screen stop and the physical stop should move with it.

You can now repeat this procedure for the remaining connected stops.

Configuring your stops in Grand Orgue.

Start by opening Grand Orgue and loading your desired organ. In this example I am going to use the default organ that is downloaded with the Grand Orgue windows installer. Once you have it installed and working you should see a window similar to the one below.
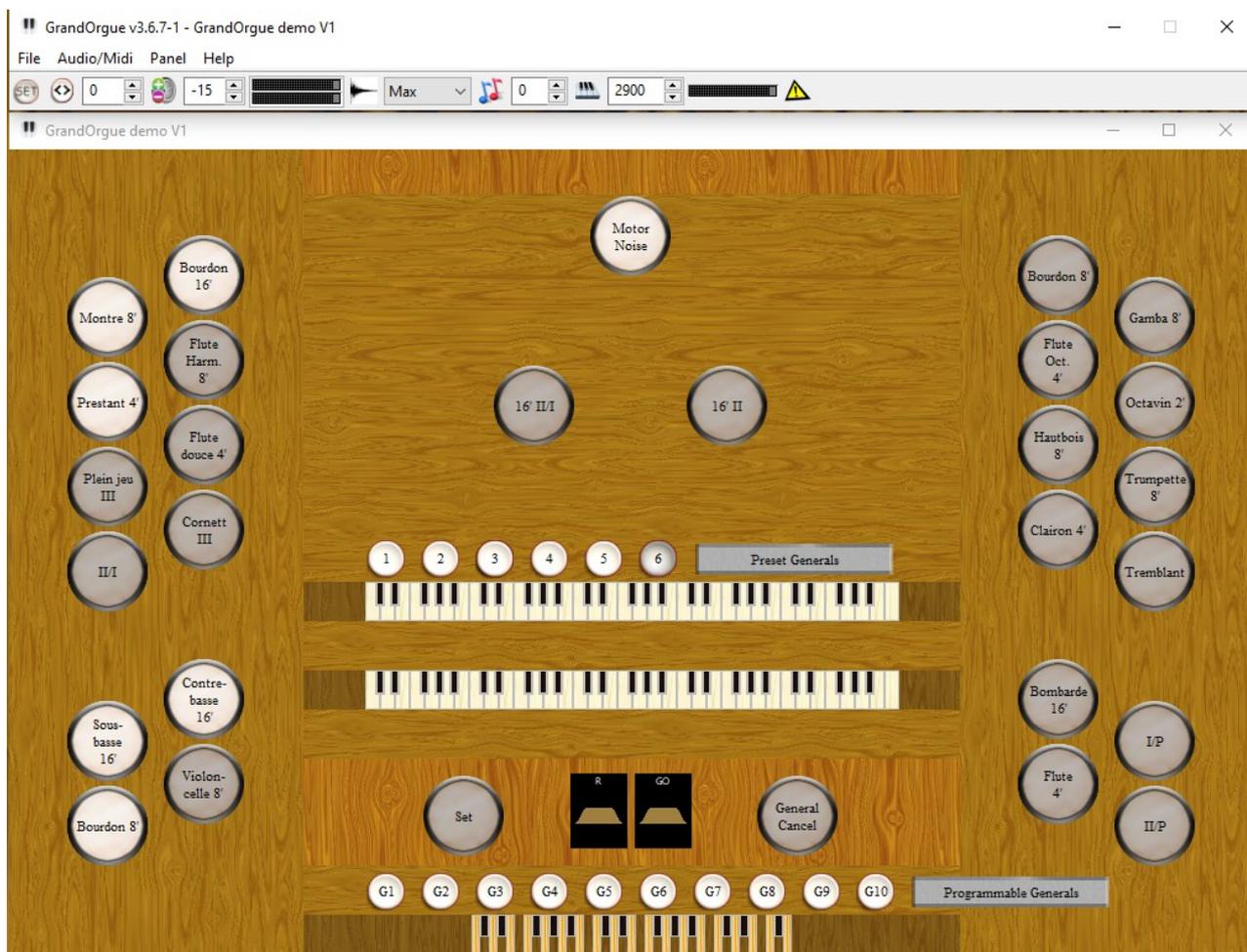

For this example I am going to use the I/II stop.

Right click the desired stop and immediately you should see a dialogue box like the one below. The important part here is the button marked as 'Listen for Event'. Click this and you will see the instruction 'Please press the MIDI element' appear underneath the button.
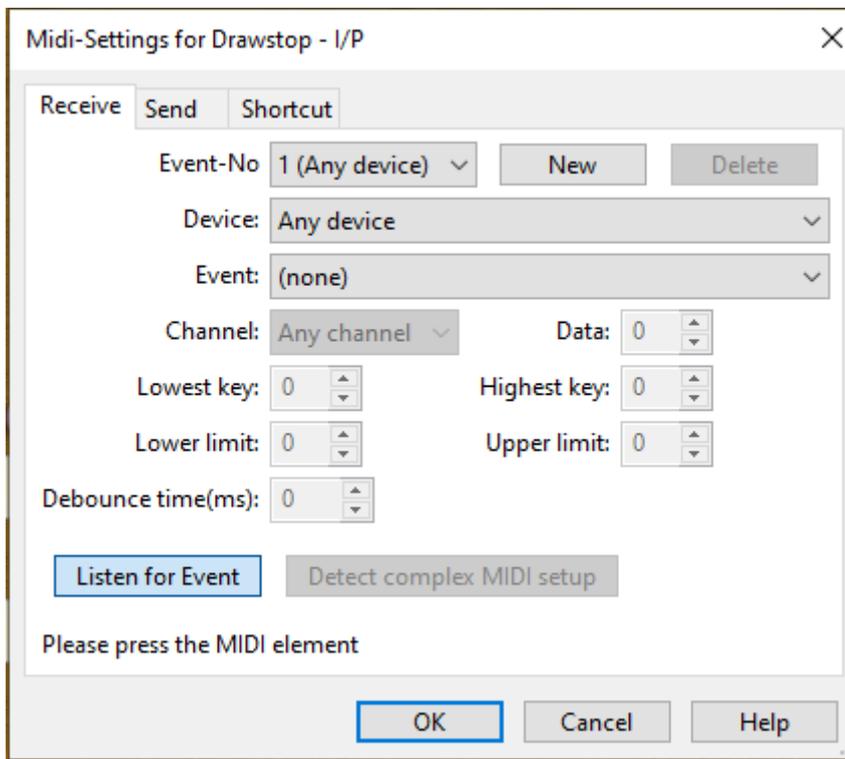
Now - operate the desired stop, move it to the 'ON' position, then back to the 'OFF' position. Once you have done this you will see that the information in the other fields is automatically populated with the MIDI information about the stop that you operated. This is shown in the next picture below. At this point we have completed setting up the receive event. This means that, at this point, Grand Orgue will respond to the operation of that physical stop.
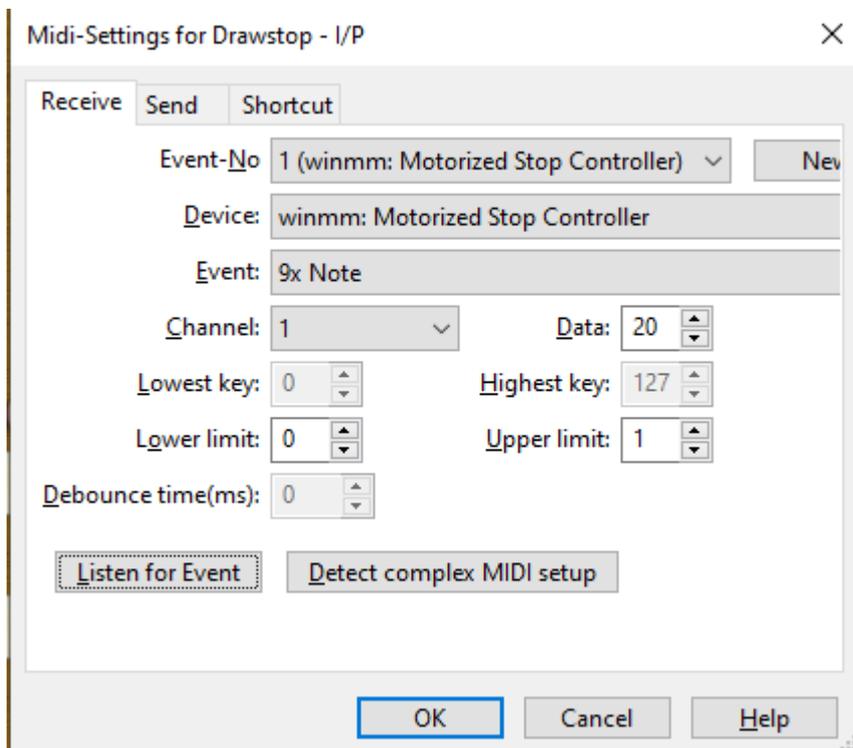
Next we have to complete the send setup of this stop. Click the 'Send' tab at the top of the dialogue

box and you will see the 'Send' page as below.
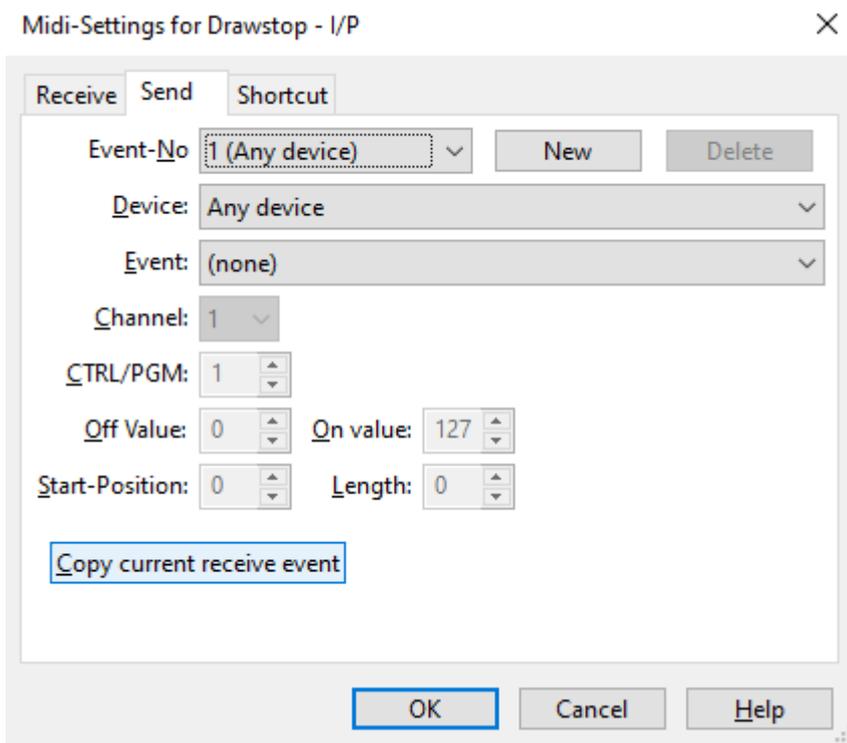
Click the button marked 'Copy current receive event'. This will automatically populate the fields with the information required for Grand Orgue to send MIDI data to operate the physical stop, as shown in the picture below.
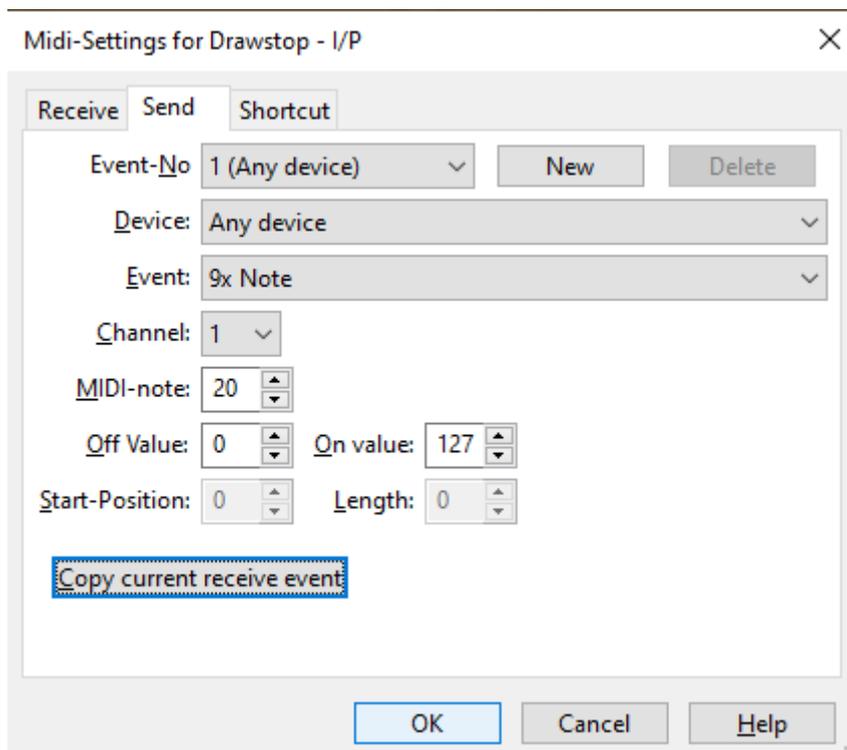
Now click the 'OK@ button to complete the setup for that stop.

Now simply perform the above procedure for the rest of the stops you will be using. This completes the setup of the Grand Orgue software to work with your Motorized Stop controller.

Configuring other virtual organ software.

The controller will work with any MIDI capable virtual organ software. Hauptwerk and Grand Orgue have the Midi Auto-detect feature which makes it easy to set them up. If you want to use the controller with software that does not have this feature you can easily input the information manually. The things that the software will require are:-

- Midi Device
- Midi Channel
- Midi Note On/off value

The Midi Device name will be 'Motorized Stop Controller', if you have more then one controller, second and subsequent controllers will have a number appended to them. e.g. 'Motorised Stop Controller (1)'

These are displayed in the serial terminal whenever a stop is operated (see page 15). Using a terminal program such as PuTTY connect to the controller as detailed on page 10. Once connected DO NOT press Enter though, or if you do and are presented with the Main Menu select Option 5. 'Exit Configurator & Resume Operation'.

Operating the desired stop will print on the screen the Midi Channel number along with the MIDI Note On/off number.

Now that you have this information you can simply enter it into the relevant speces in your virtual organ software for each stop you are using.

Mounting.

The controller should be mounted as close as possible to the stops that it serves. The controller has 6 mounting holes of 3mm diameter each. These are for mounting the board in a convenient place within your console. It is important to consider that the reverse of the board is made from copper and that parts of this copper surface carry the electrical signals as well as control voltages around the board. It is therefore necessary to ensure that whatever mounting method you use does not allow the reverse of the board to come into contact with any conductive surface as doing so may present a fire risk and or cause irreparable damage to both the board and the controller itself. It is suggested that suitable insulating spacers be used in mounting the board leaving a gap of at least 5mm between the board and the mounting surface.

The board is suitable for mounting at any angle in any plane. The board must be installed in a position where it will not suffer condensing moisture, water, physical shock or any contact with moving parts. It must be protected from any conductive items, parts or waste that may fall on it.

Identifying stop connections.

There are a surprising number of different types of motorized stops around. Some manufacturers publish the connections in their manuals or on their websites, however it is usually the case, in my experience anyway, that you cannot usually find any information for the actual stop you have in your console!

I have made a video showing exactly how to check stops and figure out which connections do what so that you can be sure how to connect them to your controller. Scan the QR code opposite or follow this link to watch the video. https://youtu.be/f0KqakWrPUM

Notes

The hardware used in this controller is an Atmel AVR along with other components. Some of these components are readily available as a ready assembled 'core' unit which can then be programmed with whatever firmware you wish. Hauptwerk Hardware buy these 'dev' boards and use to build our products. These microprocessors exclusively use our own production firmware and contain no boot loaders or other third party code. This firmware remains our intellectual property. It is copyright and protected from being read from the AVR.

The logic behind using these 'dev' boards is that they are readily available and likely to remain so for some considerable time. Should any of our products ever fail in the future, it is easy to simply unplug the dev board and replace it with a new one, safe in the knowledge that one will still be available. This is in contrast to our competitors bespoke boards that whose availability is entirely dependent on provisions made by that particular manufacturer at the time.

LEGAL DISCLAIMER:

As mentioned in the introduction section of this document, interfacing motorized stops to computer equipment is a task fraught with technical pitfalls and challenges. It is the installers responsibility to ensure that they have familiarized themselves with the product and its documentation and have the necessary understanding and technical and practical competence to be able to install and use it correctly. Whilst every care has been taken in the design, testing and documentation of this product, Hauptwerk Hardware will accept no liability whatsoever for any physical or consequential damage or injury caused by the use of our products in any circumstances.