MIDI Control Unit
User Manual
MCU-1
Version 1.5
Classic Organ Works

Div. of:
ARTISAN CLASSIC ORGAN INC.

MIDI CONTROL UNIT MCU-1

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MIDI CONTROL UNIT MCU-1

WARRANTY

Classic Organ Works warrants the MCU to be free from defects in materials and workmanship under normal use for a period of one year from the delivery date. This warranty applies only if the original purchaser owns the product and the original purchaser has the bill of sale.

This warranty explicitly excludes any cables included, which may become defective because of normal wear and tear. The DC wall adaptor is included in the warranty however.

In the event of a defect in materials or workmanship, please contact **Classic Organ Works** immediately. Defects due to shipping should be reported within 15 days for insurance claim purposes. For all other defects, **Classic Organ Works** will repair the product, replace the product, or refund the purchase price less shipping and handling charges. If repairs are required, the purchaser will be responsible for shipment to **Classic Organ Works**. **Classic Organ Works** will be responsible for shipment to return the repaired unit to the customer.

In the event that **Classic Organ Works** determines the product requires repair because of user misuse or regular wear, it will assess a fair repair or replacement fee. The customer will have the option to pay this fee and have the unit repaired and returned, or not pay this fee and have the unit returned un-repaired.

Classic Organ Works will not be liable for consequential, special, indirect, or similar damages or claims including loss of profit or any other commercial damage, and in no event will **Classic Organ Works**' liability for any damages to the purchaser or any other person exceed the price paid for the product, regardless of any form of the claim. **Classic Organ Works** specifically disclaims all other warranties, expressed or implied. Specifically, **Classic Organ Works** makes no warranty that the product is fit for any particular purpose.

This warranty shall be interpreted, and governed by applicable laws in the province of Ontario, Canada. If any provision of this warranty is found void, invalid or unenforceable, it will not affect the validity of the balance of the warranty, which shall remain valid and enforceable according to its terms. In the event any remedy hereunder is determined to have failed of its essential purpose, all limitations of liability and exclusion of damages set forth herein shall remain in full force and effect.

MIDI CONTROL UNIT MCU-1

1. INTRODUCTION

Description

Congratulations! You are now the proud owner of the MCU-1 (MIDI Control Unit, MCU). The MCU-1 is a MIDI interface that allows MIDI sound modules to be added to a pipe or electronic organ, or even to create a whole organ through the use of computer-driven virtual organ software such as Hauptwerk™ [1]. Designed as a modular unit, it provides a 'smart' add-on interface so that organs can be provided with MIDI voices that can be controlled as though they were part of the organ.

The MCU is designed for organists, organ enthusiasts, and MIDI users. In particular, organists may connect keyboards, stops, pistons, tuning devices, expression controls, crescendo controls, volume controls and a pedal board to the MCU. Organ enthusiasts with an Ahlborn Archive Series™ module[2] may use the MCU to control divisions, channel, stops, couplers, combinations, pistons, tremulants, crescendo, expression, Sforzando (Tutti), cancel, set, and tuning. Up to four Archive modules may be controlled simultaneously. By purchasing the optional GM-MIDI module, MIDI users can control channel, voice variation, drumset variation, volume, expression and tuning using the MCU. Furthermore, a convenient MIDI merge feature allows simultaneous control of multiple MIDI devices. An additional 48 output pins are available on the MCU, but they are presently not implemented being reserved for future use.

Key-switch information from keyboards, pedalboards, stops, pistons and other switches is converted into MIDI control data. The MCU can support as many as three 61-note keyboards and one 32-note pedalboard.

Keyboard and pedalboard switches are interpreted by the microprocessor in the MCU to generate MIDI messages describing key-switch actions. Thus, a MIDI message details whether a key was pressed or released, the MIDI channel that the information should be transmitted on, and the key number pressed or released.

Up to 105 stop and piston switches can be wired to the MCU. The concept of a stop and piston used in the MCU differs somewhat from that used in organ terminology. MIDI was originally developed for electronic music use in synthesizers. It was only a few years ago that organ-builders began adding MIDI capabilities to pipe organs. However, MIDI was not designed for a complex musical instruments such as the organ. Thus, the application of the MIDI standard to the organ is subject to organ-builders' preferences, and standards are still evolving. On the MCU, stop switches are connected to input pins. When switches such as drawknobs, rocker-tabs, and pushbuttons are activated, the microprocessor identifies the switch action and generates a MIDI message to indicate a switch-on or switch-off. Piston switches are also connected to the input pins. However, when piston switches are activated a MIDI message is sent to select a combination of stops.

The piston and stop switches allow the MCU-1 to simultaneously drive up to four Ahlborn Archive Series™ modules that generate pipe-organ voices. In addition, any MIDI-controlled sound module or PC-based synthesizer software may be connected. Typical units would be Hauptwerk virtual organs or Viscount Accupipe CM-100 pipe voice modules. There is also provision for an optional internal plug-in General MIDI sound generator, Classic type GM 9773.

Five analog input pins can be configured for volume, expression, tuning and crescendo. By adjusting the analog device, a voltage on the analog input pin is interpreted by the microprocessor. In the case of a volume adjustment, a MIDI message will detail to the

[1] Hauptwerk is a registered trademark of Crumhorn Laboratories Limited, England.

[2] Archive Module Series is a registered Trademark of Ahlborn-Galanti Organs, a division of General Music Corporation, Italy.

MIDI-controlled device the loudness level of the stop or sound. MIDI messages are also sent for a crescendo adjustment that will gradually add stops to a registration. An expression adjustment will change the volume level in excess of the set volume. A tuning adjustment will change the tuning of the MIDI-controlled device or an Ahlborn Archive unit.

The MCU is completely customizable and is shipped with five pre-configurations. The default configuration supports two 61-note keyboards, one 32-note pedalboard, 93 stops, and tuning and expression controls. The other four pre-configurations support various Ahlborn Archive modules. The MCU also includes a compact disc containing the Classic 'MCUConfig' software for both Windows and MacIntosh computers.

The software allows users to completely customize the MCU to their specifications. With the software, 128 configurations may be programmed into the MCU (123 additional configurations are available if the five pre-configurations are not overwritten). Up to three keyboards, a pedal board, 105 stop and piston switches, and five analog inputs may be configured for Ahlborn Archive modules, General MIDI sound modules, and a MIDI controlled PC-based synthesizer software: Sound Canvas Pipe Organ Project (SCPOP™). The software also supports Hauptwerk ™ that is computer software simulating an organ and capable of running numerous organ sample sets.

MCU configurations are saved as computer files that may be stored in the user's home computer, or in the MCU. Configurations that are saved on the MCU will not be lost when power is turned off because the memory is non-volatile. These configurations may be selected using a DIP-switch on the MCU. Eventually, users may inexpensively upgrade their software as well as configurations by visiting the Classic Organ Works website at http://www.organworks.com.

Dimensions

Width	12.35 inches, 31.4 cm
(including mounting flanges 0.50" either side)	
Height	3.50 inches, 8.89 cm
(including connectors)	
Depth	7.50 inches, 19.5 cm

Weight

Fully loaded	7 lbs, 3.2 kg

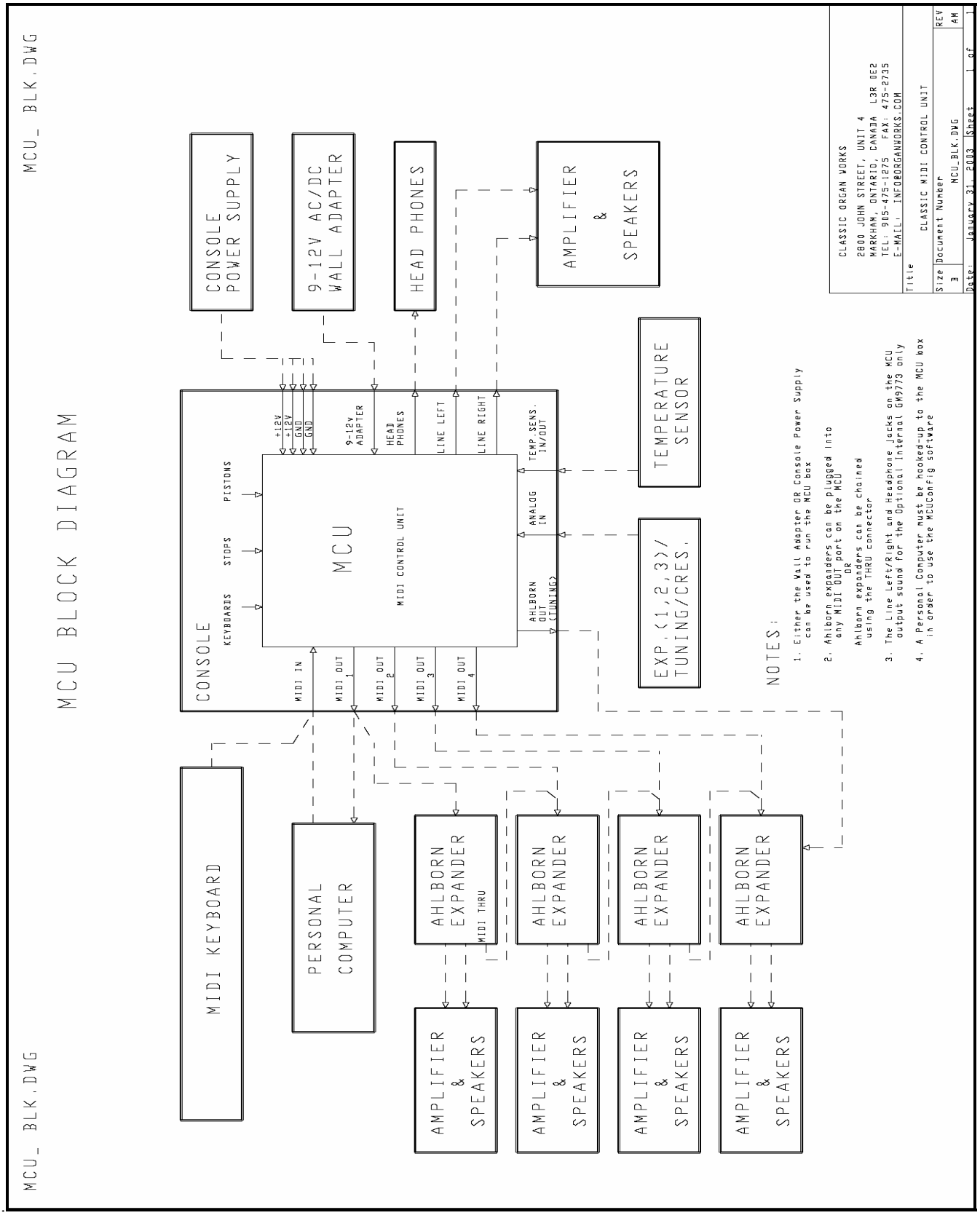


Figure 1: MCU connections

MIDI CONTROL UNIT MCU-1

2. INSTALLATION

IMPORTANT
READ THIS DOCUMENT BEFORE INSTALLATION

Upon receiving this unit, discard any packing material inside the unit that may have been included to prevent movement of components or wiring during shipping.
(For internal access, ensure the unit is disconnected from all power sources. Then undo the eight screws at the edges of the front panel.)

As supplied, the unit may be partly loaded depending on the configuration (for instance, the quantity of keyboards).

Mounting

The unit is intended to be located near the keyboards within an organ console because of the amount of wiring to those keyboards. It should be placed so that the connections are readily accessible.

Four holes are provided in the side flanges so that it may be screwed to the wooden parts of the console. The holes are 0.2-inch diameter and will take up to a #10 screw if necessary. However, since the unit is not heavy, a #6 or #8 screw will be sufficient.

The unit may be mounted in any convenient place. Its orientation is not important.

Connections

There are three essential connections and two optional connections. The latter will depend on the use of the MCU. The user must connect Power, MIDI, and input connections for keyboards, stops, and/or pistons. RCA Phono jacks, a 3.5mm headphone connector, and a 6-pin DIN connector for tuning an Ahlborn Archive unit are provided. Cables and hardware for these connections is available separately.

Power

The MCU requires **between +9V and +15V** DC power at a **minimum current of 400mA**. There are several ways to provide power to the MCU according to the application.

1. If the MCU were to be used as a standalone unit, the most convenient method of providing power would be to use the supplied 2.1mm ID Co-axial DC wall adaptor.
2. However, if the MCU is to be used as part of an organ, the 4-input terminal block can be connected to an existing organ power supply making power and ground connections.
3. If an output board is present, an alternative power source must be wired to the 2-input terminal block labeled ‘FROM CONSOLE SUPPLY FOR OUTPUTS ONLY’. This extra power source provides the required current to drive high-current outputs such as magnets or lamps. Please note that this output feature is not implemented in the current version of the MCU.

The MCU has features to ensure safe and easy operation. For ease of use, an isolated +12 Volt, DC wall adaptor of **either** positive or negative polarity may be used. It must have a 2.1mm ID co-axial power jack. A bridge-rectifier is present within the MCU to ensure the proper polarity. A 500mA self-resetting Polyfuse connects the common power supply to all the input boards. Each input board has its own 250mA Polyfuse. In addition, the extra power supply input for the output driver board incorporates a 5A self-resetting

Polyfuse to provide over-current protection for the output loads only.

MIDI

The MCU has one MIDI input and four MIDI outputs that can be connected to several MIDI devices and/or a personal computer. In the current version of the MCU, all four MIDI OUT connectors produce the same messages. The MIDI IN connector allows another MIDI source to be merged with the MIDI signal from this unit.

The MCU has the capability to drive up to four different Ahlborn Archive Series™ modules. These can be controlled through the general pistons on an existing organ. Thus, additional stops and sounds on multiple Ahlborn Archive modules may be controlled as though they were part of the organ.

Switch Inputs

The MCU can support up to five standard input boards, thus allowing many different configurations. The default configuration (with an internal GM9773 General MIDI sound module) supports two 61-note keyboards, one 32-note pedalboard, 9 'stops' (to select MIDI output channels), 93 pistons, one analog input for expression control, and one analog input for General MIDI fine tuning.

The switches and analog inputs may be connected to the appropriate input rows of pins using Molex crimped-pin connectors or mass-termination insulation-displacement connectors (MAS-CON) in multiples of eight pins. Please see the **Configuration table** for details. For the analog inputs, the user must ensure that there is one connection to Ground, one connection to an appropriate positive voltage (usually +5V), and one connection to an analog input pin. In the default configuration, 'ANALOG IN 1' is used for expression control, and 'ANALOG IN 4' is used for General MIDI fine-tuning.

Each input row has a 2-pin terminal block for the commons for all switches in that row. The two pins on the terminal block are paralleled.

Temperature sensing/tuning (*optional*)

Due to temperature changes in the operating environment, it may be necessary to adjust the tuning of any connected sound modules. An optional function on the MCU permits temperature sensing and sound module tuning. To use this, an optional temperature-sensing device is plugged into the 3-pin DIN connector labeled 'TEMP. SENS IN/OUT'. If an Ahlborn Module needs to be tuned, another cable is plugged from the Ahlborn Archive Module to the 6-pin DIN connector labeled 'AHLBORN OUT'. The MCU produces a voltage signal on the 'AHLBORN OUT' port to correct the tuning on the Ahlborn Archive unit. If General MIDI tuning is required, data is sent via the 'MIDI OUT' port.

Note: The Ahlborn tuning connector has 6-pin at 240°. This is intentional to differentiate it from the MIDI connector with five pins at 180°.

Audio outputs (*optional)*

The MCU is equipped with RCA Phono jacks labeled 'LINE LEFT' and 'LINE RIGHT', as well as a 3.5mm Stereo Jack. These connectors provide line-level audio output from the optional GM sound module to external audio amplifiers and speakers. The RCA Phono jacks provide 100mV high-impedance output, while the 3.5mm Stereo Jack (for headphones) provides 1.6 Watts output per channel into 4 Ohms.

Table 1: Connection Chart

Connection Name	Connection Type	Hardware	Description
Required Connections			
Power	Input	1. Co-ax 2.1mm (either polarity) **OR** 2. 4-input Terminal Block	9-12V, 400mA minimum
Switches	Input	Pins, 0.025" Square, 0.3" long, 0.1" pitch. The 2-input terminal blocks are for switch commons in each row.	In groups of 8 pins
MIDI IN	Input	DIN 5-pin socket 180°	Standard MIDI signals
MIDI OUT 1-4	Output	DIN 5-pin socket 180°	Standard MIDI signals
Optional Connections			
Power	Input	2-Input Terminal Block	For output drive only (magnets, pipes, etc.). Use a separate power supply with appropriate current-drive capability (5 Amps maximum) connected via 18AWG (minimum) wire.
Analog	Input	Pins, 0.025" Square, 0.3" long, 0.1" pitch	'Analog In 1,2,3' are for volume and expression. 'Analog In 4' is for fine-tuning. 'Analog In 6' is for crescendo.
Lamps or Magnets	Output	Pins, 0.025" Square, 0.3" long, 0.1" pitch	**For Future Use. Not available on the current version.**
Temperature Sensor	Input	DIN 3-pin 180°	Use temperature-sensing device (sold separately)
Ahlborn Out	Output	DIN 6-pin socket 240° (Only pins 2 & 3 are wired)	For Ahlborn Archive unit tuning
Line Audio (Left and Right)	Output	RCA Phono Jack	100mV high impedance, General MIDI output for the GM9773 module
Headphones	Output	3.5mm Stereo Jack	1.6Watts per channel into 4 Ohms for General MIDI output

Software Installation (*Windows[1] and MacIntosh[2] users only*)

Software installation instructions are described in the 'MCU Configuration Software' section of the manual.

*Note: To use the software, the MCU **must** be connected to a computer using **MIDI**. If a MIDI port is not available on your computer, a commercial MIDI adapter for the game port, USB port, or parallel port may be used.*

[1] Windows is a registered Trademark of the Microsoft Corporation.

[2] MacIntosh is a registered Trademark of Apple Computer.

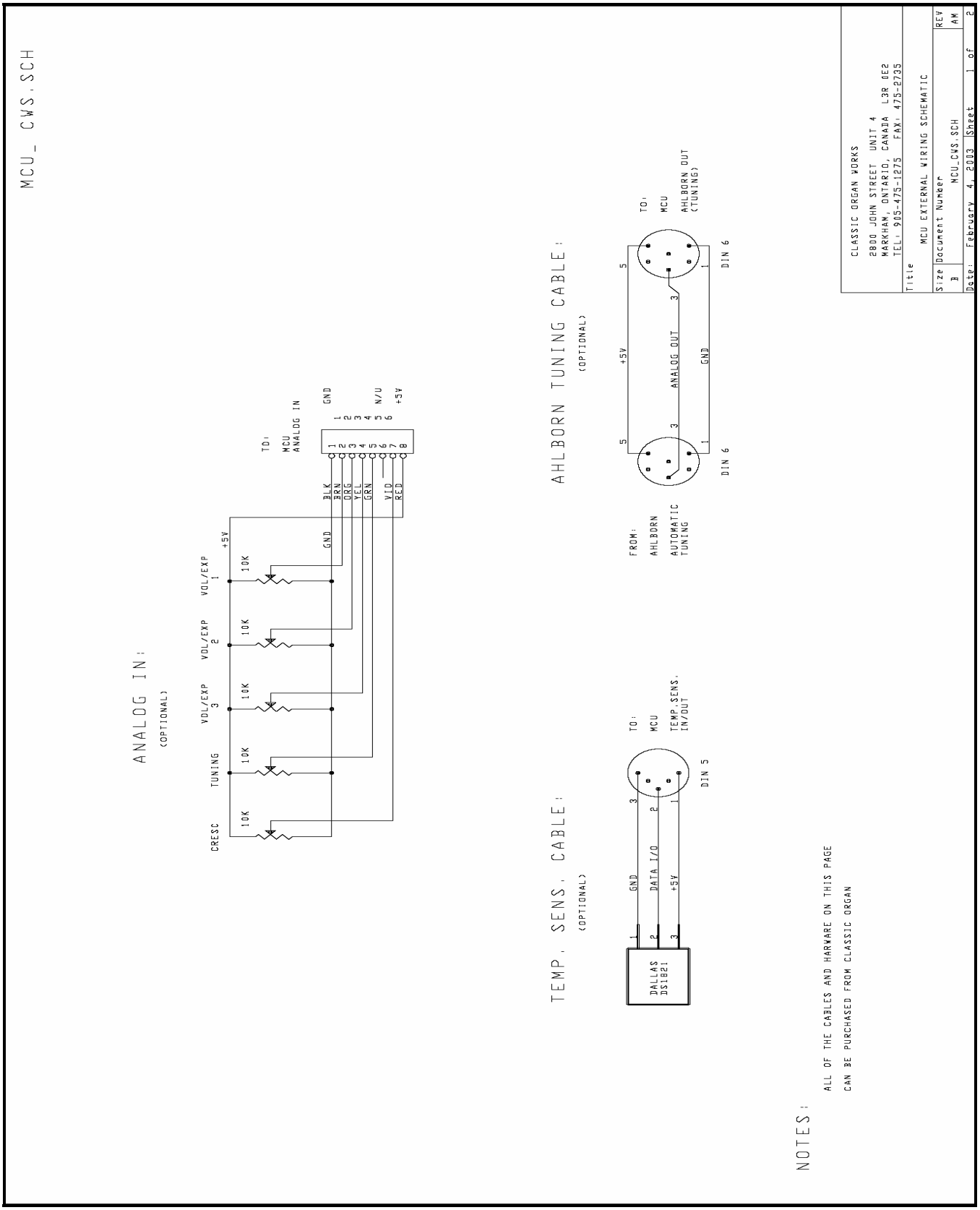


Figure 2: External Wiring Schematic for Analog inputs, temperature sensor and Ahlborn tuning cable.

MIDI CONTROL UNIT MCU-1

3. MIDI SPECIFICATION

MIDI (Music Instrument Digital Interface) is a communication system between computer controlled music instruments. MIDI describes all the actions of a musical performance. It was originally developed for music synthesizers but now enjoys a varied range of uses from computer games to electronic organs.

MIDI is composed of three components which are the language (protocol), hardware (MIDI connector), and distribution format (MIDI file) [1]. The MIDI language is in binary format and is a uni-directional asynchronous stream of bits at 31.25 kBits per second with 10 bits transmitted per byte. The 10 bits-per-byte consists of a start bit, eight data bits, and a stop bit. In the hardware domain, the MIDI 1.0 Specification (maintained by the MIDI Manufacturers Association) recommends the 5-pin DIN 180° connector. The 5-pin DIN connector is standard and allows MIDI equipment from differing manufacturers to be connected together. Finally, to capture all the details of MIDI onto a hardcopy medium, MIDI files are the standard distribution format. MIDI files are similar to the MIDI language except that each event adds a time-stamp so that MIDI equipment can replicate the timing required to generate accurate performances. [1] MIDI Message information can be found in Appendix-C and Appendix-D.

MIDI Sound Sets

General MIDI [2]

The MIDI Manufacturers Association (MMA) developed General MIDI (GM) to provide a standard relationship between commands and sounds generated by synthesizers. A serious problem developed as the number of MIDI device manufacturers grew. Every manufacturer associated a different command to a different sound. Users were confused when they used a command to play a piano sound but ended up with a different sound. To alleviate this confusion, the MIDI Manufacturers Association dictated that commands termed 'Patch numbers' would be the standard reference to a sound. A 'Patch Map' shows Patch numbers and their respective sounds. In addition, since MIDI transmits using MIDI channels, every MIDI sequence begins by assigning a MIDI channel for each sound that is transmitted. This assignment is termed 'Program Change'.

In addition to standardizing the mapping of patch numbers to their respective sounds, the General MIDI protocol defines a set of capabilities for General MIDI instruments. Included are a General MIDI Sound Set (patch map), a General MIDI Percussion map (maps percussion sounds to note numbers), and a set of General MIDI performance capabilities (number of voices, MIDI messages recognized, etc.).

MIDI channels 1-9 and 11-16 are used for chromatic instrument sounds while MIDI channel 10 is used for 'key-based' percussion sounds. Furthermore, the 128 program numbers are grouped into related sounds sets. For example, program numbers 1-8 are for piano sounds, 25-32 are guitar sounds, etc. (a chart is shown on the next page). A note number indicates the pitches of the sounds. Note numbers on the 'key-based' percussion sounds of MIDI Channel 10 represent different percussion instruments. It should be noted that although sounds may have the same label, they might not necessarily produce the same sound from different manufacturers' equipment. The sound output depends on the way the sound was made, which is not standard (an 'Acoustic Grand Piano' will sound different depending on the way the sound was made). Only the patch numbers and their labels are standardized.

Table 2: Sound Set Groups [3]

Set	Sound
1-8	Piano
9-16	Chromatic Percussion
17-24	Organ
25-32	Guitar
33-40	Bass
41-48	Strings
49-56	Ensemble
57-64	Brass
65-72	Reed
73-80	Pipe
81-88	Synthesizer Lead
89-96	Synthesizer Pad
97-104	Synthesizer Effects
105-112	Ethnic
113-120	Percussive
121-128	Sound Effects

Table 3: General MIDI Program Numbers (Patches) for MIDI Channels 1-9 and 11-16 [3]

Patch Number	Name	Patch Number	Name	Patch Number	Name
1	Acoustic Grand Piano	44	Contrabass	87	Lead 7 (fifths)
2	Bright Acoustic Piano	45	Tremolo Strings	88	Lead 8 (bass+lead)
3	Electric Grand Piano	46	Pizzicato Strings	89	Pad 1 (new age)
4	Honky-tonk Piano	47	Orchestral Harp	90	Pad 2 (warm)
5	Electric Piano 1	48	Timpani	91	Pad 3 (polysynth)
6	Electric Piano 2	49	String Ensemble 1	92	Pad 4 (choir)
7	Harpsichord	50	String Ensemble 2	93	Pad 5 (bowed)
8	Clavinet	51	SynthStrings 1	94	Pad 6 (metallic)
9	Celesta	52	SynthStrings 2	95	Pad 7 (halo)
10	Glockenspiel	53	Choir Aahs	96	Pad 8 (sweep)
11	Music Box	54	Voice Oohs	97	FX 1 (train)
12	Vibraphone	55	Synth Voice	98	FX 2 (soundtrack)
13	Marimba	56	Orchestra Hit	99	FX 3 (crystal)
14	Xylophone	57	Trumpet	100	FX 4 (atmosphere)
15	Tubular Bells	58	Trombone	101	FX 5 (brightness)
16	Dulcimer	59	Tuba	102	FX 6 (goblins)
17	Drawbar Organ	60	Muted Trumpet	103	FX 7 (echoes)
18	Percussive Organ	61	French Horn	104	FX 8 (sci-fi)
19	Rock Organ	62	Brass Section	105	Sitar
20	Church Organ	63	Synth Brass 1	106	Banjo
21	Reed Organ	64	Synth Brass 2	107	Shamisen
22	Accordion	65	Soprano Sax	108	Koto
23	Harmonica	66	Alto Sax	109	Kalimba
24	Tango Accordion	67	Tenor Sax	110	Bagpipe
25	Acoustic Guitar (nylon)	68	Baritone Sax	111	Fiddle
26	Acoustic Guitar (steel)	69	Oboe	112	Shanai
27	Electric Guitar (jazz)	70	English Horn	113	Tinkle Bell
28	Electric Guitar (clean)	71	Bassoon	114	Agogo
29	Electric Guitar (muted)	72	Clarinet	115	Steel Drums
30	Overdriven Guitar	73	Piccolo	116	Woodblock
31	Distortion Guitar	74	Flute	117	Tailo Drum
32	Guitar Harmonics	75	Recorder	118	Melodic Drum
33	Acoustic Bass	76	Pan Flute	119	Synth Drum
34	Electric Bass (finger)	77	Blown Bottle	120	Reverse Cymbal
35	Electric Bass (pick)	78	Shakuhachi	121	Guitar Fret Noise
36	Fretless Bass	79	Whistle	122	Breath Noise
37	Slap Bass 1	80	Ocarina	123	Seashore
38	Slap Bass 2	81	Lead 1 (square)	124	Bird Tweet
39	Synth Bass 1	82	Lead 2 (sawtooth)	125	Telephone Ring
40	Synth Bass 2	83	Lead 3 (calliope)	126	Helicopter
41	Violin	84	Lead 4 (chiff)	127	Applause
42	Viola	85	Lead 5 (charang)	128	Gunshot
43	Cello	86	Lead 6 (voice)		

Shaded areas indicate groups of similar sounds.

Table 4: General MIDI `Percussion` Key Map for MIDI Channel 10 [4]

MIDI Key	Drum Sound	MIDI Key	Drum Sound
35	Acoustic Bass Drum	59	Ride Cymbal 2
36	Bass Drum 1	60	Hi Bongo
37	Side Stick	61	Low Bongo
38	Acoustic Snare	62	Mute Hi Conga
39	Hand Clap	63	Open Hi Conga
40	Electric Snare	64	Low Conga
41	Low Floor Tom	65	High Timbale
42	Closed Hi-Hat	66	Low Timbale
43	High Floor Tom	67	High Agogo
44	Pedal Hi-Hat	68	Low Agogo
45	Low Tom	69	Cabasa
46	Open Hi-Hat	70	Maracas
47	Low-Mid Tom	71	Short Whistle
48	Hi-Mid Tom	72	Long Whistle
49	Crash Cymbal 1	73	Short Guiro
50	High Tom	74	Long Guiro
51	Ride Cymbal 1	75	Claves
52	Chinese Cymbal	76	Hi Wood Block
53	Ride Bell	77	Low Wood Block
54	Tambourine	78	Mute Cuica
55	Splash Cymbal	79	Open Cuica
56	Cowbell	80	Mute Triangle
57	Crash Cymbal 2	81	Open Triangle
58	Vibraslap		

Ahlborn [5]:

The Ahlborn MIDI specification allows additional pipe organ sounds to be played on an existing organ. There are four different Ahlborn Archive modules with 20 different stops each in three separate divisions. The stop list for each module is shown below:

For more information on Ahlborn Archive modules, please visit: http://www.ahlbornorgans.com/archive. The messages for controlling Ahlborn Archive modules can be found in Appendix E.

Table 5: Ahlborn Archive Classic Module [6]

Division A	Division B	Pedal
Description	**Description**	**Description**
Gemshorn 8'	Principal 8'	Contre Basse 32'
Gemshorn Celeste 8'	Holzgedackt 8'	Contre Gambe 16'
Flûte à cheminée 8'	Flûte Harmonique 8'	Contre Bombarde 32'
Koppelflöte 4'	Flûte Octaviante 4'	Bombarde 16'
Plein Jeu IV-V	Octave 2'	Div. A to Ped.
Bombarde 16'	Cymbale III	Div. B to Ped.
Harmonic Trumpet 8'	Tremulant	
Corno di Bassetto 8'	Div. A to Div. B	
Festival Trumpet 8'		
Clarion 4'		
Tremulant		
Div. B to Div. A		

Table 6: Ahlborn Archive Romantic Module [6]

Division A	Division B	Pedal
Description	Description	Description
Cello 8'	Open Diapason 8'	Contre Violone 32'
Cello Celeste 8'	Flauto Mirabilis 8'	Contre Gambe 16'
Cornet des Bombardes IV	Concert Flute 4'	Contre Bassoon 32'
Cornopean 16'	Quint Flute 2 2/3'	Ophicleide 16'
Clarinet 8'	Piccolo 2'	Div. A to Ped.
Orchestral Oboe 8'	Vox Humana 8'	Div. B to Ped.
French Horn 8'	Tremulant	
Cor Anglais 8'	Div. A to Div. B	
Tuba Mirabilis 8'		
Clarion 4'		
Tremulant		
Div. B to Div. A		

Table 7: Ahlborn Archive 201 Module [6]

Division A	Division B	Pedal
Description	Description	Description
Bourdon 16'	Gedackt 8'	Subbass 16'
Principal 8'	Gamba 8'	Octave 8'
Flûte à cheminée 8'	Nachthorn 4'	Bourdon 8'
Unda Maris 8'	Cymbale III	Posaune 16'
Octave 4'	Cornet III	Div. A to Ped.
Spitzflöte 2'	Oboe 8'	Div. B to Ped.
Nasard 2 2/3'	Tremulant	
Superoctave 2'	Div. A to Div. B	
Mixture IV		
Trompete 8'		
Tremulant		
Div. B to Div. A		

Table 8: Ahlborn Archive 202 Module [6]

Division A	Division B	Pedal
Description	Description	Description
Contregambe 16'	Bourdon 8'	Soubasse 32'
Diapason 8'	Flûte harmonique 8'	Violone 16'
Quintadena 8'	Flûte octaviante 4'	Contrebombarde 32'
Terz 1 3/5'	Larigot 1 1/3'	Bombarde 16'
Septime 1 1/7'	Corno di Bassetto 8'	Div. A to Ped.
Scharff III	Clarion 4'	Div. B to Ped.
Bombarde 16'	Tremulant	
Trompette 8'	Div. A to Div. B	
Tuba Mirabilis 8'		
Chimes		
Tremulant		
Div. B to Div. A		

HAUPTWERK™[1] [7]

The Hauptwerk (German for 'Great Organ') system provides a computer simulation of a pipe organ. It produces a realistic organ sound by use of a 'virtual sampler' technique. Traditionally, synthesizers (and MIDI) used a small number of samples by recording keys at intervals across the keyboard. In order to simulate all the keys, the samples were time-stretched. Hauptwerk uses a three-to-five-second sample of every pipe in the organ. To accommodate the intensive requirement for memory, a personal computer must be used. With current technology, thousands of individual sample sounds can be stored and recalled when a key is pressed. Thus, the software is able to capture many different and customizable organ configurations and sounds that can be loaded via '.organ' files. The '.organ' file contains information regarding number of stops, pistons, and keyboards in addition to other organ-related details.

Hauptwerk was initially designed for use with one MIDI keyboard that would be connected to the personal computer through the sound card game port. When numerous keyboards were required, a MIDI merge box would have to be purchased. This revised MCU not only handles the MIDI merge function but also provides an interface for volume controls, expression controls, stops, pistons, pedalboard, and keyboards. MIDI messages are sent through the MIDI out port to the personal computer where Hauptwerk software translates the MIDI message commands into actions on the virtual organ. A table listing the types of messages sent for the individual functions is shown below.

Table 9: MIDI messages relevant to Hauptwerk

Function	MIDI command
Keyboards	1. Note on/off 2. Channel number 3. Key number
Pedalboard	1. Note on/off 2. Channel number 3. Key number
Stops	Note on/off
Pistons	Program change
Volume	Program change
Expression	Program change
Crescendo	Program change

For more information, or to download a shareware version of Hauptwerk software, please visit: http://www.crumhorn-labs.com

SCPOP™[2]

Sound Canvas Pipe Organ Project (SCPOP) is a computer program that emulates organ features such as stop changes, keyboard coupling, tremolo, assignable memories, temperament changes, and the ability to choose different reverb settings. All of the features can be accessed using the computer keyboard's keys like a true organ console. [8]

SCPOP requires a Roland Sound Canvas MIDI Expander module and is only compatible with Roland hardware containing the 'Sound Canvas' label [9]. The messages used to control SCPOP can be found in Appendix F.

[1] Hauptwerk is a registered Trademark of Crumhorn Labs.
[2] SCPOP is a registered Trademark of the Roland Corporation.

MIDI Hardware Specification [1]

The only MIDI connector approved by the MIDI Manufacturers Association is a 5-pin 180° DIN connector. There are other ways of connecting devices to send MIDI messages but it is easier to have compatibility between different MIDI devices if there is a standard connector. In connecting a MIDI device to a personal computer, the simplest way is through the MIDI ports of a computer. Due to space limitations of computer circuit boards, most computers are not equipped with a MIDI port. Thus, adapters must be used which connect the MIDI device to another port. The most common port is the computer's game port that is found on most soundcards. Serial port, parallel port, and USB port adapters are also available.

A schematic of the standard 5-pin DIN MIDI connections is shown below:

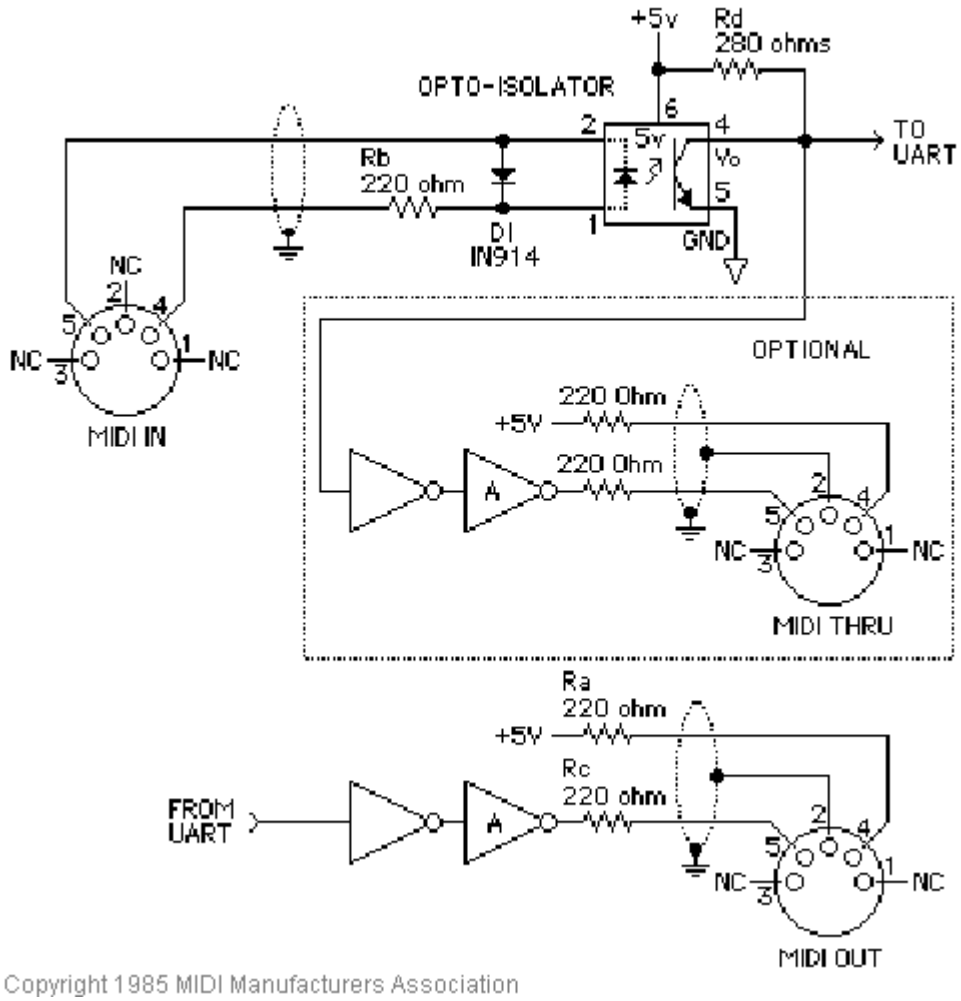


Figure 3: Schematic of 5-pin 180° DIN connections

MIDI Hardware notes:
1. Opto-isolator shown is Sharp PC-900. HP 6N138 or other can be used with changes.
2. Gates "A" are IC or transistor; resistors are 5%.
3. **Maximum cable length** is fifty feet (15 meters), terminated at each end by a 5-pin 180° male plug (e.g. SWITCHCRAFT 05GM5M).
4. Cable is shielded twisted-pair, with shield connected to pin 2 at both ends.
5. The receiving end has no ground connection (to avoid ground loops between units).

MIDI CONTROL UNIT MCU-1

4. MCU PIN FUNCTIONS

Keyboard Pins

The keyboard pin connections are located in slots IN1, IN2, and IN3 using pins 1-61. The switches on each keyboard are connected to a switch common (+12V) and to the input pins. When a key is pressed, an electrical signal (+5V to +12V) is applied to a pin on the MCU and read by the processor of the MCU. When a key is released, a pull-down resistor generates an electrical signal equal to ground potential signifying a key-switch off.

The keyboard switch inputs generate Channel messages on the MIDI output ports. These messages describe the key number (1-61), whether the key was pressed (note on) or released (note off), and the MIDI channel(s) (1-16) that are being used to transmit the MIDI information. Each keyboard uses a different MIDI channel number.

Pedalboard Pins

The pedalboard pin connections are located in slot IN4 using pins 1-32. The switches on the pedalboard are connected to a switch common (+12V) and to the input pins. When a key is depressed, an electrical signal (+5V to +12V) is applied to a pin on the MCU and is read by the processor of the MCU. When a key is released, a pull-down resistor generates an electrical signal equal to ground potential signifying a key-switch off.

The pedalboard switch inputs generate Channel messages on the MIDI output ports. These messages describe the key number (1-32), whether the key was pressed (note on) or released (note off), and the MIDI channel(s) (1-16) that are being used to transmit the MIDI information.

Custom Input Pins

There are up to 105 custom input pins that can be used to connect pistons, stops, and other switch inputs. Pins 62-64 in slots IN1 to IN3, 33-64 in slot IN4, and 1-64 in slot IN5 are used for these input pins. Normally, the pins 62-64 associated with the keyboards are used to set the MIDI channel for that keyboard, thus leaving 96 others. A connection to a +5V (up to +12V) switch common enables an active high switch input.

MIDI Stops

MIDI was originally developed for electronic music use in synthesizers. It was only a few years ago that organ-builders began adding MIDI capabilities to pipe organs. MIDI was not designed for complex musical instruments such as the organ. Thus, the application of the MIDI standard to the organ is subject to organ-builders' preferences and standards are still evolving.

Almost all MIDI expanders have the capability to generate at least 128 sounds or stops (in organ language). The difference is in the control of these sounds. Organs have many switches in the form of drawknobs, rocker-tabs, pushbuttons, etc., allowing organists to turn on and off one sound per switch. However, MIDI expanders lack these switches. The musician using an expander must decide which of the 128 stops will be used because if an organist wanted to access all the sounds on an expander, 128 switches would be required. Of course, not all the sounds are appropriate to organs. Nevertheless, a good many are useful. Having so many switches would be impractical due to space limitations on a console. Furthermore, organists generally prefer to have MIDI stops in each division rather than grouping them all into one division as is often the case in a MIDI expander.

The MCU uses MIDI channels to transmit basic stop information while the various sound samples are derived from Ahlborn Archive modules, Hauptwerk, SCPOP, or a GM9773 General MIDI card (all sold

separately). Stop switches (drawknobs, rocker-tabs, or pushbuttons) are connected to the switch inputs on the MCU. When the switch is activated, a MIDI message containing the MIDI channel number (up to 16) and 'note on' or 'note off' command will be generated.

Pistons

Some pistons may be used to control the 'combination action', a feature that allows organists to quickly play a combination of sounds by operating several stops at the same time. On the MCU, if an input pin is configured for a combination piston, multiple sounds will be produced by several MIDI channels by sending Program Change message from This differs from the traditional definition of a 'MIDI piston' which assigns one MIDI sound to a particular pushbutton using a Patch command.

The MCU uses MIDI channels to transmit the combination of sounds data (stops). Piston switches (usually pushbuttons) are connected to the switch inputs on the MCU. When the switch is activated, a MIDI message with a program change command is used which will select the combination of stops.

Analog Input Pins

There are up to 5 analog inputs which can be configured for volume or expression ('ANALOG IN 1,2,3'), tuning ('ANALOG IN 4') and crescendo ('ANALOG IN 6'). Each analog device must be connected to three pins: the analog input pin, a positive voltage (+5V) pin, and a ground potential pin such that the analog input will vary in voltage between 0V and +5V. Depending on the position of the analog device, a voltage will be read by the processor that will determine the appropriate setting. In the case of a volume control, the voltage from the analog device will determine the loudness level.

MIDI Volume (Archive units)

A MIDI program change message is sent to change the loudness level of the stop or sound. MIDI volume messages apply only to Ahlborn Archive modules. Input pins 'ANALOG IN 1,2,3' are used for either MIDI volume selection or for MIDI expression depending on the configuration.

MIDI Expression (GM-MIDI modules)

A MIDI program change message is sent to set the volume level. The Expression input differs from the Volume input in that the expression input can increase the loudness level in excess of the volume level setting. MIDI expression messages only apply to GM-MIDI modules. Input pins 'ANALOG IN 1,2,3' are used for either MIDI volume selection or for MIDI expression depending on the configuration.

MIDI Tuning

'ANALOG IN 4' is used for tuning of both General MIDI devices and Ahlborn Archive units. In the case of General MIDI, a MIDI tuning message is sent via the standard MIDI cable. For tuning of the Ahlborn Archive units, the tuning is performed by an analog output pin from the processor of the MCU that connects to the Ahlborn Archive unit via a separate 6-pin DIN tuning cable.

MIDI Crescendo

MIDI program change messages derived from a voltage input are sent to add stops to a registration. As the voltage increases, more stops are added. 'ANALOG IN 6' is used for Crescendo.

Custom Output Pins

This feature is currently not supported on the MCU. In the future, these 48 output pins will be used for driving lamps and/or magnets. Pins 1-48 in slot OUT6 are provided for outputs. These pins generate +12V at a total maximum current of 5A. Each output can continuously drive a 40-Ohm load (or greater).

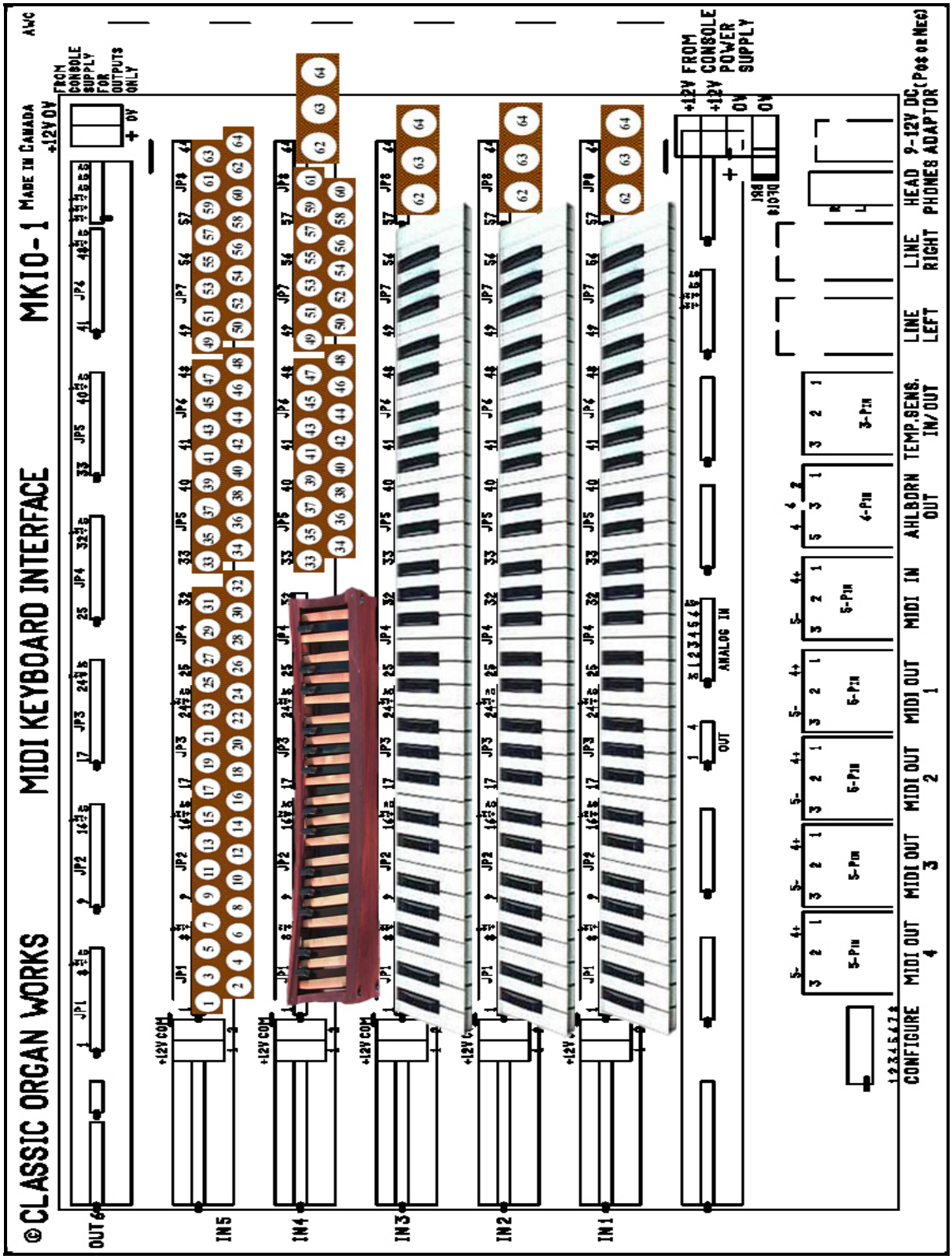


Figure 4: Block Diagram of MCU connections

MIDI CONTROL UNIT MCU-1

5. MCU CONFIGURATIONS

Introduction

The MCU allows many different 'configurations' encompassing both hardware and software.

In terms of hardware, the MCU is customizable to fit many organ applications. The MCU supports switch inputs for keyboards, pedalboards and pistons. Expression controls, volume regulation, and tuning controls connect to one of the five function-specific analog inputs. In the future, 48 outputs for lamps or magnets may be driven by adding an optional output board.

On the software side, the function of each switch input is customizable. The custom configurations support up to three 61-note keyboards, one 32-note pedalboard, and 105 additional switch inputs.

All settings for instrument sounds generated, and MIDI channels used are customizable in two ways. The most convenient is through the use of a personal computer and the included Classic 'MCUConfig' software. Either Windows[1] or MacIntosh[2] computers may be used, as both versions are included on the disc. However if a personal computer is not readily accessible, applications engineers at Classic Organ Works can assist customers to develop custom configurations. In this case, the user must change a chip inside the MCU.

Some configurations are pre-programmed while others are programmable and customizable. The pre-programmed configurations are included in the MCU. To edit configurations, the MCU must be connected to a personal computer running Windows or MacIntosh operating system software via a MIDI connection. However, if the computer does not have such connectors, an interface unit can be used. For example, a suitable USB-to-MIDI unit is the M-Audio 'MIDIman'.

[1] Windows is a registered Trademark of the Microsoft Corporation.
[2] MacIntosh is a registered Trademark of the Apple Computer Corporation.

Default Configuration (Config. #1: cfg001.mcu)

The MCU is equipped with a default configuration that is ***pre-programmed*** and coded into software. It is selected by setting the DIP-switch to '0000 0000' (all switches in the 'off' position) or '1111 1111' (all switches in the 'on' position). This configuration suits the general user making the MCU a 'ready to use' system. The user is required to change the DIP-switch settings if some other configuration is required.

The default configuration also serves the purpose of being a diagnostic tool for ***users with custom configurations***. By using the DIP-switch, the user can choose other configurations. The on-board processor reads the DIP-switch settings and compares it with the internal settings. If the DIP-Switch settings have changed, the processor downloads the new configuration from external memory according to the DIP-Switch settings. In the event of a failure of the memory chip containing the custom configurations, the MCU software automatically detects the failure, and switches to use the default configuration. If a user switches between different configurations, and always receives the default configuration, an error is present and needs to be corrected.

In the default configuration:

- The DIP-Switch must be set to '1111 1111' or '0000 0000'
- IN-5 allows for an additional 64 switch inputs
- IN-3 and OUT-1 slots are not used
- Stops are wired to select GM-MIDI voices (if the optional GM-MIDI module is purchased)
- MIDI Channels may be altered (see Changing MIDI Channels section) via pins 62-64 in the IN1 to IN3 slots. If the pins

are unaltered, the keyboard will be on the default MIDI channel as shown in the configuration table.

Note: Ahlborn Archive units use default Channels 1, 2, and 4 for Swell, Great and Pedal, respectively.

The default configuration supports:

- Two 61-note keyboards (manuals)
- One 32-note pedalboard
- 9 MIDI Channel Selectors
- 93 MIDI sound selectors
- one analog input for expression regulation
- one analog input for General MIDI fine tuning

Changing MIDI Channels (Config. #1 only)

The MIDI Channels can be changed via pins 62-64 on input rows IN1, IN2, and IN4. By changing the MIDI Channel, the user is able to transmit MIDI information on the specified channels for the specified keyboard or pedalboard. By default, Input #1 (IN1) provides MIDI information only on MIDI channel-1, Input #2 (IN2) provides MIDI information only on MIDI channel-2, and Input #4 (IN4) provides MIDI information only on MIDI channel-4.

To change these settings, the user may connect pins 62 (selects MIDI channel 1), 63 (selects MIDI channel 2), and 64 (selects MIDI channel 4) to +12 Volts. By doing so, the user specifies the MIDI channel(s) output for the keyboard. Each keyboard is capable of producing MIDI information on up to three channels (1, 2, and 4) at the same time. If the user wishes to return to the default MIDI channels after changing the default channel settings, he/she must first power off the system and then power it on again. Removing the individual switches will not reset the system to the default MIDI channel settings.

Table 10: Configuration #1 - Default (file: cfg001.mcu)
MCU-1 DIP-Switch setting: '0000 0000' or '1111 1111'

Pin Number	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
Board	SIB-4	SIB-4	SIB-4	SIB-4	SIB-4	OUTN-1	
	Swell	**Great**	**Choir**	**Pedal**	**Stops**	**Outputs**	
			Not Fitted		*For MCU with GM9773*	*Not Fitted*	
	Keys	**Keys**	**Keys**	**Keys**	**GM-MIDI Stops**		
1	C1	C1	C1	C1	Piano 1 (Grand) **(Ch 1)**		
2	C#1	C#1	C#1	C#1	Piano 2 (Bright) **(Ch 1)**		
3	D1	D1	D1	D1	Piano 3 (Elect. Grand) **(Ch 1)**		
4	D#1	D#1	D#1	D#1	Piano 4 (Honky-tonk) **(Ch 1)**		
5	E1	E1	E1	E1	Piano 5 (Elect. 1) **(Ch 1)**		
6	F1	F1	F1	F1	Piano 6 (Elect. 2) **(Ch 1)**		
7	F#1	F#1	F#1	F#1	Harpsichord **(Ch 1)**		
8	G1	G1	G1	G1	Clavinet **(Ch 1)**		
9	G#1	G#1	G#1	G#1	Celesta **(Ch 1)**		
10	A1	A1	A1	A1	Glockenspiel **(Ch 1)**		
11	A#1	A#1	A#1	A#1	Music Box **(Ch 1)**		
12	B1	B1	B1	B1	Vibraphone **(Ch 1)**		
13	C2	C2	C2	C2	Marimba **(Ch 1)**		
14	C#2	C#2	C#2	C#2	Xylophone **(Ch 1)**		
15	D2	D2	D2	D2	Tubular Bells **(Ch 1)**		
16	D#2	D#2	D#2	D#2	Dulcimer **(Ch 1)**		
17	E2	E2	E2	E2	Drawbar Organ **(Ch 1)**		
18	F2	F2	F2	F2	Percussive Organ **(Ch 1)**		
19	F#2	F#2	F#2	F#2	Rock Organ **(Ch 1)**		
20	G2	G2	G2	G2	Church Organ **(Ch 1)**		
21	G#2	G#2	G#2	G#2	Reed Organ **(Ch 1)**		
22	A2	A2	A2	A2	Accordion **(Ch 1)**		
23	A#2	A#2	A#2	A#2	Harmonica **(Ch 1)**		
24	B2	B2	B2	B2	Tango Accordion **(Ch 1)**		
25	C3	C3	C3	C3	Acoustic Guitar (Nylon) **(Ch 1)**		
26	C#3	C#3	C#3	C#3	Acoustic Guitar (Steel) **(Ch 1)**		
27	D3	D3	D3	D3	Elect. Guitar (Jazz) **(Ch 1)**		
28	D#3	D#3	D#3	D#3	Elect. Guitar (Clean) **(Ch 1)**		
29	E3	E3	E3	E3	Elect. Guitar (Muted) **(Ch 1)**		
30	F3	F3	F3	F3	Elect. Guitar (Over driven) **(Ch 1)**		
31	F#3	F#3	F#3	F#3	Elect. Guitar (Distorted) **(Ch 1)**		
32	G3	G3	G3	G3	Elect. Guitar (Harmonics) **(Ch 1)**		

Position	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
Board	SIB-4	SIB-4	SIB-4	SIB-4	SIB-4	OUTN-1	
	Swell	**Great**	**Choir**	**Pedal**	**Stops**	**Outputs**	
	Keys	**Keys**	**Keys** *Not fitted*	**Stops** *For MCU with GM9773*	**Stops** *For MCU with GM9773*	*Not Fitted*	
33	G#3	G#3	G#3	Soprano Sax **(Ch 4)**	Acoustic Bass **(Ch 2)**		
34	A3	A3	A3	Alto Sax **(Ch 4)**	Finger Bass **(Ch 2)**		
35	A#3	A#3	A#3	Tenor Sax **(Ch 4)**	Picked Bass **(Ch 2)**		
36	B3	B3	B3	Baritone Sax **(Ch 4)**	Fretless Bass **(Ch 2)**		
37	C4	C4	C4	Oboe **(Ch 4)**	Slap Bass 1 **(Ch 2)**		
38	C#4	C#4	C#4	English Horn **(Ch 4)**	Slap Bass 2 **(Ch 2)**		
39	D4	D4	D4	Bassoon **(Ch 4)**	Synth. Bass 1 **(Ch 2)**		
40	D#4	D#4	D#4	Clarinet **(Ch 4)**	Synth. Bass 2 **(Ch 2)**		
41	E4	E4	E4	Piccolo **(Ch 4)**	Violin **(Ch 2)**		
42	F4	F4	F4	Flute **(Ch 4)**	Viola **(Ch 2)**		
43	F#4	F#4	F#4	Recorder **(Ch 4)**	Cello **(Ch 2)**		
44	G4	G4	G4	Pan Flute **(Ch 4)**	Contrabass **(Ch 2)**		
45	G#4	G#4	G#4	Blown Bottle **(Ch 4)**	Trem. Strings **(Ch 2)**		
46	A4	A4	A4	Shakuhachi **(Ch 4)**	Pizz. Strings **(Ch 2)**		
47	A#4	A#4	A#4	Whistle **(Ch 4)**	Orch. Harp **(Ch 2)**		
48	B4	B4	B4	Lead 1 (Square) **(Ch 4)**	Tympani **(Ch 2)**		
49	C5	C5	C5	Lead 2 (Sawtooth) **(Ch 4)**	String Ensem. 1 **(Ch 2)**		
50	C#5	C#5	C#5	Lead 3 (Calliope) **(Ch 4)**	String Ensem. 2 **(Ch 2)**		
51	D5	D5	D5	Lead 4 (Chiff) **(Ch 4)**	Synth. Strings 1 **(Ch 2)**		
52	D#5	D#5	D#5	Lead 5 (Charang) **(Ch 4)**	Synth. Strings 2 **(Ch 2)**		
53	E5	E5	E5	Lead 6 (Voice) **(Ch 4)**	Choir Aahs **(Ch 2)**		
54	F5	F5	F5	Lead 7 (Fifth) **(Ch 4)**	Voice Oohs **(Ch 2)**		
55	F#5	F#5	F#5	Lead 8 (Bass+Lead) **(Ch 4)**	Synth. Voice **(Ch 2)**		
56	G5	G5	G5	Pad 1 (Fantasia) **(Ch 4)**	Orchestra Hit **(Ch 2)**		
57	G#5	G#5	G#5	Pad 2 (Warm) **(Ch 4)**	Trumpet **(Ch 2)**		
58	A5	A5	A5	Guitar Fret Noise **(Ch 4)**	Trombone **(Ch 2)**		
59	A#5	A#5	A#5	Breath Noise **(Ch 4)**	Tuba **(Ch 2)**		
60	B5	B5	B5	Seashore **(Ch 4)**	Muted Trumpet **(Ch 2)**		
61	C6	C6	C6	Bird Tweet **(Ch 4)**	French Horn **(Ch 2)**		
62	MIDI Ch-1	MIDI Ch-1	MIDI Ch-1	MIDI Ch-1	Brass Section **(Ch 2)**		
63	MIDI Ch-2	MIDI Ch-2	MIDI Ch-2	MIDI Ch-2	Synth. Brass 1 **(Ch 2)**		
64	MIDI Ch-4	MIDI Ch-4	MIDI Ch-3	MIDI Ch-4	Synth. Brass 2 **(Ch 2)**		
Default	MIDI Ch-1	MIDI Ch-2	MIDI Ch-3	MIDI Ch-4			

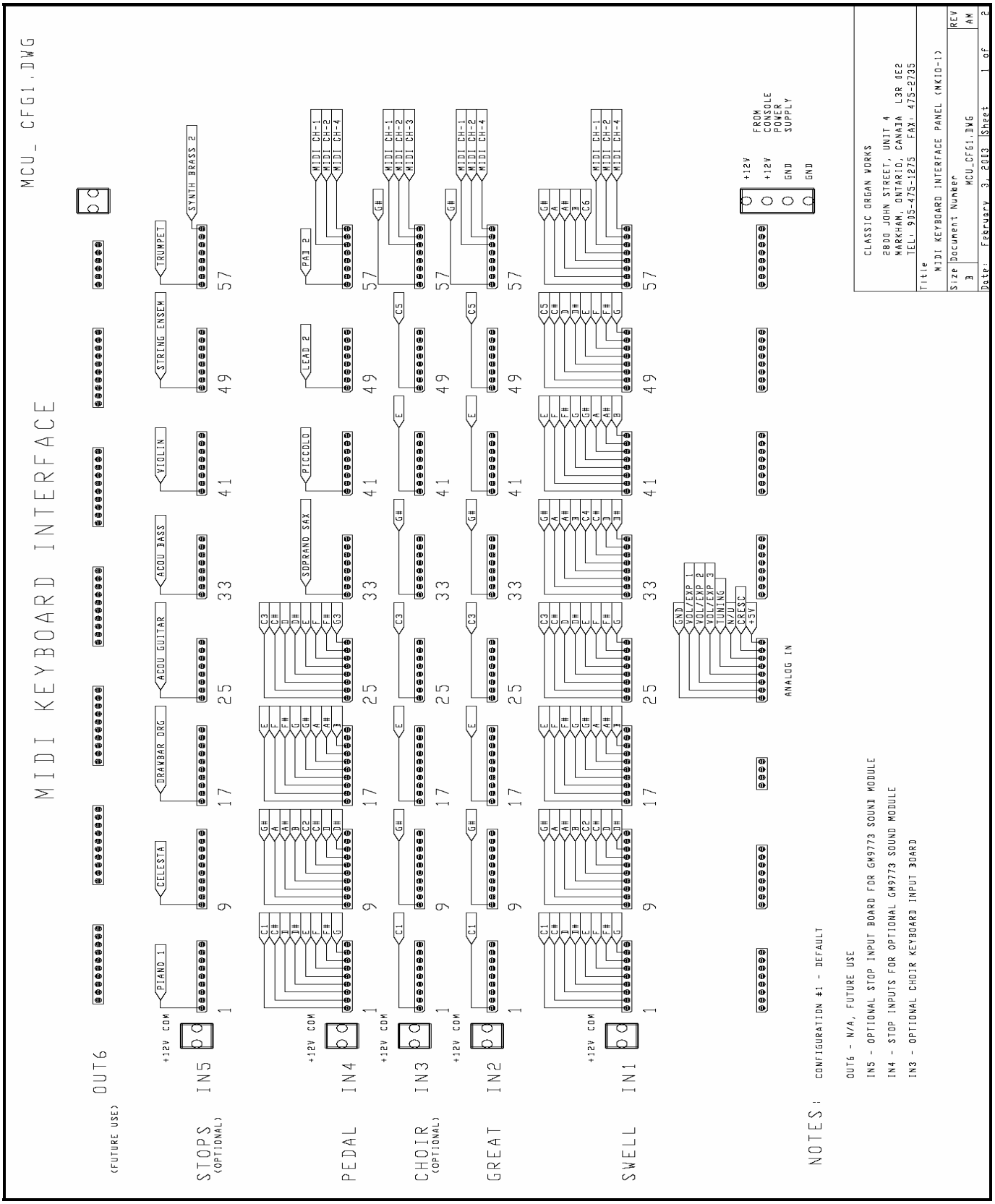


Figure 5: MCU Configuration #1 (default) connection diagram.

Configurations for Ahlborn Archive Units (Config. # 2, 3, 4, 5)

Four ***pre-programmed*** configurations are included in the internal EEPROM. These configurations are for users who have Ahlborn Archive modules, or those who anticipate purchasing them. Ahlborn Archive modules are available in four models: Romantic (filename: cfg002.mcu), Classic (filename: cfg003.mcu), Archive 202 (filename: cfg004.mcu), and Archive 201 (filename: cfg005.mcu) [6]. The differences between the four are in the stop lists that generate different tonal palettes. The configuration connection diagram shown on page 38 can be applied to the other Ahlborn modules by associating pins with stop names provided in the other configuration charts.

Table 11: Configuration #2: Ahlborn Archive Module – Romantic (file: cfg002.mcu)
MCU-1 DIP-Switch setting: '1000 0000' (Ahlborn MIDI Channels should be set to 1, 2, off, 4, 16)

Pin Number	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
Board	SIB-4	SIB-4	SIB-4	SIB-4	SIB-4	OUTN-1	
	Swell	**Great**	**Choir**	**Pedal**	**Stops**	**Outputs**	
			Not Fitted			*Not Fitted*	
	Keys	**Keys**	**Keys**	**Keys**			
1	C1	C1		C1	Ahlborn - General Cancel		
2	C#1	C#1		C#1	Ahlborn - Mem. A Gen. #1		
3	D1	D1		D1	Ahlborn - Mem. A Gen. #2		
4	D#1	D#1		D#1	Ahlborn - Mem. A Gen. #3		
5	E1	E1		E1	Ahlborn - Mem. A Gen. #4		
6	F1	F1		F1	Ahlborn - Mem. A Gen. #5		
7	F#1	F#1		F#1	Ahlborn - Mem. A Gen. #6		
8	G1	G1		G1	Ahlborn - Mem. B Gen. #1		
9	G#1	G#1		G#1	Ahlborn - Mem. B Gen. #2		
10	A1	A1		A1	Ahlborn - Mem. B Gen. #3		
11	A#1	A#1		A#1	Ahlborn - Mem. B Gen. #4		
12	B1	B1		B1	Ahlborn - Mem. B Gen. #5		
13	C2	C2		C2	Ahlborn - Mem. B Gen. #6		
14	C#2	C#2		C#2	Ahlborn - Mem. C Gen. #1		
15	D2	D2		D2	Ahlborn - Mem. C Gen. #2		
16	D#2	D#2		D#2	Ahlborn - Mem. C Gen. #3		
17	E2	E2		E2	Ahlborn - Mem. C Gen. #4		
18	F2	F2		F2	Ahlborn - Mem. C Gen. #5		
19	F#2	F#2		F#2	Ahlborn - Mem. C Gen. #6		
20	G2	G2		G2	Ahlborn - Mem. D Gen. #1		
21	G#2	G#2		G#2	Ahlborn - Mem. D Gen. #2		
22	A2	A2		A2	Ahlborn - Mem. D Gen. #3		
23	A#2	A#2		A#2	Ahlborn - Mem. D Gen. #4		
24	B2	B2		B2	Ahlborn - Mem. D Gen. #5		
25	C3	C3		C3	Ahlborn - Mem. D Gen. #6		
26	C#3	C#3		C#3	Ahlborn - Mem. E Gen. #1		
27	D3	D3		D3	Ahlborn - Mem. E Gen. #2		
28	D#3	D#3		D#3	Ahlborn - Mem. E Gen. #3		
29	E3	E3		E3	Ahlborn - Mem. E Gen. #4		
30	F3	F3		F3	Ahlborn - Mem. E Gen. #5		
31	F#3	F#3		F#3	Ahlborn - Mem. E Gen. #6		
32	G3	G3		G3	Cancel Crescendo		

Position	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
	Keys	Keys	Keys *Not Fitted*	Stops	Stops	*Not Fitted*	
33	G#3	G#3		Cornopean 16' **(A)**	Crescendo Stage #1 / Off		
34	A3	A3		Cornet des Bombardes IV **(A)**	Crescendo Stage #2 / 1		
35	A#3	A#3		Tuba Mirabilis 8' **(A)**	Crescendo Stage #3 / 2		
36	B3	B3		Clarion 4' **(A)**	Crescendo Stage #4 / 3		
37	C4	C4		Orchestral Oboe 8' **(A)**	Crescendo Stage #5 / 4		
38	C#4	C#4		Clarinet 8' **(A)**	Crescendo Stage #6 / 5		
39	D4	D4		French Horn 8' **(A)**	Crescendo Stage #7 / 6		
40	D#4	D#4		Cor Anglais 8' **(A)**	Crescendo Stage #8 / 7		
41	E4	E4		Cello 8' **(A)**	Crescendo Stage #9 / 8		
42	F4	F4		Cello Celeste 8' **(A)**	Crescendo Stage #10/ 9		
43	F#4	F#4		Quint Flute 2 2/3' **(B)**	Crescendo Stage #11/10		
44	G4	G4		Piccolo 2' **(B)**	Crescendo Stage #12/11		
45	G#4	G#4		Vox Humana 8' **(B)**	Crescendo Stage #13/12		
46	A4	A4		Open Diapason 8' **(B)**	Crescendo Stage #14/13		
47	A#4	A#4		Flauto Mirabilis 8' **(B)**	Crescendo Stage #15/14		
48	B4	B4		Concert Flute 4' **(B)**	Crescendo Stage #16/15		
49	C5	C5		Contre Gamba 16' **(P)**	Crescendo Stage #17/16		
50	C#5	C#5		Ophicleide 16' **(P)**	Crescendo Stage #18/17		
51	D5	D5		Contre Violone 32' **(P)**	Crescendo Stage #19/18		
52	D#5	D#5		Contre Bassoon 32' **(P)**	Crescendo Stage #20/19		
53	E5	E5		A/P coupler	Sw. Division Cancel		
54	F5	F5		B to Pd coupler	Gt. Division Cancel		
55	F#5	F#5		B to A coupler	Pedal Division Cancel		
56	G5	G5		A to B coupler	SET piston		
57	G#5	G#5		A to Aux coupler	SFZ control		
58	A5	A5		B to Aux coupler			
59	A#5	A#5		All stops On / Off			
60	B5	B5		Swell Tremulant			
61	C6	C6		Great Tremulant			
62	MIDI Ch-1	MIDI Ch-1		MIDI Ch-1	Choir Tremulant		
63	MIDI Ch-2	MIDI Ch-2		MIDI Ch-2			
64	MIDI Ch-4	MIDI Ch-4		MIDI Ch-4			
Default	MIDI Ch-1	MIDI Ch-2		MIDI Ch-4			

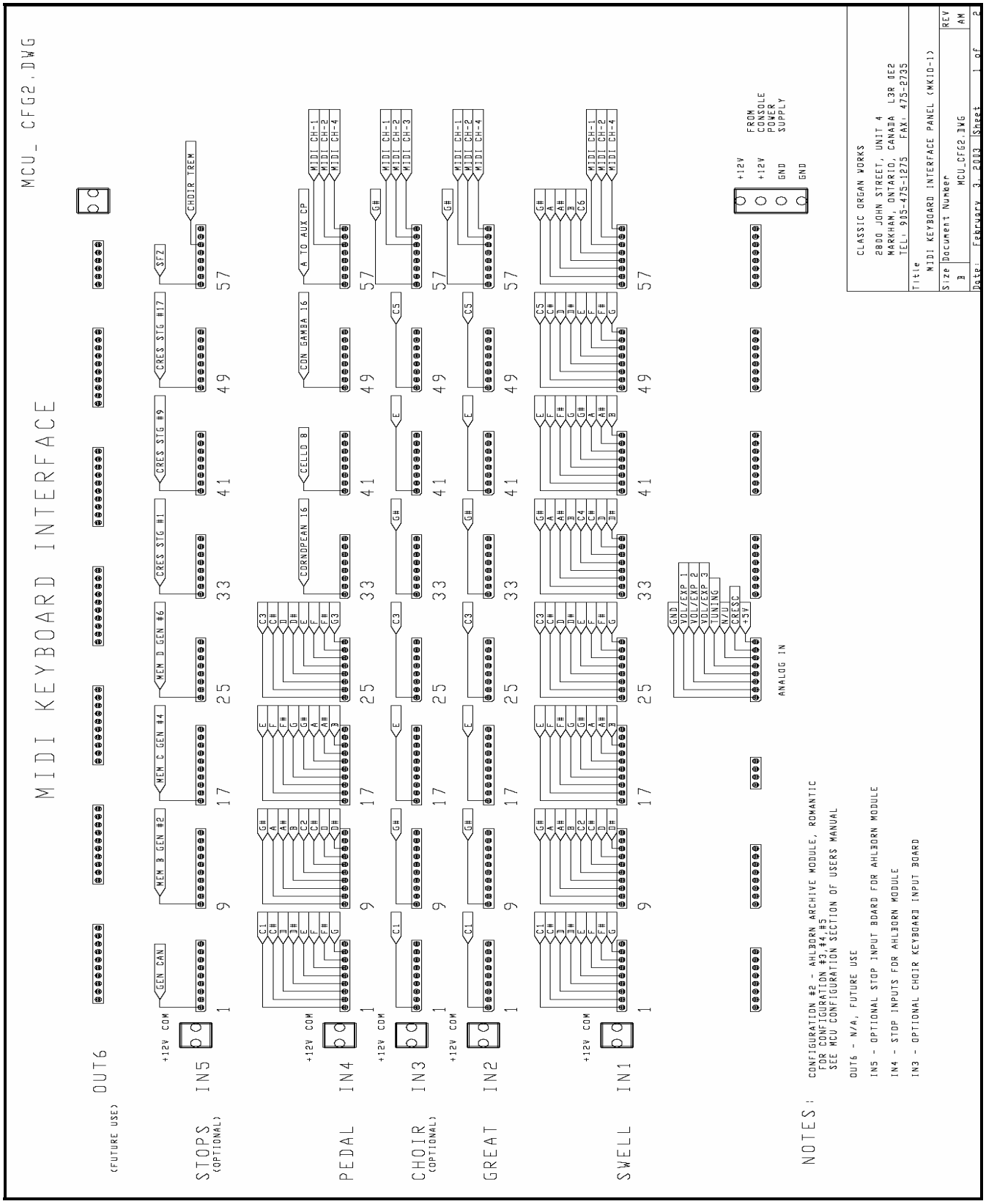


Figure 6: MCU Configuration #2 (Ahlborn Archive) typical connection diagram.

Table 12: Configuration #3: Ahlborn Archive Module – Classic (file: cfg003.mcu)
MCU-1 DIP-Switch setting: 0100 0000 (Ahlborn MIDI Channels should be set to 1, 2, off, 4, 16)

Pin Number	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
Board	SIB-4	SIB-4	SIB-4	SIB-4	SIB-4	OUTN-1	
	Swell	**Great**	**Choir**	**Pedal**	**Stops**	**Outputs**	
			Not Fitted			*Not Fitted*	
	Keys	**Keys**	**Keys**	**Keys**			
1	C1	C1		C1	Ahlborn - General Cancel		
2	C#1	C#1		C#1	Ahlborn – Mem. A Gen. #1		
3	D1	D1		D1	Ahlborn – Mem. A Gen. #2		
4	D#1	D#1		D#1	Ahlborn – Mem. A Gen. #3		
5	E1	E1		E1	Ahlborn – Mem. A Gen. #4		
6	F1	F1		F1	Ahlborn - Mem. A Gen. #5		
7	F#1	F#1		F#1	Ahlborn - Mem. A Gen. #6		
8	G1	G1		G1	Ahlborn - Mem. B Gen. #1		
9	G#1	G#1		G#1	Ahlborn - Mem. B Gen. #2		
10	A1	A1		A1	Ahlborn - Mem. B Gen. #3		
11	A#1	A#1		A#1	Ahlborn - Mem. B Gen. #4		
12	B1	B1		B1	Ahlborn - Mem. B Gen. #5		
13	C2	C2		C2	Ahlborn - Mem. B Gen. #6		
14	C#2	C#2		C#2	Ahlborn - Mem. C Gen. #1		
15	D2	D2		D2	Ahlborn - Mem. C Gen. #2		
16	D#2	D#2		D#2	Ahlborn - Mem. C Gen. #3		
17	E2	E2		E2	Ahlborn - Mem. C Gen. #4		
18	F2	F2		F2	Ahlborn - Mem. C Gen. #5		
19	F#2	F#2		F#2	Ahlborn - Mem. C Gen. #6		
20	G2	G2		G2	Ahlborn - Mem. D Gen. #1		
21	G#2	G#2		G#2	Ahlborn - Mem. D Gen. #2		
22	A2	A2		A2	Ahlborn - Mem. D Gen. #3		
23	A#2	A#2		A#2	Ahlborn - Mem. D Gen. #4		
24	B2	B2		B2	Ahlborn - Mem. D Gen. #5		
25	C3	C3		C3	Ahlborn - Mem. D Gen. #6		
26	C#3	C#3		C#3	Ahlborn - Mem. E Gen. #1		
27	D3	D3		D3	Ahlborn - Mem. E Gen. #2		
28	D#3	D#3		D#3	Ahlborn - Mem. E Gen. #3		
29	E3	E3		E3	Ahlborn - Mem. E Gen. #4		
30	F3	F3		F3	Ahlborn - Mem. E Gen. #5		
31	F#3	F#3		F#3	Ahlborn - Mem. E Gen. #6		
32	G3	G3		G3	Cancel Crescendo		

Position	Slot-1 IN-1 Keys	Slot-2 IN-2 Keys	Slot-3 IN-3 Keys *Not Fitted*	Slot-4 IN-4 Stops	Slot-5 IN-5 Stops	Slot-6 OUT-1 *Not Fitted*	Remarks
	Keys	Keys	Keys	Stops	Stops		
33	G#3	G#3		Corno di Bassetto 8' **(A)**	Crescendo Stage #1 / Off		
34	A3	A3		Plein Jeu IV-V **(A)**	Crescendo Stage #2 / 1		
35	A#3	A#3		Clarion 4' **(A)**	Crescendo Stage #3 / 2		
36	B3	B3		Festival Trumpet 8' **(A)**	Crescendo Stage #4 / 3		
37	C4	C4		Gemshorn Celeste 8' **(A)**	Crescendo Stage #5 / 4		
38	C#4	C#4		Koppelflote 4' **(A)**	Crescendo Stage #6 / 5		
39	D4	D4		Bombarde 16' **(A)**	Crescendo Stage #7 / 6		
40	D#4	D#4		Harmonic Trumpet 8' **(A)**	Crescendo Stage #8 / 7		
41	E4	E4		Gemshorn 8' **(A)**	Crescendo Stage #9 / 8		
42	F4	F4		Flute a Cheminee 8' **(A)**	Crescendo Stage #10/ 9		
43	F#4	F#4		Flute Octaviante 4' **(B)**	Crescendo Stage #11/10		
44	G4	G4		Octave 2' **(B)**	Crescendo Stage #12/11		
45	G#4	G#4		Cymbale III **(B)**	Crescendo Stage #13/12		
46	A4	A4		Principal 8' **(B)**	Crescendo Stage #14/13		
47	A#4	A#4		Holzgedackt 8' **(B)**	Crescendo Stage #15/14		
48	B4	B4		Flute Harmonique 8' **(B)**	Crescendo Stage #16/15		
49	C5	C5		Contre Gamba 16' **(P)**	Crescendo Stage #17/16		
50	C#5	C#5		Bombarde 16' **(P)**	Crescendo Stage #18/17		
51	D5	D5		Contre Basse 32' **(P)**	Crescendo Stage #19/18		
52	D#5	D#5		Contre Bombarde 32' **(P)**	Crescendo Stage #20/19		
53	E5	E5		A/P coupler	Sw. Division Cancel		
54	F5	F5		B to Pd coupler	Gt. Division Cancel		
55	F#5	F#5		B to A coupler	Pedal Division Cancel		
56	G5	G5		A to B coupler	SET piston		
57	G#5	G#5		A to Aux coupler	SFZ control		
58	A5	A5		B to Aux coupler			
59	A#5	A#5		All stops On / Off			
60	B5	B5		Swell Tremulant			
61	C6	C6		Great Tremulant			
62	MIDI Ch-1	MIDI Ch-1		MIDI Ch-1	Choir Tremulant		
63	MIDI Ch-2	MIDI Ch-2		MIDI Ch-2			
64	MIDI Ch-4	MIDI Ch-4		MIDI Ch-4			
Default	MIDI Ch-1	MIDI Ch-2		MIDI Ch-4			

Table 13: Configuration #4: Ahlborn Archive Module – 202 (file: cfg004.mcu)
MCU-1 DIP-Switch setting: 1100 0000 (Ahlborn MIDI Channels should be set to 1, 2, off, 4, 16)

Pin Number	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
Board	SIB-4	SIB-4	SIB-4	SIB-4	SIB-4	OUTN-1	
	Swell	**Great**	**Choir**	**Pedal**	**Stops**	**Outputs**	
			Not Fitted			*Not Fitted*	
	Keys	**Keys**	**Keys**	**Keys**			
1	C1	C1		C1	Ahlborn – General Cancel		
2	C#1	C#1		C#1	Ahlborn - Mem. A Gen. #1		
3	D1	D1		D1	Ahlborn - Mem. A Gen. #2		
4	D#1	D#1		D#1	Ahlborn - Mem. A Gen. #3		
5	E1	E1		E1	Ahlborn - Mem. A Gen. #4		
6	F1	F1		F1	Ahlborn - Mem. A Gen. #5		
7	F#1	F#1		F#1	Ahlborn - Mem. A Gen. #6		
8	G1	G1		G1	Ahlborn - Mem. B Gen. #1		
9	G#1	G#1		G#1	Ahlborn - Mem. B Gen. #2		
10	A1	A1		A1	Ahlborn - Mem. B Gen. #3		
11	A#1	A#1		A#1	Ahlborn - Mem. B Gen. #4		
12	B1	B1		B1	Ahlborn - Mem. B Gen. #5		
13	C2	C2		C2	Ahlborn - Mem. B Gen. #6		
14	C#2	C#2		C#2	Ahlborn - Mem. C Gen. #1		
15	D2	D2		D2	Ahlborn - Mem. C Gen. #2		
16	D#2	D#2		D#2	Ahlborn - Mem. C Gen. #3		
17	E2	E2		E2	Ahlborn - Mem. C Gen. #4		
18	F2	F2		F2	Ahlborn - Mem. C Gen. #5		
19	F#2	F#2		F#2	Ahlborn - Mem. C Gen. #6		
20	G2	G2		G2	Ahlborn - Mem. D Gen. #1		
21	G#2	G#2		G#2	Ahlborn - Mem. D Gen. #2		
22	A2	A2		A2	Ahlborn - Mem. D Gen. #3		
23	A#2	A#2		A#2	Ahlborn - Mem. D Gen. #4		
24	B2	B2		B2	Ahlborn - Mem. D Gen. #5		
25	C3	C3		C3	Ahlborn - Mem. D Gen. #6		
26	C#3	C#3		C#3	Ahlborn - Mem. E Gen. #1		
27	D3	D3		D3	Ahlborn - Mem. E Gen. #2		
28	D#3	D#3		D#3	Ahlborn - Mem. E Gen. #3		
29	E3	E3		E3	Ahlborn - Mem. E Gen. #4		
30	F3	F3		F3	Ahlborn - Mem. E Gen. #5		
31	F#3	F#3		F#3	Ahlborn - Mem. E Gen. #6		
32	G3	G3		G3	Cancel Crescendo		
	Keys	**Keys**	**Keys**	**Stops**	**Stops**		
33	G#3	G#3		Contregambe 16' **(A)**	Crescendo Stage #1 / Off		
34	A3	A3		Diapason 8' **(A)**	Crescendo Stage #2 / 1		
35	A#3	A#3		Quintadena 8' **(A)**	Crescendo Stage #3 / 2		
36	B3	B3		Terz 1 3/5' **(A)**	Crescendo Stage #4 / 3		
37	C4	C4		Septime 1 1/7 **(A)**'	Crescendo Stage #5 / 4		
38	C#4	C#4		Scharff III **(A)**	Crescendo Stage #6 / 5		
39	D4	D4		Bombarde 16' **(A)**	Crescendo Stage #7 / 6		
40	D#4	D#4		Trompette 8' **(A)**	Crescendo Stage #8 / 7		

Position	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
	Keys	**Keys**	**Keys** *Not fitted*	**Stops**	**Stops**	*Not Fitted*	
	Keys	**Keys**	**Keys**	**Stops**	**Stops**		
33	G#3	G#3		Contregambe 16' **(A)**	Crescendo Stage #1 / Off		
34	A3	A3		Diapason 8' **(A)**	Crescendo Stage #2 / 1		
35	A#3	A#3		Quintadena 8' **(A)**	Crescendo Stage #3 / 2		
36	B3	B3		Terz 1 3/5' **(A)**	Crescendo Stage #4 / 3		
37	C4	C4		Septime 1 1/7 **(A)**'	Crescendo Stage #5 / 4		
38	C#4	C#4		Scharff III **(A)**	Crescendo Stage #6 / 5		
39	D4	D4		Bombarde 16' **(A)**	Crescendo Stage #7 / 6		
40	D#4	D#4		Trompette 8' **(A)**	Crescendo Stage #8 / 7		
41	E4	E4		Tuba Mirabilis 8' **(A)**	Crescendo Stage #9 / 8		
42	F4	F4		Chimes **(A)**	Crescendo Stage #10/ 9		
43	F#4	F#4		Bourdon 8' **(B)**	Crescendo Stage #11/10		
44	G4	G4		Flute Harmonique 8' **(B)**	Crescendo Stage #12/11		
45	G#4	G#4		Flute Octaviante 4' **(B)**	Crescendo Stage #13/12		
46	A4	A4		Larigot 1 1/3' **(B)**	Crescendo Stage #14/13		
47	A#4	A#4		Corno di Bassetto 8' **(B)**	Crescendo Stage #15/14		
48	B4	B4		Clarion 4' **(B)**	Crescendo Stage #16/15		
49	C5	C5		Soubasse 32' **(P)**	Crescendo Stage #17/16		
50	C#5	C#5		Violone 16' **(P)**	Crescendo Stage #18/17		
51	D5	D5		Contrebombarde 32' **(P)**	Crescendo Stage #19/18		
52	D#5	D#5		Bombarde 16' **(P)**	Crescendo Stage #20/19		
53	E5	E5		A/P coupler	Sw. Division Cancel		
54	F5	F5		B to Pd coupler	Gt. Division Cancel		
55	F#5	F#5		B to A coupler	Pedal Division Cancel		
56	G5	G5		A to B coupler	SET piston		
57	G#5	G#5		A to Aux coupler	SFZ control		
58	A5	A5		B to Aux coupler			
59	A#5	A#5		All stops On / Off			
60	B5	B5		Swell Tremulant			
61	C6	C6		Great Tremulant			
62	MIDI Ch-1	MIDI Ch-1		MIDI Ch-1	Choir Tremulant		
63	MIDI Ch-2	MIDI Ch-2		MIDI Ch-2			
64	MIDI Ch-4	MIDI Ch-4		MIDI Ch-4			
Default	MIDI Ch-1	MIDI Ch-2		MIDI Ch-4			

Table 14: Configuration **#5: Ahlborn Archive Module – 201 (file: cfg005.mcu)**
MCU-1 DIP-Switch setting: 0010 0000 (Ahlborn MIDI Channels should be set to 1, 2, off, 4, 16)

Pin Number	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
Board	SIB-4	SIB-4	SIB-4	SIB-4	SIB-4	OUTN-1	
	Swell	**Great**	**Choir**	**Pedal**	**Stops**	**Outputs**	
			Not Fitted			*Not Fitted*	
	Keys	**Keys**	**Keys**	**Keys**			
1	C1	C1		C1	Ahlborn - General Cancel		
2	C#1	C#1		C#1	Ahlborn - Mem. A Gen. #1		
3	D1	D1		D1	Ahlborn - Mem. A Gen. #2		
4	D#1	D#1		D#1	Ahlborn - Mem. A Gen. #3		
5	E1	E1		E1	Ahlborn - Mem. A Gen. #4		
6	F1	F1		F1	Ahlborn - Mem. A Gen. #5		
7	F#1	F#1		F#1	Ahlborn - Mem. A Gen. #6		
8	G1	G1		G1	Ahlborn - Mem. B Gen. #1		
9	G#1	G#1		G#1	Ahlborn - Mem. B Gen. #2		
10	A1	A1		A1	Ahlborn - Mem. B Gen. #3		
11	A#1	A#1		A#1	Ahlborn - Mem. B Gen. #4		
12	B1	B1		B1	Ahlborn - Mem. B Gen. #5		
13	C2	C2		C2	Ahlborn - Mem. B Gen. #6		
14	C#2	C#2		C#2	Ahlborn - Mem. C Gen. #1		
15	D2	D2		D2	Ahlborn - Mem. C Gen. #2		
16	D#2	D#2		D#2	Ahlborn - Mem. C Gen. #3		
17	E2	E2		E2	Ahlborn - Mem. C Gen. #4		
18	F2	F2		F2	Ahlborn - Mem. C Gen. #5		
19	F#2	F#2		F#2	Ahlborn - Mem. C Gen. #6		
20	G2	G2		G2	Ahlborn - Mem. D Gen. #1		
21	G#2	G#2		G#2	Ahlborn - Mem. D Gen. #2		
22	A2	A2		A2	Ahlborn - Mem. D Gen. #3		
23	A#2	A#2		A#2	Ahlborn - Mem. D Gen. #4		
24	B2	B2		B2	Ahlborn - Mem. D Gen. #5		
25	C3	C3		C3	Ahlborn - Mem. D Gen. #6		
26	C#3	C#3		C#3	Ahlborn - Mem. E Gen. #1		
27	D3	D3		D3	Ahlborn - Mem. E Gen. #2		
28	D#3	D#3		D#3	Ahlborn - Mem. E Gen. #3		
29	E3	E3		E3	Ahlborn - Mem. E Gen. #4		
30	F3	F3		F3	Ahlborn - Mem. E Gen. #5		
31	F#3	F#3		F#3	Ahlborn - Mem. E Gen. #6		
32	G3	G3		G3	Cancel Crescendo		

Position	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
	Keys	Keys	Keys *Not Fitted*	Stops	Stops	*Not Fitted*	
	Keys	Keys	Keys	Stops	Stops		
33	G#3	G#3		Bourdon 16' **(A)**	Crescendo Stage #1 / Off		
34	A3	A3		Principal 8' **(A)**	Crescendo Stage #2 / 1		
35	A#3	A#3		Flute a cheminee 8' **(A)**	Crescendo Stage #3 / 2		
36	B3	B3		Unda Maris 8' **(A)**	Crescendo Stage #4 / 3		
37	C4	C4		Octave 4' **(A)**	Crescendo Stage #5 / 4		
38	C#4	C#4		Spitzflote 4' **(A)**	Crescendo Stage #6 / 5		
39	D4	D4		Nasard 2 2/3' **(A)**	Crescendo Stage #7 / 6		
40	D#4	D#4		Superoctave 2' **(A)**	Crescendo Stage #8 / 7		
41	E4	E4		Mixture IV **(A)**	Crescendo Stage #9 / 8		
42	F4	F4		Trompete 8' **(A)**	Crescendo Stage #10/ 9		
43	F#4	F#4		Gedackt 8' **(B)**	Crescendo Stage #11/10		
44	G4	G4		Gamba 8' **(B)**	Crescendo Stage #12/11		
45	G#4	G#4		Nachthorn 4' **(B)**	Crescendo Stage #13/12		
46	A4	A4		Cymbale/Scharff III **(B)**	Crescendo Stage #14/13		
47	A#4	A#4		Cornet III **(B)**	Crescendo Stage #15/14		
48	B4	B4		Oboe 8' **(B)**	Crescendo Stage #16/15		
49	C5	C5		Subbass 16' **(P)**	Crescendo Stage #17/16		
50	C#5	C#5		Octave 8' **(P)**	Crescendo Stage #18/17		
51	D5	D5		Bourdon 8' **(P)**	Crescendo Stage #19/18		
52	D#5	D#5		Posaune 16' **(P)**	Crescendo Stage #20/19		
53	E5	E5		A/P coupler	Sw. Division Cancel		
54	F5	F5		B to Pd coupler	Gt. Division Cancel		
55	F#5	F#5		B to A coupler	Pedal Division Cancel		
56	G5	G5		A to B coupler	SET piston		
57	G#5	G#5		A to Aux coupler	SFZ control		
58	A5	A5		B to Aux coupler			
59	A#5	A#5		All stops On / Off			
60	B5	B5		Swell Tremulant			
61	C6	C6		Great Tremulant			
62	MIDI Ch-1	MIDI Ch-1		MIDI Ch-1	Choir Tremulant		
63	MIDI Ch-2	MIDI Ch-2		MIDI Ch-2			
64	MIDI Ch-4	MIDI Ch-4		MIDI Ch-4			
Default	MIDI Ch-1	MIDI Ch-2		MIDI Ch-4			

Table 15: Configuration **#6: Hauptwerk (file: cfg006.mcu)**
MCU-1 DIP-Switch setting: 1010 0000

Pin Number	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
Board	SIB-4	SIB-4	SIB-4	SIB-4	SIB-4	OUTN-1	
	Swell	**Great**	**Choir**	**Pedal**	**Stops**	**Outputs**	
						Not Fitted	
	Keys	**Keys**	**Keys**	**Keys**			
1	C1	C1	C1	C1			
2	C#1	C#1	C#1	C#1			
3	D1	D1	D1	D1			
4	D#1	D#1	D#1	D#1			
5	E1	E1	E1	E1			
6	F1	F1	F1	F1			
7	F#1	F#1	F#1	F#1			
8	G1	G1	G1	G1			
9	G#1	G#1	G#1	G#1			
10	A1	A1	A1	A1			
11	A#1	A#1	A#1	A#1			
12	B1	B1	B1	B1			
13	C2	C2	C2	C2			
14	C#2	C#2	C#2	C#2			
15	D2	D2	D2	D2			
16	D#2	D#2	D#2	D#2			
17	E2	E2	E2	E2			
18	F2	F2	F2	F2			
19	F#2	F#2	F#2	F#2			
20	G2	G2	G2	G2			
21	G#2	G#2	G#2	G#2			
22	A2	A2	A2	A2			
23	A#2	A#2	A#2	A#2			
24	B2	B2	B2	B2			
25	C3	C3	C3	C3			
26	C#3	C#3	C#3	C#3			
27	D3	D3	D3	D3			
28	D#3	D#3	D#3	D#3			
29	E3	E3	E3	E3			
30	F3	F3	F3	F3			
31	F#3	F#3	F#3	F#3			
32	G3	G3	G3	G3			

Position	Slot-1 IN-1	Slot-2 IN-2	Slot-3 IN-3	Slot-4 IN-4	Slot-5 IN-5	Slot-6 OUT-1	Remarks
	Keys	**Keys**	**Keys**	**Stops**	**Stops**	*Not Fitted*	
	Keys	**Keys**	**Keys**	**Stops**	**Stops**		
33	G#3	G#3	G#3				
34	A3	A3	A3				
35	A#3	A#3	A#3				
36	B3	B3	B3				
37	C4	C4	C4				
38	C#4	C#4	C#4				
39	D4	D4	D4				
40	D#4	D#4	D#4				
41	E4	E4	E4				
42	F4	F4	F4				
43	F#4	F#4	F#4				
44	G4	G4	G4				
45	G#4	G#4	G#4				
46	A4	A4	A4				
47	A#4	A#4	A#4				
48	B4	B4	B4				
49	C5	C5	C5				
50	C#5	C#5	C#5				
51	D5	D5	D5				
52	D#5	D#5	D#5				
53	E5	E5	E5				
54	F5	F5	F5				
55	F#5	F#5	F#5				
56	G5	G5	G5				
57	G#5	G#5	G#5				
58	A5	A5	A5				
59	A#5	A#5	A#5				
60	B5	B5	B5				
61	C6	C6	C6				
62	MIDI Ch-1	MIDI Ch-1	MIDI Ch-1	MIDI Ch-1			
63	MIDI Ch-2	MIDI Ch-2	MIDI Ch-2	MIDI Ch-2			
64	MIDI Ch-4	MIDI Ch-4	MIDI Ch-4	MIDI Ch-4			
Default	MIDI Ch-3	MIDI Ch-2	MIDI Ch-4	MIDI Ch-1			

MIDI CONTROL UNIT
MCU-1

6. CONFIGURATION SOFTWARE
(PC and MAC)

Introduction

Users with access to a personal computer can use the Classic 'MCUConfig' software (contained in the compact disc) to program additional configurations for the MCU. The software allows users to use existing configuration files, change existing configuration files, and create new configuration files by editing existing ones. Both Windows and MacIntosh versions are substantially the same though differing in appearance. Some configuration files are provided on the CD supplied.

Software Installation

The MCU includes a compact disc with software allowing users to create custom configurations. To use the software, the MCU **must be connected via MIDI to a personal computer running Windows™ [1] operating system** software (Windows 98, 2000, XP) or **System-X on the MacIntosh™ [2]**. You can use the software without the MCU if all you want to do it to edit or create files on the computer.

If a MIDI port is not available on your computer, commercial MIDI adapters for the game port, USB port, or parallel port may be used. A suitable USB-to-MIDI interface unit is the M-Audio 'MIDIsport 1x1', which has drivers for both PC and Mac.

When the installation CD is placed in the optical drive of your computer (CD drive), the software installation wizard should automatically run. If however, the software installation wizard does not automatically run, follow the steps below:

For Windows:

1. Open the 'Start' menu and click on 'Run'.
2. Click on 'Browse' and select the optical drive (CD drive) from the 'Look-in' drop-down menu.
3. Locate and click on a file named 'MCU_Setup.exe'.
4. Follow the instructions in the software installation wizard.
5. Right-click to make a Shortcut for this program.

For MacIntosh:

1. The CD icon will appear on the desktop. Double-click on the icon to show its contents.
2. Drag all the files to a new folder on the hard drive. Name it MCU.
3. Double-click on the zipped file among the list and it will open up into a list of files.
4. Double-click on 'MCUconfig.app'.
5. Right-click to make an Alias of this program.

[1] Windows is a registered Trademark of the Microsoft Corporation.
[2] MacIntosh is a registered Trademark of the Apple Computer Corporation.

Software Startup

After installation, a file titled Classic 'MCUConfig' (or 'MCUConfig.app' for the MacIntosh) will be created in a folder of the same name (Start menu→ Programs→ Classic MCUConfig). To start using the software, double-click your left mouse button on the file named 'Classic MCUConfig'. You should briefly see a screen as shown below (the MacIntosh version will say 1.5.1 but is otherwise identical):

Figure 7: Classic MCUConfig software startup screen.

After a few moments the main menu selection will appear:

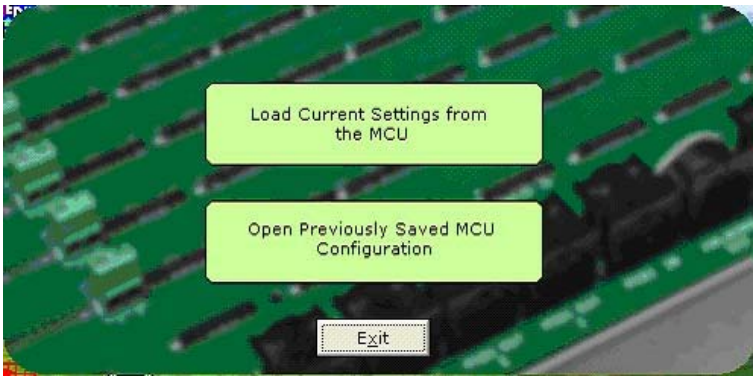


Figure 8: Classic MCUConfig software main menu.

The main menu allows you to select one of two sources for the basic configuration and presents you with a selection window from which you choose a file in the normal manner:

1. **Load Current Settings from the MCU**: This mode reads from a file in the MCU memory.
2. **Open a Previously Saved MCU Configuration**: This mode reads from a file stored on your computer.

Both sources allow you to modify the settings and eventually save either back to the MCU or to the computer under a new filename if you so wish.

Functions of the Toolbars

The software has toolbars that contain three main menu functions. Four of these from the File menu are shown as icons while the fifth icon is from the Options menu. MacIntosh icons are similar but more concise. Mac and PC data files are interchangeable:

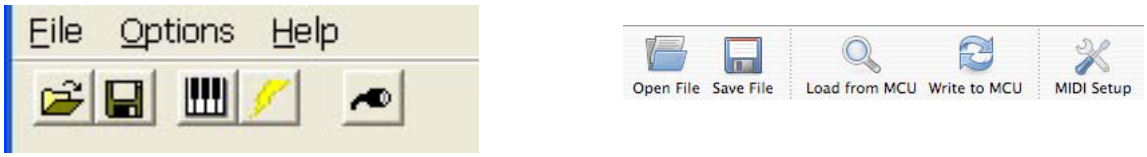
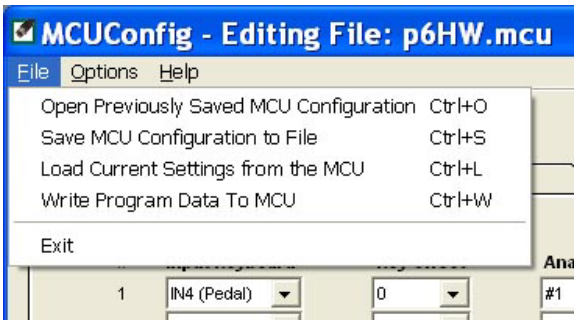


Figure 9: Toolbars in Classic MCUConfig software (Windows and MacIntosh (right)).

1. File Menu



- **Open Previously Saved MCU Configuration** – Loads a configuration file (a text file with a '.mcu' extension) from the computer to the Classic MCUConfig software. The user may then edit the file as desired.
  Keyboard shortcut: **Ctrl+O** Windows Icon: 

  To begin loading a configuration go to File → Open Previously Saved MCU Configuration, or use the Keyboard shortcut, or icon shown above. A window prompting the user for a filename should appear:

  The user can then select the filename and click on the 'Open' button or double-click on the filename.

- **Save MCU Configuration to File** – Saves a configuration file to the computer. All configuration files have a '.mcu' extension. On the Mac, the default name is 'data' and the file will save with a '.mcu' suffix.
  Keyboard shortcut: **Ctrl+S** Windows Icon: 

  To save a configuration file to the computer, go to File → Save MCU Configuration to File, or use the Keyboard shortcut or icon shown above.

  A window prompting the user for a filename should appear. Give the file a name (no need to type .mcu) and it need not be 'p#'. It can have any name you wish.

  Tip: A single click on an existing name will put that name into the box. You can then modify it to save some typing before you save it.

  If the configuration uses the same name as a previous configuration, a warning window will ask the user for confirmation in replacing the old file with the newly revised one.

- **Load Current Settings From the MCU** – Loads a configuration file from the MCU memory chip. An MCU may contain numerous configuration files that are selectable by changing the DIP-switch, so the software displays an initial configuration number as currently set by the DIP-switch. If a configuration number different from the DIP switch is required, it may be specified by the user in a drop-down menu. Mac-generated data files have a text icon with .mcu extension.
  Keyboard shortcut: **Ctrl+L** Windows Icon: 

  To load a configuration from the MCU memory chip, the user must ensure that the MCU is connected to power and to a computer using a MIDI cable (please see software installation for details on connecting MIDI devices to computers). Then go to File → Load Program Data From MCU, or use the keyboard shortcut or icon as shown above. A window appears attempting to make a connection with the MCU:

  If a connection is not available, a window will appear as a reminder to make connections to the MCU:

  If a connection is available, a window will appear and the program will read the DIP-Switch to get the configuration number. The user may change the configuration number to be loaded if desired.

  After the user has the desired configuration number, pressing 'OK' will display a window to confirm the selection:

- **Write Program Data to MCU** – Saves a configuration file to the MCU memory chip. Typical MCU units will have numerous configuration files so, the configuration number of the current file may be chosen by the user. It will save as a 'p#' format but all you have to do is to select a number in the lower box.
  Keyboard shortcut: **Ctrl+W** Windows Icon: 

  To save a configuration to the MCU, go to File → Write Program Data to MCU or, use the keyboard shortcut or icon as shown above. The Software attempts to make a connection to the MCU.

NOTE: The 'DIP Switch is set to' field reflects the current DIP Switch setting. Care must be taken when choosing a new 'Configuration Number'. If a 'Configuration Number' already contains settings, writing to the same 'Configuration Number' will overwrite this information.

A window should appear to confirm that the contents were written.

2. Options Menu

- **MIDI I/O Setup** – This function shows the current MIDI input and output ports on your PC and they may be changed using drop-down menus. You must have the drivers installed for the MIDI interface device that you are using.
  Keyboard shortcut: **Ctrl+M** Windows Icon: 

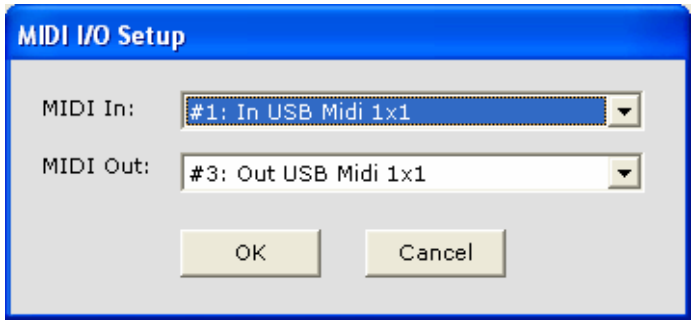
3. Help Menu

- **About Classic MCUConfig** – This function contains the software title, company and version number.

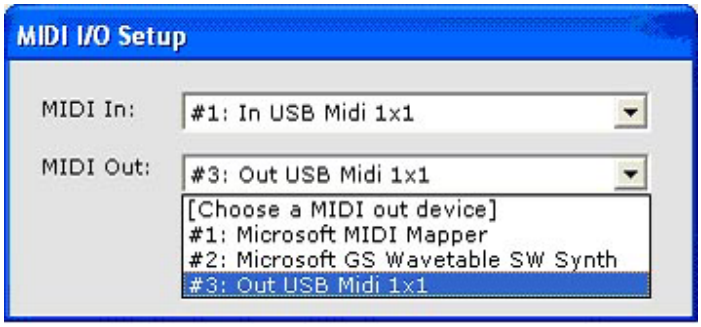
The current version does not have any actual Help files. Future versions will have proper Help files.

Load Current Settings from MCU

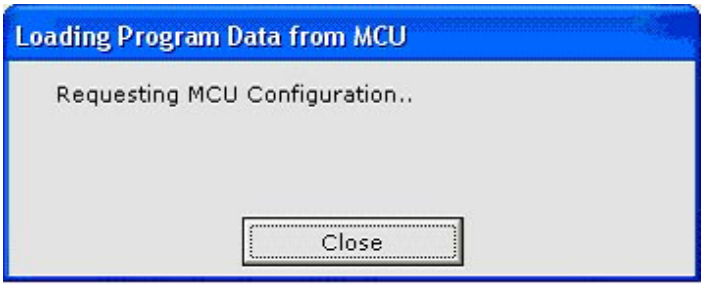
The screen that appears is used to determine the MIDI input and output interface connections to and from the MCU:



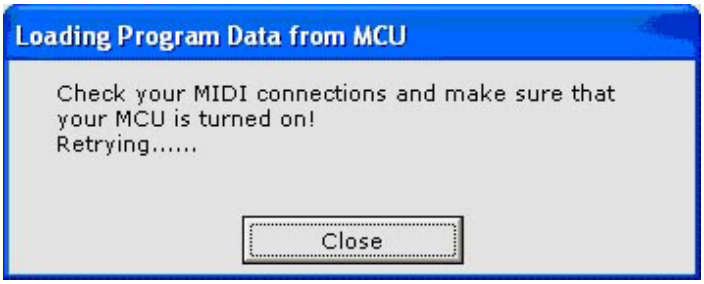
Each of the boxes has a pull-down selection from which you can select a suitable interface device if you have the necessary driver file installed. The one shown is for the M-Audio MIDIsport 1x1, which is a 1-In, 1-Out, USB-to-MIDI converter:



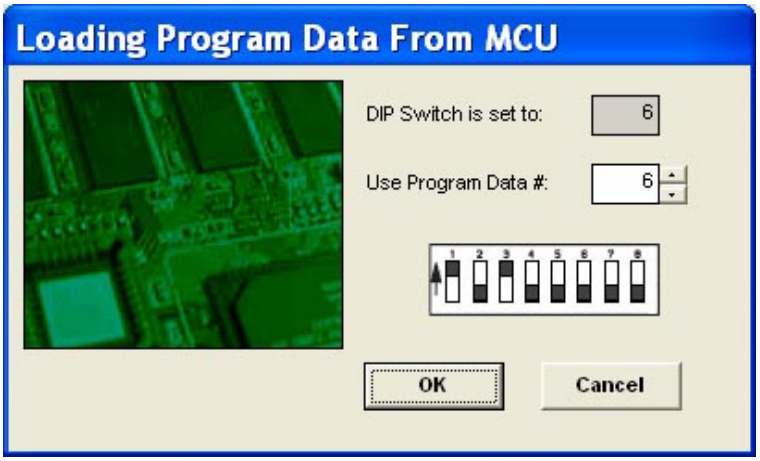
Left-click on OK. The computer requests the MCU configuration:



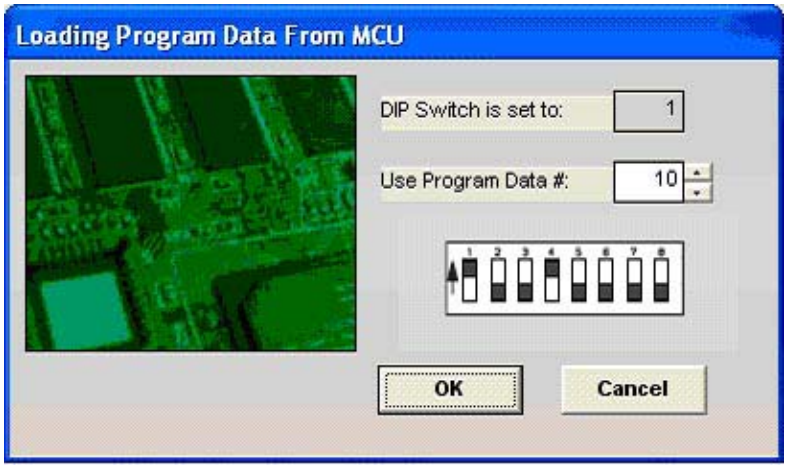
If your MIDI connections are NOT made properly, you will get the following screen:



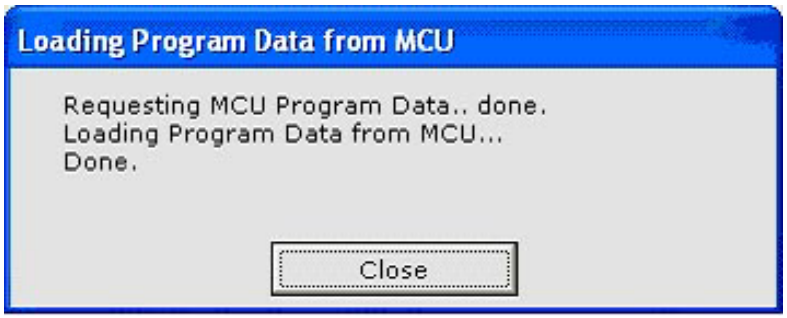
If all is well, a window appears showing the DIP-Switch as it is currently set:



You can use the lower drop-down menu to select another DIP-Switch setting from which to load the configuration data. The DIP-Switch in the window will move to show you how to adjust its switches. If this is the one you want, then you should move the switches to match the screen so that you will then work with it again when you next load/save to/from the MCU.

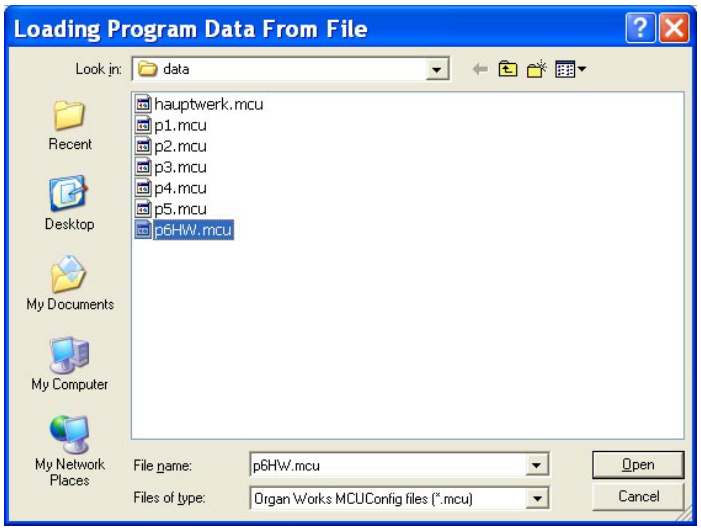


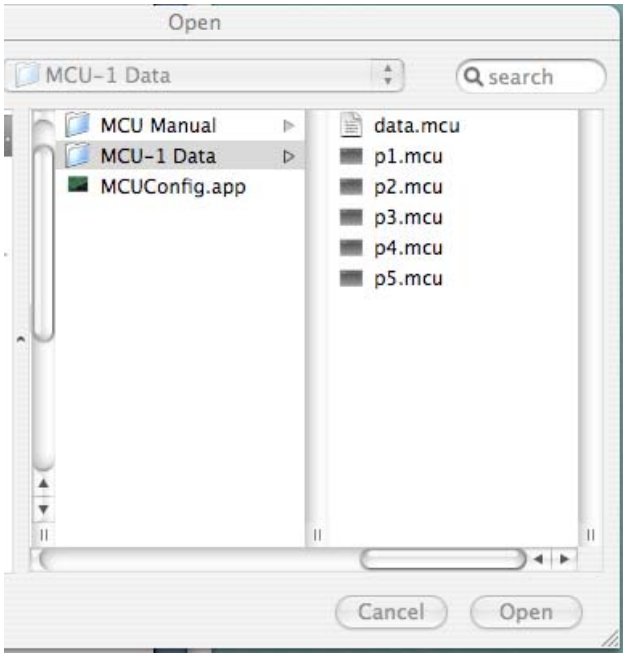
The diagram above shows the DIP-Switch changed to load Program Data number 10. Note that the number in the box is always 1 greater than the sum of the switches. e.g., the switches here show binary number 0000 1001, which is 9 but the box shows 10, because binary numbers start at 0, not 1. Note also that only the first seven switches are used to select any number from 1 to 128. If Switch-8 is put to On, you will get Configuration #1 and the switches will show as all Off even though they may be set otherwise. The number in the upper box will, however, be 128 plus the value of switches 1 to 7, while the upper box will be red. The following window appears briefly:



Open Previously Saved MCU Configuration

The screen that appears is the usual window for loading a file. Double-click on a filename or select the name and click on Open to load it:

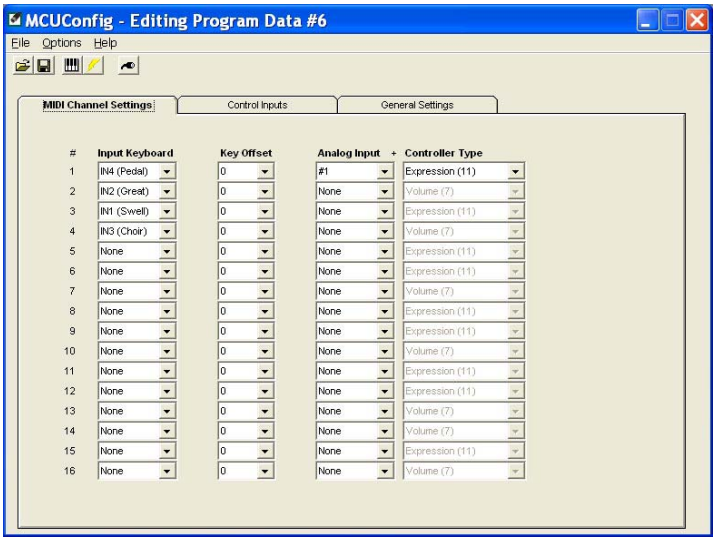


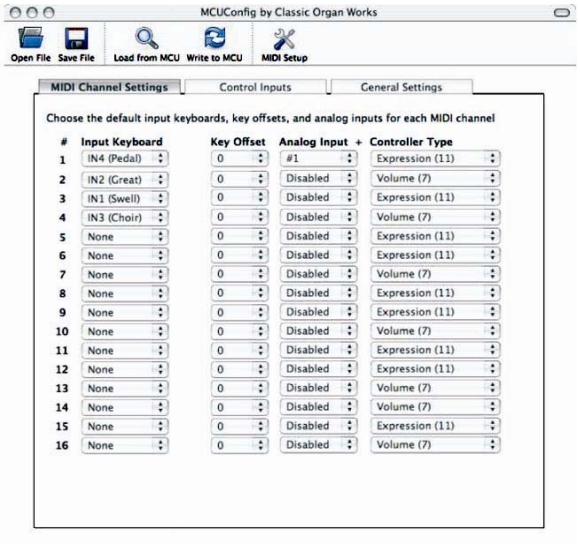


Left: a typical Windows Loading screen. Right: a typical MacIntosh loading screen. The first file is Mac-generated, the others were generated by Windows. All will open.

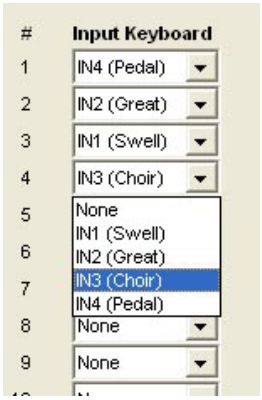
Edit the Configuration

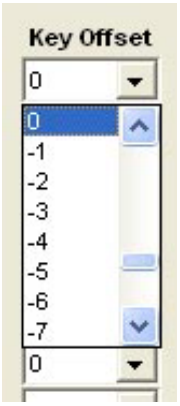
Whichever way you load the configuration file, the configuration then appears as below showing the MIDI Channel settings (for both Windows and MacIntosh):





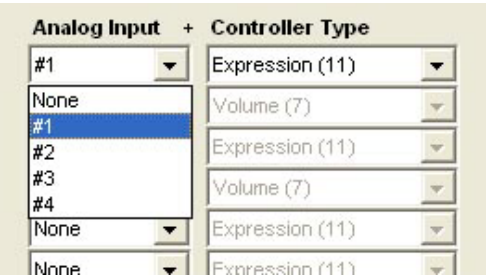
In this particular file, the first four MIDI channels have been assigned to keyboards according to the Hauptwerk preferred channels, but they could be set differently if some other device must have, say, Channel-1.
Opening a drop-down menu under the Input Keyboard item reveals the choice of keyboards that can be assigned to any available MIDI channel. You can assign a keyboard to more than one MIDI channel if you wish to drive multiple sound generators but some channels will be needed for stops and pistons. So unless there is a good reason for multiple channels, use only one. There are only 16 MIDI channels for everything and MIDI stops require one each. Hauptwerk uses one channel for all its stops (or perhaps two if it is a big organ with more than 128 stops). A **yellow triangle** next to a MIDI channel indicates that it has been assigned to a MIDI stop or other function in the Control Inputs Tab section and that should be changed there to some other channel.





The screen above-right shows a pull-down menu on the Key Offset column. It gives a choice of numbers between +91 and –36 allowing the keyboard pitch to be transposed in semi-tone steps by changing the key number. 0 is normal.

The next screen shows a pull-down menu for the Analog input with which you want a MIDI Channel to be associated for volume or expression. None is also an option if you do not want either. If the keyboard is associated with more than one MIDI channel, each can be set differently depending on the device being controlled.



The Controller Type gives you only the choice of Volume or Expression for the chosen Analog input. Which one you pick depends on the MIDI sound-generating device the MCU will be driving. Typically, Archive units use Volume (7) while Hauptwerk uses Expression (11).

Inputs #1-4 input refer to pins #2-5 on JP-3 of the bottom row. See diagram on page-30 and schematic on page-92. Up to four separate analog inputs may be used for expression shoes or other analog controls. There is also a #6 used for a global tuning control but that is not available in this window. See Functions of the Tabs, 3. General Settings.

The next section shows the functions of the other tabs.

Functions of the Tabs

The tabs represent the items that a user needs to specify in a configuration. These tabs, labeled 'MIDI Channel Config', 'Control Inputs', and 'General Settings', are described below:

1. MIDI Channel Settings

- **Input Keyboard** - One of four keyboards (three manual keyboards and one pedalboard) may be specified to transmit on one or more MIDI channels. Note that a keyboard can transmit on multiple MIDI channels so that more than one sound generator can be used at the same time. Some generators may not have readily-changeable MIDI channels.
- **Key Offset** - The user may select any offset between +91 and –36 if the keyboard pitch is to be transposed. 0 being no transposition.
- **Analog Input & Controller Type** - The user may select one of four pin numbers for analog inputs (#1 = 'Analog In 1', #2 = 'Analog In 2', #3 = 'Analog In 3'', #4 = 'Analog In 4') associated with the keyboards, e.g., Swell Expression. Analog inputs control the output Volume (7) (for Ahlborn Archive modules) or Expression (11) (for GM-MIDI modules, Hauptwerk, etc.) transmitted on each MIDI channel. Selecting 'none' means no analog input controls for that MIDI channel.

2. Control Inputs

There are105 inputs that may be used for stops, pistons, and other switch inputs. Double-clicking on the items for a particular pin gives drop-down menus from which the function and its particular parameters may be assigned to that pin.

- **Row/Slot** - Corresponds to the pin row labels on the MCU panel, starting with the three at the end of each manual keyboard row, then the 32 on the pedal row, finally the whole 64 on Row-5.
- **Pin** - Corresponds to the pin number (1-64) on the various MCU connectors.
- **Function** - The pins may be specified to control different sound modules:
    - Unassigned
    - Ahlborn Archive unit stops (Romantic, Classic, 201, or 202)
    - Common Ahlborn Functions/Pistons (couplers, tremulants, all stops on/off, General Cancel, Memory Level select, Crescendo, Division Cancel, Sforzando, and SET)
    - MIDI Stop
    - GM Bank Select MSB
    - GM Bank Select LSB
    - Program Change
    - Note On/Off
    - CM-100 Stop
    - CM-100 Trem
    - CM-100 Cancel

- **MIDI Channel** - Select channel (1-16) on which to transmit MIDI information.
- **Parameter** - Items that may be selected depending on the function that was specified.

Bear in mind that there are only 16 MIDI channels available for all functions, including keyboards, and that Channel-10 is used for percussive sounds in GM-MIDI.

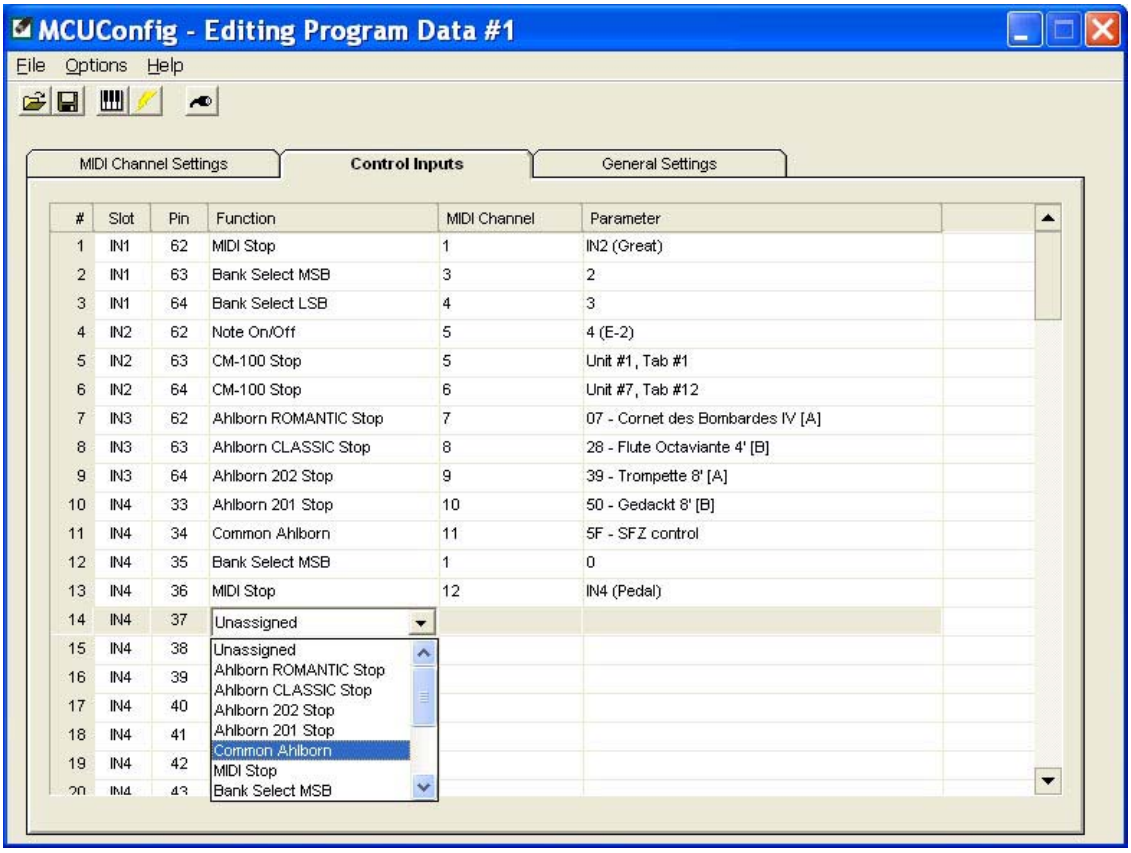


Figure 10: MCUConfig software with Pin Config tab selected.

Notes on the Parameter selections:

Ahlborn Modules: There will be a list of the 20 stops applicable to the particular module from which you choose one stop per pin. The list content depends on the model chosen.
Common Ahlborn: These are for couplers, tremulants and other control functions.
MIDI Stops: There are four keyboards with which to associate the stops. Be sure that the MIDI stop channels do not clash with any other MIDI channels. Each MIDI stop must have a channel that differs from the keyboard channels. Therefore, there is a practical limit as to how many MIDI stops there can be.
MIDI Banks: Each MSB and LSB can be assigned to a MIDI channel (1-16) and a Bank number from 0 to 127. Refer to the MIDI device manual for details.
Program Change: Gives a choice of 128 sounds for GM-MIDI or Program Change numbers when used for Hauptwerk.
Note On/Off: Gives a choice of 128 keys from C2 to G8 (and is intended for use with MIDI percussions on Channel-10). Can also be used for Hauptwerk.
CM-100 modules: There can be up to seven units controlled simultaneously, each with 12 stops. Choose one stop per pin. For Tremulant, the choice is 0 to 127 that sets the depth (the CM-100 has only one tremulant whose speed is preset). CM-100 Cancel has no choices.

For **Hauptwerk**, you need one MIDI channel per keyboard and one (or two) for stops. Pistons could be on another. You would use Program Change or Note On/Off numbers (0-127).

3. General Settings

These globally affect all MIDI devices that may be controlled.

- **Tuning Configuration** - is specified by the user to tune General MIDI devices, Ahlborn modules, or any other MIDI device. A drop-down menu reveals a choice of input (None, 1-4 or 6). Tick boxes are used to select the method. Note that there is an extra analog input (#6) compared with the earlier volume/expression settings so this can have a unique control just for tuning. There is no #5 in either. The analog input and the temperature sensor will add together if both selected.

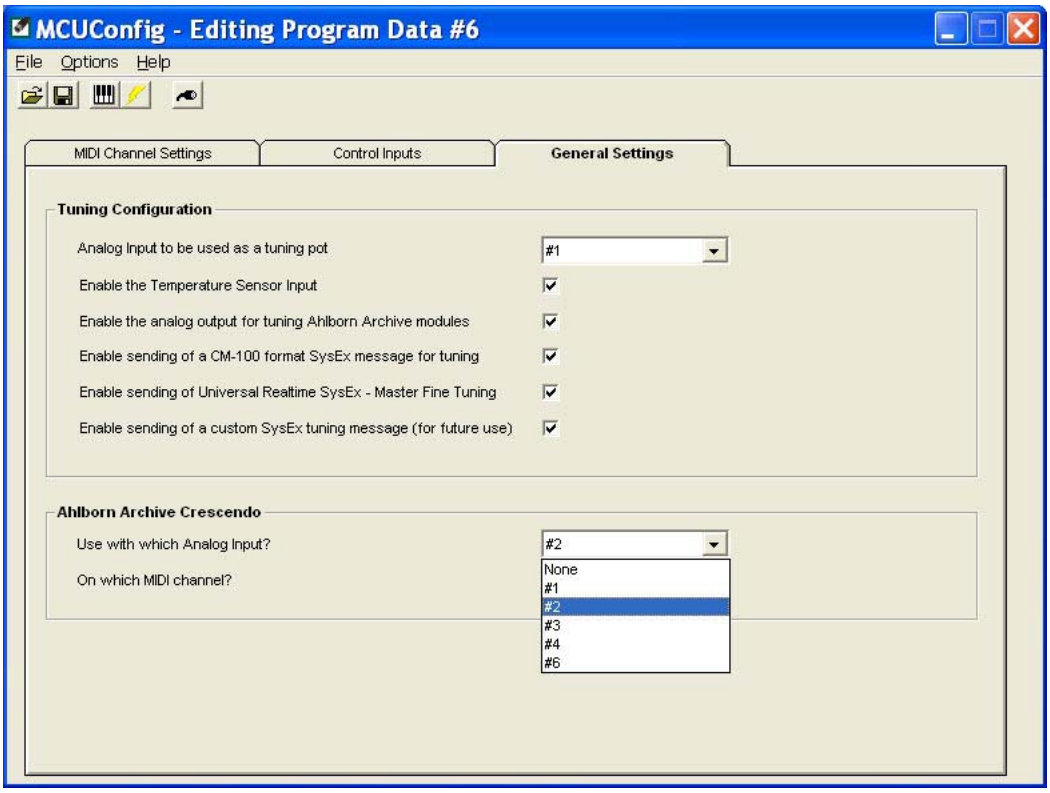


Figure 11: MCUConfig software with Fine Tuning Config tab selected.

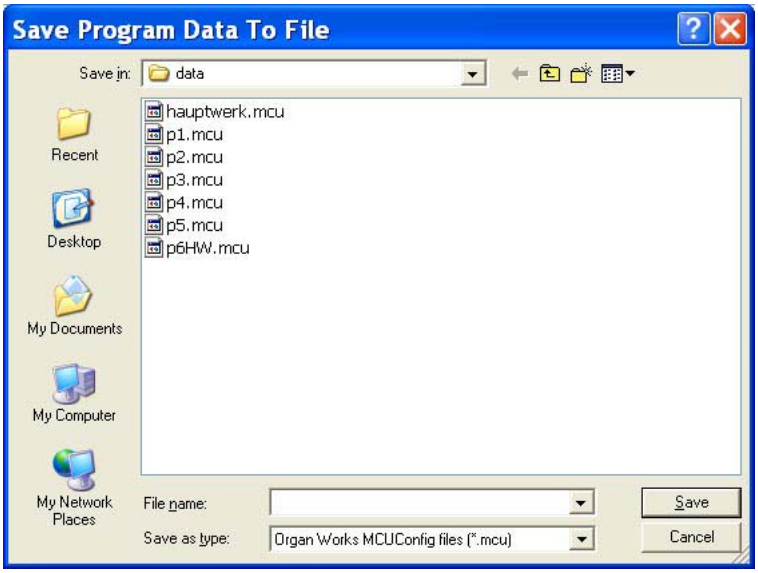
- **Ahlborn Archive Crescendo** – A drop-down menu (the same as for tuning) allows the choice of analog input for a Crescendo shoe while another menu allows for choosing the MIDI channel on which to send the Crescendo messages to the Archive unit.

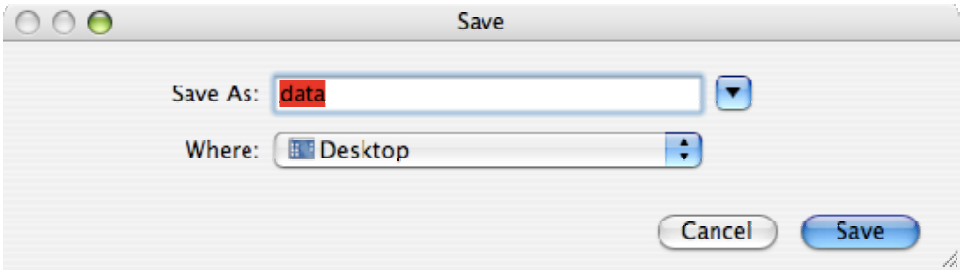
Saving Configurations

1. Saving to the computer

When you are satisfied with the settings, you may save the configuration back to the MCU under the same file number or as another one of similar format ('p#'). Alternatively, you can save it to the computer under any name you like. There is no need to include .mcu in the name. The MacIntosh may give the file the name 'data' but you can easily change it.

Keyboard shortcut: **Ctrl+W.** Windows Icon: 

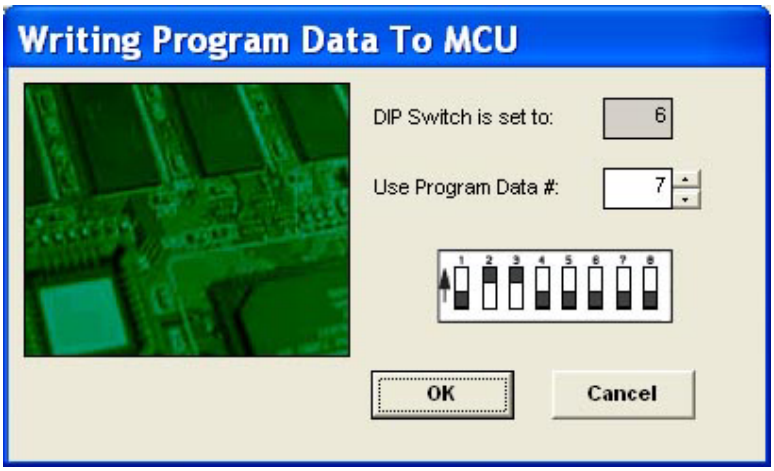


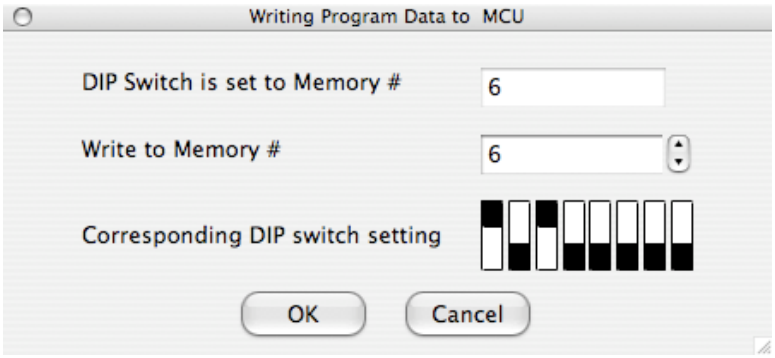


2. Saving to the MCU

Saving to the MCU calls up the list of configurations and presents the window showing DIP-Switch settings. You can save the file as is to where it came from (over-writing the original) or change the settings in the lower drop-down menu. You do not need to type any filename as it will save to a number that automatically becomes a 'p#'.

Keyboard shortcut: **Ctrl+S.** Windows Icon:





MIDI CONTROL UNIT MCU-1

7. GM9773 INFORMATION

Introduction

The GM9773 is a General MIDI Sound Generator board (sold separately) with a single chip on a 2”x2” printed-circuit board. It is a plug-in replacement for EMU and other standard GM MIDI sound modules. It has stereo audio outputs, 38-note polyphony, reverb and chorus [10]. It contains a typical 16-channel GM MIDI sound set with 38-voice polyphony (and two variations), including five variations of percussions on Channel 10.

Usage

The GM9773 board requires power from any DC supply providing +5V and +12V at a minimum current of 100mA. If the GM9773 board is purchased with the MCU, it should already be installed. However, if the board was purchased separately and requires installation, ensure that power is removed from whatever unit the board will be plugged into. Extreme caution must be exercised when plugging the connector because of the polarity (Pin-1 is the corner of the board). When plugged in, the card should power on.

Dimensions

Width	2.0 inches, 5.08 cm
Height	2.0 inches, 5.08 cm
Depth	0.55 inches, 1.4 cm (including connector)

Audio

Output Level	Full-scale 2Vpp ±200mV
Harmonic Distortion	–68 dB, 0.04%, for 0dB signal
Channel Separation	80 dB
Output Impedance	100 Ohms

Pin Functions

2x13-pin socket for standard 0.1" grid headers with 0.025" square posts.

Table 16: Pin functions **of the GM9773**

Pin	Function	Pin	Function
1	Audio Ground	2	RESET
3	Audio Ground	4	AUDIO LEFT OUT
5	Audio Ground	6	NC
7	Audio Ground	8	AUDIO RIGHT OUT
9	Audio Ground	10	+12V IN
11	Audio Ground	12	NC
13	NC	14	+Vcc IN (+5V)
15	0V Power Ground	16	NC
17	0V Power Ground	18	+Vcc IN (+5V)
19	0V Power Ground	20	NC
21	0V Power Ground	22	+Vcc IN (+5V)
23	0V Power Ground	24	MIDI IN
25	0V Power Ground	26	NC

Note: Pin-1 is at the corner of the board. NC denotes No Connection.

MIDI Features

The following MIDI parameters are presently supported:

Note On, Velocity, Pitch Bend, Program Change, Channel Aftertouch, MIDI Reset, Patch, Voice Variation (Bank) [Main or MT-32 Sound Variation #127], Drumset Variation [Standard, Power, Brush, Orchestra or CM-64/32 (Partial)], Volume, Pan, Expression, Sustain, Sostenuto, Soft Pedal, Tuning, Portamento, Pitch Bend, Reverberation, Chorus, Vibrato.

It should be noted that some of these parameters are not implemented in Classic applications although this unit supports them.

Table 17: GM9773 Detailed MIDI Implementation Chart [11]

MIDI Message	Hex Code	Description	Compatibility
NOTE ON	9nh kk vv	MIDI channel n(0 - 15) note ON #kk(1-127), velocity vv(1-127). vv = 0 means NOTE OFF	MIDI
NOTE OFF	8nh kk vv	MIDI channel n(0 – 15) note OFF #kk(1 - 127), vv is don't care.	MIDI
PITCH BEND	Enh bl bh	Pitch bend as specified by bh|bl (14 bits). Maximum swing is ±1 tone (power-up). Can be changed using "pitch bend sensitivity". Center position is 00h 40h.	GM
PROGRAM CHANGE	Cnh pp	Program (patch) change. Specific action on channel 10 (n = 9): select drumset. Refer to sounds /drumset list. Drumsets can be assigned to other channels (see SYSEX MIDI channel-to-part assign and part-to-rhythm allocation)	GM/GS
CHANNEL AFTERTOUCH	Dnh vv	vv pressure value. Effect set using Sys. Ex. 40h 2nh 20h-26hh	MIDI
MIDI RESET	FFh	Reset to power-up condition	
CTRL 00	Bnh 00h cc	Bank select: Refer to sounds list. No action on drumset.	GS
CTRL 01	Bnh 01h cc	Modulation wheel. Rate and maximum depth can be set using SYSEX.	MIDI
CTRL 05	Bnh 05h cc	Portamento time.	MIDI
CTRL 06	Bnh 06h cc	Data entry: provides data to RPN and NRPN	MIDI
CTRL 07	Bnh 07h cc	Volume (default = 100)	MIDI
CTRL 10	Bnh 0Ah cc	Pan (default = 64 center)	MIDI
CTRL 11	Bnh 0Bh cc	Expression (default = 127)	MIDI/GM
CTRL 64	Bnh 40h cc	Sustain (damper) pedal	MIDI
CTRL 65	Bnh 41h cc	Portamento on/off	MIDI
CTRL 66	Bnh 42h cc	Sostenuto pedal	MIDI
CTRL 67	Bnh 43h cc	Soft pedal	MIDI
CTRL 80	Bnh 50h vv	Reverb program vv = 00h to 07h (default 04h) 00h: Room1 01h: Room2 02h: Room3 03h: Hall1 04h: Hall2 05h: Plate 06h: Delay 07h: Pan delay	DREAM
CTRL 81	Bnh 51h vv	Chorus program vv = 00h to 07h (default 02h) 00h: Chorus1 01h: Chorus2 02h: Chorus3 03h: Chorus4 04h: Feedback 05h: Flanger 06h: Short Delay 07h: FB Delay	DREAM
CTRL 91	Bnh 5Bh vv	Reverb send level vv = 00h to 7Fh	GS

GM9773 Detailed MIDI Implementation Chart, Cont'd.

MIDI Message	Hex Code	Description	Compatibility
CTRL 93	Bnh 5Dh vv	Chorus send level vv = 00h to 7Fh	GS
CTRL 120	Bnh 78h 00h	All sound off (abrupt stop of sound on channel n)	MIDI
CTRL 121	Bnh 79h 00h	Reset all controllers	MIDI
CTRL 123	Bnh 7Bh 00h	All notes off	MIDI
CTRL 126	Bnh 7Eh 00h	Mono on	MIDI
CTRL 127	Bnh 7Fh 00h	Poly on (default power-up)	MIDI
CTRL CC1	Bnh cch vvh	Assignable Controller 1. cc = Controller number (0 - 5Fh), vv = Control value (0 - 7Fh). Control number (cch) can be set on CC1 CONTROLLER NUMBER (Sys. Ex 40 1x 1F). The resulting effect is determined by CC1 controller function (Sys.Ex. 40 2x 40-4A).	GS
CTRL CC2	Bnh cch vvh	Assignable Controller 2. cc = Controller number (00h - 5Fh), vv = control value (0 - 7Fh). Control number can be set on CC2 CONTROLLER NUMBER (Sys.Ex. 40 1x 20). The resulting effect is determined by CC2 controller function (Sys.Ex.40 2x 50-5A).	GS
RPN 0000h	Bnh 65h 00h 64h 00h 06h vv	Pitch bend sensitivity in semitones (default = 2)	MIDI/GM
RPN 0001h	Bnh 65h 00h 64h 01h 06h vv	Fine tuning in cents (vv = 00 -100, vv = 40h 0, vv = 7Fh +100)	MIDI
RPN 0002h	Bnh 65h 00h 64h 02h 06h vv	Coarse tuning in half-tones (vv = 00 -64, vv = 40h 0, vv =7Fh +64)	MIDI
NRPN 0108h	Bnh 63h 01h 62h 08h 06h vv	Vibrate rate modify (vv = 40h -> no modif)	GS
NRPN 0109h	Bnh 63h 01h 62h 09h 06h vv	Vibrate depth modify (vv = 40h -> no modif)	GS
NRPN 010Ah	BnN 63h 01h 62h 0Ah 06h vv	Vibrate delay modify (vv = 40h -> no modif)	GS
NRPN 0120h	Bnh 63h 01h 62h 20h 06h vv	TVF cutoff freq modify(vv = 40h -> no modif)	GS
NRPN 0121h	Bnh 63h 01h 62h 21h 06h vv	TVF resonance modify (vv = 40h -> no modif)	GS
NRPN 0163h	Bnh 63h 01h 62h 63h 06h vv	Env. attack time modify (vv = 40h ->no modif)	GS
NRPN 0164h	Bnh 63h 01h 62h 64h 06h vv	Env. decay time modify (vv = 40h -> no modif)	GS
NRPN 0166h	Bnh 63h 01h 62h 66h 06h vv	Env. release time modif (vv = 40h ->no modif)	GS
NRPN 18rrh	Bnh 63h 18h 62h rr 06h Vv	Pitch coarse of drum instr. note rr in semitones (vv = 40h -> no modif)	GS
NRPN 1Arrh	Bnh 63h 1Ah 62h rr 06h Vv	Level of drum instrument note rr (vv = 00 to 7Fh)	GS
NRPN 1Crrh	Bnh 63h 1Ch 62h rr 06h Vv	Pan of drum instrument note rr (40h = middle)	GS
NRPN 1Drrh	Bnh 63h 1Dh 62h rr 06h Vv	Reverb send level of drum instrument note rr (vv = 00 to 7Fh)	GS

GM9773 Detailed MIDI Implementation Chart, Cont'd.

MIDI Message	Hex Code	Description	Compatibility
NRPN 1Errh	Bnh 63h 1Eh 62h rr 06h Vv	Chorus send level of drum instrument note rr (vv = 00 to 7Fh)	GS
NRPN 37xxh	Bnh 63h 37h 62h xx 06h vv	Special Synthesis features controls (see Section 2.3)	DREAM
NRPN 38xxhh	Bnh 63h 38h 62h xx 06h vv	3DMIDI control (see Section 2.3)	DREAM
Standard SysEx	F0h 7Eh 7Fh 09h 01h F7h	General MIDI reset	GM
Standard SysEx	F0h 7Fh 7Fh 04h 01h 00h ll F7h	Master volume (ll = 0 to 127, default 127)	GM
SYSEX	F0h 41h 00h 42h 12h 40h 00h 00h dd dd dd dd xx F7h	Master tune (default dd = 00h 04h 00h 00h) -100.0 to +100.0 Cents. Nibblized data should be used (always four bytes). For example, to tune to +100.0 cents, sent data should be 00h 07h 0Eh 08h	GS
SYSEX	F0h 41h 00h 42h 12h 40h 00h 04h vv xx F7h	Master volume (default vv = 7Fh)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 00h 05h vv xx F7h	Master key-shift (default vv = 40h, no transpose)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 00h 06h vv xx F7h	Master pan (default vv = 40h, center)	
SYSEX	F0h 41h 00h 42h 12h 40h 00h 7Fh 00h xx F7h	GS reset	GS
SYSEX	F0h 41h 00h 42h 12h 40 01h 10h vv1 vv2 vv3 vv4 vv5 vv6 vv7 vv8 vv9 vv10 vv11 vv12 vv13 vv14 vv15 vv16 xx F7h	Voice reserve : vv1 = Part 10 (Default vv = 2) vv2 to vv10 = Part 1 to 9 (Default vv = 2) vv11 to vv16 = Part 11 to 16 (Default vv = 0)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 30h vv xx F7h	Reverb type (vv = 0 to 7), default = 04h 00h: Room1 01h: Room2 02h: Room3 03h: Hall1 04h: Hall2 05h: Plate 06h: Delay 07h: Pan delay	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 31h vv xx F7h	Reverb character, default 04h	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 33h vv xx F7h	Reverb master level, default = 64	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 34h vv xx F7h	Reverb time	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 35h vv xx F7h	Reverb delay feedback. Only if reverb number = 6 or 7 (delays).	GS

GM9773 Detailed MIDI Implementation Chart, Cont'd.

MIDI Message	Hex Code	Description	Compatibility
SYSEX	F0h 41h 00h 42h 12h 40h 01h 38h vv xx F7h	Chorus type (vv = 0 to 7), default = 02h 00h: Chorus1 01h: Chorus2 02h: Chorus3 03h: Chorus4 04h: Feedback 05h: Flanger 06h: Short delay 07h: FB delay	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 3Ah vv xx F7h	Chorus master level, default = 64	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 3Bh vv xx F7h	Chorus feedback	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 3Ch vv xx F7h	Chorus delay	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 3Dh vv xx F7h	Chorus rate	GS
SYSEX	F0h 41h 00h 42h 12h 40h 01h 3Eh vv xx F7h	Chorus depth	GS
SYSEX	F0h 41h 00h 42h 12h 40h 1ph 02h nn xx F7h	MIDI channel to part assign, p is part (0 to 15), nn is MIDI channel (0 to 15, 16 = OFF). This SYSEX allows several parts to be assigned to a single MIDI channel or to mute a part. Part 0, MIDI channel 9 (DRUMS) Part 1 - 9, MIDI channel 0 - 8 (DRUMS) Part 10 - 15, MIDI channel 10 - 15 (DRUMS)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 1ph 15h vv xx F7h	Part-to-rhythm allocation, p is part (0 to 15), vv is 00 (sound part) or 01 (rhythm part). This SYSEX allows a part to play sound or drumset. There is no limitation of the number of parts playing drumset. Default assignment: part 0 plays drums (default MIDI channel 9), all other parts play sound.	GS
SYSEX	F0h 41h 00h 42h 12h 40h 1nh 40h v1 v2 ... v12 xx F7h	Scale tuning, n is MIDI channel (0 to 15), v1 to v12 are 12 semi-tones tuning values (C, C#, D, ... A#, B), in the range -64 (00h) 0 (40h) +63(7Fh) cents. This SYSEX allows non chromatic tuning of the musical scale on a given MIDI channel. Default v1, v2, ... ,v12 = 40h, 40h,...,40h (chromatic tuning). Scale tuning has no effect if the part is assigned to a rhythm channel or if the sound played is not of chromatic type.	GS
SYSEX	F0h 41h 00h 42h 12h 40h 1nh 1Ah vv xx F7h	Velocity slope from 00h to 7Fh (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 1nh 1Bh vv xx F7h	Velocity offset from 00h to 7Fh (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 1nh 1Fh vv xx F7h	CC1 Controller number (00-5Fh) (default = 10h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 1nh 20h vv xx F7h	CC2 Controller number (00-5Fh) (default = 11h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 00h vv xx F7h	Mod pitch control (-24, +24 semitone) (default = 40h)	GS

GM9773 Detailed MIDI Implementation Chart, Cont'd.

MIDI Message	Hex Code	Description	Compatibility
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 01h vv xx F7h	Mod tvf cutoff control (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 02h vv xx F7h	Mod Amplitude control (-100% ± 100%) (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 03h vv xx F7h	Mod lfo1 rate control (default = 40h). n is don't care. Rate is common on all channels.	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 04h vv xx F7h	Mod lfo1 pitch depth (0 - 600 cents) (default = 0Ah)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 05h vv xx F7h	Mod lfo1 tvf depth (default = 0h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 06h vv xx F7h	Mod lfo1 tva depth (0 - 100%) (default = 0h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 10h vv xx F7h	Bend pitch control (-24, +24 semitone) (default = 42h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 11h vv xx F7h	Bend tvf cutoff control (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 12h vv xx F7h	Bend Amplitude control (-100% ± 100%) (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 14h vv xx F7h	Bend lfo1 pitch depth (0 - 600 cents) (default = 0Ah)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 15h vv xx F7h	Bend lfo1 tvf depth (default = 0h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 16h vv xx F7h	Bend lfo1 tva depth (0 – 100%) (default = 0h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 20h vv xx F7h	CAF pitch control (-24, +24 semitone) (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 21h vv xx F7h	CAF tvf cutoff control (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 22h vv xx F7h	CAF Amplitude control (-100% ± 100%) (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 24h vv xx F7h	CAF lfo1 pitch depth (0 - 600 cents) (default = 0Ah)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 25h vv xx F7h	CAF lfo1 tvf depth (default = 0h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 26h vv xx F7h	CAF lfo1 tva depth (0 - 100%) (default = 0h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 40h vv xx F7h	CC1 pitch control (-24, +24 semitone) (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 41h vv xx F7h	CC1 tvf cutoff control (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 42h vv xx F7h	CC1 Amplitude control (-100% ± 100%) (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 44h vv xx F7h	CC1 lfo1 pitch depth (0 - 600 cents) (default = 0Ah)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 45h vv xx F7h	CC1 lfo1 tvf depth (default = 0h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 46h vv xx F7h	CC1 lfo1 tva depth (0 - 100%) (default = 0h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 50h vv xx F7h	CC2 pitch control (-24, +24 semitone) (default = 40h)	GS

GM9773 Detailed MIDI Implementation Chart, Cont'd.

MIDI Message	Hex Code	Description	Compatibility
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 51h vv xx F7h	CC2 tvf cutoff control (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 52h vv xx F7h	CC2 Amplitude control (-100% ± 100%) (default = 40h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 54h vv xx F7h	CC2 lfo1 pitch depth (0 - 600 cents) (default = 0Ah)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 55h vv xx F7h	CC2 lfo1 tvf depth (default = 0h)	GS
SYSEX	F0h 41h 00h 42h 12h 40h 2nh 56h vv xx F7h	CC2 lfo1 tva depth (0 - 100%) (default = 0h)	GS

Table 18: General MIDI Presets [11]

The following are Program numbers for GS-MIDI sounds available on Channels 1–9, 11–16:
To select variation: Send CTRL 0 = 0, then Program change.

1	Acoustic Piano	2	Bright Piano	3	Electric Piano	4	Honky tonk piano
5	Rhodes piano	6	Chorus piano	7	Harpsichord	8	Clavinet
9	Celesta	10	Glockenspiel	11	Music Box	12	Vibraphone
13	Marimba	14	Xylophone	15	Tubular bells	16	Dulcimer
17	Hammond Organ	18	Percussive Organ	19	Rock Organ	20	Church Organ
21	Reed organ	22	Accordion	23	Harmonica	24	Tango Accordion
25	Nylon string guitar	26	Steel string guitar	27	Electric Guitar (jazz)	28	Electric Guitar (clean)
29	Electric Guitar (mute)	30	Overdriven Guitar	31	Distorted Guitar	32	Guitar Harmonics
33	Acoustic Bass	34	Electric bass (finger)	35	Electric bass (pick)	36	Fretless bass
37	Slap bass 1	38	Slap bass 2	39	Synth bass 1	40	Synth bass 2
41	Violin	42	Viola	43	Cello	44	Contra Bass
45	Tremolo Strings	46	Pizzicato Strings	47	Orchestral Harp	48	Tympani
49	String Ensemble 1	50	String Ensemble 2	51	Synth Strings 1	52	Synth Strings 2
53	Choir Aahs	54	Voice Ooohs	55	Synth voice	56	Orchestra Hit
57	Trumpet	58	Trombone	59	Tuba	60	Muted Trumpet
61	French Horn	62	Brass Section	63	Synthbrass 1	64	Synthbrass 2
65	Soprano Sax	66	Alto Sax	67	Tenor Sax	68	Baritone Sax
69	Oboe	70	English Horn	71	Bassoon	72	Clarinet
73	Piccolo	74	Flute	75	Recorder	76	Pan Flute
77	Blown Bottle	78	Shakuhachi	79	Whistle	80	Ocarina
81	Synth Lead 1	82	Synth Lead 2	83	Synth Lead 3	84	Synth Lead 4
85	Synth Lead 5	86	Synth Lead 6	87	Synth Lead 7	88	Synth Lead 8
89	Synth Pad 1	90	Synth Pad 2	91	Synth Pad 3	92	Synth Pad 4
93	Synth Pad 5	94	Synth Pad 6	95	Synth Pad 7	96	Synth Pad 8
97	Synth FX 1	98	Synth FX 2	99	Synth FX 3	100	Synth FX 4
101	Synth FX 5	102	Synth FX 6	103	Synth FX 7	104	Synth FX 8
105	Sitar	106	Banjo	107	Shamisen	108	Koto
109	Kalimba	110	Bag Pipe	111	Fiddle	112	Shanai
113	Tinkle Bell	114	Agogo Bells	115	Steel Drum	116	Woodblock
117	Taiko Drum	118	Melodic Drum	119	Synth Drum	120	Reverse Cymbal
121	Guitar Fret Noise	122	Breath Noise	123	Seashore	124	Bird Tweet
125	Telephone Ring	126	Helicopter	127	Applause	128	Gunshot

The SAM9773 chip also has the MT-32 Sound Variation #127 on all of these sounds.
Shaded areas denote groups with similar sounds.

Table 19: MT-32 Sound Variation #127 [11]

[All Channels except 10. To select variation, send CTRL 0 = 127, then Program Change.
C0= controller 0 value (zero for General MIDI capital sounds)

PC Number	Instrument Name	PC Number	Instrument Name	PC Number	Instrument Name	PC Number	Instrument Name
1	Piano 1	2	Piano 2	3	Piano 3	4	Detuned EP 1
5	E.Piano 1	6	E.Piano 2	7	Detuned EP 2	8	Honky-Tonk
9	Organ 1	10	Organ 2	11	Organ 3	12	Detuned Or. 1
13	Church Org. 2	14	Church Org.	15	Church Org.	16	Accordion Fr.
17	Harpsichord	18	Coupled Hps.	19	Coupled Hps.	20	Clav.
21	Clav.	22	Clav.	23	Celesta	24	Celesta
25	Synth Brass 1	26	Synth Brass 2	27	Synth Brass 3	28	Synth Brass 4
29	Synth Bass1	30	Synth Bass 2	31	Synth Bass 3	32	Synth Bass 4
33	Fantasia	34	Syn Calliope	35	Choir Aahs	36	Bowed Glass
37	Soundtrack	38	Atmosphere	39	Crystal	40	Bagpipe
41	Tinkle Bell	42	Ice Rain	43	Oboe	44	Pan Flute
45	Saw Wave	46	Charang	47	Tubular Bells	48	Square Wave
49	Strings	50	Tremolo Str.	51	Slow Strings	52	Pizzicato Str.
53	Violin	54	Viola	55	Cello	56	Cello
57	Contrabass	58	Harp	59	Harp	60	Nylon-str. Gt
61	Steel-Str. Gt	62	Chorus Gt.	63	Funk Gt.	64	Sitar
65	Acoustic Bs.	66	Fingered Bs.	67	Picked Bs.	68	Fretless Bs.
69	Slap Bs. 1	70	Slap Bs. 2	71	Fretless Bs.	72	Fretless Bs.
73	Flute	74	Flute	75	Piccolo	76	Piccolo
77	Recorder	78	Pan Flute	79	Soprano Sax	80	Alto Sax
81	Tenor Sax	82	Baritone Sax	83	Clarinet	84	Clarinet
85	Oboe	86	English Horn	87	Bassoon	88	Harmonica
89	Trumped	90	Muted Trumpet	91	Trombone	92	Trombone
93	French Horn	94	French Horn	95	Tuba	96	Brass
97	Brass 2	98	Vibraphone	99	Vibraphone	100	Kalimba
101	Tinkle Bell	102	Glockenspiel	103	Tubular Bell	104	Xylophone
105	Marimba	106	Koto	107	Taisho Koto	108	Shakuhachi
109	Whistle	110	Whistle	111	Bottle Blow	112	Pan Flute
113	Timpani	114	Melo Tom	115	Concert BD	116	Synth Drum
117	Melo Tom	118	Taiko	119	Taiko	120	Reverse Cym.
121	Castanets	122	Tinkle Bell	123	Orchestra Hit	124	Telephone
125	Bird	126	Helicopter	127	Bowed Glass	128	Ice Rain

Shaded areas denote groups with similar sounds. Note that the individual sounds differ somewhat from the standard GM-MIDI sounds.

Drumset Variations (MIDI Channel 10), Cont'd.

* = No sound
Blank = Same sound as "Standard Set"
[EXC] = Sounds with same EXC number are mutually exclusive

	Prog 1: Standard Set	Prog 17: Power set	Prog 41: Brush	Prog 49: Orchestra	Prog 127: CM-64/32 (Partial)
27 - D#1				Closed Hi-Hat	*
28 - E1				Pedal Hi-Hat	*
29 - F1				Open Hi Hat	*
30 - F#1				Ride Cymbal	*
31 - G1					*
32 - G#1					*
33 - A1					*
34 - A#1					*
35 - B1	Kick drum2		Jazz BD 2		Kick drum
36 - C2	Kick drum1		Jazz BD 1		Kick drum
37 - C#2	Side Stick				Rim Shot
38 - D2	Snare Drum 1	Gated Snare	Brush Tap	Snare Drum 2	Snare Drum
39 - D#2	Hand Clap		Brush Slap	Castanets	Hand Clap
40 - E2	Snare Drum 2		Brush Swirl	Snare Drum 2	Elec Snare Drum
41 - F2	Low Floor Tom			Timpani F	Acoustic Low Tom
42 - F#2	Closed Hi-Hat [EXC1]			Timpani F#	Closed Hi-Hat [EXC1]
43 - G2	High Floor Tom			Timpani G	Acoustic Low Tom
44 - G#2	Pedal Hi-Hat [EXC1]			Timpani G#	Open Hi-Hat 2
45 - A2	Low Tom			Timpani A	Acoustic Middle Tom
46 - A#2	Open Hi-Hat [EXC1]			Timpani A#	Open Hi-Hat 1 [EXC1]
47 - B2	Low-Mid Tom			Timpani B	Acoustic Middle Tom
48 - C3	Hi Mid Tom			Timpani C	Acoustic High Tom
49 - C#3	Crash Cymbal 1			Timpani C#	Crash Cymbal
50 - D3	High Tom			Timpani D	Acoustic High Tom
51 - D#3	Ride Cymbal 1			Timpani D#	Ride Cymbal
52 - E3	Chinese Cymbal			Timpani E	*
53 - F3	Ride Bell			Timpani F	*
54 - F#3	Tambourine				Tambourine
55 - G3	Splash Cymbal				*
56 - G#3	3 Cowbell				Cowbell
57 - A3	Crash Cymbal 2				*
58 - A#3	Vibraslap				*
59 - B3	Ride Cymbal 2				*
60 - C4	Hi Bongo				
61 - C#4	Low Bongo				
62 - D4	Mute Hi Conga				
63 - D#4	Open Hi Conga				
64 - E4	Low Conga				
65 - F4	High Timbale				

Drumset Variations (MIDI Channel 10), Cont'd.

* = No sound
Blank = Same sound as "Standard Set"
[EXC] = Sounds with same EXC number are mutually exclusive

	Prog 1: Standard Set	Prog 17: Power set	Prog 41: Brush	Prog 49: Orchestra	Prog 127: CM-64/32 (Partial)
66 - F#4	Low Timbale				
67 - G4	High Agogo				
68 - G#4	Low Agogo				
69 - A4	Cabasa				
70 - A#4	Maracas				
71 - B4	Short Whistle [EXC2]				
72 - C5	Long Whistle [EXC2]				
73 - C#5	Short Guiro [EXC3]				Vibra Slap
74 - D5	Long Guiro [EXC3]				*
75 - D#5	Claves				Claves
76 - E5	Hi Wood Block				*
77 - F5	Low Wood Block				*
78 - F#5	Mute Cuica [EXC4]				*
79 - G5	Open Cuica [EXC4]				*
80 - G#5	Mute Triangle [EXC5]				*
81 - A5	Open Triangle [EXC5]				*
82 - A#5					Applause
83 - B5					*
84 - C6					*
85 - C#6					*
86 - D6					*
87 - D#6					*
88 - E6				Applause	*
89 - F6					*
90 - F#6					*
91 - G6					*
92 - G#6					*
93 - A6					*
94 - A#6					Helicopter
95 - B6					*
96 - C7					Gunshot
97 - C#7					*
98 - D7					*
99 - D#7					*
100 - E7					*
101 - F7					*
102 - F#7					Birds
103 - G7					*
104 - g#7					*
105 - A7					*
106 - A#7					Seashore

Note: TO access MIDI #27-35 (which are below the bottom key on the keyboard), transpose down. To access MIDI #97-106 (which are above the top key on the keyboard), transpose up.

Special MIDI Controls

Various features of the SAM9773 are controlled by NRPN MIDI messages.

Table 20: NRPN MIDI Messages [11]

NRPN (High/Low)	Description	Power-up Default
3700h	Equalizer low band (bass) 0 = -12 dB, 40h = 0 dB, 7Fh = +12 dB	60h
3701h	Equalizer med Llw band 0 = -12 dB, 40h = 0 dB, 7Fh = +12 dB	40h
3702h	Equalizer med high band 0 = -12 dB, 40h = 0 dB, 7Fh = +12 dB	40h
3703h	Equalizer high band (treble) 0 = -12 dB, 40h = 0 dB, 7Fh = +12 dB	60h
3707h	Master volume 0 to 7Fh	7Fh
3708h	Equalizer low cutoff freq 0 = 0 Hz, 7Fh = 4.7 kHz	0Ch
3709h	Equalizer med low cutoff freq 0 = 0 Hz, 7Fh = 4.2 kHz	1Bh
370Ah	Equalizer med high cutoff freq 0 = 0 Hz, 7Fh = 4.2 kHz	72h
370Bh	Equalizer high cutoff freq 0 = 0 Hz, 7Fh = 18.75 kHz	40h
3713h	Clipping mode select 0 = soft clip, 7Fh = hard clip	00h
3715h	General MIDI reverb send 0 = no send, 40h = default send, 7Fh = max	40h
3716h	General MIDI chorus send 0 = no send, 40h = default send, 7Fh = max	40h
3718h	Post-effects applied on GM 0 = Post-effects not applied, 7Fh = Post-effects applied	7Fh
371Ah	Post-effects applied on reverb/chorus 0 = Post-effects not applied, 7Fh = Post-effects applied	7Fh
3720h	Spatial effects volume 0 = no effect, 7Fh = maximum effect	00h
3722h	General MIDI volume 0 to 7Fh	7Fh
3723h	General MIDI pan 0 = left, 40h = center, 7Fh = right	40h
372Ch	Spatial effects delay 0 = shortest to 7Fh = longest	1Dh
372Dh	Spatial effects input 0 = stereo, 7Fh = mono	00h
372Eh	Spatial effects output mode 0 = 2-speaker mode, 7Fh = 4-speaker mode	00h
3751h	Auto-test. See Auto-Test Section.	
3755h	Effects on/off. See Section on Configuration NRPN 3755h: Output Mode Select	
3757h	System Exclusive Device ID 0 to 1Fh, 20h = all accepted	20h
380xh	3DMIDI control, x = MIDI channel 0 = output channel to front speakers, 7Fh = output channel to rear speakers	00h
3810h	3DMIDI global control 0 = output all channels to front speakers, 7Fh = output all channels to rear speakers	00h
3820h	3DMIDI reverb volume front speakers 0 to 7Fh	7Fh
3821h	3DMIDI reverb volume rear speakers 0 to 7Fh	00h
3830h	3DMIDI chorus volume front 0 to 7Fh speakers	7Fh
3831h	3DMIDI chorus volume rear speakers 0 to 7Fh	00h

Circuit Description

Processor

The heart of this board is an Atmel®[1] integrated circuit type SAM9773 that is a single-chip Synthesizer with Effects and a Serial Interface. This chip contains a synthesizer, Reverb and Chorus with all the ROM and RAM included and requires only an external Digital-to-Analog converter and power.

Built into the chip are a MIDI Control Processor, GM MIDI wave tables, spatial sound effects and stereo equalizers. The chip can generate four audio channels for surround sound but is not used that way in the MCU.

The SAM9773 has 38-voice polyphony and outputs with 16-to-20 bit resolution (Set to 16 in this board). The sound set contains the basic 16-channel GM MIDI set as well as some other variations that are accessible by control codes in the MIDI signal.

The chip is a surface-mounted type in an 80-lead TQFP package. A crystal of 9.6 MHz is used for the clock oscillator while a filter compensation network stabilizes the phase-locked loop feedback.

A TTL-level serial MIDI signal is applied at pin-24 of the Input connector to operate the chip. The codes in this signal affect all controls. The Reset pin is wired out to the Input Socket so that external devices can perform a Reset function if required.

Power Supplies

There are two separate power inputs. Pin-10 of the header has +12V which is used to power the audio stages after regulation to +5V by IC3. Pins 14, 18 and 22 have +5V (Vcc) from the digital MIDI source and this is used as the supply for part of the processor, IC1. The core of the processor requires +2.7 Volts that is generated from Vcc by Regulator IC5. Separate ground planes are used for power and audio systems and are linked together by R11 (0 Ohms).

Digital-to-Analog Converter

A type TDA1311A digital-to-analog converter changes serial digital 16-bit data to stereo audio. This device contains its own reference supplies and is powered by a single +5 Volt supply. It requires only three input signals to operate — Data, Bit Clock and Word Select (Left or Right) — which come directly from the SAM9773 chip.

Output Amplifiers

A dual FET-input operational amplifier, IC4, has unity gain at D.C. and audio frequencies but zero gain for frequencies above the audio band. The two amplifiers also provide buffered low-impedance line-level outputs. R5 and R9 isolate line capacitance while C8 with R4 (and C11 with R8) provide high-pass filtering to attenuate any hum as well as blocking D.C. The audio system has its own 5-volt regulator to ensure clean audio signals.

Low-Pass Filters

Each audio output is filtered by a second-order, low-pass, active filter employing a FET-input operational amplifier, to remove clock-rate transients and other high-frequency noise to give clean audio. Two such amplifiers are contained in IC4, a TL062 dual package.

[1] Atmel® is a registered Trademark of Atmel Corporation.

Additional Information

DAC Configuration

Table 21: DAC Configuration [11]

DACSEL	Configuration
GND	IIS-format DAC (16 to 22 bits)
VCC	Sony-format DAC, 16 bits

In this board, this is set to Sony Format, 16 Bits.

Configuration NRPN 3755h: Output Mode Select

MIDI message code (in hexadecimal): B0h 63h 37h, B0h 62h 55h, B0h 06h vv

Table 22: Configuration NRPN 3755h (11)

7	6	5	4	3	2	1	0
0	0	0	0	1	OM	0	0

OM: If 0 (default power-on value), spatial effects will be ON.

Spatial effect parameters can be controlled using NRPN 3720h (volume), 372Ch (delay time), 372Dh (stereo/mono) and 372Eh (2/4 speaker mode). See Section on Special MIDI Controls.

OM: If 1, 3DMIDI™ mode, four-speaker MIDI output.

Each MIDI channel can be output to front or rear speakers using NRPN 3800h to 380Fh, reverb and chorus can also be routed.

- NRPN 38xxh = 0h: MIDI channel xxh is front speaker output
- NRPN 38xxh = 7Fh: MIDI channel xxh is rear speaker output
- NRPN 3810h assign all MIDI channels to front or rear speakers:
  - NRPN 3810h = 0h: all MIDI channels are front speaker output
  - NRPN 3810h = 07Fh: all MIDI channels are rear speaker output
- NRPN 3820h and 3821h control reverb output volume :
  - NRPN 3820h = 0h to 7Fh: reverb front speaker volume (Default value = 07Fh)
  - NRPN 3821h = 0h to 7Fh: reverb rear speaker volume (Default value = 0h)
- NRPN 3830h and 3831h control chorus output volume :
  - NRPN 3830h = 0h to 7Fh: chorus front speakers volume (Default value = 07Fh)
  - NRPN 3831h = 0h to 7Fh: chorus rear speakers volume (Default value = 0h)

Note: The GM9773 board has only two outputs for stereo.

Auto-test

A built-in auto-test program is included and can be used for board production testing.
To start auto-test, send NRPN 3751h = 23h.

Sine waveforms at different frequencies will be output to the DAC to indicate the test in progress.
Refer to Table below.

If 'PASS' frequency is detected, the part is functional.

Table 23: Auto-test results [11]

Test in Progress	Output Frequency
On-chip RAM	1.18 kHz
On-chip ROM	876 Hz
PASS	295 Hz

Instruments Requiring Two Voices

Table 24: Two-layer Instruments [11]

PC	Name	PC	Name
4	Honky-tonk Piano	88	Lead8 (bass + lead)
19	Rock Organ	89	Pad 1 (new age)
22	Accordion (French)	91	Pad 3 (polysynth)
24	Tango Accordion	93	Pad 5 (bowed)
40	Synth Bass 2	94	Pad 6 (metallic)
52	Synth Strings 2	95	Pad 7 (halo)
56	Orchestra Hit	97	FX 1 (rain)
61	French Horn	98	FX 2 (soundtrack)
63	Synth Brass 1	99	FX 3 (crystal)
64	Synth Brass 2	100	FX4 (atmosphere)
81	Lead 1 (square wave)	101	FX 5 (brightness)
82	Lead 2 (saw wave)	102	FX 6 (goblins)
83	Lead 3 (calliope)	104	FX 8 (sci-fi)
84	Lead 4 (chiff)	123	Seashore
85	Lead 5 (charang)	124	Bird
86	Lead 6 (voice)	127	Applause
87	Lead 7 (fifths)		

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9. APPENDIX A: DIP-Switch Configuration

Table 25: DIP Switch settings and their corresponding Configuration numbers

Configuration Number	Switch 1	Switch 2	Switch 3	Switch 4	Switch 5	Switch 6	Switch 7	Switch 8
1 (default)	0	0	0	0	0	0	0	0
2	1	0	0	0	0	0	0	0
3	0	1	0	0	0	0	0	0
4	1	1	0	0	0	0	0	0
5	0	0	1	0	0	0	0	0
6	1	0	1	0	0	0	0	0
7	0	1	1	0	0	0	0	0
8	1	1	1	0	0	0	0	0
9	0	0	0	1	0	0	0	0
10	1	0	0	1	0	0	0	0
11	0	1	0	1	0	0	0	0
12	1	1	0	1	0	0	0	0
13	0	0	1	1	0	0	0	0
14	1	0	1	1	0	0	0	0
15	0	1	1	1	0	0	0	0
16	1	1	1	1	0	0	0	0
17	0	0	0	0	1	0	0	0
18	1	0	0	0	1	0	0	0
19	0	1	0	0	1	0	0	0
20	1	1	0	0	1	0	0	0
21	0	0	1	0	1	0	0	0
22	1	0	1	0	1	0	0	0
23	0	1	1	0	1	0	0	0
24	1	1	1	0	1	0	0	0
25	0	0	0	1	1	0	0	0
26	1	0	0	1	1	0	0	0
27	0	1	0	1	1	0	0	0
28	1	1	0	1	1	0	0	0
29	0	0	1	1	1	0	0	0
30	1	0	1	1	1	0	0	0
31	0	1	1	1	1	0	0	0
32	1	1	1	1	1	0	0	0
33	0	0	0	0	0	1	0	0
34	1	0	0	0	0	1	0	0
35	0	1	0	0	0	1	0	0
36	1	1	0	0	0	1	0	0

* DIP-Switch settings: Off = 0, On = 1
* If DIP-Switch 8 is set to ‘1’, the default configuration is selected.

DIP Switch settings and their corresponding Configuration numbers, Cont'd.

Configuration Number	Switch 1	Switch 2	Switch 3	Switch 4	Switch 5	Switch 6	Switch 7	Switch 8
37	0	0	1	0	0	1	0	0
38	1	0	1	0	0	1	0	0
39	0	1	1	0	0	1	0	0
40	1	1	1	0	0	1	0	0
41	0	0	0	1	0	1	0	0
42	1	0	0	1	0	1	0	0
43	0	1	0	1	0	1	0	0
44	1	1	0	1	0	1	0	0
45	0	0	1	1	0	1	0	0
46	1	0	1	1	0	1	0	0
47	0	1	1	1	0	1	0	0
48	1	1	1	1	0	1	0	0
49	0	0	0	0	1	1	0	0
50	1	0	0	0	1	1	0	0
51	0	1	0	0	1	1	0	0
52	1	1	0	0	1	1	0	0
53	0	0	1	0	1	1	0	0
54	1	0	1	0	1	1	0	0
55	0	1	1	0	1	1	0	0
56	1	1	1	0	1	1	0	0
57	0	0	0	1	1	1	0	0
58	1	0	0	1	1	1	0	0
59	0	1	0	1	1	1	0	0
60	1	1	0	1	1	1	0	0
61	0	0	1	1	1	1	0	0
62	1	0	1	1	1	1	0	0
63	0	1	1	1	1	1	0	0
64	1	1	1	1	1	1	0	0
65	0	0	0	0	0	0	1	0
66	1	0	0	0	0	0	1	0
67	0	1	0	0	0	0	1	0
68	1	1	0	0	0	0	1	0
69	0	0	1	0	0	0	1	0
70	1	0	1	0	0	0	1	0
71	0	1	1	0	0	0	1	0
72	1	1	1	0	0	0	1	0
73	0	0	0	1	0	0	1	0
74	1	0	0	1	0	0	1	0
75	0	1	0	1	0	0	1	0
76	1	1	0	1	0	0	1	0
77	0	0	1	1	0	0	1	0
78	1	0	1	1	0	0	1	0
79	0	1	1	1	0	0	1	0
80	1	1	1	1	0	0	1	0
81	0	0	0	0	1	0	1	0
82	1	0	0	0	1	0	1	0
83	0	1	0	0	1	0	1	0
84	1	1	0	0	1	0	1	0
85	0	0	1	0	1	0	1	0
86	1	0	1	0	1	0	1	0

* DIP-Switch settings: Off = 0, On = 1
* If DIP-Switch 8 is set to '1', the default configuration is selected.

DIP Switch settings and their corresponding Configuration numbers, Cont'd.

Configuration Number	Switch 1	Switch 2	Switch 3	Switch 4	Switch 5	Switch 6	Switch 7	Switch 8
87	0	1	1	0	1	0	1	0
88	1	1	1	0	1	0	1	0
89	0	0	0	1	1	0	1	0
90	1	0	0	1	1	0	1	0
91	0	1	0	1	1	0	1	0
92	1	1	0	1	1	0	1	0
93	0	0	1	1	1	0	1	0
94	1	0	1	1	1	0	1	0
95	0	1	1	1	1	0	1	0
96	1	1	1	1	1	0	1	0
97	0	0	0	0	0	1	1	0
98	1	0	0	0	0	1	1	0
99	0	1	0	0	0	1	1	0
100	1	1	0	0	0	1	1	0
101	0	0	1	0	0	1	1	0
102	1	0	1	0	0	1	1	0
103	0	1	1	0	0	1	1	0
104	1	1	1	0	0	1	1	0
105	0	0	0	1	0	1	1	0
106	1	0	0	1	0	1	1	0
107	0	1	0	1	0	1	1	0
108	1	1	0	1	0	1	1	0
109	0	0	1	1	0	1	1	0
110	1	0	1	1	0	1	1	0
111	0	1	1	1	0	1	1	0
112	1	1	1	1	0	1	1	0
113	0	0	0	0	1	1	1	0
114	1	0	0	0	1	1	1	0
115	0	1	0	0	1	1	1	0
116	1	1	0	0	1	1	1	0
117	0	0	1	0	1	1	1	0
118	1	0	1	0	1	1	1	0
119	0	1	1	0	1	1	1	0
120	1	1	1	0	1	1	1	0
121	0	0	0	1	1	1	1	0
122	1	0	0	1	1	1	1	0
123	0	1	0	1	1	1	1	0
124	1	1	0	1	1	1	1	0
125	0	0	1	1	1	1	1	0
126	1	0	1	1	1	1	1	0
127	0	1	1	1	1	1	1	0
128	1	1	1	1	1	1	1	0

* DIP-Switch settings: Off = 0, On = 1
* If DIP-Switch 8 is set to '1', the default configuration is selected.

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10. APPENDIX B: Schematics

MKSC-3: MIDI KEYBOARD SCAN COMPUTER

The MKSC-3 is the control board for the MCU. At the heart of the MKSC-3 is the Microchip PIC16F877 8-Bit microcontroller. It contains 256 bytes of internal EEPROM memory for storing the default configuration. An external EEPROM chip with 256K-Bits of serial electrically erasable memory is used for storage of additional configurations including those that will be customized by the user. The specific configuration is selected by reading a DIP-switch located on the MCU top panel.

Audio outputs for RCA Phono jacks and Stereo Headphone jacks are provided. The RCA Phono jacks provide 100mV high impedance output for GM MIDI output. The stereo headphone jacks provide 1.6 Watts per channel into 4 Ohms for GM MIDI output. Due to a weak GM MIDI output signal, an integrated circuit stereo amplifier magnifies the weak signal for stereo headphone use. The MKSC-3 has one MIDI input and four MIDI outputs. The MIDI outputs transmit in parallel. MIDI outputs and inputs are transmitted via standard 5-pin DIN jacks.

There are five analog input pins available which are diode protected and use 10K resistors and a capacitor in a low-pass setting to obtain a voltage reading between 0V and +5V. The on-board processor uses sample and hold circuitry to digitize the voltage reading for functions such as expression, volume and crescendo. An additional analog input is available for tuning. By attaching a temperature sensor, an Ahlborn Archive unit may be tuned.

Board power is regulated to +5V by a regulator with a reverse-polarity protection diode on its input.

Miscellaneous Inputs:

Analog:	5 inputs at 0-5V 10 k-Ohms (0V and +5V on adjacent header pins)	For Expression and Crescendo shoes and tuning input
Digital:	1 input at TTL levels (0-5V).	(For future use)
GM MIDI:	Connections for Classic GM 9773 module, 2x13 header (ribbon type, 0.1"x0.1").	

Miscellaneous Outputs:

LED Drivers	4 at 0-5V Active-low outputs	Maximum current of 20mA (external resistors required)

In/Out I^2CBuss: (For memory expansion)

SCL	Output
SCA	Input
Reset	Output

SIB-4: Switch Input Board (Maximum 5)

The Switch Input Board converts up to 64 active-high (+12V) inputs to an 8x8-matrix system. Eight tri-state octal inverters are used to select eight groups of eight switch-data inputs onto a common octal bus as decided by the outputs of a Binary-to-Octal decoder. This has three address inputs and one Board Select input. The address lines define which one of the eight groups of input switch-data is sent to the output bus while the Board Select determines which one of the five SIB-4 boards will be sending this data. The board has pull-down inputs and high-resistance series resistors to protect against static and excessive input voltages. The power system comprises a 5-volt Zener diode as a regulator.

Switch inputs Header pins
Inputs 1-64 in eight groups of 8. Signals 0-12V. +12V = On.
Common fused +12V on row Screw-Terminal Block

MKIO-1: MIDI Keyboard Input Output top panel

The MKIO-1 is the through-pin top panel of the MCU. The panel has many purposes and is used for mounting internal boards, connecting various external inputs and outputs, and reducing electro-magnetic interference. The panel also provides all the necessary power connections for inputs and outputs of the entire unit. Power is sourced from an external adaptor or via the 'Console' Terminal Block. A bridge rectifier allows an external power adaptor of either polarity to be used. Self-resetting polyfuses are used on the inside of the top panel for protection of individual boards. The common supply from the power input is fused at 500 mA to the processor and all input boards. Each input board has an individual fuse at 250 mA from this fused supply. The Output board has its own fuse at 5 Amps from the separate Terminal block. Switch common connections can be made via pin connections or through the 2-input terminal blocks on each input pin row.

The outside of the top panel has five DIN 5-pin 180º sockets for interfacing between MIDI devices and the main controller board. A 6-pin 240° DIN socket, with pins 2 & 3 wired, transmits a voltage signal to Ahlborn Archive Units. A 3-pin 180° DIN socket connects a Dallas temperature-sensing device generating digital data for Ahlborn tuning purposes. Audio jacks for stereo headphones and RCA Phono for left and right signals connect audio equipment to the main controller board inside the top panel.

Width	12.35 inches, 31.4 cm (including mounting flanges 0.50" either side)
Depth	7.50 inches, 19.5 cm

Inputs:

MIDI In	DIN 5-pin Socket receives standard MIDI signals
Temperature Sensor	DIN 3-pin Socket
Power	Co-axial Jack, 2.1mm ID, 9-12V DC, either polarity, 400 mA minimum. Fused at 500mA
Switches	Pins, 0.025" Square, 0.3" long, 0.1" pitch. Fused at 250mA

Outputs:

MIDI 1-4	DIN 5-pin Sockets transmits standard MIDI signals
Ahlborn	DIN 6-pin Socket for Ahlborn Tuning
Line Audio Left & Right	RCA Phono Jack providing 100 mV high-impedance for GM MIDI output
Headphones	3.5mm Stereo Jack at 1.6 Watts per channel into 4 Ohms for GM MIDI output
Lamps or Magnets	Pins, 0.025" Square, 0.3" long, 0.1" pitch. Fused at 5A (future use)

GM9773: GM MIDI Module (sold separately)

The GM9773 unit consists of a single printed-circuit board with all sound processing and storage in a single chip. It is a Plug-in replacement for standard GM MIDI modules. No special ventilation is necessary however, the GM9773 unit requires +5V and +12V to operate. Stereo audio at line levels is generated. For more information on the GM MIDI Module, please see the GM9773 Information section of this manual.

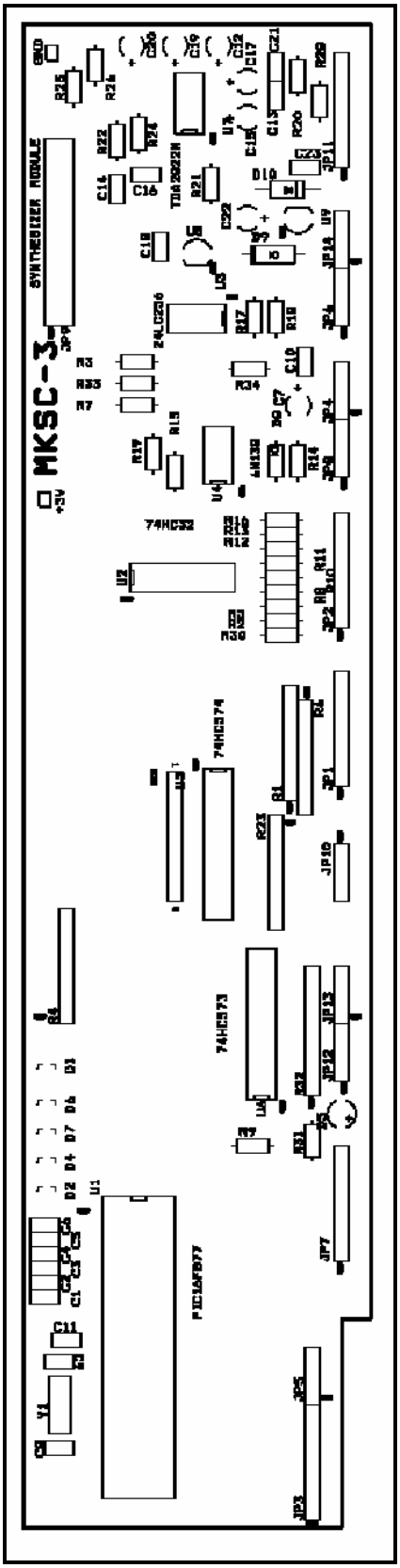

Figure 12: MKSC-3 Circuit Board Silk Screen layer

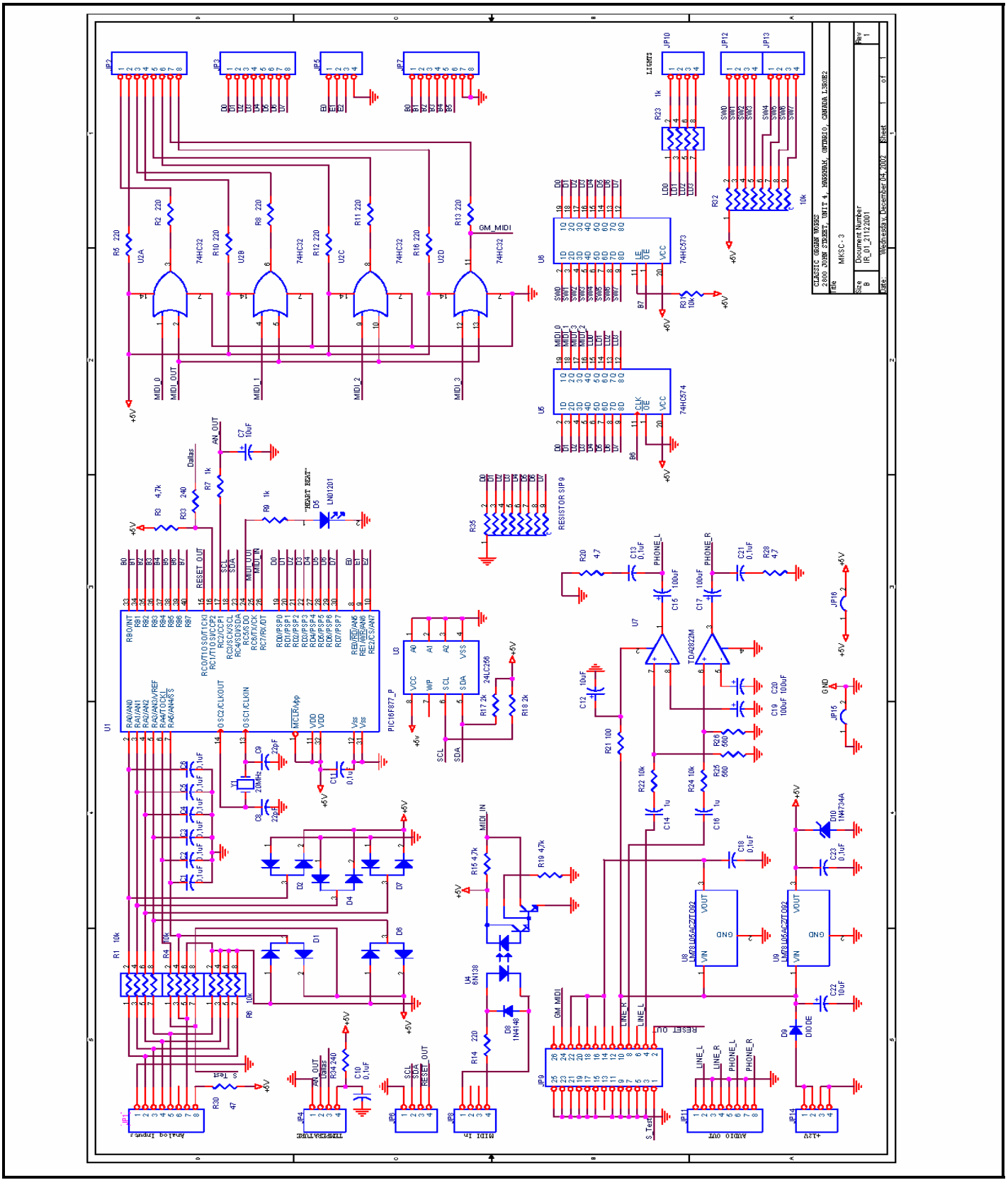

Figure 13: MKSC-3 Schematic

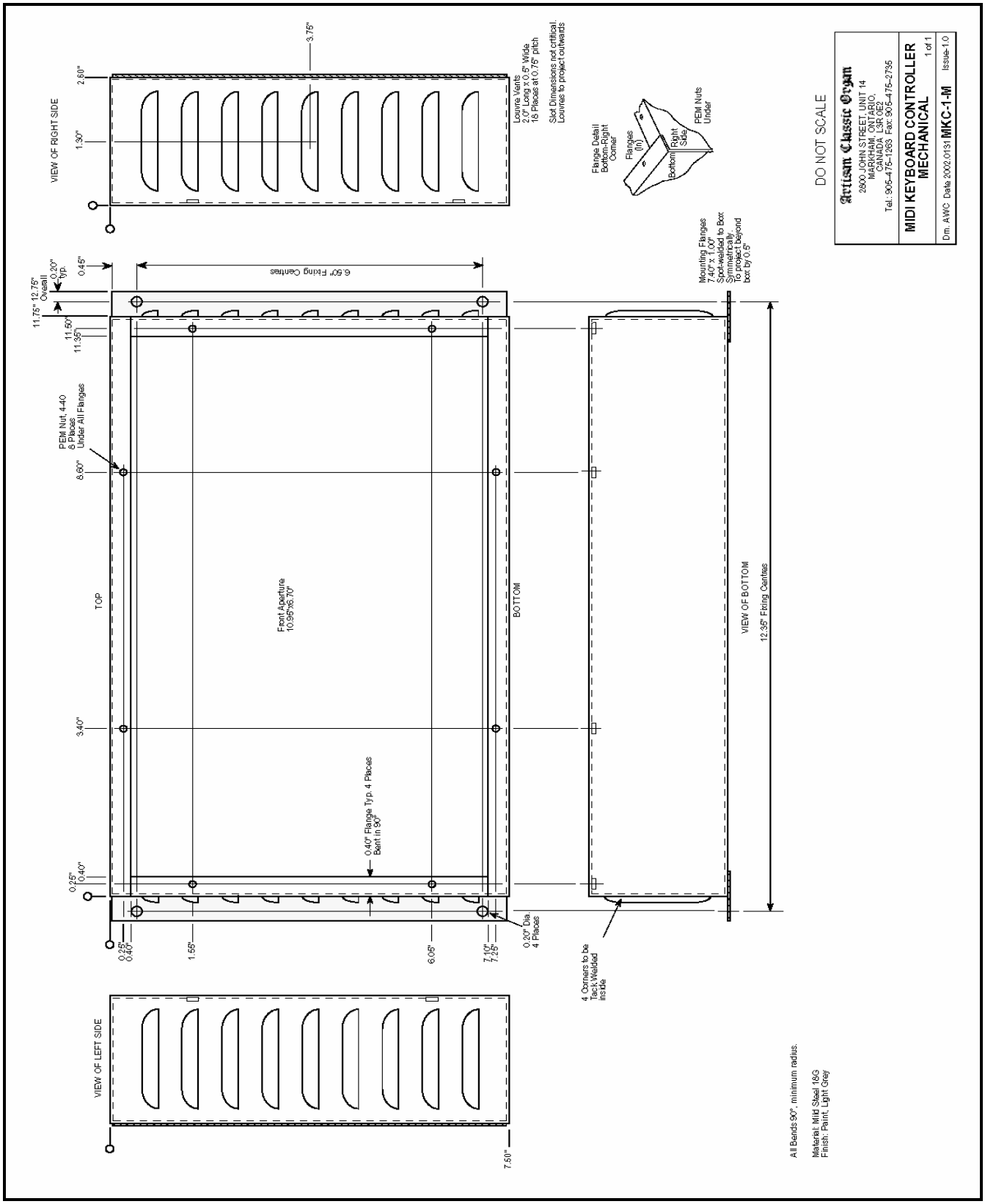

Figure 14: MCU Mechanical Drawing

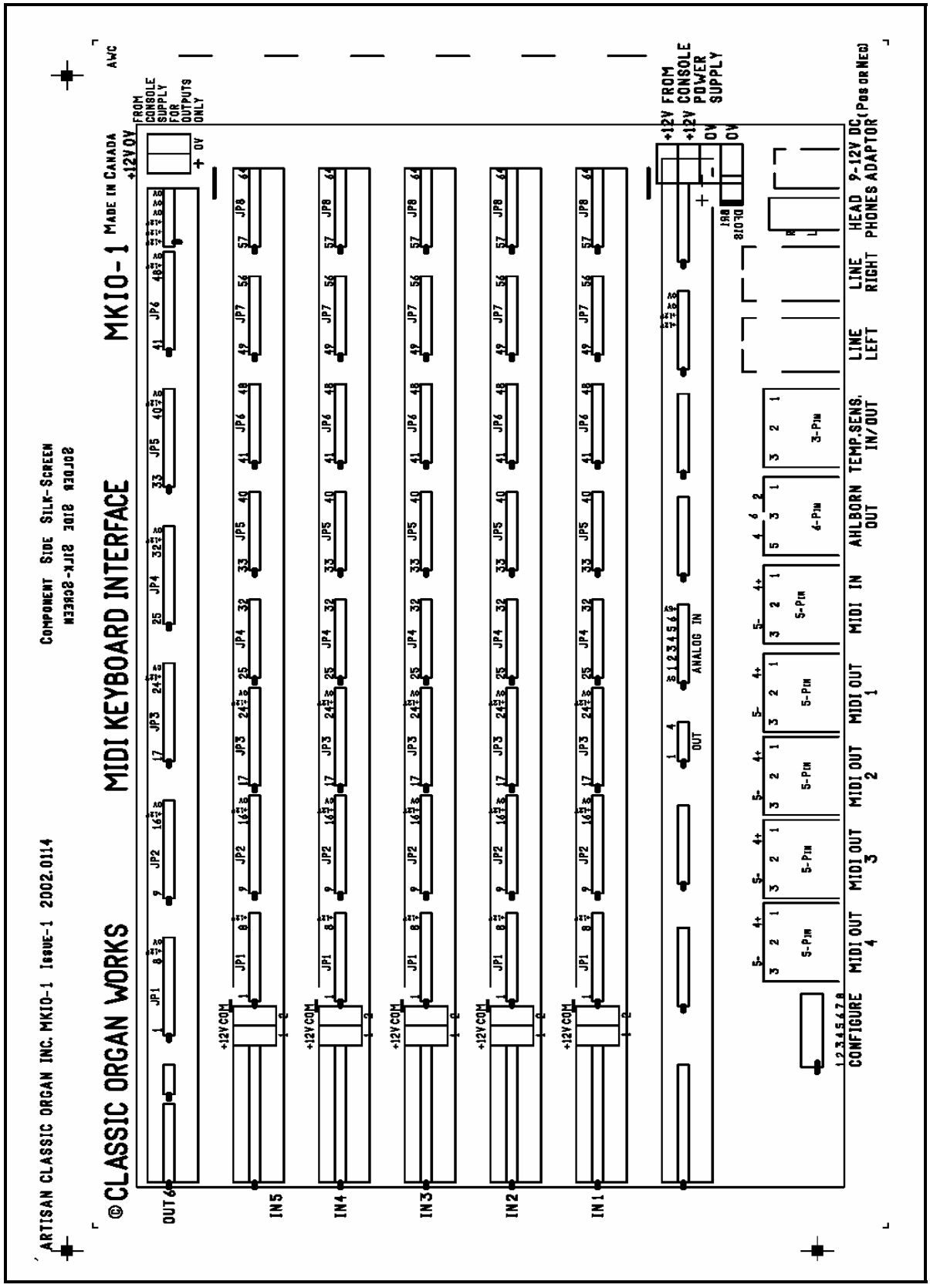

Figure 15: MCU Top Panel Board Layout

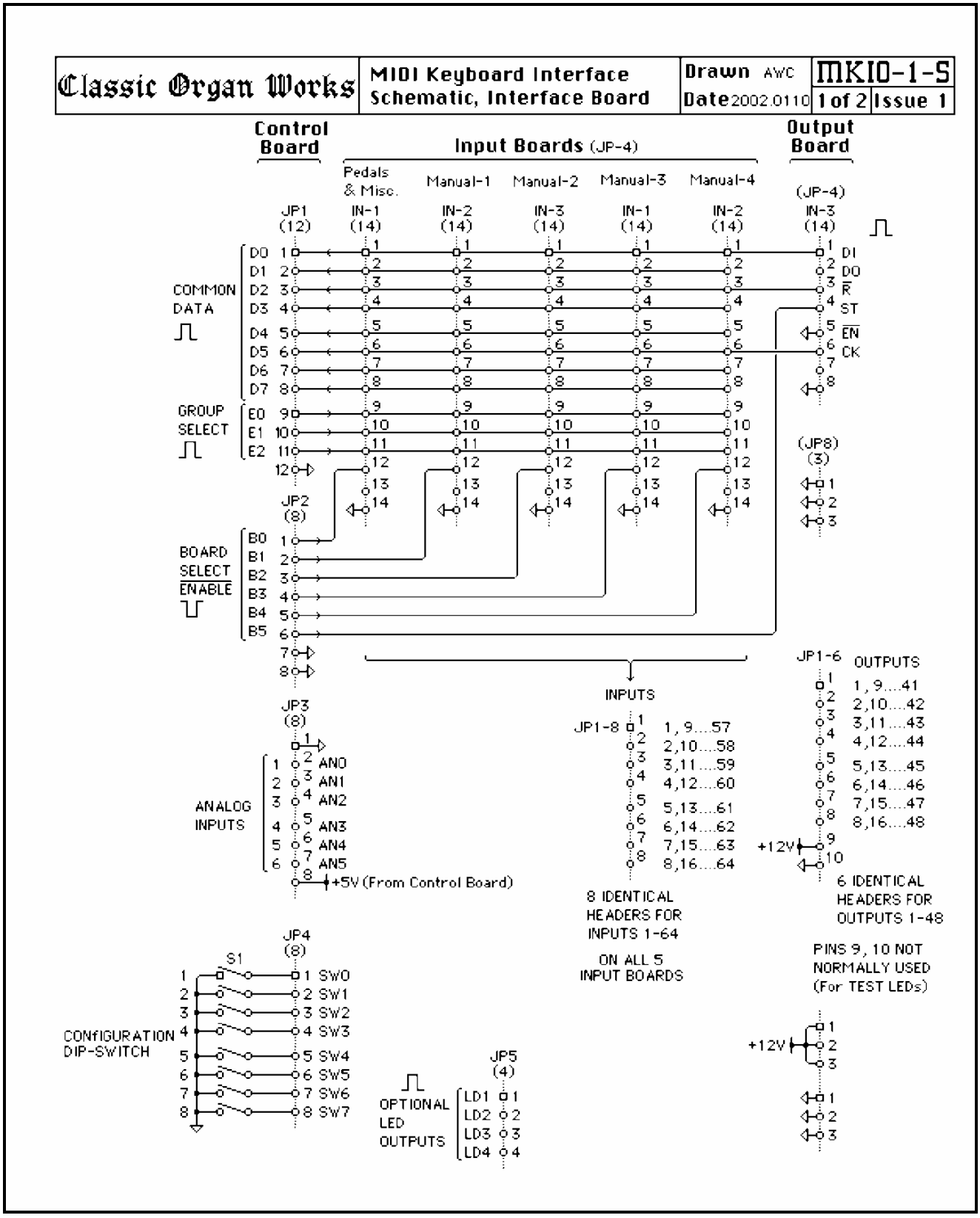

Figure 16: MKIO Schematic (page 1 of 2)

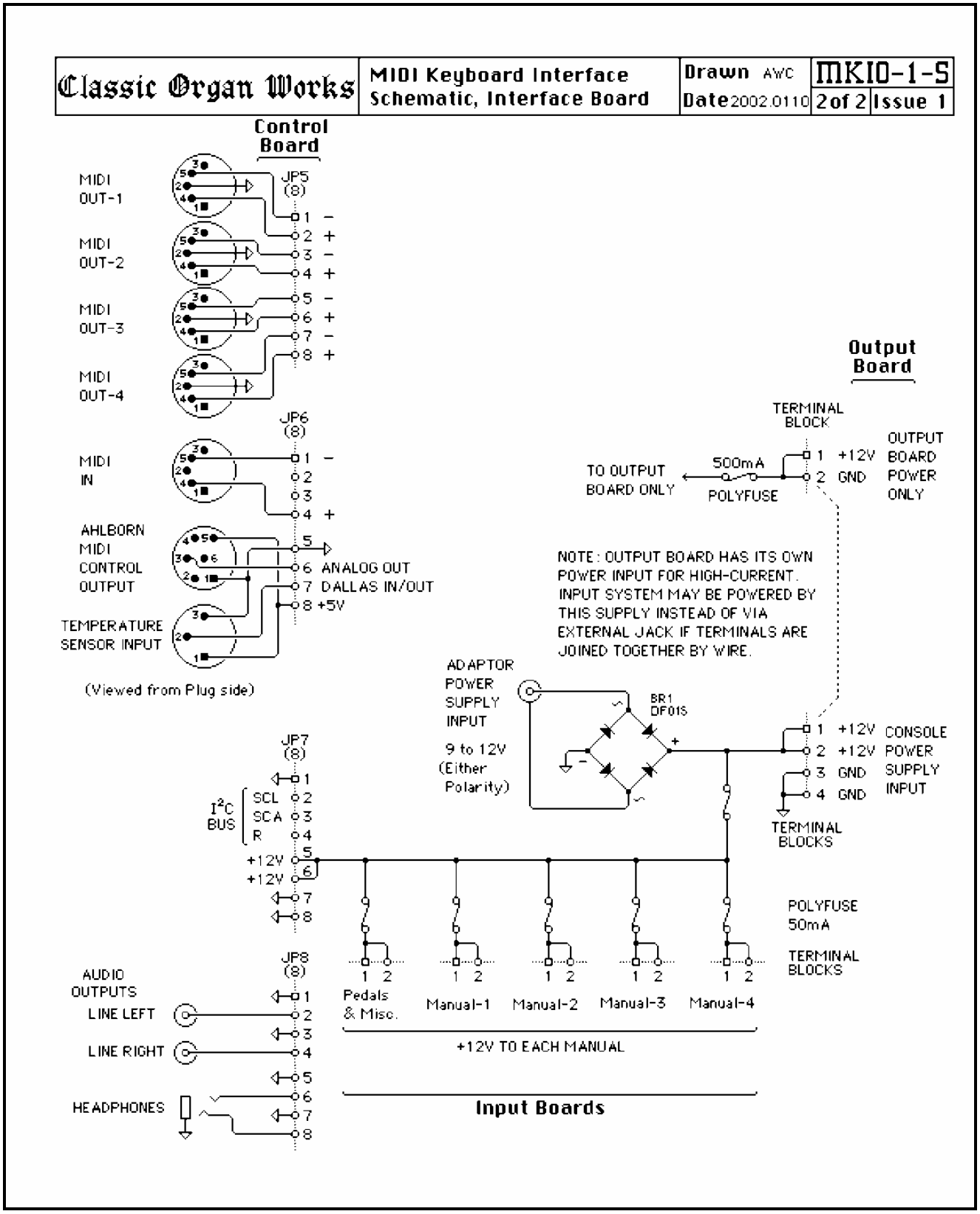

Figure 17: MKIO Schematic (page 2 of 2)

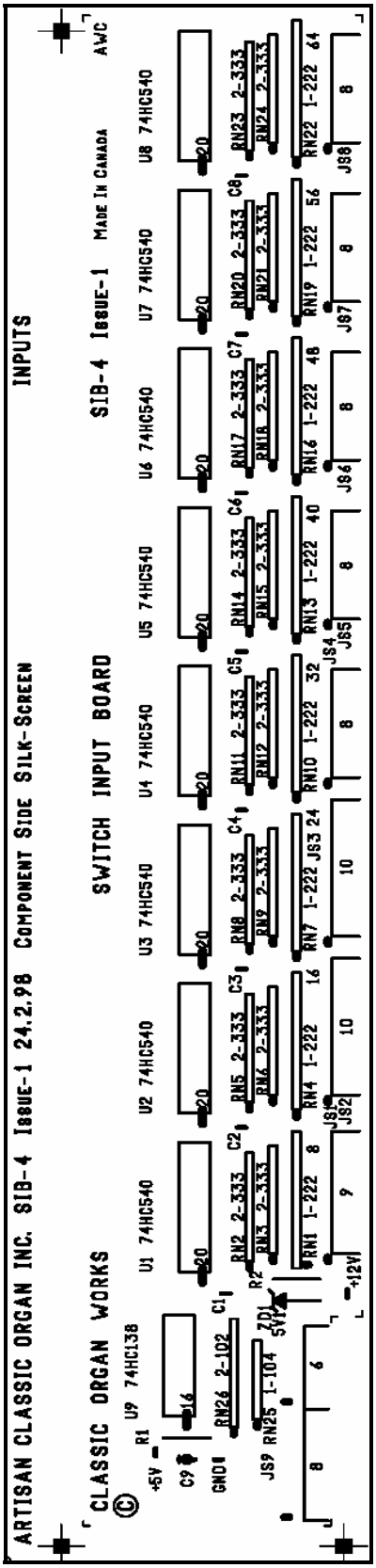

Figure 18: SIB-4 Circuit Board Layout

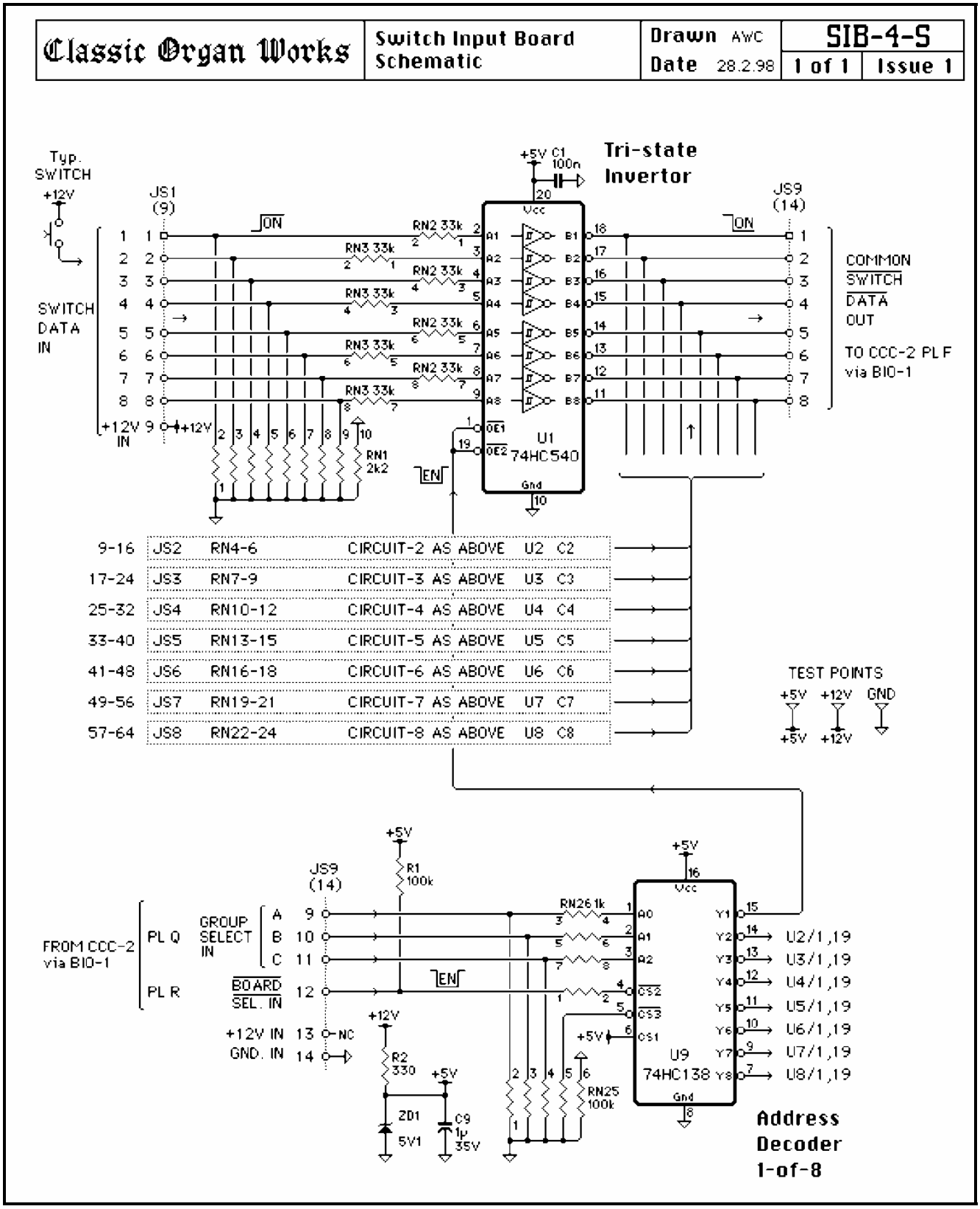

Figure 19: SIB-4 Schematic

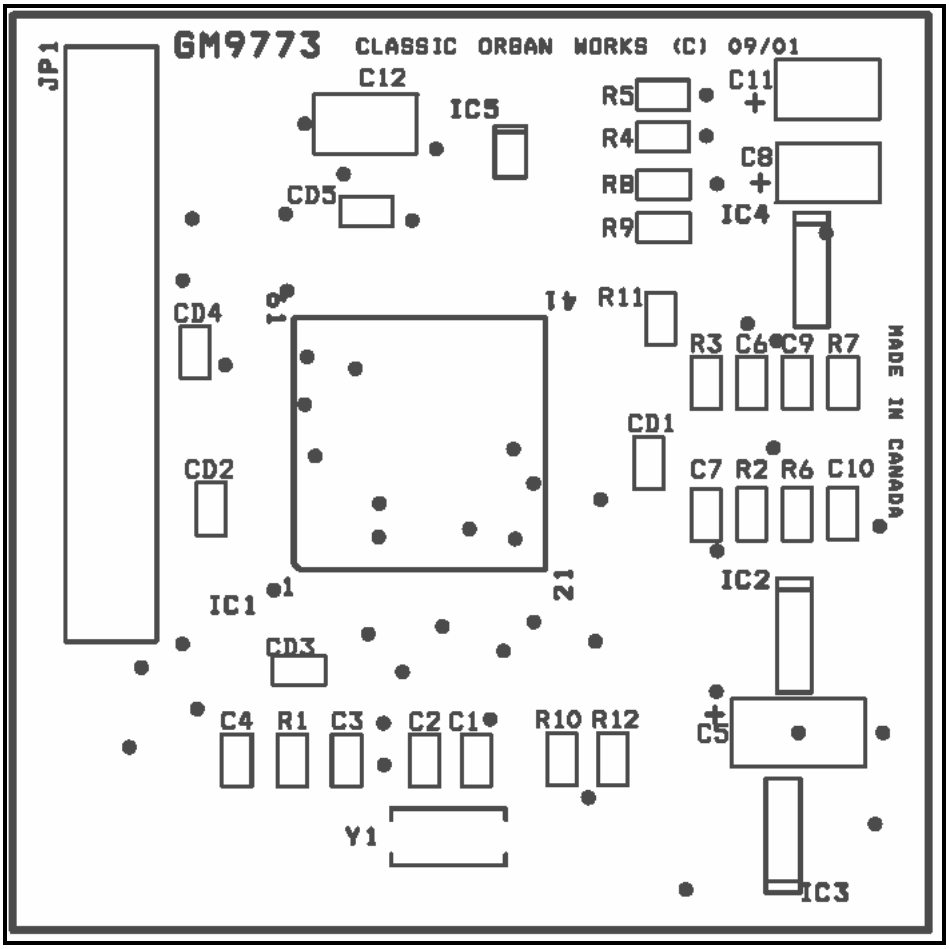

Figure 20: GM9773 Circuit Board Layout

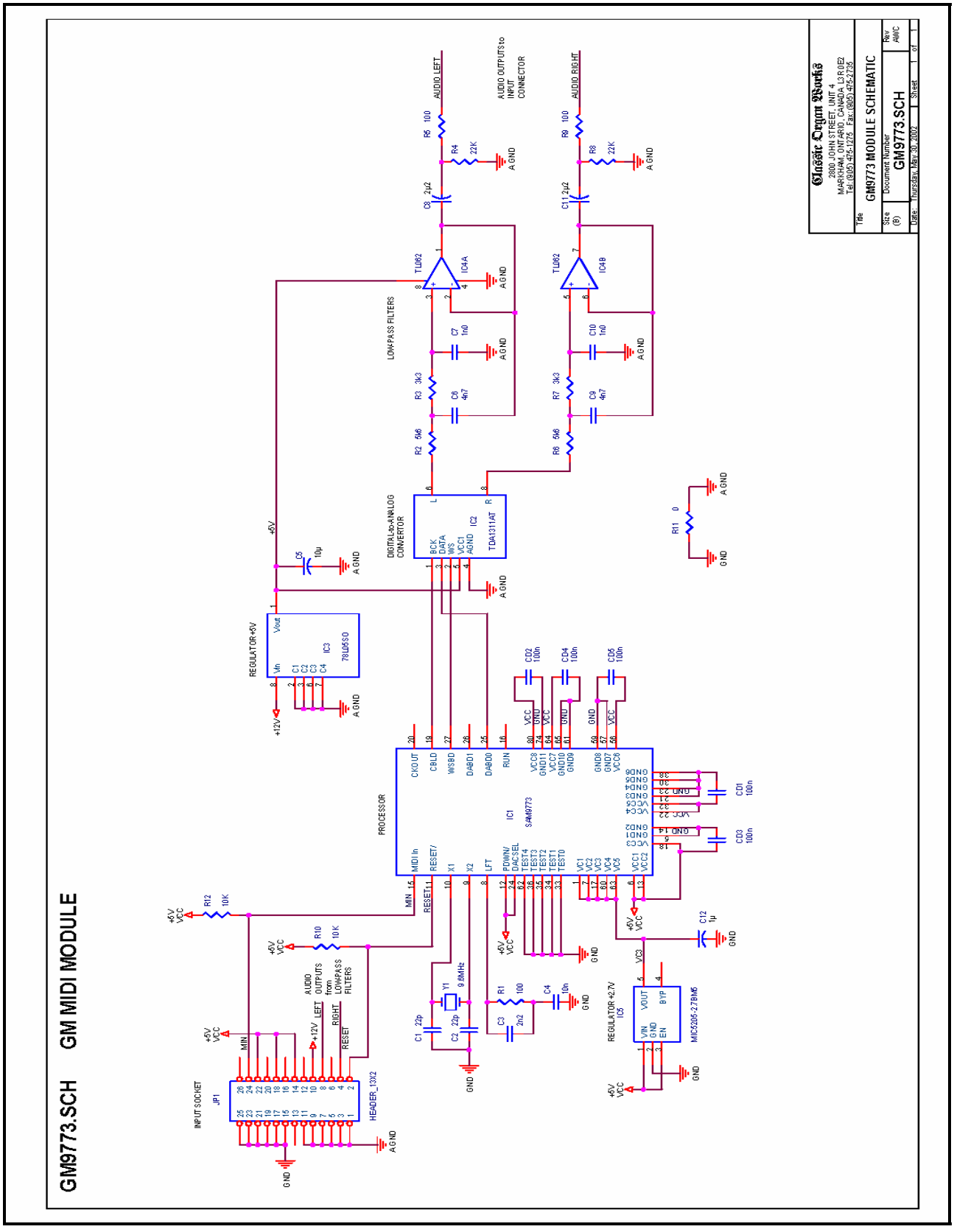

Figure 21: GM9773 Schematic

MIDI CONTROL UNIT MCU-1

11. APPENDIX C: MIDI Protocol

MIDI Protocol Specification [2]

MIDI is a convenient method of electronically recording performances and transferring them to a number of audio devices supporting MIDI software and hardware. MIDI files are smaller than their counterparts in the electronic audio music category. In the simplest form, MIDI is a sequence of messages that describe the exact steps that a soundcard plays. The two primary message types are 'Channel' and 'System'.

Channel Messages

Channel Messages apply to a specific MIDI channel and include the MIDI channel number in their status byte.

Note On, Note Off, and Velocity messages are transmitted on any of the sixteen logical MIDI channels. The message is sent as three data bytes. The first byte termed the 'status' byte indicates the Channel number. The second byte specifies the key number. The third byte specifies the velocity, which is the amount of force, applied to a key, or the volume of the key pressed.

Aftertouch is a message that is transmitted to describe the amount of pressure applied to keys after they are pressed to control aspects of sound production such as vibrato. The message is in the form of one data byte specifying the pressure value.

Pitch Bend modifies the sound on a given MIDI channel. The message is in the form of two data bytes that specify the position of the pitch wheel.

Program Change allows the user to control and change the type of instrument being played on a given MIDI channel. The message is in the form of one data byte.

Control Change allows the user to specify the function of the synthesizer. The message is in the form of two bytes, the first is a Status Byte indicating the controller number, and the second is a data byte indicating the control value.

Bank Select expands the number of different instrument sounds that may be selected. A Control Change message usually precedes a Program Change message allowing 16,384 banks of 128 sounds to be played. Mapping of the sounds is dependent upon the manufacturer, which have adopted their own standards.

RPN and ***NRPN*** are Registered Parameter Number and Non-Registered Parameter Number respectively. These messages allow expansion of the number of controllers available via MIDI. Registered Parameters are numbers assigned for functions like control pitch bend sensitivity and master tuning. Non-Registered Parameters are those that can be assigned by manufacturers to handle other functions.

Channel Mode messages affect the way in which a synthesizer responds to MIDI data. Controller number 121 represents a reset. Channel number 122 represents an enable/disable local control. Channel numbers 124-127 select whether a synthesizer responds to MIDI data on all channels or on one channel only (Omni Mode On or Omni Mode Off). The notes are then played polyphonically or monophonically (Poly Mode and Mono Mode) respectively.

System Messages

These are messages which are not Channel specific, and thus do not indicate the channel number in their status bytes.

System Common Messages serve to synchronize MIDI equipment (MIDI Time code), select songs (for MIDI equipment with the capability to store and recall a number of different songs), select the playback point (for MIDI equipment with MIDI system real time message recognition), tune internal oscillators, and flag the end of a System Exclusive Message.

System Real Time Messages are used to set the playback tempo (timing clock), control the playback start position (start), continue playback (continue), set the stop position (stop), eliminate 'stuck notes' (active sensing) in the event of a MIDI cable disconnection, and reset and initialize the equipment receiving a message (system reset).

System Exclusive Messages are specific to a manufacturer. Each manufacturer of MIDI equipment is granted a unique identification number by the MIDI Manufacturers Association and forms the first byte of the message. Afterwards, a manufacturer can send data and patch commands.

Running Status

In addition to the messages sent between MIDI devices, the MIDI language has a '*Running Status*' feature which eliminates the delayed effect caused by a large number of musical events occurring 'simultaneously'. The Running Status does this by omitting the status byte if the current status byte is the same as the previous status byte. Therefore, one byte less is sent which will vacate that byte for other data. Often, to make use of the Running Status feature, the 'Note On' message is used for both 'Note on' and 'Note off' functions. Since the 'Note On' and 'Note Off' messages have differing status bytes, by making use of a 'velocity=0' command in place of the 'Note Off' command, running status is utilized.

Table 26: MIDI 1.0 Specification Message Summary [12]

Status D7----D0	Data Byte(s) D7----D0	Description
Channel Voice Messages [nnnn = 0-15 (MIDI Channel Number 1-16)]		
1000nnnn	0kkkkkkk 0vvvvvvv	Note Off event. This message is sent when a note is released (ended). (kkkkkkk) is the key (note) number. (vvvvvvv) is the velocity.
1001nnnn	0kkkkkkk 0vvvvvvv	Note On event. This message is sent when a note is depressed (start). (kkkkkkk) is the key (note) number. (vvvvvvv) is the velocity.
1010nnnn	0kkkkkkk 0vvvvvvv	Polyphonic Key Pressure (Aftertouch). This message is most often sent by pressing down on the key after it "bottoms out". (kkkkkkk) is the key (note) number. (vvvvvvv) is the pressure value.
1011nnnn	0ccccccc 0vvvvvvv	Control Change. This message is sent when a controller value changes. Controllers include devices such as pedals and levers. Controller numbers 120-127 are reserved as "Channel Mode Messages" (on the next page). (ccccccc) is the controller number. (vvvvvvv) is the new value (0-119).
1100nnnn	0ppppppp	Program Change. This message sent when the patch number changes. (ppppppp) is the new program number.
1101nnnn	0vvvvvvv	Channel Pressure (After-touch). This message is most often sent by pressing down on the key after it "bottoms out". This message is different from polyphonic after-touch. Use this message to send the single greatest pressure value (of all the current depressed keys). (vvvvvvv) is the pressure value.
1110nnnn	0lllllll 0mmmmmmm	Pitch Wheel Change. This message is sent to indicate a change in the pitch wheel. The pitch wheel is measured by a fourteen-bit value. Center (no pitch change) is 2000H. Sensitivity is a function of the transmitter. (lllllll) are the least significant 7 bits. (mmmmmmm) are the most significant 7 bits.

MIDI 1.0 Specification Message Summary, Cont'd.

Status D7----D0	Data Byte(s) D7----D0	Description
Channel Mode Messages (See also Control Change, previous page)		
1011nnnn	0ccccccc 0vvvvvvv	Channel Mode Messages. This the same code as the Control Change, but implements Mode control and special message by using reserved controller numbers 120-127. The commands are: All Sound Off. When All Sound Off is received all oscillators will turn off, and their volume envelopes are set to zero as soon as possible. c = 120, v = 0: All Sound Off Reset All Controllers. When Reset All Controllers is received, all controller values are reset to their default values. (See specific Recommended Practices for defaults). c = 121, v = x: Value must only be zero unless otherwise allowed in a specific Recommended Practice. Local Control. When Local Control is Off, all devices on a given channel will respond only to data received over MIDI. Played data, etc. will be ignored. Local Control On restores the functions of the normal controllers. c = 122, v = 0: Local Control Off. c = 122, v = 127: Local Control On All Notes Off. When an All Notes Off is received, all oscillators will turn off. c = 123, v = 0: All Notes Off (See text for description of actual mode commands). c = 124, v = 0: Omni Mode Off. c = 125, v = 0: Omni Mode On c = 126, v = M: Mono Mode On (Poly Off) where M is the number of channels (Omni Off) or 0 (Omni On) c = 127, v = 0: Poly Mode On (Mono Off) (Note: These four messages also cause All Notes Off)

MIDI 1.0 Specification Message Summary, Cont'd.

Status D7----D0	Data Byte(s) D7----D0	Description
		System Common Messages
11110000	0iiiiiii 0ddddddd 0ddddddd 11110111	System Exclusive. This message makes up for all that MIDI does not support. (iiiiiii) is usually a seven-bit Manufacturer's I.D. code. If the synthesizer recognizes the I.D. code as its own, it will listen to the rest of the message (ddddddd). Otherwise, the message will be ignored. System Exclusive is used to send bulk dumps such as patch parameters and other non-spec data. (Note: Real-Time messages ONLY may be interleaved with a System Exclusive.) This message is also used for extensions called Universal Exclusive Messages.
11110001		Undefined. (Reserved)
11110010	0lllllll 0mmmmmmm	Song Position Pointer. This is an internal 14 bit register that holds the number of MIDI beats (1 beat= six MIDI clocks) since the start of the song. l is the LSB, m is the MSB.
11110011	0sssssss	Song Select. The Song Select specifies which sequence or song is to be played.
11110100		Undefined. (Reserved)
11110101		Undefined. (Reserved)
11110110		Tune Request. Upon receiving a Tune Request, all analog synthesizers should tune their oscillators.
11110111		End of Exclusive. Used to terminate a System Exclusive dump (see above).
		System Real-Time Messages
11111000		Timing Clock. Sent 24 times per quarter note when synchronization is required (see text).
11111001		Undefined. (Reserved)
11111010		Start. Start the current sequence playing. (This message will be followed with Timing Clocks).
11111011		Continue. Continue at the point the sequence was Stopped.
11111100		Stop. Stop the current sequence.
11111101		Undefined. (Reserved)
11111110		Active Sensing. Use of this message is optional. When initially sent, the receiver will expect to receive another Active Sensing message each 300ms (max), or it will be assume that the connection has been terminated. At termination, the receiver will turn off all voices and return to normal (non-active sensing) operation.
11111111		Reset. Reset all receivers in the system to power-up status. This should be used sparingly, preferably under manual control. In particular, it should not be sent on power-up.

Table 27: Expanded Status Bytes List

(adapted from "MIDI by the Numbers" by D. Valenti, Electronic Musician 2/88) [13]

STATUS BYTE					DATA BYTES	
1st Byte Value			Function		2nd Byte	3rd Byte
Binary	Hex	Dec				
10000000	80	128	Chan 1	Note Off	Note Number	Note Velocity
10000001	81	129	Chan 2	"	(0-127)	(0-127)
10000010	82	130	Chan 3	"	see	"
10000011	83	131	Chan 4	"	Table	"
10000100	84	132	Chan 5	"	4	"
10000101	85	133	Chan 6	"	"	"
10000110	86	134	Chan 7	"	"	"
10000111	87	135	Chan 8	"	"	"
10001000	88	136	Chan 9	"	"	"
10001001	89	137	Chan 10	"	"	"
10001010	8A	138	Chan 11	"	"	"
10001011	8B	139	Chan 12	"	"	"
10001100	8C	140	Chan 13	"	"	"
10001101	8D	141	Chan 14	"	"	"
10001110	8E	142	Chan 15	"	"	"
10001111	8F	143	Chan 16	"	"	"
10010000	90	144	Chan 1	Note on	"	"
10010001	91	145	Chan 2	"	"	"
10010010	92	146	Chan 3	"	"	"
10010011	93	147	Chan 4	"	"	"
10010100	94	148	Chan 5	"	"	"
10010101	95	149	Chan 6	"	"	"
10010110	96	150	Chan 7	"	"	"
10010111	97	151	Chan 8	"	"	"
10011000	98	152	Chan 9	"	"	"
10011001	99	153	Chan 10	"	"	"
10011010	9A	154	Chan 11	"	"	"
10011011	9B	155	Chan 12	"	"	"
10011100	9C	156	Chan 13	"	"	"
10011101	9D	157	Chan 14	"	"	"
10011110	9E	158	Chan 15	"	"	"
10011111	9F	159	Chan 16	"	"	"
10100000	A0	160	Chan 1	Polyphonic	"	Aftertouch
10100001	A1	161	Chan 2	Aftertouch	"	Amount
10100010	A2	162	Chan 3	"	"	(0-127)
10100011	A3	163	Chan 4	"	"	"
10100100	A4	164	Chan 5	"	"	"
10100101	A5	165	Chan 6	"	"	"
10100110	A6	166	Chan 7	"	"	"
10100111	A7	167	Chan 8	"	"	"
10101000	A8	168	Chan 9	"	"	"
10101001	A9	169	Chan 10	"	"	"
10101010	AA	170	Chan 11	"	"	"
10101011	AB	171	Chan 12	"	"	"

Expanded Status Bytes List, Cont'd.

STATUS BYTE					DATA BYTES	
1st Byte Value			Function		2nd Byte	3rd Byte
Binary	Hex	Dec				
10101100	AC	172	Chan 13	"	"	"
10101101	AD	173	Chan 14	"	"	"
10101110	AE	174	Chan 15	"	"	"
10101111	AF	175	Chan 16	"	"	"
10110000	B0	176	Chan 1	Control/	See	See
10110001	B1	177	Chan 2	Mode change	Table	Table
10110010	B2	178	Chan 3	"	3	3
10110011	B3	179	Chan 4	"	"	"
10110100	B4	180	Chan 5	"	"	"
10110101	B5	181	Chan 6	"	"	"
10110110	B6	182	Chan 7	"	"	"
10110111	B7	183	Chan 8	"	"	"
10111000	B8	184	Chan 9	"	"	"
10111001	B9	185	Chan 10	"	"	"
10111010	BA	186	Chan 11	"	"	"
10111011	BB	187	Chan 12	"	"	"
10111100	BC	188	Chan 13	"	"	"
10111101	BD	189	Chan 14	"	"	"
10111110	BE	190	Chan 15	"	"	"
10111111	BF	191	Chan 16	"	"	"
11000000	C0	192	Chan 1	Program	Program #	NONE
11000001	C1	193	Chan 2	change	(0-127)	"
11000010	C2	194	Chan 3	"	"	"
11000011	C3	195	Chan 4	"	"	"
11000100	C4	196	Chan 5	"	"	"
11000101	C5	197	Chan 6	"	"	"
11000110	C6	198	Chan 7	"	"	"
11000111	C7	199	Chan 8	"	"	"
11001000	C8	200	Chan 9	"	"	"
11001001	C9	201	Chan 10	"	"	"
11001010	CA	202	Chan 11	"	"	"
11001011	CB	203	Chan 12	"	"	"
11001100	CC	204	Chan 13	"	"	"
11001101	CD	205	Chan 14	"	"	"
11001110	CE	206	Chan 15	"	"	"
11001111	CF	207	Chan 16	"	"	"
11010000	D0	208	Chan 1	Channel	Aftertouch	"
11010001	D1	209	Chan 2	Aftertouch	amount	"
11010010	D2	210	Chan 3	"	(0-127)	"
11010011	D3	211	Chan 4	"	"	"
11010100	D4	212	Chan 5	"	"	"
11010101	D5	213	Chan 6	"	"	"
11010110	D6	214	Chan 7	"	"	"
11010111	D7	215	Chan 8	"	"	"
11011000	D8	216	Chan 9	"	"	"

Expanded Status Bytes List, Cont'd.

STATUS BYTE					DATA BYTES	
1st Byte Value			Function		2nd Byte	3rd Byte
Binary	Hex	Dec				
11011001	D9	217	Chan 10	"	"	"
11011010	DA	218	Chan 11	"	"	"
11011011	DB	219	Chan 12	"	"	"
11011100	DC	220	Chan 13	"	"	"
11011101	DD	221	Chan 14	"	"	"
11011110	DE	222	Chan 15	"	"	"
11011111	DF	223	Chan 16	"	"	"
11100000	E0	224	Chan 1	Pitch	Pitch	Pitch
11100001	E1	225	Chan 2	Wheel	wheel	Wheel
11100010	E2	226	Chan 3	Control	LSB	MSB
11100011	E3	227	Chan 4	"	(0-127)	(0-127)
11100100	E4	228	Chan 5	"	"	"
11100101	E5	229	Chan 6	"	"	"
11100110	E6	230	Chan 7	"	"	"
11100111	E7	231	Chan 8	"	"	"
11101000	E8	232	Chan 9	"	"	"
11101001	E9	233	Chan 10	"	"	"
11101010	EA	234	Chan 11	"	"	"
11101011	EB	235	Chan 12	"	"	"
11101100	EC	236	Chan 13	"	"	"
11101101	ED	237	Chan 14	"	"	"
11101110	EE	238	Chan 15	"	"	"
11101111	EF	239	Chan 16	"	"	"
11110000	F0	240	System Exclusive		**	**
11110001	F1	241	MIDI Time Code Qtr. Frame		-see spec-	-see spec-
11110010	F2	242	Song Position Pointer		LSB	MSB
11110011	F3	243	Song Select(Song #)		(0-127)	NONE
11110100	F4	244	Undefined (Reserved)		?	?
11110101	F5	245	Undefined (Reserved)		?	?
11110110	F6	246	Tune request		NONE	NONE
11110111	F7	247	End of SysEx (EOX)		"	"
11111000	F8	248	Timing clock		"	"
11111001	F9	249	Undefined (Reserved)		"	"
11111010	FA	250	Start		"	"
11111011	FB	251	Continue		"	"
11111100	FC	252	Stop		"	"
11111101	FD	253	Undefined (Reserved)		"	"
11111110	FE	254	Active Sensing		"	"
11111111	FF	255	System Reset		"	"

** *Note: System Exclusive (data dump) 2nd byte= Vendor ID (or Universal Exclusive) followed by more data bytes and ending with EOX.*

Table 28: Control Changes and Mode Changes (Status Bytes 176-191)

Adapted from "MIDI by the Numbers" by D. Valenti-Electronic Musician 2/88, updated 1995/1999/2002 by the MIDI Manufacturers Association [14]

Control Number (2nd Byte Value)			Control Function	3rd Byte Value	
Decimal	Binary	Hex		Value	Used As
0	00000000	00	Bank Select	0-127	MSB
1	00000001	01	Modulation Wheel or Lever	0-127	MSB
2	00000010	02	Breath Controller	0-127	MSB
3	00000011	03	Undefined	0-127	MSB
4	00000100	04	Foot Controller	0-127	MSB
5	00000101	05	Portamento Time	0-127	MSB
6	00000110	06	Data Entry MSB	0-127	MSB
7	00000111	07	Channel Volume (formerly Main Volume)	0-127	MSB
8	00001000	08	Balance	0-127	MSB
9	00001001	09	Undefined	0-127	MSB
10	00001010	0A	Pan	0-127	MSB
11	00001011	0B	Expression Controller	0-127	MSB
12	00001100	0C	Effect Control 1	0-127	MSB
13	00001101	0D	Effect Control 2	0-127	MSB
14	00001110	0E	Undefined	0-127	MSB
15	00001111	0F	Undefined	0-127	MSB
16	00010000	10	General Purpose Controller 1	0-127	MSB
17	00010001	11	General Purpose Controller 2	0-127	MSB
18	00010010	12	General Purpose Controller 3	0-127	MSB
19	00010011	13	General Purpose Controller 4	0-127	MSB
20	00010100	14	Undefined	0-127	MSB
21	00010101	15	Undefined	0-127	MSB
22	00010110	16	Undefined	0-127	MSB
23	00010111	17	Undefined	0-127	MSB
24	00011000	18	Undefined	0-127	MSB
25	00011001	19	Undefined	0-127	MSB
26	00011010	1A	Undefined	0-127	MSB
27	00011011	1B	Undefined	0-127	MSB
28	00011100	1C	Undefined	0-127	MSB
29	00011101	1D	Undefined	0-127	MSB
30	00011110	1E	Undefined	0-127	MSB
31	00011111	1F	Undefined	0-127	MSB
32	00100000	20	LSB for Control 0 (Bank Select)	0-127	LSB
33	00100001	21	LSB for Control 1 (Modulation Wheel or Lever)	0-127	LSB
34	00100010	22	LSB for Control 2 (Breath Controller)	0-127	LSB
35	00100011	23	LSB for Control 3 (Undefined)	0-127	LSB
36	00100100	24	LSB for Control 4 (Foot Controller)	0-127	LSB
37	00100101	25	LSB for Control 5 (Portamento Time)	0-127	LSB
38	00100110	26	LSB for Control 6 (Data Entry)	0-127	LSB
39	00100111	27	LSB for Control 7 (Channel Volume, formerly Main Volume)	0-127	LSB
40	00101000	28	LSB for Control 8 (Balance)	0-127	LSB
41	00101001	29	LSB for Control 9 (Undefined)	0-127	LSB
42	00101010	2A	LSB for Control 10 (Pan)	0-127	LSB
43	00101011	2B	LSB for Control 11 (Expression Controller)	0-127	LSB
44	00101100	2C	LSB for Control 12 (Effect control 1)	0-127	LSB

Control Changes and Mode Changes, Cont'd.

Control Number (2nd Byte Value)			Control Function	3rd Byte Value	
Decimal	Binary	Hex		Value	Used As
45	00101101	2D	LSB for Control 13 (Effect control 2)	0-127	LSB
46	00101110	2E	LSB for Control 14 (Undefined)	0-127	LSB
47	00101111	2F	LSB for Control 15 (Undefined)	0-127	LSB
48	00110000	30	LSB for Control 16 (General Purpose Controller 1)	0-127	LSB
49	00110001	31	LSB for Control 17 (General Purpose Controller 2)	0-127	LSB
50	00110010	32	LSB for Control 18 (General Purpose Controller 3)	0-127	LSB
51	00110011	33	LSB for Control 19 (General Purpose Controller 4)	0-127	LSB
52	00110100	34	LSB for Control 20 (Undefined)	0-127	LSB
53	00110101	35	LSB for Control 21 (Undefined)	0-127	LSB
54	00110110	36	LSB for Control 22 (Undefined)	0-127	LSB
55	00110111	37	LSB for Control 23 (Undefined)	0-127	LSB
56	00111000	38	LSB for Control 24 (Undefined)	0-127	LSB
57	00111001	39	LSB for Control 25 (Undefined)	0-127	LSB
58	00111010	3A	LSB for Control 26 (Undefined)	0-127	LSB
59	00111011	3B	LSB for Control 27 (Undefined)	0-127	LSB
60	00111100	3C	LSB for Control 28 (Undefined)	0-127	LSB
61	00111101	3D	LSB for Control 29 (Undefined)	0-127	LSB
62	00111110	3E	LSB for Control 30 (Undefined)	0-127	LSB
63	00111111	3F	LSB for Control 31 (Undefined)	0-127	LSB
64	01000000	40	Damper Pedal on/off (Sustain)	<63 off, >64 on	---
65	01000001	41	Portamento On/Off	<63 off, >64 on	---
66	01000010	42	Sostenuto On/Off	<63 off, >64 on	---
67	01000011	43	Soft Pedal On/Off	<63 off, >64 on	---
68	01000100	44	Legato Footswitch	<63 Normal, >64 Legato	---
69	01000101	45	Hold 2	<63 off, >64 on	---
70	01000110	46	Sound Controller 1 (default: Sound Variation)	0-127	LSB
71	01000111	47	Sound Controller 2 (default: Timbre/Harmonic Intensity)	0-127	LSB
72	01001000	48	Sound Controller 3 (default: Release Time)	0-127	LSB
73	01001001	49	Sound Controller 4 (default: Attack Time)	0-127	LSB
74	01001010	4A	Sound Controller 5 (default: Brightness)	0-127	LSB
75	01001011	4B	Sound Controller 6 (default: Decay Time - see MMA RP-021)	0-127	LSB
76	01001100	4C	Sound Controller 7 (default: Vibrato Rate - see MMA RP-021)	0-127	LSB
77	01001101	4D	Sound Controller 8 (default: Vibrato Depth - see MMA RP-021)	0-127	LSB
78	01001110	4E	Sound Controller 9 (default: Vibrato Delay - see MMA RP-021)	0-127	LSB
79	01001111	4F	Sound Controller 10 (default undefined - see MMA RP-021)	0-127	LSB
80	01010000	50	General Purpose Controller 5	0-127	LSB
81	01010001	51	General Purpose Controller 6	0-127	LSB
82	01010010	52	General Purpose Controller 7	0-127	LSB
83	01010011	53	General Purpose Controller 8	0-127	LSB
84	01010100	54	Portamento Control	0-127	LSB
85	01010101	55	Undefined	---	---
86	01010110	56	Undefined	---	---

Control Changes and Mode Changes, Cont'd.

Control Number (2nd Byte Value)			Control Function	3rd Byte Value	
Decimal	Binary	Hex		Value	Used As
87	01010111	57	Undefined	---	---
88	01011000	58	Undefined	---	---
89	01011001	59	Undefined	---	---
90	01011010	5A	Undefined	---	---
91	01011011	5B	Effects 1 Depth (default: Reverb Send Level - see MMA RP-023) (formerly External Effects Depth)	0-127	LSB
92	01011100	5C	Effects 2 Depth (formerly Tremolo Depth)	0-127	LSB
93	01011101	5D	Effects 3 Depth (default: Chorus Send Level - see MMA RP-023) (formerly Chorus Depth)	0-127	LSB
94	01011110	5E	Effects 4 Depth (formerly Celeste [Detune] Depth)	0-127	LSB
95	01011111	5F	Effects 5 Depth (formerly Phaser Depth)	0-127	LSB
96	01100000	60	Data Increment (Data Entry +1) (see MMA RP-018)	N/A	---
97	01100001	61	Data Decrement (Data Entry -1) (see MMA RP-018)	N/A	---
98	01100010	62	Non-Registered Parameter Number (NRPN) – LSB	0-127	LSB
99	01100011	63	Non-Registered Parameter Number (NRPN) – MSB	0-127	MSB
100	01100100	64	Registered Parameter Number (RPN) – LSB*	0-127	LSB
101	01100101	65	Registered Parameter Number (RPN) - MSB*	0-127	MSB
102	01100110	66	Undefined	---	---
103	01100111	67	Undefined	---	---
104	01101000	68	Undefined	---	---
105	01101001	69	Undefined	---	---
106	01101010	6A	Undefined	---	---
107	01101011	6B	Undefined	---	---
108	01101100	6C	Undefined	---	---
109	01101101	6D	Undefined	---	---
110	01101110	6E	Undefined	---	---
111	01101111	6F	Undefined	---	---
112	01110000	70	Undefined	---	---
113	01110001	71	Undefined	---	---
114	01110010	72	Undefined	---	---
115	01110011	73	Undefined	---	---
116	01110100	74	Undefined	---	---
117	01110101	75	Undefined	---	---
118	01110110	76	Undefined	---	---
119	01110111	77	Undefined	---	---
Note: Controller numbers 120-127 are reserved for Channel Mode Messages, which rather than controlling sound parameters, affect the channel's operating mode.					
120	01111000	78	[Channel Mode Message] All Sound Off	0	---
121	01111001	79	[Channel Mode Message] Reset All Controllers (See MMA RP-015)	0	---
122	01111010	7A	[Channel Mode Message] Local Control On/Off	0 off, 127 on	---
123	01111011	7B	[Channel Mode Message] All Notes Off	0	---
124	01111100	7C	[Channel Mode Message] Omni Mode Off (+ all notes off)	0	---
125	01111101	7D	[Channel Mode Message] Omni Mode On (+ all notes off)	0	---
126	01111110	7E	[Channel Mode Message] Poly Mode On/Off (+ all notes off)	**	---
127	01111111	7F	[Channel Mode Message] Poly Mode On (+ mono off +all notes off)	0	---

** *Note: This equals the number of channels or zero if the number of channels equals the number of voices in the receiver.*

Table 29: Registered Parameter Numbers [14]

To set or change the value of a Registered Parameter:

1. Send two Control Change messages using Control Numbers 101 (65H) and 100 (64H) to select the desired Registered Parameter Number, as per the following table.

2. To set the selected Registered Parameter to a specific value, send Control Change messages to the Data Entry MSB controller (Control Number 6). If the selected Registered Parameter requires the LSB to be set, send another Control Change message to the Data Entry LSB controller (Control Number 38).

3. To make a relative adjustment to the selected Registered Parameter's current value, use the Data Increment or Data Decrement controllers (Control Numbers 96 and 97).

Parameter Number			Parameter Function	Data Entry Value
Decimal	**Control 101 Value** (MSB)	**Control 100 Value** (LSB)		
0	00H = 0	00H = 0	Pitch Bend Sensitivity	MSB = +/- semitones LSB =+/--cents
1	00H = 0	01H = 1	Channel Fine Tuning (formerly Fine Tuning - see MMA RP-022)	Resolution 100/8192 cents 00H 00H = -100 cents 40H 00H = A440 7FH 7FH = +100 cents
2	00H = 0	02H = 2	Channel Coarse Tuning (formerly Coarse Tuning - see MMA RP-022)	Only MSB used Resolution 100 cents 00H = -6400 cents 40H = A440 7FH = +6300 cents
3	00H = 0	03H = 3	Tuning Program Change	Tuning Program Number
4	00H = 0	04H = 4	Tuning Bank Select	Tuning Bank Number
5	00H = 0	05H = 5	Modulation Depth Range (see MMA General MIDI Level 2 Specification)	For GM2, defined in GM2 Specification. For other systems, defined by manufacturer

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12. APPENDIX D: System Exclusive Messages

Messages common to all products [15]

General Information Identity Request

F0 7E *dd* 06 01 F7

Request the identity and special characteristics of a device. *dd* selects a particular device in the MIDI chain. *dd* = 7Fh selects all devices at once.

General Information Identity Reply

F0 7E *dd* 06 02 00 20 1C *pp pp mm mm ss ss tt tt* F7

dd: identifies the device that is responding.
pp pp = 04 03 for MKSC v3
mm mm: gives the organ model number
ss ss: identifies the major and minor software revision level, as it affects data format compatibility.
tt tt: identifies the major and minor software revision level, as it affects program capabilities.
In the case of the MKSC v3, after the *tt tt*, also pass two bytes indicated the current DIPSWITCH setting

MCU - Special layouts [15]

Config Memory

The config memory contains a number of 256-byte blocks, each containing MCU configuration information.
The message formats are:

F0 00 20 1C *dd* 04 01 03 aa aa aa ss ss F7

Request Config Memory data. This message should be sent by an external sequencer or by the MCU config application.

dd: identifies the device which is responding.
aa aa aa: starting offset (21-bit address) of the config block (packed 7 bits).
ss ss: number of bytes of original data to be retrieved (packed 14 bits)

F0 00 20 1C *dd* 04 01 04 *bb bb ss* <*data*, 8-for-7 format> F7

Transfer Config Memory data. This message should be sent from the MCU in response to a request message.

dd: identifies the device that is responding.
bb bb: block-count within the sequence of saved data blocks' memory data, low-order 7 bits first. The first message in a restore sequence must have a block-count of `00 00`.
ss: number of bytes of original data transferred in this block.
data: 8-for-7 coded bytes of data.

F0 00 20 1C *dd* 04 01 08 *bb bb aa aa aa ss* <*data*, 8-for-7 format> F7

Update Config Memory data. The message with subcommand 08 will be generated by the external MCU config application.

dd: identifies the device which is responding.
bb bb: block-count within the sequence of saved data blocks' memory data, low-order 7 bits first. The first message in a restore sequence must have a block-count of `00 00`.
aa aa aa: starting offset (21-bit address) of the config block (packed 7 bits).
ss: number of bytes of original data transferred in this block.
data: 8-for-7 coded bytes of data.

F0 00 20 1C *dd* 04 01 20 F7

Soft reboot MCU. The message will cause the MCU to resume operation and reload the PIC's EEPROM from the contents of the FLASH ROM as indicated by the DIPSWITCH.

dd: identifies the device which is responding.

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13. APPENDIX E: Ahlborn Messages

Table 30: Note On/Off MIDI functions to control Ahlborn Archive sound modules [16]

Slot	Pins:	Data sent: Off ----> On	Data sent: On ----> Off		Description:		Note:
					Key On/Off Data		
IN1	1-61	90 kk 40	90 kk 00	Sw	Ahlborn - Note On / Off		1
IN2	1-61	91 kk 40	91 kk 00	Gt	Ahlborn - Note On / Off		2
IN3	1-61	92 kk 40	92 kk 00	Ch	Ahlborn - Note On / Off		3
IN4	1-32	93 kk 40	93 kk 00	Pd	Ahlborn - Note On / Off		4

NOTES:

1) *"Swell Channel" defaults to 1 (0h) - usually the Ahlborn "A" division for key On/Off messages. kk = Note number 0-127 (00h to 7Fh) where 60 (3Ch) = middle "C". Normal (untransposed) output from key inputs 1-61 = 36-96 (24h - 60h). Transposer may shift this down or up in the range of -24 to +31. Input defaults to input row #1 (IN1).*
2) *"Great Channel" defaults to 2 (1h) - usually the Ahlborn "B" division for key On/Off messages. Input defaults to input row #2 (IN2).*
3) *"Choir Channel" defaults to 3 (2h) - usually the Ahlborn "AUX" division for key On/Off messages. Input defaults to input row #3 (IN3).*
4) *"Pedal Channel" defaults to 4 (3h) - usually the Ahlborn "Pedal" division for key On/Off messages. Normal (untransposed) output from key inputs 1-32 = 36-67 (24h - 43h). Transposer may shift this down or up in the range of -24 to +31. Input defaults to input row #4 (IN4).*
5) *Ahlborn modules respond only in the range - kk = 30-99 (1Eh to 63h) for A and B divisions and kk = 30-70 (1Eh to 46h) for the Pedal division.*

Table 31: Ahlborn Archive 'ROMANTIC' sound module commands for stops and couplers [16]

(These can be assigned to any input pin in slot 5, to pins 33-64 in slot 4, or to pins 62-64 in slots 1-4.)

Group	No.	Data sent Off ----> On	Data sent On ----> Off		Description		Note
		Controller 73	**Controller 74**		**Ahlborn ROMANTIC stops**		
0	0	Bn 49 00	Bn 4A 00	Pd	Contre Gamba	16'	1
	1	Bn 49 01	Bn 4A 01		Ophicleide	16'	
	2	Bn 49 02	Bn 4A 02		Contre Violone	32'	
	3	Bn 49 03	Bn 4A 03		Contre Bassoon	32'	
	4	Bn 49 04	Bn 4A 04		A/P coupler		
	5	Bn 49 05	Bn 4A 05		B to Pd coupler		
	6	Bn 49 06	Bn 4A 06	A	Cornopean	16'	
	7	Bn 49 07	Bn 4A 07		Cornet des Bombardes	IV	
	8	Bn 49 08	Bn 4A 08		Tuba Mirabilis	8'	
	9	Bn 49 09	Bn 4A 09		Clarion	4'	
	A	Bn 49 0A	Bn 4A 0A		Orchestral Oboe	8'	
	B	Bn 49 0B	Bn 4A 0B		Clarinet	8'	
	C	Bn 49 0C	Bn 4A 0C		French Horn	8'	
	D	Bn 49 0D	Bn 4A 0D		Cor Anglais	8'	
	E	Bn 49 0E	Bn 4A 0E		Cello	8'	
	F	Bn 49 0F	Bn 4A 0F		Cello Celeste	8'	
	10	Bn 49 10	Bn 4A 10		B to A coupler		
	11	Bn 49 11	Bn 4A 11	B	Quint Flute	2 2/3'	
	12	Bn 49 12	Bn 4A 12		Piccolo	2'	
	13	Bn 49 13	Bn 4A 13		Vox Humana	8'	
	14	Bn 49 14	Bn 4A 14		Open Diapason	8'	
	15	Bn 49 15	Bn 4A 15		Flauto Mirabilis	8'	
	16	Bn 49 16	Bn 4A 16		Concert Flute	4'	
	17	Bn 49 17	Bn 4A 17		A to B coupler		
	18	Bn 49 18	Bn 4A 18		A to Aux coupler		
	19	Bn 49 19	Bn 4A 19		B to Aux coupler		

NOTES:

1) n = Channel number used by Ahlborn stop On/Off messages, defaults to 16 (Fh).

2) Controls "A" or "B" division Tremulant on corresponding channel number used by Ahlborn divisions.

Table 32: Ahlborn Archive 'CLASSIC' sound module commands for stops and couplers on [16]

Group	No.	Data sent: Off ----> On	Data sent: On ----> Off		Description		Note
		Controller 73	**Controller 74**		**Ahlborn CLASSIC stops**		
3	1A	Bn 49 1A	Bn 4A 1A	Pd	Contre Gambe	16'	1
	1B	Bn 49 1B	Bn 4A 1B		Bombarde	16'	
	1C	Bn 49 1C	Bn 4A 1C		Contre Basse	32'	
	1D	Bn 49 1D	Bn 4A 1D		Contre Bombarde	32'	
	1E	Bn 49 1E	Bn 4A 1E	A	Corno di Bassetto	8'	
	1F	Bn 49 1F	Bn 4A 1F		Plein Jeu	IV-V	
	20	Bn 49 20	Bn 4A 20		Clarion	4'	
	21	Bn 49 21	Bn 4A 21		Festival Trumpet	8'	
	22	Bn 49 22	Bn 4A 22		Gemshorn Celeste	8'	
	23	Bn 49 23	Bn 4A 23		Koppelflote	4'	
	24	Bn 49 24	Bn 4A 24		Bombarde	16'	
	25	Bn 49 25	Bn 4A 25		Harmonic Trumpet	8'	
	26	Bn 49 26	Bn 4A 26		Gemshorn	8'	
	27	Bn 49 27	Bn 4A 27		Flute a Cheminee	8'	
	28	Bn 49 28	Bn 4A 28	B	Flute Octaviante	4'	
	29	Bn 49 29	Bn 4A 29		Octave	2'	
	2A	Bn 49 2A	Bn 4A 2A		Cymbale	III	
	2B	Bn 49 2B	Bn 4A 2B		Principal	8'	
	2C	Bn 49 2C	Bn 4A 2C		Holzgedackt	8'	
	2D	Bn 49 2D	Bn 4A 2D		Flute Harmonique	8'	

NOTES:
1) n = Channel number used by Ahlborn stop On/Off messages, defaults to 16 (Fh).
2) *Controls "A" or "B" division Tremulant on corresponding channel number used by Ahlborn divisions.*

Table 33: Ahlborn Archive '202' sound module commands for stops and couplers [16]

Group	No.	Data sent: Off ----> On	Data sent: On ----> Off		Description		Note
		Controller 73	**Controller 74**		**Ahlborn 202 stops:**		
	2E	Bn 49 2E	Bn 4A 2E	Pd	Soubasse	32'	1
	2F	Bn 49 2F	Bn 4A 2F		Violone	16'	
	30	Bn 49 30	Bn 4A 30		Contrebombarde	32'	
	31	Bn 49 31	Bn 4A 31		Bombarde	16'	
	32	Bn 49 32	Bn 4A 32	A	Contregambe	16'	
	33	Bn 49 33	Bn 4A 33		Diapason	8'	
	34	Bn 49 34	Bn 4A 34		Quintadena	8'	
	35	Bn 49 35	Bn 4A 35		Terz	1 3/5'	
	36	Bn 49 36	Bn 4A 36		Septime	1 1/7'	
	37	Bn 49 37	Bn 4A 37		Scharff	III	
	38	Bn 49 38	Bn 4A 38		Bombarde	16'	
	39	Bn 49 39	Bn 4A 39		Trompette	8'	
	3A	Bn 49 3A	Bn 4A 3A		Tuba Mirabilis	8'	
	3B	Bn 49 3B	Bn 4A 3B		Chimes		
	3C	Bn 49 3C	Bn 4A 3C	B	Bourdon	8'	
	3D	Bn 49 3D	Bn 4A 3D		Flute Harmonique	8'	
	3E	Bn 49 3E	Bn 4A 3E		Flute Octaviante	4'	
	3F	Bn 49 3F	Bn 4A 3F		Larigot	1 1/3'	
	40	Bn 49 40	Bn 4A 40		Corno di Bassetto	8'	
	41	Bn 49 41	Bn 4A 41		Clarion	4'	

NOTES:
1) n = Channel number used by Ahlborn stop On/Off messages; defaults to 16 (Fh).
2) Controls "A" or "B" division Tremulant on corresponding channel number used by Ahlborn divisions.

Table 34: Ahlborn Archive '201' sound module commands for stops and couplers [16]

Group	No.	Data sent: Off ----> On	Data sent: On ----> Off		Description		Note
		Controller 73	**Controller 74**		**Ahlborn 201 stops:**		
	42	Bn 49 42	Bn 4A 42	Pd	Subbass	16'	1
	43	Bn 49 43	Bn 4A 43		Octave	8'	
	44	Bn 49 44	Bn 4A 44		Bourdon	8'	
	45	Bn 49 45	Bn 4A 45		Posaune	16'	
	46	Bn 49 46	Bn 4A 46	A	Bourdon	16'	
	47	Bn 49 47	Bn 4A 47		Principal	8'	
	48	Bn 49 48	Bn 4A 48		Flute a Cheminee	8'	
	49	Bn 49 49	Bn 4A 49		Unda Maris	8'	
	4A	Bn 49 4A	Bn 4A 4A		Octave	4'	
	4B	Bn 49 4B	Bn 4A 4B		Spitzflote	4'	
	4C	Bn 49 4C	Bn 4A 4C		Nasard	2 2/3'	
	4D	Bn 49 4D	Bn 4A 4D		Superoctave	2'	
	4E	Bn 49 4E	Bn 4A 4E		Mixture	IV	
	4F	Bn 49 4F	Bn 4A 4F		Trompete	8'	
	50	Bn 49 50	Bn 4A 50	B	Gedackt	8'	
	51	Bn 49 51	Bn 4A 51		Gamba	8'	
	52	Bn 49 52	Bn 4A 52		Nachthorn	4'	
	53	Bn 49 53	Bn 4A 53		Cymbale/Scharff	III	
	54	Bn 49 54	Bn 4A 54		Cornet	III	
	55	Bn 49 55	Bn 4A 55		Oboe	8'	
	56	Bn 49 7F	Bn 4A 7F		All stops On / Off		
					Ahlborn Tremulants:		
	57	Bn 5C 7F	Bn 5C 00		Swell Tremulant		2
	58	Bn 5C 7F	Bn 5C 00		Great Tremulant		2
	59	Bn 5C 7F	Bn 5C 00		Choir Tremulant		2

NOTES:
1) n = Channel number used by Ahlborn stop On/Off messages, defaults to 16 (Fh).
2) Controls "A" or "B" division Tremulant on corresponding channel number used by Ahlborn divisions.

Table 35: Ahlborn Archive sound module Piston and Crescendo input functions [16]

Group	No.	Data sent: Off ----> On	Data sent: On ----> Off		Description		Note
	A0	CF 20			Ahlborn - General Cancel		1
	81	CF 01			Ahlborn - Mem. A Gen. #1		2
	82	CF 02			Ahlborn - Mem. A Gen. #2		
	83	CF 03			Ahlborn - Mem. A Gen. #3		
	84	CF 04			Ahlborn - Mem. A Gen. #4		
	85	CF 05			Ahlborn - Mem. A Gen. #5		
	86	CF 06			Ahlborn - Mem. A Gen. #6		
	87	CF 07			Ahlborn - Mem. B Gen. #1		
		…….			etc.		
	9E	CF 1E			Ahlborn - Mem. E Gen. #6		
	E4	CF 64			Cancel Crescendo		
	E5	CF 65	CF 64		Crescendo Stage #1 / Off		3
	E6	CF 66	CF 65		Crescendo Stage #2 / 1		
	E7	CF 67	CF 66		Crescendo Stage #3 / 2		
		…….			etc.		
	EF	CF 6F	CF 6E		Crescendo Stage #11/10		
	F7	CF 77	CF 6F		Crescendo Stage #12/11		
	F8	CF 78	CF 77		Crescendo Stage #13/12		
		…….			etc.		
	FF	CF 7F	CF 7E		Crescendo Stage #20/19		

NOTES:

1) *Prog#1 (00h) on the Control Channel will actually act as a "Recall Hand Registration", but will correspond to a General Cancel if hand registration is not used.*
2) *Ahlborn Archive Modules have 6 Programmable Presets on each of 5 Memory levels, accessed by sending Prog#1-30 (01h - 1Eh).*
3) *These functions are presumed to be connected to a "shade roller" Crescendo switch, which provides sequential switch closures and releases. These messages can also be generated by an analog input.*

Table 36: Ahlborn Archive sound module additional Piston input commands [16]

Group	No.	Data sent: Off ----> On	Data sent: On ----> Off		Description		Note
	5A	Cn 40			Ahlborn – Division Cancel		1
	5E	BF 47 46	BF 47 06		SET piston		2
	5F	BF 47 42	BF 47 02		SFZ control		3

NOTES:

1) *Prog. Change 51-85 (32h - 54h) on a Division Channel (1-4) will actually act as a Divisional Cancel.*
2) *Works with General Pistons to allow their setting via remote (MIDI) control, i.e., press & hold SET, press and release a General, then release SET, to store a new registration.*
3) *Should allow for a lamp output for this. In addition, possibly another input function that would act as a "reversible"; i.e., push-ON, push-OFF.:*
4) *n = Channel number used by Ahlborn stop On/Off messages; defaults to 16 (Fh).*

Table 37: Ahlborn Archive and other MIDI sound modules Analog input function commands [16]

Input		Data sent	Function		Description		Note
'ANALOG IN 1,2,3'		B0 07 aa		Sw	Ahlborn – Division Volume		1
'ANALOG IN 1,2,3'		B1 07 aa		Gt	Ahlborn – Division Volume		1
'ANALOG IN 1,2,3'		B2 07 aa		Ch	Ahlborn – Division Volume		1
'ANALOG IN 1,2,3'		B3 07 aa		Pd	Ahlborn – Division Volume		1
'ANALOG IN 4'		Bn 65 00 64 01 06 xx 26 yy	Tuning		Tuning and/or Temperature Sensor		2
'ANALOG IN 5'			Not used		Not used		
'ANALOG IN 6'		CF ss	Crescendo		Crescendo		3

NOTES:

1) *Ahlborn modules use Controller #7 for expression. Outputs on Ahlborn channels (1-4) must be configurable, connecting to Analog inputs 1-3. aa = volume value from an analog input, where 0<aa<127.*
2) *Analog input #4 is dedicated to tuning. It should be configurable to allow a temperature sensor to be connected, which would use 2/3 of the available +/- tuning range, in which case the tuning pot would have reduced sensitivity (1/3). Tuning is sent as a 14-bit value with 7-bit MSB (xx) and 7-bit LSB (yy)*
3) *"ss" is the Crescendo stage, where Off=64h, Stage#1=65h, #2=66h, etc., #11=6Fh, #12=77h, #13=78h, etc., #20=7Fh.*

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14. APPENDIX F: SCPOP Messages

Table 38: General MIDI Pipe Organ Emulation Upper Manual for SCPOP

(General MIDI patch commands converted from SYSEX messages of SCPOP) [17]

Upper Manual [using Parts 1-6]							
1	Principale 8	GM Patch	73	77	78		
		Volume	110	70	60		
		Panning	R10	L10	0		
		Reverb	100	100	80		
		Key Shift	-12	-12	-12		
2	Flauto cuspide 8	GM Patch	74	85			
		Volume	100	80			
		Panning	R15	L15			
		Reverb	100	100			
		Key Shift	-12	-12			
3	Principali 16-8	GM Patch	73	77	78	74	
		Volume	110	70	60	100	
		Panning	R10	L10	0	0	
		Reverb	100	100	80	80	
		Key Shift	-12	-12	-12	-24	
4	Fondi 16-4	GM Patch	73	77	78	74	
		Volume	105	70	60	95	
		Panning	R10	L10	0	0	
		Reverb	76	100	80	80	
		Key Shift	0	-12	-12	-24	
5	Flauti 8-4	GM Patch	74	78	74		
		Volume	90	80	105		
		Panning	R15	L15	0		
		Reverb	100	100	100		
		Key Shift	-12	0	0		
6	Fondi 16-2	GM Patch	73	77	78	74	
		Volume	110	80	80	95	
		Panning	R10	R10	L10	0	
		Reverb	115	100	80	80	
		Key Shift	12	-12	-12	-24	
7	Fondi 8-2	GM Patch	74	78	75		
		Volume	90	85	100		
		Panning	R15	L15	0		
		Reverb	100	100	105		
		Key Shift	-12	0	12		

General MIDI Pipe Organ Emulation Upper Manual for SCPOP, Cont'd.

Upper Manual [Using parts 1-6]								
8	Fondi 8-2-1	GM Patch	74	78	75	73		
		Volume	90	100	95	90		
		Panning	R10	L10	L20	R20		
		Reverb	100	100	110	100		
		Key Shift	-12	0	12	24		
9	Mutazioni 2	GM Patch	74	78	76	75		
		Volume	95	100	95	100		
		Panning	0	0	R24	L24		
		Reverb	100	100	100	110		
		Key Shift	-12	-12	7	12		
10	Mutazioni 1	GM Patch	74	78	75	76	73	
		Volume	90	106	90	90	80	
		Panning	0	L15	R12	L25	R25	
		Reverb	90	100	100	110	110	
		Key Shift	-12	0	0	19	24	
11	Mutazioni in Terza	GM Patch	76	74	78	75	73	
		Volume	80	100	105	85	85	
		Panning	0	R10	L10	L63	R63	
		Reverb	110	90	90	100	100	
		Key Shift	16	-12	-12	12	12	
12	Pienino	GM Patch	78	79	20	73	76	
		Volume	100	70	85	80	82	
		Panning	0	0	0	R20	L20	
		Reverb	100	90	100	110	100	
		Chorus	0	3	0	0	0	
		Key Shift	-12	-12	-12	12	19	
13	Ripieno Leggero	GM Patch	74	79	20	73	76	
		Volume	105	110	110	110	115	
		Panning	L15	R12	R30	0	L30	
		Reverb	90	90	110	100	110	
		Chorus	0	3	0	0	0	
		Key Shift	-12	-12	12	0	19	
14	Ripieno forte	GM Patch	74	20	74	20	21	76
		Volume	120	124	112	107	109	100
		Panning	0	0	0	L30	R10	R30
		Reverb	90	80	90	110	110	0
		Chorus	3	0	0	0	0	0
		Key Shift	0	-12	-24	19	7	24
15	Grand Jeux	GM Patch	58	20	74	73	59	73
		Volume	125	125	110	110	120	110
		Panning	0	L24	0	L44	R24	R44
		Reverb	85	100	80	100	85	100
		Chorus	3	0	0	0	0	0
		Key Shift	-12	0	-12	24	0	19

General MIDI Pipe Organ Emulation Upper Manual for SCPOP, Cont'd.

Upper Manual [Using parts 1-6]								
16	Petit Jeux	GM Patch	58	20	73	73	70	73
		Volume	115	100	95	95	115	90
		Panning	R12	0	R24	L24	L12	0
		Reverb	105	100	103	103	105	100
		Reverb	3	0	0	0	0	0
		Key Shift	-12	-12	0	7	-12	19
17	Recit des Ances	GM Patch	58	70	67			
		Volume	105	90	120			
		Panning	2	L20	R20			
		Reverb	100	100	100			
		Key Shift	-12	-12	-12			
18	Salicionale 8	GM Patch	75	75	76			
		Volume	85	85	45			
		Panning	R63	L63	0			
		Reverb	115	115	100			
		Key Shift	0	0	0			
19	Principale 8 in Tremolo	GM Patch	73	77	76			
		Volume	110	70	60			
		Panning	R10	L10	0			
		Reverb	100	100	80			
		Key Shift	-12	-12	-12			

Table 39: General MIDI Pipe Organ Emulation Lower Manual SCPOP

(General MIDI patch commands converted from SYSEX messages of SCPOP) [17]

Lower Manual [using Parts 7-11]							
1	Flauto Camino 8	GM Patch	74	74	76		
		Volume	85	85	80		
		Panning	R63	L63	0		
		Reverb	103	103	95		
		Key Shift	-12	-12	0		
2	Quintadena 8	GM Patch	73	76	77	73	
		Volume	75	80	51	75	
		Panning	R63	0	0	L63	
		Reverb	90	90	90	90	
		Key Shift	-12	-12	0	-12	
3	Flauti 8-4	GM Patch	74	76	74	74	
		Volume	85	75	85	85	
		Panning	L63	R12	R63	L12	
		Reverb	100	90	100	90	
		Key Shift	0	0	0	-12	
4	Flauti 16-4	GM Patch	74	74	76		
		Volume	95	85	75		
		Panning	R20	L20	0		
		Reverb	90	103	80		
		Key Shift	-24	0	0		
5	Fondi 8-2	GM Patch	76	73	74	74	
		Volume	75	82	82	82	
		Panning	L15	R63	L63	R15	
		Reverb	90	100	100	90	
		Key Shift	0	12	12	-12	
6	Fondi 4-2	GM Patch	73	74	77	73	76
		Volume	80	100	90	100	60
		Panning	L63	R63	0	0	0
		Reverb	103	103	103	110	103
		Key Shift	12	12	12	0	12
7	Septade	GM Patch	76	74	73	74	
		Volume	80	80	45	100	
		Panning	L15	0	0	R15	
		Reverb	103	103	80	103	
		Key Shift	0	24	14	-12	
8	Nazardo	GM Patch	76	74	80	79	80
		Volume	90	100	90	100	80
		Panning	0	L20	0	R20	0
		Reverb	90	100	115	90	100
		Key Shift	0	0	7	-12	19
9	Fondi 8-4-1	GM Patch	74	76	73		
		Volume	100	100	100		
		Panning	R15	L15	0		
		Reverb	100	100	105		
		Key Shift	-12	12	24		

General MIDI Pipe Organ Emulation Lower Manual SCPOP, Cont'd.

10	Sesquialtera	GM Patch	76	73	73	74	73
		Volume	105	100	53	100	105
		Panning	L15	L24	R24	0	R15
		Reverb	100	100	90	90	100
		Key Shift	0	7	23	-12	0
11	Pienino Flauti	GM Patch	76	73	73	74	74
		Volume	95	70	70	100	85
		Panning	L15	L63	R63	R10	0
		Reverb	90	100	100	90	100
		Key Shift	0	24	24	-12	0
12	Ripieno I	GM Patch	73	76	73	73	20
		Volume	90	100	90	85	80
		Panning	0	0	0	L35	R30
		Reverb	100	100	100	100	100
		Key Shift	-12	0	0	19	12
13	Ripieno II	GM Patch	74	76	73	73	20
		Volume	105	120	115	110	105
		Panning	0	0	0	L35	R35
		Reverb	100	90	110	110	110
		Key Shift	-12	0	7	24	0
14	Cromorno	GM Patch	60	70			
		Volume	110	100			
		Panning	0	0			
		Reverb	115	115			
		Key Shift	-12	-12			
15	Jeux	GM Patch	70	74	73	60	73
		Volume	120	110	120	127	105
		Panning	R20	0	0	L20	0
		Reverb	103	95	103	103	115
		Key Shift	-12	-12	0	-12	19
16	Jeux Doux	GM Patch	70	76	73	60	
		Volume	110	110	125	115	
		Panning	L12	0	0	R12	
		Reverb	103	100	90	103	
		Key Shift	-12	-12	-12	-12	
17	Vox Umana 8	GM Patch	73	74	76		
		Volume	75	75	55		
		Panning	R12	L12	0		
		Reverb	95	95	95		
		Chorus	3	0	0		
		Key Shift	-12	-12	-12		
18	Flauto 4 in Tremolo	GM Patch	73	73	76		
		Volume	85	85	70		
		Panning	R63	L63	0		
		Reverb	127	127	70		
		Key Shift	0	0	0		

Table 40: General MIDI Pipe Organ Emulation Pedals SCPOP

(General MIDI patch commands converted from SYSEX messages of SCPOP) [17]

Pedals [using parts 12-16]							
1	Principale 16	GM Patch	74	74	73		
		Volume	95	85	80		
		Panning	0	R12	L12		
		Reverb	91	91	91		
		Key Shift	-24	-12	-12		
2	Subbasso 16	GM Patch	73	79	74		
		Volume	110	110	105		
		Panning	0	0	0		
		Reverb	65	80	80		
		Key Shift	-24	-12	-24		
3	Fondi 16-8	GM Patch	74	74	73	73	76
		Volume	90	75	80	100	60
		Panning	0	L63	0	R63	0
		Reverb	91	91	91	90	90
		Key Shift	-24	-12	-12	-12	0
4	Quintadena	GM Patch	73	79	74	73	
		Volume	110	110	105	100	
		Panning	0	0	0	0	
		Reverb	65	80	80	80	
		Key Shift	-24	-12	-24	0	
5	Fondi 16-4	GM Patch	74	74	73	73	74
		Volume	95	90	68	100	95
		Panning	0	L36	0	R36	0
		Reverb	90	90	90	90	90
		Key Shift	-12	0	-12	0	0
6	Ancia da 8	GM Patch	74	74	73	59	65
		Volume	90	75	70	80	100
		Panning	0	0	0	R12	L12
		Reverb	91	91	91	90	90
		Key Shift	-24	-12	-12	0	0
7	Ripieno I	GM Patch	74	74	73	20	73
		Volume	90	125	80	112	110
		Panning	0	0	0	L20	R20
		Reverb	105	110	90	110	100
		Key Shift	7	-12	-12	-12	12
8	Ripieno II	GM Patch	58	73	74	20	20
		Volume	125	90	120	120	120
		Panning	0	0	0	L63	R63
		Reverb	120	110	115	125	125
		Key Shift	-12	-12	0	0	0
9	Tutte le Ancie	GM Patch	20	73	73	70	59
		Volume	120	90	70	86	115
		Panning	0	0	0	L48	R48
		Reverb	125	110	100	125	127
		Key Shift	-12	-12	-12	0	0

MIDI CONTROL UNIT MCU-1

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