M100 MIDI Interface

Figure 1

Introduction

The M100 MIDI Interface is a module ready to receive incoming MIDI messages from any MIDI equipment like musical keyboards, sequencers, MIDI controlers, etc. Figure 1 shows a summary of the module's front panel.

This circuit closes the gap when you want to control your older analog synthesiser with MIDI. As long as your instrument has volt/oct response and Gate inputs you can use this module. The unit uses 12 precises MAX551 12 bits DAC's for maximum precision and reliability with temperature. The actual firmware brings the following possibilities:

Polyphony: 6 voices in polyphonic MODE

Monophony: 6 CV's outs and Gates outs have same values.
This MODE brings **Pitch Bend**, **Mod Wheel**, **Aftertouch** and **CC0**, **CC1** availables to their connectors replacing Mono velocity 2-6 outs.

Gates: +8v gates

Pitch CV's: 10 octaves (120 steps) of 12 bits accurate pitch voltages
That conforms to 1V/octave standard.

Velocities: 0 to 5v proportional to MIDI note on velocities

Pitch Bend: -5v to +5v proportional to pitch bend wheel position with 12 bits accuracy. 0v corresponds to a centred wheel. Front panel control adjustable. (Monophonic MODE only)

Modulation: 0 to 5v proportional to modulation wheel position. Front panel control adjustable. (Monophonic MODE only)

Aftertouch: 0 to 5v proportional to MIDI channel aftertouch. (Monophonic MODE only)

CC0, CC1: 0 to 5v proportional to MIDI selected Continuous Controller. Can be selected via DIP switches on PCB for each CC0 and CC1. (Monophonic MODE only)

Tune: Front panel control adjustable from -6 to +6 semitones.

Arpeggio: Arpeggio effect available in MODE positions 4 to 8. Front panel speed control from 1.7 seconds to 100msec.

MODE:

position	Function
1	Learn MODE
2	Monophonic
3	Polyphonic 6 voices (no arpeggio)
4	Polyphonic 6 voices (ascending arpeggio)
5	Polyphonic 6 voices (descending arpeggio)
6	Polyphonic 6 voices (ascend/descend arpeggio)
7	Polyphonic 6 voices (descend/ascend arpeggio)
8	Polyphonic 6 voices (random arpeggio)

Portamento: Front panel control adjustable from 0.4msec. to 6 seconds. (with IN/OUT switch)

MIDI: MIDI In and Thru connectors availables.

Features

The design features a PIC16F877 running at 20Mhz. The use of the onboard UART allows it to process MIDI far more efficiently. The processor scans 12 high precision MAX551 12 bits DAC's for all the CV's and voltage controls making it very reliable and stable. The circuit also includes 6 X 1meg digital pots for portamento effects on all 6 polyphonic voices making the design quite special. As stated above the standard 1V/oct scale is used here so please note this product does not support the use of V/Hz or linear VCOs.

The MIDI interface features a built in MIDI THRU connector to produce a copy of the MIDI input signal which can be rerouted to another MIDI device.

Learn MODE features: (MODE switch position 1)

Learn incoming MIDI channel:
In this position the last incoming MIDI signal will be read and it's MIDI channel number (1 to 16) will be registered for uses in the MIDI Interface.
Low-Key Transpose:
Most digital keyboards assign the midi note number 36 to their lowest key.
Well for my M100 MIDI Interface, MIDI note 36 corresponds to 3 octaves above the lowest MIDI key, so it produces a 3.00vdc Pitch CV.
To most analog keyboards, 3vdc corresponds to the key 3 octaves above the lowest (0vdc) key. Consequently, oscillators pitched for use with an analog keyboard will play three octaves higher on a digital keyboard.
My M100 has by default a Low Key Transpose at startup that transposes the lowest key on any 61 keys MIDI keyboard to 0vdc. output to make them behave like analog keyboard in front of a 'standard' modular VCO.
If you want complete normal control from a MIDI note generator (like a sequencer) MIDI notes 0 to 127 should be read.
So you will need to de-activate the Low-Key Transpose feature.

To de-activate this feature and regain standard MIDI note# to CV relationship do the following:
-Put the MODE selector switch at position #1
-Press any of the keyboard key (this only read the MIDI channel)
-Toggle the PORTAMENTO OUT/IN switch OUT-IN-OUT or IN-OUT-IN
(depending on the original toggle switch position)
The MIDI IN led will blink 3 times to acknowledge the Low-Key Transpose feature has been de-activated.
-Put the MODE selector switch at any other position that position #1
Now the lowest C key MIDI note#36 generates 3.00vdc.

To re-activate Low-Key Transpose feature do the following:
-Put the MODE selector switch at position #1
-Press any of the keyboard key (this only read the MIDI channel)
-Put the MODE selector switch at any other position that position #1
Now the Low-Key Transpose feature is back !
That's it !

Monophonic MODE features: (MODE switch position 2)
There is a note stack within the firmware to allow the MIDI interface to remember notes pressed earlier. So if two or more notes are pressed at the same time, the oldest notes will be remembered so that if the more recent notes are removed the pitch will return to the still pressed older notes.
In this case 'retriggering' the gate is present when changing monophonic notes. That means that whenever a note is released and an oldest one starts back the 6 gate outputs will go low for 1msec then back to high to retrigger whatever is connected to the gates outs.

Polyphonic MODE features: (MODE switch position 3 to 8)

In this MODE up to 6 voices can be played at the same time
and the Interface will capture the 1V/oct CV, velocity and Gate
for each played note. **Since velocities 1,4,5,6 are directly wired to the DAC's but velocities 2 & 3 pass thru the Pitch Bend level & Mod Wheel Levels pots, for a normal Polyphonic play both pots should be put to MAX to get 0-5vdc velocities outputs like vel 1,4,5,6 do.**

Arpeggio:
This brings 6 possible Arpeggio behaviours.
Here are explained the 6 switch positions:

3 Polyphonic 6 voices (no arpeggio)
4 Polyphonic 6 voices (ascending arpeggio)
5 Polyphonic 6 voices (descending arpeggio)
6 Polyphonic 6 voices (ascend/descend arpeggio)
7 Polyphonic 6 voices (descend/ascend arpeggio)
8 Polyphonic 6 voices (random arpeggio)

Note that the order the notes are arpeggio played is the scale order and not the historical played order. To understand this lets suppose we play all the following notes in that order:

D#1,C#1,C1,E1,D1 (these 5 notes are held down)

In the ascending Arpeggio MODE it will play using this order:
C1,C#1,D1,D#1,E1

In the descending Arpeggio MODE it will play using this order:
E1,D#1,D1,C#1,C1

If the player removes some notes and play others the arpeggio
will sorts all the new list of played notes and play them
in the scale order. In that way, ascending and descending arpeggio
mean something.

Power requirements

The MIDI interface requires a split supply of +/-15vdc @ +82mA/-65mA for analog section and a separate +5vdc @ 17-55mA for digital. 2 sets of 0V or ground are required so both analog and digital grounds are ONLY wired together at the power supply ground bus pin using 'STAR' connection for noise consideration. Do not connect nearby supply connector ground wires to the MIDI interface. Connect the interface supply connector directly to the power supply output pins and join both analog and digital grounds ONLY at supply common pin to keep the analog and ground path separately.

The printed circuit board

The PCB has been designed to fit behind a 4U Moog style front panel. It is a double side board 7" X 8" and is mounted using 4-40 1.5" hexa standoffs to keep accessibles all the onboard trimmers. All the wirings are hidden behind the PCB connecting all the needed controls mounted on front panel. All the parts are through hole types. Only the AD5242 digital pots are SMT type. Power is connected by use of a 6 pins 0.156" Molex type connector. The PCB has 4 mounting holes, one on each corner.

The MIDI data is electrically isolated by U5, a high speed logic output opto-coupler PC900V. The U5 output goes back to Q1, Q2 MIDI thru driver to be used again if needed. Then the incoming MIDI signal goes to U1, a PIC16F877 the micro-controler to be buffered for later use by the software. The software do a 'polling' of all its connected controls and scans/refresh the onboard 12 MAX551 DAC's to get all the sampled control voltages to the needed outputs like CV1-6, velocity1-6, Pitch Bend, Mod Wheel, After touch, CC0,CC1. The scan is helped thru the use of U2, a 74HC154 4 to 16 line decoder chip. This IC scans all the 12 DAC's and refreshes their new received values.

DAC circuits decriptions:
All DAC circuits are mostly using the same approach. They are made of a MAX551 DAC's. These are current output multiplying DAC's. A very precise +5v reference chip, U3 is used to feed all the DAC's for stable and accurate readings.
The MAX551 are refreshed by SPI datas coming from U1. The data is latched inside the DAC then outputed by the use of a current amplifier opamp. The result is a 12bits precise 0 to -5v value.

Note here that this approach is different from most of the 'multiplexed outputs' MIDI2CV converters that use only one DAC and charge a serie of capacitors using a multiplexer chip like the CD4051 to keep the CV values and must constantly refresh the capacitors voltages to keep them correct. The MIDI Interface has rock solid CV values that don't need to be refreshed to keep their values .

For the 6 X 1V/oct sections that voltage is passed thru a summing and inverting amp to bring back the voltage value to 0 to +5v. The voltage is tuned and fine tuned by the use of the P12 TUNE front panel pot and P13 FINE TUNE trimmer on the PCB. When the TUNE pot is centered on the front panel, P13 is used to adjust the final output to the right calibrated value for this position. An adjustment procedure is described later in this document. The 0 to +5v value is then fed thru a low pass path made of a 1meg digital pot and A 1Uf capacitor to produce a sliding effect whenever needed by the use of the Portamento front panel control. A switch can switch IN/OUT this effect. The digital pots U21, 22, 23 are I2C controlled SMT parts and are scanned like the DAC's to be refreshed with the most recent portamento value. The 0 to 5v value is then fed to a non-inverting opamp that has a gain of 2 bringing the final CV value to 0 to 10v with a 1V/oct scale.

The 6 other DAC circuits (U24,26,28,30,32,34) use the same DAC/current opamp approach bringing a 0 to -5v value but then use only one inverting opamp to Get a final value of 0 to +5v at the output connectors. Modifications have been made to the Pich Bend and Mod Wheel circuits though. The Pitch Bend output needs to be trimmed at the Keyboard's Pitch Bend rest position. That means P14 needs to be adjusted for a 0.00 output Pitch Bend value when the Pitch wheel is not used (rest position). Both Pitch Bend and Mod Wheel outputs can be adjusted 0-100% using their respective front panel controls.

The printed circuit board (continued)

The following controls are read using the PIC16F877 A/D inputs:
Arpeggio speed, MODE switch, Portamento.

Finally the 6 Gate outputs are made using NPN transistors and bring 8v pulses when MIDI notes are actives. They are also displayed by 6 LEDS on front panel. Incoming MIDI notes are shown by a LED close to the MIDI IN connector.
The Arpeggio speed is also shown by the use of a LED close the speed control.

CC0, CC1 DIP switches settings:

In Monophonic MODE the CC0 and CC1 outputs can be configured to respond to some type of Continuous Controller messages. Any message will result in a 0-5vdc output. Here are the settings for each supported types for CC0 & CC1 pictured in Figure 2: (dip switches all closed = 0, all open = 15)

Possible Controller 0..15

00 Bank select
01 Modulation wheel
02 Breath control
03 Continuous Controller #3
04 Foot Controller (coarse)
05 Portamento Time (coarse)
06 Data Entry Slider (coarse)
07 Main Volume (coarse)
08 Stereo Balance (coarse)
09 Continuous Controller #9
10 Pan (coarse)
11 Expression (Sub volume) (coarse)
12 Effect control #1 (coarse)
13 Effect control #2 (coarse)
14 Continuous Controller #14
15 Continuous Controller #15

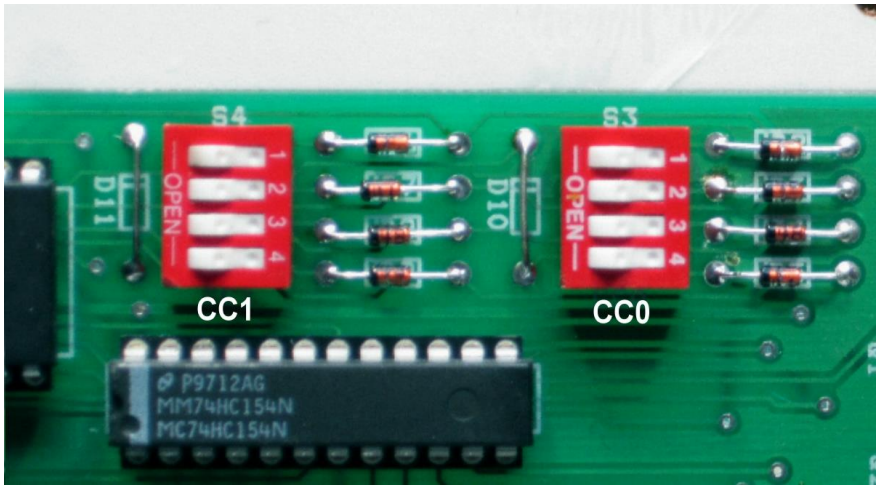

Figure 2

Adjustments and trimmings:

To trim the 6 X 1V/oct CV outputs follow the below procedure:

1 - Power up the MIDI Interface with a stable +/-15v, +5vdc power supply.
2 - Put the MODE switch to Learn position #1.
3 - Connect a MIDI keyboard to the MIDI input connector. The following example is for a 5 octaves (61 notes) keyboard.
4 - Power up the keyboard and hit any key on the keyboard (to read the MIDI channel number and store it in the Interface).
5 - Put the MODE switch to Monophonic position #2.
6 - Press the most left key (MIDI C3 note).
7 - Connect a precise voltmeter with at least 3 ½ digits resolution to the CV out#1 connector and read the voltage value. The value should be around 0vdc (ex: +0.012v).
8 - Hit the very last key (MIDI C8 note). Theoriticaly you should expect the value to be 5 volts higher than C3, (ex: +8.012v).
9 - Adjust P3 to get exactly a difference of 5.00vdc within 1% precision between C3 and C8 readings.
10 - Do the same procedures starting from step 6 to 9 for CV2,3,4,5,6 and adjust the specific trim pot for that voice (P4,5,6,7,8).
11 – Now all the 6 CV outputs have precise 1V/oct range.

To trim TUNE Center:

12 – Connect the voltmeter to CV#1
13 – Hit the very first left note again (MIDI C3 note)
14 – Put the front panel TUNE potentiometer to 0 position
15 – Adjust the P13 fine tune trimmer on the PCB to get 0.00v at CV#1 out.

At this point ALL the 6 CV outputs should have 1V/oct output precision adjusted To 0.00vdc at MIDI C3 note. Hitting C8 should give you a 5.00v reading.

Adjusting the Pitch Bend output:

1 - Power up the MIDI Interface with a stable +/-15v, +5vdc power supply.
2 - Put the MODE switch to Learn position #1.
3 - Connect a MIDI keyboard to the MIDI input connector.
4 - Power up the keyboard and hit any key on the keyboard (to read the MIDI channel number and store it in the Interface).
5 - Put the MODE switch to Monophonic position #2.
6 – With no note played and the Pitch Bend wheel at rest position adjust P14 trimmer for 0.00vdc at Pich Bend/Velocity#1 output.

At this point the Pitch Bend wheel should give +5.00vdc at Max position
And –5.00vdc at Minimum position. 0volt at center.
No more adjustment needed.

February, 2012
Jean-Pierre Desrochers
ArcEnSon inc.

Specifications:

- Up to 10 octave keyboard range (0-10vdc)for standard 1V/oct ratio
- Learn MODE 'reads' the incoming MIDI channel number and keeps it, De-activation or Activation of Low-Key transpose feature.
- Fast response - valid CV and Gate voltages appear 0.4ms after MIDI transmission ends.
- Voltages are generated with 12 bits precision DAC's better than 0.2 cent (1/100 of a semitone) at 1V/oct ratio
- Tune (semitones) potentiometer to adjust +/- 6 semitones to all CV outs
- Portamento control from 0.4msec to 6 seconds (with ON/OFF switch)
- Polyphonic arpeggio speed control
- Monophonic MODE brings the following possibilities:
    - All the 6 CV outs represent the last played note pitch, while the 6 GATE outs control the last played note duration.
    - Velocity#1 follows the last played note velocity
    - Velocity#2 becomes Pitch Bend with full 14-bit resolution, adjustable with Pitch Bend potentiometer. (+/- 5vdc, 0vdc at rest)
    - Velocity#3 becomes Modulation Wheel, adjustable with Mod Wheel potentiometer. (0 to +5vdc)
    - Velocity#4 becomes After Touch of the last note played (0 to +5vdc)
    - Velocity#5 Continuous Controler 0 (assignable using rear DIP switch)
    - Velocity#6 Continuous Controler 1 (assignable using rear DIP switch)
- Polyphonic MODE brings the following possibilities:
    - For each 6 voices: CV out represent the 1v/oct pitch, the other velocity, while GATE out control the note duration.
    - Arpeggio speed from 100msec. To 1.7 seconds
    - Arpeggio directions: UP, DOWN, UP/DOWN, DOWN/UP, RANDOM
- 8 Leds help user to keep signals condition
- Accepts one of 16 MIDI channels using Learn MODE
- Moog standard 4U size.

ELECTRONIC SPECIFICATIONS

POWER CONNECTOR PIN ASSIGNMENTS

1	-15V
2	A GND
3	A GND
4	+15V
5	D GND
6	+5V

Panel Size: 4 units width 8.50"w x 8.75"h.
Portamento Range: 0.4ms – 6 sec
Arpeggio speed Range: 1.7sec. to 100ms
CV outputs Range: 0 – 10vdc (1v/oct).
Velocity Range: 0-5 volts
Gate Level: 0-8 volts
Pitch Bend Range: -5v / +5v, (0v at rest)
Mod Wheel Range: 0-5volts
CC0, CC1 Range: 0-5volts

Power:
+15V @ 82mA,
-15V @ 65mA,
+5V @ 17-55mA.

ArcEnSon