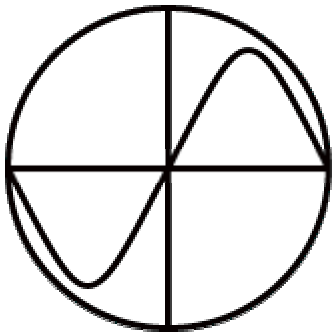

synthesis technology

MOTM-650 4 Channel MIDI→CV Converter User's Guide Firmware Version 1.4

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GENERAL INFORMATION

Thank you for purchasing the MOTM-650 4CH MIDI-CV Converter. If you have any issues concerning the use of the MOTM-650, please contact us at (888) 818-MOTM or by email: synth1@airmail.net

TROUBLESHOOTING GUIDE

If your MOTM-650 does not work as expected, keep in mind the MOTM-650 is a complex modal device, and more often than not, problems encountered are related to a higher level feature set to an unexpected value.

THEORY OF OPERATION

The MOTM-650's functionality is provided by an Atmel AT89C51RD2 embedded CPU, a version of the 8051. Its built-in UART is used to send and receive MIDI data, and its internal clock is used to drive the 650's two arpeggiators. Its internal FLASH memory makes it possible to update the chip's firmware via MIDI. The chip has numerous inputs and outputs which are used to read the front panel buttons and the clock input, to control the LCD, and to drive the gate outputs & LEDs. The CPU also has an SPI interface which is used to talk to the two analog-to-digital converters (ADCs).

The four main CV outputs are provided by an AD5541 16-bit ADC. Its output is fed into a DG408 4-channel analog demultiplexer, which provides four control voltage (CV) outputs from the in turn feeds four AD822 dual op-amps. The AD822s sample and hold the CVs between updates from the CPU, which occur once every millisecond.

The eight velocity and auxiliary CV outputs are provided by a TLV5608 8-channel 10-bit ADC. Because this chip has eight latching DACs, it does not require a demultiplexer or sample-and-hold circuitry. Its outputs are buffered by two TL074 quad op-amps.

TERMINOLOGY AND SYMBOLS

Settings are module features which can be changed using the MOTM-650's front panel user interface or via MIDI System Exclusive (SysEx) or Continuous Controller (CC) messages.

Options are the various choices that can be made for each setting.

Voices are the 4 vertical groups of CV, GATE, VEL, & AUX output jacks, which are usually associated with one of the current MIDI Note On messages.

BOLD fonts like this in the middle of text indicate a button, jack, or LED legend on the MOTM-650's front panel.

Bold fonts like this indicate the name of a Setting or Option.

Fonts like this show what appears on the MOTM-650's LCD.

FRONT PANEL

The MOTM-650's front panel looks like this:

From top to bottom:

LCD – This 8 character by 2 line LCD is the primary user interface for settings, status, and other MOTM-650 related information. The LCD backlight can be controlled via global settings.

MIDI – Indicates MIDI activity on input to the MOTM-650. This is an indicator of all MIDI data sent to the MOTM-650's MIDI IN – not just MIDI data bound for the MOTM-650. Note that this LED is lit by the MOTM-650's processor, not directly from MIDI data pin.

V1-V4 LEDs – These LEDs indicate when a voice's gate is either on (lit) or off (not lit). If a voice is set as an S Trigger, an LED on indicates the gate is shorted and off indicates the gate is open.

BEAT LED – This LED will blink at the rate of the clock source.

ESC – The ESCAPE button is used to either cancel a setting change, or move to a higher level function. Just remember, when in doubt, press ESC.

ENTER – The ENTER button is used to accept a setting change, step to a lower level function, or confirm that a changed setting is desired.

DEC / INC – The DECREMENT and INCREMENT buttons are used to step through the menu options and change settings. In some contexts, holding down either button will cause an accelerated repeat of either button, which makes changes happen more quickly (much like the key repeat on a computer keyboard).

MIDI IN – The MOTM-650's MIDI input.

MIDI OUT – The MOTM-650's MIDI output.

EXT CLK – External clock pulse input for external clocking of the MOTM-650.

AUX 1-4 – 10 Bit assignable auxiliary outputs – one for each voice. Each output has its own settings and menus to control them. See the **Voice Group Settings** section of this manual for information on their operation.

VEL 1-4 – 10 Bit velocity output or trigger output. The function of these jacks is dependent on their **Voice Group Setting**.

GATE 1-4 – Gates for each of the individual voices. These directly track the Voice 1-4 LEDs as described above.

CV 1-4 – 16 Bit control voltage outputs, used to convert MIDI note data to control voltages. They are usually connected directly to VCOs, but can be used for any module that needs a highly accurate control voltage.

USER INTERFACE INTRODUCTION

Before getting in to the specifics of the MOTM-650's feature set, let's get comfortable using the MOTM-650's user interface. Switch on the MOTM-650. The LCD will light up and indicate the MOTM-650 and its firmware version number, followed by a screen looking something like this:

```
G1  CH=1
   Solo
```

For now, ignore its meaning – press ENTER. The MOTM-650 will display this:

```
  Global
Settings
```

Press the DEC / INC buttons to scroll through the top-level user functions. INC moves forward and DEC moves backward through the list of top-level functions. Notice that eventually the options will loop back around to **Global Settings**.

With INC or DEC, select **Global Settings** and press ENTER. The LCD will show:

```
VGrpType
      4
```

Get comfortable scrolling through the **Global Settings** by using INC or DEC, and when finished, press ESC. This backs the display out to the top-level menu, and will show:

```
  Global
Settings
```

This is how the entire menu system is structured – a top level of function categories, followed by a single level of settings or actions. And pressing ESC at any time will back up one level.

Okay, now that you have a basic understanding of top-level/sub-level menus, get the screen back to **Global Settings**, and press ENTER to display the first setting, **VGrpType**. For the time being, let's ignore what this means, and use the INC or DEC buttons until the display shows:

```
  Clock
Internal
```

The display will be steady. Press ENTER – notice that **Internal** begins to flash. This indicates that the setting can be changed. Press INC or DEC to scroll through **INTERNAL**,

MIDI Clk, **Ext. Reg**, or **Ext. Irr**. Select **MIDI CLK**, and press ENTER. The display should show:

…and **MIDI Clk** should be steady. You've just changed the clock source from the 650's internal clock to MIDI clock. This is how any setting is changed – press ENTER to edit the setting, use INC or DEC to choose an option or set the value, and press ENTER again to tell the MOTM-650 to store the change.

Let's try one more aspect of the MOTM-650's user interface – With the display showing **Clock MIDI Clk**, press ENTER again. **MIDI Clk** will begin to flash. Use INC or DEC to select **Internal** on the display, but instead of pressing ENTER, press ESC instead. The display will show:

This allows the user to back out of a change before it becomes permanent, and the setting will be set back to whatever it was before the change was made.

In short, press ENTER to edit a setting, change the setting with INC or DEC, then press either ENTER to select the change or ESC to cancel it. All the settings work this way!

Keep in mind that the entire MOTM-650's user interface works just as above, regardless of function or feature.

Note that all MOTM-650 setting changes can be transmitted via MIDI. This is useful when a live performance is being done and a recording of all front panel changes is desired.

All settings are stored in internal flash memory. Once a setting change is made, it's saved across power cycles. The MOTM-650's entire active state is saved in nonvolatile memory.

DETAILED FEATURE DESCRIPTION

Top-level Function Categories

The MOTM-650's functionality can be broken up into four categories:

Global Settings – Global settings apply to the MOTM-650 as a whole. Most global settings apply to all voice groups simultaneously. These features include, but are not limited to, clock source, tuning tables, tempo, voice group configuration, etc…

Voice Group Settings – A voice group is a logical grouping of voices that share the same settings, including MIDI channel.

Arpeggiator Settings – The MOTM-650 has two arpeggiators, each of which can be assigned to a voice group, no voice group, or both to the same voice group. Arpeggiators use settings from global settings (such as clocking) and have their own settings available.

Module Actions – These are one-shot actions that perform various functions, such as dumping patches, storing patches, etc… They are not settings as in global, voice group, or arpeggiator categories, rather just instructions to perform a specific action.

Note: Settings may appear and disappear in the menus depending upon how the MOTM-650's options are set. For example, setting the **Clock Source** to **MIDI Clock** will cause the **Internal Clock BPM** setting to disappear from the **Global Settings** menu. There are only a few cases where this occurs, and it's done to ensure that only the settings that will have an effect on the MOTM-650's operation are visible at any given time. If one of the expected setting doesn't appear, check the MOTM-650 Menu Chart in Appendix A to see if another setting controls whether or not it appears.

Global Settings

The MOTM-650 has the following settings with a global effect:

Voice Group Type
Velocity Scale
Trigger Pulse Width
Solo Note Priority
Tuning Table
Note Inversion
Backlight Intensity
System Status
SysEx Device ID
Global Control MIDI Channel
Patch Reception
Clock Source
MIDI Clock Output
Internal Clock BPM

Return to the menu's top-level by pressing ESC a couple of times, then press INC until the LCD displays:

Press ENTER, and the first setting will be displayed – the **Voice Group Type** (abbreviated as **VGrpType**).

Note: In reviewing the settings and their associated options, each setting will be presented in the center of the page abbreviated as it appears on the LCD, along with its default option. The full name and description of the setting will follow, and then each option or group of options will be explained.

The **Voice Group Type** setting sets the number and configuration of voice groups available. At this point, you may be wondering – what is a voice group? A voice group is a logical grouping of the MOTM-650's four voices, allowing each voice to either share control settings or have separate settings, depending on how the voices are being used. For example, if you have several VCOs and want to use them polyphonically, you'll probably want to group them together so they have the same settings. If, on the other hand, you're using your MOTM-650 to control four monophonic synth voices, it may make sense to have different settings for each voice. The **Voice Group Type** setting allows the following combinations of voice groups:

- 1 Voice Group with all 4 voices.
- 2 Voice Groups with 2 voices per group
- 4 Voice Groups with 1 voice per group

You will probably only change the **Voice Group Type** when setting up a new patch, as it radically changes the way that MIDI data is interpreted and routed to the MOTM-650's 16 CV outputs.

For now, leave the **Voice Group Type** set to **4**. The settings available to each voice group will be explained later.

The **Velocity Scale** setting sets the output scaling of the VEL outputs when they are set to output velocity. It can be set to output **1**, **2**, **4**, or **8 Volts** when a velocity of 127 is received, and will be scaled between 0 volts and full scale in proportion to other velocity values.

The **Pulse Width** setting sets the width in milliseconds of the GATE outputs when they are set to **Shorting Trigger** mode, and the VEL outputs when they are set to **Trigger** mode. The width can be set to **1**, **10**, or **100 ms**, with an accuracy of 2 ms.

The **Solo Note Priority** setting controls which note is voiced when the **Voice Allocation Mode** is set to one of the solo modes and several notes are held.

Last Note priority uses the solo voice(s) to sound the last note played. Last note is how most monosynths operate.

Low Note voices the lowest note still held. This is useful for playing the low note of a chord to double the bassline.

High Note voices the highest note still held. This is best used for playing a solo using the high note of a chord.

The **Tuning Table** setting sets the tuning table used to map the MIDI note values to the CV output voltages. There are 16 tuning memories to choose from. These are programmed at the factory with 16 tunings, which were selected by Robert Rich (see Appendix B for Robert's description of each tuning). All but the first **Tuning Table** (standard Equal Temperament) can be overwritten by sending MIDI Tuning Standard messages to the MOTM-650. Once overwritten, they can only be restored by sending the 650 a tuning dump with the correct tuning data.

The default tunings are as follows:

Name	**Memory**	**Description**
12 Tone	1	12 Tone Equal Temperament
HrmA1-60	2	Harmonic Series
HrmA1-12T	3	Carlos Harmonic 12 Tone
Meantone	4	Meantone Temperament
1/4TonET	5	¼ Tone Equal Temperament
19TonET	6	19 Tone Equal Temperament
31TonET	7	31 Tone Equal Temperament
PythagoC	8	Pythagorean C
JIA7/5D#	9	Just Intonation in A w/ 7-limit Tritone at D#
3-5LattA	10	3-5 Lattice in A
3-7LattA	11	3-7 Lattice in A
7LimBlkC	12	Other Music 7-limit Black Keys in C
Pel5lenB	13	Dan Schmidt Pelog/Slendro
JIMajYam	14	Yamaha Just Intonation Major C
JIMinYam	15	Yamaha Just Intonation Minor C
Partch11	16	Harry Partch 11-Limit 43 Note Just Intonation

The **Note Inversion** setting turns note inversion **On** or **Off**.

Off

With inversion **Off** , the keyboard plays normally.

On

When inversion is **On,** the note numbers are reversed, so that Note #0 becomes #127, #1 becomes #126, etc. This is useful for playing your keyboard backwards like Joe Zawinul.

The **Backlight** setting controls the output level of the LCD's backlight. It can be set to **Off**, **Dim**, **Normal**, **Bright**, and **Auto**. **Auto** will turn the backlight on whenever a button is pressed, leave it on as long as the setting is being changed, then turn it off a few seconds the last button is released.

The **System Status** setting turns the display of status updates **On** or **Off**.

On

When system status is **On,** status updates are shown whenever the LCD is idle for a few seconds. The status update shows the current MIDI channel and voice allocation mode setting for each voice group. If more than one voice group is enabled, then the updates rotate through each voice group's status every few seconds.

Off

With system status is **Off** , no status updates are shown.

The **SysEx Device ID** setting selects the device ID used in system exclusive messages.
ID=Glob1

When the ID is set to **Global**, the 650 will process all valid SysEx messages it receives. It will also transmit messages using the Global ID, which will be processed by any other 650s that receive them.

ID=0

When the **SysEx Device ID** is set to an integer from 0 to 15, the 650 will transmit and receive SysEx messages using this ID. Messages received with other IDs will be ignored, unless it's the Global ID.

Disabled

When set to **Disabled**, the 650 will ignore SysEx messages.

Ctrl MIDI
Chan=16

The **Global Control MIDI Channel** setting sets the MIDI channel for MIDI continuous controller (CC) messages to control **Global Settings**. This can be any channel from 1 to 16. See the MIDI Implementation Table in Appendix C for a definition of each CC message.

Note: Because each each voice group can have its own MIDI channel setting, notes sent to the **Global Control MIDI Channel** will only be played if there is a voice group whose **MIDI Channel** is set to that same channel.

Patch RX
Disabled

The **Patch Reception** setting enables or disables the reception of patch data using MIDI CC messages. It does not affect the reception of SysEx patch data. See the **Module Actions** section for a description of patches.

Clock
Internal

The **Clock Source** setting selects the clock source for the arpeggiators.

Internal

Internal uses the clock of the 650's CPU to generate a clock signal for the arpeggiator.

MIDI Clk

MIDI Clock uses clock messages received on the MIDI IN to sync the arpeggiators to. If a stop signal is received, or if the clock messages drop out, then the 650 will generate an internal clock at the last tempo received, so that a clock doesn't have to be running to try out a new arpeggio.

Ext. Reg.

External Regular syncs the arpeggiators to the rising edge of CV pulses on the EXT CLK input. This option requires a regular pulse for best results when **MIDI Clock Transmit** is enabled, or when using a **Clock Divisor / Multiplier** setting other than **X1**. When the clock pulse stops, the 650 will generate an internal clock at the last tempo received, just as it does with the **MIDI Clock** setting.

Ext. Irr.

External Irregular also syncs the arpeggiators to the rising edge of CV pulses on the EXT CLK input, but it does not allow the additional clocking features that the other clock sources do. It plays one note per clock pulse, and is best used when the clock source is irregular.

MIDI Clk
Transmit

The **MIDI Clock Output** setting is only displayed when the **Clock Source** is set to **Internal**, or to **External Regular**.

Transmit

The **Transmit** option turns MIDI clock transmission on whenever one of the arpeggiators is enabled. Whenever **Transmit**, selected, a Start command will be sent from the MIDI OUT and Clock commands will be sent regularly. This option is useful for synchronizing sequencers and drum machines to the 650's arpeggiators.

Off

The **Off** option disables MIDI clock transmission.

IClk BPM
120.0

The **Internal Clock BPM** setting is only displayed when the **Clock Source** is set to **Internal**. It sets the tempo of the internal clock to one of 128 tempos, ranging from 60 beats per minute (BPM) to 238 beats per minute. At the middle of the range, the resolution is .5 BPM; at the extremes it is 2 BPM.

Voice Group Settings

As explained previously, the MOTM-650 can have up to 4 logical groups of voices, as determined by the global **Voice Group Type** option. Each voice group has the following settings that apply to all the voices in that group:

MIDI Channel
Voice Allocation Mode
Pitch Bend Amount
Glide Type
Glide Time
Glide Rate
Gate Type
Velocity/Trigger Output
Auxiliary Output
Auxiliary Output Scale

Each one of the settings listed above applies only to the voices in that voice group. That means there can be different glide settings for each voice group, different voice allocation modes, different MIDI channels, etc., or in the odd case, more than one group can have the same MIDI receive channel! They are completely independent from each other.

To get a feel for how a voice group works, let's hook up the MOTM-650 to some modules. For the sake of this example, we'll assume you want to control a single VCO. Set the MOTM-650 as follows:

- Go to the **Global Settings** menu and change the **Voice Group Type** (**VGrpType**) to **4** (single group, 4 voices per group).
- Press ESC to return to the top menu level, select the **VoxGrp 1 Settings** submenu, and press ENTER. The first option shown is **VG1 MIDI**. If it's not already set to the same channel as your MIDI control, then set it now.
- Pressing INC should display **VG1Alloc** – set the option to **Solo** for now. This will cause the MOTM-650 to allocate only the first voice in the group of 4.
- Connect a cable from the CV1 output to the 1V/OCT input of a VCO. Connect the VCO's output to a VCA's audio input. Connect the MOTM-650's GATE 1 output to the VCA's CV input. Finally, connect the VCA's output to a monitoring setup (e.g. amplifier or headphones).

Now press a key on the MIDI controller. If everything is set correctly, then several things should happen:

- The MIDI LED will blink
- The V1 LED will turn on
- The played note will be heard

Try the pitch bend (set to 2 note -/+ bend range by default), a few more notes, etc… Everything should respond like a normal monophonic synthesizer.

Now, change **VG1Alloc** to **Poly1**. This will cause the MOTM-650 to allocate voices polyphonically. Since the MOTM-650 is set to 4 voices, it will allocate from a pool of all 4 voices. Even if voices 2 through 4 aren't connected to anything, play some notes. Every note press will cause the next voice to be allocated, as you will see on the V1-V4 LEDs. With one VCO connected, only 1 voice will be heard out of every 4 notes.

The MOTM-650 is currently set up for a single voice group. Go into the **Global Settings** menu and change the **Voice Group Type** to **2/2** (two groups, 2 voices per group). Escape out to the top-level menu, and notice that **VoxGrp 2 Settings** is now a new menu option! As with **VoxGrp 1**, change **VG2Alloc** to **Poly1** just like with **Voice Group 1**. Also set the **MIDI Channel** to a different channel (preferably one higher than it's currently set).

Now press notes on the controller keyboard. Notice now that only voices 1 and 2 are active – this is sending MIDI data to **Voice Group 1**. Change the keyboard controller to the same MIDI channel as **Voice Group 2**, and play. Voices are allocated out of voices 3 and 4. The voice grouping operation allows completely different behaviors, turning the MOTM-650 into a dual 2 voice MIDI/CV converter, or a quad single voice MIDI/CV converter. Very powerful and flexible!

The MOTM-650 has one very unique function – voice groups can be assigned to the same **MIDI Channel**. Change **Voice Group 1**'s channel to the same as **Voice Group 2**'s channel. Play notes. Watch voice 1 & 3 turn on simultaneously, and 2 & 4 turn on simultaneously.

Having both voice groups set to the same **MIDI Channel** is identical to sending notes/controllers on two different channels – the single incoming note is being sent to both voice groups.

One possible use for this is to have multiple VCOs on a single voice. Connect one VCO to voice 1, and another to voice 3. Detune the second VCO to an octave below (or above), etc… it's a great way to get unique voices if a CV splitter isn't available. Also consider that each voice group can have different glide settings. Configuration of a modular system with this voice group setup is only limited by the user's imagination.

Now that the voice group concept has been covered, let's explore all of the settings available for each voice group. For each setting, a typical LCD display will be shown, then the various options for that setting will be described in detail. Every voice group setting begins with the letters **VG**, for Voice Group, and the number of the group selected – **1**, **2**, **3**, or **4**. Here are the settings, in the order they appear as the INC button is pushed:

The **MIDI Channel** setting selects the voice group's MIDI channel. **Chan** refers to the channel number, of course, and can be set to any channel from 1 to 16. The voice group will respond to MIDI CCs, pitch bend, notes, and all other voice group functions on this channel. As mentioned earlier, more than one voice group can be set to the same MIDI channel.

Voice Allocation Mode - What is "voice allocation"? In an ideal world, we'd always have all the synth voices we need to sound the notes we want to play. Unfortunately, there are usually fewer synth voices than notes on the keyboard, so there has to be a way to allocate the many possible notes to the few available voices. In fact, there are many ways to allocate voices to notes, some having surprisingly different musical results.

The MOTM-650 has 9 voice allocation modes that are assignable on a per group basis. Each voice allocation mode has a specific use, and is described below. For the sake of understanding how they differ, set the **Voice Group Type** to **4** and pay close attention to the voice gate LEDs (V1-V4) to visually grasp how the voices are allocated.

Solo

Solo mode will only sound one note at a time. Which note is selected depends on the setting of the global **Solo Note Priority** option – either the **Low Note**, **High Note**, or **Last Note** played. When a second note is played while the first one is still held, the CV output will change, but the GATE output will stay high. If the **Velocity/Trigger Output** is set to **S-Trigger** mode, then the VEL output won't retrigger. Only one voice is used in **Solo** mode – the first voice in the group. This the only allocation mode that doesn't use all available voices.

Solo Rot

Solo Rotate also sounds only one note. However, each new note is assigned to a new voice, rotating through all the voices in the group, starting with the first voice. This mode is good for playing short, percussive sounds with a long release, because new notes will not immediately interrupt the release with a new attack like in **Solo** mode (unless many notes are played quickly). All available voices are used in **Solo Rotate** mode.

Solo Uni

Solo Unison, like the other solo modes, only sounds one note. However, all available voices are used to play this note. If the **Voice Group Type** is set to **1/1/1/1**, this means only one voice is available, so **Solo Unison** will work exactly like **Solo** mode. If the **Voice Group Type** is set to **2/2** or **4**, then more voices are available. Detuning the oscillators that the CV outputs are connected to can create a very fat sound in **Solo Unison** mode.

Poly1

Poly 1 mode is polyphonic, meaning more than one note can be played at a time. Its allocation algorithm is designed to preserve a note's release as long as possible. The last note released is the last voice to be reallocated. For example: if A B C D are played in

order, releasing the keys in reverse order (D C B A) will cause the next allocated voice to be D. That is because it has been released the longest, so it has the best chance of having completed the release cycle of its envelopes. If more notes are played than there are voices, then only the first notes will sound, at least until one of those notes playing is released. At that point, its voice will be reallocated to the next note in line. The GATE output will stay high. If the **Velocity/Trigger Output** is set to **S-Trigger**, then the VEL output won't retrigger when the previously held note is sounded.

Poly1 St.

Poly 1 Steal works like the **Poly 1** mode until all the voices are used and another note is played. At that point, the new note will "steal" the voice of the first note played. If the **Velocity/Trigger Output** is set to **S-Trigger**, then it will retrigger when the voice is stolen. If the first note is still held when the new note is released, its voice will be restored, however, the VEL output won't retrigger if set to **S-Trigger**.

Poly2

Poly 2 is a polyphonic allocation algorithm which always allocates the first voice in its voice group first, the second voice second, and so on. **Poly 2** is useful for ensuring that notes are assigned to voices in a predictable manner. This can be used with the **Glide** feature to make a super cool polyphonic portamento sound. **Poly 2**, like **Poly 1**, does nothing when more notes are played than there are voices.

Poly2 St.

Poly 2 Steal works like the **Poly 2** mode until all the voices are used and another note is played. At that point, the new note will "steal" the voice of the first note played, just like **Poly 1 Steal** mode.

Unison

Unison is yet another polyphonic mode. The idea behind **Unison** is to make the fattest sound possible, by assigning multiple voices to each note. **Unison** mode works like **Solo Unison** for the first note played, in that it allocates all of the voices to playing the note. Then things start getting strange. If two or more notes are being played, the voices are divided between the notes played. For instance, if the **Voice Group Type** is **4**, then there are 4 voices available. The first note played will use all 4 voices, the second note will steal 2 of those voices so that each note has 2 voices, the third note will steal one voice from the first note and turn off one of the second note's voices, the fourth note will play that turned off note, and subsequent notes will be ignored until one of the first 4 notes are released. If the **Voice Group Type** is **2/2**, then there are 2 voices available, so the first note will play with 2 voices, the second note with one, and subsequent notes will be ignored, just as they are with **Poly 1** and **Poly 2**.

Unison Steal works like **Unison** mode until all the voices are used and another note is played. At that point, the new note will "steal" the voice of the first note played, just like the **Poly 1 Steal** & **Poly 2 Steal** modes do.

The **Pitch Bend Range** setting controls the number of notes (half-steps) that the pitch will change when a pitch bend wheel is at either end of its range (i.e. the pitch bend CC received is at its maximum or minimum value). The range can be set from **0** (off) to **24** (2 octaves). When using MIDI pitch bend to control an AUX output, you may not want it to change the pitch as well, in which case you should set the **Pitch Bend Range** to **0**.

The **Glide Type** setting selects between one of the MOTM-650's two modes of Glide (or portamento as it's referred to by almost everyone except Moog & MOTM!), or having no glide at all. Normally, when a voice is reallocated to a new note, the CV output changes voltages nearly instantaneously. When glide is enabled, the voltage changes a **Constant Rate** or **Constant Time**, depending on which **Glide Type** is selected. This allows the pitch to "glide" from the old note to the new note.

When playing polyphonically, each individual voice within a voice group will glide independently to the target note assigned to that voice. For example, with the **Voice Group Type** set to **4**, it's possible for voice 1 to be sliding from middle C to high C, while voice 2 is sliding from middle C to low C, and voices 3 and 4 are not gliding at all. CVs continue to slide even after notes are released – glide works independently of the gates.

Glides always occur between the CVs of the source and target notes. This means that it's based on CV value, not on MIDI note. Glide will slide between the CV values for any **Tuning Table**.

On powerup, all CVs are set to 0 volts, and will glide from that point to the first note pressed.

The possible settings for **Glide Type** are as follows:

As you'd expect, this option turns glide off. Glide can also be toggled on and off by sending the standard portamento continuous controller message via MIDI.

ConsTime

Constant Time glide will maintain the same time between two notes regardless of their distance. The time can be set differently for each voice group.

ConsRate

Constant Rate glide allows a consistent rate of glide, meaning a shorter glide time for notes that are closer together than those farther apart. This rate can be set differently for each voice group.

The **Glide Time** setting controls the time it takes a CV to glide from one note to another. The **Glide Time** is adjustable in 1 millisecond increments from 1 ms to 65.535 seconds. This menu only appears when the **Glide Type** is set to **Constant Time**.

The **Glide Rate** setting controls rate and which a CV glides from one note to another. The rate follows an exponential curve from 60.562 cents/second to 16898.837 cents/second with 128 steps. This menu only appears when the **Glide Type** is set to **Constant Rate**.

The **Gate Type** setting controls the behavior of the voltage present at the GATE outputs associated with the current voice group.

Normal

The **Normal Gate Type** option will keep the GATE output at 0VDC until a Note On is received, at which point the output will go to 12VDC. It will stay there as long as the note is held. When a Note Off is received, the output will return to 0VDC. This is how gates work on almost all non-Moog synthesizers (though the full scale voltage may vary).

STrigger

The **Shorting Trigger Gate Type** option will keep the GATE output at 12VDC until a Note On is received, at which point the output will go to 0VDC until a Note Off is received, when the output will return to 12VDC. This is how gates work on Moogs. When the **S-**

Trigger setting is selected, the voice gate LED (V1-V4) associated with the voices in the voice group will turn on, because the LEDs are driven directly by the GATE outputs.

The **Velocity/Trigger Output** setting controls how the VEL outputs work.

Velocity

The **Velocity** option makes the VEL output a CV that corresponds to the velocity value received with the current Note On. A velocity of 127 will set the voltage to the maximum as determined by the global **Velocity Scale** option. Velocities of 0 are ignored, as these messages are interpreted as a Note Off command.

Trigger

The **Trigger** option will output a trigger pulse of 12VDC whenever a new note is played. The pulse width is controlled by the global **Trigger Pulse Width** setting. This is useful for retriggering envelopes in the solo **Voice Allocation Modes**, as the GATE output will remain high if notes are played legato. Remember though, that in some cases a new note will not cause a trigger pulse, as described in the **Voice Allocation Mode** section.

The **Auxiliary Output** setting controls how the AUX outputs work. AUX 1 is part of Voice 1, AUX 2 is part of Voice 2, etcetera, so when the **Voice Group Type** changes, the Auxiliary Output setting may change Voice Groups with the other voice settings. If the AUX out is controlled by a MIDI parameter, then it receives messages on the same channel as its Voice Group. The control options are as follows:

CC0-CC31

Continuous Controller messages **0** through **31** can be selected as sources for the **AUX** outputs, with 128 possible voltage levels corresponding to the controller's current value. Note that some CCs, such as **CC1 ModW**, include an abbreviated description of the controller commonly associated with that controller number - in this case, the Modulation Wheel.

PitchBnd

The **Pitch Bend** option will output a CV that is proportional to the value of the Pitch Bend CC. The most significant 10 bits are used to scale the voltage set by the **Auxiliary Scale** setting, for 1024 possible voltage levels.

ChATouch

The **Channel Aftertouch** option will output a CV that is proportional to the value of the Channel Aftertouch message, with 128 possible voltage levels.

Velocity

The **Velocity** option will output a CV that corresponds to the value of the current Note On's velocity.

ClkPulse

The **Clock Pulse** option will output a full-scale pulse that is synchronized with the arpeggiator's clock source.

Disabled

The **AUX** output will default to 0 volts when **Disabled** is selected.

The **Auxiliary Output Scale** setting controls the full-scale output voltage of the AUX outputs, with **1**, **2**, **4**, or **8 Volts** being the available options.

Arpeggiator Settings

The MOTM-650's two arpeggiators share their **Clock Source**, as set in the **Global settings,** and can have independent settings for the following:

Arpeggiator Assignment
Note Mode
Note Order
Clock Divisor/Multiplier

The arpeggiators are referred to as Arpeggiator 1 (abbreviated as **A1** in the menus) and Arpeggiator 2 (**A2**).

The **Arpeggiator Assignment** determines which voice group the arpeggiator plays.

The **Off** option turns the arpeggiator off. Note that none of the other arpeggiator menu items will be displayed when the arpeggiator is off.

The **Voice Group** option plays all arpeggiated notes on the voice group selected. The global **Voice Group Type** option determines how many voice groups are available.

The **Arpeggio Mode** setting determines the method the arpeggiator uses to scan the notes currently being played or held. The **Arpeggio Mode** interacts with the **Note Order** setting to allow up to 13 different ways to arpeggiate a given set of held notes.

The **Normal** mode scans the notes by note number. With the default **Note Order** of **Forward**, the notes are scanned from lowest to highest. For example, if the following notes are played and held:

C E D F A B

Normal mode will arpeggiate them as:

A B C D E F

Ordered

The **Ordered** mode scans the notes in the order that the notes are played. For example:

C E D F A B

will be arpeggiated as:

C E D F A B

PingPong

The **PingPong** mode scans the notes from first played, to last played, second played, second to the last pressed, etc… For example, if the following notes are played and held:

C E D F A B

PingPong mode will arpeggiate them as:

C B E A D F

Random

Random mode scans the notes randomly. Note that the **Note Order** has no effect on **Random** mode. For example:

C E D F A B

may be arpeggiated as:

A A C D E B F E C B F A

or whatever random order the CPU selects.

The **Note Order** setting determines which direction the arpeggiator scans through the notes.

Forward

The **Forward** option scans the notes in a forward direction. All the examples so far have featured **Forward** mode, so we will skip repeating them here.

Reverse

The **Reverse** option scans the notes in reverse. For example:

C E D F A B

will be arpeggiated in **Normal** mode as:

F E D C B A

will be arpeggiated in **Ordered** mode as:

B A F D E C

and in **PingPong** mode as:

F D A E B C

Fwd/Rev

The **Forward/Reverse** option scans forward to the last note, then reverses direction until the first note is scanned again, then repeats. For example:

C E D F A B

will be arpeggiated in **Normal** mode as:

A B C D E F E D C B

will be arpeggiated in **Ordered** mode as:

C E D F A B A F D E

and in **PingPong** mode as:

C B E A D F D A E B

Rev/Fwd

The **Reverse/ Forward** option works the opposite of **Forward/Reverse** mode, just as you'd expect. For example:

C E D F A B

will be arpeggiated in **Normal** mode as:

F E D C B A B C D E

will be arpeggiated in **Ordered** mode as:

B A F D E C E D F A

and in **PingPong** mode as:

F D A E B C B E A D

The **Clock Multiplier/Divider** setting controls the ratio between the arpeggiator's clock and the master clock source. This setting is not available when the **Clock Source** setting is **External Irregular**.

The **Multiply by 1** option arpeggiates 1/8 notes if the **Clock Source** is set to **Internal Clock** or **MIDI Clock,** and plays a note for every clock pulse if set to **External Regular**.

The **Multiply by 1.5** option arpeggiates 1/8 triplets if the **Clock Source** is set to **Internal Clock** or **MIDI Clock,** and plays 3 notes for every 2 clock pulses if set to **External Regular**.

The **Multiply by 2** option arpeggiates 1/16 notes or 2 notes per clock, depending on the source.

The **Multiply by 4** option arpeggiates 1/32 notes or 4 notes per clock, depending on the source.

The **Divide by 4** option arpeggiates 1/2 notes or 1 note per 4 clocks, depending on the source.

The **Divide by 3** setting arpeggiates 1/2 triplets or 1 note per 3 clocks, depending on the source.

The **Divide by 2** option arpeggiates 1/4 notes or 1 note per 2 clocks, depending on the source.

The **Divide by 1.5** option arpeggiates 1/4 triplets or 2 notes per 3 clocks, depending on the source.

Module Actions

These initiate various useful operations when selected. The actions available are:

Load Patch
Save Patch
Load Default Settings
Dump All Patches
Dump Tuning Table

Selecting the **Load Patch** action will bring up the following submenu:

Pressing the **INC** button will step through the 32 internal memories. Pressing ENTER will load that patch into the current patch memory, and the LCD will display:

Selecting the **Save Patch** action will bring up the following submenu:

Pressing the INC button will step through the 32 internal memories. Pressing ENTER will save the current patch to that memory location, and the LCD will display:

Selecting the **Load Default Settings** action will load the default option for every setting and then display:

Selecting the **Dump All Patches** action will send a SysEx message for every patch memory. As it does so, it will display the patch currently being dumped like so:

When done, it will display:

Dump All Patches can be used with an external sequencer or patch librarian to back up the MOTM-650's internal settings.

Selecting the **Dump Tuning** action will bring up the following submenu:

Pressing the INC button will step through the 16 tuning memories. Pressing ENTER will send a tuning dump of that memory and when done, the LCD will display:

APPENDIX A – MENU CHART

Note: The default option is listed either first, or in parentheses () when a numeric range is given. Options which have dependent settings menus are followed by a superscript. The settings whose menus appear are preceded by a superscript.

- Global Settings
  - Voice Group Type
    - 4 [1]
    - 2/2 [2]
    - 1/1/1/1 [2, 3]
  - Velocity Scale
    - 4 Volts
    - 8 Volts
    - 1 Volt
    - 2 Volts
  - S-Trigger Pulse Width
    - 10 ms
    - 100 ms
    - 1 ms
  - Solo Note Priority
    - Last Note
    - Low Note
    - High Note
  - Tuning Table
    - 12 Tone Equal Temperament
    - Harmonic Series
    - Carlos Harmonic 12 Tone
    - Meantone Temperament
    - ¼ Tone Equal Temperament
    - 19 Tone Equal Temperament
    - 31 Tone Equal Temperament
    - Pythagorean C
    - Just Intonation in A w/ 7-limit Tritone at D#
    - 3-5 Lattice in A
    - 3-7 Lattice in A
    - Other Music 7-limit Black Keys in C
    - Dan Schmidt Pelog/Slendro
    - Yamaha Just Intonation Major C
    - Yamaha Just Intonation Minor C
    - Harry Partch 11-Limit 43 Note Just Intonation
  - Note Inversion
    - Off
    - On
  - Backlight Intensity
    - Auto
    - Off
    - Dim
    - Normal
    - Bright

System Status
- On
- Off

SysEx Device ID
- Global
- Disabled
- ID=0-15

Controller MIDI Channel
- 1-16 (16)

Patch Reception
- Disabled
- Enabled

Clock Source
- Internal [4, 5, 6]
- MIDI Clock [6]
- External Regular [5, 6]
- External Irregular

[5] MIDI Clock Output
- Transmit
- Off

[4] Clock rate
- 60-238BPM (120BPM)

Voice Group 1 Settings

MIDI Channel
- 1-16 (1)

Voice Allocation Mode
- Solo
- Solo Rotate
- Solo Unison
- Poly 1
- Poly 1 Steal
- Poly 2
- Poly 2 Steal
- Unison
- Unison Steal

Pitch Bend Amount
- 0-24 (2)

Glide Type
- Off
- Constant Time [7]
- Constant rate [8]

[7] Glide Time
- 1ms-30 seconds (1 second)

[8] Glide Rate
- 1-127 (5)

Gate Type
- Normal
- S-Trigger

Velocity/Trigger Output
    Velocity
    Trigger
Auxiliary Output 1
    Pitch Bend
    Channel Aftertouch
    Velocity
    Clock Pulse
    Disabled
    CC #0 – CC# 31
Auxiliary Output 1 Scale
    4 Volts
    8 Volts
    1 Volt
    2 Volts
[1, 2] Auxiliary Output 2
    …
[1, 2] Auxiliary Output 2 Scale
    …
[1] Auxiliary Output 3
    …
[1] Auxiliary Output 3 Scale
    …
[1] Auxiliary Output 4
    …
[1] Auxiliary Output Scale
    …

[2] Voice Group 2 Settings
…
[3] Voice Group 3 Settings
…
[3] Voice Group 4 Settings
…

Arpeggiator 1 Settings
Arpeggiator Assignment
    Off
    Voice Group 1 [9]
    [2] Voice Group 2 [9]
    [3] Voice Group 3 [9]
    [3] Voice Group 4 [9]
[9]Arpeggio Mode
    Normal
    Ordered
    Ping Pong
    Random
[9]Note order
    Forward

Reverse
Forward/Reverse
Reverse/Forward

[6, 9]Clock Multiplier/Divisor
1X
1.5X
2X
4X
/4
/3
/2
/1.5

Arpeggiator 2 Settings
…

Module Actions
Load Patch
Patch 1-32 (1)
Save patch
Patch 1-32 (1)
Load Default Settings
Dump All pPatches
Dump Tuning
Memory 1-16 (1 – 12 Tone)

APPENDIX B – TUNING TABLE DESCRIPTIONS (Compiled by Robert Rich)

0. 12 Tone Equal Temperament (non-erasable)

The default Western tuning, based on the twelfth root of two. Good fourths and fifths, horrible thirds and sixths.

1. Harmonic Series

MIDI notes 36-95 reflect harmonics 2 through 60 based on the fundamental of A = 27.5 Hz. The low C on a standard 5 octave keyboard acts as the root note (55Hz), and the harmonics play upwards from there. The remaining keys above and below the 5 octave range are filled with the same intervals as Carlos' Harmonic 12 Tone that follows.

2. Carlos Harmonic Twelve Tone

Wendy Carlos' twelve note scale based on octave-repeating harmonics. A = 1/1 (440 Hz).
1/1 17/16 9/8 19/16 5/4 21/16 11/8 3/2 13/8 27/16 7/4 15/8

3. Meantone Temperament

An early tempered tuning, with better thirds than 12ET. Sounds best in the key of C. Use this to add an authentic touch to performances of early Baroque music. C=1/1 (260 Hz)

4. 1/4 Tone Equal Temperament

24 notes per octave, equally spaced 24root2 intervals. Mexican composer Julian Carillo used this for custom-built pianos in the early 20th century.

5. 19 Tone Equal Temperament

19 notes per octave (19root2) offering better thirds than 12 ET, a better overall compromise if you can figure out the keyboard patterns.

6. 31 Tone Equal Temperament

Many people consider 31root2 to offer the best compromise towards just intonation in an equal temperament, but it can get very tricky to keep track of the intervals.

7. Pythagorean C

One of the earliest tuning systems known from history, the Pythagorean scale is constructed from an upward series of pure fifths (3/2) transposed down into a single octave. The tuning works well for monophonic melodies against fifth drones, but has a very narrow palate of good chords to choose from. . C=1/1 (261.625 Hz)
1/1 256/243 9/8 32/27 81/64 4/3 729/512 3/2 128/81 27/16 16/9 243/128

8. Just Intonation in A with 7-limit Tritone at D#

A rather vanilla 5-limit small interval JI, except for a single 7/5 tritone at D#, which offers some nice possibilities for rotating around bluesy sevenths. A=1/1 (440 Hz)
1/1 16/15 9/8 6/5 5/4 7/5 3/2 8/5 5/3 9/5 15/8

9. 3-5 Lattice in A

A pure 3 and 5-limit tuning which resolves to very symmetrical derived relationships between notes. A=1/1 (440 Hz) 1/1 16/15 10/9 6/5 5/4 4/3 64/45 3/2 8/5 5/3 16/9 15/8

10. 3-7 Lattice in A

A pure 3 and 7-limit tuning which resolves to very symmetrical derived relationships between notes. Some intervals are very close together, offering several choices for the same nominal chords. A=1/1 (440 Hz) 1/1 9/8 8/7 7/6 9/7 21/16 4/3 3/2 32/21 12/7 7/4 63/32

11. Other Music 7-Limit Black Keys in C

Created by the group Other Music for their homemade gamelan, this offers a wide range of interesting chords and modes.
C=1/1 (261.625 Hz) 1/1 15/14 9/8 7/6 5/4 4/3 7/5 3/2 14/9 5/3 7/4 15/8

12. Dan Schmidt Pelog/Slendro

Created for the Berkeley Gamelan group, this tuning fits an Indonesian-style heptatonic Pelog on the white keys and pentatonic Slendro on the black keys, with B and Bb acting as 1/1 for their respective modes. Note that some of the notes will have the same frequency. By tuning the 1/1 to 60 Hz, Dan found a creative way to incorporate the inevitable line hum into his scale. Bb, B = 1/1 (60 Hz) 1/1 1/1 9/8 7/6 5/4 4/3 11/8 3/2 3/2 7/4 7/4 15/8

13. Yamaha Just Major C

When Yamaha decided to put preset microtunings into their FM synth product line, they selected this and the following tuning as representative just intonations. As such, they became the de-facto introduction to JI for many people. Just Major gives preferential treatment to major thirds on the sharps, and a good fourth relative to the second.
C= 1/1 (261.625) 1/1 16/15 9/8 6/5 5/4 4/3 45/32 3/2 8/5 5/3 16/9 15/8

14. Yamaha Just Minor C

Similar to Yamaha's preset Just Major, the Just Minor gives preferential treatment to minor thirds on the sharps, and has a good fifth relative to the second. C= 1/1 (261.625)
1/1 25/24 10/9 6/5 5/4 4/3 45/32 3/2 8/5 5/3 16/9 15/8

15. Harry Partch 11-limit 43 Note Just Intonation

One of the pioneers of modern microtonal composition, Partch built a unique orchestra with this tuning during the first half of the 20th century, to perform his own compositions. The large number of intervals in this very dense scale offers a full vocabulary of expressive chords and complex key changes. The narrow spacing allows fixed-pitched instruments like marimbas and organs to perform glissando-like passages. G = 1/1 (392 Hz, MIDI note 67)

1/1 81/80 33/32 21/20 16/15 12/11 11/10 10/9 9/8 8/7 7/6 32/27
6/5 11/9 5/4 14/11 9/7 21/16 4/3 27/20 11/8 7/5 10/7 16/11
40/27 3/2 32/21 14/9 11/7 8/5 18/11 5/3 27/16 12/7 7/4 16/9
9/5 20/11 11/6 15/8 40/21 64/33 160/81