



**MIDI CPU**  
**Firmware Version 1.2**  
**User Manual**

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Additional documentation available at:

<http://highlyliquid.com/support/>

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## 1.0 Overview

Users are encouraged to read *MIDI CPU Hardware User Manual* before continuing with this document.

### 1.1 About The MIDI CPU

The MIDI CPU is a multipurpose MIDI input/output device. The MIDI CPU accepts input at the *control terminals* and MIDI IN port. Output is generated at the MIDI OUT port. Depending on configuration, certain control terminals may also generate output signals. See [Theory of Operation](#) for more information.

The MIDI CPU is configured via MIDI System Exclusive (SysEx) message. [Control Terminal Configuration](#) messages contain information related to individual control terminals. [Global Configuration](#) messages contain information related to the MIDI CPU as a whole. [Configuration Examples](#) are provided and may be adapted for specific applications.

The MIDI CPU ships with a “factory default” configuration which can be described in terms of equivalent SysEx messages. See [Factory Default Configuration](#).

SysEx messages can also be used to examine the current MIDI CPU configuration. See [Configuration Retrieval](#).

### 1.2 About This Document

Throughout this document, SysEx message contents are shown in hexadecimal format. Hexadecimal numbers either are described as “hex” or are followed by the 'h' suffix. Decimal format should be assumed for all other numbers.

Key to character formatting:

- Clickable links to tables and figures appear in **blue**.
- Clickable links to sections within the document are underscored.
- Names of specific MIDI message types generated by the MIDI CPU appear in **red**.

Sections of the manual that have changed significantly since the previous firmware version are highlighted in yellow.

### 1.3 Additional Resources

Instructions for using a PC to create and send SysEx messages can be found at:

<http://highlyliquid.com/support/library/midi-sysex.html>

Support inquiries should be posted at the Highly Liquid support forums. Project examples and other information is posted at the forums:

<http://forum.highlyliquid.com/>

## 2.0 Theory of Operation

MIDI CPU functionality can be understood in terms of automatically repeating Tasks performed by the MIDI CPU and the resulting Data which is used to generate MIDI output.

### 2.1 Tasks

After power-up and initialization, the MIDI CPU continuously performs the following tasks: **MIDI Merge**, **Matrix Select Signal Generation**, **Control Input Monitoring**, **MIDI Message Generation**, and **LED Control**.

#### 2.1.1 MIDI Merge

Messages received by the MIDI CPU at the MIDI IN port are echoed in real time at the MIDI OUT port, interspersed with any locally generated messages. This allows the MIDI CPU to be combined with another MIDI controller or with additional MIDI CPU units to function as a single unit with a single MIDI OUT port.

All messages received by the MIDI CPU at the MIDI IN port are echoed at the MIDI OUT port with the exception of MIDI **SysEx** messages and MIDI “**Active Sense**” messages. **Active Sense** messages are generated locally per the MIDI specification.

The MIDI CPU employs an efficient merge algorithm:

- Typical latency between an incoming message and the echoed output approaches the theoretical minimum of approximately 300µs.
- Merged messages and locally generated messages share the same “running status” when possible, resulting in a compact output data stream.
- Merged messages preempt locally-generated messages, allowing successful processing of a saturated data stream.

#### 2.1.2 Matrix Select Signal Generation

When configured as a *matrix select output*, a MIDI CPU control terminal generates a matrix select logic signal. Matrix select outputs are used together with logic inputs in order to monitor a switch matrix.

#### 2.1.3 Control Input Monitoring

The MIDI CPU continuously monitors each control terminal configured as an analog or logic input. Each input signal is used in up to two ways:

- The current value of the input, updated in real time, can be incorporated into outbound MIDI messages. See Data.
- A change to the input state can trigger the generation of a MIDI message.

#### 2.1.4 MIDI Message Generation

The MIDI CPU generates MIDI messages based on user configuration. Message generation is triggered by changes to control terminal input. See Control Terminal Configuration and Global Configuration. Data acquired during operation can be incorporated into the generated messages. See Data.

### 2.1.5 LED Control

In addition to the built-in and optional remote Activity LED, the MIDI CPU can control multiple matrixed indicator LEDs and/or 7-segment LED displays. See *MIDI CPU Hardware User Manual* for wiring information. See [Logic Output LED Control Modes](#) for more details.

## 2.2 Data

The MIDI CPU has several internal memory locations called *data registers* which contain real-time data from control terminal inputs. Each data register contains up to a single byte (8 bits) and is identified by a unique hex *address*.

When the MIDI CPU generates a MIDI message, information in the message (note number & velocity, CC number & value, program number, etc) can be formed from fixed values and/or the contents of data registers.

Each data register is described below. [Control Terminal Configuration](#) and [Global Configuration](#) determine how the MIDI CPU uses the data registers.

### 2.2.1 Logic Input Data

*Logic input data registers* contain the current states of any control terminals configured as logic inputs. See [Table 2.2.1-a](#). If the control terminal input state is low (0V or grounded), the corresponding data register bit is '0'. If the control terminal input state is high ( $V_{REG}$  or unconnected), the corresponding bit is '1'. For a control terminal not configured as a logic input, the value of the corresponding logic input data register bit is unknown.

**Table 2.2.1-a: Logic Input Data Registers**

| Register Address | Control Terminal # |       |       |       |       |       |       |       |
|------------------|--------------------|-------|-------|-------|-------|-------|-------|-------|
|                  | Bit 7              | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| 00h              | 7                  | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
| 01h              | 15                 | 14    | 13    | 12    | 11    | 10    | 9     | 8     |
| 02h              | 23                 | 22    | 21    | 20    | 19    | 18    | 17    | 16    |

### 2.2.2 Analog Input Data

Each *analog input data register* contains a 7-bit representation of the input voltage on the corresponding control terminal. See [Table 2.2.2-a](#).

For a control terminal not configured as an analog input, the corresponding analog input data register contains the value 0x7F.

**Table 2.2.2-a: Analog Input Data Registers**

| Register Address | Control Terminal # |
|------------------|--------------------|
| 03h              | 16                 |
| 04h              | 17                 |
| 05h              | 18                 |
| 06h              | 19                 |
| 07h              | 20                 |
| 08h              | 21                 |
| 09h              | 22                 |
| 0Ah              | 23                 |
| 0Bh              | 10                 |
| 0Ch              | 11                 |
| 0Dh              | 9                  |
| 0Eh              | 12                 |
| 0Fh              | 8                  |
| 10h              | 13                 |



### 2.2.3 Multipurpose Data

Each *multipurpose data register* can contain a 7-bit or 8-bit value.

If a control terminal pair is configured for rotary encoder input, the 7-bit value in the corresponding data register is incremented or decremented by input activity. See [Table 2.2.3-a](#).

If any multipurpose register is not used for encoder input, it is available for “general purpose” use: the register value can be altered via arithmetic operations and the register contents can be used to form MIDI or LED output. For bitwise operations, the register is treated as an 8-bit value. For other arithmetic operations, the register is assumed to contain a 7-bit value.

The power-up value for each register is user-configurable. See [Multipurpose Data Register Initial Values](#).

**Table 2.2.3-a: Multipurpose Data Registers: Encoder Data**

| Register Address | Encoder Control Terminal Pair |
|------------------|-------------------------------|
| 11h              | 0,1                           |
| 12h              | 2,3                           |
| 13h              | 4,5                           |
| 14h              | 6,7                           |
| 15h              | 8,9                           |
| 16h              | 10,11                         |
| 17h              | 12,13                         |
| 18h              | 14,15                         |
| 19h              | 16,17                         |
| 1Ah              | 18,19                         |
| 1Bh              | 20,21                         |
| 1Ch              | 22,23                         |

### 3.0 Control Terminal Configuration

Each MIDI CPU control terminal is associated with a *control terminal configuration* which is defined by one or more *configuration chunks*. The user sets the configuration for each control terminal via MIDI SysEx message. Configuration is retained when the MIDI CPU is disconnected from a power supply.

The MIDI CPU acknowledges an incoming configuration message via the Activity Indicator LED.

New users may benefit from first reviewing the Configuration Examples.

The factory default configuration for each control terminal is described in Factory Default Configuration.

#### 3.1 SysEx Message Format

**Figure 3.1-1** shows the format of the *Control Terminal Configuration SysEx Message*. The message consists of a fixed header, a variable length body, and a fixed footer.

The body of the message consists of a layer number followed by one or more 6-byte configuration chunks, each specifying a behavior for a single MIDI CPU control terminal. The configuration of control terminals not specified in the message will remain unchanged.

When the MIDI CPU configuration is updated via a MIDI SysEx message, the device will reset, followed by the LED self-test. If no LED activity is observed, then the attempted configuration was unsuccessful.

**Figure 3.1-1: Control Terminal Configuration SysEx Message Format (Hex)**

| Header<br>(6 bytes) | Layer<br>(1 byte) | Configuration Chunk<br>(repeat as desired) |           |           |           |           |           | Footer<br>(1 byte) |
|---------------------|-------------------|--|-----------|-----------|-----------|-----------|-----------|--------------------|
| F0 00 01 5D 04 01   | <i>yy</i>         | <i>nn</i>                                  | <i>tt</i> | <i>mm</i> | <i>ch</i> | <i>d0</i> | <i>d1</i> | F7                 |

##### 3.1.1 Layer (yy)

Configuration *layers* allow a single control terminal to be associated with multiple functions.

There are 4 control terminal configuration layers. Valid values for *yy* are 00h, 01h, 02h, or 03h. A control terminal's layer 00h configuration will always be used to determine its behavior.

If a control terminal's layer 00h configuration specifies one of the Logic Input Trigger Modes, additional Logic Input Trigger Modes can be associated with the control terminal via configuration layers 01h, 02h, and 03h. This allows a single control terminal to simultaneously trigger multiple events upon a state change. Only Logic Input Trigger Modes may be specified for configuration layers 01h, 02h, and 03h.

If a control terminal's layer 00h configuration does **not** specify a Logic Input Trigger Mode, configuration layers 01h, 02h, and 03h are ignored.

Use of configuration layers 01h, 02h, and 03h is optional and can vary independently by control terminal.

For each control terminal, specify Logic Input: Data Only mode for configuration layers which are not needed. This is the factory default setting for all control terminals in layers 01h, 02h, and 03h. See Factory Default Configuration.

### 3.1.2 Control Terminal Identifier (*nn*)

Parameter *nn* specifies the MIDI CPU control terminal associated with the configuration chunk. Values 00h thru 17h correspond to control terminal numbers 0 thru 23.

### 3.1.3 Transition (*tt*)

Control terminals configured in [Logic Input Trigger Modes](#) can trigger one event on the input signal transition from high to low, and a different event on the transition from low to high. For example, a control terminal might trigger a **Note On** message when the input signal changes from high to low, and a **Note Off** message when the signal changes from low to high. For Logic Input Trigger Modes only, the value of *tt* associates the configuration chunk with one transition or the other. See [Table 3.1.3-a](#).

When configuring a control terminal for any mode other than a Logic Input Trigger Mode, use the value *tt* = 00h.

**Table 3.1.3-a: Logic Input Trigger Mode Transitions**

| <i>tt</i> | Associated Transition      |
|-----------|----------------------------|
| 00h       | High to Low (Falling Edge) |
| 01h       | Low to High (Rising Edge)  |

### 3.1.4 Mode (*mm*)

Parameter *mm* specifies a function for the control terminal specified by *nn*. Valid range is 00h to 7Fh. The meanings of *d0* and *d1* depend on the value of *mm*.

Each control terminal mode falls into one of three categories:

- **Logic Input:** Control terminal is configured as a high-impedance digital logic input with a built-in pull-up resistor. The input state is either a binary '1' or '0' that is accessible from the [Logic Input Data](#) Register associated with the control terminal. Some modes cause a MIDI message to be generated when the input state changes.
- **Analog Input:** Control terminal is configured as an analog input. The input signal is continuously converted to a 7-bit digital value that is accessible from the Register associated with the control terminal. Some modes cause a MIDI message to be generated when the input state changes.
- **Logic Output:** Control terminal is configured as a digital logic output. The resulting signal can be used together with logic inputs to monitor a switch matrix, or can be used to drive an LED matrix.

Wiring examples for each category can be found in *MIDI CPU Hardware User Manual*.

Individual modes are described in sections 3.2 thru 3.5.

### 3.1.5 MIDI Channel (*ch*)

Some values of *mm* associate the control terminal with a channel-specific MIDI message. For these modes, the value of *ch* specifies which MIDI channel is used. *ch* can direct the MIDI CPU to generate messages using either a fixed channel value or the channel value specified by the [MIDI Channel Selection Jumper](#). See [Table 3.1.5-a](#).

The value of *ch* is ignored for modes which are not associated with a channel-specific MIDI message.

**Table 3.1.5-a: MIDI Channel by *ch* Value**

| <i>ch</i> | MIDI Channel                                       |
|-----------|--|
| 00h       | From <a href="#">MIDI Channel Selection Jumper</a> |
| 01h       | 1  |
| 02h       | 2  |
| 03h       | 3  |
| 04h       | 4  |
| 05h       | 5  |
| 06h       | 6  |
| 07h       | 7  |
| 08h       | 8  |
| 09h       | 9  |
| 0Ah       | 10   |
| 0Bh       | 11   |
| 0Ch       | 12   |
| 0Dh       | 13   |
| 0Eh       | 14   |
| 0Fh       | 15   |
| 10h       | 16   |

### 3.1.6 Data (*d0*, *d1*)

Depending on the value of *mm*, *d0* and *d1* can specify fixed values, data register addresses, or other information which determines the behavior of the control terminal. Details are provided in the description of each mode.

## 3.2 Logic Input Trigger Modes

*Logic Input Trigger Modes* configure the control terminal specified by *mn* as a logic input. Changes to input state may trigger MIDI output or other events.

### 3.2.1 Logic Input Trigger: **Note Off**

A **Note Off** message (status 80h) is generated when the control terminal input state changes. Note numbers are subject to MIDI Number Remapping.

Note: **Note Off** velocity data is ignored by most MIDI devices.

For efficient operation, do not configure the MIDI CPU to send **Note Off** messages. Instead, use **Note On** messages with a fixed velocity value of 00h.

| <i>mn</i> | <i>d0</i> Meaning                     | <i>d1</i> Meaning                       |
|-----------|---------------------------------------|---|
| 40h       | Fixed note number                     | Fixed note velocity                     |
| 41h       | Data register address for note number | Fixed note velocity                     |
| 42h       | Fixed note number                     | Data register address for note velocity |
| 43h       | Data register address for note number | Data register address for note velocity |

### 3.2.2 Logic Input Trigger: **Note On**

A **Note On** message is generated when the control terminal input state changes. Note numbers are subject to MIDI Number Remapping.

Note: A **Note On** message with a velocity of 00h is equivalent to a **Note Off** message.

| <i>mn</i> | <i>d0</i> Meaning                     | <i>d1</i> Meaning                       |
|-----------|---------------------------------------|---|
| 44h       | Fixed note number                     | Fixed note velocity                     |
| 45h       | Data register address for note number | Fixed note velocity                     |
| 46h       | Fixed note number                     | Data register address for note velocity |
| 47h       | Data register address for note number | Data register address for note velocity |

### 3.2.3 Logic Input Trigger: **Aftertouch**

An **Aftertouch** message is generated when the control terminal input state changes. Note numbers are subject to [MIDI Number Remapping](#).

| <i>mm</i> | <i>d0</i> Meaning                     | <i>d1</i> Meaning                        |
|-----------|---------------------------------------|--|
| 48h       | Fixed note number                     | Fixed pressure value                     |
| 49h       | Data register address for note number | Fixed pressure value                     |
| 4Ah       | Fixed note number                     | Data register address for pressure value |
| 4Bh       | Data register address for note number | Data register address for pressure value |

### 3.2.4 Logic Input Trigger: **Control Change (CC)**

A **Control Change (CC)** message is generated when the control terminal input state changes.

| <i>mm</i> | <i>d0</i> Meaning                   | <i>d1</i> Meaning                  |
|-----------|-------------------------------------|------------------------------------|
| 4Ch       | Fixed CC number                     | Fixed CC value                     |
| 4Dh       | Data register address for CC number | Fixed CC value                     |
| 4Eh       | Fixed CC number                     | Data register address for CC value |
| 4Fh       | Data register address for CC number | Data register address for CC value |

### 3.2.5 Logic Input Trigger: **Control Change (CC) Toggle**

A **Control Change (CC)** message is generated when the control terminal input state changes. The CC value alternates between the global CC “on” value and the global CC “off” value. See [Control Change \(CC\) “On/Off” Values](#).

| <i>mm</i> | <i>d0</i> Meaning                   | <i>d1</i> Meaning |
|-----------|-------------------------------------|-------------------|
| 56h       | Fixed CC number                     | Ignored           |
| 57h       | Data register address for CC number | Ignored           |

### 3.2.6 Logic Input Trigger: Program Change

A **Program Change** message is generated when the control terminal input state changes.

For modes 52h and 53h, the program number is the result of adding the values specified by *d0* and *d1*.

| <i>mm</i> | <i>d0</i> Meaning                        | <i>d1</i> Meaning                               |
|-----------|--|---|
| 50h       | Fixed program number                     | Ignored   |
| 51h       | Data register address for program number | Ignored   |
| 52h       | Fixed program number                     | Data register address for program number addend |
| 53h       | Data register address for program number | Data register address for program number addend |

### 3.2.7 Logic Input Trigger: Channel Pressure

a **Channel Pressure** message is generated when the control terminal input state changes.

| <i>mm</i> | <i>d0</i> Meaning                        | <i>d1</i> Meaning |
|-----------|--|-------------------|
| 54h       | Fixed pressure value                     | Ignored           |
| 55h       | Data register address for pressure value | Ignored           |

### 3.2.8 Logic Input Trigger: Pitch Wheel

A **Pitch Wheel** message is generated when the control terminal input state changes.

Pitch Wheel messages contain 14 bits of position data. The high-order bits (bits 13 thru 7) have a large impact on pitch change and the low-order bits (bits 6 thru 0) have a small impact.

For *mm* = 5Ah, it is recommended that *d0* = 00h.

| <i>mm</i> | <i>d0</i> Meaning                           | <i>d1</i> Meaning                            |
|-----------|---|--|
| 58h       | Fixed value for position bits 6-0           | Fixed value for position bits 13-7           |
| 59h       | Data register address for position bits 6-0 | Fixed value for position bits 13-7           |
| 5Ah       | Fixed value for position bits 6-0           | Data register address for position bits 13-7 |
| 5Bh       | Data register address for position bits 6-0 | Data register address for position bits 13-7 |

### 3.2.9 Logic Input Trigger: **System Exclusive (SysEx)**

An arbitrary **SysEx** message is generated when the control terminal input state changes.

The generated **SysEx** message consists of the standard “SysEx Begin” status byte (F0h) followed by data from the SysEx Data Buffer as specified by *d0* & *d1* and closed with the standard “SysEx End” status byte (F7h).

| <i>mm</i> | <i>d0</i> Meaning             | <i>d1</i> Meaning   |
|-----------|-------------------------------|---------------------|
| 5Ch       | SysEx buffer starting address | Data length (bytes) |

### 3.2.10 Logic Input Trigger: **MIDI Start**

A **MIDI Start** message is generated when the control terminal input state changes.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 64h       | Ignored           | Ignored           |

### 3.2.11 Logic Input Trigger: **MIDI Stop**

A **MIDI Stop** message is generated when the control terminal input state changes.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 65h       | Ignored           | Ignored           |

### 3.2.12 Logic Input Trigger: **MIDI Start / MIDI Stop Toggle**

Alternating **MIDI Start** and **MIDI Stop** messages are generated when the control terminal input state changes.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 66h       | Ignored           | Ignored           |

### 3.2.13 Logic Input Trigger: **MIDI Clock**

A **MIDI Clock** message is generated when the control terminal input state changes.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 67h       | Ignored           | Ignored           |



**3.2.14 Logic Input Trigger: Analog Continuous Note Start**

If the control terminal specified by *d0* is configured in Analog Input: Continuous Note mode, note generation begins.

| <i>mm</i> | <i>d0</i> Meaning               | <i>d1</i> Meaning |
|-----------|---------------------------------|-------------------|
| 68h       | Analog Input Control Terminal # | Ignored           |

**3.2.15 Logic Input Trigger: Analog Continuous Note Stop**

If the control terminal specified by *d0* is configured in Analog Input: Continuous Note mode, note generation halts.

| <i>mm</i> | <i>d0</i> Meaning               | <i>d1</i> Meaning |
|-----------|---------------------------------|-------------------|
| 69h       | Analog Input Control Terminal # | Ignored           |

**3.2.16 Logic Input Trigger: Encoder Continuous Note Start**

If the control terminal pair specified by *d0* is configured in Encoder Input: Continuous Note mode, note generation begins. For *d0*, use the lower of the two control terminal numbers in the pair.

| <i>mm</i> | <i>d0</i> Meaning                | <i>d1</i> Meaning |
|-----------|----------------------------------|-------------------|
| 6Ah       | Encoder Input Control Terminal # | Ignored           |

**3.2.17 Logic Input Trigger: Encoder Continuous Note Stop**

If the control terminal specified by *d0* is configured in Encoder Input: Continuous Note mode, note generation halts. For *d0*, use the lower of the two control terminal numbers in the pair.

| <i>mm</i> | <i>d0</i> Meaning                | <i>d1</i> Meaning |
|-----------|----------------------------------|-------------------|
| 6Bh       | Encoder Input Control Terminal # | Ignored           |

**3.2.18 Logic Input Trigger: MIDI Reset**

A **MIDI Reset** message is generated when the control terminal input state changes.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 7Eh       | Ignored           | Ignored           |

**3.2.19 Logic Input Trigger: Data Register: Increment**

The register specified by *d0* is incremented by the amount *d1* when the control terminal input state changes. No MIDI event is triggered.

| <i>mm</i> | <i>d0</i> Meaning     | <i>d1</i> Meaning |
|-----------|-----------------------|-------------------|
| 70h       | Data Register Address | Increment Value   |

**3.2.20 Logic Input Trigger: Data Register: Decrement**

The register specified by *d0* is decremented by the amount *d1* when the control terminal input state changes. No MIDI event is triggered.

| <i>mm</i> | <i>d0</i> Meaning     | <i>d1</i> Meaning |
|-----------|-----------------------|-------------------|
| 71h       | Data Register Address | Decrement Value   |

**3.2.21 Logic Input Trigger: Data Register: Store Value**

The value specified by *d1* is stored in the register specified by *d0* when the control terminal input state changes. No MIDI event is triggered.

| <i>mm</i> | <i>d0</i> Meaning     | <i>d1</i> Meaning |
|-----------|-----------------------|-------------------|
| 74h       | Data Register Address | Value             |

**3.2.22 Logic Input Trigger: Data Register: Clear / Set / Toggle Bit**

A bit in the register specified by *d0* is cleared, set or toggled when the control terminal input state changes. No MIDI event is triggered.

The value of *d1* specifies both the bit to be altered, and whether the bit should be cleared, set, or toggled. Values 00h-07h cause the bit numbered *d1* to be cleared. Values 08h-0Fh cause the bit numbered (*d1*-8) to be set. Values 10h-17h cause the bit numbered (*d1*-16) to be toggled.

| <i>mm</i> | <i>d0</i> Meaning     | <i>d1</i> Meaning           |
|-----------|-----------------------|-----------------------------|
| 76h       | Data Register Address | Clear / Set / Toggle; Bit # |

### 3.2.23 Logic Input: Data Only

The following mode configures the control terminal as a logic input. The input state is available as Logic Input Data, but no event is triggered by state changes.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 7Fh       | Ignored           | Ignored           |

### 3.3 Logic Input Rotary Encoder Modes

*Logic Input Rotary Encoder Modes* configure the control terminal specified by *mn* as a logic input. For proper operation, both control terminals in an encoder input pair must be given the same configuration. See [Table 2.2.3-a](#) for a list of control terminal encoder input pairs. When the attached rotary encoder is adjusted, the value in the control terminal pair's corresponding data register is incremented or decremented.

The initial value upon power-up for each data register is user configurable. See [Multipurpose Data Register Initial Values](#).

#### 3.3.1 Encoder Input: Continuous Note

A continuous stream of MIDI notes is generated. The encoder data register for the control terminal determines the note number of the current note. Must be used in conjunction with modes [Logic Input Trigger: Encoder Continuous Note Start](#) and [Logic Input Trigger: Encoder Continuous Note Stop](#).

If note generation has begun, input from the rotary encoder simultaneously causes the previous MIDI note to be canceled with a **Note Off** message and a new note to be initiated with a **Note On** message. Note numbers are subject to [MIDI Number Remapping](#).

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning                       |
|-----------|-------------------|---|
| 10h       | Ignored           | Fixed note velocity                     |
| 11h       | Ignored           | Data register address for note velocity |

#### 3.3.2 Encoder Input: **Control Change (CC)**

A **Control Change** message is generated when input is received from the rotary encoder.

| <i>mm</i> | <i>d0</i> Meaning                   | <i>d1</i> Meaning                  |
|-----------|-------------------------------------|------------------------------------|
| 14h       | Fixed CC number                     | Data register address for CC value |
| 15h       | Data register address for CC number | Data register address for CC value |

#### 3.3.3 Encoder Input: **Program Change**

A **Program Change** message is generated when input is received from the rotary encoder.

| <i>mm</i> | <i>d0</i> Meaning                        | <i>d1</i> Meaning |
|-----------|--|-------------------|
| 16h       | Data register address for program number | Ignored           |

### 3.3.4 Encoder Input: **Channel Pressure**

A **Channel Pressure** message is generated when input is received from the rotary encoder.

| <i>mm</i> | <i>d0</i> Meaning                        | <i>d1</i> Meaning |
|-----------|--|-------------------|
| 17h       | Data register address for pressure value | Ignored           |

### 3.3.5 Encoder Input: **Matrix Note Velocity**

Input from the encoder sets the note velocity value for any **Note On** messages associated with control terminals operating in a Matrix Select Mode.

Control terminal input overrides the global Matrix Note Velocity setting.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 1Ah       | Ignored           | Ignored           |

### 3.3.6 Encoder Input: **Control Change (CC) “On” Value**

Input from the encoder sets the global **CC** “On” value.

Control terminal input overrides the Control Change (CC) “On/Off” Values setting.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 1Bh       | Ignored           | Ignored           |

### 3.3.7 Encoder Input: **Control Change (CC) “Off” Value**

Input from the encoder sets the global **CC** “Off” value.

Control terminal input overrides the Control Change (CC) “On/Off” Values setting.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 1Ch       | Ignored           | Ignored           |

### 3.3.8 Encoder Input: **Data Only**

When input from the rotary encoder is received, the value in the corresponding data register is adjusted, but no MIDI message is generated.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 1Fh       | Ignored           | Ignored           |

### 3.4 Analog Input Modes

*Analog Input Modes* configure the control terminal specified by *nn* as an analog input. Changes to input state may trigger MIDI output or other events.

Only certain control terminals can be configured as analog inputs – see *MIDI CPU Hardware User Manual*.

#### 3.4.1 Analog Input: Continuous Note

A continuous stream of MIDI notes is generated. The analog data register for the control terminal determines the note number of the current note. Must be used in conjunction with modes Logic Input Trigger: Analog Continuous Note Start and Logic Input Trigger: Analog Continuous Note Stop.

If note generation has begun, change to the analog input simultaneously causes the previous MIDI note to be canceled with a **Note Off** message and a new note to be initiated with a **Note On** message. Note numbers are subject to MIDI Number Remapping.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning                  |
|-----------|-------------------|------------------------------------|
| 00h       | Ignored           | Fixed note velocity                |
| 01h       | Ignored           | Data register address for velocity |

#### 3.4.2 Analog Input: **Aftertouch**

Change to the analog input signal causes an **Aftertouch** message to be generated. Note numbers are subject to MIDI Number Remapping.

| <i>mm</i> | <i>d0</i> Meaning                     | <i>d1</i> Meaning                        |
|-----------|---------------------------------------|--|
| 02h       | Fixed note number                     | Data register address for pressure value |
| 03h       | Data register address for note number | Data register address for pressure value |

#### 3.4.3 Analog Input: **Control Change (CC)**

Whenever the analog input signal changes, a **Control Change** message is generated.

| <i>mm</i> | <i>d0</i> Meaning                   | <i>d1</i> Meaning                  |
|-----------|-------------------------------------|------------------------------------|
| 04h       | Fixed CC number                     | Data register address for CC value |
| 05h       | Data register address for CC number | Data register address for CC value |

### 3.4.4 Analog Input: Program Change

Whenever the analog input signal changes, a **Program Change** message is generated.

| <i>mm</i> | <i>d0</i> Meaning                        | <i>d1</i> Meaning |
|-----------|--|-------------------|
| 06h       | Data register address for program number | Ignored           |

### 3.4.5 Analog Input: Channel Pressure

Whenever the analog input signal changes, a **Channel Pressure** message is generated.

| <i>mm</i> | <i>d0</i> Meaning                         | <i>d1</i> Meaning |
|-----------|---|-------------------|
| 07h       | Data register address for pressure number | Ignored           |

### 3.4.6 Analog Input: Pitch Wheel

Whenever the analog input signal changes, a **Pitch Wheel** message is generated.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning                        |
|-----------|-------------------|--|
| 08h       | Ignored           | Data register address for position value |

### 3.4.7 Analog Input: Matrix Note Velocity

The analog input signal sets the note velocity value for any **Note On** messages associated with control terminals operating in a Matrix Select Mode.

Control terminal input overrides the global Matrix Note Velocity setting.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 0Ah       | Ignored           | Ignored           |

### 3.4.8 Analog Input: Control Change (CC) “On” Value

The analog input signal sets the global **CC** “On” value.

Control terminal input overrides the Control Change (CC) “On/Off” Values setting.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 0Bh       | Ignored           | Ignored           |

### 3.4.9 Analog Input: **Control Change (CC)** “Off” Value

The analog input signal sets the global **CC** “Off” value.

Control terminal input overrides the Control Change (CC) “On/Off” Values setting.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 0Ch       | Ignored           | Ignored           |

### 3.4.10 Analog Input: Data Only

Analog input is converted to a 7-bit value and stored in the analog data register corresponding to the control terminal, but no MIDI message is generated.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 0Fh       | Ignored           | Ignored           |



### 3.5 Logic Output Matrix Select Modes

A *Logic Output Matrix Select Mode* causes the associated control terminal to periodically generate a matrix select output signal, allowing the MIDI CPU to monitor the states of switches in a switch matrix.

Only certain control terminals can be configured as logic outputs – see *MIDI CPU Hardware User Manual*.

When a control terminal is configured in a Logic Output Matrix Select Mode, the following “select cycle” will repeat continuously:

1. Control terminal begins in a high-impedance (input) state.
2. A select pulse (0V output) from the control terminal is initiated.
3. The MIDI CPU takes a “snapshot” of the switch state data register associated with the mode.
4. Control terminal returns to high-impedance (input) state.
5. The Matrix Data Bitmask is applied to the snapshot.
6. MIDI messages are generated according to any changed switch states.
7. The output remains inactive (high-impedance) while select pulses are generated by other matrix select control terminals.
8. Cycle repeats with step 1.

The frequency of the select cycle (or “matrix sampling rate”) varies depending on MIDI CPU configuration and input activity. The typical rate approaches 1,000 select cycles per second.

#### 3.5.1 Matrix Select: **Note On / Note Off**

When a switch state changes from high to low, a **Note On** message is generated. When a switch state changes from low to high, a **Note Off** message is generated.

The note number for each switch is determined by the value of *d0*. Switch state data register bit 0 generates messages with note number *d0*, bit 1 generates messages with note number *d0* + 1, bit 2 generates messages with note number *d0* + 2, etc. Note numbers are subject to MIDI Number Remapping.

Note velocity is determined by either global configuration variable, analog input, or encoder input. See Matrix Note Velocity, Analog Input: Matrix Note Velocity, or Encoder Input: Matrix Note Velocity.

| <i>mm</i> | Switch State Data Register | <i>d0</i> Meaning          | <i>d1</i> Meaning          |
|-----------|----------------------------|----------------------------|----------------------------|
| 2Ch       | 00h                        | Note number for data bit 0 | <u>Matrix Data Bitmask</u> |
| 2Dh       | 01h                        | Note number for data bit 0 | <u>Matrix Data Bitmask</u> |
| 2Eh       | 02h                        | Note number for data bit 0 | <u>Matrix Data Bitmask</u> |

### 3.5.2 Matrix Select: Note Toggle

Alternating **Note On** and **Note Off** messages are generated when a switch state changes from high to low.

The note number for each switch is determined by the value of  $d0$ . Switch state data register bit 0 generates messages with note number  $d0$ , bit 1 generates messages with note number  $d0 + 1$ , bit 2 generates messages with note number  $d0 + 2$ , etc. Note numbers are subject to [MIDI Number Remapping](#).

Note velocity is determined by either global configuration variable, analog input, or encoder input. See [Matrix Note Velocity](#), [Analog Input: Matrix Note Velocity](#), or [Encoder Input: Matrix Note Velocity](#).

| <i>mm</i> | Switch State Data Register | <i>d0</i> Meaning          | <i>d1</i> Meaning                   |
|-----------|----------------------------|----------------------------|-------------------------------------|
| 30h       | 00h                        | Note number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |
| 31h       | 01h                        | Note number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |
| 32h       | 02h                        | Note number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |

### 3.5.3 Matrix Select: **Control Change (CC)** On/Off

When a switch state changes, a **Control Change** message is generated.

The CC number for each switch is determined by the value of  $d0$ . Switch state data register bit 0 generates messages with CC number  $d0$ , bit 1 generates messages with CC number  $d0 + 1$ , bit 2 generates messages with CC number  $d0 + 2$ , etc.

When a switch state changes from high to low, the CC “on” value is used. When a switch state changes state from low to high, the CC “off” value is used. CC on/off values are determined by global configuration variables. See [Control Change \(CC\) “On/Off” Values](#).

| <i>mm</i> | Switch State Data Register | <i>d0</i> Meaning        | <i>d1</i> Meaning                   |
|-----------|----------------------------|--------------------------|-------------------------------------|
| 34h       | 00h                        | CC number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |
| 35h       | 01h                        | CC number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |
| 36h       | 02h                        | CC number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |

### 3.5.4 Matrix Select: **Control Change (CC)** Toggle

When a switch state changes from high to low, a **Control Change** message is generated.

CC number for each switch is determined by the value of  $d0$ . Switch state data register bit 0 generates messages with CC number  $d0$ , bit 1 generates messages with CC number  $d0 + 1$ , bit 2 generates messages with CC number  $d0 + 2$ , etc.

The CC value alternates between the global CC “on” value and the global CC “off” value. See [Control Change \(CC\) “On/Off” Values](#).

| <i>mm</i> | Switch State Data Register | <i>d0</i> Meaning        | <i>d1</i> Meaning                   |
|-----------|----------------------------|--------------------------|-------------------------------------|
| 38h       | 00h                        | CC number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |
| 39h       | 01h                        | CC number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |
| 3Ah       | 02h                        | CC number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |

### 3.5.5 Matrix Select: **Program Change**

When a switch state changes from high to low, a **Program Change** message is generated.

The program number for each switch is determined by the value of  $d0$ . Switch state data register bit 0 generates messages with program number  $d0$ , bit 1 generates messages with program number  $d0 + 1$ , bit 2 generates messages with program number  $d0 + 2$ , etc.

| <i>mm</i> | Switch State Data Register | <i>d0</i> Meaning             | <i>d1</i> Meaning                   |
|-----------|----------------------------|-------------------------------|-------------------------------------|
| 3Ch       | 00h                        | Program number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |
| 3Dh       | 01h                        | Program number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |
| 3Eh       | 02h                        | Program number for data bit 0 | <a href="#">Matrix Data Bitmask</a> |

### 3.5.6 Matrix Data Bitmask

Logic Output Matrix Select Modes employ a *bitmask* specified by the value of *d1*.

When processing data from the switch state data register, the MIDI CPU can ignore certain data bits as directed by the bitmask. Bits with a bitmask value of '0' are ignored. Values for *d1* and the corresponding bitmasks are shown in [Table 3.5.6-a](#).

When a switch matrix does not employ all 8 control terminals associated with a data register, the correct bitmask prevents the unused control terminals from interfering with matrix monitoring. The unused control terminals can therefore be configured for other purposes.

**Table 3.5.6-a: Matrix Data Bitmasks**

| <i>d1</i> | Data Bitmask |       |       |       |       |       |       |       |
|-----------|--------------|-------|-------|-------|-------|-------|-------|-------|
|           | Bit 7        | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
| 00h       | 1            | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 01h       | 1            | 1     | 1     | 1     | 1     | 1     | 1     | 0     |
| 02h       | 1            | 1     | 1     | 1     | 1     | 1     | 0     | 0     |
| 03h       | 1            | 1     | 1     | 1     | 1     | 0     | 0     | 0     |
| 04h       | 1            | 1     | 1     | 1     | 0     | 0     | 0     | 0     |
| 05h       | 1            | 1     | 1     | 0     | 0     | 0     | 0     | 0     |
| 06h       | 1            | 1     | 0     | 0     | 0     | 0     | 0     | 0     |
| 07h       | 1            | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| 08h       | 0            | 1     | 1     | 1     | 1     | 1     | 1     | 1     |
| 09h       | 0            | 0     | 1     | 1     | 1     | 1     | 1     | 1     |
| 0Ah       | 0            | 0     | 0     | 1     | 1     | 1     | 1     | 1     |
| 0Bh       | 0            | 0     | 0     | 0     | 1     | 1     | 1     | 1     |
| 0Ch       | 0            | 0     | 0     | 0     | 0     | 1     | 1     | 1     |
| 0Dh       | 0            | 0     | 0     | 0     | 0     | 0     | 1     | 1     |
| 0Eh       | 0            | 0     | 0     | 0     | 0     | 0     | 0     | 1     |

### 3.6 Logic Output LED Control Modes

The following modes configure the control terminal specified by *nn* for logic output.

The MIDI CPU can control up to 64 LEDs arranged in an 8x8 matrix. The matrix can be comprised of a mixture of individual indicator LEDs, 7-segment numerical displays, and 8-segment “bar graph” displays.

LED control functionality requires that at least one control terminal (0-7) be configured for [LED Data Output](#) and at least one control terminal (8-15) be configured for [LED Common Output](#).

Control terminals configured for LED control output are subject the electrical limitations described in *MIDI CPU Hardware User Manual*.

#### 3.6.1 LED Data Output

The control terminal generates a control signal that drives an attached LED matrix. Must be used in conjunction with control terminals configured for [LED Common Output](#).

Note: Only control terminals 0-7 can be configured for LED data output. If one or more control terminals are configured for LED data output, control terminals 0-7 cannot be configured as matrix select outputs.

| <i>mm</i> | <i>d0</i> Meaning | <i>d1</i> Meaning |
|-----------|-------------------|-------------------|
| 2Bh       | Ignored           | Ignored           |

#### 3.6.2 LED Common Output

The control terminal generates a “common” control signal for up to 8 LEDs arranged in either a common-anode or common-cathode configuration. The data signal for each LED is automatically generated by control terminals configured for [LED Data Output](#).

The contents of the data register at address *d1* are formatted as specified by *d0*.

Note: Only control terminals 8-15 can be configured for LED common output.

| <i>mm</i> | <i>d0</i> Meaning                 | <i>d1</i> Meaning  |
|-----------|-----------------------------------|--------------------|
| 2Ah       | <a href="#">LED Output Format</a> | LED State Register |

#### 3.6.3 LED Output Format

LED common output mode employs an *output format* specified by the value of *d0*. The output format encodes all of the following:

- The polarity of the attached LED array (“common anode” or “common cathode”)
- Whether or not the common signal is externally inverted
- The *display type* for the value in the LED state register

When a *common anode* format is used, the control terminal drives the anodes of up to 8 LEDs. Each LED cathode must be connected to a different MIDI CPU control terminal configured for [LED Data Output](#).

When a *common cathode* format is used, the control terminal drives the cathodes of up to 8 LEDs. Each LED anode must be connected to a different MIDI CPU control terminal configured for LED Data Output.

Because of the electrical limitations of the MIDI CPU, LED common output signals may be externally buffered by the user. *Inverted common* output formats are available for applications where “inverting” buffering methods are employed.

The following LED display types are available:

**Bit Indication:** The state of each LED reflects the corresponding bit in the LED state register. 1 = on; 0 = off.

**7-Segment Display (00h = “0”):** The LED state register value is interpreted as an integer. Use these formats to display an unsigned value between 0 and 127.

**7-Segment Display (40h = “0”):** The LED state register value is interpreted as an integer. Use these formats to display a signed value between -64 and 63.

**Bar Graph:** The LED state register value is interpreted as an integer. When the state register value is 0, only LED0 is illuminated. Each increase of 16 to the state register value causes the illumination of an additional LED.

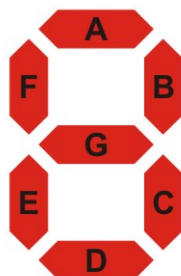
The LED state summary for each display type is shown in [Table 3.6.3-a](#). For any group of LEDs sharing the same LED common output, LED0-LED7 correspond to LED data output from control terminals 0-7. [Figure 3.6.3-1](#) shows the standard segment labels for a 7-segment digit.

Output formats and corresponding *d0* values are shown in [Table 3.6.3-b](#).

**Table 3.6.3-a: LED State Summary by Display Type**

| Display Type   | LED State  |           |           |           |           |           |           |       |
|----------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|-------|
|                | LED7       | LED6      | LED5      | LED4      | LED3      | LED2      | LED1      | LED0  |
| Bit Indication | Bit 7      | Bit 6     | Bit 5     | Bit 4     | Bit 3     | Bit 2     | Bit 1     | Bit 0 |
| 7-Segment      | Off        | G         | F         | E         | D         | C         | B         | A     |
| Bar Graph      | $\geq 112$ | $\geq 96$ | $\geq 80$ | $\geq 64$ | $\geq 48$ | $\geq 32$ | $\geq 16$ | On    |

**Figure 3.6.3-1: 7-Segment Display Segment Labels**



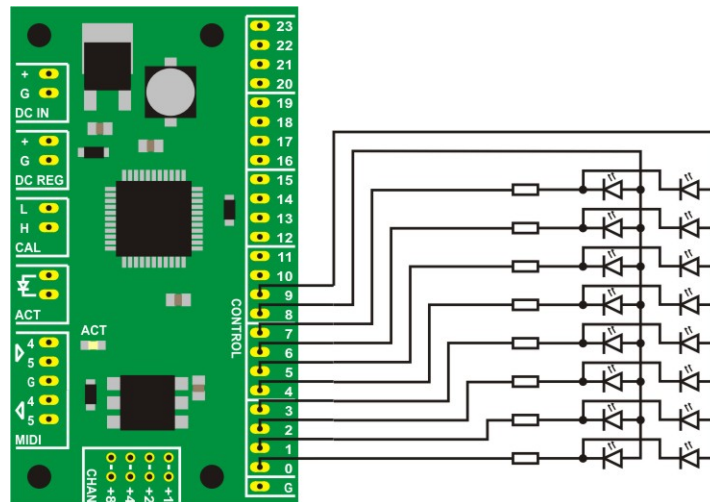
**Table 3.6.3-b: LED Common Output Formats**

| <i>d0</i> | Common                | Display Type   |
|-----------|-----------------------|--|
| 00h       | Anode, Non-Inverted   | <u>Bit Indication</u>                                  |
| 01h       | Anode, Inverted       | Bit Indication   |
| 02h       | Cathode, Non-Inverted | Bit Indication   |
| 03h       | Cathode, Inverted     | Bit Indication   |
| 04h       | Anode, Non-Inverted   | <u>7-Segment Display (00h = “0”)</u> , Hundreds Column |
| 05h       | Anode, Inverted       | 7-Segment Display (00h = “0”), Hundreds Column         |
| 06h       | Cathode, Non-Inverted | 7-Segment Display (00h = “0”), Hundreds Column         |
| 07h       | Cathode, Inverted     | 7-Segment Display (00h = “0”), Hundreds Column         |
| 08h       | Anode, Non-Inverted   | 7-Segment Display (00h = “0”), Tens Column             |
| 09h       | Anode, Inverted       | 7-Segment Display (00h = “0”), Tens Column             |
| 0Ah       | Cathode, Non-Inverted | 7-Segment Display (00h = “0”), Tens Column             |
| 0Bh       | Cathode, Inverted     | 7-Segment Display (00h = “0”), Tens Column             |
| 0Ch       | Anode, Non-Inverted   | 7-Segment Display (00h = “0”), Ones Column             |
| 0Dh       | Anode, Inverted       | 7-Segment Display (00h = “0”), Ones Column             |
| 0Eh       | Cathode, Non-Inverted | 7-Segment Display (00h = “0”), Ones Column             |
| 0Fh       | Cathode, Inverted     | 7-Segment Display (00h = “0”), Ones Column             |
| 10h       | Anode, Non-Inverted   | <u>Bar Graph</u>                                       |
| 11h       | Anode, Inverted       | Bar Graph  |
| 12h       | Cathode, Non-Inverted | Bar Graph  |
| 13h       | Cathode, Inverted     | Bar Graph  |
| 14h       | Anode, Non-Inverted   | <u>7-Segment Display (40h = “0”)</u> , Sign Column     |
| 15h       | Anode, Inverted       | 7-Segment Display (40h = “0”), Sign Column             |
| 16h       | Cathode, Non-Inverted | 7-Segment Display (40h = “0”), Sign Column             |
| 17h       | Cathode, Inverted     | 7-Segment Display (40h = “0”), Sign Column             |
| 18h       | Anode, Non-Inverted   | 7-Segment Display (40h = “0”), Tens Column             |
| 19h       | Anode, Inverted       | 7-Segment Display (40h = “0”), Tens Column             |
| 1Ah       | Cathode, Non-Inverted | 7-Segment Display (40h = “0”), Tens Column             |
| 1Bh       | Cathode, Inverted     | 7-Segment Display (40h = “0”), Tens Column             |
| 1Ch       | Anode, Non-Inverted   | 7-Segment Display (40h = “0”), Ones Column             |
| 1Dh       | Anode, Inverted       | 7-Segment Display (40h = “0”), Ones Column             |
| 1Eh       | Cathode, Non-Inverted | 7-Segment Display (40h = “0”), Ones Column             |
| 1Fh       | Cathode, Inverted     | 7-Segment Display (40h = “0”), Ones Column             |

### 3.6.4 LED Output Examples

The figures below show four different configurations for a (2 common) x (8 data) LED matrix. Additional groups of 8 LEDs can be driven with the additional common lines, up to a total of 64 LEDs.

**Figure 3.6.4-1: LED Matrix, Non-Inverted Common Anode**



**Figure 3.6.4-2: LED Matrix, Inverted Common Anode**

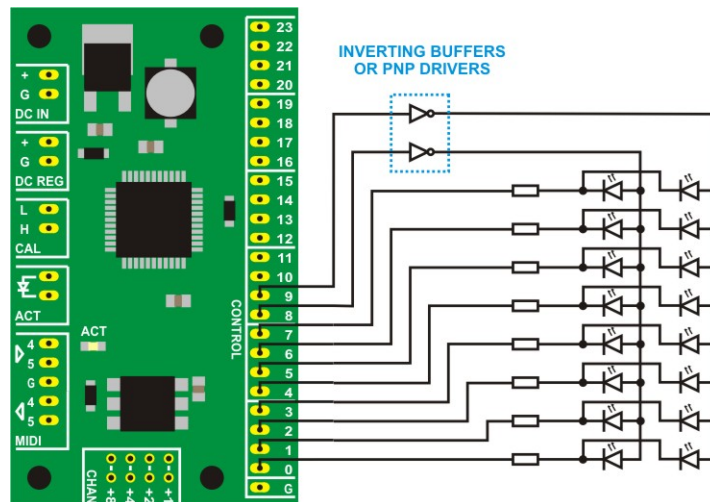




Figure 3.6.4-3: LED Matrix, Non-Inverted Common Cathode

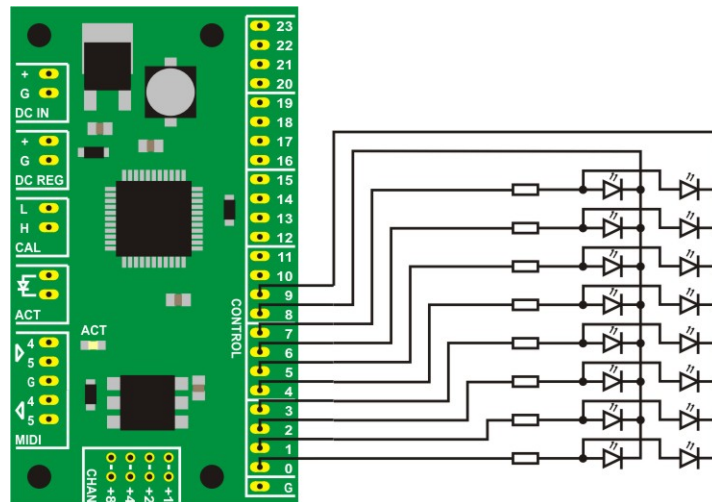
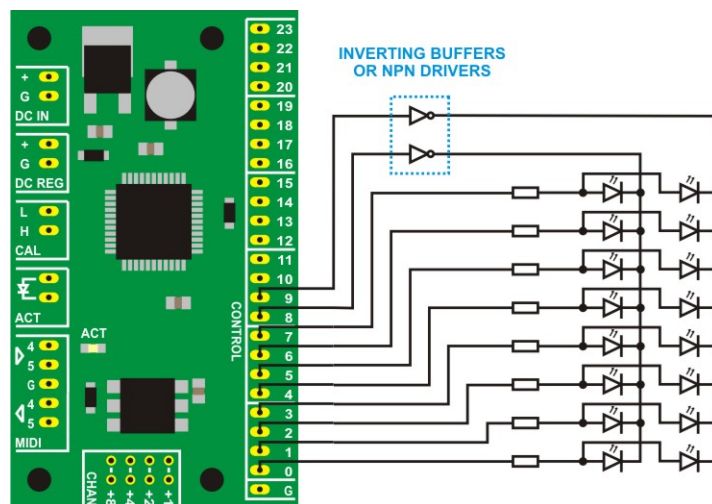


Figure 3.6.4-4: LED Matrix, Inverted Common Cathode



## 4.0 Global Configuration

The MIDI CPU has several user-configurable settings which are not associated with individual control terminals. Each setting and the associated SysEx message is described below.

The MIDI CPU acknowledges an incoming configuration message via the Activity Indicator LED.

The factory default value for each setting is described in Factory Default Configuration.

### 4.1 Matrix Note Velocity

The velocity of MIDI notes generated as a result of matrix select control terminal modes can be changed via the SysEx message described in [Figure 4.1-1](#).

Alternatively, velocity can be changed in real time via control terminal modes Encoder Input: Matrix Note Velocity and Analog Input: Matrix Note Velocity.

**Figure 4.1-1: Matrix Note Velocity SysEx Message (Hex)**

| Header<br>(6 bytes) | Note Velocity<br>(1 byte) | Footer<br>(1 byte) |
|---------------------|---------------------------|--------------------|
| F0 00 01 5D 04 02   | <i>vv</i>                 | F7                 |

### 4.2 Control Change (CC) “On/Off” Values

The CC value of messages generated by modes Logic Input Trigger: Control Change (CC) Toggle, Matrix Select: Control Change (CC) On/Off, and Matrix Select: Control Change (CC) Toggle can be changed via the SysEx message described in [Figure 4.2-1](#).

Alternatively, on/off values can be changed in real time via control terminal modes: Encoder Input: Control Change (CC) “Off” Value, Encoder Input: Control Change (CC) “On” Value, Analog Input: Control Change (CC) “Off” Value, and Analog Input: Control Change (CC) “On” Value.

**Figure 4.2-1: Matrix Control Change (CC) On/Off Values SysEx Message (Hex)**

| Header<br>(6 bytes) | “On” Value<br>(1 byte) | “Off” Value<br>(1 byte) | Footer<br>(1 byte) |
|---------------------|------------------------|-------------------------|--------------------|
| F0 00 01 5D 04 03   | <i>xx</i>              | <i>yy</i>               | F7                 |

### 4.3 Multipurpose Data Register Initial Values

The initial value (at power-up) contained in the multipurpose data registers can be changed via the MIDI SysEx message described in [Figure 4.3-1](#). Values *v0-v11* correspond to data register addresses 11h-1Ch (see [Table 2.2.3-a](#)).

**Figure 4.3-1: Multipurpose Data Register Initial Values SysEx Message (Hex)**

| Header<br>(6 bytes) | Initial Values<br>(12 bytes)                 | Footer<br>(1 byte) |
|---------------------|--|--------------------|
| F0 00 01 5D 04 04   | <i>v0 v1 v2 v3 v4 v5 v6 v7 v8 v9 v10 v11</i> | F7                 |

### 4.4 Note Transposition

The MIDI CPU can transpose locally generated notes by an amount that is adjustable in “real time”. Note transposition is configured via the SysEx message described in [Figure 4.4-1](#).

If the register at address *aa* contains the value *vv*, note numbers are increased by the value (*vv* - 40h). This allows a range of transposition values between -64 (*vv* = 00h) and +63 (*vv* = 7Fh). When *vv* = 40h, no transposition takes place.

To disable note transposition, use the value *aa* = 7Fh.

The MIDI CPU transposes note numbers before performing any [MIDI Number Remapping](#).

**Figure 4.4-1: Note Transposition SysEx Message (Hex)**

| Header<br>(6 bytes) | Transposition Register Address<br>(1 byte) | Footer<br>(1 byte) |
|---------------------|--|--------------------|
| F0 00 01 5D 04 0B   | <i>aa</i>                                  | F7                 |

### 4.5 MIDI Number Remapping

The MIDI CPU can remap any locally generated note number, CC number, or program number to another before MIDI output is generated. This can be useful for unusual switch matrix configurations or for changing the musical scale of MIDI output.

Remapping for each message type is independently activated via SysEx message. See [Figure 4.3-1](#) and [Table 4.5-a](#).

**Figure 4.5-1: MIDI Number Remapping Flags SysEx Message (Hex)**

| Header<br>(6 bytes) | Remap Flags<br>(1 byte) | Footer<br>(1 byte) |
|---------------------|-------------------------|--------------------|
| F0 00 01 5D 04 0A   | <i>ff</i>               | F7                 |

**Table 4.5-a: MIDI Number Remapping Flags Hex Values**

| <i>ff</i> (Hex) | Program Remap | CC Remap  | Note Remap |
|-----------------|---------------|-----------|------------|
| 00              | off           | off       | off        |
| 01              | off           | off       | <b>on</b>  |
| 02              | off           | <b>on</b> | off        |
| 03              | off           | <b>on</b> | <b>on</b>  |
| 04              | <b>on</b>     | off       | off        |
| 05              | <b>on</b>     | off       | <b>on</b>  |
| 06              | <b>on</b>     | <b>on</b> | off        |
| 07              | <b>on</b>     | <b>on</b> | <b>on</b>  |

When the MIDI CPU generates a message type for which remapping is active, the (note, CC, or program) number resulting from control terminal configuration is used as a look-up address for the *MIDI Number Remap Table*. The value contained in the table at that address is substituted for the (note, CC, or program) number in the outgoing message.

By default, each value within the table is equal to its address: therefore, no remapping takes place. Values in the table may be updated via SysEx as described in [Figure 4.5-2](#). The SysEx message includes the remap value for each MIDI number in order from numbers 0 to 127.

To return the MIDI Number Remap Table to its default (no remap) state, use the SysEx message described in [Figure 4.5-3](#).

**Figure 4.5-2: MIDI Number Remapping Table SysEx Message (Hex)**

| Header<br>(6 bytes) | MIDI Number Remap Table Contents<br>(128 bytes) | Footer<br>(1 byte) |
|---------------------|---|--------------------|
| F0 00 01 5D 04 05   | <i>n0 n1 n2 ...</i>                             | F7                 |

**Figure 4.5-3: MIDI Number Remapping Table Reset SysEx Message (Hex)**

| Complete Message<br>(7 bytes) |
|-------------------------------|
| F0 00 01 5D 04 06 F7          |

## 4.6 SysEx Data Buffer

The MIDI CPU is capable of sending arbitrary **SysEx** messages in response to control terminal input. See the [Logic Input Trigger: System Exclusive \(SysEx\)](#) control terminal mode.

The data payload of the generated **SysEx** message is formed from the contents of the *SysEx Data Buffer*. To update the contents of the buffer, send a SysEx message as shown in [Figure 4.6-1](#). The SysEx data is written to the SysEx Data Buffer starting at address 00h. If fewer than 128 bytes are specified, the remainder of bytes in the SysEx Data Buffer is filled with the value 7Fh.

**Figure 4.6-1: SysEx Data Buffer Contents SysEx Message (Hex)**

| Header<br>(6 bytes) | SysEx Data Buffer Contents<br>(up to 128 bytes) | Footer<br>(1 byte) |
|---------------------|---|--------------------|
| F0 00 01 5D 04 07   | <i>d0 d1 d2 ...</i>                             | F7                 |

## 4.7 ADC Configuration

The MIDI CPU uses an analog-to-digital converter (ADC) to measure the voltages on control terminals configured as analog inputs. Measurements from the ADC are processed based on settings from the SysEx message shown in [Figure 4.7-1](#).

**Figure 4.7-1: ADC Configuration SysEx Message (Hex)**

| Header<br>(6 bytes) | Analog<br>Input<br>Threshold<br>(1 byte) | Analog<br>Input<br>Smoothing<br>(1 byte) | Reference<br>Voltage<br>(1 byte) | Footer<br>(1 byte) |
|---------------------|--|--|----------------------------------|--------------------|
| F0 00 01 5D 04 08   | <i>tt</i>                                | <i>ss</i>                                | <i>rr</i>                        | F7                 |

### 4.7.1 Analog Input Threshold (*tt*)

When a control terminal is configured as an analog input, the MIDI CPU first converts the analog signal to a 10-bit digital value, and then reduces the 10-bit value to the 7-bit resolution employed by MIDI messaging.

Due to “noise” resulting from the analog-to-digital conversion process and/or the instability of an analog input signal, analog input values may fluctuate excessively, causing the MIDI CPU to generate unwanted quantities of MIDI messages. The *Analog Input Threshold* is the minimum quantity by which any 10-bit analog input value must change in order to trigger message generation.

The Analog Input Threshold acts on the 10-bit input value, but is ignored whenever the resulting 7-bit input value reaches its minimum (0) or maximum (127) value.

### 4.7.2 Analog Input Smoothing (*ss*)

The MIDI CPU uses a rolling average algorithm to smooth the data waveform resulting from analog to digital conversion. The value of *ss* determines the weight of the rolling average compared to the immediate analog input value. Larger values of *ss* result in a smoother waveform. Smaller values of *ss* result in a waveform that responds more quickly to input changes. The valid range for *ss* is 00h to 04h.

### 4.7.3 Analog Reference Voltage (*rr*)

When one or more MIDI CPU control terminals are configured as analog inputs, the MIDI CPU uses two *reference voltages* during the analog-to-digital conversion process. These voltages, called “ $V_{REF-}$ ” and “ $V_{REF+}$ ”, represent the analog voltages that are converted to the digital values 00h and 7Fh, respectively.

The MIDI CPU can use its own voltage regulator to supply the reference voltages, or it can use external reference voltages connected by the user.

External reference voltages can be useful when:

- Lower-noise analog-to-digital conversion is required
- The analog input signal does not span the entire range between MIDI CPU ground and  $V_{REG}$ .

When *rr* is set to 00h, the MIDI CPU will use its on-board ground as  $V_{REF-}$ , and its on-board  $V_{REG}$  as  $V_{REF+}$ .

When *rr* is set to 01h, the MIDI CPU will use the external  $V_{REF-}$  and  $V_{REF+}$  connected by the user to control terminals 18 and 19.

See *MIDI CPU Hardware User Manual* for external reference voltage wiring diagrams and for additional details regarding  $V_{REG}$ .

Regardless of the reference voltages used, analog input voltages must not exceed the limits described in *MIDI CPU Hardware User Manual*.

## 4.8 Active Sense On/Off

During periods of inactivity, a MIDI device can send **Active Sense** messages to notify the receiving device that the MIDI link is still operating. **Active Sense** messages are automatically generated at the rate of approximately 4 per second when no other MIDI data is being generated. This function is not required for most applications.

MIDI CPU **Active Sense** generation can be enabled or disabled using the SysEx message shown in [Figure 4.8-1](#). When *aa* = 00h, **Active Sense** is disabled. When *aa* = 01h, **Active Sense** is enabled.

**Figure 4.8-1: Active Sense On/Off SysEx Message (Hex)**

| Header<br>(6 bytes) | Active Sense<br>(1 byte) | Footer<br>(1 byte) |
|---------------------|--------------------------|--------------------|
| F0 00 01 5D 04 09   | <i>aa</i>                | F7                 |

## 5.0 Configuration Retrieval

At any time, the current MIDI CPU configuration can be retrieved via *SysEx Configuration Retrieval Messages*. When the MIDI CPU receives a SysEx Configuration Retrieval Message at its MIDI IN port, it will output the associated configuration data in the form of a SysEx Configuration Message.

The format of each SysEx Configuration Retrieval message is shown in [Table 5-a](#).

**Table 5-a: SysEx Configuration Retrieval Messages**

| SysEx Configuration Retrieval Message (Hex) | Resulting Output   |
|---|--|
| F0 00 01 5D 04 00 01 00 F7                  | Control terminal configurations, all terminals, layer 00h. Formatted as <u>Control Terminal Configuration</u> SysEx Message. |
| F0 00 01 5D 04 00 01 01 F7                  | Control terminal configurations, all terminals, layer 01h. Formatted as <u>Control Terminal Configuration</u> SysEx Message. |
| F0 00 01 5D 04 00 01 02 F7                  | Control terminal configurations, all terminals, layer 02h. Formatted as <u>Control Terminal Configuration</u> SysEx Message. |
| F0 00 01 5D 04 00 01 03 F7                  | Control terminal configurations, all terminals, layer 03h. Formatted as <u>Control Terminal Configuration</u> SysEx Message. |
| F0 00 01 5D 04 00 02 00 F7                  | <u>Matrix Note Velocity</u> SysEx Message  |
| F0 00 01 5D 04 00 03 00 F7                  | <u>Control Change (CC) “On/Off” Values</u> SysEx Message   |
| F0 00 01 5D 04 00 04 00 F7                  | <u>Multipurpose Data Register Initial Values</u> SysEx Message   |
| F0 00 01 5D 04 00 05 00 F7                  | <u>MIDI Number Remapping</u> Table SysEx Message   |
| F0 00 01 5D 04 00 07 00 F7                  | <u>SysEx Data Buffer</u> Contents SysEx Message  |
| F0 00 01 5D 04 00 08 00 F7                  | <u>ADC Configuration</u> SysEx Message   |
| F0 00 01 5D 04 00 09 00 F7                  | <u>Active Sense On/Off</u> SysEx Message   |
| F0 00 01 5D 04 00 0A 00 F7                  | <u>MIDI Number Remapping</u> Flags SysEx Message   |
| F0 00 01 5D 04 00 0B 00 F7                  | <u>Note Transposition</u> SysEx Message  |
| F0 00 01 5D 04 00 7D 00 F7                  | <u>Firmware Version</u> SysEx Message  |
| F0 00 01 5D 04 00 7F 00 F7                  | Configuration dump: all of the configuration data listed above, formatted as a series of SysEx messages.                     |

## 6.0 MIDI Channel Selection Jumper

Depending on Control Terminal Configuration, the *MIDI Channel Selection Jumper* can be used to select the MIDI channel for messages sent or received by the MIDI CPU. See ***MIDI CPU Hardware User Manual*** for diagrams.

When none of the channel jumpers are shorted, the channel setting is 1. Shorting the “+1” jumper adds 1 to the channel setting, the “+2” adds 2 to the channel setting, etc.

For example, if both the “+2” and “+4” jumpers are shorted, the resulting channel setting is  $1 + 2 + 4 = 7$ .



## 7.0 Activity Indicator LED

The MIDI CPU Activity Indicator LED performs several functions:

- **Self Test:** Upon power-up or device reset, the Activity LED lights briefly before normal operation begins.
- **Configuration Update Indication:** When the MIDI CPU configuration is updated via a MIDI SysEx message, the device will reset, followed by the LED self-test. If no LED activity is observed, then the attempted configuration was unsuccessful.
- **MIDI Activity Indication:** The LED blinks when locally generated or merged MIDI events are sent via the MIDI CPU MIDI Out port.
- **Firmware Update Mode Indication:** The LED will remain lighted while the MIDI CPU awaits a firmware update SysEx message.
- **Firmware Update Error:** The LED blinks continuously when the receipt of a firmware update SysEx message has failed, or when the firmware has become corrupt.

## 8.0 Firmware Update

MIDI CPU firmware can be upgraded via MIDI SysEx message. Firmware update files, when available, can be downloaded from: <http://highlyliquid.com/midi-cpu>

### 8.1 Firmware Update Procedure

1. Download and unzip the firmware update SysEx message. The resulting file should have the extension “.syx”.
2. Disconnect power to the MIDI CPU.
3. Connect the “CAL L” terminal to ground.
4. Re-connect power to the MIDI CPU. The Activity LED will remain lighted.
5. Send the firmware update SysEx message to the MIDI CPU. Transmission of the message may require several seconds.
6. Upon completion of the update, the Activity LED will deactivate.
7. Disconnect the “CAL L” terminal.
8. Disconnect power to the MIDI CPU.
9. Power up the MIDI CPU, and send the following SysEx message: F0 00 01 5D 04 0B 7F F7

### 8.2 Notes

- When updating firmware, use a MIDI CPU power supply voltage of 6.0V or greater.
- Do not interrupt the transmission of the firmware update SysEx message.
- A continuously blinking Activity LED indicates an error in the transmission of the firmware update SysEx message.
- If a continuously blinking Activity LED is observed, repeat the procedure from the beginning.

### 8.3 Firmware Version SysEx Message

During normal operation, the current MIDI CPU firmware version can be retrieved by sending the SysEx message shown in [Figure 8.3-1](#). In response, the MIDI CPU will send a SysEx message as shown in [Figure 8.3-2](#). The key to firmware versions is shown in [Table 8.3-a](#).

**Figure 8.3-1: Firmware Version Retrieval SysEx Message (Hex)**

| Complete Message (9 bytes) |
|----------------------------|
| F0 00 01 5D 04 00 7D 00 F7 |

Figure 8.3-2: Firmware Version SysEx Message (Hex)

| Header (6 bytes)  | Version (1 byte) | Footer (1 byte) |
|-------------------|------------------|-----------------|
| F0 00 01 5D 04 7D | <i>vv</i>        | F7              |

Table 8.3-a: Firmware Versions

| <i>vv</i> (Hex) | Firmware Version                               |
|-----------------|--|
| 00              | 1.0  |
| 01              | 1.1  |
| <b>02</b>       | <b>1.2</b>                                     |
| 03              | 1.3 (beta releases)                            |
| <b>04</b>       | <b>1.2a (includes a fix for a bug in v1.2)</b> |
| 05              | 1.3 (production version)                       |
| 06              | 1.4 (beta releases)                            |
| 07              | 1.4 (production version)                       |
| 08 thru 7F      | Reserved for future versions.                  |

## 9.0 Factory Default Configuration

The MIDI CPU “factory default” configuration can be described in terms of equivalent configuration SysEx messages.

**Figure 9-1: Factory Default Control Terminal Configuration: Layer 00h (Part 1 of 3)**

| SysEx Data (Hex)  | Meaning   |
|-------------------|---|
| F0 00 01 5D 04 01 | Fixed Header  |
| 00                | Configuration Layer 0   |
| 00 00 44 00 3C 7F | Control Terminal 0: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 60, Velocity 127                               |
| 00 01 44 00 3C 00 | Control Terminal 0: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 60, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 01 00 44 00 3D 7F | Control Terminal 1: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 61, Velocity 127                               |
| 01 01 44 00 3D 00 | Control Terminal 1: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 61, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 02 00 44 00 3E 7F | Control Terminal 2: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 62, Velocity 127                               |
| 02 01 44 00 3E 00 | Control Terminal 2: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 62, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 03 00 44 00 3F 7F | Control Terminal 3: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 63, Velocity 127                               |
| 03 01 44 00 3F 00 | Control Terminal 3: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 63, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 04 00 44 00 40 7F | Control Terminal 4: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 64, Velocity 127                               |
| 04 01 44 00 40 00 | Control Terminal 4: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 64, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 05 00 44 00 41 7F | Control Terminal 5: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 65, Velocity 127                               |
| 05 01 44 00 41 00 | Control Terminal 5: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 65, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 06 00 44 00 42 7F | Control Terminal 6: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 66, Velocity 127                               |
| 06 01 44 00 42 00 | Control Terminal 6: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 66, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 07 00 44 00 43 7F | Control Terminal 7: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 67, Velocity 127                               |
| 07 01 44 00 43 00 | Control Terminal 7: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 67, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |

**Figure 9-2: Factory Default Control Terminal Configuration: Layer 00h (Part 2 of 3)**

| <b>SysEx Data (Hex)</b> | <b>Meaning</b>   |
|-------------------------|--|
| 08 00 44 00 44 7F       | Control Terminal 8: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 68, Velocity 127                                |
| 08 01 44 00 44 00       | Control Terminal 8: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 68, Velocity 0 (Velocity 0 = <b>Note Off</b> )  |
| 09 00 44 00 45 7F       | Control Terminal 9: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 69, Velocity 127                                |
| 09 01 44 00 45 00       | Control Terminal 9: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 69, Velocity 0 (Velocity 0 = <b>Note Off</b> )  |
| 0A 00 44 00 46 7F       | Control Terminal 10: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 70, Velocity 127                               |
| 0A 01 44 00 46 00       | Control Terminal 10: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 70, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 0B 00 44 00 47 7F       | Control Terminal 11: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 71, Velocity 127                               |
| 0B 01 44 00 47 00       | Control Terminal 11: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 71, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 0C 00 44 00 48 7F       | Control Terminal 12: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 72, Velocity 127                               |
| 0C 01 44 00 48 00       | Control Terminal 12: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 72, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 0D 00 44 00 49 7F       | Control Terminal 13: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 73, Velocity 127                               |
| 0D 01 44 00 49 00       | Control Terminal 13: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 73, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 0E 00 44 00 4A 7F       | Control Terminal 14: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 74, Velocity 127                               |
| 0E 01 44 00 4A 00       | Control Terminal 14: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 74, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 0F 00 44 00 4B 7F       | Control Terminal 15: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 75, Velocity 127                               |
| 0F 01 44 00 4B 00       | Control Terminal 15: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 75, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |

**Figure 9-3: Factory Default Control Terminal Configuration: Layer 00h (Part 3 of 3)**

| SysEx Data (Hex)  | Meaning  |
|-------------------|--|
| 10 00 44 00 4C 7F | Control Terminal 16: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 76, Velocity 127                               |
| 10 01 44 00 4C 00 | Control Terminal 16: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 76, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 11 00 44 00 4D 7F | Control Terminal 17: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 77, Velocity 127                               |
| 11 01 44 00 4D 00 | Control Terminal 17: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 77, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 12 00 44 00 4E 7F | Control Terminal 18: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 78, Velocity 127                               |
| 12 01 44 00 4E 00 | Control Terminal 18: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 78, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 13 00 44 00 4F 7F | Control Terminal 19: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 79, Velocity 127                               |
| 13 01 44 00 4F 00 | Control Terminal 19: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 79, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 14 00 44 00 50 7F | Control Terminal 20: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 80, Velocity 127                               |
| 14 01 44 00 50 00 | Control Terminal 20: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 80, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 15 00 44 00 51 7F | Control Terminal 21: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 81, Velocity 127                               |
| 15 01 44 00 51 00 | Control Terminal 21: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 81, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 16 00 44 00 52 7F | Control Terminal 22: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 82, Velocity 127                               |
| 16 01 44 00 52 00 | Control Terminal 22: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 82, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| 17 00 44 00 53 7F | Control Terminal 23: Transition High to Low<br>Logic Input Trigger: <b>Note On</b> : Note 83, Velocity 127                               |
| 17 01 44 00 53 00 | Control Terminal 23: Transition Low to High<br>Logic Input Trigger: <b>Note On</b> : Note 83, Velocity 0 (Velocity 0 = <b>Note Off</b> ) |
| F7                | Fixed Footer   |

**Figure 9-4: Factory Default Control Terminal Configuration: Layers 01h, 02h, 03h**

| SysEx Data (Hex)        | Meaning   |
|-------------------------|---|
| F0 00 01 5D 04 01       | Fixed Header  |
| [01, 02, 03]            | Configuration Layers 01h, 02h, 03h  |
| [00..17] 00 7F 00 00 00 | For each control terminal 0 thru 23: Transition High to Low Logic Input Data Only |
| [00..17] 01 7F 00 00 00 | For each control terminal 0 thru 23: Transition Low to High Logic Input Data Only |
| F7                      | Fixed Footer  |

**Figure 9-5: Factory Default Matrix Note Velocity**

| SysEx Data (Hex)              | Meaning   |
|-------------------------------|---|
| F0 00 01 5D 04 02<br>7F<br>F7 | For any MIDI notes generated via a switch matrix, the default note velocity is 127. |

**Figure 9-6: Factory Default Control Change (CC) “On/Off” Values**

| SysEx Data (Hex)                 | Meaning  |
|----------------------------------|--|
| F0 00 01 5D 04 03<br>7F 00<br>F7 | For any CC messages generated via a switch matrix or CC “toggle” mode, the default “on” CC value is 127 and the default “off” CC value is 0. |

**Figure 9-7: Factory Default Multipurpose Data Register Initial Values**

| SysEx Data (Hex)  | Meaning   |
|---|---|
| F0 00 01 5D 04 04<br>00 00 00 00 00 00<br>00 00 00 00 00 00<br>F7 | At power up, each Multipurpose Data Register is initialized with the value 0. |

**Figure 9-8: Factory Default Note Transposition**

| SysEx Data (Hex)              | Meaning                            |
|-------------------------------|------------------------------------|
| F0 00 01 5D 04 0B<br>7F<br>F7 | Note transposition is deactivated. |

**Figure 9-9: Factory Default MIDI Number Remapping Flags**

| SysEx Data (Hex)              | Meaning   |
|-------------------------------|---|
| F0 00 01 5D 04 0A<br>00<br>F7 | Remapping is deactivated for all message types. |

**Figure 9-10: Factory Default MIDI Number Mapping**

| SysEx Data (Hex)  | Meaning   |
|---|---|
| F0 00 01 5D 04 05<br>00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F<br>10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F<br>20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F<br>30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F<br>40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F<br>50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F<br>60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F<br>70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F<br>F7 | Each number is mapped to itself. Effectively, no remapping takes place. |

**Figure 9-11: Factory Default SysEx Data Buffer Contents**

| SysEx Data (Hex)  | Meaning  |
|---|--|
| F0 00 01 5D 04 07<br>00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F<br>10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F<br>20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F<br>30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D 3E 3F<br>40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D 4E 4F<br>50 51 52 53 54 55 56 57 58 59 5A 5B 5C 5D 5E 5F<br>60 61 62 63 64 65 66 67 68 69 6A 6B 6C 6D 6E 6F<br>70 71 72 73 74 75 76 77 78 79 7A 7B 7C 7D 7E 7F<br>F7 | The SysEx data buffer contains arbitrary data. |

**Figure 9-12: Factory Default ADC Configuration**

| SysEx Data (Hex)                    | Meaning   |
|-------------------------------------|---|
| F0 00 01 5D 04 08<br>06 04 00<br>F7 | Analog Input Threshold = 6; Analog Input Smoothing = 4; Reference Voltage = On-Board. |



**Figure 9-13: Factory Default Active Sense**

| SysEx Data (Hex)              | Meaning   |
|-------------------------------|---|
| F0 00 01 5D 04 09<br>00<br>F7 | Generation of <b>Active Sense</b> messages is disabled. |

## 10.0 Configuration Examples

Configuration examples are provided below. Wiring methods and control terminal configurations can be mixed and matched between the different examples as desired. See *MIDI CPU Hardware User Manual* for the I/O capabilities of each control terminal.

### 10.1 CC Output: Potentiometers, Encoders, Switches

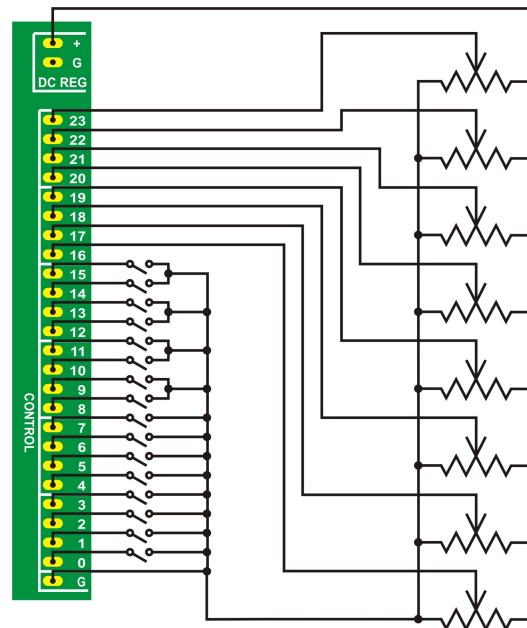
In this example the following input devices are connected to the MIDI CPU (See [Figure 10.1-1](#)):

- Control terminals 0 thru 7: SPST toggle switches (8 total)
- Control terminals 8 thru 15: Rotary encoders (4 total)
- Control terminals 16 thru 23: Potentiometers (8 total)

Input devices are used to generate **Control Change (CC)** messages, each with a unique CC number. Potentiometers generate CC values based on wiper position, encoders generate incremented/decremented CC values upon adjustment, and toggle switches generate fixed CC “off” and “on” values when opened/closed. The MIDI channel for all messages is specified by the [MIDI Channel Selection Jumper](#).

See [Figure 10.1-2](#) and [Figure 10.1-3](#) for the contents of the Control Terminal Configuration SysEx Message.

**Figure 10.1-1: Wiring Diagram**



**Figure 10.1-2: Control Terminal Configuration (Part 1 of 2)**

| SysEx Data (Hex)  | Meaning  |
|-------------------|--|
| F0 00 01 5D 04 01 | Fixed Header   |
| 00                | Configuration Layer 0  |
| 00 00 4C 00 00 7F | Control Terminal 0: Transition High to Low<br>Logic Input Trigger: <b>CC</b> : CC Number 0, CC Value 127 |
| 00 01 4C 00 00 00 | Control Terminal 0: Transition Low to High<br>Logic Input Trigger: <b>CC</b> : CC Number 0, CC Value 0   |
| 01 00 4C 00 01 7F | Control Terminal 1: Transition High to Low<br>Logic Input Trigger: <b>CC</b> : CC Number 1, CC Value 127 |
| 01 01 4C 00 01 00 | Control Terminal 1: Transition Low to High<br>Logic Input Trigger: <b>CC</b> : CC Number 1, CC Value 0   |
| 02 00 4C 00 02 7F | Control Terminal 2: Transition High to Low<br>Logic Input Trigger: <b>CC</b> : CC Number 2, CC Value 127 |
| 02 01 4C 00 02 00 | Control Terminal 2: Transition Low to High<br>Logic Input Trigger: <b>CC</b> : CC Number 2, CC Value 0   |
| 03 00 4C 00 03 7F | Control Terminal 3: Transition High to Low<br>Logic Input Trigger: <b>CC</b> : CC Number 3, CC Value 127 |
| 03 01 4C 00 03 00 | Control Terminal 3: Transition Low to High<br>Logic Input Trigger: <b>CC</b> : CC Number 3, CC Value 0   |
| 04 00 4C 00 04 7F | Control Terminal 4: Transition High to Low<br>Logic Input Trigger: <b>CC</b> : CC Number 4, CC Value 127 |
| 04 01 4C 00 04 00 | Control Terminal 4: Transition Low to High<br>Logic Input Trigger: <b>CC</b> : CC Number 4, CC Value 0   |
| 05 00 4C 00 05 7F | Control Terminal 5: Transition High to Low<br>Logic Input Trigger: <b>CC</b> : CC Number 5, CC Value 127 |
| 05 01 4C 00 05 00 | Control Terminal 5: Transition Low to High<br>Logic Input Trigger: <b>CC</b> : CC Number 5, CC Value 0   |
| 06 00 4C 00 06 7F | Control Terminal 6: Transition High to Low<br>Logic Input Trigger: <b>CC</b> : CC Number 6, CC Value 127 |
| 06 01 4C 00 06 00 | Control Terminal 6: Transition Low to High<br>Logic Input Trigger: <b>CC</b> : CC Number 6, CC Value 0   |
| 07 00 4C 00 07 7F | Control Terminal 7: Transition High to Low<br>Logic Input Trigger: <b>CC</b> : CC Number 7, CC Value 127 |
| 07 01 4C 00 07 00 | Control Terminal 7: Transition Low to High<br>Logic Input Trigger: <b>CC</b> : CC Number 7, CC Value 0   |

**Figure 10.1-3: Control Terminal Configuration (Part 2 of 2)**

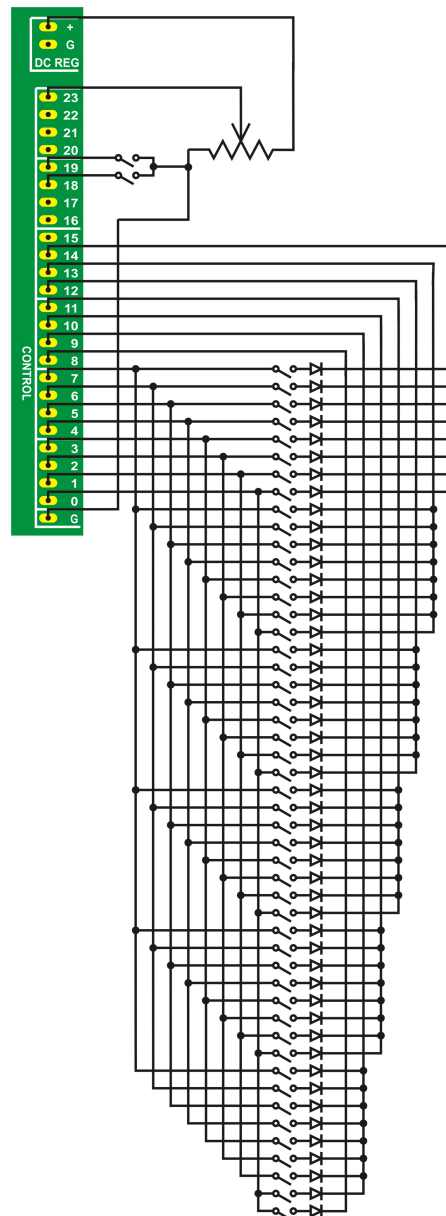
| SysEx Data (Hex)  | Meaning  |
|-------------------|--|
| 08 00 14 00 08 15 | Control Terminal 8<br>Encoder Input: <b>CC</b> : CC Number 8, CC Value from encoder        |
| 09 00 14 00 08 15 | Control Terminal 9<br>Encoder Input: <b>CC</b> : CC Number 8, CC Value from encoder        |
| 0A 00 14 00 09 16 | Control Terminal 10<br>Encoder Input: <b>CC</b> : CC Number 9, CC Value from encoder       |
| 0B 00 14 00 09 16 | Control Terminal 11<br>Encoder Input: <b>CC</b> : CC Number 9, CC Value from encoder       |
| 0C 00 14 00 0A 17 | Control Terminal 12<br>Encoder Input: <b>CC</b> : CC Number 10, CC Value from encoder      |
| 0D 00 14 00 0A 17 | Control Terminal 13<br>Encoder Input: <b>CC</b> : CC Number 10, CC Value from encoder      |
| 0E 00 14 00 0B 18 | Control Terminal 14<br>Encoder Input: <b>CC</b> : CC Number 11, CC Value from encoder      |
| 0F 00 14 00 0B 18 | Control Terminal 15<br>Encoder Input: <b>CC</b> : CC Number 11, CC Value from encoder      |
| 10 00 04 00 0C 03 | Control Terminal 16<br>Analog Input: <b>CC</b> : CC Number 12, CC Value from potentiometer |
| 11 00 04 00 0D 04 | Control Terminal 17<br>Analog Input: <b>CC</b> : CC Number 13, CC Value from potentiometer |
| 12 00 04 00 0E 05 | Control Terminal 18<br>Analog Input: <b>CC</b> : CC Number 14, CC Value from potentiometer |
| 13 00 04 00 0F 06 | Control Terminal 19<br>Analog Input: <b>CC</b> : CC Number 15, CC Value from potentiometer |
| 14 00 04 00 10 07 | Control Terminal 20<br>Analog Input: <b>CC</b> : CC Number 16, CC Value from potentiometer |
| 15 00 04 00 11 08 | Control Terminal 21<br>Analog Input: <b>CC</b> : CC Number 17, CC Value from potentiometer |
| 16 00 04 00 12 09 | Control Terminal 22<br>Analog Input: <b>CC</b> : CC Number 18, CC Value from potentiometer |
| 17 00 04 00 13 0A | Control Terminal 23<br>Analog Input: <b>CC</b> : CC Number 19, CC Value from potentiometer |
| F7                | Fixed Footer   |

## 10.2 49-Key Keyboard Controller with Matrixed Switch Input, Velocity Knob, Program Selector

In this example, a 49-keyswitch matrix triggers MIDI notes, a potentiometer adjusts the note velocity, and a rotary encoder is used for patch selection (Program Change).

Control terminals 0 thru 7 are the matrix data inputs, while control terminals 8 thru 14 are the matrix select outputs.

**Figure 10.2-1: Wiring Diagram**



**Figure 10.2-2: Control Terminal Configuration (Part 1 of 2)**

| <b>SysEx Data (Hex)</b> | <b>Meaning</b>  |
|-------------------------|---|
| F0 00 01 5D 04 01       | Fixed Header  |
| 00                      | Configuration Layer 0   |
| 00 00 7F 00 00 00       | Control Terminal 0: Transition High to Low<br>Logic Input Data Only |
| 00 01 7F 00 00 00       | Control Terminal 0: Transition Low to High<br>Logic Input Data Only |
| 01 00 7F 00 00 00       | Control Terminal 1: Transition High to Low<br>Logic Input Data Only |
| 01 01 7F 00 00 00       | Control Terminal 1: Transition Low to High<br>Logic Input Data Only |
| 02 00 7F 00 00 00       | Control Terminal 2: Transition High to Low<br>Logic Input Data Only |
| 02 01 7F 00 00 00       | Control Terminal 2: Transition Low to High<br>Logic Input Data Only |
| 03 00 7F 00 00 00       | Control Terminal 3: Transition High to Low<br>Logic Input Data Only |
| 03 01 7F 00 00 00       | Control Terminal 3: Transition Low to High<br>Logic Input Data Only |
| 04 00 7F 00 00 00       | Control Terminal 4: Transition High to Low<br>Logic Input Data Only |
| 04 01 7F 00 00 00       | Control Terminal 4: Transition Low to High<br>Logic Input Data Only |
| 05 00 7F 00 00 00       | Control Terminal 5: Transition High to Low<br>Logic Input Data Only |
| 05 01 7F 00 00 00       | Control Terminal 5: Transition Low to High<br>Logic Input Data Only |
| 06 00 7F 00 00 00       | Control Terminal 6: Transition High to Low<br>Logic Input Data Only |
| 06 01 7F 00 00 00       | Control Terminal 6: Transition Low to High<br>Logic Input Data Only |
| 07 00 7F 00 00 00       | Control Terminal 7: Transition High to Low<br>Logic Input Data Only |
| 07 01 7F 00 00 00       | Control Terminal 7: Transition Low to High<br>Logic Input Data Only |

**Figure 10.2-3: Control Terminal Configuration (Part 2 of 2)**

| <b>SysEx Data (Hex)</b> | <b>Meaning</b>   |
|-------------------------|--|
| 08 00 2C 00 24 0E       | Control Terminal 8<br>Matrix Select Output: Data Register 00h, note number 36      |
| 09 00 2C 00 25 00       | Control Terminal 9<br>Matrix Select Output: Data Register 00h, note numbers 37-44  |
| 0A 00 2C 00 2D 00       | Control Terminal 10<br>Matrix Select Output: Data Register 00h, note numbers 45-52 |
| 0B 00 2C 00 35 00       | Control Terminal 11<br>Matrix Select Output: Data Register 00h, note numbers 53-60 |
| 0C 00 2C 00 3D 00       | Control Terminal 12<br>Matrix Select Output: Data Register 00h, note numbers 61-68 |
| 0D 00 2C 00 45 00       | Control Terminal 13<br>Matrix Select Output: Data Register 00h, note numbers 69-76 |
| 0E 00 2C 00 4D 00       | Control Terminal 14<br>Matrix Select Output: Data Register 00h, note numbers 77-84 |
| 12 00 16 00 1A 00       | Control Terminal 18<br>Encoder Input: Program Change                               |
| 13 00 16 00 1A 00       | Control Terminal 19<br>Encoder Input: Program Change                               |
| 17 00 0A 00 00 00       | Control Terminal 23<br>Analog Input: Matrix Note Velocity                          |
| F7                      | Fixed Footer   |