MIDI-CI Profile for MIDI Polyphonic Expression

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PREFACE

MIDI Association Document M2-120-UM
MIDI-CI Profile for MIDI Polyphonic Expression

The MIDI Polyphonic Expression (MPE) specification defines an MMA/AMEI Recommended Practice for hardware and software manufacturers to communicate multidimensional control data between MIDI controller instruments, synthesizers, digital audio workstations, and other products, using MIDI messages. Please Note this document describes the MPE Profile for MIDI-CI. For information on how to use Profiles please read the MIDI-CI and Common Rules for MIDI-CI Profile Configuration specifications.

http://www.amei.or.jp

https://www.midi.org

Version History

Table 1 Version History

Publication Date	Version	Changes
2024-02-16	2.0.3	Initial Release of MIDI-CI Profile implementation of MPE

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1 Introduction

1.1 Executive Summary

The MIDI-CI Profile for MIDI Polyphonic Expression (MPE) specification makes it possible for artists to perform independent gestures for each musical note, with up to three dimensions of expression. With MPE, every note a musician plays can be articulated individually for much greater expressiveness. MPE has broad support from many DAWs, Synthesizers and Controllers.

The MIDI-CI Profile for MIDI Polyphonic Expression (MPE) specification defines an MMA/AMEI Recommended Practice for hardware and software manufacturers to communicate multidimensional control data between MIDI controller instruments, synthesizers, digital audio workstations, and other products, using MIDI messages.

The specification describes a recommended way of using individual MIDI Channels to achieve per-note control, enabling richer communication between increasingly expressive MIDI hardware and software.

1.2 Background

Profile Configuration is part of the ***MIDI Capability Inquiry (MIDI-CI) [MA03]*** specification and MIDI 2.0. Profile Configuration is a method for two Devices to agree to use a common set of messages. Profiles are enabled using System Exclusive Messages defined by MIDI-CI. This document defines only the messages used by the Profile. For information on how to transmit and receive these MIDI-CI System Exclusive messages, see the ***MIDI Capability Inquiry (MIDI-CI) [MA03]*** and ***M2-102-U Common Rules for MIDI-CI Profiles [MA04]***

This specification is designed for MIDI Devices that allow the performer to vary the pitch and timbre of individual notes while playing polyphonically. For example, in many of these MIDI Devices, pitch is expressed by lateral motion on a continuous playing surface, while individual timbre changes are expressed by varying pressure, or moving fingers towards and away from the player.

MPE 1.0 was designed to work with MIDI 1.0 messages, separating notes across multiple MIDI Channels. When a single note is playing on an independent MIDI Channel, the controllers on that Channel may be used for expression on that single note, separately from control of notes on other Channels. This allows each note to respond independently to Pitch Bend or Control Change messages.

MIDI 2.0 provides mechanisms for Per-Note Controllers such that individual notes on a single MIDI Channel can be independently controlled: these Per-Note controllers are not covered by the Profile. Instead, this Profile retains the multi-Channel mechanisms of MPE 1.0, while adding the bidirectional auto configuration features of MIDI-CI. This allows device implementations to use one set of fundamental control mechanisms. These same mechanisms are used whether for MPE 1.0 (for backward compatibility to pre-existing MPE) or in a MIDI-CI Profile environment.

These fundamental control mechanisms are defined in MPE 1.0 and the MPE Profile to provide three or more dimensions of control — regardless of how a particular controller physically expresses them — and defines how to configure Devices to send and receive this “multidimensional control data” for maximum interoperability.

MIDI Pitch Bend and Control Change messages are Channel Messages, meaning they affect all Active Notes assigned to that Channel. To apply Channel Messages to individual notes, an MPE controller assigns each note its own Channel.

The MPE Specification defines how to perform per-note control for Polyphonic Channel Response but will also work with synthesizers that support Monophonic Channel Response with some restrictions.

1.3 References

1.3.1 Normative References

[MA01] ***Complete MIDI 1.0 Detailed Specification***, Document Version 96.1, Third Edition, Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

[MA02] ***M2-100-U MIDI 2.0 Specification Overview,*** Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

[MA03] ***M2-101-UM MIDI Capability Inquiry (MIDI-CI),*** Version 1.2, Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

[MA04] ***M2-102-U Common Rules for MIDI-CI Profiles,*** Version 1.1, Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

[MA05] ***M2-104-UM Universal MIDI Packet (UMP) Format and MIDI 2.0 Protocol,*** Version 1.1, Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

[MA06] ***MIDI-CI Property Exchange Controller Resources,*** Version 0.61.0, Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

[MA07] ***MIDI 2.0 Bit Scaling and Resolution,*** Version 1.0.2, Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

[MA08] ***M1-101-UM MIDI Polyphonic Expression,*** Version 1.1, Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

[MA09] ***MIDI Polyphonic Expression (RP53),*** Version 1.0, Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

[MA10] ***M1-117-UM Property Exchange Controller Resources,*** Version 1.0, Association of Musical Electronics Industry, http://www.amei.or.jp/, and The MIDI Association, https://www.midi.org/

1.3.2 Informative References

No informative references.

1.4 Terminology

1.4.1 Definitions

100-Cent Unit: A unit of measure for musical intervals, corresponding to one-twelfth of an octave measured logarithmically. This term is preferred over “semitone” which may refer to various intervals.

Active Note: Any note for which a Note On message has been delivered, but a Note Off message has not.

AMEI: Association of Musical Electronics Industry. Authority for MIDI Specifications in Japan.

Device: An entity, whether hardware or software, which can send and/or receive MIDI messages and has one or more functional subsystems which generate, consume, and/or route MIDI messages. A Device has one or more MIDI inputs, outputs, or bidirectional connections for sending and/or receiving MIDI messages connected to its functional subsystems.

HCU: See 100-Cent-Unit

MA: See MIDI Association.

Manager Channel: A MIDI Channel reserved for conveying messages that apply to the entire Zone.

Member Channel: Any MIDI Channel within a Zone that is not a Manager Channel.

MIDI 1.0 Specification: Complete MIDI 1.0 Detailed Specification, Document Version 96.1, Third Edition ***[MA01]***

MIDI Association: The public facing name that the MIDI Manufacturers Association uses as its DBA.

MIDI-CI: MIDI Capability Inquiry, a specification published by The MIDI Association and AMEI.

MIDI Polyphonic Expression (MPE): The specification that defines how MIDI Devices communicate multidimensional control data. This document is the most current specification, and the original specification was ***M1-101-UM MIDI Polyphonic Expression, Version 1.1 [MA08]***

MIDI Transport: A hardware or software MIDI connection used by a Device to transmit and/or receive MIDI messages to and/or from another Device.

MMA: See MIDI Manufacturers Association.

MIDI Manufacturers Association: A California nonprofit 501(c)6 trade organization, and the legal entity name of the MIDI Association.

Monophonic Channel Response: Each Member Channel will only play one note at a time. Starting a note in such a Channel, when one is already playing, shall stop the older note, possibly invoking a legato transition between the old and the new notes.

Monotimbral: For Polyphonic Channel Response, Program Change is applied only to the Manager Channel and all member Channels are set to the same program.

MPE: See MIDI Polyphonic Expression.

MPE Profile: Shorthand for MIDI-CI Profile for MIDI Polyphonic Expression

Multidimensional Control Data: MPE defines three or more dimensions of expression. It’s left to the implementor of an MPE controller to determine what gestures are mapped to the three MPE expression messages.

Occupied Channel: A Member Channel with at least one Active Note.

Polyphonic Channel Response: Each Member Channel may play more than one note at a time. Starting a note in such a Channel, when one is already playing, shall start a new note.

Receiver: A MIDI Device which has a MIDI Transport connected to its MIDI In. A MIDI Device is not required to recognize or act upon any specific MIDI messages that it receives in order to be defined as a Receiver.

Released Note: A note for which a Note Off message has been processed. A Released Note may continue to sound for considerable time, most often owing to the length of a release envelope or an interaction with the sustain or sostenuto pedal.

Sender: A MIDI Device which transmits MIDI messages to a MIDI Transport which is connected to its MIDI Out or to its MIDI Thru port.

Sounding Note: Any Active or Released Note that is still making sound.

Third Dimension of Control: In addition to Pitch Bend and Channel Pressure, MPE controllers may provide a third dimension of continuous control using Control Change #74 (or RC Bank 0x20, index 0x21) see ***Section 4.5***

Unoccupied Channel: A Channel for which all Active Notes have received Note Off messages.

Zone: Contiguous MIDI Channels comprising a Manager Channel and one or more Member Channels

1.4.2 Reserved Words and Specification Conformance

In this document, the following words are used solely to distinguish what is required to conform to this specification, what is recommended but not required for conformance, and what is permitted but not required for conformance:

Table 2 Words Relating to Specification Conformance

Word	Reserved For	Relation to Specification Conformance
shall	Statements of requirement	**Mandatory** A conformant implementation conforms to all 'shall' statements.
should	Statements of recommendation	**Recommended but not mandatory** An implementation that does not conform to some or all 'should' statements is still conformant, providing all 'shall' statements are conformed to.
may	Statements of permission	**Optional** An implementation that does not conform to some or all 'may' statements is still conformant, providing that all 'shall' statements are conformed to.

By contrast, in this document, the following words are never used for specification conformance statements; they are used solely for descriptive and explanatory purposes:

Table 3 Words Not Relating to Specification Conformance

Word	Reserved For	Relation to Specification Conformance
must	Statements of unavoidability	Describes an action to be taken that, while not required (or at least not directly required) by this specification, is unavoidable. Not used for statements of conformance requirement (see 'shall' above).
will	Statements of fact	Describes a condition that as a question of fact is necessarily going to be true, or an action that as a question of fact is necessarily going to occur, but not as a requirement (or at least not as a direct requirement) of this specification. Not used for statements of conformance requirements (see 'shall' above).
can	Statements of capability	Describes a condition or action that a system element is capable of possessing or taking. Not used for statements of conformance permission (see 'may' above).
might	Statements of possibility	Describes a condition or action that a system element is capable of electing to possess or take. Not used for statements of conformance permission (see 'may' above).

1.4.3 Bit Scaling and Resolution

For critical information on understanding resolution of various fields in MIDI messages in the UMP Format, see the specification ***MIDI 2.0 Bit Scaling and Resolution [MA07]*** That document defines recommended practices for scaling values, handling of stepped/enumerated values and translating values between MIDI 1.0 Protocol and MIDI 2.0 Protocol and translation between MIDI 1.0 and MIDI 2.0 Messages.

1.4.4 Data Values in This Specification

Data values in this specification are expressed for both MIDI 1.0 (7/14 bit) and MIDI 2.0 (32 bit) form.

2 MPE Profile Overview

2.1 MPE Profile Functional Overview

The MPE Profile is a MIDI-CI Profile which conforms to the definition of a Multi-Channel Profile as defined in the ***M2-102-U Common Rules for MIDI-CI Profiles [MA04]*** See ***Template Instructions:a)i)(1)(a)(i)Appendix A*** "Turning On and Enabling a Profile".

This overview summarizes the main elements of the MPE Profile specification, additional important details can be found in later sections.

MPE Profile is switched on and configured using the following messages:

- MIDI-CI Profile Configuration mechanisms to setup the devices and enable the MPE Profile
- Registered Controller/RPN [0x00, 0x00] to change the Pitch Bend Sensitivity from the default MPE Profile value of 48 HCUs, if desired or needed.

MPE offers per-note expressive control using the following messages:

- Note On/Off
- Pitch Bend
- Channel Pressure or alternatively, bipolar Registered Controller/RPN [0x20, 0x20]
- Third Dimension of Control using Control Change #74 or, alternatively, bipolar Registered Controller/RPN [0x20, 0x21]

MPE uses the following mechanisms to coordinate per-note control:

- The range of Channels over which notes are sent and received can be set by enabling this Profile. The MIDI Channel space can be divided into multiple Zones by enabling multiple MPE Profiles with non-overlapping Channels.
- Each MPE Profile has a number of Member Channels for notes plus a dedicated extra Channel, called the Manager Channel, which conveys information common to all Active Notes in that Zone. The Manager Channel is always the lowest Channel in the Profile and is not used for notes.
- Wherever possible, every note is assigned its own Channel for the lifetime of that note. This allows MPE messages to be addressed uniquely to that Active Note.

2.2 Differences Between MPE (v1.1) and this MIDI-CI Profile for MPE

There are a number of differences between MPE 1.1 and MPE Profile. Specifically:

- The Profile is receiver centric. The receiver will report back the range of Channels that it can support, and the Sender will adapt.
- The MPE 1.1 configuration parameter formerly set by RPN 6 (MCM), is now handled by enabling an MPE Profile using MIDI CI. See ***M2-102-U Common Rules for MIDI-CI Profiles [MA04].***
- Multiple Zones are realized by enabling multiple MPE Profiles with non-overlapping Channels.
- The Manager Channel is always the lowest Channel in the Profile.
- Notes sent on the Manager Channel are not defined by this Profile.
- Because the Manager Channel is always the lowest Channel, the MPE 1.1 Upper Zone is not possible with an MPE Profile.
- Profile Details Inquiry mechanism is used to determine the number of MIDI Channels which will be used by MPE and to discover the Receiver's properties which are addressed by the MPE controls.
- There is no need to send Pitch Bend Sensitivity to every individual Member Channel, it is sent to the Manager Channel only.

3 Turning On and Configuring MPE Profile

The following subsections specify how to turn MPE on, and how to configure MPE.

3.1 Profile Details inquiry – How to Enable a Profile and Assign a Number of Channels

How Profiles are enabled is described in ***M2-102-U Common Rules for MIDI-CI Profiles [MA04].*** A generalization of how a Profile is enabled is as follows:

1. Initiator sends a “Profile Inquiry” message to discover which Profiles are supported by the Responder.
2. Responder sends a “Reply to Profile Inquiry” to declare a list of supported Profiles for each Channel.
3. Initiator sends a message to “Request Number of Channels Supported” plus “Optional Features Supported”. The destination Channel for this message is the desired Manager Channel.
4. Responder sends a “Reply to Profile Details” Message for the Profile, declaring the maximum number of Channels available and which optional features are supported.
5. Initiator sends a “Set Profile On” message with the desired number of Channels (shall not exceed the number of Channels declared by the Responder in Step 4). The destination Channel of this message is the desired Manager Channel.
6. Responder sends a “Profile Enabled” message which includes the number of Channels which have been assigned.
7. MPE communication can begin.

A detailed example for how this works can be found in ***M2-102-U Common Rules for MIDI-CI Profiles [MA04]*** See ***Template Instructions:a)i)(1)(a)(i)Appendix A*** “Turning On and Enabling a Profile”.

An example is also provided in ***Template Instructions:a)i)(1)(a)(i)Appendix A***. Note that these may overlap with examples provided in ***M2-102-U Common Rules for MIDI-CI Profiles [MA04]***.

3.2 Profile Id

The Profile Identifiers for the MPE Profile are as follows:

Table 4 MPE Profile Id

5 bytes	Profile ID	
	Byte 1	0x7E (Standard Defined Profile)
	Byte 2	0x31 (MPE Profile Bank)
	Byte 3	0x00 (MPE Profile Number)
	Byte 4	0x01 (MPE Profile Version)
	Byte 5	0x01 (MPE Profile Level)

3.3 Receiver Behavior When Disabling an MPE Profile

To avoid the possibility of a Sender leaving a receiver with hanging Sounding Notes when changing Profiles, the receiver shall stop all Sounding Notes and reset all controls to reasonable default values on each Channel when entering or leaving MPE control.

3.4 How to Handle Overlapping Channels.

Multiple MPE Profiles can be optionally used on one Device. This is the equivalent of multiple Zones in MPE version 1.0 and version 1.1.

MPE Profiles shall not use Channels which overlap with another instance of MPE Profile. If a Responder receives a Set Profile On message on a Channel that is already part of an active MPE Profile, then the Device shall either refuse the new Profile request (reply with a Profile Disabled Message for the new Profile) or disable the prior existing MPE Profile (and reply with a Profile Disabled Message for the prior Profile) before enabling the new MPE Profile. Which method of handling overlapping Channels is left to the manufacturer.

3.5 Pitch Bend Sensitivity

The Pitch Bend Sensitivity range of the Manager Channel and of every Member Channel shall be the same value and shall always be set on the Manager Channel. The Pitch Bend Sensitivity range shall not be sent to the Member Channels. Receivers shall respond to Pitch Bend Sensitivity on the Manager Channel.

The default value of 48 Hundred Cent Units (HCUs) shall be used at the time that the MPE Profile is enabled. The sensitivity values may subsequently be changed at any time by using the Registered Controller/RPN [0x00, 0x00] sent to the Manager Channel. MPE Devices should support the selection of the sensitivity from 0 to 96 HCUs. MPE Devices should transmit the MSB with the integer number of HCUs and should set the LSB to zero.
In many cases, it is desirable to implement a narrower range of Pitch Bend response for the Manager Channel than the response used on Member Channels. A Sender may implement a unique amount of Pitch Bend for the Manager Channel using the following steps:

1. The Sender should set the value of the Registered Controller/RPN for Sensitivity to the widest Pitch Bend range (usually the range for Member Channels).
2. When the Manager Channel requires a narrower Pitch Bend amount, the Sender should send Manager Channel Pitch Bend messages with only a subset of the values from the whole range of available values. Pitch Bend has sufficient resolution to provide smooth changes of pitch, even while using only a subset range of the total available values.

3.6 Channel Response

Channel Response type is determined by the type of sound selected on the Receiver. Some sounds are intended to be played monophonically, while others are polyphonically.

3.6.1 Polyphonic Channel Response

When MPE is used with Polyphonic Channel Response, a Channel is maximally polyphonic: it will handle as many simultaneous notes as possible. An MPE controller shall assign every new note its own MIDI Channel, until there are no unoccupied Channels available.

When there are more notes than unoccupied Channels, a new note shall share a MIDI Channel with an existing note. Since Control Change, Registered Controller/RPNs, and Pitch Bend are Channel Messages, they then affect all Active Notes on that Channel.

When there is more than one concurrent Active Note on a Member Channel, implementation of how controllers affect the notes is up to the Device.

Note: Recommendations about the ordering of note and control messages in MPE that help to improve compatibility, editability, and the quality of rendered sound are presented in ***Template Instructions:a)i)(1)(a)(i)Appendix B***

3.6.2 Monophonic Channel Response

When MPE is used with Monophonic Channel Response, starting a note in such a Channel when one is already playing shall stop the older note, possibly invoking a legato transition between the old and the new notes. Monophonic Channel Response is thus ideal for controllers that model stringed instruments, in which a ‘one Channel per string’ allocation assists realistic rendering of hammer-on and pull-off.

MPE Devices are not required to support Monophonic Channel Response.

3.6.3 Channel Response Type Notification

The following optional Profile Specific Data is sent by the Receivers to notify Senders of a change in the Channel Response Mode.

Table 5 Channel Response Type Notification

Value	Parameter
F0	System Exclusive Start
7E	Universal System Exclusive
1 byte	Device ID: Source or Destination (depending on type of message): 00–0F: To/from MIDI Channels 1-16
0D	Universal System Exclusive Sub-ID#1: MIDI-CI
0x2F	Universal System Exclusive Sub-ID#2: Profile Specific Data
1 byte	MIDI-CI Message Version/Format
4 bytes	Source MUID (LSB first)
4 bytes	Destination MUID (LSB first)
5 bytes	MPE Profile Id (0x7E 0x31 0x00 0x01 0x01)
0x01 0x00 0x00 0x00	Length of Following Profile Specific Data (LSB first)

1 bytes	0x00 - Polyphonic Channel Response 0x01 - Monophonic Channel Response
F7	End Universal System Exclusive

3.7 Discovering Optional Features

The following are defined as optional features:

- MPE devices are not required to use all three core MPE Expression Controllers.
- MPE devices may optionally and mutually exclusively use high resolution versions of Channel Pressure or Third Dimension of Control ***Section 4.5***
- MPE devices may optionally respond to Channel Response Type notification ***(Section 3.6.3)***

Which optional features are supported by a Devices may be discovered using the MIDI-CI Profile Details Inquiry mechanism as follows:

3.7.1 Optional Features Profile Details Inquiry Message

Table 6 Profile Details Inquiry Message

Value	Parameter
F0	System Exclusive Start
7E	Universal System Exclusive
1 byte	Destination 00–0F: To/from MIDI Channels 1-16
0D	Universal System Exclusive Sub-ID#1: MIDI-CI
28	Universal System Exclusive Sub-ID#2: Profile Details Inquiry
1 byte	MIDI-CI Message Version/Format
4 bytes	Source MUID (LSB first)
4 bytes	Destination MUID (LSB first)
5 bytes	MPE Profile Id (0x7E 0x31 0x00 0x01 0x01)
01	Inquiry Target: Profile Optional Features Supported
F7	End Universal System Exclusive

3.7.2 Reply to Profile Details Inquiry Message

Table 7 Reply to Profile Details Inquiry Message

Value	Parameter
F0	System Exclusive Start
7E	Universal System Exclusive
1 byte	Destination 00–0F: To/from MIDI Channels 1-16
0D	Universal System Exclusive Sub-ID#1: MIDI-CI
29	Universal System Exclusive Sub-ID#2: Reply to Profile Details Inquiry
02	MIDI-CI Message Version/Format
4 bytes	Source MUID (LSB first)
4 bytes	Destination MUID (LSB first)
5 bytes	MPE Profile Id (0x7E 0x31 0x00 0x01 0x01)
01	Inquiry Target: Profile Optional Features Supported
2 bytes	Inquiry Target Data Length (dl) (LSB first)
4 bytes	Inquiry Target Data – Features Supported
F7	End Universal System Exclusive

3.7.3 Inquiry Target Data – Features Supported

The Inquiry Target Data field declares features supported as follows:

Table 8 Profile Features Supported

Bytes	Features Supported
Byte 1 (bitmap*)	D0: Supports Channel Response Type Notification See ***Section 3.6*** D1-D6: Reserved
Byte 2 (enum)	Pitch Bend: See ***Section 4.3*** 0x00 - No Support 0x01 – Pitch Bend Supported
Byte 3 (enum)	Channel Pressure: See ***Section 4.4*** 0x00 - No Support 0x01 - CC Only Supported 0x02 - Bipolar Controller Supported

Byte 4 (enum)	Third Dimension of Control See ***Section 4.5*** 0x00 - No Support 0x01 - CC Only Supported 0x02 - Bipolar Controller Supported

**Bitmap fields in MIDI-CI messages are presented as follows:*

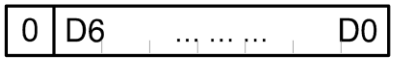

Figure 1 Bitmap Format Per Byte

3.8 Discovering Mapping of MPE Controls

Property Exchange may be used to discover the mapping of MPE controls. This is generally used for display to the user. Property Exchange may be used on both Manager and Member Channels. See the Property Exchange Controller Resources specification ***[MA10]***.

4 MPE Performance Messages

The following subsections specify messages that are used during an MPE performance.

4.1 Messages Only on Manager Channel

An MPE Profile represents one polyphonic instrument in which certain MIDI messages, for example, Damper Pedal, Course Tuning and Fine Tuning, can be expected to affect all Sounding Notes.

To reduce MIDI traffic and make event editing easier, those messages should be sent only for a Profile's Manager Channel (not on Member Channels). If an MPE Device receives any of those messages on a Member Channel, it should ignore them. See ***Template Instructions:a)i)(1)(a)(i)Appendix E*** for a list of MIDI messages that are Manager Channel Messages but not Member Channel Messages.

4.2 Messages on Both Manager Channel and Member Channels

Some MIDI messages are used on both the Manager Channel and on Member Channels. For example, Pitch Bend messages from a pitch wheel on a typical MIDI controller affect all Sounding Notes, which makes them Manager Channel Messages.

However, MPE defines Pitch Bend on a per Member Channel basis. Therefore, Pitch Bend is both a Manager Channel Message and a Member Channel Message. If an MPE synthesizer receives Pitch Bend (for example) on both a Manager and a Member Channel, it shall combine the data meaningfully.

The same is true for Channel Pressure, Control Change #74, and the Bipolar Controllers. See the table in ***Template Instructions:a)i)(1)(a)(i)Appendix E*** for a list of MIDI messages that are both Manager Channel and Member Channel Messages. ***Template Instructions:a)i)(1)(a)(i)Appendix D*** addresses MPE Receiver behavior when these messages are sent both on the Manager Channel and on Member Channels, including suggested implementation strategies for handling the possible interactions.

4.3 Pitch Bend

An MPE Device may send Pitch Bend messages on both the Manager Channel and on Member Channels. An MPE Profile Receiver shall respond to Pitch Bend Messages on both the Manager Channel and the Member Channels. On the Manager Channel, Pitch Bend is typically performed through movement of a global control (for example, a pitch wheel or a tremolo bar). On Member Channels, Pitch Bend is typically performed by the movement of a single finger on the playing surface.

The pitch of a new note is affected by the Pitch Bend message most recently received on both the Manager Channel and that note's Member Channel before Note On. A receiver shall continue to track Pitch Bend messages from both the Manager Channel and the Member Channels even when no note is playing. Messages on the Manager Channel continue to affect all Sounding Notes even after the Note Off message occurs. A Released Note shall cease to be affected by Pitch Bend messages from the Member Channels after the Note Off message occurs.

Because Pitch Bend may span across multiple semitones, Pitch Bend should be linear across the sensitivity range.

See ***Section 3.5*** for Pitch Bend Sensitivity

4.4 Channel Pressure

An MPE Device may send Channel Pressure messages both on the Manager Channel and on Member Channels to convey pressure. An MPE Profile Receiver shall respond to Channel Pressure Messages on both the Manager Channel and the Member Channels.

The control of a new note is affected by the Channel Pressure message most recently received on its Channel before Note On. A receiver shall continue to track Channel Pressure messages even when no note is playing. Channel Pressure also influences the note's initial state. The note will cease to be affected by Channel Pressure messages on its Channel after the Note Off message occurs.

If a Device receives Channel Pressure on both a Manager Channel and a Member Channel, then it shall combine such data meaningfully and separately for each Sounding Note. It's left to the manufacturer how to meaningfully combine Manager Channel and Member Channel, Channel Pressure data.
Registered Controller/RPN 0x20,0x20 may be used as a Bipolar alternative to Channel Pressure. All of the above rules will apply to the Registered Controller/RPN. See ***Section 4.8.***
A number of examples and strategies are provided in ***Template Instructions:a)i)(1)(a)(i)Appendix D.***

4.5 Third Dimension of Control

In addition to Pitch Bend and Channel Pressure, MPE controllers may provide a third dimension of continuous control. For example, some instruments inspired by the piano keyboard can track finger movement along the length of the key. This additional dimension is mapped to Control Change #74.
An MPE Device may send Control Change #74 messages both on the Manager Channel and on Member Channels. An MPE Profile Receiver shall respond to the Third Dimension of Control on both the Manager Channel and the Member Channels.

The control of a new note is affected by a Control Change #74 message most recently received on its Channel before Note On. Thus, a receiver shall continue to track Control Change #74 messages even when no note is playing. Control Change #74 also influences the note's initial state. The note will cease to be affected by Control Change #74 messages on its Channel after the Note Off message occurs.

If a Device receives Control Change #74 on both a Manager Channel and Member Channels, it shall combine such data meaningfully and separately for each Sounding Note. It's left to the manufacturer how to meaningfully combine this data.

A number of examples and strategies are provided in ***Template Instructions:a)i)(1)(a)(i)Appendix D.***

Registered Controller/RPN 0x20,0x21 may be used as a Bipolar alternative to Control Change #74. All of the above rules will apply to the Registered Controller/RPN. See ***Section 4.8.***

4.6 Channels for Program Change and Bank Selection

In Polyphonic Channel Response mode, a Sender may send Program Change/Bank Select (Control Change #0, Control Change #32) on the Manager Channel and shall not send Program Change/Bank Select on the Member

Channels. A Receiver shall respond to Program Change/Bank Select on the Manager Channel and shall not respond to Program Change/Bank Select on Member Channels.

In Monophonic Channel Response mode, a Sender may send Program Change/Bank Select Messages on individual Member Channels for a multitimbral response. A Receiver shall respond to Program Change/Bank Select on the Manager Channel and may respond to Program Change/Bank Select on Member Channels.

4.7 Channel Mode Messages

Here are rules regarding how Channel Mode Messages are handled by Senders and Receivers.

- Control Change #120, [All Sounds Off] , Senders may optionally send this message on either the Manager or Member Channels. Receivers should respond to it on both the Master and Member Channels
- Control Change #121 [Reset All Controllers] – Senders may optionally send this message on the Manager Channel. Receivers shall respond to it on the Manager Channel. Senders shall not send this message on the Member Channels and Receivers shall not respond to it on the Member Channels.
- Control Change #123[All Notes Off] - Senders may optionally send this message on the Manager Channel. Receivers shall respond to it on the Manager Channel. Senders shall not send this message on the Member Channels and Receivers shall not respond to it on the Member Channels.
- Control Change #124 [Omni Off] – Senders shall not send this message to either the Manager or Member Channels. Receivers shall not respond to this message on either the Manager or Member Channels.
- Control Change #125 [Omni On] – Senders shall not send this message to either the Manager or Member Channels. Receivers shall not respond to this message on either the Manager or Member Channels.
- Control Change #126 [Mono Mode On] – Senders shall not send this message to either the Manager or Member Channels. Receivers shall not respond to this message on either the Manager or Member Channels.
- Control Change #127 [Poly Mode On] – Senders shall not send this message to either the Manager or Member Channels. Receivers shall not respond to this message on either the Manager or Member Channels.

4.8 Bipolar MPE Controllers

The MPE Profile uses the 7-bit and 14-bit controllers of MIDI 1.0 Protocol. MPE uses three expression controllers by default: Pitch Bend, Channel Pressure, and Control Change #74. MPE enabled using a Profile may optionally

use two Registered Controllers/RPNs for bipolar control with higher resolution to replace Channel Pressure, Control Change #74, or both.

4.9 Rules When Using Bipolar Controllers

Here are rules defining the use of the Expression Controllers:

- MPE Profile Devices shall use the Profile Details Inquiry mechanism to discover if they will use the default Controllers or the alternate Bipolar Controllers.
- Bipolar Controllers don't have to be enabled. When a Receiver responds positively to the Profile Details Inquiry, a Sender can decide to use the Bipolar Registered Controller/RPNs without additional coordination.
- If an MPE Receiver supports Bipolar Pressure Registered Controller/RPN and the MPE Sender decides to send Bipolar Pressure Registered Controller/RPN, then the Sender shall not send Channel Pressure messages.
- If an MPE Receiver supports Third Dimension of Control Controller/RPN and the MPE Sender decides to send Bipolar Third Dimension of Control Registered Controller/RPN, then the Sender shall not send Control Change #74 messages.
- When Bipolar Controllers are being used:
    - They shall be used by both the Manager and the Member Channels.
    - When using RPNs, the data field shall be an unsigned bipolar value, centered at 0x2000.
    - When using Registered Controllers, the data field shall be an unsigned bipolar value, centered at 0x80000000.
    - When using RPNs, Senders shall send data atomically as 2 messages (MSB followed by LSB), and receivers shall wait until they receive both the MSB and LSB values.
    - When a Sender has a property which is not bipolar, the Sender shall send only the upper half of the total range.
- For information about scaling between MIDI 1.0 and MIDI 2.0 see ***MIDI 2.0 Bit Scaling and Resolution [MA07]***

Table 9 MPE Expression Controllers

Property (in Priority Order)	**Controller**	**Alternate Bipolar Controller**	
Pitch Bend	Pitch Bend	Pitch Bend	
Pressure	Channel Pressure	RPN MSB/RC Bank 0x20	RPN LSB/RC Index 0x20
Third Dimension of Control	Control Change #74	RPN MSB/RC Bank 0x20	RPN LSB/RC Index 0x21

4.10 Polyphonic Key Pressure

Response to Polyphonic Key Pressure is not defined by this Profile.

4.11 MIDI 2 Per Note Controllers

Response to MIDI 2 Per Note Controllers is not defined by this Profile.

5 MPE Control Messages and Note On-Off Messages

Senders that use MPE Controllers or alternate Bipolar Controllers should send initial values for these controllers before a Note On message. The order in which these Controllers are sent does not matter. Senders that also use other controller messages may decide whether sending an initial value for those controllers is necessary or not.

If the Sender does not use this mechanism, the Receiver will likely play notes with its own current values for these properties, which might not match the user intention or expectation.

To play a note that sounds one quarter tone above middle C, with an initial timbre value, the following controllers would be sent prior to the Note On (using MIDI Channel 3 as an example):

Table 10 Note On Setup Controllers Example

Message Sequence	Description	Effect
1	Pitch Bend	Pitch Bend is sent Quartertone bend upwards, assuming sensitivity has been set to 48 HCUs. This is to ensure that the Channel already has a Pitch Bend value before the Note On message.
2	Third Dimension of Control.	Control Change #74 or Bipolar Controller (0x20, 0x21) with an initial value for timbre. This is to ensure that the Channel already has a Third Dimension of Control value before the Note On message.
3	Channel Pressure	Set to zero ***Template Instructions:a)i)(1)(a)(i)Appendix D***
4	Note On	Note = Middle C with a velocity

Appendix A : Example Turning on and Enabling a Profile

A.1 Step 1: Initiator Sends Profile Details Inquiry Message

Table 11 Negotiating Number of Channels Step 1

Value	Parameter
F0	System Exclusive Start
7E	Universal System Exclusive
1 byte	Device ID: Source or Destination (depending on type of message): 00–0F: To/from MIDI Channels 1-16 (set to desired Manager Channel)
0D	Universal System Exclusive Sub-ID#1: MIDI-CI
0x28	Universal System Exclusive Sub-ID#2: Inquiry: Profile Details Inquiry Message
1 byte	MIDI-CI Message Version/Format
4 bytes	Source MUID (LSB first)
4 bytes	Destination MUID (LSB first)
5 bytes	MPE Profile Id (0x7E 0x31 0x00 0x01 0x01)
0x00	Inquiry Target = Number of MIDI Channels
F7	End Universal System Exclusive

A.2 Step 2: Responder Sends Reply to Profile Details Inquiry Message

Table 12 Negotiating Number of Channels Step 2

Value	Parameter
F0	System Exclusive Start
7E	Universal System Exclusive
1 byte	Device ID: Source or Destination (depending on type of message): 00–0F: To/from MIDI Channels 1-16 (set to requested Manager Channel)
0D	Universal System Exclusive Sub-ID#1: MIDI-CI
0x29	Universal System Exclusive Sub-ID#2: Inquiry: Reply to Profile Details Message
1 byte	MIDI-CI Message Version/Format
4 bytes	Source MUID (LSB first)
4 bytes	Destination MUID (LSB first)
5 bytes	MPE Profile Id (0x7E 0x31 0x00 0x01 0x01)
0x00	Inquiry Target = Number of MIDI Channels
0x04 0x00	Inquiry Target Data length = 4

2 bytes	The number of Channels currently in use by this Profile. Value = Total Number of Channels, including Manager and Member Channels. (LSB First). If the Profile is not currently enabled, set to 0x00 0x00.
2 bytes	Maximum Number of Channels (available for use by this Profile). Value = Total number of Channels, including Manager and Member Channels. (LSB first)
F7	End Universal System Exclusive

A.3 Step 3: Initiator Sends Set Profile On Message

Table 13 Negotiating Number of Channels Step 3

Value	Parameter
0xF0	System Exclusive Start
0x7E	Universal System Exclusive
1 byte	Destination 00–0F: To/from MIDI Channels 1-16 (set to desired Manager Channel)
0x0D	Universal System Exclusive Sub-ID#1: MIDI-CI
0x22	Universal System Exclusive Sub-ID#2: Set Profile On
1 byte	MIDI-CI Message Version/Format
4 bytes	Source MUID (LSB first)
4 bytes	Destination MUID (LSB first)
5 bytes	Profile ID of Profile to be Set to On (to be enabled) (0x7E 0x31 0x00 0x01 0x01)
The following fields (except F7 End) were added in MIDI-CI Message Version 2	
2 bytes	Number of Channels Requested (LSB First) to assign to this Profile when it is enabled
0xF7	End Universal System Exclusive

The value of the Number of Channels field shall not be higher than the Maximum Number of Channels declared by the Responder in Step 2.

A.4 Step 4: Responder Sends Profile Enabled Message

Table 14 Negotiating Number of Channels Step 4

Value	Parameter
0xF0	System Exclusive Start
0x7E	Universal System Exclusive
1 byte	Destination 00–0F: To/from MIDI Channels 1-16 (set to enabled Manager Channel)
0x0D	Universal System Exclusive Sub-ID#1: MIDI-CI
0x24	Universal System Exclusive Sub-ID#2: Inquiry: Profile Enabled

0x02	MIDI-CI Message Version/Format
4 bytes	Source MUID (LSB first)
4 bytes	Destination MUID (LSB first)
5 byte	MPE Profile Id (0x7E 0x31 0x00 0x01 0x01)
The following fields (except F7 End) were added in MIDI-CI Message Version 2	
2 bytes	Number of Channels enabled on this Profile. (Manager + Member Channels, LSB first)
0xF7	End Universal System Exclusive

A.5 Step 5: Profile Enabled

Initiator knows that the Profile is enabled and how many Channels have been allocated.

Appendix B : Allocation of Notes to Member Channels

An MPE Sender determines the allocation of each note to a Channel. The following considerations should be taken into account when designing the Sender's Channel allocation algorithm for MPE notes:

- Simple circular assignment of new notes to Member Channels of an active MPE Profile will not usually provide satisfactory results. In the simplest workable implementation, a new note will be assigned to the Channel with the lowest count of Active Notes. Typically, the Channel with the oldest last Note Off would be preferred.
- Senders can preferentially re-use a Channel that has been most recently deployed to play a certain Note Number once the previous note has entered its Note Off state.
- In particular circumstances it is appropriate to have the same Note Number active on two different MIDI Channels. For example, a note may start at a certain pitch and be bent to another before a second note is initiated at the original pitch. Alternatively, a guitar-type controller might permit the same pitch to be played simultaneously on different strings.

Appendix C : Example Pitch Bend Equations for Senders and Receivers

C.1 Equations for Senders

If an MPE controller sends Pitch Bend on a Member Channel or Manager Channel in a pitch-precise way dependent on the active Pitch Bend Sensitivity, it could calculate the data in the following way. Note that this is purposefully asymmetrical with the equations for Receivers described below due to the neutral Pitch Bend value making the upwards range being different from the downwards range by 1.

The examples presented here use a single linear equation in order to remain as close to ***M1-101-UM MIDI Polyphonic Expression, Version 1.1 [MA08]*** as possible and to focus on how to handle Pitch Bend across member and manager channels. MIDI 2.0 recommends Min-Center-Max as the scaling method, as detailed in the ***MIDI 2.0 Bit Scaling and Resolution [MA07]*** document, which preserves compatibility in all translation scenarios.

While these equations have been carefully designed for maximal correctness in the integer domain, floating point precision is recommended for these calculations.

- With **`pbSense`** the +/- `range` of Pitch Bend in HCUs and **`pbMem`** the Pitch Bend for the Member Channel, the Pitch Bend value for the Member Channel is **`pbValMem`**:

  MIDI 1.0 Protocol:
  ```
  pbValMem = min((pbMem * 0x2000 / pbSense) + 0x2000, 0x3FFF)
  ```

  MIDI 2.0 Protocol:
  ```
  pbValMem = min((pbMem * 0x80000000 / pbSense) + 0x80000000, 0xFFFFFFFF)
  ```

- With **`pbSense`** the +/- range of Pitch Bend in HCUs and **pbMan** the Pitch Bend for the Manager Channel, the Pitch Bend value for the Manager Channel is **`pbValMan`**:

  MIDI 1.0 Protocol:
  ```
  pbValMan = min((pbMan * 0x2000 / pbSense) + 0x2000, 0x3FFF)
  ```

  MIDI 2.0 Protocol:
  ```
  pbValMan = min((pbMan * 0x80000000 / pbSense) + 0x80000000, 0xFFFFFFFF)
  ```

C.2 Sender Example

- The Pitch Bend Sensitivity is 48 HCUs.
- The Member Channel has a Pitch Bend of +7 HCUs
- The Manager Channel has Pitch Bend of +2 HCUs
- Here is an example of the computation:

  MIDI 1.0 Protocol:

  ```
  pbValMem = min((7 * 0x2000 / 48) + 0x2000, 0x3FFF)
           = 0x24AB Pitch Bend value
  pbValMan = min((2 * 0x2000 / 48) + 0x2000, 0x3FFF)
  ```

```
         = 0x2155 Pitch Bend value
```

MIDI 2.0 Protocol:

```
pbValMem = min((7 * 0x80000000 / 48) + 0x80000000, 0xFFFFFFFF)
         = 0x92AAAAAB Pitch Bend value
pbValMan = min((2 * 0x80000000 / 48) + 0x80000000, 0xFFFFFFFF)
         = 0x85555555 Pitch Bend value
```

C.3 Equations for Receivers

If an MPE synthesizer receives Pitch Bend on a Manager and a Member Channel, it could combine the data in the following way

- With **`pbSense`** being the +/- range of Pitch Bend in HCUs. The Pitch Bend in HCUs for the Manager Channel is:

  MIDI 1.0 Protocol:
  ```
  pMan = max(pbSense * (pbValMan – 0x2000) / 0x1FFF, -pbSense)
  ```

  MIDI 2.0 Protocol:
  ```
  pMan = max(pbSense * (pbValMan - 0x80000000) / 0x7FFFFFFF, -pbSense)
  ```

- With **`pbSense`** the +/- range of Pitch Bend in HCUs. The Pitch Bend in HCUs for the Member Channel is:

  MIDI 1.0 Protocol:
  ```
  pMem = max(pbSense * (pbValMan - 0x2000) / 0x1FFF, -pbSense)
  ```

  MIDI 2.0 Protocol:
  ```
  pMem = max(pbSense * (pbValMan - 0x80000000) / 0x7FFFFFFF, -pbSense)
  ```

- The total Pitch Bend sum of Manager Channel and Member Channel Pitch Bends in HCUs.

  ```
  pbTotal = pbMan + pbMem
  ```

- The variables **`pbMan`** and **`pbMem`** should be stateful so that when **`pbTotal`** is computed it is the sum of the most recent values for these variables.

C.4 Receiver Example

- The Pitch Bend Sensitivity is 48 HCUs.

- The manager Channel has Pitch Bend of +2 HCUs with values

  ```
  MIDI 1.0: 0x2155
  MIDI 2.0: 0x85555555
  ```

- The member Channel has a Pitch Bend of +7 HCUs with a values

  ```
  MIDI 1.0: 0x24AB
  MIDI 2.0: 0x92AAAAAB
  ```

- Here is an example of the computation:

MIDI 1.0 Protocol:

```
pbMan = max(48 * (0x2155 - 0x2000) / 0x1FFF, -48)
      = 2 HCUs
pbMem = max(48 * (0x24AB - 0x2000) / 0x1FFF, -48)
      = 7 HCUs
pbTotal = 9 HCUs
```

MIDI 2.0 Protocol:

```
pbMan = max(48 * (0x85555555 - 0x80000000) / 0x7FFFFFFF, -48)
      = 2 HCUs
pbMem = max(48 * (0x92AAAAAB - 0x80000000) / 0x7FFFFFFF, -48)
      = 7 HCUs
pbTotal = 9 HCUs
```

Appendix D : Handling Channel Pressure and Third Dimension of Control

Typical uses for Channel Pressure and/or Control Change #74 might be for volume (a swell), expression, or a filter cutoff.

Channel Pressure is often generated by a pressure sensor and typically starts with a value of 0x00 at the time of Note On, and typically ends with 0x00 at the time of Note Off. Some controllers may use Channer Pressure in a different way, for instance starting with a non-zero Channel Pressure value before a Note On message.

Control Change #74 is often generated by a vertical position on a key. Note that Control Change #74 might not necessarily start from, or end with a value of 0x00.

A receiver might need to apply these controls from both the Manager Channels and the Member Channels for a Sounding Note. There are several possible ways that these controls might be combined, the actual implementation is left to the manufacturer. For example:

- **Add**: The two controller values might be added together. As an example, Control Change #74 might be used to control a filter cutoff on a per Member Channel basis. The Manager Channel might also send a value for Control Change #74 which is intended to be a bias or Manager offset.
- **Max**: The max value of the two controller values might be used. As an example, Channel Pressure might be used to control volume (a swell) on a per Member Channel basis. The Manager Channel might also send a value for Channel Pressure which serves as an offset from the Sounding Note's current value.
- **Custom**: Manufacturers may choose to create an algorithm for combining Manager and Member Channel Expression.

These same handling concepts can be applied to Bipolar Controllers

Appendix E : MIDI Messages Used on MPE Channels

Table 15 MIDI Messages Used on MPE Channels

MIDI Message or Feature	Manager Channel		Member Channels		Details
	Tx	Rx	Tx	Rx	
Registered Controller/RPN #0 [Pitch Bend Sensitivity]	O	M	P	P	***See Section 3.5***
Pitch Bend	O	M	O	M	***See Section 4.3***
Channel Pressure or Registered Controller/RPN 0x20 0x20	O	M	O	M	***See Section 4.4*** ***See Section 4.8***
Third Dimension of Control: Control Change #74 or Registered Controller/RPN 0x20 0x21	O	M	O	M	***See Section 4.5*** ***See Section 4.8***
MIDI Mode Messages Control Change #120 [All Sounds Off] Control Change #121 [Reset all CC] Control Change #123 [All Notes Off] Control Change #124 [Omni Off] Control Change #125 [Omni On]	 O O O P P	 O M M P P	 O P P P P	 O P P P P	***See Section 4.7***
Control Change #126 [Mono Mode On] Control Change #127 [Poly Mode On]	P P	P P	P P	P P	***See Section 3.6.3*** Lowest Member Channel
Program Change Bank Select Control Change #0 and Control Change #32	O O O	M M M	P/O P/O P/O	P/O P/O P/O	***See Section 3.6 and 4.6*** Refer to monophonic and polyphonic Channel response for the rules around the allowance for these messages.
Note On/Off messages	U	U	M	M	***See Section 5***

Tx: Transmit **Rx:** Receive

M: Mandatory **O**: Optional **P:** Prohibited **U:** Undefined

Note: Messages tagged as Undefined are not used in the context of this MPE Profile but are included in this table because they were defined in MPE version 1.0/1.1.

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