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| **[Refining Sound: A Practical Guide to Synthesis and Synthesizers by Brian K. Shepard](http://www.oup.com/us/refiningsound)**  **Companion Website Materials** [**Instructions for using the interactive demonstrations**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Introduction.html) |

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| Chapter 7: External Control Sources | |
| * [**Jump to:**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter7.html)   + [**Introduction**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Introduction.html)   + [**Chapter 1: Synthesis and Synthesizers**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter1.html)   + [**Chapter 2: Oscillators**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter2.html)   + [**Chapter 3: Oscillator Combinations**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter3.html)   + [**Chapter 4: Amplitude Envelope Generators**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter4.html)   + [**Chapter 5: Audio Filters**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter5.html)   + [**Chapter 6: Internal Modulation Sources**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter6.html)   + [**Chapter 7: External Control Sources**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter7.html)   + [**Chapter 8: Effects Processors**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter8.html)   + [**Chapter 9: Putting It All Together**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/Chapter9.html) | |
|  | **MIDI Messages** MIDI messages consist of groups of 8-bit words or bytes. The first byte, the status byte, describes the type of event being transmitted. Most status bytes are followed by one or more data bytes that provide additional information about the event. Some status bytes, however, are sufficient by themselves and do not need any data bytes. The table below lists the different status bytes and the type and number of data bytes that follow. Undefined values are available for future MIDI development.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Message Type** | **Message Name** | **Binary Value** | **Data Byte #1** | **Data Byte #2** | | Channel Message | Note Off1 | 1000xxxx2 | Note Number | Velocity | | Channel Message | Note On | 1001xxxx | Note Number | Velocity | | Channel Message | Polyphonic Key Pressure | 1010xxxx | Note Number | Pressure | | Channel Message | Control Change | 1011xxxx | Controller Number3 | Controller Value | | Channel Message | Program Change | 1100xxxx | Program Number | none | | Channel Message | Channel Pressure (Aftertouch) | 1101xxxx | Pressure | none | | Channel Message | Pitch Bend | 1110xxxx | Bend LSB4 | Bend MSB | | System Common Message | System Exclusive | 111100005 | Numerous data bytes depending on device and function | | | System Common Message | MIDI Time Code | 11110001 | MTC Quarter Frames | none | | System Common Message | Song Position Pointer | 11110010 | Sequence Location LSB | Sequence Location MSB | | System Common Message | Song Select | 11110011 | Song Number | none | | System Common Message | Undefined | 11110100 | none | | | System Common Message | Undefined | 11110101 | none | | | System Common Message | Tune Request | 11110110 | Status byte only | | | System Common Message | End of Exclusive | 11110111 | Status byte only | | | System Real-Time Message | Timing Clock (24ppq)6 | 11111000 | Status byte only | | | System Real-Time Message | Undefined | 11111001 | none | | | System Real-Time Message | Sequence Start | 11111010 | Status byte only | | | System Real-Time Message | Sequence Continue | 11111011 | Status byte only | | | System Real-Time Message | Sequence Stop | 11111100 | Status byte only | | | System Real-Time Message | Undefined | 11111101 | none | | | System Real-Time Message | Active Sensing | 11111110 | Status byte only | | | System Real-Time Message | Reset | 11111111 | Status byte only | |   **Notes:** 1Due to the efficiency protocol known as *running status* most instruments use a Note On/Velocity 0 message rather than a Note Off message to stop a note from sounding. 2In Channel Message status bytes, the second nybble identifies the particular MIDI channel. In this table, xxxx represents a binary value between 0000 and 1111 that indicates one of the 16 MIDI channels. 3See the MIDI Controller Numbers and Names table below for more information on controller types. 4Some instruments have 7-bit resolution for Pitch Bend and only transmit the MSB (most significant byte). Other instruments have 14-bit resolution for Pitch Bend and transmit both the MSB and LSB (least significant byte). 5System messages apply to the entire instrument, not to a specific MIDI channel. Thus, system messages all begin with 1111, and use the second nybble to identify the message type, not to indicate a MIDI channel. 6Timing Clock messages are transmitted at a rate of 24 pulses-per-quarter note (ppq). |
|  | **MIDI Note Numbers and Frequencies** The MIDI protocol specifies 128 notes numbered 0 - 127. Note numbers 21 - 108 (A0 - C8, indicated in **black**) correspond to the 88 notes of the standard piano keyboard. Notes outside the range of the standard piano keyboard (indicated in **blue**) are sometimes used as controllers or simply ignored by many synthesizers. Octaves are numbered beginning with the note C and all notes through the note B in that octave share the same number (e.g., C3 through B3, then C4 through B4, etc.). Although the most common octave numbering system begins with C-1 and places "Middle C" at C4, two other systems are used as well. One begins with C-2 putting "Middle C" at C3 and the other begins with C0 putting "Middle C" at C5. Regardless of the octave numbering system, "Middle C" is always MIDI note number 60. The frequencies in this diagram are based on equal temperament with A4 tuned to 440 Hz. MIDI Note Numbers and Frequencies |
|  | **MIDI Controller Numbers and Names** Following a Control Change message status byte (1011xxxx), the first data byte will identify one of the following controller types.   * Controllers 0-119 are known as Channel *Voice* Controllers that affect the sound being produced on a channel * Controllers 120-126 are known as Channel *Mode* Controllers that affect the operational mode of a channel * Most controllers are *continuous* controllers that respond to range of values from 0-127. * Controllers 64-69 are *switched* controllers that treat values ≤63 as Off and values ≥64 as On. * Column 2 contains the LSBs (Least Significant Bytes) for the controllers in column 1 to create 14-bit resolution. (Just as Pitch Bend messages have a 14-bit resolution, using a complimentary pair of controllers like #1 and #33 together creates a 14-bit resolution for Modulation Wheel messages.)  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **No.** | **Name** | **No.** | **Name** | **No.** | **Name** | **No.** | **Name** | | 0 | Bank Select | 32 | Bank Select (14-bit) | 64 | Sustain Pedal | 96 | Data Button Increment | | 1 | Modulation Wheel | 33 | Modulation Wheel (14-bit) | 65 | Portamento | 97 | Data Button Decrement | | 2 | Breath Controller | 34 | Breath Controller (14-bit) | 66 | Sustenuto Pedal | 98 | Non-Registered Parameter (14-bit) | | 3 | Undefined | 35 | Undefined (14-bit) | 67 | Soft Pedal | 99 | Non-Registered Parameter | | 4 | Foot Controller | 36 | Foot Pedal (14-bit) | 68 | Legato Pedal | 100 | Registered Parameter (14-bit) | | 5 | Portamento Time | 37 | Portamento Time (14-bit) | 69 | Hold 2 Pedal | 101 | Registered Parameter | | 6 | Data Entry | 38 | Data Entry (14-bit) | 70 | Sound Variation | 102 | Undefined | | 7 | Volume | 39 | Volume (14-bit) | 71 | Sound Timbre | 103 | Undefined | | 8 | Balance | 40 | Balance (14-bit) | 72 | Sound Release Time | 104 | Undefined | | 9 | Undefined | 41 | Undefined (14-bit) | 73 | Sound Attack Time | 105 | Undefined | | 10 | Pan Position | 42 | Pan Position (14-bit) | 74 | Sound Brightness | 106 | Undefined | | 11 | Expression | 43 | Expression (14-bit) | 75 | Sound Control 6 | 107 | Undefined | | 12 | Effect Control 1 | 44 | Effect Control 1 (14-bit) | 76 | Sound Control 7 | 108 | Undefined | | 13 | Effect Control 2 | 45 | Effect Control 2 (14-bit) | 77 | Sound Control 8 | 109 | Undefined | | 14 | Undefined | 46 | Undefined (14-bit) | 78 | Sound Control 9 | 110 | Undefined | | 15 | Undefined | 47 | Undefined (14-bit) | 79 | Sound Control 10 | 111 | Undefined | | 16 | General Purpose Slider 1 | 48 | General Purpose Slider 1 (14-bit) | 80 | General Purpose Button 1 | 112 | Undefined | | 17 | General Purpose Slider 2 | 49 | General Purpose Slider 2 (14-bit) | 81 | General Purpose Button 2 | 113 | Undefined | | 18 | General Purpose Slider 3 | 50 | General Purpose Slider 3 (14-bit) | 82 | General Purpose Button 3 | 114 | Undefined | | 19 | General Purpose Slider 4 | 51 | General Purpose Slider 4 (14-bit) | 83 | General Purpose Button 4 | 115 | Undefined | | 20 | Undefined | 52 | Undefined (14-bit) | 84 | Undefined | 116 | Undefined | | 21 | Undefined | 53 | Undefined (14-bit) | 85 | Undefined | 117 | Undefined | | 22 | Undefined | 54 | Undefined (14-bit) | 86 | Undefined | 118 | Undefined | | 23 | Undefined | 55 | Undefined (14-bit) | 87 | Undefined | 119 | Undefined | | 24 | Undefined | 56 | Undefined (14-bit) | 88 | Undefined | 120 | All Sound Off | | 25 | Undefined | 57 | Undefined (14-bit) | 89 | Undefined | 121 | All Controllers Off | | 26 | Undefined | 58 | Undefined (14-bit) | 90 | Undefined | 122 | Local Keyboard | | 27 | Undefined | 59 | Undefined (14-bit) | 91 | Effects Level | 123 | All Notes Off | | 28 | Undefined | 60 | Undefined (14-bit) | 92 | Tremolo Level | 124 | Omni Mode Off | | 29 | Undefined | 61 | Undefined (14-bit) | 93 | Chorus Level | 125 | Omni Mode On | | 30 | Undefined | 62 | Undefined (14-bit) | 94 | Celeste Level | 126 | Mono Operation | | 31 | Undefined | 63 | Undefined (14-bit) | 95 | Phaser Level | 127 | Poly Operation | |
|  | [**Utility: Mega MIDI Monitor**](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/media/7_0MIDIMonitor.zip) (1.0 MB) A handy utility for monitoring the different types of MIDI messages your controller transmits. **[Mega MIDI Monitor](https://global.oup.com/us/companion.websites/fdscontent/uscompanion/us/static/companion.websites/9780199922963/media/7_0MIDIMonitor.zip)** |
| **Related Links** | [**MIDI Manufacturers Association**](http://www.midi.org/aboutmidi/resources.php) (numerous resources and links related to using MIDI and to the MIDI protocol) [**MIDI Technical Specifications and Information**](http://www.midi.org/techspecs/midispec.php) (maintained by the MIDI Manufacturers Association, this page has links to view or purchase all the technical documents for MIDI implementation) [**Detailed MIDI Message Descriptions**](http://www.midi.org/techspecs/midimessages.php) (more detailed versions of the tables above) |