Matrix-12/Xpander MIDI Specification

image courtesy of http://www.soundofmusic.se

Note: This document is a rework of three old plain text files dealing with the MIDI spec of the Xpander/Matrix-12.

- http://machines.hyperreal.org/manufacturers/Oberheim/Xpander.Matrix-12/info/Xpander.MIDI-spec.txt
- http://www.soundofmusic.se/files/xpander_usergroup.htm
- http://www.soundofmusic.se/files/xpander_midi_controller_notes.txt

This rework has been done to get a more human readable and unique set of information. Changes or additional information about the MIDI implementation were added when required. Redundant information between these files has been removed.

The last version of this document is available here:

- https://github.com/xplorer2716/OberheimXpanderMidiSpec

https://github.com/xplorer2716 – April 2024

This document assumes familiarity with the MIDI 1.0 specification and the operation of the Xpander (or Matrix-12). Unless otherwise stated, all specifications and references to Xpander apply to both Xpander and Matrix-12. For further information on the Xpander refer to the 0berheim Xpander Owner's Manual (Part number 950036).

Change log

Date	Change
05/27/2024	Minor updates
08/15/2008	Program data dump follows and bulk data format updates. Sample C/C++ source code of a single patch viewer application provided in the archive containing this document. “Xpander MIDI Controller Notes” chapter moved before “MIDI Implementation”.
08/04/2008	Initial revision.

XPANDER OVERVIEW

The Xpander is an unusual musical instrument both in operation and in its MIDI implementation. To understand some of the ramifications of MIDI applied to the Xpander it is necessary to understand certain terms and concepts. This section discusses some of the important concepts and features of the Xpander.

MIDI Control

It should be mentioned at the start that at the present time almost all functions of the Xpander which are accessible from the front panel may be controlled via MIDI system exclusive data. In addition, every button-press and knob-turn may be transmitted to MIDI. This means that almost every feature described in this document is controllable from MIDI.

The Xpander/Matrix-12 remote editing system is designed so that virtually every action on the front panel is echoed to MIDI, and conversely any action which can be performed at the front panel can also be performed remotely from MIDI.

Page Editing

The Xpander differs from most synthesizers in the fact that it's voices are separately programmable. This means that there are six independent monophonic synthesizers in one package (twelve in the Matrix-12) that share a common front panel and MIDI interface. More than 1200 controls share the same set of six front panel knobs and switches. This is accomplished by grouping the controls into units called pages. For example, all of the controls for Oscillator 1 are displayed at once when the 'VCO 1 page select" button is pressed. The controls in the PAGE MODIFIER section allow editing of the frequency, detune, pulse width and volume of Oscillator 1. Other pages allow control of the VCF, FM, envelopes, LFOS, transpositions, the MIDI and cassette interfaces, and many other aspects of the Xpander's sound and operation.

Edit Modes

The Xpander's voices can be operated in several different modes. In Single Patch mode all voices play the same sound. The page select buttons select pages which pertain to the sound of a voice and any modification of the sound is played by all voices. There are 100 single patch programs for storing sounds.
Each stores all information needed to play a sound on one voice. When a single patch is recalled, that sound is copied to all voices. Single patch mode emulates a normal homogenous synthesizer and may be used to create sounds to be used in a multi patch. When using the Xpander merely to double another synthesizer, single patch mode is normally used.

In Multi Patch mode, a different single patch sound can be assigned to each voice. The page select buttons select pages which affect this collection of sounds. Each of the 1 00 multi patch programs will remember the assignment of patches to voices as well as the relative transpositions, panning, volume, and control sources of each voice. So in effect, a single patch remembers a sound, while a multi patch remembers information about a collection of sounds but not the sounds themselves. Multi patch mode must be used when voices are to play different sounds. A multi patch, unlike a single patch, remembers keyboard assignment modes, and must be used when creating patches that play all voices in unison.

A submode of multi patch mode is Patch Edit mode where the Xpander still plays separate sounds on each voice, but the controls affect the sound of one or more voices as though in single patch mode. This submode is useful for editing one or more voices in the context of an entire multi patch.

Voice Assignment

It is desirable to have completely independent control of each voice by assigning each voice to its own MIDI channel. But it is also necessary to be able to do polyphonic voice assignment so that a note stream may be sent on one channel and the machine will assign voices to those notes as available. The Xpander provides the flexibility to operate in both modes simultaneously and even makes the configuration programmable with a multi patch. This is accomplished by allowing independent assignment of the control source for each voice.

Zones

Options for control sources are any of the six Control voltage/Gate inputs on the rear panel (Xpander only), any one of the sixteen MIDI channels, or one of three Zones (six Zones on the Matrix-12).

These Zones, an Oberheim innovation, are polyphonic note assignment modules. For each Zone, its control source (one of the sixteen MIDI channels or OMNI) , the range of notes over which it is active (MIDI notes 1 through 127), and the method by which it should assign notes to voices (including Rotate, Reassign, Reset, and three unison modes) may be specified.

The following additional parameters apply only to Matrix-12 Zones: The built in keyboard may be used as a control source, MIDI IN and MIDI OUT may be enabled or disabled separately, and the VOICE ROB feature may been enabled or disabled. When MIDI OUT is enabled, notes played on the keyboard will also go to MIDI OUT on the selected Basic Channel. If the CONTROLLERS option is enabled, the levers, pressure and pedal inputs will also be transmitted to MIDI OUT.

Master MIDI Page

Accessing the master MIDI page allows further control of the MIDI configuration. These parameters are not programmable. The Xpander's Basic Channel is the MIDI channel which is used when addressing the machine as a whole, i.e. program changes, global controllers and "All Notes Off" commands. The Basic Channel may be set to any one of the sixteen MIDI channels.

Controller assignment (Lever 1/2, Pedal 1/2)

The controller assignment page is used to define what MIDI data is used when a patch refers to "Lever 1", "Lever 2", "Pedal 1', or "Pedal 2".

The defaults are:

- Lever 1 is assigned to MIDI "Channel Pitch Bend".
- Lever 2 is assigned to MIDI Continuous Controller #1 which is commonly the modulation lever or wheel.
- Pedal 1 is assigned to the Xpander's Pedal 1 jack.
- Pedal 2 is assigned to the Xpander’s Pedal 2 jack.
- Pressure is assigned to MIDI "Channel Pressure".

Any of these may be assigned to any of the MIDI controllers (O - 121). In addition, Lever 2 may be assigned to "Channel Pitch Bend".

There is a fundamental difference between Lever 1/Pedal 1 and Lever 2/ Pedal 2. The difference is that while Lever 1 and Pedal 1 are separate for each channel, Lever 2 and Pedal 2 are only received on the Basic Channel and sent to all voices. An example of this practice is using the default assignments given above, modulate the pitch of each voice with Lever 1, and modulate the amount of vibrato on each voice with Lever 2.
If each voice is receiving notes from a different channel, this will allow independent pitch bends on each voice while Controller #1 data received on the Basic Channel will affect all voices in parallel.

MIDI Enables

The MIDI Enables page allows selection of which information is transmitted and received via MIDI. The SYSTEMX option controls flow of system exclusive information which includes all page editing and patch transfer.

The XMITCV option (Xpander only), when selected, converts all Control voltage/Gate information received at the back of the Xpander into MIDI Note On/Note Off information. When CV POLY is selected, the CV information is transmitted on the Basic Channel. When CV MONO is selected, the CV information is transmitted on consecutive MIDI channels starting with the Basic Channel.

The ECHO option allows the Xpander to function as a mixer, accumulating commands appearing at its MIDI input (excepting system exclusive commands), combining them with locally generated data (including system exclusive and converted CVs), and re-transmitting them to its MIDI output.

The CONTROL option determines whether "Channel Pitch Bend", "Channel Pressure", and "Channel Controller" information is accepted from MIDI.

The PATCH option enables recognition and transmission of "Channel Patch Change" commands. The MIDI Enables page also allows selection of the scaling of the velocity in Note On and Note Off commands.

The choices are:

- LINEAR - the velocity is not modified before application as a modulation amount.
- EXPO 1 - the velocity is passed through an exponential table where an input of 1 corresponds to an output of 1 and an input of 127 corresponds to an output of 255.
- EXPO 2 - the same as EXPO 1 except the input range for maximum output range is 16 to 120. This is primarily for machines which are capable of sending only a limited range of velocity values.
- EXPO 3 (Matrix-1 2 only) - Similar to the other EXPO modes with linear response in the normal playing range.

The final control on this page is the DEFAULTS option (Xpander Main Processor Software Version 1.1 and earlier only), which when in the NO DEFAULTS mode leaves the MIDI configuration intact when power is cycled. The DEFAULTS ON selection will reset the MIDI configuration at power up (see below).

Send

The SEND subpage (one of the few not accessible from MIDI) allows the user to send the contents of the current edit buffer to MIDI. There is a separate protocol for requesting patches from and sending patches to an Xpander which is under external control.

Midi Reset

The MIDI RESET subpage allows the user to reset all MIDI parameters to the default status. That is:

- Basic Channel = 1
- All options on the MIDI Enables page OFF.
- All notes off

The MIDI MUTE key allows the user to clear the gates of all voices as though an All Notes Off command had been received. Alternatively, selecting the TUNE page will both remove the gates of all voices and reset all envelopes.

Triggers and Gates

Traditionally, triggers have been used to start the attack phase of an envelope. On monophonic synthesizers, a single trigger is generated by playing a key while no other keys are down, and a multi trigger is generated by playing a new key, regardless of whether the voice is already playing. In other words, one single trigger is generated when the gate becomes active, and multi triggers are generated by changing the note while the gate is not changing. The gate is active as long as the key is down.
In the Xpander, the envelopes may be triggered independently from either the single or multi trigger sources as well as from an external signal or any of the LFOS. In addition, the LFOs themselves may be reset to a programmable point in their cycle by the single or multi triggers, an external source, or any of the LFOS.

In general, when a voice is not gated and it receives a Note On command, both a multi and a single trigger are generated and its gate is set active. Successive Note On commands to that voice while it is still gated only generate new multi triggers. When a voice is not gated, successive Note Off commands will also generate multi triggers. However, Zones will not pass Note On commands to already gated voices, but instead turn off an already playing voice and re-gate it.

When the XMITCV option (Xpander only) is selected, a back panel gate which becomes active will generate a MIDI Note On command with a velocity of 40H and the associated CV as the note. If the CV changes while the gate is active, a Note Off for the old CV followed by a Note On with the updated CV will be sent. Internally, however, the CV which changes while the gate is active will generate a multi trigger, but not a single trigger.

XPANDER MIDI CONTROLLER NOTES

MIDI controllers must be enabled on the Xpander.

1. Select Master Page.
2. Select MIDI.
3. Select Enables.
4. Select (underline) Control.
5. Press page 2 and return to MIDI page.
6. Select CTRLS and check MIDI controller assignments for correct controller routing.
7. Switch to NO DEFAULTS on MIDI ENABLES page if settings are to remain the same on power up.

Pitch Bend

1. Select VCO 1.
2. Select page 2.
3. Select (underline) Lev 1.
4. Repeat for VCO 2.

Individualized Vibrato Stored by Patch / Mod Lever

1. Select VCO 1.
2. Select FREQ to modulate.
3. Select LFO X (modulation source).
3. Choose which LFO to use (1 to 5). Enter number in X SELECT.
4. Increase mod amount to hear vibrato.
5. Select LFO page and enter number of the LFO mod source.
6. Reduce LFO AMP amount to 0.
7. Select AMP to modulate.
8. Select LEVER 2 as mod source and adjust amount to full.
9. Adjust LFO mod amount on VCO 1 FREQ for desired depth.
10. Repeat procedure for VCO 2 if desired.

Single Patch Global Vib (programable enables per patch)

Single patch VIB is a special preassigned multi-patch vib that can add vibrato to all enabled single patches without having to program frequency modulation (vibrato) into each patch separately. For each single patch, VIB is enabled by selecting (underlining) VIB while in page 2 of both VCO 1 and VCO 2 pages. "VIB enable" can be stored in each single patch.
After routing depth amount desired MIDI controller (LEV 2), VIB can be used as a live-performance mod wheel (lever) controller on all enabled single patches.

1. Select VCO 1.
2. Select page 2.
3. Select (underline) VIB.
4. Repeat procedure for VCO 2.
5. Select Master page.
6. Select VIB.
7. Increase AMP amount to audible vibrato depth.
8. Adjust LFO SPEED, and WAVE SHAPE to preference.
9. Reduce AMP amount to 0.

10. Select VIB page 2.
11. Select MIDI controller (LEV 2).
12. Adjust VIB depth amount on Xpander while mod wheel (lever) controller on full.

Note: "VIB enable" should be stored into each patch program that user may use VIB on.

Programming Sustain Pedal (Non-MIDI)

This procedure is for programming sustain pedal control into a patch when using an Oberheim footswitch directly into an Xpander external Pedal input controller.

1. Plug pedal into "PEDAL 2" for global control.
2. Observe which envelope is modulating VCA 2.(press mod dot). Enter ENV X and number of VCA envelope.
3. Without pressing down on the pedal, increase "RELEASE" amount of the envelope to desired amount of sustain, as if the pedal was depressed.
4. Press "RELEASE" button to modulate and select "PED 2" as source.
5. Reduce the modulation of "PED 2" to a negative amount. Continue reducing, until the sustain level of the sound returns to the desired amount when the foot pedal is not depressed.

Midi Sustain Controller

MIDI controls must be enabled on the Xpander first, in order for any MIDI controller information to be received. The MIDI Controller number being used (Yamaha sust ped = 64) should be assigned to the appropriate Modulation Source (PED 2) on the MIDI CTRLS page. When using a MIDI controller to operate sustain, the pedal modulation amount (affecting env RELEASE) may operate best with a positive amount.

Velocity

1. Single patch; select Filter/VCA.
2. Reduce VCA 1 amount to 7.
3. Select VCA 1 to modulate.
4. Select VELOCITY as modulation source.
5. Increase Velocity mod amount to full for reference.
6. Check keyboard response and adjust VEL mod amount.
7. Repeat procedure for filter envelope if desired.

IMPLEMENTATION NOTES

This section discusses the specifics of the data actually transmitted and received via MIDI. There is also discussion of how ambiguous aspects of the MIDI specification 1.0 were interpreted.

Status Bytes

Running status is implemented.

Data bytes

No action is taken on a command until all status and data bytes for that command have been received correctly. This includes patch transfers.

When the ECHO option is on, a received message is not transmitted until all of the corresponding data bytes have been received and the message has been determined valid. When retransmitted, a complete message, including status byte, is always sent.

All Notes Off

On machines with Main Processor software versions 1.4 and later (both Xpander and Matrix-12), an All Notes Off command received on a given MIDI channel will only turn off notes that were turned on from the same channel. On units with earlier software versions, an All Notes Off command will turn off all notes that were turned on by MIDI commands. Turning a note off involves removing the gate from a voice and starting the release phase of the envelopes.

Modes

The Xpander does respond to Mode Change messages because the POLY/MONO and OMN I ON/OFF status is programmable with each mufti patch and the Xpander is capable of operating in more than one mode simultaneously. The only response to Mode Change messages is to perform an All Notes Off operation for the specified channel.

There are, however, some similarities between voice configurations and normal MIDI modes. Assigning a voice directly to a MIDI channel (or CV) effectively puts that voice in MONO/OMNI OFF mode. Using a Zone is the same as putting the voices assigned to that Zone into POLY mode. If the Zone input is specified as OMNI, then those voices are in POLY/OMNI ON mode, otherwise they are in POLY/OMNI OFF mode.

Thus a single Xpander multi patch can, for example, be simultaneously run from a CV/Gate input, a single MIDI channel in MONO/OMNI OFF, one Zone in POLY/OMNI ON, and another Zone in POLY/OMNI OFF. This configuration, complete with channel assignments, is programmable with the patch.

Power On Defaults

(Xpander Main Processor software version 1.1 and earlier only)

If the 'DEFAULTS ON' option is selected, when power is applied the Xpander will reset to Basic channel one- (1), with all voice messages disabled except Note On/Note Off. If the "NO DEFAULTS" option is selected, the state of the MIDI parameters at power-up will be the same as it was before power down.

Note:the DEFAULTS ON/NO DEFAULTS option has been eliminated starting with Xpander Main Processor software version 1.2 ; the Matrix-1 2 will always be in NO DEFAULTS mode.

Note Off (Status = 1000nnnn / 8xH)

Any voice which is both playing the specified note and listening to the specified channel (directly or through a Zone) will have its gate removed. If any voice is assigned directly to the specified channel, but is not currently gated, reception of a note off event will generate a multi trigger (but not a single trigger) on the voice, and its pitch will be updated to the value specified in the Note Off event. In addition, that voice's release velocity will be updated.

Note On (Status = 1001nnnn / 9xH)

Any voice assigned directly to the specified channel will have its pitch and velocity assigned to those specified in the Note On event. A multi trigger will be generated for that voice and, if the voice was not already gated, a single trigger will be generated as well.
If a Zone is listening to the specified channel and the note value is within the limits specified for the Zone, the note and corresponding velocity will be assigned according to the assignment mode to voices in that Zone. A new single and multi trigger will be generated for the affected voices.
If there are no un-gated voices in the Zone, the next voice in the rotation will be "robbed" of its gate and the new note will be played on that voice as though the voice had been free.

Control Change (Status = 1011nnnn / BxH)

All controllers are received as seven bit values, that is, no distinction is made between MSB and LSB controllers (controllers #0 - 31 and #32 - 63) and values from 1 through 126 are not ignored for switches (controllers 64 - 95). Channel mode messages are only received on the Basic channel and are ignored except that they perform an All Notes Off command.

Control changes which are received for controllers assigned to Pressure, Lever 1, or Pedal 1 are maintained separately for each MIDI channel. Control changes which are received on any channel to which any voice or Zone is assigned will, if the specified controller is assigned to Lever 2 or Pedal 2, update the global Lever 2 or Pedal 2 values respectively.

Program Change (Status = 1100nnnn / CxH)

Program change messages received on the Basic channel will select that patch number. If the machine is in Multi patch mode, a multi patch will be selected. If in Single mode, a single patch will be selected. If in Patch edit mode, all selected voices will receive that single patch.

Channel Pressure (Status = 1101nnnn / DxH)

The pressure values used in voice modulation are separate for each channel and are only updated by the channel pressure message. This means that when a key is released, a pressure value of zero should be sent, since a Note Off does not automatically clear-the pressure.

Pitch Wheel Change (Status = 1110nnnn / ExH)

Only eight bits of pitch bend are used. A Pitch Wheel Change message can be assigned to either the Lever 1 or Lever 2 modulation sources (or both). Data sent to lever 1 is kept separate for each channel. If a pitch wheel change message comes in on any channel to

which a voice or Zone is assigned and Lever 2 is assigned to BENDER, the Lever 2 value used by all voices will be updated.

The intended use for this difference is to make ft possible to run the voices "monophonically" and have separate pitch bends or to have all voices respond to a pitch bend on any of the channels.

System Exclusive (Status = F0H)

The Xpander/Matrix-12 uses the system exclusive format extensively to allow exhaustive control from external sources. Patch request and send, page select, edit mode select, and edit value are some of the commands. For more detail on system exclusive formats see Appendix B.

Tune Request (Status = F6H)

The Xpander does not transmit this message, but will respond to a received Tune Request by selecting the TUNE page and auto-calibrating the VCO frequency and pulse width and the VCF frequency and resonance.

EOX (Status = F7H)

The Xpander expects incoming system exclusive transmissions to contain a known amount of information. Thus, the command byte will define the amount of information to be received. When that number of data bytes has been received, the transmission is considered to be complete. The machine then waits for the next status byte.
The EOX (End of transmission) message is therefore considered a No-op by the Xpander, although is transmitted as the last byte of every system exclusive message generated. Edit page commands, however, may contain up to six consecutive updates in one transmission. These are processed three bytes at a time.

APPENDIX A: MIDI IMPLEMENTATION SUMMARY

Transmitted Data - Channel Voice Messages

Program select

Status	Data bytes	Description
C0H	0nnn nnnn = 0 through 99	Program select (If enabled)

Recognized Receive Data - Channel Voice Messages

Note:
1. xxxx: Basic Channel number minus one (i.e., 0000 is Ch. 1, 0001 is Ch.2, etc.).
2. kkkkkkk = Note number.

Note off

Status	Data bytes	Description
1000 xxxx	0kkk kkkk 0vvv vvvv	Note Off (See notes 1,2) 0vvv vvvv = note off velocity

Note on

Status	Data bytes	Description
1001 xxxx	0kkk kkkk 0vvv vvvv	Note On (See notes 1,2) 0vvv vvvv - 0 Note Off 0vv vvvv > 0 note on velocity

Control Change

Status	Data bytes	Description
1011 xxxx	0ccc cccc 0nnn nnnn	Control Change (if enabled) 0ccc cccc = control number 0nnn nnnn = control value

Program select

Status	Data bytes	Description
1100 xxxx	0nnn nnnn	Program Select (If enabled) 0nnn nnnn = 0 through 99

Pitch Bend Change

Status	Data bytes	Description
1110 xxxx	0nnn nnnn 0nnn nnnn	Pitch Bend Change LSB Pitch Bend Change MSB

Recognized Receive Data - Channel Mode Messages

All Note off

Status	Data bytes	Description
1011 xxxx	7BH 00H	All Notes Off command. The Xpander turns off all notes that were turned on by MIDI.

OMNI off

Status	Data bytes	Description
1011 xxxx	7CH 00H	OMNI mode off The Xpander turns off all notes that were turned on by MIDI.

OMNI on

Status	Data bytes	Description
1011 xxxx	7DH 00H	OMNI mode on. The Xpander turns off all notes that were turned on by MIDI.

MONO on

Status	Data bytes	Description
1011 xxxx	7EH 00H	MONO mode on The Xpander turns off all notes that were turned on by MIDI.

POLY on

Status	Data bytes	Description
1011 xxxx	7FH 00H	POLY mode on The Xpander turns off all notes that were turned on by MIDI.

Recognized Receive Data - System messages

Status	Data bytes	Description
F6H		Tune Request (tune all)

APPENDIX B: SYSTEM EXCLUSIVE INFORMATION

Note: The Xpander and Matrix-12 both use System Exclusive Device Number 02H except during Multi Patch data dumps when the Matrix-12 uses 04H.

Transmitted Data - Channel Voice Messages

Program data dump follows

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number.
	0ddd dddd	Xpander = 02H (See note 3) Matrix-12 = 04H (Multi patch dump only)
	01H	Command byte 1 Program data dump follows.
	0ccc cccc	Command byte 2: Program type 0ccc cccc = 0 :voice data 0ccc cccc = 1: multi patch data
	0ppp pppp	Command byte 3: Program number
	<data>	Program data. See bulk data format for details.
F7H		End of System Exclusive status byte (EOX)

Copy

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	02H	Device number: Xpander = 2
	04H	Command byte 1 : Copy
	0xxx xxxx	Data : Lower 7 bits first followed by
	0000 000x	most significant bit.
F7H		End of System Exclusive status byte (EOX)

Store

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	02H	Device number: Xpander = 2
	07H	Command byte 1 : Store
	0xxx xxxx	Data: program number.
F7H		End of System Exclusive status byte (EOX)

Page edit follows

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	02H	Device number: Xpander = 2
	0AH	Command byte 1 : Page edit follows
	00H	
	<data>	See "recognized receive data", same command.
F7H		End of System Exclusive status byte (EOX)

Page and subpage select

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	02H	Device number: Xpander = 2
	0BH	Command byte 1 : Page and subpage select
	0ppp pppp	Page number
	0ppp pppp	Subpage number
F7H		End of System Exclusive status byte (EOX)

Programmer mode switches

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	02H	Device number: Xpander = 2
	0DH	Command byte 1 : Programmer Mode Switches
	0xxx xxxx	Data : Lower 7 bits first followed by
	0000 000x	most significant bit.
F7H		End of System Exclusive status byte (EOX)

Up/Down

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	02H	Device number: Xpander = 2
	0EH	Command byte 1 : Up/Down
	0000 0xx0	Data: Format = Set bit 3 = "+" key Set bit 2 = "-" key
F7H		End of System Exclusive status byte (EOX)

Modulation Edit follows

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	02H	Device number: Xpander = 2
	0FH	Command byte 1 : Modulation Edit follows
	<data>	Data. See "recognized receive data", same command.
F7H		End of System Exclusive status byte (EOX)

Recognized Receive Data

Program data dump request

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number - Xpander = 02H (See note 3)
	00H	Command byte 1 : Program data dump request
	0ccc cccc	Command byte 2: Program type
		0ccc cccc = 0 voice data
		0ccc cccc > 0 multi patch data
	0ppp pppp	Command byte 3: Program number
F7H		End of System Exclusive status byte (EOX)

On receipt of this message, an Xpander or Matrix-12 will respond by transmitting a Program Data Dump Follows message for the requested patch. This does not affect the contents of the edit buffer.

Program data dump follows

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H (See note 3)
		Matrix-12 = 04H (Multi patch dump only)
	01H	Command byte 1 Program data dump follows.
	0ccc cccc	Command byte 2: Program type
		0ccc cccc = 0 voice data ,
		0ccc cccc = 1 multi patch data
	0ppp pppp	Command byte 3: Program number (0 to 99)
	<data>	Program data. See bulk data format for details.
F7H		End of System Exclusive status byte (EOX)

On receipt of this message the data is stored into patch memory at the specified location. This does not affect the contents of the edit buffer.

All data dump request

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	02H	Command byte 1 : All data dump request
	00H	Command byte 2: voice data
F7H		End of System Exclusive status byte (EOX)

All data dump request (Matrix-12)

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	02H	Command byte 1: All data dump request
	01H	Command byte 2 Multi patch data (Matrix-12)
F7H		End of System Exclusive status byte (EOX

Receipt of this message causes the entire contents of the Xpander or Matrix-12 to be dumped in a series of Program Data Dump Follows messages. The patches are dumped in sequential ascending order, first single patches, then multi patches. Each patch is sent as a separate complete SysEx message bracketed by F0H-F7H. The contents of the edit buffer are not affected.

Copy

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0dd dddd	Device number: Xpander = 02H
	04H	Command byte 1 : Copy
		Data : Lower 7 bits first followed by most significant
	0xxx xxxx	bit. :<id_lo>: See Definitions for Programmer Mode
	0000 000x	(0DH),
F7H		:<id_hi>: but low order 2 bits of id_lo must be 0.
		End of System Exclusive status byte (EOX)

This message may only be used in multi patch mode when a single voice is currently selected. The effect is to copy the contents of that voice's edit buffer to the edit buffers of the specified voices. Note that this can not be used to copy an edit buffer from one bank to the other on a Matrix-12.

Display control command

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	0ccc cccc	Command byte 1 : Display control command **05H** = Xpander **06H** = Matrix-12 00H = display control off 01H : <disposition>: 80 bytes of ASCII data follows 02H = display on
	<data>	ASCII data
F7H		End of System Exclusive status byte (EOX)

This message will cas the receiving unit to display up to 80 characters of ASCII in the center two displays. All characters must be in the range 20H-5FH (space to underscore). The data is written into a separate buffer which is then displayed. Each message rewrites the buffer starting at the first character so that if fewer than 80 characters are written, data from a previous message may appear in the display. If no text is sent before the EOX in a <disposition>=1 message, the entire previous contents of the message buffer will be displayed.

Store

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	07H	Command byte 1 : Store
	0xxx xxxx	Data: Program number (0 to 99)
F7H		End of System Exclusive status byte (EOX)

Store the current edit buffer (single or multi) into the specified patch location.
In single patch mode this will always store the current edit buffer into a single patch location.
In multi mode, the effect depends on what is actively selected: If a multi patch is selected, then the multi patch edit buffer will be stored. But if a single voice within a multi-patch is selected, that voice's edit buffer will be stored as a single patch.

Page edit follows

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	0AH	Command byte .1 : Page edit follows
	00H	
	<data>	[<id> 00 <rot_lo> <rot_hi> <val_lo> <val_hi] <id>: = 00H - 05H for actions on with top buttons. = 08H - 0DH for actions on with bottom buttons. = 18H - 1DH for actions on rotary encoders. <rot> (8 bit value in two bytes, MS bit in d0 of second byte) : amount that a rotary switch has been turned as an 8 bit, 2's complement number.

		<val> (same as <rot>): value for controller as 8 bit 2Us complement number. Note that flags (e.g. VCO2 Sync) have a value of 0 or 1.
F7H		End of System Exclusive status byte (EOX)

In the special case when a modulation is cleared from the modulation routings page on the Matrix-12, <id> is 0AH, and <val> is 3FH.

Page and Subpage select

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	0BH	Command byte 1 : Page and Subpage select
	0ppp pppp	Page number
	0ppp pppp	Subpage number
F7H		End of System Exclusive status byte (EOX)

This message selects the specified page and sub page. If this page is not defined in the current mode, the command will be ignored.

Transpose

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	0CH	Command byte 1 : Programmer mode switches
	<xpose_lo>	These bytes represent a 8 bit, 2Us complement
	<xpose_hi>	number in the range of -24 to +24 (?)
F7H		End of System Exclusive status byte (EOX)

This sets the Master Transpose of the unit.

Programmer mode switches

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	0DH	Command byte 1 : Programmer mode switches
	<id_lo>	<id> (8 bit quantity in two bytes) as follows:
	<id_hi>	SINGLE 01H (01H 00H)
		MULTI 02H (02H 00H)
		1/7 04H (04H 00H)
		2/8 08H (08H 00H)
		3/9 10H (10H 00H)
		4/10 20H (20H 00H)
		5/11 40H (40H 00H)
		6/12 80H (00H 01H)
F7H		End of System Exclusive status byte (EOX)

Note that pressing several (Patch Edit) buttons simultaneously produces an <id> that is the inclusive OR of the appropriate bits.
(Note: if you wish, that changing from SINGLE to MULTI mode or vice-versa generates a report of the pedal and lever controller values. Power-On generates reports of the pedal positions only. Invoking the "OBERHEIM" patch via STORE-CLEAR generates controller values and a jump to the VCO1 page.)

Up/Down

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	0EH	Command byte 1 : Up/Down
	0000 0xx0	Data Format: Set bit 3 = "+" key, Set bit 2 = "-" key
F7H		End of System Exclusive status byte (EOX)

Note that these values have been corrected since the first printing of this specification.

Changing program numbers with the "+" and "-" keys generates the system exclusive message above. It does not generate a normal MIDI patch change message. Changing program numbers by typing the two digits generates a MIDI program change message, but not the system exclusive message.

The messages generated are identical in SINGLE, MULTI, and Reselecting single voices within a MULTI patch mode.

Modulation edit follows

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	0FH	Command byte 1 : Modulation edit follows
	00H	
	<data>	[<id> 00 <action> <val_lo> <val_hi>] <id>:0-5, where 0 is the first modulation for the page, 1 is the second, etc. <action>: specifies val (8 bits in 2 bytes): 00 Add Modulation Source: ID of source range 0-26 01 Delete Modulation N/A 02 Change Source New source ID range 0-26 03 Set value Value (unsigned) 04 Dial Value Amount of change 05 Set Quantize 0 = off, 1 = quantize 06 Toggle Quantize N/A 07 "+" or "-" : 0 = "+", 1 = "-"
F7H		End of System Exclusive status byte (EOX)

Card select (Matrix-12 only)

Status	Data bytes	Description
F0H	10H	System exclusive. Oberheim I.D. number
	0ddd dddd	Device number: Xpander = 02H
	10H	Command byte 1 : Card select (Matrix-12 only)
	0nnn nnnn	Voice Card number: 0 to select voices 1-6 1 to select voices 7 - 12
F7H		End of System Exclusive status byte (EOX)

PAGE NUMBER DEFINITION

Page # (dec)	Page # (hex)	Page description
0	0H	Master x
1	1H	Tune x
2	2H	Chain
3	3H	Master Misc (M12)
3	3H	Gate (Xp) x
4	4H	Voice On/Off
5	5H	MIDI
6	6H	Cassette
7	7H	Send Cassette
8	8H	Check Cassette
9	9H	From Cassette
15	FH	Load All
16	10H	Load One
17	11H	Load Single
18	2H	Load Multi
19	13H	Load Chain
20	14H	Start Load
21	15H	Load Global
22	16H	MIDI Basic Channel
23	17H	MIDI Controllers
24	18H	MIDI Enables
25	19H	MIDI Send Patch
26	1AH	MIDI Reset
27	1BH	MIDI Mute
29	1DH	Version x
32	20H	VCO 1 x
33	21H	VCO 2 x
34	22H	VCF / VCA x
35	23H	FM / Lag x
40	28H	Env 1 x
41	29H	Env 2 x
42	2AH	Env 3 x
43	2BH	Env 4 x
44	2CH	Env 5 x
48	30H	LFO 1 x
49	31H	LFO 2 x
50	32H	LFO 3 x
51	33H	LFO 4 x
52	34H	LFO 5 x
56	38H	Track 1
57	39H	Track 2
58	3AH	Track 3
64	40H	Ramp 1 x
65	41H	Ramp 2 x
66	42H	Ramp 3 x
67	43H	Ramp 4 x
80	50H	Zone 1(M12) x
81	51H	Zone 2(M12) x
82	52H	Zone 3(M12) x
83	53H	Zone 4(M12) x

84	54H	Zone 5(M12) x
88	58H	Misc Name(M12)
89	59H	Name(Xp)
96	60H	Transpose
97	61H	Pan
98	62H	VASSIGN / CVMIDI
99	63H	Zone (Xp)
100	64H	Zone Input(Xp)
101	65H	Zone Limits(Xp)
102	66H	Zone Mode(Xp)
103	67H	Volume
104	68H	VIB
105	69H	Name(M12)
106	6AH	Detune
107	6BH	Mod Routings

BULK DATA FORMAT (C/C++ programming language)

Because MIDI requires that the most significant bit of bytes transmitted within a system exclusive message be 0, 8 bit quantities must be transmitted in two bytes. In fact, with the Xpander, all data are transmitted as a pair of bytes, even though most only require the first byte, and the second byte is thus generally zero. There are only a few cases where both bytes are used.
Unused bits are sometimes set in uploads, so it is wise to mask out the unused bits before interpreting the bits from an upload.
Different ways are used to represent negative numbers depending on the parameters. See the implementation hereafter for details.

Source code

Complete commented source code for Microsoft Visual Studio 2022 is provided in the archive containing this document (see the SysExImplementation folder).
This source code was kept as simple as possible so it could be easily translated into another programming language. It is published under the GNU General Public License V3.

XpanderSysEx.h

This file contains the bit masks, values, and structures for the single patch data.

XpanderSysExViewer.cpp

This is a demo application using the XpanderSysEx.h file. Look in this file to see how values are extracted from SysEx file.

XpanderSysExViewer.README.txt

You should read this file first.

Demo application: XpanderSysExViewer

This command line utility dumps in a human readable format the content of a single patch raw SysEx file. To run this software, open a command prompt with the following command line:

```
C:\>XpanderSinglePatchViewer [your_raw_sysex_file]
```

Where [your_raw_sysex_file] is the file you want to dump.
If you specify a Multi patch sysex file, all single patches of the bank will be dumped, but not the multi patch data itself. This will be implemented in the next revision of this document.

For a single patch sysex file, the output will be similar to the following :

```
Program type:    00h
Program number:  3Bh (59)
NAME:   JUMP
---------------------------
VCO1.freq:       00h        0
VCO1.detune:     00h        0
VCO1.pw:         1Fh       31
VCO1.vol:        3Fh       63
VCO1.mod:        0Eh       14 : LAG LEV_1 VIB
VCO1.wave:       03h        3 : TRI SAW
---------------------------
VCO2.freq:       00h        0
VCO2.detune:     11h       17
VCO2.pw:         1Fh       31
VCO2.vol:        3Fh       63
VCO2.mod:        0Eh       14 : LAG LEV_1 VIB
```

```
VCO2.wave:       06h        6 : SAW PULSE
--------------------------
VCF.freq:        49h       73
VCF.res:         00h        0
VCF.mode:        01h        1 : LOW_2
VCF.vca1:        3Fh       63
VCF.vca2:        00h        0
VCF.mod:         04h        4 : LEV_1
--------------------------
FMLAG.amp        00h        0
FMLAG.dest:      01h        1 : VCF_FREQ
FMLAG.lag_in:    00h        0 : KBD
FMLAG.lag_rate:  02h        2
FMLAG.lag_mode:  01h        1 : LEGATO
--------------------------
LFO[1].speed:    1Ch       28
LFO[1].trg_mod:  00h        0 : OFF
LFO[1].lag:      00h        0 :
LFO[1].wave:     00h        0 : TRIANGLE
LFO[1].retrig:   00h        0
LFO[1].sample    00h        0 : KBD
LFO[1].amp:      3Fh       63
--------------------------
LFO[2].speed:    39h       57
LFO[2].trg_mod:  00h        0 : OFF
LFO[2].lag:      00h        0 :
LFO[2].wave:     00h        0 : TRIANGLE
LFO[2].retrig:   00h        0
LFO[2].sample    00h        0 : KBD
LFO[2].amp:      00h        0
--------------------------
LFO[3].speed:    30h       48
LFO[3].trg_mod:  00h        0 : OFF
LFO[3].lag:      00h        0 :
LFO[3].wave:     00h        0 : TRIANGLE
LFO[3].retrig:   00h        0
LFO[3].sample    00h        0 : KBD
LFO[3].amp:      3Fh       63
--------------------------
LFO[4].speed:    30h       48
LFO[4].trg_mod:  00h        0 : OFF
LFO[4].lag:      00h        0 :
LFO[4].wave:     00h        0 : TRIANGLE
LFO[4].retrig:   00h        0
LFO[4].sample    00h        0 : KBD
LFO[4].amp:      3Fh       63
--------------------------
LFO[5].speed:    0Dh       13
LFO[5].trg_mod:  00h        0 : OFF
LFO[5].lag:      00h        0 :
LFO[5].wave:     00h        0 : TRIANGLE
LFO[5].retrig:   00h        0
LFO[5].sample    00h        0 : KBD
LFO[5].amp:      3Fh       63
--------------------------
ENV[1].flags:    84h      132 : MULTI FREERUN
ENV[1].lfo_trg:  00h        0 : LFO1
ENV[1].delay:    11h       17
ENV[1].attck:    08h        8
ENV[1].decay:    07h        7
ENV[1].sustain:  17h       23
ENV[1].rel:      17h       23
ENV[1].amp:      12h       18
--------------------------
ENV[2].flags:    04h        4 : MULTI
ENV[2].lfo_trg:  00h        0 : LFO1
ENV[2].delay:    00h        0
ENV[2].attck:    00h        0
ENV[2].decay:    00h        0
ENV[2].sustain:  3Fh       63
ENV[2].rel:      09h        9
ENV[2].amp:      3Fh       63
--------------------------
ENV[3].flags:    04h        4 : MULTI
ENV[3].lfo_trg:  00h        0 : LFO1
ENV[3].delay:    00h        0
ENV[3].attck:    0Fh       15
```

```
ENV[3].decay:    00h        0
ENV[3].sustain:  3Fh       63
ENV[3].rel:      19h       25
ENV[3].amp:      3Fh       63
---------------------------
ENV[4].flags:    84h      132 : MULTI FREERUN
ENV[4].lfo_trg:  00h        0 : LFO1
ENV[4].delay:    00h        0
ENV[4].attck:    00h        0
ENV[4].decay:    00h        0
ENV[4].sustain:  3Fh       63
ENV[4].rel:      00h        0
ENV[4].amp:      3Fh       63
---------------------------
ENV[5].flags:    84h      132 : MULTI FREERUN
ENV[5].lfo_trg:  00h        0 : LFO1
ENV[5].delay:    00h        0
ENV[5].attck:    07h        7
ENV[5].decay:    00h        0
ENV[5].sustain:  3Fh       63
ENV[5].rel:      09h        9
ENV[5].amp:      3Fh       63
---------------------------
TRACK[1].input:  00h        0 : KBD
TRACK[1].points:            60,63,25,56,54
---------------------------
TRACK[2].input:  00h        0 : KBD
TRACK[2].points:            0,15,31,47,63
---------------------------
TRACK[3].input:  00h        0 : KBD
TRACK[3].points:            0,15,31,47,63
---------------------------
RAMP[1].rate:    1Fh       31
RAMP[1].flags:   00h        0 :
RAMP[1].lfotrg:  00h        0 : LFO1
---------------------------
RAMP[2].rate:    1Fh       31
RAMP[2].flags:   00h        0 :
RAMP[2].lfotrg:  00h        0 : LFO1
---------------------------
RAMP[3].rate:    1Fh       31
RAMP[3].flags:   00h        0 :
RAMP[3].lfotrg:  00h        0 : LFO1
---------------------------
RAMP[4].rate:    1Fh       31
RAMP[4].flags:   00h        0 :
RAMP[4].lfotrg:  00h        0 : LFO1
---------------------------
MOD[01]: ENV2 modulates RMP2, amount 63
---------------------------
MOD[02]: ENV5 modulates TRK2, amount 60
---------------------------
MOD[03]: LFO2 modulates KBD, amount 58
---------------------------
MOD[04]: LFO2 modulates RVEL, amount 58
---------------------------
MOD[05]: PRES modulates ENV2, amount 41
---------------------------
MOD[06]: PED1 modulates SINGLE, amount 55
---------------------------
MOD[07]: ENV1 modulates RMP2, amount 0
---------------------------
MOD[08]: LFO1 modulates PRES, amount 52
---------------------------
MOD[09]: LFO1 modulates LAG, amount -52
---------------------------
MOD[10]: ENV3 modulates KBD, amount 13
---------------------------
MOD[11]: UNUSED ENTRY
---------------------------
MOD[12]: UNUSED ENTRY
---------------------------
MOD[13]: UNUSED ENTRY
---------------------------
MOD[14]: UNUSED ENTRY
---------------------------
MOD[15]: UNUSED ENTRY
```

```
--------------------------
MOD[16]: UNUSED ENTRY
--------------------------
MOD[17]: UNUSED ENTRY
--------------------------
MOD[18]: UNUSED ENTRY
--------------------------
MOD[19]: UNUSED ENTRY
--------------------------
MOD[20]: UNUSED ENTRY
```

DECIMAL/HEXADECIMAL/BINARY CONVERSION TABLE (unsigned values)

decimal	hexa	binary	decimal	hexa	binary	decimal	hexa	binary	decimal	hexa	binary
0	0	0	64	40	1000000	128	80	10000000	192	c0	11000000
1	1	1	65	41	1000001	129	81	10000001	193	c1	11000001
2	2	10	66	42	1000010	130	82	10000010	194	c2	11000010
3	3	11	67	43	1000011	131	83	10000011	195	c3	11000011
4	4	100	68	44	1000100	132	84	10000100	196	c4	11000100
5	5	101	69	45	1000101	133	85	10000101	197	c5	11000101
6	6	110	70	46	1000110	134	86	10000110	198	c6	11000110
7	7	111	71	47	1000111	135	87	10000111	199	c7	11000111
8	8	1000	72	48	1001000	136	88	10001000	200	c8	11001000
9	9	1001	73	49	1001001	137	89	10001001	201	c9	11001001
10	a	1010	74	4a	1001010	138	8a	10001010	202	ca	11001010
11	b	1011	75	4b	1001011	139	8b	10001011	203	cb	11001011
12	c	1100	76	4c	1001100	140	8c	10001100	204	cc	11001100
13	d	1101	77	4d	1001101	141	8d	10001101	205	cd	11001101
14	e	1110	78	4e	1001110	142	8e	10001110	206	ce	11001110
15	f	1111	79	4f	1001111	143	8f	10001111	207	cf	11001111
16	10	10000	80	50	1010000	144	90	10010000	208	d0	11010000
17	11	10001	81	51	1010001	145	91	10010001	209	d1	11010001
18	12	10010	82	52	1010010	146	92	10010010	210	d2	11010010
19	13	10011	83	53	1010011	147	93	10010011	211	d3	11010011
20	14	10100	84	54	1010100	148	94	10010100	212	d4	11010100
21	15	10101	85	55	1010101	149	95	10010101	213	d5	11010101
22	16	10110	86	56	1010110	150	96	10010110	214	d6	11010110
23	17	10111	87	57	1010111	151	97	10010111	215	d7	11010111
24	18	11000	88	58	1011000	152	98	10011000	216	d8	11011000
25	19	11001	89	59	1011001	153	99	10011001	217	d9	11011001
26	1a	11010	90	5a	1011010	154	9a	10011010	218	da	11011010
27	1b	11011	91	5b	1011011	155	9b	10011011	219	db	11011011
28	1c	11100	92	5c	1011100	156	9c	10011100	220	dc	11011100

29	1d	11101	93	5d	1011101	157	9d	10011101	221	dd	11011101
30	1e	11110	94	5e	1011110	158	9e	10011110	222	de	11011110
31	1f	11111	95	5f	1011111	159	9f	10011111	223	df	11011111
32	20	100000	96	60	1100000	160	a0	10100000	224	e0	11100000
33	21	100001	97	61	1100001	161	a1	10100001	225	e1	11100001
34	22	100010	98	62	1100010	162	a2	10100010	226	e2	11100010
35	23	100011	99	63	1100011	163	a3	10100011	227	e3	11100011
36	24	100100	100	64	1100100	164	a4	10100100	228	e4	11100100
37	25	100101	101	65	1100101	165	a5	10100101	229	e5	11100101
38	26	100110	102	66	1100110	166	a6	10100110	230	e6	11100110
39	27	100111	103	67	1100111	167	a7	10100111	231	e7	11100111
40	28	101000	104	68	1101000	168	a8	10101000	232	e8	11101000
41	29	101001	105	69	1101001	169	a9	10101001	233	e9	11101001
42	2a	101010	106	6a	1101010	170	aa	10101010	234	ea	11101010
43	2b	101011	107	6b	1101011	171	ab	10101011	235	eb	11101011
44	2c	101100	108	6c	1101100	172	ac	10101100	236	ec	11101100
45	2d	101101	109	6d	1101101	173	ad	10101101	237	ed	11101101
46	2e	101110	110	6e	1101110	174	ae	10101110	238	ee	11101110
47	2f	101111	111	6f	1101111	175	af	10101111	239	ef	11101111
48	30	110000	112	70	1110000	176	b0	10110000	240	f0	11110000
49	31	110001	113	71	1110001	177	b1	10110001	241	f1	11110001
50	32	110010	114	72	1110010	178	b2	10110010	242	f2	11110010
51	33	110011	115	73	1110011	179	b3	10110011	243	f3	11110011
52	34	110100	116	74	1110100	180	b4	10110100	244	f4	11110100
53	35	110101	117	75	1110101	181	b5	10110101	245	f5	11110101
54	36	110110	118	76	1110110	182	b6	10110110	246	f6	11110110
55	37	110111	119	77	1110111	183	b7	10110111	247	f7	11110111
56	38	111000	120	78	1111000	184	b8	10111000	248	f8	11111000
57	39	111001	121	79	1111001	185	b9	10111001	249	f9	11111001
58	3a	111010	122	7a	1111010	186	ba	10111010	250	fa	11111010
59	3b	111011	123	7b	1111011	187	bb	10111011	251	fb	11111011
60	3c	111100	124	7c	1111100	188	bc	10111100	252	fc	11111100
61	3d	111101	125	7d	1111101	189	bd	10111101	253	fd	11111101
62	3e	111110	126	7e	1111110	190	be	10111110	254	fe	11111110
63	3f	111111	127	7f	1111111	191	bf	10111111	255	ff	11111111