ACXsynth
MIDI₂CV

This is the usage manual for the MIDI2CV project offered by hexinverter.net. There are actually two user manuals depending on the firmware version you have. **This manual is for firmware version 5.7.3**

> **Because firmware 5.7.3 and 4.0 are so different, this completely new user manual has been created.**

WITH A LITTLE HELP FROM THE AWESOME MODULAR COMMUNITY

We would like to thank the original creator of this design in the 5U modular format: Alain at ACXSynth. He created the MIDI2CV originally and gave us permission to make a eurorack format DIY project out of it. A special thanks also goes out to Dmitry of **modularsynth.ru** for deciding to re-write the firmware and code in many enhancements versus the original feature set. Dmitry's v5.7.3 firmware has added so many features that the module needs this new manual!

> **Dmitry spent a lot of his free time coding the firmware enhancements for this module. He did it all for free without us ever asking him to work on it. If you like the work he did to enhance this project, consider donating to him to say thanks by following this link!**
>
> http://www.modularsynth.ru/en/diy/acxsynth_midi2cv_firmware/

FEATURES

- 8HP eurorack format 4ch polyphonic MIDI to CV/Gate conversion you can build yourself
- 12bit DACs with high quality Intersil opamps for great CV accuracy
- Monophonic mode offers full control of one voice (mod, pitch wheel, etc.) as well as sequencer control (start/stop, reset, sync)
- Split and duophonic modes accessible through advanced features
- Sync output emits MIDI clock pulses for driving sequencers with
- MIDI channel auto-learn at startup means no configuration if only basic functionality is desired
- A multitude of new features added in firmware v5.7.3 are easily programmed via keys on the keyboard for deeper programming and functionality (functions detailed later in this manual)

TECHNICAL SPECIFICATIONS

Width: 8HP | **Depth:** 55mm
Approximate current draw @ 12V: +80mA, -15mA
CV output range: 0 to 10V
Gate/Trig outputs: 0 to 5V

THE MIDI2CV USER INTERFACE

MODE SELECT SWITCH

MIDI2CV has three different main modes of operation. **The pitch wheel is active in all modes, but, the mod wheel only functions in Monophonic mode.**

> **Polyphonic 1 Channel (position = UP):** In this mode of operation it is possible to play up to 4 notes of polyphony with one channel of MIDI. The notes are assigned to outputs one after the other.
>
> **Polyphonic 4 Channel OR split/duo (position = CENTRE):** In Poly4 mode, Each CV/Gate output corresponds to a different MIDI channel. The MIDI channel auto-learned at startup is output 1, then, the following three outputs are increments of one channel up from that. Split and duophonic modes become one channel up from those 4 channels. Read more about split/duo modes in the ADVANCED FEATURES section.
>
> For example, if the first channel is 3, the next poly channels will be: 4, 5, 6. *Split mode will be ch7 and duophonic mode will be ch8!*
>
> **Monophonic (position = DOWN):** The module operates in full single note mode. While only one note of polyphony is achieved, this mode allows for full control of one synthesizer voice over MIDI: velocity, mod wheel and trigger. Additional run/stop/reset outputs allow for control of an analogue sequencer on top of the single full voice. The note-handling mode in Monophonic is legato. This means the GATE output only starts a new gate when all previous notes have been released.
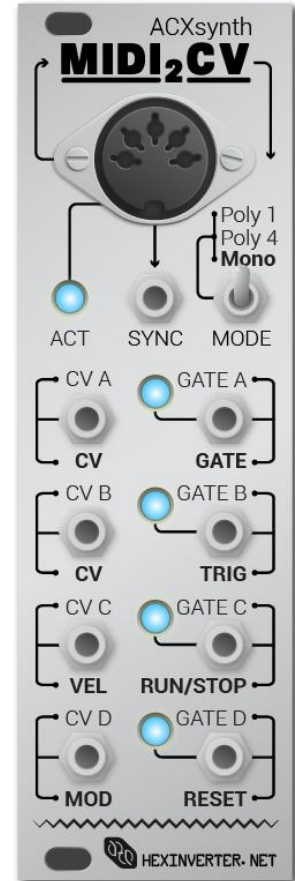
SYNC OUTPUT

While in Monophonic mode and the module receives MIDI clock from a source, this jack sends out modular level pulses you can use to clock sequencers and other gear with. The internal clock division can be set by accessing the ADVANCED FEATURES of the module and **defaults to 24ppqn**.

ACT INDICATOR

This LED gives various feedback to the user when MIDI clock is being received and also when programming ADVANCED FEATURES in the module settings.

VOICE CONTROL OUTPUTS

> **While in MONOPHONIC mode, the output jacks take on their roles below (and indicated in BOLD lettering on the panel). In the POLYPHONIC modes, however, the jacks simply become CV/Gate outputs for their respective voices.**

VEL

This jack outputs an analogue control voltage based on the velocity of the struck note. Use it to control filter cutoff, VCA volume, whatever you like!

MOD

This output produces an analogue control voltage based on the position of the mod wheel on the input MIDI keyboard/controller.

TRIG

This jack outputs a short trigger pulse every time a note is struck (behavior can be changed in ADVANCED FEATURES)

RUN/STOP

Use this digital output to start and stop a sequencer from a MIDI sync source. RUN = high, STOP = low.

RESET

Use this digital output to reset a sequencer from a MIDI sync source. This output is active high (RESET = high).

ADVANCED MIDI2CV FEATURES

> **MIDI2CV offers basic MIDI to CV/Gate functionality at startup. To set up a more advanced configuration for your module, you can program settings using your MIDI keyboard to access the ADVANCED FEATURES of MIDI2CV.**

AT STARTUP

When the module is powered up, MIDI2CV loads settings from memory, displays the firmware version number in binary on the GATE A to D LEDs, then waits to auto-learn the channel of the next MIDI note received.

THE ACT INDICATOR'S ROLE IN ADVANCED PROGRAMMING

The ACT indicator (LED) on the panel provides some feedback as to what is happening when the user modifies settings in MIDI2CV. When programming settings it is wise to refer to this table so you can confirm the module is doing what you want.

LED activity	Meaning
1 blink	Split point is set
2 fast blinks	Parameters are saved to memory
3 fast blinks	Module initialization is complete
4 fast blinks	Stack mode has been changed
5 fast blinks	MIDI receive error (too fast of data rate)
Continuous blinks	MIDI clock pulses
Lit constantly	CV2 learn mode is active

SPLIT/DUOPHONIC MODES

Part of the ADVANCED FEATURES added by Dmitry are two new modes of operation while the module is toggled into POLY4 mode: Split and Duophonic. These modes are turned on by default and accessible simply by sending MIDI data on the channels automatically assigned to these modes based on the MIDI auto-learn at startup (see the section about the MODE SELECT SWITCH above)

> In Split/Duo modes, there are two voices: A and B. The output jacks get reassigned to Voice A and Voice B such that:
>
> **CV1:** Voice A Pitch
> **CV2:** Voice B Pitch
> **CV3:** Voice A Velocity
> **CV4:** Voice B Velocity

Split Mode allows you to address two monophonic voices each from their own area of the keyboard. **The split point is set by the first note key received on the channel assigned to Split Mode.** Voice A always is the **lower** area of the split and Voice B is the **upper** split area.

Duophonic Mode is a lot like two voice polyphonic except you have velocity outputs and the voices are assigned as you press them instead of in round-robin fashion like the other polyphonic modes.

THE FUNCTION KEYS

In order to program your MIDI2CV easily, **some of the keys on the keyboard have been reserved for programming the ADVANCED FEATURES.** Do not press these keys during normal playing or you will be editing the settings! Since you're controlling analog instruments with MIDI2CV's CV output, you shouldn't have any problem tuning your VCOs to use the areas of the keyboard away from the FUNCTION KEYS during your performance.

> **The octave which contains the note C1 on the MIDI keyboard, is reserved for programming the ADVANCED FEATURES of MIDI2CV. However, every MIDI controller is different, so, get to know your keyboard/device by transposing up and down the keyboard and figuring out what YOUR keyboard identifies as the C1 note.**
>
> **The programming keys will cause the LEDs on the module to behave differently than normal performance behavior. This is the best way to find where your MIDI device assigns the C1 key to on the keyboard – look for different (constantly lit) LED activity when pressing the "C" key in different octaves.**

The FUNCTION KEYS access different settings depending on whether the module is in a MONOPHONIC or POLYPHONIC (1 or 4 channel) mode. To edit the settings with the keyboard, just press the key corresponding to the function you want to access. Depending on the setting you are editing, the key will have a different effect on the settings. We will talk about the MONO and POLY mode settings each in their own section...

MONOPHONIC MODE SETTINGS

(*Press the key for the function you want to edit*)

C:	**Enter CV2 Learn Mode**
C#:	**Change clock divider ODD (/1 or /3)**
D:	**Toggle retrigger in Legato (ON/OFF)**
D#:	**Change clock divider EVEN (/1, /2, /4 or /8)**
E:	**Toggle velocity curve (LIN or EXP)**
F:	(NOTHING)
F#:	**Toggle trigger via gate interrupt**
G:	**Assign aftertouch to CV2**
G#:	(NOTHING)
A:	(NOTHING)
A#:	**Lock function keys**
B:	**Save settings to memory**

C# D# F# G# A#

C D E F G A B
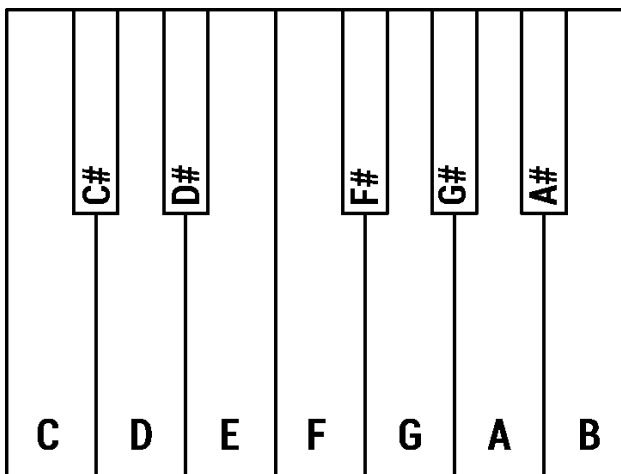
CV2 LEARN MODE

As you may have noticed, there are two CV outputs available on the panel while in MONOPHONIC mode. The top CV output (aka: CV1) always outputs the note CV from the incoming MIDI data, however, you can assign a custom MIDI CC number to the CV2 (lower) output and use a rotary encoder/slider on your MIDI controller to generate a voltage at the CV2 output. Just enter CV2 Learn Mode and then the next used encoder/slider will automatically map to the CV2 output. **If a note key is pressed, CV2 will output pitch CV. Channel aftertouch can be mapped to CV2 by pressing the G Function Key.**

PROGRAMMING THE CLOCK DIVIDER

The SYNC output defaults to 24 clock pulses every quarter note. This is the MIDI standard. That means there are 96 pulses every bar (24pulses x 4 quarter notes). This very fast clock signal is useful for plugging into other modules that perform division of clock signals. However, if you want to drive sequencers directly with MIDI2CV, you may want a custom clock division. The overall clock division is set by adjusting both the ODD and EVEN clock divider setting with their respective function keys (C# and D#).

Each press of the ODD or EVEN clock divider key steps once through the possible settings.
The default ODD and EVEN divisions are /1 at startup.
repeatedly pressing the ODD key cycles /3, /1, /3, /1…
repeatedly pressing the EVEN key cycles /2, /4, /8, /1, /2….

For example, a common sequencer clock speed might be one pulse every 16th note (1/16). This would be a good speed for driving a 16-step sequencer and programming some drums or a cool melody on. **To get this setting you would need to divide the 96 pulses per bar down to 16 pulses per bar**. We need to divide the 96 pulse clock by 6 to get this speed.

In order to program this into MIDI2CV, you would set the ODD clock divider to /3, then the EVEN clock divider to /2. Together, these divisions make an overall division of /6.

The formula for finding the overall clock division is ODD x EVEN. In the above example this would be 2x3 = 6.

POLYPHONIC MODE SETTINGS

(Press the key for the function you want to edit)

C:	4 voice mode
C#:	(NOTHING)
D:	8 voice mode (voices 1-4)
D#:	(NOTHING)
E:	8 voice mode (voices 5-8)
F:	Change polyphony limit
F#:	(NOTHING)
G:	Dedicated velocity unit
G#:	(NOTHING)
A:	(NOTHING)
A#:	(NOTHING)
B:	Save settings to memory
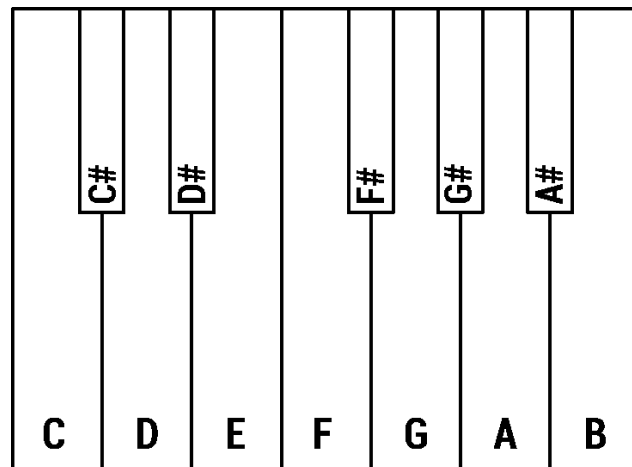
4 OR 8 VOICE MODE

MIDI2CV can operate in either 4 voice (default) or 8 voice polyphonic. **8 voice polyphony does of course require two MIDI2CV modules**. Use the C, D and E function keys to adjust the settings. To use 8 voice mode, assign one module to voices 1-4 and the other to voice 5-8 with the function keys. Connect the same MIDI signal to each module by way of a MIDI device (splitter cable, thru box, etc.)

SETTING THE POLYPHONY LIMIT

Press the F function key to toggle through the options for setting the voice limit in polyphonic mode. This is useful if you only want to patch up 2 or 3 voices of polyphony on your modular synthesizer, for example.

> **Each press of the F function key steps once through the order of polyphony limits:**
> **In 4 channel voice mode it goes 2, 3, 4, 2, 3, 4...**
> **In 8 channel voice mode it goes 2, 3, 4, 5, 6, 7, 8, 2...**

DEDICATED VELOCITY UNIT

Toggling the G Function Key will turn the module into a dedicated 4 voice velocity unit. If you connect two modules to the same MIDI signal in POLY1 mode, one unit will generate CV/Gate and the dedicated velocity unit will generate velocities for the 4 voices from its CV outputs. In this way you can build a very large, powerful MIDI to CV/Gate + velocity setup!

CALIBRATING MIDI2CV

In order to achieve accurate CV conversion, it is necessary to tune your MIDI2CV module once you are finished building it. There are 8 trim pots on the back of the module for calibration purposes. In order to accurately tune the module, you will need a decent multimeter. A $10 multimeter probably will not yield accurate results. Spend $50 to $100 on a decent quality meter and you will be very happy you did (not just for this project, but for others as well).

Tuning the module is quite easy. Just follow these steps:

1.) Plug the module into your system, turn it on and let it warm up for 30 minutes.
2.) Make sure the module is in MIDI learn mode by quickly resetting the power to your system. Don't press any keys on your MIDI controller yet or send any SYNC data to the module via MIDI.
3.) Plug your multimeter into each CV output and tune the OPAMP TUNING trim potentiometer for the CV output you are tuning so that the respective CV output reads as close to 0.000V as possible. If you cannot get to 0.000V, it's probably because you used CA3140AEZ opamps instead of CA3140EZ like was suggested to use in the Bill of Materials!
4.) Now, plug in your MIDI keyboard and tune the CV outputs for V/oct scaling. To do this, plug a CV output into a VCO in your system and either:

Read the frequency of the VCO and adjust for v/oct
OR
Read the voltage out of the CV output of the MIDI2CV module and adjust for v/oct.

I like the second method, myself. Don't forget – the screw is adjusting the SCALING that one octave spans. So think of it like a big rubber band you are stretching and compressing.

Whatever method you choose, you tune the CV output by stepping up and down octaves on your keyboard and verifying that the voltage or frequency has doubled each octave you step up.

With any luck you'll have a MIDI2CV up and running in no time!

MIDI IMPLEMENTATION CHART

For your reference, here is the MIDI Implementation Chart written by the firmware developer, Dmitry. This document contains very detailed information about the behavior of the module's function keys and other features, so, I recommend reading it if you need further detail on any of the explanations in this user manual!

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MIDI2CV firmware version 5.7.3 MIDI implementation chart and reference.
By Dmitry Shtatnov / modularsynth.ru


=======================
MODULE INITIALIZATION
=======================
Upon power up:

* Version number is displayed in Binary-coded decimal format (x.x). LSb is GATE A and MSb is GATE D.
* All controllers return to initial values
* All notes are wiped from voice memory
* All gates are turned off
* Parameters are loaded from the EEPROM (memor
* Next received Note-On message determines MIDI channel for Monophonic and 1-channel Polyphonic mode and also determines first
channel for Multichannel mode**.
** This parameter is AUTOMATIC and can not be stored to EEPROM.


=======================
ACT LED MEANING
=======================
1 blink:                  Split point is set
2 fast blinks:            Parameters are saved
3 fast blinks:            Module initialization is completed
4 fast blinks:            Stack mode is changed
5 fast blinks:            MIDI receive error (too high data rate)
Continuous blinks:  MIDI Clock
Constantly lit:           CV2 learn mode
Not lit:                  MIDI channel isn't set or no MIDI clock


=======================
CV2 LEARN MODE
=======================
When module enters CV2 Learn mode, first received MIDI controller (eg: encoder, slider, etc.) is assigned to CV2 output. If a key
is pressed instead, CV2 outputs a note pitch CV instead. Afterwards, the module returns to normal operation mode. This mode is
accessible only in Monophonic mode.


=======================
FUNCTION KEYS
=======================
Following key names are referenced strictly to MIDI specification and vary based on the MIDI keyboard you are using. MIDI Note-on
value for key C1 is 12. Some manufacturers (Roland, Steinberg for example) may use different key naming convention, but usually,
the Octave 1 should be 2 octaves below the lowest note on the 61-key keyboard and 1 octave below lowest musically usable key on
this device. There are two sets of parameters: for polyphonic mode and for monophonic mode. Each of these are accessable only in
particular mode. Function keys are completely inaccessable in multichannel mode.
There is one catch: velocity curve can be set in monophonic mode, but this parameter also affects the Duophonic and Split modes
built into POLY4 mode.

Mono mode:
------
        C1:          Enter CV2 Learn mode.
---### C#1:          Toggle software clock /3 divider rate between /1 and /3
        D1:          Toggle retrigger in legato.
---### D#1:          Select software clock /2 divider rate through /1, /2, /4 and /8
        E1:          Toggle velocity curve for monophonic, split and duophonic modes
------
        F1:          Reserved
---### F#1:          Toggle triggering via gate interrupt
        G1:          Immediately assign Aftertouch to CV2
---### G#1:          Reserved
        A1:          Reserved
---### A#1:          Lock function keys till Reset All Devices command or system reset
        B1:          Save current setup
------

Poly mode:
------
        C1:          Enable 4-voice polyphony
---### C#1:          Reserved
        D1:          Enable 8-voice polyphony, stack unit 1 (assign voices 1-4 to current module)
---### D#1:          Reserved
        E1:          Enable 8-voice polyphony, stack unit 2 (assign voices 5-8 to current module)
------
        F1:          Change polyphony limit*
---### F#1:          Reserved
        G1:          Toggle Velocity Unit Mode
---### G#1:          Reserved
        A1:          Reserved
---### A#1:          Reserved
        B1:          Save current setup
------

* (each keypress changes polyphony selection. Selection rotates in the following order: 2-3-4 (or 2-3-4-5-6-7-8 when 8-voice
stack is used)
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PARAMETERS (DEFAULT PARAMETER VALUES SHOWN IN PARENTHESIS)
========================
* CV2 function (note CV)
          This parameters determins behavior of the CV2 output. It can repeat
          the CV1 or correspond to some MIDI Controller or Channel Aftertouch.
          Value range:       [Note CV, MIDI CC, Aftertouch]
* CV2 CC (#00)
          This parameter is applicable only when CV2 function is set to MIDI CC.
          Also it only can be set the same time, via CV2 programming mode.
          Value range:       [0-127]
* Legato retrigger (Off)
          This parameter toggles the retriggering of connected Gate-driven
          modules when certain note is pressed or released in legato mode.
          Value range:       [Off, On]
* Triggering mode (Trigger)
          The retriggering can be performed either with GATE B/TRIG output
          (Trigger) or via interrupt of the GATE A signal (Gate).
          Value range:       [Trigger, Gate]
* Velocity Curve (Exponential)
          The velocity curve can be switched between normal (linear) and hard
          (exponential) curves. The linear one fits for very fine keyboards,
          the exponential is good for cheaper keyboards.
          Value range:       [Linear, Exponential]
* Polyphony limit (4 voices)
          This parameter limits the polyphony, which can be useful if the user is not
          using all 4/8 voices. If limit is set to more than 4 voices but
          maximum polyphony has been set back to 4, this parameter will be
          automatically reset to 4 until next adjustment. If limit was less than 5,
          then maximum polyphony has been set to 8, this parameter will be
          automatically reset to 8.
          If limit is set to 5, 6 or 7, disabled voices always will be on stack unit 2.
          Value range:       [2, 3, 4] / [2, 3, 4, 5, 6, 7, 8]
* Clock rate (1/24 quarter note (ie: 24ppqn))
          This parameter determines the rate of the MIDI Clock signal coming
          from the SYNC output.
          Value range:       [1/4, 1/8, 1/8 triplet, 1/16, 1/16 triplet, 1/32,
                             1/32 triplet, 1/64 triplet]
* Max polyphony (4 voices)
          This parameter defines overall module behavior on polyphonic mode.
          4-voice polyphony:
                 Only 4 voices can be played at the same time. Each keypress
                 beyond this limit reassigns most early voice to the new note.
          8-voice polyphony
                 8 voices are available with two units connected via MIDI splitter.
                 Each unit is assumed to receive identical data and process
                 all 8 voices in parallel. Stack unit 1 plays voices 1-4
                 and ignores voices 5-8. Stack unit 2 plays the remaining voices.
                 The unit which handles each range of notes can be set via Function Keys.

* Velocity unit (Disabled)
          MIDI Note On Message contains 1 status byte and two data bytes
          containing note number and velocity level.
          This parameter toggles part of the Note-on message which will be
          converted to CV in Polyphonic mode. Default option is key number,
          and second option is velocity.
          This can be used with two or more units connected via MIDI splitter
          when first unit/stack responds to notes and second - to velocity.
          Additional units in monophonic mode also may be used for controllers.

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OPERATION MODES
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Monophonic mode (Mono):
----------------
CV1 output corresponds to note pitch.
When no controller is assigned to CV2, it repeats the CV1 value.
CV3 output corresponds to Note On velocity.
CV4 output corresponds to Modulation Wheel.

Gating and triggering:
          Triggerring mode "Trigger":
          GATE A opens until every key and pedal are released.
          GATE B (Trigger) opens for 2ms and then closes.
          If Legato retrigger is enabled, GATE B opens
          when some key is pressed or released.

          Triggerring mode "Gate":
          GATE A stays closed for 2 ms, then opens until every key and pedal are released.
          If Legato retrigger is enabled, GATE A interrupts
          when some key is pressed or released.


If velocity = 0, Note off operation is performed
If note number > 12 and < 24 (C1-B1), various settings changes (see Function keys).

Polyphonic mode (Poly1):
-----------------------
Each newly pressed note is assigned to the next free voice, up to the maximum polyphony (each voice is comprised of a CV and Gate
output). When there are no free voices left, current note replaces the earliest assigned voice.

Multichannel mode (Poly4):
-------------------------
Each CV/Gate voice responds to the last pressed note on its own MIDI channel. MIDI channels are assigned by order, starting from
the channel determined during the Initialization.

Additional modes (Accessible through Poly4 extra channels)
-------------------------

Split mode:
-------------------------
First note received on this channel determines the split point between two available zones: Lower and Higher (Lower note of the
Higher zone). Lower zone is connected to voice A, Higher to Voice B. The split point is stored until main switch is toggled.**

** This parameter is AUTOMATIC and it can not be stored to EEPROM.
```

```
Intellectual Duophonic mode:
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Only two voices (A, B) are used in this mode, which helps to preserve each voice to particular hand. When two notes are held, any
additional note replaces the closer one. This make it possible to perform two parallel legato parts on the same keyboard along
the whole range.
Note: There can be a situation, when some notes in a part may seem to be disappearing, if one hand plays non-legato and second
plays legato. This is not a bug, but property of voice assign logic. The Split mode is recommended for parts, that are
uncomfortable to play in Intellectual Duophonic mode.

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LED MESSAGES
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The unit can blink SYNC LED several times to indicate a message.
Codes:
1 blink:  Split mode set
2 blinks: parameters save
3 blinks: full reset
5 blinks: MIDI overload


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RECOGNIZED MIDI MESSAGES
======================

Channel voice messages
----------------
The lowest pitching note is C2 (#24).

Note Off (8Nh, KKh, VVh)
--------
* Accepted modes: All
N         = channel number
KK        = note number
VV        = velocity

Note On (9nH, KKh, VVh)
--------
* Accepted modes: All

n         = channel number
KK        = note number
VV        = velocity

Control Change (BNh, CCh, VVh)
--------
* Accepted modes: Mono (Full), Poly1/Poly4 (partly)

N         = channel number
XX        = control number
VV        = control value

Recognized control numbers:
--------
01:       Modulation. (Mono only)
          CV4 output always corresponds to controller value

64:       Hold pedal.
          If pedal is pressed (vv>63), last note is held until pedal is released (vv<64)

120:      All Sounds Off.
          When this control is received, all gates are immediately closed

122:      Reset all controllers.
          When this control is received, pitch bend returns to center position and each controler CV out resets to 0

123:      All Notes Off
          When this control is received, all gates being not held by Hold Pedal are immediately closed.

Others:   Assignable (Mono only)
          Any MIDI control can be assigned to CV2.

Pitch Wheel (ENh, LLh, MMh)
--------
* Accepted modes: All

N         = channel number
LL        = least significant 7 bits
MM        = most significant 7 bits

Current pitch wheel value is added to the pitch present on CV1 output (and CV2 output when no controller is assigned to CV2).

Channel Real-time messages

Channel Aftertouch (DNh, VVh)
--------
* Accepted modes: Mono
N         = channel number
VV        = aftertouch value
Channel Aftertouch can be assigned to CV2 output.

System Real-time messages
----------------

MIDI Clock (F8h)
--------
* Accepted modes: All
Every clock pulse (24ppqn) is forwarded to SYNC output as a pulse with 80us duration. Also, LED flashes every quarter note.


Sequencer control
--------
* Accepted modes: Mono

Start (FAh)
When this message is received, Start/Stop output is set to high and Reset goes high for 2ms, then goes low again afterwards.

Continue (FBh)
When this message is received, Start/Stop output is set to high with no other changes
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```
Stop (FCh)
When this messages is received, Start/Stop output is set to low.


Reset all receivers (FFh)
---------
* Accepted modes: Mono, Poly1, Poly4
When this message is received, module starts initialization process
```