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AES Convention: 70 (October 1981) Paper Number: 1845 Authors: Smith, Dave; Wood, Chet Affiliation: Sequential Circuits, Inc., Publication Date: October 1, 1981 Subject: Electronic Music and Musical Instruments

San Jose, CA THE UNIVERSAL SYNTHESIZER INTERFACE

The Universal Synthesizer Interface is a specification designed to enable interconnecting synthesizers, sequencers and home computers with an industry-wide standard interface. This is a preliminary specification; comments, criticism, and alternative proposals are welcome. This interface specification has not been tested and would need to be retrofitted to any equipment presently in the field. The interface is basically specified as one-to-one between two units; ie, a synthesizer and a sequencer. Under certain circumstances, however, more units may be placed on a single line.

HISTORY

MIDI is a rare occasion where competing technologists come together to better legitimise their operations and to increase the success of their businesses. By burying rivalries, or their desire to jump on competitive advantages create an opportunity for global culture to experience a paradigm shift. No invention since music notation has had a greater impact on the history of music. MIDI is something that each and every one of us has experienced without thinking about. It is the very heart-beat of in-the-box music and the foundation of the dominion electronic instruments now reign over music.

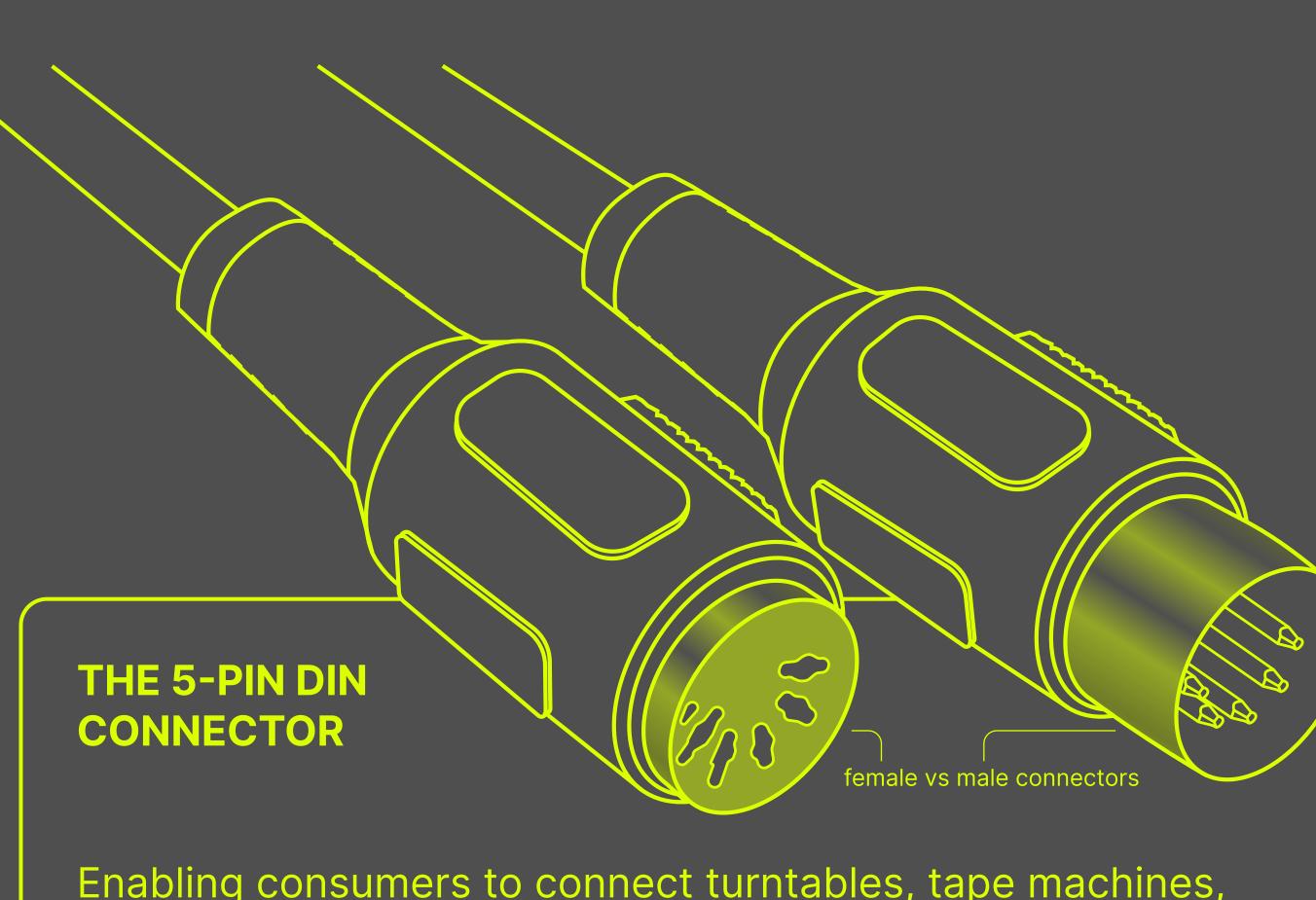
The excerpt above is a response to Roland founder Ikutaro Kakehashi's belief which he shared with fellow manufacturers Oberheim, Sequential Circuits, Yamaha, Korg and Kawai. That an inability to synchronise electronic musical devices made by different manufacturers was hindering the growth of the music-tech industry. The paper outlines a protocol defined by Dave Smith and Chet Wood based on different historical attempts to get kit to communicate. From the days of CV-gate, through a fledgling but (as Kakehashi lamented) massively complex system of Smith's devising settling on Roland's own DCB innovation as a basis.

The agreed protocol was dubbed Universal Musical Interface, or UMI (pronounced you-me) until Dave Smith aired his displeasure with a name so "corny" for something so serious. Whereby MIDI, musical instrument, digital interface was settled upon. Smith demonstrated MIDI for the first time at the 1983 NAMM convention. This ushered in the formation of the MMA (Midi Manufacturers Association) from which the protocol was agreed upon and MIDI 1.0 was born.

WHAT IS IT?

MIDI is a digital protocol that allows two or more musical devices to communicate between each other using a very simple 8-bit binary code. Fundamentally it is a protocol for a microprocessor to encode and another to decode. It contains no sonic information, but instead encodes a stream of events - such as note-on and note-off - which the receiving device must interpret. A MIDI stream has similarities to sheet music (where a musician interprets written notation) and to a paper pianoroll, which a mechanical player-piano interprets to recreate a musician's performance.

This blagsheet has two purposes. One as a reference document but also we believe that information is better retained when the concept and indeed context behind it is better understood. We hope it is a help to you in both respects.

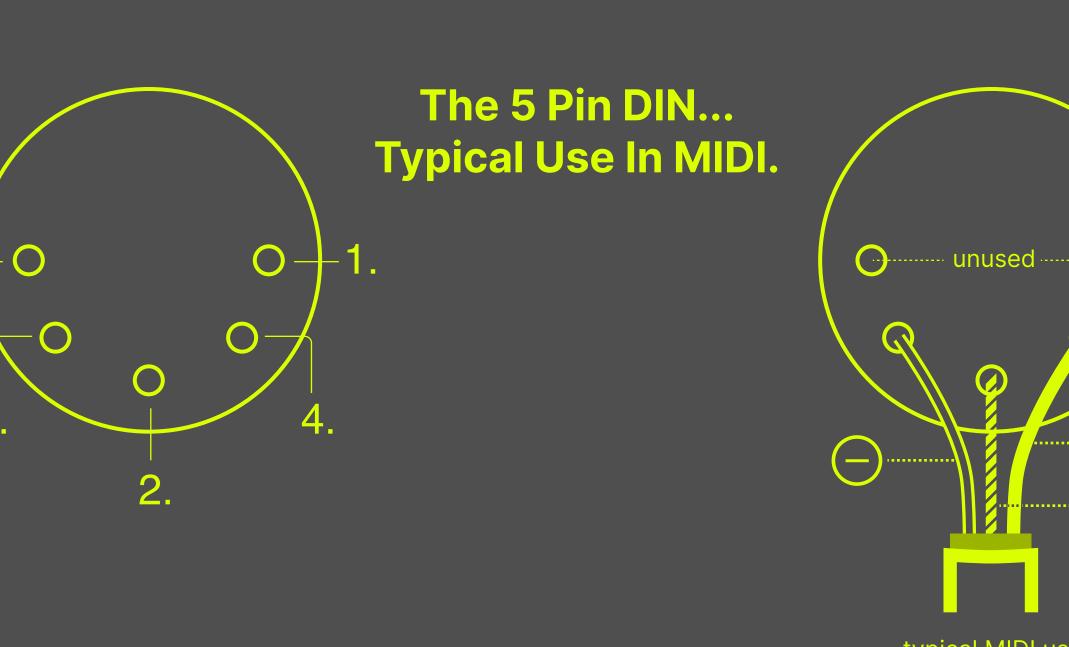


Enabling consumers to connect turntables, tape machines, tuners with amplifiers as part of "separates systems", the Din plug was the preferred choice of European electrical manufacturers in the mid-20th century. Initially starting as a 3 pin connector for mono sources, the 5 pin was adopted to accommodate stereophonic signals and was standardised by the **D**eutsches Institut für **N**ormung (which gives the cable its name) in the 1950s.

It's use outside Europe was less common and it was largely discarded in the 1980s in favour of the more universally adopted RCA cable.

When negotiations were taking place between Japanese and American corporations regarding what connectors to adopt for use in transmission of USI (or MIDI as it became known), it was felt that the connections afforded by TR and TRS cables wouldn't offer sufficient grounding of the electrical current and would result in interference.

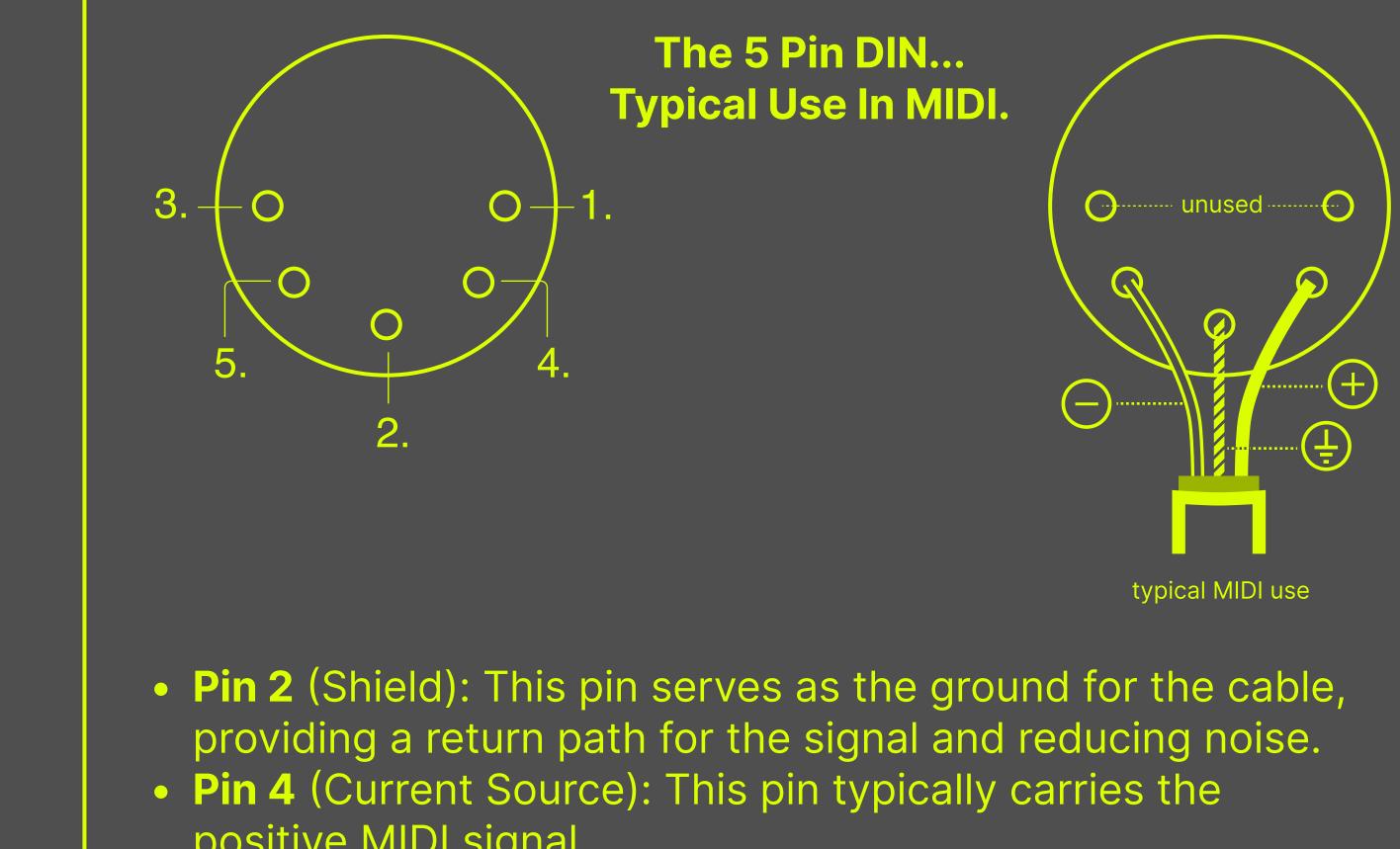
With warehouses full of tthese now-defunct cables it was suggested that the 5-pin DIN connector could be adopted; its shielding, grounding and availability made it an excellent candidate. It is because of this make-do solution that only 3 of the 5 pins is actually used when transmitting MIDI data.



positive MIDI signal. • Pin 5 (Current Sink): This pin typically carries the negative MIDI signal. • Pin 1 & Pin 3 (Unused): These pins are not used for standard MIDI communication, although they might be

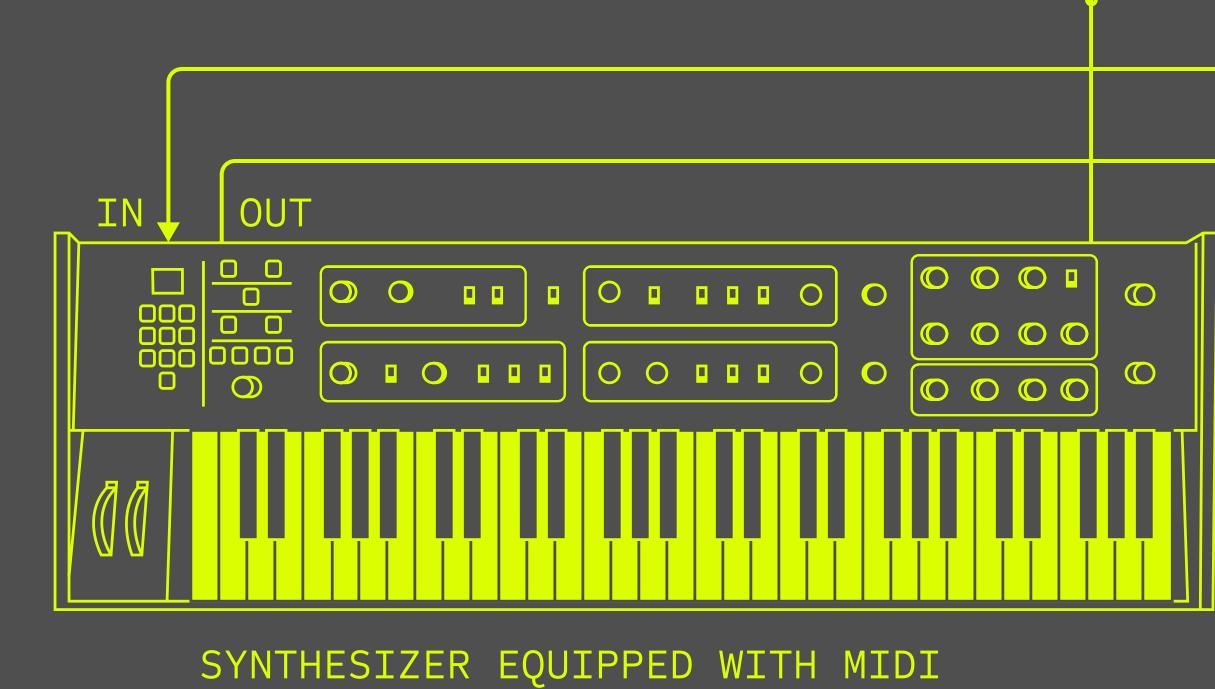
The MIDI cable is a unidirectional one, so outputs (OUT & THRU) always need to be connected to inputs (IN).

utilized by specific devices or applications.



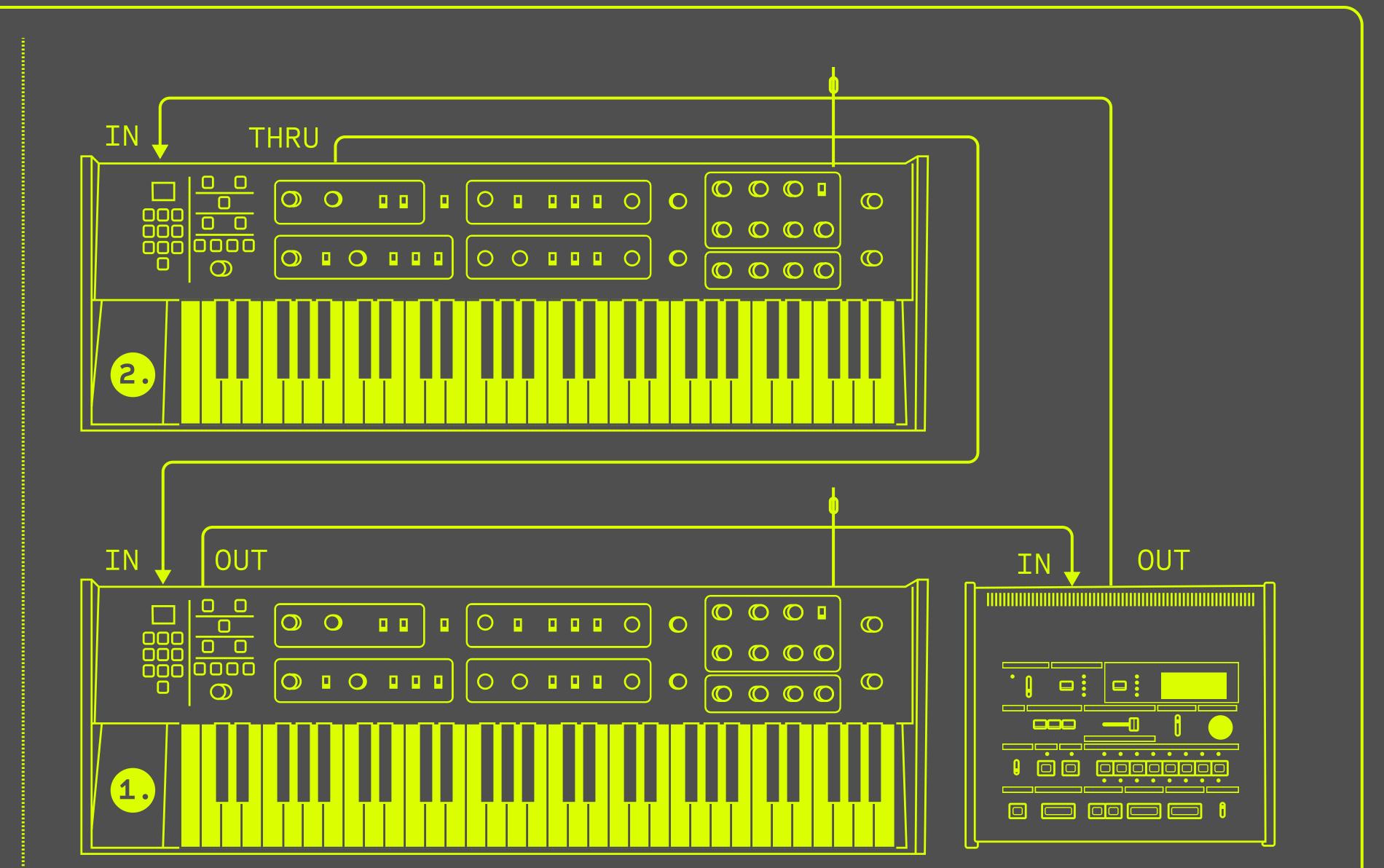
IN, OUT & THRU

MIDI allows several devices to be connected together and controlled by one another; each connection is made over a uni-directional cable. Different ports are required to communicate correctly. The OUT port sends MIDI information, IN receives it and the THRU port simply passes on all the MIDI data it receives so several devices can be "daisy-chained" on different channels.



SEQUENCER

In this example, a performance is converted into MIDI by the synthesiser; the MIDI data representing the performance is transmitted from the synthesiser's MIDI OUT port to the sequencer's MIDI IN port. Later, the sequencer transmits the MIDI data from its MIDI OUT port back to the synthesiser's MIDI IN port to replay the performance. The synthesiser outputs that sound to a mixer, amplifier or pair of cans independently of the sequencer.



As a single MIDI stream is not limited to a single device this example shows how you could enter MIDI data from a single keyboard but layer two different sound sources on top of each other on separate sequencer tracks. This achieved by setting each synthesizer to its own unique channel (1-16). In this instance the sequencer then plays out both channels via its MIDI OUT. The second (upper pictured) synthesiser plays the instructions contained in the MIDI stream on its own channel, ignoring any instructions for other channels; it passes on all the MIDI data it receives via its MIDI THRU port.

WHY IS MIDI SO "QUIRKY".

8 different types of MIDI messages, 16 Channels, 0-127 values counted in 128 steps. Why???

MIDI is a stream of asynchronous serial data traditionally sent through an analogue audio-grade electric cable. In order to understand what could be percelved as "quirks" of MIDI one must first understand how data is transmitted via copper wire.

Binary data is sent over a continuous flowing current by differences in voltage; 0v for 0 for example 5v for 1. Each fluctuation is referred to as a bit. And the rate that a cable can transmit these bits is called the "baud rate" (a baud rate of 31250 bps; bits per second was agreed by the MMA).

To communicate meaningful data, the individual bits are evaluated in a groups of 8, known as bytes. In the MIDI protocol, data units are 1 byte (8 bits) wide - so MIDI is as an 8-bit system In order to deliver all the necessary information without cramming the cable with too much data and creating digital lag that could impede a musical performance it was decided that each MIDI "message" was to be made up of 3 bytes, with byte 1 describing the type of message and bytes 2 and 3 giving two independent data values. All deliverable in 320 microseconds.

An actual depiction of a MIDI message as seen through an oscilloscope.

MIDI speification determines two basic types of message bytes: the status byte and the data byte. The Most Significant Bit (MSB - or, first bit of a byte!) of a status byte is always 1. The MSB of a data byte is always 0. Lets first establish how a **status** byte works...

The status byte is split into 'nibbles' (these tech-bros and their sense of humour). Take this byte:

MSB TYPE VALUE As the byte's first bit (its MSB) starts with a 1, this declares it's a status byte. This is then combined with the next 3 bits to give 8 possible outcomes numbered 1000-1111 in binary = 8-15 in decimal. The next nibble 10000010 has 16 possible outcomes 0000-1111 = 0-15. Giving us a total of 16.

1st NIBBLE 2nd NIBBLE With the 8 possible status types, the agreed MIDI protocol is that the first 7 are channel dependent

BINARY	DECIMAL	TYPE	2nd NIBBLE DATA VALUE
1000	8	Note Off	xxxx = channel number
1001	9	Note On	xxxx = channel number
1010	10	Polyphonic Aftertouch	xxxx = channel number
1011	11	Control Change	xxxx = channel number
1100	12	Program Change	xxxx = channel number
1101	13	Channel Aftertouch	xxxx = channel number

GENERAL MIDI (GM)
Developed by the MMA and launched in 1991 this was the second MIDI revolution that never really materialised. Simply put it is an agreed list of 128 instruments and sounds that could offer a universal collaborative opportunity by standardising program change events when sharing MIDI files. It never really caught on largely down to technology at the time not having the capabilities to create affordable sound-devices that could cater to the entire list without being sonically compromised.**

Keyboards 0=Acoustic Grand Piano 1=Bright Acoustic Piano 2=Electric Grand Piano 3=Honky-tonk Piano 4=Rhodes Piano 5=Chorused Piano 6=Harpsichord 7=Clavinet	Reeds 64=Soprano Sax 65=Alto Sax 66=Tenor Sax 67=Baritone Sax 68=Oboe 69=English Horn 70=Bassoon 71=Clarinet 72=Piccolo
Tuned Percussion 8=Celesta 9=Glockenspiel 10=Music Box 11=Vibraphone 12=Marimba 13=Xylophone 14=Tubular Bells 15=Dulcimer	Winds 73=Flute 74=Recorder 75=Pan Flute 76=Bottle Blow 77=Shakuhachi 78=Whistle 79=Ocarina
Organs 16=Hammond Organ 17=Percussive Organ	Synth Leads 80=Lead 1 (square) 81=Lead 2 (sawtooth)

19=Church Organ	83=Lead 4 (chiff lead)		
20=Reed Organ	84=Lead 5 (charang)		
21=Accordion	85=Lead 6 (voice)		
22=Harmonica	86=Lead 7 (fifths)		
23=Tango Accordion	87=Lead 8 (bass + lead)		
Guitars	Synth Pads		
24=Acoustic Guitar (nylon)	88=Pad 1 (new age)		
25=Acoustic Guitar (steel)	89=Pad 2 (warm)		
26=Electric Guitar (jazz)	90=Pad 3 (polysynth)		

82=Lead 3 (calliope lead)

18=Rock Organ

CC Control Change (CC) No°	Use Protocol	CHANGE KI Value(s)	EY Notes
MIDI CC 0	Bank Select (MSB)	0-127	Allows user to switch bank for patch selection. Program change used with Bank Select. MIDI can access 16,384 patches per MIDI channel.
MIDI CC 1	Modulation Wheel (MSB)	0-127	Generally this CC controls a vibrato effect (pitch, loudness, brighness). What is modulated is based on the patch. Oftentimes associated
MIDI CC 2	Breath Controller (MSB)	0-127	with aftertouch messages. It was originally intended for use with a breath MIDI controller in which blowing harder produced higher MIDI control values. It can be used for
MIDI CC 3	Undefined (MSB)	0-127	modulation as well.
MIDI CC 4	Foot Pedal (MSB)	0-127	Often used with aftertouch messages. It can send a continuous stream of values based on how the pedal is used.
MIDI CC 5	Portamento Time (MSB)	0-127	Controls portamento rate to slide between 2 notes played subsequently.
MIDI CC 6	Data Entry (MSB)	0-127	Controls Value for NRPN or RPN parameters.
MIDI CC 7	Volume (MSB)	0-127	Controls the volume of the channel. Controls the left and
MIDI CC 8	Balance (MSB)	0-127	right balance, generally for stereo patches. A value of 64 equals the center.
MIDI CC 9	Undefined (MSB)	0-127	
MIDI CC 10	Pan (MSB)	0-127	Controls the left and right balance, generally for mono patches. A value of 64 equals the center.
MIDI CC 11	Expression (MSB)	0-127	Expression is a percentage of volume (CC7).
MIDI CC 12	Effect Controller 1 (MSB)	0-127	Usually used to control a parameter of an effect within the synth or workstation.
MIDI CC 13	Effect Controller 2 (MSB)	0-127	Usually used to control a parameter of an effect within the synth or workstation.
MIDI CC 14	Undefined (MSB)	0-127	Synth of Workstation.
MIDI CC 15	Undefined (MSB)	0-127	
MIDI CC 16 – 19	General Purpose (MSB)	0-127	
MIDI CC 20 – 31 MIDI CC	Undefined (MSB) LSB Controller	0-127	
32 – 63	for 0-31	0-127	On/off switch that controls sustain pedal.
MIDI CC 64	Damper Pedal on/off	≤63 off, ≥64 on	Nearly every synth will react to CC 64. (See also Sostenuto CC 66)
MIDI CC 65	Portamento on/ off	≤63 off, ≥64 on	On/off switch
MIDI CC 66	Sostenuto Pedal on/off	≤63 off, ≥64 on	On/off switch – Like the Sustain controller (CC 64), However, it only holds notes that were "On" when the pedal was pressed. People use it to "hold" chords" and play melodies over the held chord.
MIDI CC 67	Soft Pedal on/ off	≤63 off, ≥64 on	On/off switch – Lowers the volume of notes played.
MIDI CC 68	Legato FootSwitch	≤63 off, ≥64 on	On/off switch – Turns Legato effect between 2 subsequent notes on or off.
MIDI CC 69	Hold 2	≤63 off, ≥64 on	Another way to "hold notes" (see MIDI CC 64 and MIDI CC 66). However notes fade out according to their release parameter rather than when the pedal is released.
MIDI CC 70	Sound Controller 1	0-127	Usually controls the way a sound is produced. Default = Sound Variation.
MIDI CC 71	Sound Controller 2	0-127	Allows shaping the Voltage Controlled Filter (VCF). Default = Resonance also (Timbre or Harmonics) Controls release time
MIDI CC 72	Sound Controller 3	0-127	of the Voltage controlled Amplifier (VCA). Default = Release Time.
MIDI CC 73	Sound Controller 4	0-127	Controls the "Attack' of a sound. The attack is the amount of time it takes for the sound to reach maximum amplitude.
MIDI CC 74	Sound Controller 5	0-127	Controls VCFs cutoff frequency of the filter. Generic – Some
MIDI CC 75	Sound Controller 6	0-127	manufacturers may use to further shave their sounds.
MIDI CC 76	Sound Controller 7	0-127	Generic – Some manufacturers may use to further shave their sounds.
MIDI CC 77	Sound Controller 8	0-127	Generic – Some manufacturers may use to further shave their sounds.
MIDI CC 78	Sound Controller 9	0-127	Generic – Some manufacturers may use to further shave their sounds.
MIDI CC 79	Sound Controller 10	0-127	Generic – Some manufacturers may use to further shave their sounds.
MIDI CC 80	General Purpose MIDI CC Controller	0-127	Decay Generic or on/ off switch ≤63 off, ≥64 on
MIDI CC 81	General Purpose MIDI	0-127	Hi-Pass Filter Frequency or Generic on/off switch
MIDI CC	CC Controller General Purpose MIDI	0-127	≤63 off, ≥64 on Generic on/off switch ≤63 off, ≥64 on
MIDI CC	CC Controller General Purpose MIDI	0-127	Generic on/off switch
MIDI CC	CC Controller Portamento CC	0-127	≤63 off, ≥64 on Controls the amount
84 MIDI CC 85 – 87	Control Undefined		of Portamento.
MIDI CC 88	High Resolution Velocity Prefix	0-127	Extends the range of possible velocity values
MIDI CC 89 & 90	Undefined		
MIDI CC 91	Effect 1 Depth	0-127	Usually controls reverb send amount
MIDI CC MIDI CC	Effect 2 Depth	0-127	Usually controls tremolo amount
MIDI CC 93 MIDI CC	Effect 3 Depth Fffect 4 Depth	0-127 0-127	Usually controls chorus amount Usually controls
94	Effect 4 Depth	0-127	detune amount Usually controls phaser amount
MIDI CC 95	Effect 5 Depth		The state of the s
MIDI CC 95 MIDI CC 96	(+1) Data Increment	N/A	Usually used to increment data for RPN and NRPN
95 MIDI CC	(+1) Data	N/A N/A	increment data for

MIDI NOTE NAMES	NAMES		*		
NUMBERS NUMBERS	MIDI No°	Piano Key No°	Note Name (Roland)	Note Name (Yamaha)	
	108	88	C8	C7	
	107	87	B7	B6	
	106	86	A#7/Bb7	A#6/Bb6	
	105	85	A7	A6	
	104	84	G#7/Ab7	G#6/Ab6	
	103	83	G7	G6	
	102	82	F#7/Gb7	F#6/Gb6	
	101	81	F7	F6	
	100	80	E7	E6	
	99	79 70	D#7/Eb7	D#6/Eb6	
	98	78 77	D7 C#7/Db7	D6 C#6/Db6	
	96	76	C7	C6	
	95	75	B6	B5	
	94	74	A#6/Bb6	A#5/Bb5	
	93	73	A6	A5	
	92	72	G#6/Ab6	G#5/Ab5	
	91	71	G6	G5	
	90	70	F#6/Gb6	F#5/Gb5	
	89	69	F6	F5	
	88	68	E6	E5	
	87	67	D#6/Eb6	D#5/Eb5	
	86	66	D6	D5	
	85	65	C#6/Db6	C#5/Db5	
	84	64 63	C6 B5	C5 B4	
	82	62	A#5/Bb5	A#4/Bb4	
	81	61	A5	A4	
	80	60	G#5/Ab5	G#4/Ab4	
	79	59	G5	G4	
	78	58	F#5/Gb5	F#4/Gb4	
	77	57	F5	F4	
	76	56	E5	E4	
	75	55	D#5/Eb5	D#4/Eb4	
	74	54	D5	D4	
	73	53	C#5/Db5	C#4/Db4	
	72	52	C5	C4	
	71 	51 50	B4 Λ#4/Rh4	A#2/Ph2	
	69	49	A#4/Bb4 A4 concert	A#3/Bb3 A3	
	68	48	G#4/Ab4	G#3/Ab3	
	67	47	G4	G3	
	66	46	F#4/Gb4	F#3/Gb3	
	65	45	F4	F3	
	64	44	E4	E3	
	63	43	D#4/Eb4	D#3/Eb3	
	62	42	D4	D3	
	61	41	C#4/Db4	C#3/Db3	
	60	40	C4 (middle C)	C3 (middle C)	
	59	39	B3	B2	
	58 	38	A#3/Bb3	A#2/Bb2	
	57 56	37 36	A3 G#3/Ab3	A2 G#2/Ab2	
	55	35	G#3/AD3 G3	G#Z/ADZ G2	
	54	34	F#3/Gb3	F#2/Gb2	
	53	33	F3	F2	
	52	32	E3	E2	
	51	31	D#3/Eb3	D#2/Eb2	
	50	30	D3	D2	
	49	29	C#3/Db3	C#2/Db2	
	48	28	C3	C2	
	47	27	B2	B1	
	46	26	A#2/Bb2	A#1/Bb1	
	45	25	A2	A1	
	44	24	G#2/Ab2	G#1/Ab1	
	43	23	G2	G1	