REAL WORLD INTERFACES

User Manual for the Devil Fish MIDI In and Out system, with Dynamic Bank/Channel Switching

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Please see the Devil Fish site for separate manuals for the V1.0.0 to V1.0.3 MIDI In systems and for the V1.0.4 and later MIDI In system.

The words AND and OR denote the logic functions *and* and *or*.

The pages which concern the **MIDI Out** functionality are:

This manual covers four installation options, and for any one Devil Fish, in the printed and bound version of the manual, some of these pages will either not be included or will be marked with a cross, since they are inapplicable to this particular Devil Fish. These page numbers are listed on page 2.

This Devil Fish has the following installed features. *Some pages are either not included or are marked with an* **X** *in the printed version manual because they do not refer to this installation.*

Installation	32 Bank Memory system	Two 3.5mm Audio or CV Input sockets, with detector circuits & XOR gates to potentially invert the output bits of 2 switches:		Pages which do not apply to this Devil Fish Those in pale blue italics are retained in the printed manual for reference, but are marked with an X.
		Two left-most Memory Address switches for Dynamic Bank and Channel Switching	Two switches for Dynamic Channel Switching	
3 **Dynamic Channel Switching via MIDI In Ch 15/16.**	No	na	No	68, 69, 70, 71, 72, 73, 74, 78 and 86.
4 **Dynamic Channel Switching via MIDI In Ch 15/16 AND two switches, each with an Audio/CV input socket, detector circuit and switch bit inverter circuit.**	No	na	Yes	67, 72, 73, 74, 77, 84 and 86.
5 **Dynamic Channel Switching via MIDI In Ch 15/16.** **The 32 Bank Memory system is not part of this.**	Yes	No	na	68, 69, 70, 71, 72, 73, 74, 78 and 86.
6 **As for 4 above, but the two switches are the left two of the 32 Bank Memory system. Their potentially inverted bits are used for both Dynamic (Memory) Bank Switching and Dynamic (MIDI In) Channel Switching.**	Yes	Yes	na	67, *68*, *69*, *70*, *71*, 77, 84 and 85.

One of the above table rows and some text on pages 59, 60 and 61 are highlighted in a manner specific to this particular Devil Fish.

Contents

0 - Features, quickstart and what to do with this User Manual

The ***Devil Fish*** modified TB-303 can be fitted with a MIDI In system or a MIDI In and Out system. Here are the most important things you need to know about the MIDI In and Out system. It does *not* support:

- Loading or dumping of Pattern or Track data from the battery backed up memory system.
- MIDI In control of any knob or button functions.
- MIDI Out transmission of the state of any knobs or buttons, except the Run/Stop button (in the absence of MIDI In Sync reception or an external source of DIN/Roland Sync) and in Int Seq and Ext CV modes, the Accent button, which affects the Velocity of MIDI Out notes.

MIDI In capabilities of the MIDI In (only) system

The following features are supported by both the Devil Fish MIDI In (only) system (for which there is a separate manual) and the MIDI In sub-system of the MIDI In and Out system:

- The Devil Fish receives MIDI if you plug a MIDI lead into the Sync Socket.
- It receives Note and Filter Frequency messages on Channel 1. (This is the default – the system can receive in any channel 1 to 16, with this and other user-controllable settings being stored in non-volatile memory.) Middle C is the C on the left of the TB-303 keyboard in Pattern Write mode when there is no transpose up or down. There are non-volatile user settings for transposition. (User Definable Parameters 1 and 2, as described on page 36.)

  Reception of Notes and Control Changes can be enabled and disabled with the procedure described on page 20. This state is stored in non-volatile memory so it is possible that the machine can be turned on with MIDI In reception of Notes and Control Changes disabled. This is indicated by a distinctive pattern of flashing by the Blue LED, as described on page 19. If the Devil Fish does not receive any Notes or Control Changes and you are unable to understand why, perhaps it is because you previously turned off this reception (not necessarily intentionally), and because this state is retained in non-volatile memory and so disables this reception when the machine is turned off and on.
- Note On events with velocities 1 to 63 will be played without Accent and those with velocities 64 to 127 will be played with Accent ON. Instructions for selecting different thresholds are on page 41.
- The ***Devil Fish*** modified TB-303 is a monophonic instrument. If two or more notes are active from MIDI In, it will play the pitch of the most recent of these notes. As this and other notes are turned off, the pitch revert to the most recently turned on of the currently playing notes, for up to a maximum of 8 notes being on at once. (There is an 8 note deep Note Stack for the MIDI In sub-system of the MIDI In and Out system, while the MIDI In only system, without MIDI Out, uses a 10 note deep Note Stack.)

- If one or more MIDI In notes is still active when a new one is played, the new note will, by default, be played with Slide ON. This can be disabled by setting the value of User Definable Parameter 4: *MIDI In Slide on Tied Notes* (see page 40) to 0.

- By default, Control Change 1 messages (Mod Wheel) control the Filter Frequency, with an approximately 5 octave range. This source of control adds to, rather than overrides, all the other internal signals and the Cutoff pot, which also affect the Filter Frequency. (This Controller number can be altered from the default of 1 with User Definable Parameter 3, as described on page 38.)

- A Controller number 1 to 19 can be selected (User Definable Parameter 5, described on page 40) so that Control Changes values can turn independently turn on Slide and Sustain (Gate On in the absence of a note being played).

- The machine receives MIDI Sync messages: Start, Continue, Stop and Timing Clock. If your master sequencer or drum machine outputs these, (most will do so by default) then when you drive the ***Devil Fish*** from the master device's MIDI Out, the TB-303's Internal sequencer will start, run in time and stop in sync with the master device. When the master device is not playing a song, it will typically output MIDI Timing Clock messages at whatever tempo it is set to run at. These will enable the TB-303's Internal Sequencer to flash its LEDs in whatever mode it is in: Pattern or Track Write or Play.

Additional MIDI In facilities which are part of the MIDI In and Out system

The MIDI In subsection of the MIDI In and Out system has these altered and additional facilities:

- The firmware's **Note Stack** for storing previously played notes, which will be played if they are still on when the currently played note is turned off, holds 8 notes, rather than the 10 notes of the MIDI In (only) system . This means that 8 notes can be played and held on in succession, and the last one played will drive the Synthesizer DAC (which creates the voltage for the VCO, and so controls the VCO's pitch) and MIDI Out. When that note is turned off, the most recently played note, if it is still on, with will control DAC voltage of the Synthesizer, but the Accent drive to the Synthesizer will remain that of the first note which caused Gate to be turned on, as is the case with the MIDI In (only) system.

  There are 16 **Note Stacks** – one for each MIDI In Channel – to support the Dynamic Channel Switching (DBS) system. This system works with the top note of the Note Stacks of four adjacent MIDI In channels, such as those of channels 1, 2, 3 and 4, or of 8, 9, 10 and 11, or 16, 1, 2 and 3. The top note of each channel's Note Stack is the note the Devil Fish would be playing if DBS was not enabled and the (Base) MIDI In Channel (Parameter 0, see page 35) was set to this channel.

- The Dynamic Bank/Channel Switching (DBCS) System has a number of facilities concerning MIDI In. These are an advanced topic and are explained in Section 7 on pages 58 to 105.

  These facilities enable switching MIDI In Note reception between four contiguous MIDI In channels – such as 4, 5, 6 and 7 – in response to MIDI In messages on Channel 15 or 16 and/or (with appropriate switches and input sockets for

Installations 4 or 6) to the positions of two toggle-switches and the detection of two Audio or CV signals. The reception of Control Changes, such as for Filter Frequency, is unaffected by this switching. These messages are always received on the Base MIDI In Channel, which is channel 4 in this example.

These facilities are only enabled after turning the machine on with a special procedure involving the **BACK** button – as described on page 58 – which must be repeated every time the machine is turned on and these facilities are to be used.

Facilities of the MIDI Out sub-system in the MIDI In and Out system

- The machine sends MIDI Note On events on the same channel it receives on (by default, channel 1) in one of three modes, which are automatically selected:

    - **Int Seq mode**. Note pitches result from the Internal Sequencer when it is *playing* a pattern, in Pattern Write, Pattern Play, Track Write or Track Play modes. This includes the potentially complex set of notes which result from Dynamic Bank Switching causing the Internal Sequencer to play notes from different memory banks from one moment to the next.

    - **Ext CV mode**. This is a CV-to-MIDI mode of operation. Note pitches result from measuring the voltage of an externally applied Pitch CV, plugged into the CV In socket – or, if no lead is plugged into this socket, from the notes generated by the Internal Sequencer playing notes during Pattern Write mode, when it is *not playing* the pattern. This is when the user is entering and altering pitch, timing, Accent and Slide information. This enables the Devil Fish to function as a **CV to MIDI converter**.

    - **MIDI In Follow mode**. When the MIDI In system has reception of Notes and Control Changes ON (hold **TAP** and press and release **BACK**), the MIDI Out system replicates via MIDI Out Note On and Off messages the notes the MIDI In system is playing on the Devil Fish, including the notes which result from Dynamic Channel Switching.

Please see Section 7 below (pages 58 to 105) for explanations of MIDI Out functionality regarding:

- Note On and Off events resulting from the Gate signals of the Internal Sequencer, of the Gate In socket and due to more than +4 volts being applied to the Slide In socket.

- Slide, including from the Slide In socket.

- Accent due to the Internal Sequencer, the Accent In socket and the Accent button.

- Dynamic control of velocity values for non-Accented and Accented notes via Control Changes 20 and 21 being sent to MIDI In.

- MIDI Out messages for Filter Frequency which follow those received on MIDI In.

The exact behavior of the MIDI Out sub-system takes a lot of explaining, because there are so many combinations of circumstances which can occur. For a fuller description of this, please see the two tables on pages 46 and 47, which summarise most of the distinctions between the three MIDI Out Note modes.

- By default, the Devil Fish sends MIDI Sync messages to MIDI Out, in response to whichever of the following sources are driving the Internal Sequencer. Please see page 41 for further explanation, including how to disable the reception and/or transmission of MIDI Sync.

    - The internal Tempo system: the Tempo knob and the Run/Stop button and its flip-flop.

    - DIN/Roland Sync from an external source, via a Sync cable plugged into the Sync Socket.

    - MIDI Sync being received via a MIDI cable plugged into the Sync socket. (This includes MIDI In being received via the special optional Devil Fish Sync Lead, which enables the MIDI In sub-system's decoding of MIDI In Sync to drive not just the Devil Fish's Internal Sequencer, but one, two or three DIN/Roland Sync slave devices which are connected to the cable.)

Quickstart and what to do with this User Manual

Initially, please read, or at least scan, Sections 0 and 1. This will give you an idea of what the MIDI In and Out system is capable of. Within this, there are two complex sub-systems which cannot be fully understood except by extensive further reading: the MIDI Out sub-system and the Dynamic Bank/Channel Switching sub-system.

To use MIDI In initially, you can send the Devil Fish (by plugging the MIDI lead into the Sync Socket) MIDI Sync (Start, Tempo Clock and Stop messages) and the Devil Fish's Internal Sequencer will respond to this by playing patterns or tracks. You can send the Devil Fish both Note events and Control Change 1 (Mod Wheel) messages on Channel 1 and the Devil Fish will (with the default Base MIDI In Channel of 1) play these notes and respond to the Control Changes with changes to Filter Frequency.

When the Devil Fish MIDI In sub-system responds to the first Note event, it takes control of the TB-303's DAC (Digital to Analog Converter) which controls the pitch of the Synthesizer's VCO, so this is no longer controlled by the Internal Sequencer. The MIDI In sub-system also drives the Gate signal to the Synthesizer. It is possible for the MIDI In system to be doing this, and so playing notes on the Synthesizer, while the Internal Sequencer is running in time with the MIDI Sync bytes which are also being received. In these circumstances, the pitches produced by the Internal Sequencer will have no effect, since it no longer controls the DAC. The Synthesizer Gate signal can be turned on by either or both of the MIDI In sub-system or the Internal Sequencer. Assuming you want the Synthesizer to play only the notes being received from MIDI In, and your MIDI In source includes MIDI Sync bytes (Start/Continue, Clock and Stop), then it is best to have the Internal sequencer playing a pattern without any notes. (Alternatively, the Devil Fish can be configured not to receive MIDI In Sync, but at this early stage of using the machine without wanting to read much of the manual, it is easiest to select a blank pattern.)

See page 20 for how to enable and disable the reception of MIDI In Note and Control Change messages by pressing the **TAP** and **BACK** buttons. The setting for not receiving these is retained when the Devil Fish is turned off and on again, so if you later find that it does not receive these messages when you want it to, perhaps the cause is that you previously turned this off. Another possible explanation would be that the Base MIDI In Channel is different from the channel on which the external device is sending the Notes and Control Changes you want to play. See page 35 for how to change the Base MIDI In Channel.

To use MIDI Out initially, I suggest you just plug the MIDI Out into a slave device (or into several slaves via a MIDI Thru box or via an external sequencer) and concentrate on music. The MIDI Out system replicates as much as possible the activity of the Devil Fish Synthesizer, whether it is being driven by the Internal Sequencer, from external CV and Gate or from MIDI In. The default MIDI Out channel is the same as the Base MIDI In Channel, which defaults to 1.

There is only one User Definable Parameter which affects the MIDI Out system: Parameter 8 (MIDI Out Channel) – as explained on page 44. The only reason for changing this would be if you want the MIDI Out channel to be different from the Base MIDI In Channel. While the MIDI Out system is quite complex, it is intended to do what you want in all the circumstances, without any further configuration parameters.

If you want **to change anything concerning MIDI In or MIDI Out**, then you will need to read Section 2 (The "Front Panel"), Section 3 (User Definable Parameters 0 to 8) and at least some of Sections 4 (Interaction between the MIDI In system and the TB-303 / Devil Fish) and 5 (Details of MIDI In features and User Definable parameters 0 to 8).

If you want to **understand the MIDI Out system in detail**, then you have quite a lot of reading to do! Section 6 (MIDI Out further explanation) contains detailed descriptions of the three modes of MIDI Out operation. For simplicity, section 6 assumes a single MIDI In Channel – that is, no Dynamic Channel Switching.

If you want to **use the Dynamic Bank/Channel Switching (DBCS) system** in any way, then you should first become highly familiar with all the MIDI In facilities and be comfortable using the Devil Fish in general. The DBCS system cannot be understood without extensive reading of Section 7. Furthermore, the MIDI In facilities of DBCS will not operate unless the machine is turned on with a special pattern of button activity, which is explained at the start of that section. This is because the DBCS system's behavior is complex and likely to be confusing if it was activated when you were not expecting it.

Within your complete musical set-up, the Devil Fish with MIDI In and Out involves a variety of interacting sub-systems:

1. The basic TB-303, with its internal Tempo Clock system, Sync Socket selection of this, or an external source of DIN/Roland Sync (AKA *Sync-24*), Internal Sequencer and Synthesizer – where the Synthesizer has been extensively modified to be that of a Devil Fish.

2. The Devil Fish's new controls, new CV, Gate etc. inputs, the new Audio Inputs (Audio In to Filter and Audio In to Frequency Modulate the Filter) and Audio Out (Audio Out from Filter).

3. The optional 32 Bank Memory system.

4. The Devil Fish MIDI In sub-system, as it operates without DBCS.

5. The Devil Fish MIDI Out sub-system.

6. The DBCS system, which is primarily an elaboration of the MIDI In system, but which can also receive MIDI events to drive two bits to the default contacts of the two 3.5mm sockets of the DBCS Detector circuits, toggle-switches and XOR gate address bit inversion circuits (though there is an option for Dynamic Channel Switching without these).

   In the case where the Devil Fish has the 32 Bank Memory System and the full DBCS installation, the signals sent to the default inputs of the two Audio or CV Input sockets (if nothing is plugged into these sockets) will cause MIDI In messages received on Channel 15 or 16 by the DBCS system to alter the inversion of two 32 Bank Memory address bits, so affecting the patterns played by the Internal Sequencer.

   When you use one or both of these Audio or CV input sockets, then other signals from your studio can dynamically alter the current Memory bank (Dynamic

Channel Switching – affecting the Internal Sequencer's pattern playback) or the current Effective MIDI In Channel (Dynamic Channel Switching), so switching MIDI In reception between up to four contiguous MIDI Channels. The intention of Dynamic Channel Switching is that the Devil Fish will be sent two, three or four separate patterns of notes (or any notes at all, not necessarily repeating patterns) via MIDI In, with MIDI channel 15 or 16 Note and/or Control Change messages, toggle-switch manipulation and/or external Audio or CV signals dynamically controlling which of these four channels notes are received on.

The MIDI In system is reasonably complex, and some effort is required to understand how to alter its User Definable Parameters. The MIDI Out system is highly complex in detail, but apart from altering User Definable Parameter 8 to select a different MIDI Out Channel than the Base MIDI In Channel, there's nothing to adjust and it should do what you want musically without the need for understanding it fully.

The DBCS (Dynamic Bank/Channel Switching) system is highly complex and can only be used after it and the rest of the Devil Fish sub-systems are understood reasonably well.

Be sure to annotate this manual and add Post-It notes to identify pages of interest for quick reference. I can't imagine how this material could be useful in a purely electronic form, such as by reading the PDF on screen. The Devil Fish is provided with A4 comb-bound versions of all the relevant User Manuals. *There will not be a test of your comprehension* – I can't remember all these details.

1 - Overall description

This MIDI In and Out system is an additional modification I can install in a ***Devil Fish*** modified TB-303. It is not available as kit for someone else to install. I usually install it as part of the ***Devil Fish*** mods, where I have provision for it on the Version 4.0 and later printed circuits. It is also possible for me to install this system on Version 2.x or 3.x ***Devil Fish*** modified TB-303s – by replacing the two original Devil Fish circuit boards with two new ones.

Pages 5, 7 and 12 to 44 this manual primarily concern the ordinary facilities (not to the Dynamic Bank/Channel Switching facilities) of the *MIDI In system* or *sub-system*. Some parts of these pages concern the ***MIDI Out system*** too, and are **highlighted in Green**. Pages 44 to 56 concern only the ***MIDI Out system***. The *MIDI Out system* is implemented by the same microcontroller chip as the MIDI In sub-system, but is conceptually and functionally largely independent of this.

There is no MIDI Thru, but the MIDI Sync timing messages received via MIDI In are (by default, this can be disabled with User Definable Parameter 8) replicated on MIDI Out. The MIDI Out system has three modes of operation: *Internal Sequencer Mode*, *External CV Mode* and *MIDI In Follow Mode*. In all three modes, the system reproduces via MIDI Out the Filter Frequency Control Changes which are received via MIDI In. In *MIDI In Follow Mode*, the notes – with Accent and Slide – which are received via MIDI In are replicated to MIDI Out. This includes the way the Dynamic Channel Switching system can switch between notes on four adjacent MIDI In channels to play a set of notes which does not exist on any one of these: the MIDI Out system causes slave devices to play that the notes produced by the Dynamic Channel Switching system.

The existing DIN socket is used for MIDI In – but it can still be used for Sync when not used for MIDI In. The MIDI In system uses the TB-303's internal Digital to Analogue Converter (DAC), so the control voltages and therefore oscillator pitches for each semitone in the are identical to those produced by the internal sequencer. The Internal Sequencer has a five octave range from C2 to C6 (MIDI note numbers 48 to 96). Without transposition, the MIDI In sub-system receives MIDI note numbers 45 to 100 (as shown in the table on page 37), which goes three semitones below and four semitones above the range of the Internal Sequencer.

MIDI Out is via a short 5 pin DIN socket adaptor lead which plugs into a 3.5mm stereo socket located on the rear panel of the Devil Fish, between the Sync socket and the Tuning knob.

User Definable Parameters are settings which are altered via the **BACK** and **TAP** buttons, with status indicated by a new Blue LED, which shines through the same 'e' in the Devil Fish logo as the Red Gate LED. The values of the user-definable parameters are stored in non-volatile memory within the MIDI In and Out system's microcontroller chip. This non-volatile memory does not depend on the TB-303's C-cell batteries or on the Devil Fish's lithium battery, which ensures the TB-303's standard memory system, or the 32 Bank Memory system, retains its data at all times. So these settings remain after the machine has been turned off and on.

The settings stored in non-volatile memory are:

1 - Whether or not the Devil Fish is able to receive MIDI In Note and Control Change messages (see page 20).

Changes to this have effect immediately and are also stored immediately into non-volatile memory. This is not one of the User Defined Parameters.

2 - The twelve User Defined Parameters numbered 0 to 11. For brevity, these are sometimes referred to simply as “Parameters”, such as in “Parameter 7”.

Changes to the values of these have immediate effect on the Devil Fish, but are only stored into non-volatile memory by a special pattern of pressing the **BACK** and **TAP** buttons. If you have altered one of these values and not yet pressed these buttons to store the new value to non-volatile memory, and you do not want to do this, turn the Devil Fish off and on again.

The MIDI In system receives Note Commands and some Control Change Commands on a single, user-definable, MIDI channel, which is Parameter 0, the Base MIDI In Channel. (The Dynamic Bank / Channel Switching system extends the reception of Note Commands on one of four channels, being the Base MIDI In Channel plus 0, 1, 2 or 3.) It also receives MIDI Sync: Start, Clock, Stop and Continue. The system ignores all other MIDI messages. Brief descriptions of the MIDI In system’s and MIDI Out system’s capabilities are as follows. Tables listing all the received and transmitted MIDI messages can be found in Section 11, starting at page 110.

MIDI In Notes

The full 4 octave range of the TB-303's internal sequencer is received – with the C on the left of the TB-303 keyboard in Pattern Write mode (2 Volts) corresponding to MIDI Middle C (note number 60). In addition, 3 additional semitones below and above this range are also received, although the accuracy of the TB-303's VCO may not be ideal at these voltages. The lowest MIDI note number received is 45 (A1 = 0.75 volts = 3 semitones below the internal sequencer's lowest C) and the highest is 100 (E6 = 5.333 volts = 4 semitones above the internal sequencer's highest C when the pattern is transposed upwards by 12 semitones). The table on page 37 lists these note numbers and voltages.

A transposition of +/- 24 semitones can be applied to the MIDI note numbers before the notes are played within the above range, with Parameters 1 and 2 (page 36). There is no pitch bend facility.

MIDI In Accent

Accent is turned on according to the note's Velocity being above a threshold. The threshold is one of four preset values, according to the setting of Parameter 6 (page 41). The default threshold, which the received note must equal or exceed in order to turn on Accent, is 65. This is one above the velocity value of 64 which is usually sent by MIDI keyboards which are not velocity sensitive.

MIDI In Slide

Slide can be turned on for “tied notes” – where one note starts before the last one is released.

Slide can also be turned on via MIDI Control Change (AKA “MIDI Controller”) 65

(Portamento) or by a user definable Control Change number which also drives Sustain (Gate). This facility is off by default, but can be turned on and made to respond to Control Change numbers 1 to 19, by setting Parameter 5 (page 40) accordingly.

Sliding – slewing of the DAC voltage slowly from the previous pitch to the new pitch – is a separate function from keeping the Gate on between what would otherwise be two separate Gate pulses for two separate notes.

MIDI In Gate (Sustain)

In addition to normal Gate operation from the received MIDI notes, Controller 64 (Sustain or Hold) can be used to independently turn on the TB-303's Synthesizer Gate.

Another user definable MIDI Controller (the same as just mentioned for MIDI In Slide) can also turn on Gate and/or Slide. This facility is off by default, but can be turned on and made to respond to Control Change numbers 1 to 19, by setting Parameter 5 (page 40) accordingly.

MIDI In Filter Frequency

A user definable Controller can be used to drive the Filter Frequency, over a range of about 5 octaves, in a similar manner to the Devil Fish Filter CV In socket. This MIDI In control of Filter Frequency adds to, rather than replaces or overrides, the control exerted by the Filter CV In socket and all the other internal signals which affect Filter Frequency. This Controller Number defaults to 1 (Mod Wheel) but can be disabled, or changed to any number 1 to 10, by Parameter 3 (page 38).

MIDI In Sync

The system receives MIDI Sync (Start, Continue, Clock and Stop) to drive the TB-303's internal sequencer. With a suitable lead, such as the Sync Lead (see sync-lead/ page on the Devil Fish website) the MIDI In system can also produce DIN Sync for external devices in response to these received Sync messages. Please see page 41 for a full explanation if MIDI Sync reception and transmission.

MIDI Out Notes

Here are brief descriptions of the three modes of operation, each of which is automatically selected according to the circumstances:

- **Int Seq mode - when the Internal Sequencer is playing a pattern and MIDI In notes are not being received**. MIDI Out notes with note numbers 48 to 96 are generated in response to notes played by the TB-303's Internal Sequencer when it is playing a pattern (Pattern Write or Pattern Play modes) or playing a pattern as part of a track (Track Write or Track Play modes). This is true even when there is an external CV plugged into the CV In socket, which controls the Devil Fish's synthesizer.

- **Ext CV mode - when the Internal Sequencer is *not* playing a pattern and MIDI In notes are not being received**. MIDI Out notes are typically generated in response to an external pitch Control Voltage which is plugged into the Devil Fish's 3.5mm CV In socket. The input range is 1.0 volts to 5.0 volts, which is the normal range of operation of the TB-303 and its internal sequencer. This generates MIDI notes with note numbers 48 to 96. The exception to this typical usage is that Ext CV mode is also used when the Internal Sequencer is not playing a pattern, but is in Pattern Write Step mode. In this case, in the absence of a CV being input to the CV In socket, the MIDI Out notes will result from the CV generated in the DAC as it is driven by the Internal Sequencer as it plays individual notes as part of the Step mode writing and editing process.

- **MIDI In Follow mode - when MIDI In notes are being received**. MIDI Out notes result from notes received by the MIDI In system, including according to the complex interpretation of Notes on four MIDI In channels with the Dynamic Channel Switching system. This generates MIDI notes with note numbers 45 to 100.

In all three modes, MIDI In received Control Change values for the Controller number which is selected for Filter Frequency will be replicated on MIDI Out, with the same Controller number, on the MIDI Out channel. This is described more fully in the subsection below entitled "MIDI Out Control Changes for Filter Frequency" (page 16).

In both **Int Seq** and **Ext CV modes**:

- The MIDI Out notes result from the Gate signal which controls the Devil Fish synthesizer, which is an OR of:
  - The Gate signal created by the Internal Sequencer. (Int Seq mode: due to the Internal Sequencer playing notes as it plays a pattern. Ext CV mode: due the Internal Sequencer playing notes as part of Pattern Write > Step writing and editing of notes.)
  - The Gate signal from the Gate CV input socket.
  - The Gate signal which results from the Slide CV Input socket being driven with more than about +4.0 volts.

- The Slide which can be applied to these notes, by way of tied note-on-note-off (the new note starts before the old note ends), is controlled by the Slide signal which controls the Devil Fish synthesizer, which is the OR of:
  - The Slide signal produced by the Internal Sequencer.
  - The Slide signal from the Slide CV Input socket, when it is above about +2.3 volts.

- The Accent which is applied to these notes, by way of choosing between two velocities for non-accented and accented notes, is controlled by the Accent signal which controls the Devil Fish synthesizer which is the OR of:
  - The Accent signal created by the Internal Sequencer.
  - The Accent signal from the Accent CV Input socket.
  - The front panel Accent button.

In **MIDI In Follow mode**, the Accent state of the received notes which are sent to MIDI Out is an OR of how the MIDI In system determines whether to Accent that note (according to a user definable choice of four velocity thresholds – Parameter 6) and the three Accent signals mentioned immediately above.

MIDI Out Velocities for Accented and Non-Accented Notes can be controlled by MIDI In Control Changes

By default, at power on, the non-accented MIDI Out note velocity will be 64 and the accented MIDI Out note velocity will be 127 (the maximum possible). These two values can be altered while the MIDI Out system is running in any of the three modes, by sending Control Change messages for Controller 20 (velocity for non-Accented notes) and 21 (velocity for Accented notes) via MIDI In. In this manner, the dynamics of the notes produced by the instrument(s) which are receiving the MIDI Out notes can be altered dynamically, including a full range of 1 to 127 as velocities for both the non-Accented and the Accented notes.

When the values for Accented and Non-Accented notes are altered in this way, they are stored in ordinary microcontroller memory, not in its non-volatile memory. So these values will remain until the Devil Fish is turned off and on again.

This reception of MIDI In Control Change 20 messages on the Base MIDI In Channel is always active. As explained below (page 20) this is *not* affected by the setting *Turning on and off the reception of MIDI Notes and Control Changes*.

No transposition of MIDI Out notes with respect to the pitches played on the Synthesizer

The MIDI In sub-system (including with Dynamic Channel Switching) can transpose the note numbers of MIDI In notes with a range of plus or minus two octaves, before it is used to drives the Devil Fish synthesizer and therefore MIDI Out notes. There is no transposition between the pitches of the Devil Fish synthesizer and the notes numbers used for MIDI Out.

So the MIDI Out notes may be transposed with respect to MIDI In notes.

MIDI Out Control Changes for Filter Frequency

The MIDI Out system cannot sense the position of the Filter Frequency ("CUTOFF") knob. Nor can it sense any voltage which might be applied to the Filter Frequency CV input socket, or the other signals which affect the Filter Frequency of the Synthesizer.

However, it always replicates on MIDI Out whatever Filter Frequency values it receives from MIDI In, assuming the reception of MIDI In Notes and Control Changes is enabled (hold **TAP** and press and release **BACK** – see page 11). This occurs in all three MIDI Out modes – Int Seq. Ext CV and MIDI Follow. This replication of MIDI In received Control Change data is obviously required for the MIDI Follow mode. However, when the machine is not receiving MIDI Notes – meaning the MIDI Out mode is either Ext CV or Int Seq – then the MIDI In system can still receive Control Changes for Filter Frequency, which will affect the Synthesizer as it plays notes arising from the Internal Sequence and/or external CV In and Gate In.

The MIDI Out Control Changes which carry the Filter Frequency values are on the MIDI Out channel (Parameter 8). The Control Change number for these outgoing messages is the same Control Change number as is currently selected (Parameter 3) for receiving MIDI In Filter Frequency Control Changes.

Not every received Filter Frequency Control Change will generate a corresponding MIDI Out Filter Frequency Control Change. The two circumstances where one will not be generated are:

1. If the most recently received MIDI In Filter Frequency Control Change had the same value as the previous one.

2. If there is a high level of MIDI Out activity due to Sync messages (primarily Sync Clock messages) and/or Note On and Off messages, both of which have a higher priority than these Filter Frequency Control Change messages.

Due to point 2, it is possible that a high rate of incoming Filter Frequency Control Changes will lead to a smaller number of outgoing Filter Frequency Control Changes, even if each incoming message has a different value. This will result in a slight reduction in the ability of slave devices to respond to the Filter Frequency Control Changes which have been received. This is likely to be inaudible.

MIDI Out Sync

MIDI Out Sync is enabled by default but can be disabled with Parameter 7. Please see page 41 for a full explanation. When this is enabled, Sync messages (Run, Clock and Stop) are sent to MIDI Out as a result of:

- The TB-303's Internal Tempo system: the Tempo knob and the Run/Stop button with its internal flip-flop.
- External DIN Sync In via the Sync socket.
- MIDI In Sync.

Firmware updates via installing a new microcontroller chip

The MIDI In and Out system's microcontroller (PIC16F1936) is a 28 pin DIP device which can be replaced with a new one containing later versions of the firmware, to fix any bugs and to implement new features. This involves completely dismantling the TB-303 / Devil Fish and reassembling it – so this should only be undertaken by an experienced technician. The microcontroller is small and easy to send in the post.

The Sync / MIDI In socket is not an ordinary MIDI In socket

The Sync / MIDI socket of the Devil Fish with MIDI In is not an ordinary MIDI In socket. The two outside pins carry Run/Stop and Clock. This means that devices such as the Evolution 225C (and no-doubt other keyboards from this company: www.evolution.co.uk) should not be plugged into the Devil Fish, except with a lead which does not connect to the outside pins.

The Evolution 225C has +5 volts and a 5 volt MIDI signal on the outside pins so that it can be powered by a special lead which plugs into a PC sound card's joystick connector. Please use a special lead, or an ordinary lead with the outside pins broken off, between such a keyboard and the Devil Fish's MIDI In socket (the Sync socket). Another approach is to plug the keyboard into some other MIDI device and use the Thru of that device to drive the Devil Fish.

2 - The "Front Panel"

The MIDI In and Out system uses a very minimal *Front Panel* – the user-interface by which User Definable Parameters (for brevity, below, often referred to as just "Parameters") can be changed and by which several other functions can be activated:

The **BACK button** and the **TAP** (NEXT) **button** are the two *Input* elements.

A **Blue LED** mounted so it shines through the 'e' of the ***Devil Fish*** logo is the sole *Display* element.

The TB-303's CPU sees the **BACK** and **TAP** buttons too, so pressing them for the purposes of controlling the MIDI In system may also affect what the TB-303's CPU does. **BACK** and **TAP** have little or no effect when playing patterns in Pattern Play or Pattern Write modes, except that when the internal sequencer is stopped in Pattern Play mode, pressing **TAP** will cause it to play a high C note which lasts until the **TAP** button is pressed again or until some other action occurs. (See Section 10 below: *The Pesky C4 Note in Pattern Play Mode*, on page **Error! Bookmark not defined.**.)

When writing patterns, **BACK** and **TAP** (NEXT) directly affect the writing operation, so it is best not to try to control the MIDI In system while writing patterns. Likewise for the even more complex use of these buttons when writing tracks.

This minimal "Front Panel" system will drive you bananas if you don't read the following section clearly! Please pay close attention to these instructions regarding Pressing, Holding and Releasing these two switches. The order and timing of these actions is crucial.

Initialising the User Definable Parameters

The Microcontroller at the heart of the MIDI In and Out system uses non-volatile memory, which is completely independent of the memory of the TB-303 and which does not rely on any batteries. If, for some reason, you want to initialise the values of the twelve User Definable Parameters to the defaults listed in the table on page 15 (include receiving MIDI Notes and Controllers on Channel 1, receiving MIDI In Note and Control Change messages and receiving **and transmitting** MIDI Sync), **turn the machine on whilst holding both BACK and TAP**.

The Blue LED will flash **triple flash – triple flash – triple flash**.

Release the **BACK** and **TAP** buttons during or after these flashes and the machine will be ready for ordinary operation – except that it does not recognise any of the button combinations listed below. To use these, turn the machine off and on again.

Firmware version display

To display the version of firmware programmed into the MIDI In and Out system's microcontroller, **turn the machine on whilst holding the BACK button but not the TAP button**. The Blue LED will continually cycle through a pattern of varying brightness. A long moderate brightness period is followed by three dim periods, within which 0, 1 or more bright flashes may be inserted. The number of flashes indicates the software version. Version 2.1.0 is indicated by two flashes in the first dim period, one in the second dim period and none in the third. In this mode, the microcontroller is not receiving or transmitting MIDI or driving the TB-303 hardware. To restore normal operation, turn the machine off and on again.

Power-on display of whether Notes & Control Changes are being received

When the machine is turned on normally, or as described below for disabling Blue LED display of MIDI In activity, the Blue LED will indicate the state of Reception of MIDI Notes and Control Changes (see page 20).

If this is **enabled**, which is the default, the LED will display in 0.5 second intervals **bright, dim, bright, dim**.

If it is **disabled**, then the LED will display **double-flash – double-flash – double-flash – double-flash**.

Blue LED MIDI activity display and how to disable it

The Blue LED which shines through the Red Gate LED in the 'e' of the Devil Fish logo has six functions.

The Blue LED circuit may cause very slight interference with the audio output. Its operation for functions 5 and 6 below can be disabled, by **turning the machine on with the TAP button pressed, and the BACK button not pressed**.

The six functions are:

1. Acknowledging the Initialise all Parameters command, as described above.

2. Displaying the firmware version. as described above.

3. Power on display of whether the MIDI In system is enabled to receive MIDI Notes and Control Changes, as described above.

4. Indicating the status of "Front Panel" operations – the pressing and releasing of the **BACK** and **TAP** buttons.

5. Indicating successfully received MIDI In messages with brief flashes, as described in the section below *The Blue LED*. This function is normally on, except for when "Front Panel" operation is in progress and except when it is disabled as is described below.

6. Indicating the ending and starting of notes when the DCS (Dynamic Channel Switching) system is activated and is operating in Immediate mode, rather than Delayed mode and the Effective MIDI In Channel is changed from the current one of the possible four to one of the other three possible channels.

   The notes themselves have been previously received on the previous and/or the current Effective MIDI In Channel and the most recently received Note On of these on the previous Effective MIDI In Channel has previously generated a flash when it was received. If this note is turned off at this instant, there will be a flash to indicate this. Likewise if a note previously received on the new Effective MIDI In Channel is turned on at this instant, due to the Effective MIDI In Channel now being this channel, the LED will also flash, even though that note was received at an earlier time. If both these occur: turning off an old note and turning on a new note, there will still be one flash. These note off and on events are caused by a change in the Effective MIDI In Channel due to either reception of a MIDI In Note or Control Change event (in the absence of any input sockets, detector circuitry, LEDs, toggle-switches and bit inversion circuitry) or by a change in the two bits produced by this address bit inversion circuitry.

Turning on and off Reception of MIDI Notes and Control Changes

This is a single setting, which is stored immediately in non-volatile memory. So whatever change you make will remain after the machine is turned off and on.

The title *Reception of MIDI Notes and Control Changes* is a simplification of the true function of this setting. The three paragraphs below in bold explain the exceptions.

Before following either of the procedures below, make sure that the machine is not in the middle of the "Altering the value of a parameter" operation, as described on pages 12 to 14. If the machine is in this state, press and hold both **BACK** and **TAP** buttons for a few seconds, until there is either a series of double flashes (a normal exit from editing a parameter, involving saving the potentially altered value to non-volatile memory) or a continual series of flashes at about 6 Hz (an exit before a parameter has been selected for editing).

This setting does not affect MIDI Out for Notes or Sync. These are typically on at all times, except as described below (*User Definable Parameter 7: Receive and Transmit MIDI Sync*, page 41) where the reception and transmission of MIDI Sync can be disabled.

There are three exceptions to the general principle that this setting controls the reception of MIDI In Note and Control Change messages:

1 - **It does not affect the reception of Control Changes for Controller 20 and 21, which are used to alter the Velocities of non-Accented and Accented MIDI Out notes.**

2 - **It does not disable the reception of Control Changes for Controller 1 to 10 for Filter Frequency, if Parameter 3 (page 38) is set to values between 11 and 20, which select Controller numbers 1 to 10 respectively.** If it is desired to disable Filter Frequency Control Change reception in this way, please use values 1 to 10.

3 - **Nor does this affect the Dynamic Bank/Channel Switching (DBCS) system's reception of Notes and Control Changes on channel 15 or 16** (as set by User Definable Parameter 10, page 80) for the purposes of generating two bits which may be used directly for Dynamic Channel Switching (Installations 3 and 5) or to drive the default contacts of the two 3.5mm Audio / CV Input sockets of the DBCS hardware (Installations 4 and 6).

Here is the procedure:

Turn ON reception of MIDI Notes and Control Changes

Hold down the TAP button.

Press and release the BACK button within a second or so.

While both buttons are pressed, the Blue LED will flash rapidly. After the Back button is released the Blue LED will stay ON for 0.8 seconds and will then turn OFF.

Release the TAP button.

After reception is turned on, the MIDI In system will not take control of the TB-303's DAC (to control the pitch CV and so the pitch of the Synthesizer's Oscillator, assuming nothing is plugged into the CV In socket an the back panel) until a Note On is received on the correct MIDI channel, within the currently valid range of note numbers. This will be the Base MIDI In Channel if DCS (Dynamic Channel Switching) is not enabled, or if it is enabled, one of the channels in the set starting with this channel, and going up by 1, 2 and 3 channels, with wraparound from 17 to 1.

This state of the microcontroller controlling the DAC will still be maintained after no more MIDI events are received, even if the MIDI In lead is removed from the Sync/MIDI socket. This state prevents the Internal Sequencer from controlling the DAC and therefore from controlling the Synthesizer's pitch.

The MIDI In system will begin to drive the Filter Frequency only after a Control Change for this is received. Slide and Gate (Sustain) can be driven by several types of MIDI In Control Change messages (as described above, on pages 13 and 14) , as well as after a Note On event has been received.

In order to return control of the DAC etc. to the TB-303's internal sequencer so the MIDI In system no longer drives Gate, Slide, Accent or Filter Frequency, use the following procedure:

Turn OFF reception of MIDI Notes and Control Changes

Hold down the BACK button.

Press and release the TAP button within a second or so.

While both buttons are pressed, the Blue LED will flash rapidly. After the Tap button is released the Blue LED will stay ON for 0.2 seconds and will then turn OFF.

Release the BACK button.

The control of the reception of MIDI Sync is separate – see Parameter 7 in the table and descriptions below, on pages 25 and 41 respectively.

Altering the value of a User Definable Parameter

There are twelve User Definable Parameters, numbered 0 to 11, which can have their values changed with the following procedure. The details of Parameters 0 to 8 are listed on page 25 and the details of Parameters 9, 10 and 11 – which only concern Dynamic Bank/Channel Switching, are listed in a subsection which starts at page 76.

Please be aware that pressing the **TAP** button in Pattern Play mode can cause the Internal Sequencer to play a sustained C4 note, as described in Section 9 - *The Pesky C4 Note in Pattern Play mode* (page **Error! Bookmark not defined.**).

The MIDI In and Out system continues to receive MIDI and play notes etc. while a Parameter's value is being altered – the effects, if any, of the new value take place immediately. **Likewise, while a Parameter's value is being altered, the MIDI Out system continues to generate MIDI Out Notes and Sync messages, unless the changed value directly affects this.**

The final step writes the altered value into non-volatile memory. If this final step is not performed, the changed setting will remain in ordinary microcontroller memory until the machine is turned off, and the operation of the machine will be controlled by this setting. However, when the machine is turned on, this altered value will no longer exist and the Parameter will be set to whatever value was previously stored for this Parameter in non-volatile memory.

Entering Parameter Select mode

Press and Hold both BACK and TAP buttons, for as long as it takes for the Blue LED to stop flashing, which will be about 4 seconds.

While the two switches are both pressed, the Blue LED will flash repeatedly very quickly. After about 4 seconds, the flashing will stop and the Blue LED will turn ON continually.

It doesn't matter whether you press **BACK** or **TAP** first, or how long after pressing the first switch you press the second.

Release both switches.

The Blue LED will turn OFF.

(If you release either switch before the Blue LED turns on continually, then the MIDI In and Out system will not enter Parameter Select mode. The system will resume normal operation once both switches have been released.)

Selecting which parameter to alter

If you want to alter the first parameter – Parameter 0: MIDI Receive **and Transmit** Channel (page 35) – then there is nothing to do at this stage, since this is parameter 0. For other parameters 1 to 7 (table on page 25), or for parameters 8 to 11 (the tables on the two pages following page 76), the Parameter number is how many times the **BACK** button should be pressed:

> **Press and Release the BACK button the number of times indicated in the table. For instance, for Parameter 7, press and release the BACK button 7 times.**

> The Blue LED will flash briefly each time the **BACK** button is released.

Once you have done this the appropriate number of times – including, for Parameter 0 as just mentioned, not pressing the **BACK** button at all – perform the next step which tells the MIDI In and Out system which Parameter you will be altering the value of:

> **Press and Release the TAP button.**

> The Blue LED will flash once.

(If, before performing the above step, you decide not to change the value of a Parameter, press and hold both **BACK** and **TAP** for about 3 seconds. During this time, the LED will not light, but at the end of the time, it will flash with a distinctive sequence of double flashes. These double-flashes indicate that your command to exit has been accepted. Release the buttons and the MIDI In and Out system will resume normal operation.)

Altering the selected parameter's value

The parameter you selected is now ready to be incremented (made one higher than it currently is) with the **BACK** button or decremented (made one lower) with the **TAP** button.

+ Increment the parameter: **Press and Release the BACK button.**

– Decrement the parameter: **Press and Release the TAP button.**

> The Blue LED will flash briefly once for either of the above actions except when the parameter has reached its minimum or maximum value.

Each parameter has a minimum and maximum value. If you Decrement when it is at its minimum, or Increment when it is at its maximum, the value will not change and the Blue LED will flash for a longer time. If you changed the value of the parameter to a new state, then the Blue LED will flash for a short time.

There is no display of the parameter's current value, but you can find the value by stepping it down with **TAP** until it reaches is minimum, which is visible by a longer flash of the Blue LED when you try to reduce it further from this value. For instance, if the original value was 3 and the minimum value is 0, then it will take three presses of the **TAP** button to change the value to 0, each of which will generate a normal flash. A fourth press of the **TAP** button will attempt to reduce the value from its minimum, and this will be indicated by a long flash. In this example, with a minimum value of 0, a double-flash on the fourth press of the **TAP** button shows that the original value was 3, so pressing the **BACK** button 3 times will restore the original value.

Similarly, to determine the current value, you can step up to the maximum value with the **BACK** button, until there is a longer flash of the Blue LED, indicating that the previous press of the **BACK** button had taken the value to its maximum.

Changing the value of a parameter has immediate effects on the MIDI In system. **Changing the values of some of the parameters has an immediate effect on the MIDI Out system.** Furthermore, changes to the values of some parameters cause specific actions, such as clearing received notes, Accent, Slide etc. if the Base MIDI In Channel is changed. These are explained in the detailed information below on each of the parameters.

The changed value of the parameter will not be written into non-volatile memory unless the next step is performed.

If you wish to abandon whatever change you just made to the parameter, turn the machine off. Turning it on will restore the value to whatever was stored in non-volatile memory.

Saving to non-volatile memory and returning to normal operation

Whether or not you have altered the value of a parameter in the step above, to return to normal operation, you must perform the following procedure – which also writes the new value (or the original value, if unchanged) to non-volatile memory.

> **Press and hold both the BACK and TAP buttons until the Blue LED flashes with a distinctive double flash pattern. This will involve holding both buttons for about 3 seconds.**

When you have pressed and held them for long enough, the Blue LED will flash with a distinctive double-flash pattern. This is the signal to:

> **Release both buttons.**

after which the Blue LED will turn OFF and the MIDI In and Out system’s “Front Panel” will be in normal operation mode.

3 - User Definable Parameters 0 to 8

User Definable Parameters 0 to 11 are accessed and altered by the procedure described immediately above – Altering the Value of a parameter, starting on page 22. Each parameter 0 to 8 is discussed in greater detail in Section 5 below on the page numbers shown in **blue**. **Parameters 9, 10 and 11** are described in Section 9: Dynamic Bank/Channel Switching.

Name of parameter More details on page **xx**	**User Definable Parameter number = number of presses of the BACK button to select this parameter before pressing TAP**	**Range & (default)**	**Function** **Red bold = default**
Base MIDI In Channel **35**	**0** (None – just press **TAP**.)	1 – 16 (**1**)	Selects which channel will be used for receiving Note and Controller messages from MIDI In.
MIDI In Transpose Enable **36**	**1**	0 – 2 (**0**)	**0 = No transposition.** 1 = Transpose Up. 2 = Transpose Down.
MIDI In Transpose Amount **36**	**2**	0 – 24 (**12**)	Number of semitones to transpose the MIDI note number up or down before playing a note on the Devil Fish synthesizer.
MIDI In Filter Frequency Controller **38**	**3**	0 – 20 (**1**)	0 = Disabled. **1 = Controller 1, which is Mod wheel.** 2 to 10 = this controller number. 11 to 20, controller numbers 1 to 10, but always operating, rather than being turned off when reception of MIDI In Notes and Control Changes is disabled.
MIDI In Slide on Tied Notes **40**	**4**	0 – 1 (**1**)	0 = Disabled. **1 = Turn on Slide when a new note is started before the previous one ends.**
MIDI In Sustain-Slide Controller **40**	**5**	0 – 19 (**0**)	**0 = Disabled.** 1 = Mod wheel. 2 to 19 = this controller number.
MIDI In Accent Velocity Threshold **41**	**6**	0 – 3 (**0**)	The value which Note On Velocity must equal or exceed in order that Accent will be turned on: **0 = 65***, 1 = 80, 2 = 100, 3 = 120. * 64 for MIDI In V1.0.0 to V1.0.3.
Receive and Transmit MIDI Sync **41**	**7** * Disables the Unplug Timer. See page **41** for full details	0 – 5 (**1**)	0 = Receive Off. Transmit Off. **1 = Receive ON. Transmit ON.** **2 = Receive ON.** Transmit Off. 3 = Receive Off. **Transmit ON.** **4 = Receive ON*. Transmit ON.** **5 = Receive ON*.** Transmit Off.
MIDI Out Channel **44**	**8**	0 – 16 (**0**)	**0 = Transmit on the MIDI In channel** (Parameter 0, above). 1 to 16 = Transmit on this channel.

“Base” in “Base MIDI In Channel” means that this Channel number is the lowest of four Channel numbers on which the Devil Fish will receive note information, when Dynamic Channel Switching is used. For instance, if it is set to 3, then the Devil Fish can receive, according to the actions of Dynamic Channel Switching, on channels 3, 4, 5 or 6. When Dynamic Channel Switching is not used, this is the sole MIDI In channel. When Dynamic Channel Switching is being used, this channel is still used for receiving Control Changes.

4 - Interaction between the MIDI In system and the TB-303 / Devil Fish

A full understanding of the various parameters and features requires a good understanding of the three elements of hardware – the basic TB-303, the Devil Fish enhancements to it and how the MIDI In system interfaces to these.

The standard TB-303

The TB-303 can be divided into two sections: Internal Sequencer and Synthesizer.

The **Internal Sequencer section** comprises:

- The CPU chip (a 4 bit NEC microcontroller).
- Battery backed-up memory – three 1024 x 4 bit static RAM chips.
- Push-button switches, rotary switches and LEDs.
- The Sync section:
  - Run/Stop button and flip-flop.
  - Tempo pot and oscillator.
  - Sync socket, which switches the above two to its outer pins and to the CPU unless a lead is plugged into it, in which case, the lead can drive these pins.

The CPU contains firmware built into the chip which makes it respond to all the above and so perform the functions of the Internal Sequencer. This involves reading and writing data from and to the memory and controlling the Synthesizer section with the following signals:

A 6 bit DAC (Digital to Analogue Converter) which provides a voltage between 1.0 and 5.0 volts, in 1/12 volt steps. This voltage is subject to a Slide process and made available at the CV Out socket. (Its range is 1 to 64 steps of 1/12 volt each, but below 1 volt and above 5 volts it is not necessarily accurate and the VCO tracking of these voltages is less accurate than in the 1.0 to 5.0 volt range.

A Gate signal which is high when a note is ON. This is available at the Gate Out socket as an approximately +6 volt signal.

An internal Slide signal which controls the slewing of the DAC's CV (to the Synthesizer's VCO and the CV Out socket) so that it takes a fraction of a second to slew from the voltage of the previous note to the voltage of the new note.

An internal Accent signal which alters the way the Synthesizer works. (See the Devil Fish User Manual for more information on Slide and Accent.)

The TB-303's **Sync section** consists of two front-panel circuits – a Tempo Clock oscillator and a Run/Stop switch, flip-flop and LED – and a special 5 pin DIN socket. This socket uses the middle pin (2) for ground (as does MIDI) and the two outside pins (1 and 3) for the Run/Stop and Clock signals, respectively. (Pin 4 is also an input for the TAP function and Pin 5 for some undocumented function. These are not normally used in any Sync arrangement, and these functions are removed when the MIDI In and Out system is installed.)

Normally, with nothing plugged into the Sync socket, a two-part switch in the socket connects the local Run/Stop signal (generated by the Run/Stop switch and its associated flip-flop) to pin 1 – and the Clock signal, from the Tempo oscillator to pin 3. These are both +5 volt signals. 0 volts on the Run/Stop pin means that the TB-303's Internal Sequencer will not play a pattern or track, but is ready to start or write a pattern or track, according to the MODE switch. +5 volts or more (up to + 15 volts) on the Run/Stop pin tells the TB-303's Internal Sequencer to "Run": play a pattern or the patterns in a track, according to the pulses which arrive on the Clock pin. The positive (rising) edge of these pulses (again typically +5 volts, but perhaps as high as +15 volts), on the Clock pin tells the Internal Sequencer that this is the start of a 1/24th of a quarter note.

The Clock circuit is normally a free-running square-wave oscillator – but it is reset and made to restart with a slight delay when the Run/Stop button is pressed so as to turn Run/Stop on. This ensures that when the Run/Stop signal goes high, the Clock signal is low – and that there will be a delay of about 7 msec before the rising edge of the first Clock pulse. This delay is musically unimportant, but is vital to allow the TB-303's CPU to recognise this first Clock pulse, rather than miss it while the CPU is responding to the rising edge of the Run/Stop signal.

If a plug is inserted into the Sync socket, without activating the switch, pins 1 and 3 function as outputs for the Run/Stop and Clock signals respectively. This can be done by partially inserting the plug, or by removing its shell (or part of the shell) so it doesn't press against the white rod inside the top of the Sync socket. This is not a standard part of TB-303 functionality, but it can be useful. (For further discussion, see Section 9 below: *Advanced use of the Sync-MIDI-In socket*.)

If a plug is inserted normally into the Sync socket, this activates the two-pole normally closed switch at the back of the socket, which disconnects the local Run/Stop and Clock circuits from the socket's pins 1 and 3. The idea is that the lead which has been plugged in will drive these pins. The voltage levels for receiving Run/Stop and Clock are not critical – low should be 0 to maybe 1 volts and high should be between 3 and 15 volts.

So in normal operation – whether an external Sync source is plugged into the TB-303, or whether nothing is plugged in and the local circuits drive pins 1 and 3 – these pins have a valid Run/Stop signal and a valid Clock signal. The CPU sees these signals and uses them to drive most of its operations.

The **Run Battery** LED on the front panel is turned on by a sufficiently high voltage on the Run/Stop pin of the Sync socket (it has a lower threshold than that of the circuit which senses this voltage for the CPU) AND the power supply voltage sensor circuit is sufficiently activated. If this LED is dim, this means that the LED driver circuit senses that the Run/Stop signal on the Sync socket pin is higher than its threshold AND, due to low battery voltage or an inadequate external power supply, the TB-303 is not receiving a high enough voltage to function reliably.

Without a regular Clock signal, such as dozens of pulses a second, the CPU will not play any notes, flash any LEDs or respond normally to front panel button activity.

The Sync system is a two-signal *input* to the TB-303's CPU. The TB-303's CPU does not drive the Sync socket. In a TB-303 without modification such as this MIDI In and Out system, only an external cable, or the internal Run/Stop and Clock circuits drive the socket and therefore these two inputs to the CPU.

(TB-303s may have broken solder joints at the Sync socket and its switch which prevent the CPU sensing the Run/Stop signal and/or Clock signals. Without these, the CPU will not flash the front panel LED lights, will not respond to buttons being pressed and/or will not play patterns or tracks.)

Normal note-playing activity in the TB-303, when playing or writing patterns or tracks, involves:

- The CPU latching a 6 bit number into the DAC.
- The CPU selecting whether or not the Slide circuit causes a slow slew in how the new DAC voltage drives the VCO and CV Out socket.
- The CPU turning the Accent signal on or off.
- The CPU driving the Gate signal to the Synthesizer and Gate Out socket.

The standard TB-303 has no inputs for CV (to drive the VCO), Gate, Accent, Slide or Filter frequency.

The Devil Fish Modifications add a number of inputs and new sources of control for CV, Gate, Accent, Slide and Filter CV. The Devil Fish mods also add an Accent Out socket – a +6 volt signal which can be used to drive other equipment, such as one or more other Devil Fishes. Here are descriptions of the four signals as they are handled in the Devil Fish without MIDI In, and in the Devil Fish **with MIDI In and Out**. The MIDI In and Out details are in **bold blue text**.

Devil Fish CV In

The TB-303 CPU drives the 6 bit DAC, which has in internal impedance of 100k ohms. In the TB-303, this is connected directly to a the Slide circuit, which can cause a slow slew when the voltage changes, via a 0.22uF capacitor. In the Devil Fish, the DAC drives a *normally closed* terminal of the Devil Fish's CV In socket. When nothing is plugged into this socket, the DAC signal goes to the Slide circuit, via an over-voltage protection circuit (3.3k ohms with some diodes which do not normally conduct) and the new Slide pot (0 to 500k ohms). When an external CV is plugged into this socket (probably with a much lower impedance than 100k ohms, meaning that it drives the socket in a more robust fashion than the relatively weak 100k ohm impedance of the DAC) the voltage from the DAC is ignored and input voltage goes via the over-voltage protection circuit and the Slide circuit, slewing according to (the impedance of the input signal + 3.3k ohms + the value of the Slide pot) whenever the Slide signal is on.

The output of the Slide circuit goes to the VCO, the Filter Tracking pot and the TB-303's CV Out socket.

The MIDI In and Out system is the same as the above, except that the PIC microcontroller in the MIDI In system can take control of the DAC from the TB-303's CPU. When this happens, if the TB-303 CPU drives the DAC as part of playing a note, the DAC voltage will be controlled solely by the MIDI In and Out system's microcontroller. Plugging a lead into the CV In socket will mean that the VCO, Filter Tracking pot and CV Out socket are driven by whatever signal is on that lead. This means the output of the DAC, and therefore the pitches received from MIDI In, will be ignored.

There is a potential problem with some Devil Fishes: an occasional intermittent poor connection in the CV In socket's *normally closed* function means that the VCO pitch drifts, remains static, or is way out of tune. The solution is to insert a plug a few times into the socket, so the contacts get some movement. This is discussed more fully in the Devil Fish User Manual in the section regarding reliability.

Devil Fish Gate

There are three signals which can turn on the Gate – for the Synthesizer Gate, the Gate Out socket and the Red Gate LED in the ‘e’ of “Devil”.

1. The TB-303 CPU's Gate signal.

2. The Devil Fish's Gate In socket.

3. A voltage above about +4.0 volts on the Slide In socket will also turn on the Gate. (This was not true for Devil Fishes prior to version 2.1D, 2003-11-11.)

These are ORed – one, any two or all three of them being active will turn on Gate.

The MIDI In and Out system drive the Gate in a similar way – an OR arrangement of the above three signals with its own Gate signal. The MIDI In and Out system cannot turn off the Gate if it is turned on by any of the above.

If the TB-303's CPU was turning the Gate on continually, the MIDI In system would not be able to make it go on and off. If the MIDI signal contains no Sync (Start, Clock etc.) the Internal Sequencer is unlikely to be running, because plugging a lead into the Sync socket will open the switches and disconnect the TB-303's internal Run/Stop signal from pin 1, and therefore from the Run/Stop input of the CPU. This will cause the TB-303's CPU to deactivate its Gate signal. However, if the MIDI lead was only partially inserted, or was modified so as not to activate the switch, then the TB-303's CPU could be driving Gate whilst the MIDI In system is trying to turn Gate on and off. This *might* be musically useful, but is more likely to be troublesome. (For further discussion, see Section 9 on page 107.)

With an ordinary MIDI lead, properly inserted, there could be a situation in which the TB-303's CPU is activating Gate at the same time as the MIDI In and Out system is trying to play notes by activating the Gate. This would occur when these three conditions are true:

1. The MIDI In system is configured to receive MIDI Sync, which is the default arrangement.

2. The MIDI signal includes Clock bytes and at least one Start or Continue byte, which causes the MIDI In system to turn on Run/Stop (pin 1 of the Sync socket, and as an input to the TB-303's CPU and so its Internal Sequence) and to provide Clock pulses (on pin 3, and also to the CPU and so its Internal Sequencer).

3. The TB-303 is currently set up to play a pattern, or track, such that the pattern it plays contains some notes.

In the typical situation with an external MIDI sequencer which puts out Sync bytes, there are two ways of avoiding this problem of the TB-303 CPU (Internal Sequencer) driving the Gate when you really want to be controlling the Synthesizer entirely from MIDI In. Either of these approaches will solve the problem:

1. Disable the reception of MIDI Sync (Parameter 7 in the *User Definable Parameters* section, page 41.) or:

2. Make sure the TB-303 is in Pattern Play (or Write) mode on a blank pattern.

Devil Fish Slide

There are two signals which can turn on the Slide circuit. (This is *not* the same as turning on the Gate to tie two otherwise separate periods of Gate on into a single period. The TB-303's CPU, when playing two notes with Slide, does this, leaving the Gate on as it changes the DAC voltage, whilst turning on the Slide signal to cause the resulting voltage to the VCO to slew slowly.)

1. The TB-303 CPU's Slide signal.

2. The Slide signal which results from the Devil Fish Slide input socket having more than about 2.3 volts applied to it.

The MIDI In and Out system can override the TB-303 CPU's Slide signal and the Devil Fish Slide input socket.

When the MIDI In system is driving the DAC, it doesn't matter whether the TB-303 CPU or the Slide input socket is driving the Slide – the MIDI In system will control Slide irrespective of these. This overriding begins with the first note played by the MIDI in sub-system in response to MIDI In. The override is not activated simply by the MIDI In sub-system being ready to receive notes. A note must be received first. Once this happens, the MIDI In system will control Slide, according to Tied Note Slide and the Slide-Sustain Controller – until the reception of notes is turned off by holding down the BACK button and pressing and releasing the TAP button (page 20).

Devil Fish Accent

There are three signals which can turn on the Accent to the Synthesizer, which also drives a +5 volt signal to the Devil Fish's Accent Out socket.

1. The TB-303 CPU's Accent signal. (This could be stuck On if the CPU's sequencer function is stopped in the middle of a pattern with an accented note, or perhaps if it is ready to play a pattern which starts with an accented note.)

2. The Accent signal which results from the Devil Fish Slide input socket having more than about +2.3 volts applied to it.

3. The Accent Button being pressed.

The MIDI In and Out system overrides the TB-303 CPU's Accent signal. When it is driving the DAC (as described in more detail in the paragraph in blue immediately above), it doesn't matter what the TB-303's sequencer is doing. The MIDI In system's Accent signal is ORed with the signals from the Accent In socket and the Accent button to produce the final Accent signal for the Synthesizer and the Accent Out socket.

MIDI In Sync system

The MIDI In and Out system's MIDI In sub-system cannot sense whether anything is plugged into the Sync socket to open the switches which disconnect the TB-303's internal Run/Stop and Tempo Clock circuits from pins 1 and 3 of the socket. Nor can it sense the state of these pins to know if an external signal, such as by a special lead carrying both MIDI and Sync, is driving the pins. So the MIDI In sub-system cannot sense whether the TB-303's CPU is playing a pattern, driving Gate, Accent etc.

The MIDI In sub-system can drive positive voltages (about + 5 volts) onto the pins 1 and 3 (Run/Stop and Clock respectively) of the Sync socket. Assuming there is a lead in the socket, which opens the two switches, this means that these two voltages will drive the TB-303's CPU and any external lead (such as the optional special Sync Lead) which may connect these pins to the Sync inputs of other devices. Assuming no external signal is driving these pins, and assuming that a normal lead has been inserted far enough to activate the switch which disconnects the internal Run/Stop and Clock circuits, then the MIDI In sub-system alone will drive the pins according to the bytes it receives from MIDI In, if Parameter 7 (Receive and Transmit MIDI Sync, page 41) is set to 1, 2, 4 or 5. The default value is 1.

However, if there is some other source of Run/Stop or Clock, such as due to the Sync socket switch not being properly pressed (meaning it does not disconnect both the Run/Stop and Clock drive signals from the TB-303's internal Temp oscillator and Run/Stop flip-flop), or some other signals being applied to the pins, then the MIDI In sub-system will not be able to reliably drive these pins. Also, it is possible for the MIDI In sub-system to be driving these pins after the MIDI lead has been removed, which means that the switch contacts will be closes and these two pins are also being driven by the internal Tempo oscillator and Run/Stop flip flop. Normally (Parameter 7 values 1 and 2) the **Unplug Timer** will detect this condition after 1.5 seconds, and stop the MIDI In sub-system driving these pins. If Parameter 7 is set to 4 or 5, this timer is disabled and it is possible for the machine to remain in a confusing and possibly non-functional state after the MIDI lead is removed. Please see the sub-section *Receive and Transmit MIDI Sync*, page 41, for how to avoid this.

The drive for each pin is +5 volts, via a diode and 1k resistor. This should protect the MIDI In microcontroller from shorts or externally applied positive voltages, but be sure not to apply negative voltages, or any static electricity spikes, to these pins.

5 - Details of MIDI In features and User Definable parameters 0 to 8

Here is a complete description of the operation of the MIDI In part of the MIDI In and Out system, with Parameter 8 which concerns MIDI Out, not including the MIDI In functions of Dynamic Bank/Channel Switching. **Bold green text** is used to highlight MIDI Out functionality. Please refer to the table on page 25 which lists these User Definable parameters.

Monophonic reception of multiple notes

The Devil Fish modified TB-303 is a monophonic synthesizer, but MIDI is a polyphonic interface. There are several ways a monophonic device, such as a MIDI-to-CV converter, might be designed to choose which single pitch to play when multiple note-on and note-off events are received. Common approaches include high-note or low-note priority, where the highest or lowest note of the currently active notes is the one which drives the monophonic synthesizer.

The Devil Fish MIDI In and Out system uses a *most recent note* priority system, with an eight-deep internal Note Stack of the most recently turned on notes, which are used if the currently played note is turned off. This means that up to eight notes can be active at once, and as they are released, the MIDI In sub-system will back-track through the list of currently active notes, selecting the most recently started, when more recently started notes are released.

The Blue LED

The MIDI In and Out system has a Blue LED, mounted to shine sideways into the Red LED in the ‘e’ of the ***Devil Fish*** logo. This is a conventional Blue LED, which is brighter – and somewhat more “aqua” (longer, greener, wavelength) – LED than the Blue LEDs which can be installed in the TB-303 front panel. The new Blue LED may not be clearly visible in very bright lighting, such as sunlight, but should be clearly visible in most other circumstances.

If the machine is turned on with the **BACK** button pressed, the LED will light in a continuing sequence of pulses, showing the three digit version of the MIDI In and Out system's firmware. (This is described on page 18.)

The primary purpose of the Blue LED is both to indicate various states of the “Front Panel” system and to indicate the successful reception of MIDI In Note or Control Change messages. These are messages which directly affect the Devil Fish Synthesizer, and therefore MIDI Out.

The Dynamic Bank/Channel Switching (DBCS, Section 7, pages 58 to 105) system can be configured to receive Note and Control Change messages on Channel 15 or 16, for the purposes of generating two bits which may be used in one of two ways in that system. The Blue LED does not indicate the reception of these messages, but if these messages, and/or changes in two bits received from switch bit inversion XOR gates, cause a new Note to be played, then the Blue LED will indicate in the same way as it does an ordinary just-received Note event which causes a new note to be played.

The signal which drives the Blue LED may cause slight interference with the Audio Out signal, so for critical recording purposes involving MIDI In Note and Controller messages, it may be best to turn this off as described in the next paragraph.

When no front panel operations are in progress, the LED indicates successfully received MIDI messages and DBCS note changes, unless this **Blue LED reporting of MIDI In activity is turned off** by turning the machine on with the **TAP** button pressed and the **BACK** button not pressed. When the Blue LED is enabled (when the machine is turned on without holding **TAP**), there are three types of flash for three types of message. The first two types are only received if Reception of MIDI Notes and Control Changes is enabled (page 20).

- **Bright 16 ms flash.** One or more Note On or Note Off messages have been received, or the DCS (Dynamic Channel Switching) system, in its Delayed mode, generates or ends a note due to a change in Effective MIDI In Channel number. These can only occur if Reception of MIDI Notes and Control Changes is enabled (page 20). The rest of this description does not refer to these Delayed mode DCS Note On and Off processes.

  The LED will not flash if the message is for a different channel to the one currently being received, or if it is for a MIDI note number which is outside the range the MIDI In system can play, given the current Transposition (Parameters 1 and 2) settings. If a Note On message is received for a MIDI note number which is already on, then the second message will be ignored by the interface and will not generate a flash of the LED. When Dynamic Channel Switching is being used, these LED flashes will only occur for Note events which match the current Effective MIDI In Channel, which is one of four channels, and which may change rapidly for a variety of reasons.

- **Dim 160ms flash.** One or more Control Changes have been successfully received of three types. Generally, these can only occur if Reception of MIDI Notes and Control Changes is enabled (page 20).
  - Filter Frequency Control Change (Parameter 3, page 38). If the value of this Parameter is 11 to 20, these may be received even with Reception of MIDI Notes and Control Changes is disabled.
  - Sustain-Slide Control Change (Parameter 4).
  - Standard MIDI Control Change functions:
    - Controller 64 for Sustain.
    - Controller 65 (Portamento) for Slide.
    - Controller 120 and 123 All Notes Off.

- **Bright 40ms flash.** Control Changes 20 and 21 for setting the Velocity of MIDI Out notes which are non-Accented and Accented respectively. These can be received whether Reception of MIDI Notes and Control Changes is enabled or not. Reception of these control changes does not affect the sound made by the Devil Fish – they are used only for altering the velocity of MIDI Out notes. There will be no flash or change to the Velocity values if the value in the Control Change is zero. All other values 1 to 127 set the Velocity value and create a flash on the Blue LED.

Since one flash can be terminated and replaced by another, and since one message can arrive within a millisecond of the previous one, only 1 msec of the flash due to the first message will be visible – and this is too short to perceive in the presence of a different type of flash which takes its place. For instance, a Control Change message followed by a Note On or Off message will cause a short bright flash, while these two messages received in the reverse order will cause a longer dim flash.

Base MIDI In (Receive) Channel (Parameter 0)

This sets the MIDI In Channel on which Note On and Off and Control Change messages are received, except when **Dynamic Channel Switching** is enabled, in which case this is the **Base MIDI In Channel**, with notes being received on this channel or the channels 1, 2 and 3 greater than this.

Changing the value of this parameter turns off a number of things which may be on:

1. Any note being played. This also clears the 8 deep Note Stacks of all 16 MIDI In channels, which is used to convert polyphonic notes into a monophonic note.
2. The MIDI In sub-system's control of the TB-303's DAC.
3. The MIDI In sub-system's control of Filter Frequency.
4. The MIDI In sub-system's drive of Slide, Accent and Gate.

If the MIDI Out (Transmit) Channel (parameter 8) is set to 0, then when this MIDI Receive Channel Parameter 0 changes, MIDI Out Notes and Filter Frequency Control Changes (Parameter 3) will be sent on the new channel number.

Notes and Control Changes are immediately received on the new channel, which may lead to notes being played and other effects, such as Slide or Accent. The flashing of the Blue LED for Notes and Control Change messages being received is turned off during the parameter change process – so if you are fishing for the right MIDI channel, it is probably best to do this by listening for notes (or looking at the Red Gate LED), since it takes quite a few seconds to exit from the parameter change process in order to see the Blue LED activity which indicates successful MIDI reception.

As with all the parameters, be sure to exit the change process by holding down both **BACK** and **TAP** buttons for about 3 seconds, as described on page 24, in order to save the new setting to non-volatile memory, and to return the system to ordinary operation. Here is an **example of changing the Base MIDI In Channel to 5**, assuming it was previously set at the default of 1.

a – Enter Parameter Select mode:

Press and Hold both BACK and TAP buttons, for as long as it takes for the Blue LED to stop flashing, which will be about 4 seconds.

While the two switches are both pressed, the Blue LED will flash repeatedly very quickly. After about 4 seconds, the flashing will stop and the Blue LED will turn ON continually.

Release both switches.

The Blue LED will turn OFF.

b – Select Parameter 0 (Base MIDI Receive Channel) to edit:

Since this is Parameter 0, there's no need to press the **BACK** button.

Press and Release the TAP button.

The Blue LED will flash once.

c – Alter the value from 1 to 5:

+ + + + **Press and Release the BACK button 4 times.**

The Blue LED will flash briefly once for each of the above actions except when the parameter has reached its maximum value.

If you are unsure of the MIDI Receive Channel number when you start this procedure, you can decrement it to its minimum value of 1 by pressing and releasing the **TAP** button until the Blue LED flashes for a longer time, which indicates you have reached the minimum value for this Parameter, which is 1. Then you can press and release the **BACK** button 4 times, to increment the value to 5.

d – Write the new value to Non Volatile Memory so it will be retained, even after the machine is turned off and on again:

Press and hold both the BACK and TAP buttons until the Blue LED flashes with a distinctive double flash pattern. This will involve holding both buttons for about 3 seconds.

When you have pressed and held them for long enough, the Blue LED will flash with a distinctive double-flash pattern. This is the signal to:

Release both buttons.

after which the Blue LED will turn OFF and the MIDI In and Out system's "Front Panel" will return to normal operation.

MIDI In Transposition (Parameters 1 and 2)

These two parameters affect MIDI In reception of incoming notes, enabling received Note On and Off events to play a pitch in the Devil Fish which is different from that of the incoming MIDI Note. The range of transposition is -24 to +24 semitones = +/- 2 octaves.

As with changing the MIDI Receive and Transmit Channel, changing these parameters ends any currently playing notes, disengages the drive of the Filter Frequency, and ends any drive of Slide, Accent and Gate.

Without transposition, the range of MIDI Notes which are received is:

MIDI Note number	MIDI Note name	DAC voltage	Relation to TB-303 sequencer Pale yellow means VCO tuning and CV Out voltage may be inaccurate.
45	A1	0.750 V	3 semitones below normal TB-303 range.
46	A#1	0.833 V	2 semitones below normal TB-303 range.
47	B1	0.916 V	1 semitone below normal TB-303 range.
48	C2	1.000 V	Lowest C on TB-303 sequencer: Left C of the TB-303 keyboard, when Pattern Write Transpose Down is active.
60	C3	2.000 V	Left C of TB-303 keyboard with no transposition. (Middle C.)
72	C4	3.000 V	Right C of TB-303 keyboard with no transposition.
84	C5	4.000 V	Highest C of a pattern without transposition: Right C of the TB-303 keyboard when Pattern Write Transpose UP is active.
96	C6	5.000 V	Highest C of a pattern with 12 semitone transposition: The pattern itself contains a C5 and in Pattern Play mode, or Track mode, the entire pattern has been transposed up 12 semitones.
97	C#6	5.083 V	1 Semitones above normal range.
98	D6	5.166 V	2 Semitones above normal range.
99	D#6	5.250 V	3 Semitones above normal range.
100	E6	5.333 V	4 Semitones above normal range.

A transpose value of, for instance, +3 can be achieved with Parameter 1 set to “1” and Parameter 2 set to “3”. This would cause a MIDI note number 57 (A2) to play the C3 note on the TB-303 / Devil Fish.

In one of the three modes of operation of the MIDI Out system – *MIDI In Follow* – the MIDI Out system sends Note On and Off events to slave devices according to the pitch they are played in the Devil Fish due to MIDI In Note On and Off events. Therefore, if the Transposition parameters are set for a transposition of +5, then the MIDI Out note events will be 5 semitones higher than the notes which were received via MIDI In.

For instance, with transposition +5, a MIDI In received Note On event for C3 (60) will generate a MIDI Out note event for F3 (65), which matches the pitch the Devil Fish synthesizer plays and the voltage the Devil Fish CV Out socket carries: 2 + 5/12 = 2.417 volts.

MIDI In and MIDI Out Filter Frequency Controller (Parameter 3)

When this parameter is set to 0, there will be no reception of Control Changes to drive the Filter Frequency and consequently no **resending of this information via MIDI Out. Please see page 38 for a full description of this.**

A MIDI Control Change message consists of three bytes containing three numbers:

- The MIDI Channel number 1 to 16.
- The Controller number, 0 to 127.
- The value for this Control Change, in the range 0 to 127.

For instance, if a keyboard is transmitting on channel 3, and its Mod Wheel is moved to the forward position, the resulting MIDI Out message consists of three bytes:

`10110010` Status byte for Control Change on Channel 3, encoded as 2 in a range 0 to 15 for Channels 1 to 16, with binary 0010 = decimal 02.

`00000001` First data byte: Controller 1 = Mod Wheel.

`01111111` Second data byte: Value = 127.

When this parameter is set to a value in the range **1 to 10**, and a Control Change for this MIDI Controller number is received on the currently selected channel (parameter 0) then the MIDI In system will begin to drive the Filter Frequency. This reception will be disabled if Reception of MIDI In Note and Control Change messages (page 20) is turned off. **These received changes will be conveyed to MIDI Out on the MIDI Out Channel (Parameter 8, page 44) with the same Control Change number as Parameter 3: which will be 1 to 10.**

When this parameter is set to a value in the range **11 to 20**, and a Control Change for this MIDI Controller number *minus 10* is received on the currently selected channel (parameter 0) then the MIDI In system will begin to drive the Filter Frequency. So a value of 11 selects Controller 1 (Mod Wheel) and a value of 20 selects Controller 10. This reception **will not** be disabled if Reception of MIDI In Note and Control Change messages (page 20) is turned off. **These received changes will be conveyed to MIDI Out on the MIDI Out Channel (Parameter 8, page 44) with the Control Change number which is the value of Parameter 3 minus 10: which will be 1 to 10.**

The default value for Parameter 3 is 1, which means the MIDI In system will receive Mod Wheel Control Change messages and use the values in these messages to control the Filter Frequency. **These received changes will be conveyed to MIDI Out on the MIDI Out Channel (Parameter 8, page 44) with the same Control Change number as Parameter 3, which in this case is 1.**

There is an approximately 5 octave range between controller values 0 and 127. A value of about 83 will not alter the filter frequency. Values above this will increase the filter frequency and values below will decrease it. This is equivalent to applying a 0 to 5 volt signal to the Filter CV socket, where 3.3 volts has no effect on the filter frequency.

This MIDI control of Filter Frequency does not override the other sources of control – it adds or subtracts from the sum of the signals generated by:

- The Cutoff Pot.
- The Main Envelope Generator via the Env Mod Pot.
- On Accented notes, the Main Envelope Generator via the Accent Sweep Circuit (which has three modes controlled by the Sweep Speed switch), if the Sweep-Resonance switch is in positions 1 or 2.
- The AC-coupled (only rapid changes, not the overall average DC voltage) output of the VCA (which incorporates the Muffler) via the Filter FM Pot.
- The Pitch CV (from the Internal Sequencer driving the DAC, the MIDI In system driving the DAC or from the external CV In input socket, if a lead is plugged into it) via the Filter Tracking Pot. (Linear.)
- AC coupled signal from the Audio Filter FM Input (tip of old headphone socket). (Linear as well.)
- DC coupled signal from the Filter CV Input socket on the rear panel. (Exponential: about 1 volt / octave.)

The Filter Frequency will no longer be driven by the MIDI In sub-system when any one of the following occurs:

1. Note and Filter Frequency reception is turned off by holding **BACK** and pressing and releasing **TAP**. (See page 20.)
2. The value of parameter 0 – Base MIDI In Channel – is changed.
3. The values of either of the Transpose Parameters 1 and 2 are changed.
4. The value of the Filter Frequency Controller Parameter 3 is changed.

Points 2, 3 and 4 only cause a transitory disabling of the Filter Frequency drive. As long as the MIDI In system is ready to receive Notes and Filter Frequency Control Changes (that is, point 1 has not been done – or if it has been, it is turned on again by holding **TAP** and pressing and releasing **BACK**, see page 11, OR Parameter 3's value is set in the range 11 to 20), if the MIDI In system receives a Control Change message on the correct controller number (parameter 3) and MIDI Channel (parameter 0) then the MIDI In sub-system will again turn on the Filter Frequency control.

For reference, here are the names of functions of other devices which may transmit various controller numbers. These functions have nothing to do with the Devil Fish MIDI In system. Those marked with * are common.

```
Controller number Function

       1   * Modulation Wheel
       2     Breath Controller
       3
       4     Foot Controller
       5     Portamento Time
       6   * Data Entry Slider
       7   * Volume
       8
       9
      10     Pan
```

MIDI In Slide on Tied Notes (Parameter 4)

When the value of this parameter is set to 1, which is the default, Slide will be turned on when a second note is played while one is already active. When it is set to 0, this will not happen – the CV to the VCO (and the CV Out socket) will change immediately to the new note's voltage. Changing the value of this parameter to 0 will end any Slide which is on at that time due to tied notes.

This parameter also controls whether Slide is activated when a note XX ends and the DAC is made to output the voltage of a note YY which started before XX started. This is the operation of the 8-deep Note Stack for each MIDI In Channel. See page 6.

If this parameter is set to 0, then Slide will not be activated when Tied Notes are received, or when reverting to a previously started note, so the DAC voltage and therefore the VCO pitch will switch abruptly to those of the previously started note.

MIDI In Sustain-Slide Controller (Parameter 5)

When the value of this parameter is set to 0 (the default), this feature is disabled. When set to 1 to 19, and a Control Change message for this controller number is received on the Base MIDI In channel (Parameter 0) then the value of this message will drive Slide and/or Sustain (Gate On, even if there is no note currently playing). However this will only occur *after* at least one Note On has been received so that the MIDI In system has taken control of the TB-303's DAC. (The Blue LED will show a longer dim flash for each reception of this controller, but only when a note is played will the Gate and Slide be turned on.)

The intention is that a sequencer, or more likely a live player, will manipulate a controller number (such as 6 via a Data Entry Slider of a keyboard) to select Slide and/or Sustain. The effect of the controller values are:

Controller value	**Sustain (Gate)**	**Slide**
0 – 31		
32 – 63		On
64 – 95	On	
96 – 127	On	On

See the Gate and Slide sections of Section 4 (pages 19 and 2) for details of how these signals are ORed with other signals to create the Gate and Slide signals for the synthesizer.

Reception of these Control Changes affects the Synthesizer and the generation of MIDI Out notes.

MIDI In Accent Velocity Threshold (Parameter 6)

This parameter selects which of four thresholds will be used to decide whether a new Note On event will activate the Accent signal to the synthesizer. For instance, if this parameter is set to 0 (default) then any Note On with a velocity of 65 or above will activate the Accent signal. Instruments which output a Note On event without variable velocity typically use 64 for each note's velocity. Changing this value has no effect on any Note which is currently playing.

Parameter 6 value	Threshold equal to or above which Note On Velocity will activate Accent
0	65 (For MIDI In V1.0.0 to V1.0.3 this was 64.)
1	80
2	100
3	120

Receive and Transmit MIDI Sync (Parameter 7)

The MIDI In reception of Sync and **MIDI Out transmission** of Sync is controlled according to the six possible values of Parameter 7:

Parameter 7 value	Receive Sync from MIDI In	Transmit Sync to MIDI Out	MIDI Out Sync from MIDI In?	MIDI Out Sync from Internal Tempo & Run/Stop system or external DIN/Roland Sync?	Unplug Timer
0	**Off**	**Off**			
Default: 1	**On**	**On**	**Yes**	**Yes**	**Enabled**
2	**On**	**Off**			
3	**Off**	**On**		**Yes**	
4	**On**	**On**	**Yes**	**Yes**	**Disabled**
5	**On**	**Off**			

Changing this parameter's value to 0 or 3 resets any currently active Run/Stop and Clock which the MIDI In system is driving to the Sync socket and TB-303 CPU.

If the MIDI Out system is currently transmitting Sync, changing the parameter's value to 0, 2 or 5 will cause a Stop command to be sent to MIDI Out.

MIDI Out Sync results from typically one (see note below for exceptions) of:

- **MIDI In Sync – but only when reception of MIDI In Sync is On.**
- **The TB-303's Internal Tempo system: the Tempo knob, its clock oscillator and the Run/Stop button with its internal flip-flop.**
- **External DIN Sync via the Sync socket. Plugging in the lead opens two switches behind the socket so that the Internal Tempo system's Run/Stop and Clock signals no longer drive the pins of the socket and the TB-303's internal sequencer.**

The "Turn Off reception of MIDI Notes and Control Changes" command (page 20: holding **BACK** and pressing and releasing **TAP**) *does not* affect the reception or transmission of MIDI Sync. So it is possible to receive MIDI Sync, have the Internal Sequencer playing in time with a master device which is putting out Sync and possibly notes and Control Changes, including the Filter Frequency Controller (Parameter 3) and to alternate between:

- Enabling reception of MIDI Notes and Control Changes (with these notes controlling the TB-303's DAC (which provides the Pitch voltage to the CV In socket where, if nothing is plugged in, it is routed to the Synthesizer) and:
- Disabling this, so the DAC is then controlled by the Internal Sequencer.

There is a potential problem when receiving MIDI Sync (and when transmitting MIDI Sync which is derived from this received MIDI Sync), if a Start byte has been received (which causes the MIDI In system to turn on Run/Stop drive to the Sync Socket and therefore the Internal Sequencer, and causes the MIDI Out system to send a Start byte) and if, as is usual, Clock bytes are being received (and likewise used to create Clock pulses for the Sync Socket and Internal Sequencer and to send Clock bytes to MIDI Out). The potential problem occurs if the MIDI In lead is unplugged from whatever is driving it, and/or from the Sync socket.

Without special provisions, the MIDI In system would keep driving the Run/Stop high, but would not be generating Clock pulses (to the Sync Socket, and so the Internal Sequencer) – and the MIDI Out system would not be sending Clock bytes, but would not have sent a Stop byte. Some MIDI slave devices such as the Cyclone Analogic TT-303 Bass Bot cope with this loss of Clock bytes by turning off their Run/Stop state within less than a second. However, other devices remain in a state of their Run/Stop state being On, while no clock bytes are received to drive the device's internal sequencer.

In order to halt the MIDI In system's drive of Run/Stop if there are no incoming Clock bytes, there is an **Unplug Timer** in the MIDI In/Out firmware, which turns off this drive after 1.5 seconds have elapsed with no incoming Clock bytes. When Parameter 7's value is 4 or 5, this timer is disabled. This timer is started by the reception of any of the MIDI Sync bytes: Start, Continue (which is treated like Start), Clock and Stop. Normally, as long as Sync bytes are being received, this timer will not time out.

Generally it is best to enable the **Unplug Timer**, so generally it is best to use values 0 to 3 for Parameter 7. Whenever the **Unplug Timer** is disabled (values 4 or 5), once the Devil Fish receives MIDI In Sync bytes the MIDI In sub-system will continue to drive the Sync Socket, even if no such bytes are received, including if the MIDI In cable (or the special Devil Fish Sync Lead) is disconnected from the Sync socket.

If the MIDI In cable is still connected, this may not be a problem, provided you are not relying no the Internal Sequencer. In this state, there is a plug in the Sync socket (opening two internal switches which disconnect the socket and so the Internal Sequencer from the Internal Tempo Clock oscillator and Run/Stop Button and flip-flop), so the pins of the Sync socket (and so any slave devices connected to the special Devil Fish Sync Lead) will be stuck with Run/Stop high or low (depending on its state when the MIDI Sync bytes were last received) and with the Clock signal low. So the Internal Sequencer will not step through patterns or flash its LEDs. Likewise any slave Roland/DIN Sync devices connected via the special Sync Lead.

Confusion due to Unplug Timer being disabled

A more confusing situation can occur with whenever the **Unplug Timer** is disabled (Parameter 7 values 4 or 5) if the lead which is plugged into the Sync socket, and which was formerly carrying a MIDI In signal with Sync bytes to the Devil Fish, is **unplugged**. (This could be either the MIDI lead itself, or the special Sync Lead, into which the MIDI lead is connected via its 5 pin DIN socket connector.)

This confusing situation is that the Sync Socket pins are being driven by both the Internal Tempo Clock oscillator and Run/Stop button and flip-flop *and* the MIDI In sub-system's two signals which drive the Sync socket. Exactly how this situation may appear is difficult to predict, but one scenario is as follows, assuming that the MIDI In sub-system was driving Run/Stop high at the time the MIDI lead was unplugged from the Sync socket:

1 - The Run/Stop LED is On, but the Internal Sequencer is not running. (Perhaps some slave devices on the special Sync Lead will run.)

  The problem is that the voltage of the Run/Stop pin of the Sync Socket is intermediate, due to being driven high by the MIDI In system and low by the Internal Run/Stop flip-flop. It is a high enough voltage to turn on the LED driver circuit, but too low to be recognised by the circuit the TB-303 CPU uses to read this voltage.

2 - Pressing the Run/Stop button will turn on the Internal Run/Stop flip-flop and the voltage of the Run/Stop pin will rise to a proper high level (around + 5 volts) which is above the threshold of the circuit which the TB-303 CPU uses to sense this Run/Stop signal. This causes the Internal Sequencer to start running. (Likewise, perhaps, one or more slave devices on the special Sync Lead.) This is confusing because the Run/Stop LED was on and is still on.

Similar confusion could result on the Clock signal of the Sync socket, due to two circuits driving it at the same time and voltages arising which are not sensed properly by the Internal Sequencer (and any slave devices on the special Sync Lead) as being high or low.

If, for some reason, it is necessary to use values **4 or 5**, in which the **Unplug Timer** is disabled, **please be aware** of the above condition which can occur as a result of either the MIDI In lead being unplugged, or the MIDI Sync bytes no longer being sent to the Devil Fish. This condition is unlikely to be desirable and may cause considerable confusion.

Whenever the value of Parameter 7 is 4 or 5, in which the **Unplug Timer** is disabled, **once the Devil Fish receives any MIDI In Sync bytes, the MIDI In sub-system will drive the Sync Socket's pins** (and so the Internal Sequencer and any slave devices on the special Sync Lead) **until either the power is turned off or Parameter 7 is set to a value between 0 and 4**.

Note: With a conventional MIDI lead plugged into the Sync Socket, it is not possible to simultaneously receive MIDI Sync and receive DIN Sync. However, if a special cable is used (including the Sync Cable, with one of its three normally output DIN Sync connectors being driven with DIN Sync) then it is possible that both the MIDI In system and the external source of DIN Sync will be driving the Sync Socket's Run/Stop and Clock pins – and therefore driving the Internal CPU. The outcome of this would depend on many factors and I will not attempt to discuss this usage of the system. For more details on such arrangements, please see the section below "Advanced use of the Sync-MIDI-In socket: MIDI In whilst still using the internal Tempo Clock and Run/Stop".

MIDI Out (Transmit) Channel ***(Parameter 8)***

While the 16 values of Parameter 0, Base MIDI In (Receive) Channel, are numbered 1 to 16, this parameter's values are numbered 0 to 16.

If the value of this parameter is set to 0, MIDI Out Note and Control Change messages will be sent on whatever channel 1 to 16 is set in parameter 0.

If this parameter is set to a value 1 to 16, MIDI Out notes and control changes will be sent on this channel.

If the MIDI Out channel number is changed – by either a change to this parameter's value, or if it is 0, a change in the value of the Base MIDI In (Receive) Channel (Parameter 0) – when a note has been turned on via MIDI Out, but not yet turned off, then on the original MIDI Out channel, a Note Off message for that note will be sent.

(This is a situation in which the Control Change 123 message – All Notes Off – might be used, to turn off all notes which might have been played on the MIDI Out channel. However, some devices, such as the Cyclone Analogic Bass Bot TT-303 (firmware versions 1.0 and 11) do not respond to this All Notes Off command, and other devices may do so in a way which truncates the decay tails of notes. The Devil Fish does not send All Notes Off messages.)

6 - MIDI Out further explanation

This section is for reference – for those who are interested in exactly how the MIDI Out sub-system works.

Other than Parameter 8, for the MIDI Out Channel, there are no User Definable Parameters for the MIDI Out sub-system. The MIDI Out sub-system's functionality for sending MIDI Sync is described in the sub-section above for parameter 7 (page 41). Its functionality regarding sending Control Changes for Filter Frequency is described on page 38.

The MIDI Out sub-sections of the ***1 - Overall description*** section above gives a good functional description of the MIDI Out capabilities.

This section contains extensive tables and descriptions which I hope will help all users understand how the various sub-systems of the Devil Fish will behave in particular circumstances. There are too many combinations of Sync source; MIDI In activity; Internal Sequencer mode (and within Pattern Write mode, the Pitch and Time modes); External CV inputs etc. to describe every possible combination. If you can't figure out what you want to know from this manual, please let me know and I should be able to advise you by email or phone.

Tabular description of the 3 MIDI Out modes

There are three modes of MIDI Out operation. These are automatically selected – there is no need or opportunity for the user to select these:

- **Int Seq mode** – Note pitches result from the Internal Sequencer when it is *playing* a pattern, in Pattern Write, Pattern Play, Track Write or Track Play modes.

- **Ext CV mode** – Note pitches result from measuring the voltage of an externally applied Pitch CV, plugged into the CV In socket – or, if no lead is plugged into this socket, by measuring the internally generated CV (from the TB-303's 6 bit DAC) which results from the Internal Sequencer playing notes during Pattern Write mode when it is *not playing* the pattern. This is when the user is entering and altering pitch, timing, Accent and Slide information.

- **MIDI In Follow mode** – When the MIDI In system has reception of Notes and Control Changes ON (hold **TAP** and press and release **BACK**), the MIDI Out system replicates via MIDI Out Note On and Off messages the notes the MIDI In system is playing on the Devil Fish.

The following tables summarise the functionality of these three modes. Following the table are further explanations of the three modes.

MIDI Note Out Mode	**Int Seq**	**Ext CV**	**MIDI In Follow**
Is MIDI In note reception active?	**No**. No MIDI In notes are currently playing, either due to Note and Control Change reception being disabled or due to no notes having been received so far.		**Yes**. MIDI In notes are currently playing, or have been playing but no note is currently on.
The state of Run/Stop and Clock to the Sync Socket and so to the TB-303's CPU, which is the Internal Sequencer.	The Run/Stop LED is **ON**, due to one of: ○ Internal Run/Stop being high (Run/Stop button has been pressed). ○ External DIN/Roland Sync via the Sync socket. ○ MIDI In Sync reception is enabled and a Start or Continue has been received, but not a Stop. Assuming the TB-303's CPU also gets Clock pulses and the Internal Sequencer's mode is Track Write, Track Play, Pattern Play or Pattern Write in *Normal Mode*, the Internal Sequencer will be playing a Pattern, driving DAC, Gate, Slide and Accent signals to the Synthesizer.	The Run/Stop LED is **OFF** due to none of the three just-mentioned reasons for Run/Stop being high (at the Sync socket and therefore the input to the TB-303's CPU) currently being true. Assuming the CPU also gets Clock pulses, the TB-303s Internal Sequencer will be flashing its LEDs and responding to button presses, such as for entering and altering the pitches, timing, Accent and Slide of a Pattern.	The Run/Stop LED, which indicates the Run/Stop signal seen by the TB-303's CPU, could be ON or OFF. The TB-303's CPU may be playing a pattern, driving DAC (pitch CV), Gate, Slide and Accent signals to the Synthesizer.
What is controlling the TB-303's DAC? If nothing is plugged into the CV In socket, this controls the pitch of the Synthesizer.	Both of the circumstances described immediately above mean the MIDI In system **is not** currently controlling the TB-303's DAC, Gate, Slide or Accent signals. The **TB-303's CPU is** controlling the DAC.		The **MIDI In system is** currently controlling the TB-303's DAC, Slide and Accent signals. The **TB-303's CPU is not** controlling the DAC. **Both** may be driving the Gate signal to the Synthesizer.
What is the source of pitch information for MIDI Out Notes? How does this relate to the pitch voltage which goes to the Synthesizer: through the Slide circuit and then to the VCO and Filter Tracking pot?	**The 6 bit numbers the TB-303's CPU – the Internal Sequencer – latches into the DAC.** If nothing is plugged into the CV In socket, then the pitch voltage to the Synthesizer comes from the DAC. If a lead is plugged into the CV In socket, the voltage on that lead will control the pitch of the Synthesizer. However, the MIDI Out Notes will be for the pitches generated by the Internal Sequencer.	**The voltage from the CV In socket** and which goes to both: the Slide circuit and then the VCO and Filter Tracking pot; and the 1/12 volt step discriminating ADC of the MIDI Out system. **If a lead is plugged into the CV In socket, MIDI Out Notes will have pitches based on this lead's voltage. If no such lead is inserted in the CV In socket, the MIDI Out Notes will be based on the pitches the TB-303's CPU sends to the DAC.** This is measured at the input of the Slide circuit, so it can be measured instantly, even if Slide is On.	**The MIDI In Notes which are currently being received.** If no lead is plugged into the CV In socket, then the Synthesizer will be playing the same pitch as is being sent to MIDI Out: the pitch of the most recently received MIDI In note which is still on. subject to Transpose (Parameters 1 & 2). If a lead is plugged into the CV In socket, the voltage on that lead will control the pitch of the Synthesizer, and the MIDI Out notes will still have their pitches controlled by the MIDI In notes.

<table>
<tr><th>MIDI Note Out Mode</th><th>Int Seq</th><th>Ext CV</th><th>MIDI In Follow</th></tr>
<tr><td>What controls the starting and stopping of MIDI Out notes?

Does this differ from the Gate signal which the Synthesizer runs from?</td><td colspan="2">The Gate signal which drives the Synthesizer Gate and Gate Out socket, which is the OR of (one, two or three being On will drive the final Gate signal On):
The Gate signal created by the Internal Sequencer.
The Gate signal from the Gate CV input socket.
The Gate signal which results from the Slide CV Input socket being driven with more than about +4.0 volts.
No – the MIDI Out Note will be On only when the Synthesizer Gate is On.</td><td>The Gate signal from MIDI In, the OR of:
One or more MIDI In received notes.
The Gate signal from any MIDI In received Gate/Slide or Sustain Control Change messages.
It may differ: The Synthesizer Gate and Gate Out is the OR of:
The two signals mentioned above, which affect MIDI Out Notes.
The three signals mentioned on the left.
So the Synthesizer Gate will be On while there is no MIDI Out note playing if one or more of the three signals on the left are On.</td></tr>
<tr><td>What controls the Slide of MIDI Out notes?

Does this differ from the Slide signal which the Synthesizer runs from?</td><td colspan="2">The Slide signal which drives the Synthesizer, at the time the MIDI Out system samples it, which is at the start of MIDI Out notes: when the abovementioned Gate signal goes On.
This Slide signal is the OR of :
The Slide signal produced by the Internal Sequencer.
The Slide signal from the Slide CV Input socket, when it is above about 2.3 volts.
No – the MIDI Out notes' Slide will follow that of the Synthesizer Slide. The Slide process in the slave instruments is independent of the Slide process in the Devil Fish synthesizer, so there may be different Slide times. Only some instruments implement the tied note Slide facility, sensed by the first note being turned off just after the second note is turned on: Devil Fishes with MIDI In or MIDI In and Out, the Cyclone Analogic TT-303 Bass Bot and TB-303s/Devil Fishes with either the Sequentix MIDI Bass 303 or Quicksilver 303.</td><td>The Slide status of MIDI Out Notes is transmitted using tied Note On Off for Slide. This will be done according to the OR of:
MIDI In received Notes with Tied Note On Off – the new note begins before the previous note(s) end (assuming Parameter 4 = 1).
Slide due to a MIDI In received Control Change with the Controller number selected by Parameter 5: MIDI In Sustain-Slide Control Change.
In MIDI In Follow mode, the Slide signal to the Synthesizer is not affected by the Slide output of the TB-303's CPU (Internal Sequencer), which may be playing notes with or without Slide.
It may differ: The Synthesizer Slide signal is the OR of:
The MIDI In received Slide – the two items listed above, which drive MIDI Out Slide.
The signal from the Slide CV Input socket, when it is above about 2.3 volts.</td></tr>
<tr><td>What controls the Accent of MIDI Out notes?

Does this differ from the Accent signal which the Synthesizer runs from?</td><td colspan="2">The Accent signal which drives the Synthesizer, at the time the MIDI Out system samples it, which is at the start of MIDI Out notes, as mentioned above. This is the OR of :
The Accent signal created by the Internal Sequencer.
The Accent signal from the Accent CV Input socket.
The Accent button.
No – the MIDI Out notes' Velocities are selected by the same Accent signal as controls the Synthesizer's Accent.</td><td>The MIDI Out Accent is the same as that the Synthesizer runs from: the OR of:
The Accent signal received by the MIDI In signal, by comparing incoming note velocities with the threshold selected by Parameter 6.
The Accent signal from the Accent CV Input socket.
The Accent button.
During MIDI note reception, the MIDI In system overrides the Accent signal which may be created by the Internal Sequencer, such as if the Internal Sequencer is playing notes or has stopped on an Accented note.
No, they are the same.</td></tr>
</table>

MIDI In control of Velocity values for MIDI Out notes

All three MIDI Note Out modes use a common system for setting the velocity of notes.

When the Devil Fish is turned on, the **Velocity of non-Accented MIDI Out notes is 64**. This can be set to 1 and 127 by sending the machine a Control Change 20 on the Base MIDI In Channel (Parameter 0) with a value between 1 and 127.

When the Devil Fish is turned on, the **Velocity of Accented MIDI Out notes is 127**. This can be varied between 1 and 127 by sending the machine a Control Change 21 on the Base MIDI In Channel (Parameter 0) with a value between 1 and 127.

Reception of Control Changes for Controllers 20 and 21 *is not affected by whether the MIDI In system is currently receiving Note and Control Change messages* (page 20). Please see this page for a full description of what this affects, since "Note and Control Changes" does not give enough detail. Control Change messages for Controllers 20 and 21 are received at all times, since they affect the MIDI Out system, which is always active.

When such a Control Change is received – and assuming the MIDI In activity display of the Blue LED has not been disabled (by turning the machine on with the **TAP** button pressed and the **BACK** button not pressed – page 19) – the Blue LED will indicate this with a **bright 40ms flash**. There will be no flash for an Control Change messages for which the value in the message is 0.

These values only affect the MIDI Out notes – they do not alter the sounds produced by the Devil Fish synthesizer. The idea is that manual, automatic or algorithmic processes will send these messages to the Devil Fish in order to change the dynamics of sounds produced by slave MIDI instruments, including the possibility of changing these Velocity values from one note to the next. For instance, the Devil Fish could be outputting a fixed pattern of MIDI notes, some Accented and some not, and two LFO oscillators in some system such as *Max* or *Audio Mulch* could be sending Control Changes for Controller 20 and 21, so the sound on the slave device(s) is articulated by these LFOs, which need not be synchronised to each other or to the pattern.

Int Seq mode

The Internal Sequencer mode of generating MIDI Out notes performs the most important function of any TB-303 MIDI Out system: sending Note On and Off events in response to the output of the Internal Sequencer, complete with Accent and Slide. MIDI has no direct way of encoding Accent or Slide, so the MIDI Out system conveys Accent by altering the Velocity of the Note On events as described in the previous sub-section.

The transition between one note and the next with Slide ON is conveyed by sending the Note On for the new note immediately before the Note Off for the old note. This technique is widely recognised by slave instruments which have a Slide function, including the Devil Fish MIDI In system, the Devil Fish MIDI In and Out system and the Cyclone Analogic TT-303 Bass Bot.

Int Seq mode is selected if all of these conditions are true – a logical AND of the two following conditions:

- The Run/Stop signal at the Sync socket is On, which means the Run/Stop LED is On and the Internal Sequencer (the TB-303's CPU) senses that Run/Stop is On. The fully explained reason for this will be one of:
  - The dual sets of switch contacts inside the Sync Socket have not been opened, most likely due to there being no lead plugged into the socket. (If there is a lead plugged in then the shell must have been modified not to activate the switch, which disconnects the Internal Tempo system [Tempo oscillator and Run/Stop flip-flop, which is toggled by the Run/Stop button] from the Run/Stop and Clock pins of the Sync socket.) AND the Internal Tempo system's Run/Stop signal is On, due to the Run/Stop button having been pressed at some time in the past.
  - A lead is plugged into the Sync socket, opening the contacts of its double pole normally closed switch, so the Internal Tempo system's Run/Stop and Clock signals do not drive these pins of the Sync Socket AND this lead is carrying DIN/Roland Sync from some external device AND that device is driving the Run/Stop signal On.
  - A lead is plugged into the Sync socket, so the Internal Tempo system's Run/Stop and Clock signals do not drive these pins of the Sync Socket AND this lead is carrying MIDI signals AND the MIDI In system has Sync reception enabled (Parameter 7) AND the MIDI In system has received a Start or Continue message but not yet a Stop message. When all these conditions are true, the MIDI In system drives the Run/Stop pin of the Sync socket On, thereby driving the Run/Stop LED On (though if the power supply voltage is too low this LED will be dim or off), potentially driving this to external DIN/Roland Sync devices via the Sync Lead (see the Devil Fish site) or similar and driving Run/Stop On to the TB-303's CPU.
- The MIDI In system is not controlling the TB-303's DAC, Slide or Accent signals. This will be the case if either Note and Control Change reception is currently disabled (page 20), or if it is enabled, because since it was enabled (or the Devil Fish was turned on) there has not been any Note On events on the Base MIDI channel (Parameter 0), (or, if Dynamic Channel Switching is enabled, on the Effective MIDI In Channel) which resulted in the MIDI In sub-system playing a note. For instance, Note On events which, after transposition (Parameters 1 and 2), result in pitches outside the range supported by the MIDI In sub-system, will not cause the MIDI In sub-system to take control of the TB-303's DAC, Slide and Accent signals.

The purpose of Int Seq mode is to generate MIDI Out notes when the MIDI In system is not controlling the DAC etc. and when the Internal Sequencer is playing a Pattern in time with its source of Sync. In this mode, the MIDI Out sub-system uses the binary numbers sent to the DAC from the Internal sequencer, together with the state of Gate, Slide and Accent (as noted in the tables above) to generate MIDI Out notes. This does not involve measuring any voltages (the basis of Ext CV mode).

Generally, in the absence of MIDI In actively receiving notes and so driving the DAC, the MIDI Out sub-system will be in Ext CV mode rather than Int Seq mode when the user is doing either of these operations in Pattern Write mode:

- Entering pitches, with Pitch Mode LED On.

- Entering Timing (1/16th bar notes, tied 1/16th bar longer notes and 1/16th bar rests), while potentially altering Accent and Slide.

This is *generally* true because it is *generally* these operations which are being performed when Run/Stop is Off. The exception to the above principle is when these operations are initiated (as they must be) with Run/Stop Off and while these operations are in progress, Run/Stop (from whatever source is driving the Sync Socket pin and so the Run/Stop LED and the CPU = Internal Sequencer) goes On. When the Run/Stop goes On, the MIDI Out system switches from Ext CV mode to Int Seq mode.

So while Int Seq mode is intended for when the Internal Sequencer is playing patterns according to the Sync timing, under the abovementioned circumstances Int Seq mode will be used during these Pattern Write operations.

Ext CV mode

Ext CV mode makes the Devil Fish function as a **CV to MIDI Converter**. The most obvious use of Ext CV mode is to have the Internal Sequencer not playing any notes, by way of ensuring that Run/Stop (whatever its source) is Off and by controlling the Synthesizer via externally applied Pitch CV (plugged into the CV In socket) and Gate (plugged into the Gate In socket), with potential external control of Accent and Slide as well. Having Run/Stop Off is essential to this mode of use, because only when it is Off and MIDI In reception of Notes is inactive (see the tables and the sub-section above on Int Seq mode) will the MIDI Out system be in Ext CV mode.

In this mode, when the Gate signal goes On, the MIDI Out system measures the voltage which is present at the CV In socket's contact and decides which of the 1/12 volt semitone steps between 0.75 and 5.0 volts it is closest to. This measurement determines the note number of the resulting MIDI Out Note event, which is 45 (A1) for 0.75 volts to 96 (C6) for 5.00 volts.

In the simplest example of this mode's operation, this measurement of the CV In voltage is only done when the Gate signal goes On. After this measurement, the Accent signal is also read to determine which of the two of Velocity will be used for the MIDI Out Note On event. These two values default to 64 and 127, but both can be changed via MIDI In Control Changes for Controllers 20 and 21 respectively – see page 48.

The state of the Slide signal is not important when the Gate signal goes On, because Slide can only be applied when a new note directly replaces a currently On note.

If the CV In voltage changes while Gate remains On and Slide signal (the OR of: the Slide signal produced by the Internal Sequencer and the Slide signal from the Slide CV Input socket, when it is above about +2.3 volts) remains Off, the MIDI Out system will not notice, because it only measures the CV In voltage when both Gate and Slide are On. So if the CV In voltage is about 2 2/12 volts when the Gate goes On, the MIDI Out system will generate a MIDI Out Note on event for D above Middle C: note number 62. While the Gate signal remains on, and as long as Slide is Off, the CV In voltage can change in any way at all and the MIDI Out system will not take any action.

In Ext CV mode, if the Gate and Slide signals are On, the MIDI Out system continually measures the CV In voltage (from whatever is plugged into the CV In socket, or if nothing is plugged into this, from the Internal Sequencer's DAC). If it changes to a voltage which is classified as a different semitone than that of the currently playing

MIDI Out note, and if it stays in that voltage range for about **7 milliseconds**, then the MIDI Out system generates a new MIDI Out note with Slide. This involves a "tied-Note On Off" pair of messages: a Note On event for the new note is sent, with Velocity according to the current state of the Accent signal (see the centre-bottom cell of the second table above), followed immediately by the Note Off event for the MIDI Out Note which was previously On. For this brief time (2/3ms, while the two Note Off message bytes are transmitted with Running Status) the receiving device has two notes on at once. Devices, such as the Devil Fish MIDI In system the Devil Fish MIDI In and Out system and the Cyclone Analogic TT-303 Bass Bot, receive this as a command to switch to the new note, with Slide activated.

Extending the above example where CV In was 2 2/12 volts when Gate went On, a MIDI Out note number 62 note is currently On, Gate is still On and Slide is Off: if the CV In voltage changes to some other voltage, such as about 3.0 volts, nothing will happen. In this scenario, if Slide goes On, the MIDI Out system *will* measure the CV In voltage, and finding it different from that which generated the currently On MIDI Out note, it will send a Note On event with Slide (as described in the previous paragraph) to MIDI Out, for note number 72: C above Middle C.

To avoid spurious results, the MIDI Out system waits until the voltage is measured to match the one semitone voltage for a period of about **7 milliseconds** before generating a new Note event with Slide. Random or rapidly changing CV voltages could be used to generate corresponding notes, but only after the voltage remains within a single semitone range for 7 milliseconds. Since there are inaccuracies and noise in the system, the boundaries between one semitone range and the next are not precise. For instance, the range for Middle C is theoretically 2.0 volts +/- 1/24 volt: 1.958 to 2.042 volts. However, the thresholds may be different to this by a few millivolts and there may be a few millivolts of noise on the incoming voltage and/or the response of the MIDI Out system's Analogue to Digital Converter (ADC). If the CV In voltage stabilises close enough to one of these thresholds for the noise to cause the ADC's measurement to fall erratically on the semitone above and below the threshold, then it may never be measured in one or the other semitone zones for 7 milliseconds, so the new voltage may not be recognised when Gate and Slide is On. If the CV In voltage is close to such a threshold when Gate goes On, a single measurement is taken and the results of that measurement (which may be either of the two semitones) are used to generate the MIDI Out Note On event.

If, with Gate and Slide both On, the CV In voltage slews slowly – such as 1/12 of a volt every second, or 1/10 of a second, or as fast as 1/12 volt every 1/100th of a second – then (assuming there is no more than a few millivolts of noise in this signal) the MIDI Out system will measure it as being stable at every semitone voltage it traverses for 7ms or more. This will result in a Slide tied-Note On Off event for every such traversal. If the slave device (such as a TB-303 Devil Fish with MIDI In or MIDI In and Out or a Cyclone Analogic TT-303 Bass Bot) implements Slide, then, depending on the rate of transitions and the time-constant of the Slide in the slave device, the slave device will tend to produce a pitch which smoothly follows, with a slight delay, the smoothly changing CV In, to the extent that it traverses multiple semitones.

This Ext CV MIDI Out mode may be active when nothing is plugged into the CV In socket. In these circumstances – generally when the Internal Sequencer is in Pattern Write: Pitch mode or Pattern Write: Time mode – the MIDI Out system is measuring the voltage at the contact of the CV In socket, which is touching the NC (Normally Closed) terminal of the socket, because no lead is plugged into the socket. (In the DBCS section, I refer to such contacts in the two Audio/CV sockets as the "default contact". Both terms are valid, but I will retain the use of "NC" for the Pitch CV In socket on the rear panel. The NC terminal is driven directly by the DAC, without any buffer amplifiers. This is the raw 50k ohm impedance output of the DAC's R-2R resistor network. In these circumstances, the pitch of the MIDI Out notes will be determined by the notes the Internal Sequencer is playing, which will be due to Pitch mode note entry, or stepping through the notes in Pitch mode with the Tap button.

However, this point of measurement is the input to the Slide circuit, via the Slide pot. The high 50 k ohm impedance of the DAC may result in this voltage being affected by the TB-303's Slide circuit. If the Slide pot is fully clockwise, then the voltage to the MIDI Out system's ADC will hardly be affected by the Slide circuit. This will result in the MIDI Out system seeing a sudden step change from the old Note's voltage to the new Note's voltage, so it will produce a single Note On event with Slide.

Depending on how different the two notes' voltages are, and depending on how low (to the anti-clockwise) the Slide pot is set, it is possible that the ADC will receive a voltage from the DAC which is substantially affected by the TB-303's own Slide circuit. This could result in several Slide note events in a short time, following the Slide circuit, quickly arriving at the Internal Sequencer's new note. If you find the MIDI Out notes are affected in this way by the Slide pot, in Ext CV mode, then this is the explanation.

In principle the same would be true of external CV In voltages with similarly high impedances. However, most sources of voltage which are likely to be used to drive the CV In socket will have a much lower impedance, such as 100 ohms or less, and so be unaffected by the TB-303's Slide circuit, even when the Slide pot is set to 0. The TB-303 and so the Devil Fish's CV Out socket has a very low impedance of a few ohms. There is a 3.3k resistor between the CV In socket (where the signal to the ADC is taken from) and the Slide circuit. As long as the impedance of the external CV In signal is low, such as below 100 ohms, then this 3.3k ohm resistor means that the Slide circuit cannot substantially alter the voltage at this point.

MIDI In Follow mode

The MIDI Out system is in MIDI In Follow mode whenever Reception of Notes and Control Changes is enabled (page 20) and at least one Note On event has been successfully received. This will not be the case when the machine is first turned on, since while this Reception may be turned on, no Note On events can yet have been received.

To **turn Reception of Notes and Control Changes OFF**, and so to turn off MIDI In Follow mode (as described on page 20):

Hold down the BACK button.
Press and release the TAP button within a second or so.
While both buttons are pressed, the Blue LED will flash rapidly. After the Tap button is released the Blue LED will stay ON for 0.2 seconds and will then turn OFF.

Release the BACK button.

To **turn Reception of Notes and Control Changes ON**, which will cause MIDI In Follow mode to be used as soon as a Note On is successfully received (as described on page 20):

Hold down the TAP button.
Press and release the BACK button within a second or so.

While both buttons are pressed, the Blue LED will flash rapidly. After the Back button is released the Blue LED will stay ON for 0.8 seconds and will then turn OFF.

Release the TAP button.

MIDI In Follow mode is not like MIDI Thru – which replicates all MIDI In messages to the MIDI Thru socket. Nor is it like a "Soft Thru" in which some or all MIDI In messages are sent to MIDI Out, together with other messages which are generated purely to be sent to MIDI Out.

MIDI In Follow mode has the following functionality:

The note activity, with Accent and Slide, which are decoded from the MIDI In messages by the MIDI In system (including with Dynamic Channel Switching) and used to drive the TB-303, are replicated via MIDI Out.

This is not done by replicating MIDI In bytes to MIDI Out. MIDI In Follow mode generates its output by analysing the signals in the following dot points, which have one or more sources of control via MIDI In.

- Pitch information comes from the numbers sent by the MIDI In system (including if Dynamic Channel Switching is enabled) to the TB-303's 6 bit DAC. These are a function of the MIDI In Note On event note numbers and the current Transpose setting (Parameters 1 and 2). The current pitch is that of the most recently played note, or if that has been turned off, the most recently played note before that, up to a limit of 8 notes being on at once and then being turned off in any order. (Similar principles apply with Dynamic Channel Switching, which involves the Note activity of up to four adjacent MIDI In channels.)

  Therefore the pitch of the MIDI Out note events match the pitch the DAC will generate in the Synthesizer (if no lead is plugged into the CV In socket and if the Tuning pot is centred). If Transpose Enable (Parameter 1) is Up or Down (the default is Off) and Transpose Amount (Parameter 2) is non-zero (1 to 24 – and the default is 12), then these will be different note numbers to those of the MIDI In Note On messages.

- Note On and Off is determined according to the MIDI In systems drive of the Synthesizer's Gate, according to the OR of:

  - Gate On due to one or more Notes being On.

  - Gate On due to reception of a Control Change for Sustain-Slide, on the Controller number which matches Parameter 5. By default, Parameter 5 is 0, which means this facility is disabled.

- Gate On due to reception of Control Change 64 (Sustain).

  This Gate signal to the Synthesizer and to the MIDI Out system will be turned off (until one of the above turns it on again) due to the reception of a Control Change 120 or 123, both of which are All Notes Off commands.

- The Slide state of MIDI Out Note On messages is the OR of:

  - MIDI In received Notes with Tied Note On Off – the new note begins before the previous note(s) end (assuming Parameter 4 = 1).

  - Slide due to a MIDI In received Control Change with the Controller number selected by Parameter 5: MIDI In Sustain-Slide Control Change. The default for this is 0, which means this facility is disabled.

- The Accent state of the MIDI Out Note On messages is determined by how the Velocity of the most recently received MIDI In Note On event compares with the currently active threshold: 65, 80, 100 or 120, as determined by Parameter 6, with the default being 65.

  The "Accent state" is an internal concept to the MIDI In system. MIDI itself has no specific Accent facility. The non-Accented or Accented state of the most recently turned On MIDI In note (which is determined by comparing the Velocity of that note with the threshold selected by Parameter 6, which defaults to a threshold of 65) is used to select between two values, one for non-Accented and the other for Accented notes. These values default to 64 and 127 at power on, but can be changed at any time by MIDI In Control Changes 20 and 21 respectively (see page 48).

MIDI Out timing and other technical details

MIDI timing bytes (Start, Continue, Clock and Stop) can be interspersed with the status bytes and data bytes of the Note, Control Change and other MIDI messages.

In order to minimise delay in sending the timing bytes, the MIDI Out firmware inserts them in the output stream immediately, even when one or two Note On or Off messages are queued in the MIDI Out FIFO (First In First Out) buffer.

The next highest priority are the Note On and Note Off messages. When there is a pair of these occurring at essentially the same time – such as with On-Off for a tied-note Slide transition between two notes, or Off-On ending of the earlier note followed immediately by the new note – these are sent with Running Status. This means that a status byte is sent for the first event, then its two data bytes, then the two data bytes of the second event, without the need for sending a status byte for the second event. This saves 1/3 millisecond for the second event. Running Status is not used for isolated Note events or for repeated Filter Frequency Control Changes.

The measured delay times are all small enough to be of no musical concern:

- Int Seq mode: Gate On and Off from the Sequencer or external Gate In (including +4.0 volts or more into the Slide In socket) leading to Note On and Off events which last 1 msec – the delay to the start of these events is: 0.07 to 0.2 msec for Note On and 0.05 to 0.13 msec for Note Off.

- Ext CV mode: Gate goes On. 1 msec long Note On message (the three MIDI bytes take 1 msec to send) starts within 0.6 msec. Most of this time is required to measure the CV In voltage.

- Ext CV mode: Gate goes Off. 1 msec long Note Off message starts within 0.1 msec. Most of this time is required to measure the CV In voltage.

- Ext CV mode: Gate and Slide are On and CV In changes to a new stable voltage which is reasonably close to a semitone voltage: A Slide tied-Note On Off pair of messages (1.67 msec for the five bytes, with Running Status) is initiated between 7 and 11 msec after the change. (If the new voltage is close to the threshold between two semitone voltages, it may take longer due to the need for repeated consecutive measurements to match the same semitone.)

- In both Int Seq and Ext CV modes, the MIDI Out system correctly tracks a 50-50 squarewave Gate signal up to 400Hz, which is a 2.5 msec cycle time, while the system is also transmitting MIDI Clock bytes at the maximum tempo of the TB-303's internal Tempo oscillator: about 320 BPM, with Clock pulses every 8 msec. The theoretical maximum for the pairs of 3 byte messages is 520Hz. Frequencies much above 400Hz result in some On-Off cycles being ignored. There are no false Note On or Off events – every Note On event is followed by a Note Off event and vice-versa.

- Rising Clock pulse (from External DIN/Roland Sync or the Internal Tempo oscillator) to the start of the 0.3 msec MIDI Out Clock byte: 0.03 to 0.1 msec. These bytes have highest priority and may be inserted between bytes of the Note and Control Change messages.

Conventional serial MIDI, at 31,250 baud (bits per second) can convey up to 3,125 bytes per second. Each byte consists of 10 bits – one start bit, 8 data bits and one stop bit. Note On and Off messages are 3 bytes, so the maximum rate of notes which can be sent is 3,125 / = 520.83 per second. (With Running Status, where only the two data bytes of the messages are sent for Note events which are on the same channel, the maximum rate would be 3,125 / 4 = 781.25 per second.)

The fastest rate at which the Internal Sequencer can generate notes is one pair of On and Off messages per 1/16th of a bar. The internal Tempo oscillator's maximum speed is about 320 quarter-note beats per minute. This is 5.33 quarter-notes per second, which is 21.33 1/16th-notes per second.

Note rates in the hundreds per second cannot occur due to the Internal sequencer, and so can only arise due to Gate In pulses at this rate, due to MIDI In notes or perhaps due to MIDI Control Changes or Notes being sent into the Dynamic Channel Switching system, via Channel 15 or 16, which is described in the next section. While MIDI can transmit these messages, **many instruments cannot reliably receive note events in the hundreds per second**.

If the Devil Fish sends hundreds of MIDI notes per second, some slave instruments will not play all the notes. Some instruments may fail to operate normally, due to their firmware not coping with this input stream.

The Devil Fish MIDI In system (all versions) and MIDI In and Out system *can* reliably receive hundreds of notes per second. The Devil Fish synthesizer won't necessarily play distinct notes at such high rates. The VCA (volume) decay of each note is about 8 msec, which is 1/125th of a second. So if there were 200 notes a second, with 2.5 msec on and 2.5 msec off, the volume would only decay marginally before the next note starts. (In the unmodified TB-303, there is an 8 msec full volume delay before this 8 msec decay begins.)

Testing a MIDI In and Out system driving a MIDI In 1.04 system (the same performance is achieved with all Devil Fish MIDI systems), the following delay times were observed. Transmit and receive performance is not affected by using the Front Panel functions – using the Back and Tap buttons.

- Rising and falling edge of the Gate signal produced by the receiving Devil Fish was about 1.3 msec behind the rising and falling edge of the Gate In signal of the transmitting Devil Fish, in Int Seq and Ext CV modes, except for the rising edge in Ext CV mode which was about 1.8 msec.

- Jitter (variations in timing) was no more than 0.1 msec longer than this, except when MIDI Clock was being sent, in which case some edges could be delayed by up to 0.4 msec.

- Sync Clock leading edge (which the Internal sequencer uses to play a new note) in the receiving machine was delayed by 0.38 to 0.45 msec (jitter 0.7 msec) with respect to the leading edge in the transmitting machine when no other MIDI Out messages were present, such as Note events. With Note events running at the maximum rate of about 400 On and Off events per second, the delay time was 0.4 to 1.4 msec. With occasional Note or Control Change messages, the delay time is typically about 0.4 msec and occasionally up to 1.4 msec.

Slight variations in threshold voltage

The TB-303 Devil Fish Synthesizer has particular voltage thresholds for its inputs Gate, Slide and Accent. Internally, these signals are sensed by the MIDI Out sub-system which has its own threshold voltages.

In Int Seq and Ext CV modes, if the signals driving the Gate In, Accent In and Slide In sockets are robust square wave signals which go from 0 volts to well above these threshold voltages, then the MIDI Out messages will exactly reflect the behaviour of the Synthesizer. However, since the MIDI Out system and the Synthesizer have their own ways of determining whether these voltages are "On" or "Off", if you use voltages close to the threshold, you may find, for instance, the MIDI Out system playing notes which the Synthesizer does not play. The Gate In signal has a hard threshold for the MIDI Out system, though near the threshold, noise may cause erratic results. The Gate In signal to the Synthesizer does not have a completely hard-edge threshold.

For example, the following behaviour has been observed with these voltages:

- 0 to 2.87V: No action.
- 2.78V to 2.95V: Erratic activation of MIDI Out notes.
- 3.95V and above: Reliable activation of MIDI Out notes.
- 3.31V: Devil Fish 'e' LED starts to turn on, low volume sound is produced and the Gate Out socket produces about 2.0V.
- 3.36V: Devil Fish 'e' LED is fully on and volume is full, depending on the settings. However, a slow or fast transition to this voltage from 0V does not trigger the Main Envelope Generator.
- 3.37V: Main EG is activated somewhat for a quick transition from 0V to this voltage.
- 3.63V: Main EG is fully activated for a quick transition from 0V to this voltage.

Similarly, differences will exist between the voltages required at the Accent In and Slide In sockets for activating these functions of the Synthesizer and the MIDI Out system. The exact voltages of these thresholds will vary with temperature and between one machine and the next.

Ordinary use of the Gate In, Slide In and Accent In signal with square-edge 0 to +5V or more (up to +15V is fine) signals turns everything on and off at once. However, perhaps some fun can be had with modular synthesizer gear or other sources of voltages.

7 - Dynamic Bank/Channel Switching (DBCS)

Some parts of the following pages do not apply to this particular Devil Fish. In the printed manual, these are manually marked with an X. Those parts which do apply specifically to this Devil Fish are highlighted. Also, in the printed version of the manual, some pages which do not apply to this Devil Fish have been removed. These page numbers are listed on page 1. The PDF version has all these pages.

Please do not attempt to read this section in detail until you are familiar with most of what is documented on previous pages.

Special Power-Up procedure to enable DBCS MIDI features

The Devil Fish MIDI In and Out system only implements the MIDI features discussed in this section if the machine has been turned on in a special manner. Please see the section below: *Enabling and Configuring DBCS MIDI Features* on page 75.

Overview of DBCS

Dynamic Bank/Channel Switching is a set of firmware and hardware facilities which enables the Devil Fish to play notes from different patterns, with the switching between the patterns potentially occurring *during the pattern*, not just at the end of each pattern. Depending on which hardware options are installed, the control of this may include one, two or all three of:

- Manual operation of two toggle-switches.
- Two Audio or CV signals being sent into sockets on the left of the machine.
- MIDI In messages for a particular controller number and/or a set of four note numbers (keyboard keys, if played from a MIDI keyboard).

"Dynamic Bank Switching" (DBS) is an option for Devil Fishes with the 32 Bank Memory System. DBS involves the Internal Sequencer playing patterns from memory, and the dynamic (real-time control, rather than previously programmed) switching of the memory bank the Internal Sequencer accesses between four separate banks. This enables switching between four patterns, one in each of the memory banks, as the Internal Sequencer plays, since before playing each note, the Internal Sequencer reads from memory to find the pitch, Accent, Slide and timing details of each note. One form of DBS (Installation 2) does not involve the MIDI In and Out system.

"Dynamic Channel Switching" (DCS) is supported in several possible ways by the Devil Fish MIDI In and Out system. It is not supported by the Devil Fish MIDI In system. DCS works by enabling the MIDI In sub-system to switch dynamically between the notes on four MIDI In channels. So if an external sequencer plays four patterns on these four channels, DCS enables the switching between the patterns from one moment to the next.

"Dynamic Bank and Channel Switching" (DBCS) refers to a Devil Fish with both capabilities, which means it has the 32 Bank Memory system and the MIDI In and Out system – and suitable toggle-switches, input sockets and address bit inversion circuitry.

The term “Bank” in this context refers to banks of memory in the optional 32 Bank Memory system. **This Devil Fish does / does not have the 32 Bank Memory system.** Switching Memory Banks when the Internal Sequencer is playing a pattern will cause the Internal Sequencer to switch between patterns in different memory banks, including in middle of patterns, not just when a pattern ends.

The term “Channel” refers to the MIDI In (Receive) channel. If the MIDI In stream, from an external sequencer, consists of two to four different patterns on a contiguous range of two or four MIDI channels (such as 1 and 2; 5 and 6; 1, 2, 3 and 4; or 8, 9, 10 and 11) then when the MIDI In sub-system within the MIDI In and Out system is receiving and playing notes (to the Devil Fish synthesizer, to any other devices via CV, Gate and Accent Out and/or by MIDI Out) then the Dynamic Channel Switching system can be used to make the MIDI In sub-system rapidly change its effective receive channel between these channels.

DBCS is a general term which covers five several specific types of installation of modifications in the TB-303 Devil Fish (Installations 2 to 6 in the table below). Four of these installations (3 to 6) involve the MIDI In and Out system.

On the next page is a table showing the possible combinations of installed features. The line which applies to this particular Devil Fish is highlighted in the printed version of this manual. “na” means this hardware option is not applicable to the combination of options mentioned to the left.

If a Devil Fish **does not have the MIDI In and Out system** (it may or may not have the MIDI In system) **AND it has the 32 Bank Memory System WITH the additional hardware for Dynamic Bank Switching (two input sockets on the left, two LEDs next to the left-most two memory bank switches – and perhaps an Enable/Disable toggle-switch)** then **only the Memory Bank part** of the DBCS system is operational. In this case (**Installation 2** in the table below, DBS = Dynamic Bank Switching), please see separate documentation for this in the version of the 32 Bank Memory system manual which includes Dynamic Bank Switching. The manual you are reading now does not apply to such Devil Fishes.

Installation	MIDI In & Out?	32 Bank Memory system?	Two 3.5mm Audio or CV Input sockets, with detector circuits & XOR gates to potentially invert the output bits of 2 switches:		Dynamic Bank and/or Channel Switching		MIDI In Notes and/or Control Changes on Channel 15 or 16 can drive the default pins of the two 3.5mm Audio / CV input sockets, to drive the detector and inverter circuits if nothing is plugged into these sockets.
			Two left-most Memory Address switches	Two switches for Dynamic Channel Switching	Dynamic Memory Bank switching, via leftmost two Memory address switches	Dynamic MIDI In Channel switching	
0	None or MIDI In	No	na	na	No	No	No
1	None or MIDI In	Yes	No	na	No	No	No
2 DBS	None or MIDI In	Yes	Yes	na	Yes	No	No
3 DCS	MIDI In & Out	No	na	No	No	Yes, but there are no 3.5mm inputs, LEDs or toggle-switches.	No
4 DCS	MIDI In & Out	No	na	Yes	No	Yes, via the two 3.5mm sockets, LEDs and toggle-switches.	Yes
5 DCS	MIDI In & Out	Yes	No	No	No	Yes, but there are no 3.5mm inputs, LEDs or toggle-switches.	No
6 DBCS	MIDI In & Out	Yes	Yes	na	Yes	Yes, via the two 3.5mm sockets, LEDs and the two leftmost Memory address toggle-switches.	Yes

If a Devil Fish **has MIDI In and Out** (so this manual applies to it), **does NOT have the 32 Bank Memory System and it does NOT have the separate set of two 3.5mm sockets, two LEDs and two toggleswitches** (which are used for Installation 4) then this is a plain MIDI In and Out system: **Installation 3** in the table above (DCS = Dynamic Channel Switching). MIDI In Channel switching is driven directly by the two bits derived from MIDI In Channel 15 or 16 notes and or Control Changes, and this is applied within the firmware – without going to the default pins of 3.5mm sockets, through detector circuits with their indicator LEDs, to potentially invert switch outputs, since none of these exist.

Note for **Installation 3** and **Installation 5**:

Since there are no toggleswitches or LEDs, these bits are not visible in any way – so care will be required to use this facility. This generation of two bits from MIDI In channel 15 or 16 notes and/or control changes will only occur if the machine is turned on in a special way (see the section below: *Enabling and Configuring DBCS MIDI Features*), so this facility can't cause confusion by operating when not explicitly enabled.

If a Devil Fish **has MIDI In and Out** (so this manual applies to it), **does NOT have the 32 Bank Memory System and DOES have the additional hardware to support Dynamic Bank/Channel Switching (two input sockets on the left, and two LEDs above two specially installed toggleswitches –** column 5 of the table above – **and perhaps an Enable/Disable toggleswitch)** then this machine supports **only MIDI In Channel switching: DCS**. This is **Installation 4** in the table above (DCS = Dynamic Channel Switching).

If a Devil Fish **has MIDI In and Out** (so this manual applies to it) **AND the 32 Bank Memory System, but NOT the additional hardware to support Dynamic Bank/Channel Switching** (as mentioned in light blue in a paragraph above regarding Installation 2) then this machine supports **only MIDI In Channel switching, without any LEDs or Switches**. The MIDI In Channel switching is driven directly by the two bits derived from MIDI In Channel 15 or 16 notes and or Control Changes, and this is applied within the firmware – without going to the default pins of 3.5mm sockets, through detector circuits with their indicator LEDs, to potentially invert switch outputs, since none of these exist. This is **Installation 5** in the table above (DCS = Dynamic Channel Switching). The MIDI behaviour of this is identical to that of **Installation 3**. Please see the note above regarding these installations.

If a Devil Fish **has MIDI In and Out** (so this manual applies to it) **AND it has both the 32 Bank Memory System WITH the additional hardware to support Dynamic Bank/Channel Switching** (two input sockets on the left, two LEDs and perhaps an Enable/Disable toggleswitch, as mentioned in light blue in a paragraph above regarding Installation 2) then this machine supports **both Memory Bank switching and MIDI In Channel switching**. This is **Installation 6** in the table above (DBCS = Dynamic Bank and Channel Switching).

The MIDI In Channel 15 or 16 note and Control Change capability mentioned in the right-most column of the table above is used for **MIDI In control of the default contact of the two 3.5mm sockets** (**Installation 4** and **Installation 6**) and for the direct, within the firmware (without input sockets, detector circuits, LEDs or switches) control of Dynamic Channel Switching (**Installation 3** and **Installation 5**). These can also be used in (**Installation 4** and **Installation 6**) to directly drive Dynamic Channel Switching if Parameter 9 is set to a value of 1 or 2. (According to the terminology of diagrams below, this adds the `FE` bits to the `HG` bits directly within the firmware, rather than using the default contacts of the sockets to drive the detector circuits and XOR gates.)

The documentation for Dynamic Bank/Channel Switching is necessarily complex. However there is no need to read about or understand all of it in order to use **the simplest and generally most important capability of the DBCS system in Installation 4 and Installation 6: using one or two audio or CV signals to dynamically alter which memory bank the Internal Sequencer is playing from, or to dynamically switch MIDI In reception between four contiguous MIDI In channels**.

Initial explanation of DBCS - Installations 4 and 6

Installation 4 is the same as **Installation 6** except that there is no 32 Bank Memory system and so no dynamic switching of Memory Banks. This section explains **Installation 6** with notes on how **Installation 4** differs.

All three types of installations **2**, **4** and **6** can be equipped with an optional **Enable/Disable Toggle-switch** which enables or disables the two +1.15 volt Audio/CV Detector circuits. The inputs of the Detector circuits are two 3.5mm sockets on the left side of the machine, and the circuits drive two LEDs and the inputs of two XOR (exclusive OR) logic gates which invert the bit produced by their matching toggle-switch for the purposes of selecting one of the 32 memory banks and/or for selecting one of four MIDI In channels. If the switch is in the centre position, these Detector circuits are disabled. If the swith is in the up or down position, the Detector circuits are enabled. The down position is momentary – the toggle spring-returns to centre. This optional Enable/Disable Toggle-switch is not shown on the data flow diagrams below.

The best place to start this explanation is with the **32 Bank Memory system**, although on its own, this does not involve Dynamic Switching.

The 32 Bank Memory system has five address bits which control which one of the 32 banks is currently accessible (for reading and writing) by the TB-303's CPU. (We use the term CPU for brevity – it is actually a complete microcontroller chip, of which one part is a 4-bit CPU.) This part of the explanation assumes that the TB-303's Internal Sequencer (implemented in the TB-303 CPU's firmware) is playing a pattern from the memory system. (The original memory of a TB-303 is three static RAM chips, each with 1024 4-bit locations. The 32 Bank system uses three larger chips which behave like 32 separate sets of these three 1024 x 4 bit chips.)

While playing the pattern, when it is time to play the next note, the TB-303 CPU looks into memory for the pitch, length, accent and slide data of the next note in a particular pattern number 1 to 8, A or B, in a Pattern Group I, II, III or IV. In a normal TB-303, or a Devil Fish without extra memory, there is a single bank of memory, with 8 x 2 x 4 = 64 patterns. With the 32 Bank Memory system, there are 32 independent banks of 64 patterns, with each bank also containing the data for the lengths and pre-scales of these patterns and all the data for tracks.

The 32 Bank Memory system has a row of four toggle-switches, plus a fifth toggle-switch which is associated with a pushbutton switch. Each toggle-switch produces a single address bit, which can be in the 0 or 1 (low or high) state, according to whether the switch is down or up respectively. The bit produced by the fifth toggle-switch can be *inverted* by pressing the pushbutton. Normally, when the pushbutton is not pressed, the bit follows the position of the fifth switch like the others:

Pushbutton not pressed: Down: 0 Up: 1

However, when the pushbutton is pressed, the address bit follows the opposite pattern:

Pushbutton pressed: Down: 1 Up: 0

The five address bits are numbered, left to right, 4 (for the fifth toggle-switch and its inverting pushbutton), 3, 2, 1 and 0. When numbering the banks using this binary number system, we give each bit n a weight of 2^n, so that, for instance, the third address bit from the left, bit 2, has a value of 2 squared: $2^2 = 4$. On this basis, the 32 banks which are selected by the five address bits are numbered decimal 0 to 31:

```
Bit number >>> 4 3210          Weight >>>>> 16 8421

0 0000 =  0     0 1000 =  8     1 0000 = 16    1 1000 = 24
0 0001 =  1     0 1001 =  9     1 0001 = 17    1 1001 = 25
0 0010 =  2     0 1010 = 10     1 0010 = 18    1 1010 = 26
0 0011 =  3     0 1011 = 11     1 0011 = 19    1 1011 = 27
0 0100 =  4     0 1100 = 12     1 0100 = 20    1 1100 = 28
0 0101 =  5     0 1101 = 13     1 0101 = 21    1 1101 = 29
0 0110 =  6     0 1110 = 14     1 0110 = 22    1 1110 = 30
0 0111 =  7     0 1111 = 15     1 0111 = 23    1 1111 = 31
```

If all the five toggle-switches are down, and the pushbutton is not pressed, then the CPU will read the next note data from Bank 0. By manipulating the toggle-switches as the pattern plays, it is possible to make the machine play notes from various banks.

Installation 2 in the table several pages above involves extra hardware which enables two external signals to invert the address bits 3 and 2, which are produced by the leftmost two toggle-switches of the set of four.

This photo shows the standard 32 Bank Memory system switches (four plus one toggle-switches and a red push-button), with the two 3.5mm input sockets and the two LEDs above the switches for address bits 3 and 2. The centre-off toggle-switch to the right of the Tempo knob is not associated with the DBCS system in this machine – it is the Audio in to Filter Enable switch. However, this is the approximate location of where this and the optional DBCS Enable/Disable switches are located. This photo depicts the appearance of the controls for **Installation 2** and **Installation 6**.

The external signals can be a "Control Voltage" (CV) or an audio signal. There are two 3.5mm mono sockets on the left of the Devil Fish, and these are coupled to two identical circuits which detect the input voltage and when activated, both drive a LED On and *invert* the address bit was produced by the toggle-switch, in a manner similar to how the red pushbutton being pressed inverts address bit 4 bit resulting from the fifth toggle-switch.

Each detector circuit senses its input voltage going above approximately +1.15 volts. The exact threshold voltage will be between 1.05 volts and 1.25 volts, with these extremes only likely to be reached in very hot or cold conditions respectively. This voltage is chosen so it can be reliably **turned off** with a **1.0 volt** signal from a MIDI to CV converter. The TB-303 (including the Devil Fish) produces 1.0 volts from its CV out socket, when playing the lowest C of the Internal Sequencer's range.

This threshold and its +/- 100 millivolt tolerance means that the input can be reliably **turned on with 1.25 volts**, which a MIDI to CV converter can produce in response to a note event 3 semitones above that which produces 1.0 volts. The TB-303 (including the Devil Fish) produces this voltage from its CV Out socket when it is playing the D# in the lowest octave of the Internal Sequencer's range. Each semitone is represented by 1/12 of a volt = 0.08333 volts.

This approximately 1.15 volt threshold can also be activated by the positive part of the waveforms of reasonably high level audio signals. The input of each detector circuit is DC coupled with an input impedance of about 100k ohms, so the peak detection will still work if the drive is capacitively coupled.

Within a fraction of a millisecond of the input voltage going above the approximately 1.15 volt threshold, the detector is activated and **remains activated for about 33 msec**. This means that even a narrow positive pulse waveform which reaches about +1.15 volts will turn the detector on continually, as long as its frequency is above about **30Hz**. The input can handle +/- 15 volts. There's no problem feeding these inputs with a continually high +15 volt CV, or any audio or CV in this range. (It is probably fine to go to +/- 30 volts or so, but +/- 15V is the range of most modular gear, and of line level signals in studios.)

Audio signals which extend to +1.15 volts are commonly found in studios when the volume setting is maximised. Microphones and electric guitars generate smaller signals, but some sythesizers can generate signals of this magnitude. The TB-303, Devil Fish and TT-303 Bass Bot generally do not create signals with positive peaks in excess of +1.15 volts, so it will often be necessary to send audio signals through a pre-amp, effects box or a mixer channel in order to activate these detector circuits.

One or two audio or CV signals can be used to *dynamically* alter the memory bank the Internal Sequencer is playing from. "*Dynamic*" in this context means as a result of external audio or CV signals, not just as a result of manual actions on the toggle-switches.

The above is a complete description of **Installation 2**, which does not involve MIDI in any way, and to which this manual does not apply. (See DF-32-Bank-Mem-DBS-Manual.pdf.)

Installation 6 differs from **Installation 2** due to the addition of two features, which only operate after the Devil Fish has been turned on in a special manner (see the section below: *Enabling and Configuring the DBCS MIDI Features*, page 75 where these are repeated):

1 - The Devil Fish MIDI In and Out microcontroller can **sense the potentially inverted bits from two switches**. These two bits can be used to **alter the MIDI In Channel** which is used to play notes on the Devil Fish synthesizer between four MIDI In channels: the Base MIDI In Channel and this channel plus 1, 2 or 3. This is Dynamic Channel Switching (DCS), and is only enabled when User Definable Parameter 9 (page 76 and later) is set to 1, 2, 4 or 5.

2 - The Devil Fish MIDI In and Out microcontroller can receive, on **channel 15 or 16**, messages involving particular note numbers (see Keysets below – page 80) and/or a particular Control Change number (also page 80), to generate two bits: **FE** in the diagrams below. These **two FE bits are used to drive the default contacts of the two 3.5mm input sockets**. The default contact drives the signal the socket sends to the detector circuit when nothing is plugged into the socket. This means that one or both address bit inversion circuits can be driven by bits derived from MIDI In Channel 15 or 16 messages, which in turn might be created by an external sequencer and/or a manually operated MIDI keyboard.

    If User Definable Parameter 9 is set to 0, 1 or 2, this disables drive of the default pins of the 3.5mm Audio/CV Input sockets. When it is set to 1 or 2, the two bits just mentioned (**FE** in the diagrams below) are added to the **HG** bits received from the XOR gates which potentially invert the bits from the two switches.

Generally, the Devil Fish with MIDI In and Out is playing notes generated by one of:

a - The TB-303's Internal Sequencer, which is the main function of the TB-303's CPU.

b - The MIDI In sub-system taking control of the internal DAC and the Gate signals (and so preventing the Internal Sequencer from controlling these) to play notes which are being received from MIDI In.

In fact, it is possible for both processes to be active, with the DAC being controlled by the MIDI In system, but with Gate being driven by the OR of MIDI In notes; external Gate input; the external Slide input if it is above +4.0 volts; and the Internal Sequencer's Gate output. For simplicity in this manual, we will assume that only one of the above sources of note activity is working at any one time.

The first feature (1) above does not affect the Internal Sequencer's behaviour of playing notes from different memory banks due to dynamic inversion of address bits 3 and 2. However, it can affect the notes played by the MIDI In sub-system in the following manner. x indicates that the state of these memory banks address bits do not affect the MIDI In sub-system.

```
    Bit number >>> 4 3210       MIDI In sub-system receives
                                notes on a Channel which is
                                the Base MIDI In Channel
                                (parameter 0) plus:
Address bits     {  x 00xx      0
after potential  {  x 01xx      1
inversion        {  x 10xx      2
                 {  x 11xx      3
```

The simplest example is as follows. This assumes that if there is an optional Enable/Disable Switch for the Detector circuits (see page 62) that this is up or down, which enables these circuits and so the inversion of address bits. This example also assumes that the MIDI functions of DBCS have been enabled by the special turn-on procedure (see page 75: *Enabling and Configuring the DBCS MIDI Features*).

The toggle-switches for bits 3 and 4 are down, so they produce their two address bits as `00`. If neither of the inversion circuits are activated (which means that both their LEDs will be off), then the final state of these address bits to the memory system, and as inputs to the MIDI In sub-system, will be `00`. If the current value of Parameter 0 (Base MIDI In channel – see page 35) is 1, then the MIDI In sub-system will receive notes on Channel 1.

Inserting a signal of more than about +1.15 volts into the input socket on the left of the Devil Fish (the one nearer the front), which is for the inversion circuit for bit 3 (the leftmost toggle-switch of the row of four) will cause the `0` bit produced by the switch to be inverted to **`1`**. This will cause the MIDI In system to play notes from Channel 3 instead, since the MIDI In sub-system senses **`1`**`0` as the potentially inverted bits 3 and 2. **`1`**`0` binary is 2 decimal and 1 + 2 = 3. Other examples can easily be imagined. For instance, if the Base MIDI In Channel was set to 7, then by manipulating the toggle-switches for bits 3 and 2, and/or by inserting signals into the sockets for the Detectors and bit inversion circuits, the inversion circuits will produce, at different times, the bits `00`, `0`**`1`**, **`1`**`0` and **11**, which are decimal 0, 1, 2 and 3 respectively. The MIDI In sub-system will then, at different times, receive notes from Channels 7, 8, 9 or 10. Below, we refer to the result of this addition of 0, 1, 2 or 3 to the Base MIDI In Channel number as the *Effective MIDI In Channel number*.

This addition of 0, 1, 2 or 3 to a MIDI In Channel number 1 to 16 wraps around at 17. So if the Base MIDI In Channel was set to 15, the four potential effective MIDI In channels would be 15, 16, 1 and 2. The dynamic selection of MIDI In channel for notes does not alter the reception of Control Changes for Filter Frequency and other purposes, which continue to be received on the Base MIDI In Channel (User Definable Parameter 0, page 35).

Installation 4 does not include a 32 Bank Memory system. It consists of the same firmware and hardware features as are listed above in points 1 and 2 for **Installation 6**. Since there is no set of five toggle-switches, this configuration has two toggle-switches which perform the roles of the switches for address bits 3 and 2. **Installation 4** is purely for dynamic switching of MIDI In channels (DCS), using two toggles-witches and two Audio / CV input sockets, with detector circuits and LEDs.

The exact details of MIDI reception and the generation of the two bits for the default signals of the two 3.5mm input sockets are described in subsections below: *Data flow for Installation 4* and *Data flow for Installation 6.*

Data flow for Installations 3 and 5

The following diagram depicts the signal flow for the two installations which involve the MIDI In and Out system but do not have 3.5mm input sockets, Detector circuits, LEDs or toggle-switches. These are **Installation 3** and **Installation 5**. **Installation 5** has the 32 Bank Memory system, so it has toggle-switches for the memory address, but there is no connection between that system and its switches and the MIDI In and Out system's ability to switch MIDI In channels for notes, in response to receiving note and/or Control Change events on channel 15 or 16.

These MIDI features only operate if the machine has been turned on in a special manner. Please see the section below: *Enabling and Configuring DBCS MIDI Features* (page 75) AND if User Definable Parameter 9 is set to 1, 2, 4 or 5. (For Installations 3 and 5, setting 4 has he same meaning as setting 1: DCS is enabled, defaulting to Immediate mode and setting 5 has the same meaning as setting 2: DCS is enabled, defaulting to Delayed mode.

Diagram depicting data flow for Installations 3 and 5

```
Note events ("keys" in some of the following descriptions)
are received on the currently selected channel 15 or 16
(Parameter 10) which match one of the 8 keys in the currently
selected Keyset (Parameter 10).  When one or more of these keys
are On, the highest priority of them sets two things:

  1 - A single bit which determines whether MIDI In Channel
      switching occurs in the Immediate or Delayed mode.  This
      overrides the default Immediate/Delayed setting of
      Parameter 9, which remains in force only until any one of
      the keys in the currently selected Keyset is turned On.

  2 - Two bits BA - 00, 01, 10 or 11 (0, 1, 2 or 3) which are added
      to a similar two bits generated by the next stage. ------>---\
                                                                   |
If Parameter 11 is set to a value 1 to 10, and if a Control Change |
for this Controller is received on the currently selected Channel  |
15 or 16 (Parameter 10), then the 0 to 127 range of the value of   |
this Control Change is reduced to a 0 to 3 range, which is         v
00, 01, 10 or 11 binary.  These bits DC ----->--------\            |
                                                      |      BA -<--/
                                                      |    +
are added with wraparound at 4 to produce             \---> DC
two bits FE (0 to 3 decimal).                            = FE ->-\
                                                                 |
                                                         HG -<-/
These bits, here relabelled HG (0 to 3 decimal), are     +
added to the 1 to 16 decimal Base MIDI In Channel ------> BMCH
number (Parameter 0, page 35) with wraparound at        = EMCH
17.  The resulting number, 1 to 16, is the 4 bit
Effective MIDI In Channel EMCH number, on which
Note events will be received for playing the
Devil Fish synthesizer and for driving Note
events to MIDI Out.  For instance, if BMCH = 5,
then Note and/or Control Changes on the currently
selected MIDI In Channel 15 or 16 can alter the
channel on which notes are received to 5, 6, 7 or 8.
```

Installation 3 and **Installation 5** have no 3.5mm input sockets, no Detector Circuits, no LEDs and no toggle-switches which are involved in these MIDI functions.

Data flow for Installation 4

The two full-page diagrams which follow depicts the signal flow for **Installation 4** which has **no 32 Bank Memory system**, but which has two 3.5mm input sockets for Audio or CV inputs, two Detector Circuits, two LEDs and two toggle-switches. Each 3.5mm socket has a normally closed contact, depicted below as:

```
                        *-->--\ Main contact
Default contact --->--*       \    /---->--- Output of socket
                               \  /
Plug connects and lifts ====>   \/
```

where the lower (default) contact, which is physically stationary, can be driven by a signal on the left – one of the two bits **FE** created by the MIDI In sub-system, based on Note and/or Control Change messages received on Channel 15 or 16. (These MIDI features only operate if the machine has been turned on in a special manner. Please see the section below on page 75: *Enabling and Configuring DBCS MIDI Features*.)

When nothing is plugged into the socket, the contact is closed and drives any such default signal to the main contact of the socket, which drives the input of the +1.15 volt Detector Circuit. When a plug is inserted into the socket, the main contact (depicted by the large V) is lifted up, opening the contacts, so the main contact is driven only by whatever signal is applied via the inserted plug.

The first full-page diagram depicts the system working with the MIDI In sub-system driving two bits **FE** to the default contacts of the Audio/CV Input sockets. The second full-page diagram depicts these bits being used inside the MIDI In sub-system's firmware to affect the Effective MIDI In Channel directly, without driving the default pins of the sockets.

The toggle-switches depicted in these diagrams are the left and right toggle-switches of a pair which are installed to give hands-on control of MIDI In Channel switching, together with potential inversion of their bits if the Detector Circuits are activated by an approximately +1.15 volt or greater signal on their inputs. That signal could come from an external source via a plug – or if nothing is plugged into the 3.5mm socket, it could come from the MIDI In system driving bits **F** or **E** (for the left and right switches respectively) to a voltage above +1.3 volts, which will activate the detector circuit so it produces a high output, which we depict with a binary 1.

The potential inversion of the bit produced by each switch is performed by an Exclusive OR (XOR) logic gate, one of four such gates in a 14 pin integrated circuit. This is hardware, not something occurring in the MIDI In and Out system's firmware. Each such gate produces a high (1) output when only one of its two inputs is high. (An ordinary OR gate produces a high output when one or more of its inputs are high.) The XOR gate's truth table is as follows, for the four combinations of possible states on the two input terminals:

Input bits		Output bit
0	0	0
0	1	1
1	0	1
1	1	0

For instance, we can think of the left input bit column representing the first input of the XOR gate, driven by a toggle-switch, where low and high mechanical positions of the toggle-switch create low and high voltages (0 and +5 volts internally) representing `0` and `1` respectively. We can think of the second input being the output of the Detector Circuit which senses whether the Audio or CV input is above about +1.15 volts. If it is above this threshold, the output of the detector circuit is high, represented here by a `1`. If the input signal has been below threshold for more than about 33 msec then the detector circuit will be off (`0`) and so will the corresponding LED. Then, the first and third rows above apply: the output of the XOR gate (the address bit inversion circuit) is the same as its input from the toggle-switch – the bit is not inverted. If the input signal is above about +1.15 volts, the detector circuit will be activated (`1`) and the LED will be on. This means the second and fourth rows apply, and the toggle-switch states of `0` and `1` are inverted to `1` and `0` respectively.

Note: the diagrams referred to in the next paragraph are only present in the printed version of this manual if it is for a Devil Fish with Installations 4 or 6:

The next two diagrams depict the operation of Installation 4 with MIDI In features which only operate if the machine has been turned on in a special manner (described the section below, on page 75: *Enabling and Configuring DBCS MIDI Features*) AND if User Definable Parameter 9 is set to 4 or 5 (first diagram below) or 1 or 2 (second diagram below).

Installation 4 with default contact drive enabled: Parameter 9 = 4 or 5

Note events (“**keys**” in some of the following descriptions) are received on the currently selected channel **15 or 16** (Parameter 10) which match one of the 8 keys in the currently selected Keyset (Parameter 10). When one or more of these keys are On, the highest priority of them sets two things:

1 - A single bit which determines whether MIDI In Channel switching occurs in the **Immediate or Delayed mode.** This overrides the default Immediate/Delayed setting of Parameter 9, which remains in force only until any one of the keys in the currently selected Keyset is turned On.

```
  2 - Two bits BA - 00, 01, 10 or 11 (0, 1, 2 or 3) which are added
      to a similar two bits generated by the next stage. ------>---\
                                                                    |
If Parameter 11 is set to a value 1 to 10, and if a Control Change |
for this Controller is received on the currently selected Channel  |
15 or 16 (Parameter 10), then the 0 to 127 range of the value of   |
this Control Change is reduced to a 0 to 3 range, which is         v
00, 01, 10 or 11 binary.  These bits DC ----->--------\            |
                                                       |     BA -<--/
                                                       |    +
are added with wraparound at 4 to produce two          \-->  DC
bits FE (0 to 3 decimal).  These FE bits drive             = FE
the default contacts of the two inputs sockets:               |
                           /----<----/----------<------------/
                           |         |
                           |         E
                           |         | *-\         1.15 volt
Rear (right) 3.5mm         |         \-*  \     /-->-DETECTOR--\--------> Right
Audio/CV                   |               \   /     Right     |          LED
Input Socket Ext sig. ===================>  \/       *          |
Affects bit G.             |                                   v
                           F                                   |
                           |                                   |
                           | *-\         1.15 volt             |
Front (left) 3.5mm         \-*  \     /-->-DETECTOR--\-------------> Left
Audio/CV                         \   /     Left      |         |     LED
Input Socket Ext sig. =========>  \/       *         |         |
Affects bit H.                                       v         v
                                                     |         |
              Right Toggle-switch  --->------------------>--\  |
              Affects bit G.                         |      |  |
                                                     |      XOR
     Left Toggle-switch  --->------------------>---\ |       |
     Affects bit H.                                | |       |
                                                   XOR       |
  * The optional Detector Enable/Disable Switch     |        v
    is not shown.                                   \------> HG
These bits HG (representing 0 to 3 decimal) are            +
added to the 1 to 16 decimal Base MIDI In Channel ----->  BMCH
number (Parameter 0, page 35) with wraparound at        = EMCH
17 to 1.  The resulting number (1 to 16) is the
Effective MIDI In Channel EMCH number, on which Note events will be received
for playing the Devil Fish synthesizer and for driving MIDI Out.
```

For instance, if BA = 0**1** and DC = 0**1** then FE = **1**0, driving the Front (left) Socket’s default contact high. If no plug was inserted into either socket, the Left and Right Detectors and LEDs would be On and Off respectively (**1**0). If both switches were down (00) the left XOR gate would invert the left switch bit to **1** making **HG** = **1**0 (2 decimal) and so making **EMCH** = **BMCH** + 2. If a signal greater than about +1.15 volts was plugged into the Rear socket, this would turn on the Right Detector too, so the detector outputs would be **11**, inverting switch bits 00 to **11** (3 decimal), so **EMCH** = **BMCH** + 3. Now, raising the left switch would mean **1**0 XOR **11** = 0**1**, so **EMCH** = **BMCH** + 1.

Installation 4 with default contact drive disabled: Parameter 9 = 1 or 2

Note events (“**keys**” in some of the following descriptions) are received on the currently selected channel **15 or 16** (Parameter 10) which match one of the 8 keys in the currently selected Keyset (Parameter 10). When one or more of these keys are On, the highest priority of them sets two things:

1 - A single bit which determines whether MIDI In Channel switching occurs in the **Immediate or Delayed mode.** This overrides the default Immediate/Delayed setting of Parameter 9, which remains in force only until any one of the keys in the currently selected Keyset is turned On.

```
  2 - Two bits BA - 00, 01, 10 or 11 (0, 1, 2 or 3) which are added
      to a similar two bits generated by the next stage.  ------>---\
                                                                    |
If Parameter 11 is set to a value 1 to 10, and if a Control Change  |
for this Controller is received on the currently selected Channel   |
15 or 16 (Parameter 10), then the 0 to 127 range of the value of    |
this Control Change is reduced to a 0 to 3 range, which is          v
00, 01, 10 or 11 binary.   These bits DC ----->--------\            |
                                                       |     BA -<--/
                                                       |   +
are added with wraparound at 4 to produce two          \-->  DC
bits FE (0 to 3 decimal).  These FE bits are               = FE
added to the HG bits to set the KI bits                        \
                                                                \
                                     | *-\           1.15 volt   |
Rear (right) 3.5mm                   \-*   \    /-->-DETECTOR--\-------> Right
Audio/CV                                    \  /     Right     | |      LED
Input Socket Ext sig. ===================>   \/      *         | v
Affects bit G.                                                 v |
                           |                                   | |
                           | *-\           1.15 volt           | |
Front (left) 3.5mm         \-*   \    /-->-DETECTOR--\-------------> Left
Audio/CV                          \  /     Left      |         | |   LED
Input Socket Ext sig. =========>   \/      *         |         | v
Affects bit H.                                       v         v |
                                                     |         | |
              Right Toggle-switch  ---->------------------>--\ | |
              Affects bit G.                         |       | | |
                                                     |       XOR |
     Left Toggle-switch  --->------------------>---\ |        |  |
     Affects bit H.                                | |        |  |
                                                   XOR        |  v
  * The optional Detector Enable/Disable Switch     |         v  |
    is not shown.                                   \------> HG  |
                                                         +       /
                                                             FE-/
Bits HG and FE (both representing 0 to 3 decimal) are    =   KI
added with wraparound at 4 to 0, to produce bits KI
(also representing 0 to 3 decimal), which is added to    +
the 1 to 16 decimal Base MIDI In Channel ---------------> BMCH
number (Parameter 0, page 35) with wraparound at         = EMCH
17 to 1.  The resulting number (1 to 16) is the
Effective MIDI In Channel EMCH number, on which Note events will be received
for playing the Devil Fish synthesizer and for driving MIDI Out.
```

For instance, if **BA** = 0**1** and **DC** = 00 then **FE** = 0**1** (decimal 1). If the left Detector is On and the right one Off (**1**0) and both toggle-switches are down (00) the left XOR gate inverts the left switch bit to **1,** making **HG** = **1**0 (decimal 2). These two pairs of bits (which can be thought of as decimal numbers 1 and 2) are added with wraparound at 4 to 0, producing a further two bits **KI** = **11** (decimal 3). This makes EMCH = **BMCH** + 3. If a signal greater than about +1.15 volts is plugged into the Rear socket, **HG** changes to **11,** changing **KI** to **00** so EMCH = **BMCH** + 0.

Data flow for Installation 6

Installation 6 closely resembles **Installation 4**. The difference is that whereas **Installation 4** had a special set of two toggle-switches and two LEDs to go with its two 3.5mm input sockets and Detector circuits, since it had no 32 Bank Memory system, **Installation 6** **does have the 32 Bank Memory system**. This has the same appearance as that of the photo above for **Installation 2**, which does not have the MIDI In and Out system.

The signal flow for **Installation 6**, with and without the MIDI In sub-system's firmware driving bits **F** and **E** to the default contacts of the two Audio / CV Input sockets, resembles that depicted in the two full-page diagrams above, which are for **Installation 4**, with the following differences:

1 - The toggle-switches labelled Left and Right are the **Leftmost and Second from Left respectively, of the four toggle-switches** in a row which provide bits 3, 2, 1 and 0 of the memory address bits.

2 - The output of the Left and Right XOR (inversion) circuits, in addition to driving bits **HG** which are read by the firmware and can be used to alter the Effective MIDI In Channel (EMCH), **also drive bits 3 and 2 of the memory bank address**.

The two following full-page diagrams depict signal flow in **Installation 6**, with the items in **blue** being those which are part of the 32 Bank Memory system, and so which are different from the previous diagrams.

With the basic 32 Bank Memory system, the five address bits which control which of the 32 banks are selected are directly driven by the five toggle-switches, with the separate toggle-switch (bit 4) having its bit potentially inverted by the red pushbutton.

With **Installation 6**, the address bits 3 and 2 which control the memory bank are a function of both the two leftmost toggle-switches and the outputs of the Detectors, where each LED, in the On state, indicates that the bit produced by the switch will be inverted by its XOR gate.

If the respective LED is On, this indicates that any optional Enable/Disable switch (page 62) for the Detector circuits must be up or down (Enable) and that the respective Detector has been driven On by either a signal plugged into its 3.5mm Audio / CV input socket, or by no lead being plugged into the socket and by the respective bit derived from Channel 15 / 16 Notes and/or Controllers:

```
F  for the left-most switch of the four, which also drives
   memory bank address bit 3, weight = 8 of 32.

E  for the second from left switch of the four, which also drives
   memory bank address bit 2, weight = 4 of 32.
```

driving the output of the respective socket, via its default (normally closed) contact.

The next two diagrams depict the operation of Installation 6 with MIDI In features which only operate if the machine has been turned on in a special manner (described the section on page 75: *Enabling and Configuring DBCS MIDI Features*) AND if User Definable Parameter 9 (page 76) is set to 4 or 5 (first diagram below) or 1 or 2 (second diagram below).

Installation 6 with default contact drive enabled: Parameter 9 = 4 or 5

Note events ("**keys**" in some of the following descriptions) are received on the currently selected channel **15 or 16** (Parameter 10) which match one of the 8 keys in the currently selected Keyset (Parameter 10). When one or more of these keys are On, the highest priority of them sets two things:

1 - A single bit which determines whether MIDI In Channel switching occurs in the **Immediate or Delayed mode.** This overrides the default Immediate/Delayed setting of Parameter 9, which remains in force only until any one of the keys in the currently selected Keyset is turned On.

```
  2 - Two bits BA - 00, 01, 10 or 11 (0, 1, 2 or 3) which are added
      to a similar two bits generated by the next stage. ------>---\
                                                                   |
If Parameter 11 is set to a value 1 to 10, and if a Control Change |
for this Controller is received on the currently selected Channel  |
15 or 16 (Parameter 10), then the 0 to 127 range of the value of   |
this Control Change is reduced to a 0 to 3 range, which is         v
00, 01, 10 or 11 binary.  These bits DC ----->--------\            |
                                                      |     BA -<--/
are added with wraparound at 4 to produce two         |    +
bits FE (0 to 3 decimal).  These FE bits drive        \-->  DC
the default contacts of the two inputs sockets:           = FE
                                                             |
                           /----<----/----------<------------/
                           |         |
                           |         E
                           |         | *-\       1.15 volt
Rear (right) 3.5mm         |         \-*  \     /-->-DETECTOR--\-------> Right
Audio/CV                   |               \  /      Right     |         LED
Input Socket Ext sig. ===================>  \/       *         |
Affects bit 2 = G.         |                                   v
                           F                                   |
                           |                                   |
                           | *-\         1.15 volt             |
Front (left) 3.5mm         \-*  \     /-->-DETECTOR--\-------------> Left
Audio/CV                         \  /      Left      |         |     LED
Input Socket Ext sig. =========>  \/       *         |         |
Affects bit 3 = H.                                   v         v
                                                     |         |
      Second Toggle-switch from left ---->---------------->--\ |
      Affects bit 2 = G.                             |       | |
                                                     |      XOR     32 Bank
  Left-most Toggle-switch ---->---------------->---\ |       |      Memory
  Affects bit 3 = H.                               | |       |      address:
                                                  XOR        \----> Bit 2
  * The optional Detector Enable/Disable Switch    \--------------> Bit 3
    is not shown.                                  |         v
                                                   \------> HG
These bits HG (representing 0 to 3 decimal) are         +
added to the 1 to 16 decimal Base MIDI In Channel ----->  BMCH
number (Parameter 0, page 35) with wraparound at        = EMCH
17.  The resulting number, 1 to 16, is the 4 bit
Effective MIDI In Channel EMCH number, on which Note events will be received
for playing the Devil Fish synthesizer and for driving MIDI Out.
```

For an example of how this system works, please refer to the last paragraph of the Installation 4 diagrams above, and remember that bits **H** and **G** also drive bits 3 and 2 respectively of the 32 Bank Memory address. This means that the memory address bits 4 (separate toggle-switch, with its bit potentially inverted by the pushbutton) and bits 1 & 0 (right-most toggle-switches) are contributing weights 16, 2 and 1 respectively to the final 0 to 31 bank number, while bit **H** contributes 8 and bit **G** contributes 4.

Installation 6 with default contact drive disabled: Parameter 9 = 1 or 2

Note events (“**keys**” in some of the following descriptions) are received on the currently selected channel **15 or 16** (Parameter 10) which match one of the 8 keys in the currently selected Keyset (Parameter 10). When one or more of these keys are On, the highest priority of them sets two things:

1 - A single bit which determines whether MIDI In Channel switching occurs in the **Immediate or Delayed mode.** This overrides the default Immediate/Delayed setting of Parameter 9, which remains in force only until any one of the keys in the currently selected Keyset is turned On.

```
  2 - Two bits BA - 00, 01, 10 or 11 (0, 1, 2 or 3) which are added
      to a similar two bits generated by the next stage. ------>---\
                                                                   |
If Parameter 11 is set to a value 1 to 10, and if a Control Change |
for this Controller is received on the currently selected Channel  |
15 or 16 (Parameter 10), then the 0 to 127 range of the value of   |
this Control Change is reduced to a 0 to 3 range, which is         v
00, 01, 10 or 11 binary.  These bits DC ----->--------\            |
                                                      |     BA -<--/
are added with wraparound at 4 to produce two         |   +
bits FE (0 to 3 decimal).  These FE bits are          \-->  DC
added to the HG bits to set the KI bits                   = FE
                                                              \
                                                               \
                                     | *-\          1.15 volt   |
Rear (right) 3.5mm                   \-*  \    /-->-DETECTOR--\--------> Right
Audio/CV                                   \  /     Right     | |        LED
Input Socket Ext sig. ===================>  \/      *         | v
Affects bit 2 = G.                                            v |
                                                              | |
                           |                                  | |
                           | *-\          1.15 volt           | |
Front (left) 3.5mm         \-*  \    /-->-DETECTOR--\-------------> Left
Audio/CV                         \  /     Left      |         | |    LED
Input Socket Ext sig. =========>  \/      *         |         | v
Affects bit 3 = H.                                  v         v |
                                                    |         | |
      Second Toggle-switch from left ---->--------------->--\ | |
      Affects bit 2 = G.                            |       | | |
                                                    |       XOR |   32 Bank
  Left-most Toggle-switch ---->--------------->---\ |        |  |   Memory
  Affects bit 3 = H.                              | |        |  |   address:
                                                  XOR        \----> Bit 2
  * The optional Detector Enable/Disable Switch    \--------------> Bit 3
    is not shown.                                  |         v  |
                                                   \------> HG  |
                                                        +       /
                                                            FE-/
Bits HG and FE (both representing 0 to 3 decimal) are   =   KI
added with wraparound at 4 to 0, to produce bits KI
(also representing 0 to 3 decimal), which is added to   +
the 1 to 16 decimal Base MIDI In Channel --------------->  BMCH
number (Parameter 0, page 35) with wraparound at        = EMCH
17 to 1.  The resulting number (1 to 16) is the
Effective MIDI In Channel EMCH number, on which Note events will be received
for playing the Devil Fish synthesizer and for driving MIDI Out.
```

This addition is within the MIDI In and Out firmware and does not affect the two address bits sent to the 32 Bank Memory system, which are created by the XOR gates, which are hardware - a small integrated circuit near the memory switches. Please see the diagram above “Installation 4 with default pin drive disabled: Parameter 9 = 1 or 2” for an example of how this addition works.

Enabling and configuring the DBCS MIDI features

Installation 2 does not involve any firmware or MIDI. Its 3.5mm input sockets, detector circuits, LEDs and so the capability for memory bank address bit inversion is always active, unless the optional three position Detector Enable/Disable switch is in its centre position. Likewise, in **Installation 4** and **Installation 6**, the 3.5mm inputs, Detector circuits, LEDs and capability for memory bank address bit inversion are always active (except due to the optional Detector Enable/Disable switch).

To avoid potential confusion due to the MIDI In DBCS features being activated accidentally, the two firmware features listed at the bottom of this page, for **Installation 3**, **Installation 4**, **Installation 5** and **Installation 6** **will only be activated if the machine is turned on with the following procedure**:

1 - Turn the machine on either without pressing the **TAP** or **BACK** buttons, or while pressing the **TAP** button in order to disable the activation of the Blue LED in response to MIDI In note events. In either case, the Blue LED will flash with one of the two distinctive patterns described in a subsection above: "Power on display of whether MIDI Notes and Control Changes are being received" (page xx).

2 - If the **TAP** button was pressed, release it.

3 - In the two seconds during which the distinctive series of flashes occurs, press and release the **BACK** button at least four times.

4 - If the firmware detects this action, at the end of the normal 2 second flashing pattern, the Blue LED will flash very rapidly for a further two seconds to indicate that the machine will now enable the Dynamic Bank/Channel Switching MIDI features.

This enables two DBCS firmware MIDI features (this is a copy of the two points mentioned on page 65) until the Devil Fish is turned off:

1 - The Devil Fish MIDI In and Out microcontroller can **sense the potentially inverted bits from two switches**. These two bits can be used to **alter the MIDI In Channel** which is used to play notes on the Devil Fish synthesizer between four MIDI In channels: the Base MIDI In Channel and this channel plus 1, 2 or 3. This is Dynamic Channel Switching (DCS), and is only enabled when User Definable Parameter 9 (page 76 and later) is set to 1, 2, 4 or 5.

2 - The Devil Fish MIDI In and Out microcontroller can receive, on **channel 15 or 16**, messages involving particular note numbers (see Keysets below – page 80) and/or a particular Control Change number (also page 80), to generate two bits: `FE` in the diagrams below. These **two `FE` bits are used to drive the default contacts of the two 3.5mm input sockets**. The default contact drives the signal the socket sends to the detector circuit when nothing is plugged into the socket. This means that one or both

address bit inversion circuits can be driven by bits derived from MIDI In Channel 15 or 16 messages, which in turn might be created by an external sequencer and/or a manually operated MIDI keyboard.

If User Definable Parameter 9 is set to 0, 1 or 2, this disables drive of the default pins of the 3.5mm Audio/CV Input sockets. When it is set to 1 or 2, the two bits just mentioned (**FE** in the diagrams below) are added to the **HG** bits received from the XOR gates which potentially invert the bits from the two switches.

User Definable Parameters 9 to 11, for Dynamic Bank/Channel Switching

User Definable Parameters 0 to 11 are accessed and altered by the procedure described on page 22 – Altering the Value of a User Definable Parameter.

User Definable Parameters 0 to 8 are listed in a table above, on page 25. The tables on the following printed pages (three pages in the PDF version of this manual) concern User Definable Parameters 9, 10 and 11, which are only used by the Dynamic Bank/Channel Switching system for its MIDI functions. These MIDI functions are enabled by the special power-on procedure mentioned in the previous section. If this procedure is not used, then no matter what values these three User Definable Parameters are set to, the MIDI In reception of notes will not use Dynamic Channel Switching: notes will be received only on the Base MIDI In Channel, as set by User Definable Parameter 0 (page 35 above).

This page applies only to **Installation 3** and **Installation 5**.

<table>
<tr>
<td>Name of parameter
More details on page xx</td>
<td>User Definable Parameter number
= number of presses of the BACK button to select this parameter before pressing TAP</td>
<td>Range & (default)</td>
<td>Function
Red bold = default

These functions are only implemented if the Devil Fish is turned on with the special procedure described on page 75.</td>
</tr>
<tr>
<td>MIDI In Channel Switching with Immediate or Delayed Mode
87</td>
<td>9</td>
<td>0 – 5 (4)</td>
<td>
The reception of MIDI Channel 15 or 16 Keyset keys (note events) and/or Control Change messages to drive two bits FE can be used to drive Dynamic Channel Switching (DCS). These two bits add 0, 1, 2 or 3 to the Base MIDI In Channel (User Definable Parameter 0, page 35) to select the Effective MIDI In Channel.
The default value of this User Definable Parameter 9 is 4 which Enables DCS.
Immediate Mode and Delayed Mode are two ways of handling a change in Effective MIDI In Channel when a note is playing on the old and/or the new channel. This is explained on pages 91 and 93.
(For Installations 3 and 5, values 0 to 2 have the same effects as values 3 to 5. In Installations 4 and 6, the six values have different effects.)
<table>
<tr><td>Value</td><td>Dynamic (MIDI In) Channel Switching</td><td>Default DCS mode</td></tr>
<tr><td>0</td><td>Disabled</td><td></td></tr>
<tr><td>1</td><td rowspan="2">Enabled</td><td>Immediate</td></tr>
<tr><td>2</td><td>Delayed</td></tr>
<tr><td>3</td><td>Disabled</td><td></td></tr>
<tr><td>4</td><td rowspan="2">Enabled</td><td>Immediate</td></tr>
<tr><td>5</td><td>Delayed</td></tr>
</table>
</td>
</tr>
</table>

This page applies only to in **Installation 4** and **Installation 6**.

<table>
<tr>
<th>Name of parameter
More details on page xx</th>
<th>User Definable Parameter number
= number of presses of the BACK button to select this parameter before pressing TAP</th>
<th>Range & (default)</th>
<th>Function
Red bold = default

These functions are only implemented if the Devil Fish is turned on with the special procedure described on page 75.</th>
</tr>
<tr>
<td>Dynamic Bank/Channel Switching: Audio/CV Input socket Default Contact Drive and MIDI In Channel Switching with Immediate or Delayed Mode
87</td>
<td>9</td>
<td>0 – 5 (4)</td>
<td>
The reception of MIDI Channel 15 or 16 Keyset keys and/or Control Change messages can be used to drive two FE bits to the default contacts of the two 3.5mm Audio/CV Input sockets, so that if nothing is plugged into these sockets, the FE bits will drive the detector circuits which drive the XOR logic gates which potentially invert the bits produced by the switches. This drive of the default contacts can be Disabled or Enabled as shown below in the second column.
When this is disabled and Dynamic MIDI In Channel Switching is enabled (values 1 and 2) the FE bits are instead used inside the firmware to affect the choice of Effective MIDI In Channel, as depicted in the second of the two full-page diagrams for both Installation 4 and Installation 6, by adding the FE bits to the HG bits received from the XOR gates.
For Installation 6, a value of 3 enables drive of the default pins and so enables Channel 15/16 notes to affect the 32 Bank Memory bank address, while Dynamic Channel Switching is not being used.
Immediate Mode and Delayed Mode are two ways of handling a change in Effective MIDI In Channel when a note is playing on the old and/or the new channel. This is explained on pages 91 and 93.
<table>
<tr><th>Value</th><th>Drive default pins of 3.5mm Audio/CV Input sockets</th><th>Add FE bits to HG bits</th><th>Dynamic (MIDI In) Channel Switching</th><th>Default DCS mode</th></tr>
<tr><td>0</td><td rowspan="3">Disabled</td><td></td><td>Disabled</td><td></td></tr>
<tr><td>1</td><td rowspan="2">Add</td><td rowspan="2">Enabled</td><td>Immediate</td></tr>
<tr><td>2</td><td>Delayed</td></tr>
<tr><td>3</td><td rowspan="3">Enabled</td><td rowspan="3"></td><td>Disabled</td><td></td></tr>
<tr><td>4</td><td rowspan="2">Enabled</td><td>Immediate</td></tr>
<tr><td>5</td><td>Delayed</td></tr>
</table>
</td>
</tr>
</table>

Name of parameter More details on page xx	**User Definable Parameter number** **= number of presses of the BACK button to select this parameter before pressing TAP**	**Range & (default)**	**Function** **Red bold = default** These functions are only implemented if the Devil Fish is turned on with the special procedure described on page 75.
Dynamic Bank/Channel Switching: Channel 15/16 and Keyset 80	**10**	0 – 9 (**1**)	0 = Channel 15, no Keyset selected. **1 = Channel 15, Keyset 1.** 2 = Channel 15, Keyset 2. 3 = Channel 15, Keyset 3. 4 = Channel 15, Keyset 4. 5 = Channel 16, Keyset 1. 6 = Channel 16, Keyset 2. 7 = Channel 16, Keyset 3. 8 = Channel 16, Keyset 4. Keysets are described in the next sub-section. All received Keyset notes are cleared whenever this User Definable Parameter is changed. Furthermore, any value of bits **BA** (in the diagrams above) value 1 to 3 (binary 01 to 11) which is currently active due to previously received Keyset notes will be set to zero whenever this User Definable Parameter is changed.
Dynamic Bank/Channel Switching: Control Change number 80	**11**	0 – 10 (**1**)	0 = No Controller selected. **1 = Controller 1 = Mod Wheel.** 2 = Controller 2. 3 = Controller 3. . . . 10 = Controller 10. Any value of bits **DC** (in the diagrams above) 1 to 3 (binary 01, 10 or 11) which is currently active due to one of these Control Changes being most recently received will be set to zero (binary 00) whenever this User Definable Parameter is Changed.

MIDI In Channel 15 or 16 Keyset Note Events & Control Changes

Each Keyset is a group of eight MIDI note numbers. Here we refer to the note numbers as "keys", since it is convenient to imagine sending note events for these numbers by manually pressing keys on a keyboard. In practice, these notes could come from a sequencer, algorithmic MIDI system or any other source. If the Devil Fish is to use Dynamic Channel Switching, then the MIDI In stream should contain the two to four contiguous channels of patterns, or whatever notes are to be selected between, together with the note events discussed here on Channel 15 or 16 (as selected by User Definable Parameter 10 – see the table on the previous page), and any Control Change messages (also on this channel 15 or 16) which are also used. This can be achieved with various sequencing software packages or MIDI merge devices.

The DBCS system can be configured by setting User Definable Parameter 10 to respond to Keyset note events in one of these three ways:

> No Keysets when it is receiving Control Changes on Channel 15.
> One of the four Keysets when receiving keys and Control Changes on Channel 15.
> One of the four Keysets when receiving keys and Control Changes on Channel 16.

The MIDI In sub-system looks for Note Events for the on the eight keys (eight note numbers) of a particular Keyset, on a particular MIDI In channel 15 or 16. If two or more such keys are pressed (Note On events have been received, without matching Note Off events), then the two or more such keys which are on are interpreted with a particular priority order, so that one key being on will over-ride any keys in the Keyset which are of a lower priority. Pressing the keys (here we assume the user is doing this manually, but the Note On and Off events could be generated by many techniques) causes DBCS system to set two values in real-time.

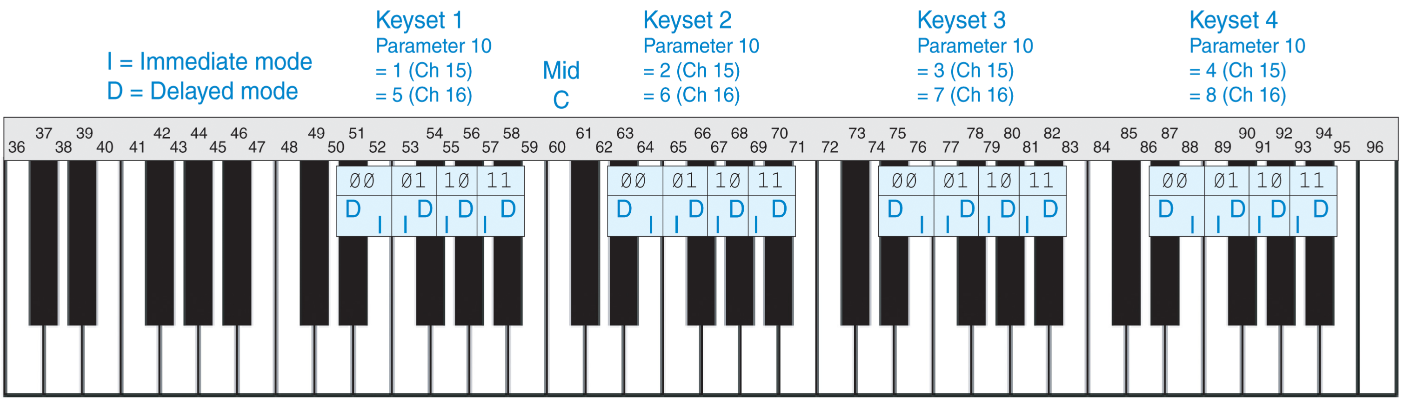
Firstly two bits are generated, 00, 01, 10 or 11 – which constitute the decimal numbers 0 to 3 – which will be used as described below. These bits are labelled `BA` in the data flow diagrams on previous pages. Secondly, the DBCS system is set into either Immediate Mode or Delayed Mode. These two modes concern how the system handles the transition from one MIDI In channel to another, as explained on pages 91 and 93.

The following table shows the 8 keys, their note numbers for each of the four Keysets, and the values they set. The priority for each key indicates the order in which notes on particular keys override notes from lower-numbered keys.

Key:	**D#**	**E**	**F**	**F#**	**G**	**G#**	**A**	**A#**
Keyset 1	51	52	53	54	55	56	57	58
Keyset 2	63	64	65	66	67	68	69	70
Keyset 3	75	76	77	78	79	80	81	82
Keyset 4	87	88	89	90	91	92	93	94
Priority	1	0	2	3	4	5	6	7
Immediate or Delayed mode	**Del**	**Imm**	**Imm**	**Del**	**Imm**	**Del**	**Imm**	**Del**
Binary bits	`00`		`01`		`10`		`11`	
Decimal	0		1		2		3	

This enables four Devil Fishes to be driven from the one set of MIDI events, with each Devil Fish responding to a different Keyset, so a single physical keyboard can be played manually to select which channel each Devil Fish is receiving on. (To press keys in all four Keysets will require more than two hands.)

The following diagram depicts note numbers, Parameter 10 values with "**= x (Ch yy)**", the binary bits which are produced by particular keys (such as `Ø1`) in the Keysets and the selection of Immediate or Delayed mode with particular keys (**D** and **I**).



Here is a simple example, for (**Installation 3** or **Installation 5**) or for (**Installation 4** or **Installation 6**) with two Audio or CV inputs and with the two toggle-switches in their down (0) positions. The four Devil Fishes could all have their Base MIDI In Channel (Parameter 0) set to the same channel, so they are selecting between the same four patterns or streams of notes. Alternatively, for example, they could have their Base MIDI In channels set to 1, 4, 8 and 12 respectively, so they could, in principle, be selecting from entirely different patterns. However, this would involve a single MIDI stream handling note events for 16 channels simultaneously, which might involve a few msec of delays.

The note events, if any, which are used with this Keyset facility are *not* received by the main MIDI In Note system. So if Channel 16 Keyset 3 is selected and the Effective MIDI In Channel is 16 at any point in time, Note messages on Channel 16 for note numbers 87 to 94 inclusive, which are used for the Keyset facility *will not be played by the MIDI In sub-system on the Devil Fish synthesizer, CV and Gate outputs and via MIDI Out*. Thus, the selected Keyset (if any – Parameter 10 set to 0 disables Keysets) punches an 8 semitone hole in the range of pitches which can be played on that channel by the main Devil Fish MIDI In Note playing system. The note numbers recognised by the Keyset system are not subject to the Transpose settings.

User Definable Parameter 11 selects which Control Change number, if any, will be received on Channel 15 or 16 (as selected by Parameter 10) to produce a second pair of bits (DC in the data flow diagrams above), which are added in binary (in decimal, with a wraparound at 4 to 0) to the two bits BA from the Keyset system, to produce a final pair of bits, which are sent to the default contacts of the two 3.5mm Audio / CV input sockets (**Installation 4** or **Installation 6**, both with Parameter 9 set to 4 or 5) or which are sent directly within the firmware to be added to the Base MIDI In Channel, to create the Effective MIDI In Channel (**Installation 3** or **Installation 5**, or **Installation 4** or **Installation 6**, both with Parameter 9 set to 1 or 2 .

Control Changes carry values between 0 and 127, which are the 128 combinations of a 7 bit binary number. For instance, if a Mod Wheel is turned towards the front of the keyboard, a Control Change 1 with a value of 0 will be sent (000 0000 binary). When it is set to half-way, a value of 64 (100 000) will be sent. When it is pushed fully towards the rear of the keyboard, a value of 127 (111 1111) will be sent. The DBCS firmware reduces this range of values to two bits representing four quadrants of the full range:

Value range	Bits which result
0 to 31	00 = 0 decimal
32 to 63	01 = 1
64 to 95	10 = 2
96 to 127	11 = 3

These two sets of bits **BA** – from any Keyset Note events which have been received, and **DC** from any Control Changes which have been received are added together with a wraparound so 4 becomes 0, 5 becomes 1 etc. to produce the final two output bits (**FE**) which are sent to the default contacts of the two sockets, or used directly to add to the **HG** bits, as shown in the data flow diagrams above. Another way of considering this is to create a table which shows the output bits in binary (**FE** in blue below), with their decimal equivalents, as a function of which of the keys in a Keyset are pressed (black text at the left, for the four lines), and which quadrant the Control Change value falls within (the four right-most columns).

FE bits which result when either of these keys is the highest priority of the keyset keys which are currently pressed, and with Control Change values in these ranges:

Keyset keys		0 to 31 00 = 0	32 to 63 01 = 1	64 to 95 10 = 2	96 to 127 11 = 3
D# E	00 = 0	00 = 0	01 = 1	10 = 2	11 = 3
F F#	01 = 1	01 = 1	10 = 2	11 = 3	00 = 0
G G#	10 = 2	10 = 2	11 = 3	00 = 0	01 = 1
A A#	11 = 3	11 = 3	00 = 0	01 = 1	10 = 2

There are quite a few hidden processes here: Three User Definable Parameters (9, 10 and 11), having to enable the MIDI features of the Dynamic Bank/Channel Switching system with a special turn-on procedure (page 75), and ensuring the Devil Fish receives various note and or Control Change messages.

For Installation 4 or Installation 6, the activity of the LEDs, which indicate the state of the Detector circuits, should help with setting up the various arrangements which are required to use this default contact aspect of Dynamic Channel/Bank Switching. With **Installation 3** or **Installation 5**, the situation is less complex, since there are no signal inputs or switches, but there are **no LEDs to indicate the state of the two bits** which are added to the Base MIDI In Channel to create the Effective MIDI In Channel, so greater care will be needed. With **Installation 6** it is possible to use the 3.5mm Audio / CV inputs and detector circuits to dynamically switch Memory Banks, without the two bits which result from potential inversion of the two left-most switches affecting MIDI In reception of notes – by setting Parameter 9 to 0 or 3. If it is set to 3, then MIDI In Notes and Control Changes on Channel 15 or 16 can be used to drive the default contacts of the 3.5mm sockets, so MIDI control of Memory Bank switching is still possible. As with Installations 3 and 5, these FE bits will not visible via the LEDs

Dynamic Channel Switching: the Effective MIDI In Channel

This manual covers four types of installation. Two of these installation types (3 and 5) have one set of behaviours for the six values 0 to 5 to which User Definable Parameter 9 can be set and the other two (4 and 6) have a different set of behaviours. On the following pages of the PDF version of this manual are tables specific to each installation, in which, for each setting 0 to 5 of User Definable Parameter 9, the behaviour of the following two functions are described. *In the printed manual, pages which do not apply to this particular Devil Fish have been removed, so just one table follows.*

1 - Whether or not the default pins of the 3.5mm Audio/CV Input sockets (if the installation has them) are driven by the `FE` bits which are created from MIDI In Channel 15/16 Control Changes and Keyset Note On and Off events.

2 - If this setting enables Dynamic MIDI In Channel Switching and how the Effective MIDI In Channel is calculated, by the addition of a 0 to 3 Offset. This Offset is added to the Base MIDI In Channel (User Definable Parameter 0) with a wraparound from 17 to 1. This Offset is one of four forms, which may be based on the `FE` bits as just mentioned and the `HG` bits which are read from the XOR gates (only Installations 4 and 6 have input sockets, detector circuits, switches and XOR gates):

a - Offset = `00` .

Dynamic Channel Switching is disabled.

The Effective MIDI In Channel is the same as the Base MIDI In Channel.

b - Offset = `HG` (from the XOR gates). (Installations 4 and 6 only.)

Dynamic Channel Switching is enabled.

The Effective MIDI In Channel is the Base MIDI In Channel plus 0, 1, 2 or 3, according to the values of these two bits.

c - Offset = `FE` (from the MIDI In Channel 15/16 events).

Dynamic Channel Switching is enabled.

The Effective MIDI In Channel is the Base MIDI In Channel plus 0, 1, 2 or 3, according to the values of these two bits.

d - Offset = `FE + HG` . (Installations 4 and 6 only.)

This is the two bits from the MIDI In Channel 15/16 events *plus* the two bits received from the XOR gates, with the sum also limited to two bits. This is a wraparound of 4 to 0, so the sum of [0 to 3] and [0 to 3] is [0 to 6], which wraps around to [0, 1, 2, 3, 0, 1, 2].

Dynamic Channel Switching is enabled.

The Effective MIDI In Channel is the Base MIDI In Channel plus 0, 1, 2 or 3, according to the values of the two bits of the sum.

<table>
<tr><th>Installations 3 & 5

Dynamic Channel Switching via MIDI In Ch 15/16.

User Definable Parameter 9 is set to:</th><th>Drive default contact of 3.5mm Audio/CV Input sockets</th><th>Effective MIDI In Channel is the Base MIDI In Channel plus this offset:

<code>FE</code> bits are generated from MIDI In Channel 15/16 Control Changes and Note events.</th><th>Comments

Settings 0 and 3 disable Dynamic MIDI In Channel Switching.

Settings 1, 2, 4 and 5 enable it.</th></tr>
<tr><td>0</td><td rowspan="6">This installation does not have Audio/CV Input sockets, detector circuits, switches or XOR gates.</td><td>0</td><td rowspan="6">Although there are no input sockets, switches or XOR gates, you can still use MIDI In Channel 15/16 events to drive Dynamic Channel Switching.</td></tr>
<tr><td>1</td><td rowspan="2"><code>FE</code> bits, with values 0, 1, 2, or 3.</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td><td>0</td></tr>
<tr><td>4</td><td rowspan="2"><code>FE</code> bits, with values 0, 1, 2, or 3.</td></tr>
<tr><td>5</td></tr>
</table>

Installation 5 has a 32 Bank Memory system, but this is not connected to the MIDI In and Out system.

<table>
<tr><th>Installation 4

Dynamic Channel Switching via MIDI In Ch 15/16 and two switches, each with an Audio/CV input socket, detector circuit and switch bit inverter circuit.

User Definable Parameter 9 is set to:</th><th>Drive default contact of 3.5mm Audio/CV Input sockets</th><th>Effective MIDI In Channel is the Base MIDI In Channel plus this offset:

<code>FE</code> bits are generated from MIDI In Channel 15/16 Control Changes & Notes.

<code>HG</code> bits are received from the XOR gates which potentially invert the two bits from the two switches, if their detector circuits are driven On by either signals to their Audio/CV Input sockets, or by there being nothing plugged into those sockets, and the default contact being driven On.</th><th>Comments

Settings 0 and 3 disable Dynamic MIDI In Channel Switching.

Settings 1, 2, 4 and 5 enable it.</th></tr>
<tr><td>0</td><td rowspan="3">No.</td><td>0</td><td></td></tr>
<tr><td>1</td><td rowspan="2"><code>FE + HG = KI</code> bits, wrapping from 4 to 0, so the sum is 0, 1, 2, or 3.</td><td rowspan="2">The default pins of the Input sockets are not driven by the <code>FE</code> bits, but these are added to the <code>HG</code> bits produced by the XOR gates, which are the states of the two toggle-switches, potentially inverted by the detector circuits being driven On by signals above +1.15 volts.</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td><td rowspan="3">Yes.</td><td>0</td><td></td></tr>
<tr><td>4</td><td rowspan="2"><code>HG</code> bits, with values 0, 1, 2, or 3.</td><td rowspan="2">The default pins of the Input sockets are driven by the <code>FE</code> bits. If nothing is plugged into each of the two Input sockets, than this drive signal can turn on the detector (and its LED) and so invert the bit produced by the corresponding toggle-switch. If a plug is inserted into the Input socket, a signal above +1.15 volts will turn on the detector circuit, irrespective of the state of that socket's <code>F</code> or <code>E</code> bit.

The XOR gates produce the potentially inverted switch bits <code>HG</code> which drive Dynamic Channel Switching, by adding 0 (<code>00</code>), 1 (<code>01</code>), 2 (<code>10</code>), or 3 (<code>11</code>) to the Base MIDI Channel.</td></tr>
<tr><td>5</td></tr>
</table>

Installation 6 **Dynamic Channel Switching via MIDI In Ch 15/16 and the left two Memory Bank switches, each with an Audio/CV input socket, detector circuit and switch bit inverter circuit.** **User Definable Parameter 9 is set to:**	**Drive default contact of 3.5mm Audio/CV Input sockets**	**Effective MIDI In Channel is the Base MIDI In Channel plus this offset:** `FE` bits are generated from MIDI In Channel 15/16 Control Changes & Notes. `HG` bits are received from the XOR gates which potentially invert the two bits from the two switches, if their detector circuits are driven On by either signals to their Audio/CV Input sockets, or by there being nothing plugged into those sockets, and the default contact being driven On.	**Comments** Settings **0** and **3** disable Dynamic MIDI In Channel Switching. Settings **1**, **2**, **4** and **5** enable it.
0	No.	0	
1		`FE + HG = KI` bits, wrapping from 4 to 0, so the sum is 0, 1, 2, or 3.	The default pins of the Input sockets are not driven by the `FE` bits, but these are added to the bits produced by the XOR gates, which are the states of the two toggle-switches, potentially inverted by the detector circuits being driven On by signals above +1.15 volts.
2			
3	Yes.	0	
4		`HG` bits, with values 0, 1, 2, or 3.	The default pins of the Input sockets are driven by the `FE` bits. If nothing is plugged into each of the two Input sockets, than this drive signal can turn on the detector (and its LED) and so invert the bit produced by the corresponding toggle-switch. If a plug is inserted into the Input socket, a signal above +1.15 volts will turn on the detector circuit, irrespective of the state of that socket's `F` or `E` bit. The XOR gates produce the potentially inverted switch bits `HG` which drive Dynamic Channel Switching, by adding 0 (`00`), 1 (`01`), 2 (`10`), or 3 (`11`) to the Base MIDI Channel.
5			

Installation 6 has a 32 Bank Memory system with its leftmost two switches being part of the MIDI In and Out system's Dynamic Bank/Channel Switching system.

The XOR gate outputs produce potentially inverted versions of the states of the left two switches. These XOR gates drive both Dynamic Channel Switching and provide two of the five Memory Bank address bits. So whatever external signals or default contact drive signals may be driving the detector circuits, and so potentially inverting the bit produced by its corresponding switch, this will affect the Memory Bank, constituting Dynamic Bank Switching, irrespective of what the MIDI In and Out firmware is doing with Dynamic Channel Switching.

Dynamic Channel Switching: receiving Notes in Immediate or Delayed Mode

If Dynamic Channel Switching is not in use, the Devil Fish MIDI In sub-system receives MIDI Note events only on the Base MIDI In Channel (User Definable Parameter 0, page 35). This straightforward MIDI In behaviour, without switching to any other MIDI In Channel, will be selected when one or both of these two conditions are true:

1 - The MIDI functions not being enabled by the special power-on technique described in the section above: *Enabling and configuring DBCS MIDI features* (page 75).

2 - MIDI Channel Switching being disabled due to Parameter 9 being set to 0 or 3.

Stated another way: the MIDI In system will only be capable of receiving on channels 1, 2 or 3 above the Base MIDI In Channel (with wraparound from 17 to 1) if the special power-on technique has been used and Parameter 9 is set to 1, 2, **4** or 5. **4** is the default setting.

The rest of this section assumes that, for whichever of the four Installation types **3**, **4**, **5** or **6**, and by whatever means, either the two bits `HG` are changing (in the diagrams above depicting data flow for Installation types **3**, **4** [1st diagram], **5** or **6** [1st diagram]) or the two bits `KI` are changing (in the 2nd diagrams above depicting data flow for Installation types **4** and **6**), so the Effective MIDI In Channel is being changed dynamically to 0, 1, 2 or 3 above the Base MIDI In Channel.

The musical implications of Immediate mode and Delayed mode vary with all the circumstances. Both modes are likely to be useful in different scenarios. There are **two ways of quickly changing between the Immediate and Delayed modes**:

1 - Use the Front Panel system to edit the value of Parameter 9, and use **BACK** (increment = add 1 to the value of this parameter) and **TAP** (decrement = subtract 1 from the value of this parameter) to step back and forth between values 1 and 2 or between values 4 and 5.

If one or more Keyset notes are currently on (AKA "Keyset keys are currently pressed") then these Front Panel changes will have no effect, since the highest priority Keyset note, as long as any Keyset notes are On, determines the choice between Immediate and Delayed mode.

If no Keyset Notes are currently On, this alters the Immediate/Delayed mode, and this choice will remain in force until either another such Front Panel operation or until a Keyset Note is received.

2 - If the Keyset notes are being used, choose between using either the four note numbers corresponding to white keys, for Immediate Mode or to the black (#) keys for Delayed Mode.

MIDI In Note reception without Dynamic Channel Switching

This section describes MIDI In reception without Dynamic Channel Switching – either because it is not enabled, or because it is enabled and the bits **HG** (or **KI** for the 2nd diagrams for Installations **4** and **6**) are 00. Then, all Note reception is on the Base MIDI In Channel.

The reception logic for a single note (only one note playing at any time), is relatively simple: After potential transposition (User Definable Parameters 1 and 2, page 36) if the note number which is within the valid range of the TB-303's DAC (see the table on page 37): the note is played via the DAC and Gate Out, with Accent according to its velocity and the Accent Velocity Threshold (User Definable Parameter 6, page 41). These actions drive the Devil Fish Synthesizer, with the Gate On condition being visible in the LED in the Devil Fish logo's 'e'. These signals also drive the Gate, CV and Accent output sockets. The MIDI Out sub-system plays this note via MIDI Out. Turning off the note is similarly simple and direct.

The actions are more complex if there are other sources of Gate via MIDI In, such as due to Sustain via a Control Change value for a Control Change matching the MIDI In Sustain-Slide Controller (User Definable Parameter 5, page 40), or due to Slide by the same mechanism. For simplicity, in this and the following sub-sections, we will assume this is not the case.

If a second note is played (turned on, by the Devil Fish MIDI In system receiving a Note On event) while one or more other notes is currently playing (a Note On event was previously received and so far, no matching Note Off event has been received), then the new note will be generated for the second note's note number. When this note is generated, if User Definable Parameter 4 (MIDI In Slide on Tied Slide, page 40) is set to 1, then Slide will be turned on to the Devil Fish Synthesizer. Irrespective of whether Slide is enabled, this new note does not involve the Gate going Off and On, so arguably it is not a new "note". It is implemented as a different value being sent to the DAC (Digital to Analogue Converter) which therefore produces a voltage matching the (potentially transposed) pitch of the new note.

If Slide is enabled (Parameter 4 = 1, which it is by default), then while the DAC voltage changes abruptly, the actions of the Slide circuit cause the voltage which drives the VCO to slew to the new voltage, resulting a pitch slide from the old note's pitch to the new note's pitch. This potentially slewed voltage drives both the VCO and the TB-303's rear panel CV Out socket. This Slide state is conveyed to MIDI Out, with tied notes to communicate Slide. (Tied notes involve the original note being turned off immediately *after* the second note's Note On event is sent. Devil Fish MIDI systems, the MIDIBass 303 system, the Quicksilver 303 and the Cyclone Analogic TT-303 Bass Bot all recognise this as a signal to keep the Gate active and to slide to the pitch of the new note.)

The situation may become more complex with two or more notes. If the first note is released before the second, there is no extra complexity. After the second note is released, the Synthesizer and any external devices via CV and Gate or MIDI Out will not be playing a note.

However, if the first note is still on when the second ends, then the Synthesizer, CV and Gate Outputs and MIDI Out will revert to the first note's pitch. If Parameter 4 is set to 0 (disabling MIDI In Slide on Tied Slide), then this reversion to the DAC voltage (and therefore VCO pitch) of a note which was turned on earlier, is abrupt. If Parameter 4 is set to 1, then the transition will be via the Slide circuit.

Inside the MIDI In and Out firmware, a facility called a **Note Stack** is used to remember notes which were started earlier, and which have not yet been turned of, for the purpose of reverting to one of these notes when all later-started notes have been turned off.

In the **Devil Fish MIDI In** (only) system (not the Devil Fish MIDI In and Out system), this was handled for up to ten notes via a **10 deep Note Stack**, within the firmware. Up to 10 notes could be played, and when the last played note was released, the Synthesizer etc. would revert to playing the note which was most recently pressed and which was still playing. On a keyboard, any number of keys can be pressed and the Devil Fish and its slave devices will always play the most recently pressed key. (A second Note On event for a note which is already On is ignored.) With the Devil Fish MIDI In (only) system, 10 keys can be held down and released in any order. The Devil Fish will play the pitch as just described, going back in the Note On history up to ten notes. A reversion to a previously played note does not alter the Accent state, which was set by the Note On event which first turned on the Gate.

In the Devil Fish MIDI In and Out system, there are 16 Note Stacks – one for each MIDI In channel. Each Note Stack performs the functions just described, except that **each stack is 8 notes deep, rather than 10**.

In both these systems (MIDI In only and MIDI In and Out) the note at the top of the stack, if there is one, is the note the Devil Fish and any slave devices will play. This is the most recently started note of all notes which have not yet been released.

MIDI In Note reception with Dynamic Channel Switching

A further elaboration in the Devil Fish MIDI In and Out system is that with Dynamic Bank/Channel Switching (DBCS) the Devil Fish and any slave devices (via CV, Gate etc. connections and by MIDI Out) plays the top note, if any, of one of the 16 Note Stacks, according to the Dynamic Channel Switching arrangements. The MIDI In sub-system of the MIDI In and Out system receives note events on all 16 Channels at once. As described in the previous sub-section, it maintains a stack of up to 8 most recently turned on, and not yet turned off, notes, for each channel.

Dynamic Channel Switching does not concern using the User Definable Parameter 0 to change the Base MIDI In Channel. Whenever this is changed, the Note Stacks are cleared so the Devil Fish MIDI In sub-system will not be playing any note.

Dynamic Channel Switching concerns how to start and stop notes on the Devil Fish Synthesizer, CV and Gate outputs and MIDI Out when the **HG** bits (or **KI** bits for the 2nd diagrams for Installations **4** and **6**) change, so changing the Effective MIDI In Channel from one of four possibilities to another.

When the Effective MIDI In channel changes, due to Dynamic Channel Switching, the MIDI In sub-system switches its attention from the note at the top of one of these stacks (that of the previous Effective MIDI In Channel, also referred to below as the "Old Channel") to the note at the top of another channel: the new Effective MIDI In Channel (also referred to below as the "New Channel").

This raises some complex questions about how to drive the synthesizer and MIDI Out in all the possible circumstances, including switching from a channel with either a note XX on, or no note on at all, to a channel with either a note YY on, or no note on at all, including the condition where YY = XX, so the new Effective MIDI In channel has the same note on as the old.

I decided on two algorithms (sets of rules) for responding to DCS changes in the Effective MIDI In Channel: Immediate Mode and Delayed Mode. The user to be able to select between these two algorithms and to change this setting in real time – dynamically – as described on page 87.

The **Immediate Mode** algorithm can result in notes starting and ending at the instant the effective MIDI In channel is changed, due to a change in the two bits **HG** bits or the two **KI** bits for the 2nd diagrams for Installations **4** and **6**.

The **Delayed Mode** algorithm will not start or end notes just because the Effective MIDI In channel has changed. It waits for a new note to start on the New Channel or, if there was a note on the Old Channel, for this note to end.

Immediate Mode

In this and the next section, we assume that the Effective MIDI In Channel is changing within a range of Base MIDI In Channel plus 0, 1, 2 or 3, with wraparound from 17 to 1. So if the Base MIDI In Channel is 15 and the two bits **HG** are `11`, meaning decimal 3, then the sum is 18 which wraps around and selects Channel 2 as the Effective MIDI In Channel.

As mentioned above, there is a Note Stack for every MIDI Channel 1 to 16, with the most recently played note (if any) on top. Below that are any notes which were played before this note, and which have not yet been turned off. Those notes below the top position are not important in the question of how to respond to a change in Effective MIDI In Channel. All that matters is the top note (if any), with its Accent flag, of the Note Stack of the channel which was previously the Effective MIDI In Channel, and the top note (if any), with its Accent flag of the Note Stack of the just-now selected Effective MIDI In Channel, due to changes in one of both of the two **HG** or bits or **KI** bits for the 2nd diagrams for Installations **4** and **6**. These are referred to, respectively, as the "Old Channel's Note" and the "New Channel's Note".

> For simplicity in what follows, the term "**HG** bits" will be used to denote the offset between the Base MIDI In Channel and the Effective MIDI In Channel, even though, as depicted in the 2nd diagrams for Installations **4** and **6**, it is the **KI** bits which determine this offset.

For instance, if the Base MIDI In Channel is 4, and the initial state of the two bits **HG** was `10` (decimal 2), then the initial (old) Effective MIDI In Channel would be 6. If the **HG** bits changed to was `11` (decimal 3), then the new initial Effective MIDI In Channel would be 7.

At the instant the Effective MIDI In Channel is changed, the Old Channel's Note can be in one of two states:

1 - Note Off.

2 - Note On for note number XX, with Accent On or Off.

At this instant, the New Channel's Note can be in one of two states:

3 - Note Off.

4 - Note On for note number YY, with Accent On or Off. If state 2 above is the case, then this YY may be the same note number as XX, or it may be different.

Immediate mode generates Note On and Off actions at the instant that the bits **HG** change. The five numbered points below depict all the possible conditions and actions.

Here are these two possible states of the Old Channel's Note, in **black bold**, followed in green with sub-states concerning the New Channel's Note, with a note number YY, which may or may not be the same as XX. The following computer programming terminology is used to denote equality and inequality of these note numbers:

== Equality: the new channel's note number YY is the same as the old channel's note number XX. (Spoken as: "equals".)

! = Inequality: the new channel's note number YY is different from the old channel's note number XX. (Spoken as "does not equals" or "bang equals".)

The resulting actions for **Immediate Mode** are in blue.

1 - **Note Off**. ← Old Channel's Note.
Note Off. ← New Channel's Note.
No action. ← Action in Immediate Mode under these circumstances.

2 - **Note Off**.
Note On for note number YY, with Accent On or Off.
Turn on Note YY with or without Accent. Flash the Blue LED.

3 - **Note On for note number XX, with Accent On or Off**.
Note Off.
Turn off Note XX. Flash the Blue LED.

4 - **Note On for note number XX, with Accent On or Off**.
Note On for note number YY, with Accent On or Off, where YY == XX.
Turn off Note XX and about 3 msec later❶ turn on YY, which is the same note number as XX, but may have a different Accent setting. Flash the Blue LED.

5 - **Note On for note number XX, with Accent On or Off**.
Note On for note number YY, with Accent On or Off, where YY ! = XX.
Turn off Note XX and about 3 msec later❶ turn on YY. Flash the Blue LED.

This is pretty straightforward. Notes may be started or ended at the moment the Effective MIDI In Channel changes – the instant the HG bits change.

❶ The delay between turning off one note and starting the next is usually 3 msec. This will be shortened under exceptional circumstances where the rate of MIDI In bytes exceeds the MIDI In sub-system's ability to process them. This cannot occur except when there are two or more 3 msec delays in quick succession. During this delay time, MIDI In bytes are still processed until one Note event (other than for a Keyset) is processed. Then, processing is delayed until the delay time ends. If 10 or more MIDI In bytes are queued awaiting processing in this way, the delay period is terminated early and normal processing resumes. If the bytes are sent without gaps 10 bytes takes 3.2 msec to send.

This approximately 3 msec delay is both to allow the Devil Fish's Synthesizer to reset its Envelope Generators and to allow the same to occur in the TB-303-like synthesizers of slave devices via MIDI Out and/or CV and Gate out. These include other Devil Fishes, ordinary TB-303s, TB-303s with the Quicksilver 303 CPU replacement (and so MIDI In and Out), TB-303s with the Sequentix MIDI Bass MIDI In and Out system and Cyclone Analogic Bass Bots (TT-303s).

Without a delay such as this, the new note may not sound like a note which was started many milliseconds after the last one finished. The TB-303 Internal Sequencer never starts one note directly after another one finishes, so the Synthesizer was not designed for almost instant retriggering. This 3 msec delay will hopefully be sufficient. Each MIDI Note Off or Note On message takes about 1 msec to be sent on the DIN MIDI cable. (The serial data rate is 31,250 bits per second, with each of the 3 bytes being one start bit, 8 data bits and one stop bit = 3125 bytes a second = 0.96 msec per three-byte message.) The 3 msec delay is after the Gate is turned off and the 3 byte Note Off message started. After the delay, the Gate for the new note is turned on and the 3 byte Note On message is started.

Delayed Mode

Continuing with the assumptions of the previous subsection, here is an explanation of Delayed Mode. This **does not involve notes starting or ending the instant there is a change in the Effective MIDI In Channel**.

In Delayed mode, as with Immediate mode, at the instant the Effective MIDI In Channel changes, the Old and New Channels' and Notes can be in the states listed above in aqua.

The five points below depict the combinations of those states, with the Old Channel's state in **black bold**, with sub-states concerning the New Effective MIDI In Channel's Note, in green, with a note number YY, which may or may not be the same as XX. The actions which occur for **Delayed Mode** at the instant the Effective MIDI In Channel changes are in **bold violet**.

The second, third and fifth of these combinations involves waiting, so the MIDI In sub-system enters a wait state until one of several conditions occur. The conditions concerning the Old Channel are depicted in black. Those concerning the New Channel are depicted in green. Conditions concerning neither channel are in light blue. The actions which result after waiting for one of these conditions to occur are in **bold orange**. Additional explanations are in rose. After one of the actions in bold orange is taken, the wait state ends and the system does not look for any other such conditions. It responds to notes normally on the Current Effective MIDI In Channel (the "New Channel").

1 - **Note Off**. ← Old Channel's Note.
Note Off. ← New Channel's Note.
No action. ← Action in Delayed Mode under these circumstances.

Since no note is playing, the change in Effective MIDI In Channel does not result in the starting or ending of any notes, or waiting for anything else to occur. The system will play whatever notes are subsequently received on the New Channel. The Blue LED will not flash.

2 - **Note Off**.

Note On for note number YY, with Accent On or Off.

No action at the instant the new Effective MIDI In Channel is selected. Wait for whichever of the following three conditions occurs first.

No note was playing when the new Effective MIDI In Channel was selected. This continues – Delay Mode does not instantly play any note, such as YY, which is On in the New Channel.

Once one of the following conditions occurs, the system will take the specified action, if any, and return to ordinary Delayed mode without waiting for any more of these conditions.

a - Note YY ends on the New Channel without being replaced by any other note.
No action.

b - Note YY ends on the New Channel and is replaced there by a new Note ZZ.
Turn on a new Note ZZ. Flash the Blue LED.

This immediate replacement can only occur by one of two means. Firstly, ZZ was played before YY and so was on the New Channel's Note Stack, and is now coming to the top because YY, which was at the top, has been turned off. Secondly, YY has not been turned off and ZZ has just been received, displacing YY from the top position.

In either case, if User Definable Parameter 4 (MIDI In Slide on Tied Notes) is enabled, which it is by default, then if the Devil Fish had been receiving on this MIDI In Channel all along, the transition from YY to ZZ would have been done with Slide and without generating a new note (the Gate remains On, rather than going Off and then On to start the Envelope Generators for a new note). If Parameter 4 was set to 0, disabling MIDI In Slide on Tied Notes, the transition would have been without Slide – an abrupt change of pitch, again with Gate remaining On.

c - The Effective MIDI In Channel changes back to the Old Channel.
No action.

If the Effective MIDI In Channel changes to some other Channel than the Old Channel, the wait state continues.

3 - **Note On for note number XX, with Accent On or Off.**
Note Off.
No action at the instant the new Effective MIDI In Channel is selected. Wait for whichever of the following four conditions occurs first.

The Devil Fish was playing note XX at the time the New Effective MIDI In Channel was selected. This note continues.

Once one of these conditions occurs, the system will take the specified action and return to ordinary Delay mode without waiting for any more of these conditions.

d - The current Note XX ends in the Old Channel. It may be replaced by nothing or by a note for another note number.
Turn off Note XX. Flash the Blue LED.

(The old note XX cannot be replaced immediately by a new note XX in the same channel. The time it takes for a new note XX to be received via MIDI In would be about 0.7ms to 1.0ms and the MIDI In system would see the gap between them. A note XX cannot appear at the top of the Old Channel's Note Stack due to being in the second from top position and due to the top note XX being turned off, since a Note Stack cannot contain two notes with the same Note Number.)

e - A new Note YY (where YY = = XX) starts in the New Channel.
Turn off Note XX and about 3 msec later ➊ (see page 92) **turn on a new note with the same note number XX, but with the Accent setting of the new note. Flash the Blue LED.**

f - A new note YY (where YY ! = XX) starts in the New Channel.
Turn off Note XX and about 3 msec later ➊ turn on a new Note YY. Flash the Blue LED.

g - The Effective MIDI In Channel changes back to the Old Channel.
No action. See the notes for condition 'c' on the previous page.

4 - **Note On for note number XX, with Accent On or Off.**
Note On for note number YY, with Accent On or Off, where YY == XX.
No action.

The two channels had notes with the same note numbers but different Accent states. The Synthesizer Accent state is not altered, because changing Accent states in the middle of a note generally sounds bad.

5 - **Note On for note number XX, with Accent On or Off.**
Note On for note number YY, with Accent On or Off, where YY != XX.
No action at the instant the new Effective MIDI In Channel is selected. Wait for whichever of the following four conditions occurs first.

The Devil Fish was playing note XX at the time the New Effective MIDI In Channel was selected. This note continues.

Once one of these conditions occurs, the system will take the specified action and return to ordinary Delay mode without waiting for any more of these conditions.

h - The current Note XX either ends in the Old Channel, or is replaced there by a new Note AA which is different from (! =) XX:
Turn off Note XX and about 3 msec later ➊ (see page 92) **turn on a new Note YY with YY's Accent setting. Flash the Blue LED.**

(See the note above for condition d on the previous page.)

i - The current Note YY on the New Channel ends without being replaced there by a new note.
Turn off Note XX. Flash the Blue LED.

j - The current Note YY on the New Channel is replaced there by a new Note ZZ. ZZ may or may not be the same note number as XX.
Turn off Note XX and about 3 msec later ➊ **turn on a new Note ZZ, with ZZ's Accent setting. Flash the Blue LED.**

k - The Effective MIDI In Channel changes back to the Old Channel.
No action. See the notes for condition 'c' two pages above.

This *is* complex, but the summary is relatively simple: **In Delayed Mode, notes for the Synthesizer and MIDI Out do not end or start at the instant the Effective MIDI In Channel changes, but will end or start with the notes on the Old or New Effective MIDI In Channels at some time after the change.**

Transitions between Immediate and Delayed modes

This sub-section contains fussy details of the Dynamic Channel Switching system which you probably do not need to know anything about.

Here is a description of how the system responds to changes between Immediate and Delayed modes, with and without a change in Offset causing a change to the Effective MIDI In channel. There are two mechanisms by which the DCS system can be switched between Immediate mode and Delayed mode:

1 - The reception of Note On or Off events on MIDI In Channel 15 or 16 so that the Keyset system creates the change. This could be by one of two patterns of events:

a - All 8 Keyset notes were Off and a Note On which is received turns one of them On. Four of the Keyset note numbers select Immediate mode and the other four select Delayed mode. If the note which was just turned On is for the opposite mode to that which is currently active, then this changes the mode accordingly.

b - Two or more Keyset notes were playing and the one with the highest priority is turned Off, meaning that the next highest priority note which remains On determines the output of the Keyset system. If this next highest priority note selects the opposite Immediate / Delayed mode, then this changes the mode accordingly.

(Turning Off the only Keyset note which is currently On will not alter the Immediate / Delayed mode, but will enable the mode to be changed by a change in the value of Parameter 9 – see page 76.)

These two keyset changes may also change the state of bits `BA` (in the signal flow diagrams above) which would change their decimal value, which is in the range 0 to 3. If the new such values of bits `BA` are different from that which the Keyset number was previously producing (including if there were no notes on, when the system sets the bits `BA` to the state they were in when the most recently On Keyset note was turned On, or to `00` if no Keyset notes have been received yet) then, depending on which Installation this is and the setting of User Alterable Parameter 9, this changed pair of bits `BA` and its resultant decimal value 0 to 3 may directly or indirectly alter the Offset value (`HG` bits or `KI` bits) which is added to the Base MIDI In channel, to set the Effective MIDI In channel. In both cases, the `BA` bits are added to the `DC` bits to produce the `FE` bits.

The indirect path (**Installation 4** or **Installation 6** only) involves the `FE` bits driving the default contacts of the Audio / CV Input sockets, which (assuming nothing is plugged into these) drives the detector circuits and so the XOR gates which invert the bits `FE` produced by the two toggle-switches. The firmware reads the output of the XOR gates as bits `HG` and uses these as a value 0 to 3 to add to the Base MIDI In Channel number, to set the Effective MIDI In Channel number. Since the detector circuits take about 33 msec to turn off, a change from high to low (`1` to `0`) will not be sensed by the firmware at the same time as a low to high transition.
The direct path involves either (**Installation 3** and **Installation 5**) the `FE` bits

being copied to the HG bits, which are added to the Base MIDI In Channel number, or (**Installation 4** or **Installation 6**) the FE bits plus the HG bits (resulting in the KI bits) being added to the Base MIDI In Channel number.

By either the direct or indirect path, the difference between the Base MIDI In Channel number and the Effective MIDI In Channel number is the **Offset** – a number between 0 and 3.

Changing the Immediate / Delayed mode with Keyset note events may or may not change the Effective MIDI In channel. If the change goes through the default contacts to the Detector circuits, a short (sub-millisecond) delay will occur for a low to high (0 to 1) transition and a longer delay, in the order of 33 msec, will occur for a high to low (1 to 0) transition. This, and the 2 msec debounce algorithm mentioned in the next sub-section, may result in the Effective MIDI In channel changing to the new channel via an intermediate channel.

2 - By altering the value of User Definable Parameter 9, while no Keyset notes are active. If the new value is 1 or 4, this will select Immediate mode, and if it is 2 or 5, this will select Delayed Mode.

If this involves changing the current state of Immediate / Delayed mode (which may have resulted from changes to this parameter or the most recently received Keyset change, as mentioned above) then this change of mode will not be accompanied by a change in Offset, so the Effective MIDI In Channel will remain the same.

A change from Immediate to Delayed mode accompanied by a change in Offset will be handled according to the arrangements described in the previous section on Delayed Mode. If a change from Immediate to Delayed mode involves no change in Offset a the same instant (fraction of a millisecond), there will not be any turning on or off of notes in the Devil Fish synthesizer or via MIDI Out. The system will not be in a wait state and will continue to respond to Note On and Off events on the current Effective MIDI In channel.

A change from Delayed mode to Immediate mode accompanied by a change in Offset will be handled by turning off the note which was on during Delayed mode, and by playing the note, if one is on, from the new Effective MIDI In channel. If there is a change from Delayed mode to Immediate mode, without a change in Offset, and the system was previously in a wait state (points 2, 3 or 5 in the previous section on Delayed Mode), then this wait state will end, together with any note which was playing as part of this state. If the Effective MIDI In channel (which is unchanged, since Offset has not changed) has a Note On, then this note will be played on the Devil Fish Synthesizer and via MIDI Out.

When in Delay mode, whether or not the system is in a wait state, it is possible to change the Offset. This will not cause any notes to send or start, but the system will be looking for notes ending on the MIDI In channel which was the Effective MIDI In channel when Delay mode was turned on, and for notes starting on the current Effective MIDI In Chanel.

Precise timing of DBCS Audio/CV, detector and toggle-switch, signals

The MIDI In and Out firmware implements a *debounce* algorithm on the two bits which are read from the two XOR gate outputs in **Installation 4** and **Installation 6**. These bits are depicted in the data flow diagrams above as the two bits **HG**. However, the diagrams do not show the debounce algorithm, which is applied before the bits are added to other bits to generate the Effective MIDI In Channel.

This debounce algorithm is **not** used for **Installation 3** or **Installation 5**, in which the two bits **HG** are generated inside the firmware as a result of Notes (for a Keyset) and/or Control Changes, which are received on MIDI In Channel 15 or 16.

This debounce algorithm is inside the MIDI In and Out system's firmware (inside its microcontroller chip) rather than being implemented by hardware such as separate integrated circuits. So this debounce algorithm does **not** affect the timing of changes to the bank address bits for the 32 Bank Memory System in the Dynamic Bank Switching part of **Installation 6**. (DBS timing is discussed at the end of this sub-section.)

This debounce algorithm is applied only to the **HG** bits which are read from the XOR gate hardware. It is **not** applied to the **FE** bits which may be used to drive the default contacts of the two Audio / CV Input sockets (User Definable Parameter 11 = 3, 4 or 5, where 4 is the default setting) or to add directly to the debounced **HG** bits to generate bits **KI** which is the offset which drives Dynamic Channel Switching (**Installation 4** and **Installation 6**, User Definable Parameter 9 = 1 or 2).

Debouncing is a process of ignoring changes which are deemed to be spurious, to give a simplified, cleaner, set of transitions between the 0 and 1 states of both bits than if the firmware read the signals several times per millisecond and acted on every change in these signals which it sensed. The term *debounce* originates in the bouncing of physical switch contacts when they first close, in which from a human point of view, the switch closes, but from an electronic point of view, the metal contact closes for a short time, bounces open, closes again, bounces open etc. potentially several times, before finally settling down to a consistently closed position after a period of, for instance, several milliseconds.

The toggles-witches which drive the XOR gates have a simple debounce circuit – a capacitor which is charged to +5 volts or discharged to 0 volts the moment the moving contact touches the upper or lower fixed contacts. These produce a clean signal which shows no sign of contact bounce. This simple arrangement works with no delay whatsoever. So the firmware's debouncing algorithm is not needed to deal with the bouncing of the toggle-switch contacts.

The two Detector Circuits for the two Audio / CV inputs involve immediate (sub-millisecond) response to the input signal going above the approximately +1.15 volt threshold and an approximately 33 msec delay in the Detector Circuit going Off after the input signal drops the threshold. (It is best to use +1.3 volts or more to be sure of turning the Detector Circuit on and 1.0 volts or less to be sure of turning it off. In between these voltages the Detector circuit's output may be unstable.) This is a form of debouncing, and is quite separate from the firmware's debouncing algorithm discussed in this section.

The firmware debouncing algorithm for each XOR gate output copes with erratic behaviour of that output which can be caused by erratic transitions in either input to the XOR gate. However, the switch signals have perfectly clean transitions, so the purpose of the firmware debounce algorithm is to deal with some aspects of the two input signals and how the Detector Circuit responds to them, each with an approximately 33 msec hold time in the On state.

The firmware debounce algorithm works with both signals together and only passes the new state of both bits to the rest of the firmware after **both signals have remained stable for about 2 msec**. The firmware looks at the signals about ten times per msec and uses a simple down counter, which it restarts to its initial value of about 20, every time one or both of the signals change. The counter is decremented every run of the code in which the signals have not changed. When it reaches zero, the signals have both been stable for 2msec and their state is reported to the rest of the firmware as the `HG` bits.

This debounce algorithm is intended to clean up the transitions of these bits to cope with several potential problems:

1 - Potentially erratic signals being sensed by the left (in the data flow diagrams above) input of each XOR gate as the (approximately) 33 msec timer in the detector circuit transitions from its On state (high = binary `1`) to its Off state (low = binary `0`). Noise and instability in the circuits can mean that a transition which is ideally clean: --------________ is in fact erratic, such as: -------_-__--____. (The Off to On transitions are typically sharp, and involve no noise or oscillation which might cause the XOR gates' inputs to sense such instability.)

2 - *Small* (such as less than 2 msec) differences in the (approximately) 33 msec hold times of the two Detector Circuits, due to component value differences, noise, temperature variations and due to exactly how hard they were turned on by the input signal – how much above the approximately 1.15 volt threshold they were and for how long. (The input circuit is a resistor divider driving the base of an NPN transistor, the collector of which discharges a capacitor, which is sensed by another HCMOS XOR gate operating as an inverter.) These hold time differences may exceed the approximately 2 msec time constant of the debounce algorithm, so the instants at which two identically driven Detector Circuits turn off may appear to the rest of the DCS firmware, even after the firmware's debounce algorithm, to be at different points in time.

3 - Slight variations in timing between the transitions to the On state of the two externally supplied CV or Audio signals which drive the detector circuits. While these transitions may be intended to occur musically "at the same time", without the debounce circuit one may be sensed as occurring before the other. If the time difference is shorter than the debounce algorithm's time constant (about 2 msec), then the two transitions will appear to the rest of the DCS firmware to go On at exactly the same time.

(If the approximately 33 msec on times of the detector circuits were within a millisecond or so of each other – which they probably won't be – then the debounce algorithm would similarly respond to slight differences in the time at which the two CV/ Audio input signals go Off in the same way – making them appear to the rest of the firmware as occurring at the same time. However, the variation in detector circuit hold times is likely to exceed the debounce time, so this is unlikely to be achieved.)

If the debounce algorithm's timer ran for, say, 10 msec or 30 msec, then any relative time differences between high-to-low and low-to-high transitions in these two XOR gate outputs would be "ironed out" by the debounce algorithm, as long as the time differences and/or instability in one or both of the signals were shorter than 10 or 30 msec. However, this would have the undesirable effect of delaying the XOR gate's ability to affect Dynamic Channel Switching by 10 or 30 msec.

The 2 msec debounce time will clean up *some* noise and *some* difference in timing between these two signals, but it will not clean up all the differences which might occur when the signals are intended to be, from a musical point of view, transitioning at the same time.

The approximately 2 msec debounce time constant means that all the changes which occur in the toggle-switches, and the outputs of the detector circuits, as reflected in how they change the output of the XOR gate (which responds in tens of nanoseconds, such as 0.00002 msec) will be sensed 2 msec after they occur, even if the transitions happen together and are very clean – without noise or other erratic changes.

If the transitions occur with some time difference less than 2 msec, then the debounce circuit will report the changes 2 msec after the last of these transitions. For example, if the left XOR gate output (which drives the bit **H** output of the debounce algorithm) changes from 0 to **1** at some time X, the left XOR gate output (which drives bit **G**) changes from 0 to **1** 1.4 msec later (X + 1.4 msec), and there are no further transitions, then the debounce algorithm will time out at about X + 3.4 msec. The rest of the DCS firmware will sense both transitions as occurring at the same time – a clean transition from 00 to **11** – about 3.4 msec after time X, when the first transition occurred.

This 2 msec debounce period is unlikely to clean up the timing differences which occur between the two XOR gate outputs as a result of a manual action to move both toggle-switches Up or Down at the same time. So for these manual switching operations involving the two bits at about the same time, for sensing Audio / CV inputs turning on the detector, and for the detector circuits turning off, each with an approximately 33 msec delay, we must accept that **signals we want to go on and off at the same time in a musical sense, are likely to be sensed by the DCS firmware as transitioning at different times**.

For instance, if the **HG** bits were initially 00 and you wanted them to both change so they became **11** at musically the same time, if the actual difference in timing between the two bits changing at the outputs of the XOR gates exceeds the approximately 2 msec debounce interval, then these transitions will not be cleaned up (reported as if they occurred at the same time) by the firmware's debounce algorithm. So the rest of the DCS firmware will sense the transitions as occurring at separate times.

Since these bits are acting to select between four MIDI In Channels, we can think of the two bits representing decimal numbers 0, 1, 2 and 3, and the two possible.

The DCS firmware *may* detect the two bits making a single transition from 00 to **11**, but it is quite likely to detect the changes as two transitions, in either of these two patterns:

00 **1**0 **11** Decimal: 0, 2, 3.

or 00 0**1** **11** Decimal: 0, 1, 3.

The top and bottom lines depict the same initial (`00`) and final (**`11`**) states, but arriving at the final state by two different intermediate states: (**`1`**`0`) or (`0`**`1`**). The two possible paths to the final state as depicted above involve traversing different intermediate MIDI In Channels. Maybe this will be fine. Perhaps these timing differences will produce musically interesting results. Alternatively they might produce unwanted glitches and confusion.

The **workaround** for this problem of unwanted intermediate states is to view the two CV / Audio inputs (as potentially driven from MIDI In Keyset Note events and/or Control Change events via the default contacts of the input sockets), the two Detector Circuits with their approximately 33 msec hold times, the LEDs and XOR gates, the firmware's 2 msec debounce algorithm for reading the XOR gate outputs, with the four MIDI In Channels 0, 1, 2 and 3 above the Base MIDI In Channel, not as a system for instantly and reliably switching between any of these four channels, but as a means of switching reliably and almost instantly (with a 2 msec time delay for On, and a 2 msec + about 33 msec time delay for Off) from the Base MIDI In Channel (**HG** bits `00` = decimal 0) to just *two* other channels:

> Channel **1** above the Base MIDI In Channel (**HG** bits `0`**`1`** = decimal 1) by causing the right XOR gate output to go high.

and:

> Channel **2** above the Base MIDI In Channel (**HG** bits **`1`**`0` = decimal 2), by causing the left XOR gate output to go high.

With the two toggle-switches and Audio / CV Inputs and their Detector Circuits you can instantly and reliably switch back and forth between the following pairs of bits, with their consequent offsets between the Base MIDI In Channel and the dynamically switched (as a result of these bit changes) Effective MIDI In Channels, since they all involve a change to just one bit, rather than both bits:

> `00` and `0`**`1`** (Decimal 0 and 1.)
> `00` and **`1`**`0` (Decimal 0 and 2.)
> **`11`** and `0`**`1`** (Decimal 3 and 1.)
> **`11`** and **`1`**`0` (Decimal 3 and 2.)

It is not possible to switch reliably between the following patterns of bits and resulting offsets, since these transitions involve changing two bits – and the 2 msec firmware debounce algorithm can't clean up dual bit transitions separated by more than 2 msec to make them into a single transition of both bits together:

> `00` and **`11`** (Decimal 0 and 3. There may be intermediate offsets of 1 and 2.)
> `0`**`1`** and **`1`**`0` (Decimal 1 and 2. There may be intermediate offsets of 0 and 3.)

Unwanted effects from transitions of both bits leading to a short period of switching to an intermediate MIDI In Channels are most likely to occur with Immediate Mode, in which Note Events are generated as soon as the transition occurs. These unwanted effects are less likely to occur with Delayed Mode, since Note Events are not generated at the instant of selecting the new channel, but afterwards, as a result of Note Events on the Old and New Channels.

If your Dynamic Channel Switching requirements involve precise control, you may find it best to adopt this approach: use the Base MIDI In channel (offset 0, **HG** bits = `00`) with its pattern of notes and two alternative channels with their patterns of notes, with those channels being 1 and 2 above the Base Channel (offsets 1 and 2, **HG** bits = 0**1** and **HG** bits = **1**0) .

The above discussion of timing differences concerns affect Dynamic Channel Switching. For **Dynamic Bank Switching**, the precise timing is less important, since – like DCS with Delay Mode – no Note Event actions are performed by the Internal Sequencer the instant the bank address changes. This is due to the Internal Sequencer having no concept of the changed bank. The Internal Sequencer does not read from the memory system until just before the next note is due to be played.

The 2 msec debouncing algorithm is within the MIDI In and Out firmware and only affects how the two bits are reported to the rest of the DCS firmware. This debouncing algorithm does not affect or delay how the outputs of the two XOR gates affect the memory bank addresses in **Installation 6**. There is effectively no delay (only tens of nanoseconds) between the XOR gate outputs changing state and the new memory bank being selected. Turning on the detector circuit will drive the XOR gate left input and alter the XOR output, and so one bit of the 5 bit Memory Bank address, within a tiny fraction of a millisecond. The instant a metal contact in the toggle-switch touches its high or low contact, this voltage drives the other input of the XOR gate and the address bit to the memory system is likewise changed in a tiny fraction of a millisecond.

It is possible that the transition from one memory bank address to another occurs while the TB-303's CPU reads several nybbles (4 bits) from the memory, as it does to retrieve the pitch, timing, Accent and Slide information for the next note. If so, then the Internal Sequencer will receives some part of its next note information from one bank and the rest from another. With both XOR gate outputs changing at about the same time, there may be a brief intermediate state, and therefore memory bank address, between the initial and the final states and addresses. If so, these three bank addresses in quick succession may cause the Internal Sequencer to read nybbles from all three banks. These events are unlikely to occur and would be impossible to reproduce reliably, so if the musical effects are desirable, you will hopefully be recording the results!

In both in **Installation 4** and **Installation 6**, if User Definable Parameter 9 is set to 1 or 2, then the two **FE** bits – which result from Channel 15 or 16 Keyset keys and/or Control Change messages – are added to the debounced XOR output bits (**HG**) so that the resulting sum of 0 to 3 and 0 to 3 is wrapped around at 4 to produce bits **KI**, also with a range of offsets 0 to 3. These **KI** bits are added to the Base MIDI In Channel to create the dynamically switched Effective MIDI In Channel. (See the second of each pair of full-page diagrams above, those whose titles end in "default pin drive disabled: Parameter 9 = 1 or 2".) The results of this addition is tabulated below, in binary and decimal, with the resulting offsets in black:

FE bits from Keyset keys and/or Control Changes on Channel 15 or 16:		00	01	10	11		0	1	2	3
HG bits from XOR of toggle-switches and Audio/ CV Input signals driving Detector Circuits	00	00	01	10	11	0	0	1	2	3
	01	01	10	11	00	1	1	2	3	0
	10	10	11	00	11	2	2	3	0	1
	11	11	00	01	10	3	3	0	1	2
		KI binary					**KI** decimal			

With **Installation 4** and **Installation 6**, and User Definable Parameter 9 set to 1 or 2, then it is possible to create clean transitions between any of the four states of the FE bits, since it is possible to generate any of the states by sending a single Note On event to the Devil Fish on Channel 15 or 16 (as selected by User Definable Parameter 10) which matches the currently selected Keyset (as selected by User Definable Parameter 10). If no other higher priority Keyset notes are currently On, then as soon as this Note On event is received, the Dynamic Channel Switching firmware will use the resulting value of the FE bits, as part of the addition with the HG bits to create the KI bits offset, which selects a new Effective MIDI In Channel in place of channel which resulted from the previous state of these FE bits.

Similarly, for the just mentioned installations and values of Parameter 9, if Control Change messages for Channel 15 or 16 (as selected by User Definable Parameter 11, page 76) are sent from a sequencer, any value can be sent in such a message, so resulting in direct transitions from any state of the FE bits to any of the three other states.

If these Control Change messages are generated by a manually operated device, such as a Mod Wheel on a MIDI master keyboard, then it likewise possible to create clean transitions, without intermediate states, between the offsets 0 and 1, 1 and 2, and 2 and 3. However, there is no way of getting from 0 to 2 or 3, or from 3 to 0 or 1, by moving the wheel, so there are bound to be intermediate states 1 between 0 and 2 and 2 between 1 and 3. This may be fine, or it may be a problem to have to transition through 1 or 2 when switching between 0 and 3.

If the HG bits are stable, it is possible to create clean transitions between all four offsets (possible values of the KI bits) 0 to 3 via the FE bits, which are not subject to any delay or debounce algorithm.

If the FE bits are stable, then you *may* be able to create clean transitions between all four offsets via toggle-switch and/or Audio / CV input signal changes – but only if the Detector Circuits' approximately 33 msec hold time and the approximately 2 msec firmware debounce algorithm are able to unify transitions of both bits into a single transition in the debounced HG bits.

In general, it will *not* be possible to generate clean two-bit transitions (without a potentially unwanted intermediate state) when for a single point in time (from a musical perspective) you change both one or both FE bits *and* one or both HG bits. The firmware processes its input states about 10 times per millisecond. It is highly unlikely that changes you create to FE bits via MIDI In will be sensed by the firmware in the same 1/10th millisecond processing cycle as the debounced HG bits change state.

So even though both the FE and the HG bits may change state cleanly, it is unlikely that they will change in the same firmware processing cycle, so you can't rely on changing both bit sets to create clean transitions in both KI bits.

However, with **Installation 4** and **Installation 6**, and User Definable Parameter 9 set to 1 or 2, as long as the real-time changes you make are just to the FE bits, with a single Note On event (Keyset keys) or with a single Control Change, while the HG bits are stable, then there will be a corresponding clean (single) transition to a new state of the KI bits.

By not changing the FE bits while changing just one of the HG bits – by moving a single toggle-switch or by turning the signal into a single Audio / CV input On or Off – you can be assured that there will be a clean transition to a new state of the KI bits. These principles remain true even if the change in state of the **KI** bits involves changes to both bits: between 00 and **11** (decimal 0 and 3) or between 0**1** and **1**0 (decimal 1 and 2).

The changes to the **KI** bits resulting from MIDI In events which drive the **FE** bits will happen as soon (within the next 1/10 msec firmware processing cycle) as they are received. The changes to the **KI** bits resulting from toggle-switch manipulation and/or changes in the outputs of the Detector Circuits will occur after the firmware debounce algorithm finds that the XOR gate outputs have been stable for about 2 msec.

8 - Summary of Power-On LED displays and button options

Initialise all Parameters in Non-Volatile Memory

To **initialise the non-volatile memory** so all the User Alterable Parameters are set to their default values, turn the machine on while holding both the **TAP** and **BACK** buttons. The Blue LED will flash **triple flash – triple flash – triple flash**. Release the **BACK** and **TAP** buttons during or after these flashes and the machine will be ready for normal operation – except that none of the functions below are available. If these are needed, turn the machine Off and On again and use the button combinations mentioned below. For further information, see page 18.

Display the MIDI In and Out system firmware version

To **display the version of firmware programmed into the MIDI In and Out system's microcontroller**, turn the machine on whilst pressing the **BACK** button but NOT the **TAP** button. For information on how to interpret the flashes, see page 18. The MIDI In and Out system will not function after doing this. To return to normal operation, turn the power Off and On again.

Disable Blue LED activity for Notes and Control Changes

To disable the operation of the Blue LED due to reception of MIDI In Notes or Control Changes, turn the machine on with the **TAP** button pressed, and the **BACK** button NOT pressed. For further information, see page 18.

Power-on display of whether Notes & Control Changes are being received

With the just-mentioned procedure or when turning the machine on without pressing any buttons, the Blue LED displays one of two patterns for the first two seconds, after which normal operation starts (unless the **BACK** button is pressed four times, see below). **These two patterns of Blue LED activity, both of them for 2 seconds, indicate whether the Reception of MIDI In Notes and Control Changes is currently enabled or not**:

> If this is **enabled**, which is the default, the LED will display in 0.5 second intervals **bright, dim, bright, dim**.
>
> If it is **disabled**, then the LED will display **double-flash – double-flash – double-flash – double-flash**.

This reception can be turned On and Off by the procedures described on page 20.

Enabling the DBCS MIDI functions

Please see *Enabling and configuring the DBCS MIDI features* on page 75.

Calibrating the microcontroller's CV In measurement system

Please see Section 12, page 113.

9 - Advanced use of the Sync-MIDI-In socket

Isolation of MIDI Pin 2

The TB-303's Sync socket uses Pin 2 (centre) for ground, via a 22 ohm resistor. In most MIDI devices, this pin of the MIDI In socket is not connected to anything. It is always connected to ground on MIDI Out sockets for the purpose of grounding the shield of the cable.

The MIDI data lines (Pins 4 and 5 – on either side of the centre pin) drive the MIDI In device via an opto-isolator, to avoid problems with ground loops, which can cause background hum etc. (An opto-isolator consists of a Light Emitting Diode driving a phototransistor in an on-off manner. The serial data bits of MIDI are conveyed by light, rather than by electrical current or any form of direct electrical connection.)

This standard MIDI arrangement of having Pin 2 being a non-connection means there is no electrical connection between the MIDI Out device and the MIDI In device, other than the current flowing between pins 4 and 5 through the LED of the opto-isolator. This is not a direct electrical connection between the sending and receiving machines, so the MIDI cable connection cannot cause any ground noise problems.

With the TB-303 / Devil Fish with MIDI In, or with MIDI In and Out, there will be no such electrical isolation between devices, so there could be some electrical noise, particularly if the driving device is a personal computer, which are notorious for generating electrical noise. A workaround is to use a special lead with the centre pin cut off, or disconnected, at the TB-303 / Devil Fish end. Any potential ground loop problems are likely to be less serious than if Pin 2 was directly connected (zero ohms, rather than 22 ohms) to the TB-303 / Devil Fish ground. The 22 ohm resistor (which is part of the original TB-303 circuitry) is low enough to connect the TB-303 / Devil Fish ground to the ground of an external Sync source, if there was no other form of connection between these two grounds. However, the 22 ohms is high enough that it is likely to have not such a strong ill-effect in the event of a "ground loop" or other such ground noise problem. (The subject of ground noise problems is extensive and difficult to comprehensively describe.)

MIDI In whilst still using the internal Tempo Clock and Run/Stop

If a MIDI lead's plug was modified so as to cut away the metal of the shell where the locating ridge is (the top of the shell when it is plugged into the TB-303 / Devil Fish) then MIDI information can be sent to the MIDI In system without activating the Sync socket switch which disconnects the internal Tempo Clock oscillator (controlled by the Tempo knob) and the internal Run/Stop flip-flop (controlled by the Run/Stop button).

This would enable MIDI control of Note, Gate, Slide, Accent and Filter Frequency via MIDI while the TB-303's internal sequencer is operating from its internal Tempo Clock oscillator. It would also be possible to play notes – but this would take control of the TB-303's DAC away from the TB-303's CPU. Then, only the TB-303 CPU's Gate output would affect the synthesizer, since the MIDI In system takes full control over Accent and Slide. It would also be possible to receive MIDI Sync in this mode, but the results are likely to be confusing, as described in the sub-section *Confusion due to Unplug Timer being disabled* on page 43.

Receiving MIDI Sync and driving external devices

With an external box, or a special lead, it is possible to achieve the following:

1. A separate MIDI In socket, which connects only pins 4 and 5 to the TB-303 / Devil Fish's Sync/MIDI socket. This solves any ground noise problems created by the noise on the ground of the MIDI Out device.

2. One or more sockets or 5 pin DIN plugs which take the pins 1, 2 and 3 (Run/Stop, Ground and Clock) signals from the Sync socket to one or more other devices.

   Since one Sync output device can drive dozens of Sync input devices and since there is no need for electrical shielding of these cables, or concern about their length (tens or hundreds of metres should be fine), a suitable box with sockets, or flying leads, could be created to extend the usefulness of the MIDI In system.

We can supply such a lead. Please see the **sync-lead/** page at the Devil Fish website

10 - The Pesky C4 Note in Pattern Play mode

There is a pesky **combination of circumstances** which may cause trouble with an unwanted sustaining C4 note for the Devil Fish synthesizer and any slave devices running from its CV and Gate outputs. **The same problem will affect any devices receiving MIDI Notes from the Devil Fish's MIDI Out system.**

When the TB-303's Internal sequencer is in Pattern Play mode and one of these two combinations occur:

A - The Internal Sequencer is Running (the TB-303's Run/Stop LED – labelled "RUN BATTERY" is On – due to local Run/Stop and Tempo, DIN Sync In or MIDI Sync Receive) and the **TAP** button is pressed for any reason, such as any of the Devil Fish MIDI In and Out system Front Panel operations, AND the Internal Sequencer is subsequently put into a Stop state, or:

B - The Internal Sequencer is not Running and the **TAP** button is pressed for any reason.

Three potentially annoying things will occur:

1 - The Internal Sequencer will play and hold a note C above Middle C = 2.0 volts = C4 = MIDI note number 72. (The pitch of this note is not affected by using the Pitch button and one of the keys to transpose the pattern.) This note will remain on until the Internal Sequencer starts playing again, in this setting of the Mode Switch (Pattern Play) or in one of the other three: Track Write, Track Play or Pattern Write. Simply changing the Mode Switch does not turn off the note.

2 - Any slave devices running from the Devil Fish's Gate output will receive a Gate On signal and so play this Pesky C4 note.

3 - **In either circumstance A or B, the MIDI Out system will be in External CV mode, unless the MIDI In system has received one or more MIDI In notes in which case it will be in MIDI In Follow mode and so will not be playing a note in Ext CV mode. Assuming it is in External CV mode and there is nothing plugged into the Pitch CV In or Gate sockets, then the MIDI Out system will detect this C4 note (via sensing the Gate and CV voltages, both of which are driven by the Internal Sequencer in the just-mentioned conditions) and will play an indefinitely long note to MIDI Out.**

As noted in A above, this Pesky C4 note will end if the Internal Sequencer starts running again. The MIDI Out version of this note will also be terminated if either of these occur:

a - The MIDI Out Channel number is changed.

b - The MIDI Out system changes to MIDI In Follow mode (due to it receiving at least one note on MIDI In).

One workaround is to use Pattern Write Mode when changing the MIDI channel or doing some other Front Panel operations. However, Pattern Write Mode does not allow two valuable features of having the Internal Sequencer playing in Pattern Play mode:

1. The ability to transpose by pressing the Transpose button and one of the keys.
2. The ability to change the Pattern being played, including selecting multiple patterns with keys 1-2; 2-3; 3-4; 1-2-3; 2-3-4; 5-6; 6-7; 7-8; 5-6-7 and 6-7-8.

The problem behaviour is built into the TB-303's Internal Sequencer and I can't see a robust way the MIDI In and Out system can correct for this.

A second workaround is to use Pattern Play mode of the Internal Sequencer and accept that the Internal Sequencer's C4 note on the Devil Fish synthesizer, via CV and Gate Out and **via the Devil Fish's MIDI Out system** will occur – but use a quick Start and Stop action on the Devil Fish's Run/Stop button, or on whatever master sequencer the Devil Fish is synched to, in order to stop the Pesky C4 note and, necessarily, play the first note of the current pattern for a fraction of a second.

11 - Summary of MIDI In and MIDI Out messages

The Devil Fish MIDI In and Out system can receive MIDI Note and Control Change messages with running status – two or more pairs of data bytes which are interpreted according to the most recent status byte. It transmits without running status except for when it sends a Tied Note On-Off Slide pair of Note events. This would take 6 bytes without running status, and by using running status, it takes 5 bytes, saving 1/3rd of a millisecond. The system does not receive or send any messages concerning System Exclusive, MIDI Timecode, Song Position, Program (Patch) Change Pitch Bend, Aftertouch or Active Sensing.

MIDI In Messages received by the Devil Fish

Messages	Purpose	User Definable Parameters which affect this	Details
MIDI Sync: Start, Clock & Stop.	1 - To generate DIN Sync which drives the Sync Socket's outer pins and the Internal Sequencer. 2 - To drive MIDI Sync bytes to MIDI Out.	7	The Continue message is interpreted in the same way as Start.
Note On & Off.	On Channel 15 or 16 for **DCS** (the Keyset system).	10	Any Note events recognised by the Keyset system are not used as mentioned below.
Note On & Off.	All Channels, for playing notes.	0 1 2 4 6	In ordinary (non-DCS) mode, only one MIDI In Channel (as selected by Parameter 0) is used for playing notes. When **DCS** is enabled, a set of four MIDI In Channels are used: the Base MIDI In Channel (Parameter 0), plus 0, 1, 2 or 3, with the addition wrapping at 17 to 1.
Control Change	On Channel 15 or 16 for **DCS**.	11	Controller numbers 1 to 10 can be selected. Any Control Change recognised in this way is not used for the purposes listed below.
Control Change	On the Base MIDI In Channel, for Filter Frequency.	3	Controller numbers 1 to 10 can be selected.

DCS: The Dynamic Channel Switching MIDI functions must be enabled with a special Power On procedure. See page 58.

(This table is continued on the next page.)

MIDI In Messages received by the Devil Fish, continued:

Messages	**Purpose**	**User Definable Parameters which affect this**	**Details**
Control Change	On the Base MIDI In Channel, for turning on Gate and/or Slide independently of the Note reception process.	5	Controller numbers 1 to 19 can be selected.
Control Change 20 & 21	On the Base MIDI In Channel, for setting the MIDI Out Velocities of Non-Accented and Accented Notes respectively.		See the sub-section above *MIDI In control of Velocity values for MIDI Out Notes* on page 48. These are always received, even if Reception of MIDI In Notes and Control Changes is disabled (page 20).
Control Change 64 (Sustain)	On the Base MIDI In Channel, for driving "Sustain", meaning the Gate of the Synthesizer.		Values 0 to 63 turn Off the internal flag which can turn the Gate On. Values 64 to 127 turn the flag On. This internal flag is ORed with two other sources of Gate: The Note On/Off system. The Control Change mentioned above which is configured by Parameter 5. If one or more of these are On, the Gate signal to the Synthesizer will be turned On.
Control Change 120 and 123 (All Notes Off)	On any MIDI Channel, with additional actions if received on the Base MIDI In Channel. These All Notes Off commands should only be sent by a master device to clear any potentially held notes after a musical piece is no longer playing. They should not be sent as part of ordinary playing MIDI Notes in the middle of a piece of music.		If this is received for the MIDI In Channel 15 or 16 as set by Parameter 10 (Keyset channel) then any currently On notes in the Keyset are turned Off. For each MIDI In Channel, all currently On notes in the Note Stack are turned Off. Additionally, for the Base MIDI In Channel, all Slide and Sustain (Gate) flags (as described above) are turned Off and if the Filter is being driven by received Control Changes, this drive is turned Off. However, this does not disable the MIDI In sub-system's drive of the TB-303's DAC.

MIDI Out Messages generated by the Devil Fish

Messages	**Purpose**	**User Definable Parameters which affect this**	**Details**
MIDI Sync: Start, Clock & Stop.	Driven by reception of MIDI Sync or by sensing the Roland/DIN Sync signals at the Sync Socket, which may originate from the internal Tempo and Run/Stop system or from the signals sent via a cable from an external master device.	7	
Note On & Off.	On a single Channel 1 to 16 as selected by Parameter 8 (MIDI Out Channel), where a setting of 0 means to transmit on the same Channel as the Base MIDI In Channel (Parameter 0).	8 (0)	The MIDI Out system generates Note events, using one of three automatically selected modes, according to the actions of the Internal Sequencer, the CV and Gate inputs, the Accent Button and the MIDI In sub-system interpreting MIDI In Notes, including with Dynamic Channel Switching.
Control Change	On the same Channel as noted above, for Filter Frequency Out.	8 (0) 3	The Controller number is the same as is used for reception of Filter Frequency. This does not sense the position of any knobs or the voltages on any CV inputs within the Devil Fish. It is simply a replication of MIDI In Control Changes for Filter, to the extent that they can be accommodated in the MIDI Out stream without delaying Note or Sync messages.

12 - Calibrating the measurement of CV In

There should be no need for users or technicians to perform this, but here is the information just in case.

Please let us know beforehand if you think there is any reason to perform this procedure, since this procedure will over-write the thresholds we stored in the non-volatile memory of the MIDI In and Out system's PIC microcontroller. The Ext CV mode of MIDI Out note generation will only work properly if there is a successfully generated set of thresholds stored in non-volatile memory.

The Ext CV MIDI Out mode requires that the MIDI In and Out system's PIC microcontroller measure voltages in the range 1.0 to 5.0 volts, to decide which of the 61 1/12 volt semitone steps the voltage is within. The reference voltage for this ADC (Analogue to Digital) operation is the internal 78L05 5.0 volt regulator which drives the PIC. This should be stable over time and temperature, but each regulator's voltage is not guaranteed to be precisely 5.000 volts.

When we install the MIDI In and Out system, we perform the following steps which cause the PIC's firmware to record a series of threshold numbers in non-volatile memory. These will be used to classify the CV In voltage (or, if nothing is plugged into the CV In socket, the voltage produced by the Internal Sequencer driving the TB-303's 6 bit DAC) into one of the 1/12 volt steps. These thresholds are *not* altered in the procedure which resets all the User Definable Parameters to their defaults (turning the machine on with both **TAP** and **BACK** buttons pressed), as described on page 18.

The TB-303's 6 bit DAC is used as the voltage reference for setting these thresholds.

The only reasons this procedure should need to be performed are:

1. The 78L05 regulator has been replaced.
2. The PIC microcontroller has been replaced, in which case it will be necessary to perform this procedure so the chip's non-volatile memory contains thresholds which work with the Devil Fish's particular 78L05 regulator.

Before performing this procedure, ensure that the 5.333 volt reference voltage for the 6 bit DAC has been set precisely – within a millivolt or so. This requires a 4.5 digit digital volt meter, connected to IC16 pin 7, and adjustment of trimpot TP5.

Make sure that nothing is plugged into the CV In socket.

Turn the machine on with the **BACK** button pressed. Release the button once the Blue LED lights up. The Blue LED will display the firmware version number as described on page 18 in a series of bright and dim flashes. This cycle takes about 9 seconds for V2.1.0 and could take up to 20 seconds for higher version numbers.

At the end of each cycle, the firmware looks for both the **TAP** and **BACK** buttons being pressed.

Press and hold both the **TAP** and **BACK** buttons for as long as it takes (no more than 20 seconds) for the Blue LED to flash in a different manner: three bright flashes over 3 seconds. The flashing pattern then changes to the reporting the activity of the calibration process. Release both buttons.

A successful calibration process will involve:

- 14, 15 or 16 dim flashes in about 4 seconds.
- A bright flash within about 1 second.
- 14, 15 or 16 dim flashes in about 4 seconds.
- A bright flash within about 1 second.
- 14, 15 or 16 dim flashes in about 4 seconds.
- A bright flash within about 1 second.
- 14, 15 or 16 dim flashes in about 4 seconds.
- A bright flash within about 1 second.
- Dim light with a short bright flash every 2 seconds.

An unsuccessful calibration process may end in the same pattern of short bright flashes every 2 seconds, or it may end in a pattern of 1 second dim and 1 second off. The test for success is the ability of the Ext CV mode to generate the correct MIDI note numbers for voltages between 1.0 and 5.0 volts.

13 - Firmware version history

- **1.0.0** 2004-12-09 to **1.0.3** (2013). These are for the PIC16F870 microcontroller and support MIDI In only. The pinout of chips programmed with these versions suits the Devil Fish 4.0x, 4.1 and 4.2 circuit boards. Versions 1.0.0 to 1.0.3 have two bugs: MIDI In notes are played 1 semitone higher than they should and invalid data being written to the non-volatile memory which stores the settings for the MIDI In system. Devil Fishes in which I originally installed Version 1.0.0 to 1.0.3 may have a problem with their Internal Sequencer Accent flip flop being On at power-on, if the Internal Sequencer has not played any notes yet. (The workaround is to briefly play a pattern which has no Accents.) This may cause notes played by MIDI In and/or external CV and Gate inputs to play with Accent On. This is fixed with a hardware modification in all machines I worked on after October 2013.
- **1.0.4** 2013-12-26. This is for the PIC16F870 microcontroller and will be used to update MIDI In systems which I originally installed between 2004 and early 2013. It is also be used for MIDI In systems of Devil Fishes after this date, with the V4.2 PCBs (which includes Devil Fish modifications V4.2A).
- **2.0.5** (not yet used in a Devil Fish) is for MIDI In and is functionally the same as V1.0.4. This is for a PIC16F1936 microcontroller and the pinout is for a future Devil Fish 5.0 circuit board.
- **2.1.0** (2014-09-2) Initial version of the MIDI-In-Out system, based on V2.0.5 code and using a PIC16F1936 microcontroller which has more memory than the PIC16F870. With some hardware modifications, this can be used in the 4.0x, 4.1 and 4.2 circuit boards. A future Devil Fish 5.0 circuit board will directly suit the pinout required for this firmware and for the MIDI-In-only V2.0.5.

14 - Document history

- 2013-08-10 Forked the MIDI In manual, which originated in December 2004, into three documents: for the V1.0.0 to V1.0.3 MIDI In systems, for the V1.0.4 MIDI In system and this one for the V2.1.0 MIDI In and Out system.
- 2013-08-19 to early 2014 Many improvements to the documentation, hardware and firmware thanks to proofreading, suggestions and testing by Lincoln Webber. On 2013-11-03 I added the section on the Pesky C4 note. This and the previous version of the manual were on the website but were only used for testing the MIDI In and Out system.
- 2014-09-27 Manual updated to cover Dynamic Bank and Channel Switching. Thanks to Lincoln again for finding problems in the text which have now been fixed.