REAL WORLD INTERFACES

Engineering Change Order ECO-DFTB-08-00: MIDI In and Out Systems prior to February 2016 which may cause pitch fluctuations in notes played by the Internal Sequencer

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For the latest version of this document and for other Engineering Change Orders concerning technician-installable hardware changes for TB-303 Devil Fishes, please refer to:

http://www.firstpr.com.au/rwi/dfish/ECO/

This page lists the serial numbers of machines to which I believe this ECO currently applies. If you modify your Devil Fish to fix this problem, please let me know and I will remove the serial number of your machine from this list.

In early February 2016 when I discovered this (no-one has mentioned the problem) this problem applies to 3 machines in Australia, 3 in Los Angeles and one each in Germany, Netherlands and France.

The problem behaviour

There are potential leakage currents inside the PIC microcontroller chip which runs the MIDI In and Out system. These can affect the internal CV voltage (in the Slide circuit) which drives the VCO, the CV Out socket and the Filter Tracking pot. This can cause a slight increase in CV and so increase in pitch, such as 20mV positive, which raises the pitch about 1/4 semitone.

This problem can only occur with notes played by the Internal Sequencer - when the Internal Sequencer is driving the DAC and the Gate signal, and when the notes are longer than 1/16th note. The problem cannot occur when the internal CV is driven either by an external voltage plugged into the CV In socket (assuming that the impedance of that signal is low - much lower than the 100k impedance of the internal DAC) or if the CV arises from the internal DAC being controlled by the MIDI In section of the MIDI In and Out system.

To reproduce the problem, program a pattern with four notes all the same pitch. For each of these notes, program the timing with an initial 1/16th note followed by three 1/16th notes tied together. This means pressing first the button labelled "9" and then, three times, the button labelled "0".

When the pattern plays, to the extent that this leakage problem is occurring, you will hear the first 1/16th part of each 1/4 note occur at about the correct pitch, and the three following 1/16th note part at a somewhat higher pitch, probably with a little wavering.

Workaround

The workaround is to run the machine from alkaline C cells which are not entirely fresh. Please do not use ordinary non-alkaline C-cells, since they are prone to leakage if you accidentally let them go flat. Perhaps fresh alkaline batteries will be fine. If not, run the batteries in the Devil Fish or some other device for a few hours to reduce their voltage a little.

The purpose of this is to run the Devil Fish from a somewhat lower battery voltage than the approximately 6 volts (internally regulated) which it runs from when powered by an external 9 volt power adaptor. When you do this, the TB-303's CPU will run at a lower voltage than normal. When running from an adaptor, the CPU runs via a diode voltage drop from the internally regulated 6 volts, which means it is running from about 5.4 volts or so. If your batteries are about 5.6 volts when the Devil Fish is operating, then the TB-303's CPU will be running from about 5.0 volts.

As long as the TB-303's CPU is running from about 5.2 volts or less, there should be little or no problem with pitch fluctuations. If the battery voltage is too low, the Run/Stop LED will not be lit. Generally, it is best to avoid running from such low voltages, since the TB-303's CPU may not function correctly under these circumstances

Technical details of the problem

The CV fluctuation is due to leakage currents inside the PIC16F1936 microcontroller – specifically a positive current (raising the voltage) flowing inside the chip into pin 2, which is used as in input to the PIC's ADC, as part of the MIDI Out system.

It is not obvious from the data sheet, but it seems that raising any one or more of the input pins more than about 0.2 or 0.3 volts above VDD will cause internal leakage currents to flow in some or I guess all other input pins.

PIC pin 2 is connected via a 10k resistor to the output of the TB-303's DAC, which is an R-2R network of 100k and 200k resistors, with an overall impedance of 100k. The leakage current raises the voltage of the DAC output, by 20 or so millivolts. So the leakage current can be 0.2uA or so.

The leakage current occurs when one or more other input pins of the PIC are raised to more than about 0.2 or 0.3 volts above the VDD positive supply voltage, which is theoretically 5.0 volts. The exact supply voltage depends on the particular 78L05 regulator chip which provides this from the TB-303's 12 volt supply.

The primary cause of the leakage current is PIC pin 21, which is driven via a 3.3k resistor (I install it on the back of the main TB-303 board) from the Clock pin 9 of the 4174 hex latch, which stores the 6 bit DAC value. The 4174, which is like a 74C174, is driven from a precise 5.333 volt supply. Normally, in the unmodified TB-303, its data input pins and its clock pins are driven directly from the TB-303 CPU pins. In the Devil Fish with MIDI In or MIDI In and Out, the data pins of the 4174 are driven via 100k resistors from the TB-303 CPU. These 6 data pins are also connected to PIC input pins 16 and 22 to 26.

The single pin 21, driven via a 3.3k resistor, is a much stronger source of leakage current than the combination of all six data pins driven via 100k resistors.

If the note played by the Internal Sequencer is a single isolated 1/16th note, there is little pitch fluctuation (or at least too little to perceive clearly in such a short note), since the 4174 Clock line (PIC pin 21 via a 3.3k resistor) remains low for this period of time. The six DAC data lines may be fluctuating, but that has a minor influence.

The problem becomes most noticeable on the second and subsequent 1/16th note sections of a note which is 1/8th a bar or longer. On these subsequent sections, the clock signal goes high, except for a brief pulse to low for each 1/16th note section. (This signal also drives the sample or slide circuit via Q29 and Q30.) When this signal is high, it pulls PIC pin 21 high enough to cause significant leakage inside the PIC chip to pin 2, so the TB-303's DAC voltage rises about 20mV.

The first fix is to reduce the voltage swing at the Clock pin of the 4174 and (PIC pin 21) so it does not exceed the VDD ~5.0 volt supply voltage of the PIC. This is done with a single 33k resistor to ground.

Once this is done, there is still some pitch fluctuation due to the 6 data lines, which the TB-303 CPU is cycling in some way as the note progresses. The fix for this is to reduce their voltage with 1 meg resistors to ground.

With or without these resistors, the leakage problem cannot occur with MIDI In control of the DAC, since the PIC is driving the DAC 4174 data pins and clock pin, and this drive prevents the PIC pins from being raised enough above the PIC's VDD voltage to cause any leakage.

There is another mechanism which may cause the PIC chip to leak current into pin 2, however, it is unlikely. As I wrote on the ECO page:

> It is also possible that pitch fluctuations would occur if an external Roland/DIN Sync source is driving the Devil Fish, where the Sync signals are driven with greater than 5 volts. This is not the case for the TR-606 or TR-808, or for the TB-303's internal tempo system or with the Devil Fish MIDI In or MIDI In and Out drive of the Sync socket, which can be used with the Sync lead to drive other machines . However, it is possible that some other sync devices output voltages to +12 or +15 volts. The workaround is to avoid such sync sources, or have a technician construct a cable with resistors and Zener diodes to limit the voltage to 4.7 volts or so.

Hardware changes to minimise the leakage to the point where there should be no audible problem

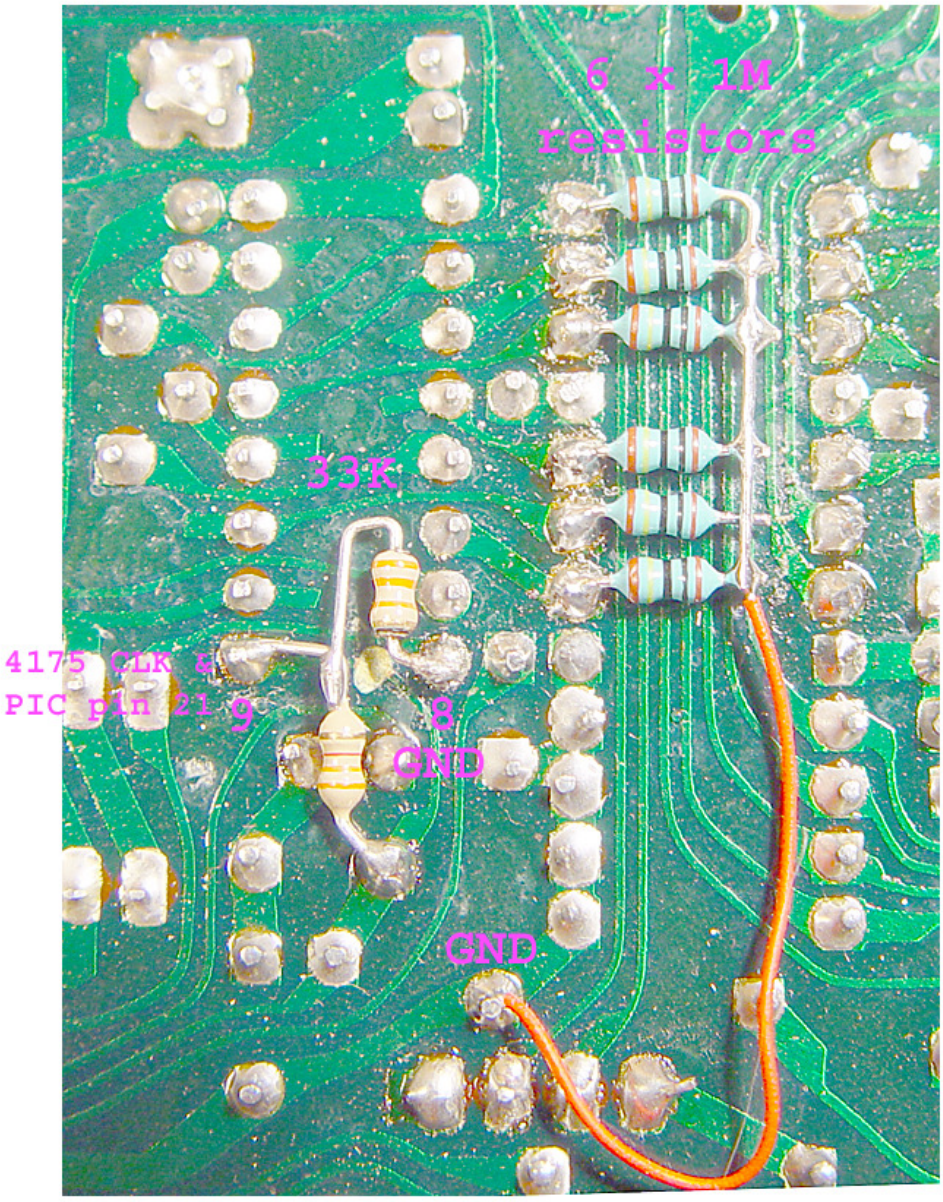
These changes can be made without too much effort, and without dismantling the entire TB-303 and Devil Fish.

In a fully static-controlled environment, remove the rear panel of the machine, and install:

1 - A 0.125 watt (or at least a similarly small axial resistor, even if its wattage rating is higher) 33k resistor between ground and the Clock pin 9 of the 4174. In this way, the Clock pin and the blue wire (soldered to pin 9 on the top side of the board, which you can't see if only the rear part of the case is removed) driving pin 21 of the PIC is the result of a 3.3k to 33k voltage divider. This means that the 4174 and the PIC get 10/11 of the voltage produced by the TB-303 CPU pin, and that pin's most positive voltage is now reduced somewhat by this new path to ground. Solder the resistor between pin 8 (ground) and the 3.3k resistor's wire to pin 9. It is best to solder the pin 9 connection to the lead of the 3.3k resistor, rather than to pin 9 itself, in case the heat from the soldering iron desolders the blue wire on the top side which is soldered to that pin. Fixing this would involve some disassembly and reassembly.

2 - Solder six 1M 0.125 watt resistors so that the right end goes to the right end of one of the 6 new 100 k resistors I installed in place of wire links, and so the left ends all go to ground.

The following photo shows how this can be done.



Document history

- 2016-02-07: Initial document.