'MIDI'fying the Hammond X-66

by Dan.Vigin

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TABLE OF CONTENTS.

MIDI IMPLEMENTATION ON HAMMOND X-66.

by Dan.Vigin

Forewords.

While the X-66 console is featured with numerous sound possibilities, it was interesting to envisage the MIDI implementation on Upper keyboard without falsifying its original performances.

The next two chapters provide the procedure to be followed for those who want to equip their X-66 console with MIDI converter and from there drive any external MIDI equipment such as expanders, synthesizers, sequencers, etc....

Nowadays, MIDI converters are available in the market at affordable price and are quite easy to install in the X-66 console.

In this specific case, only '**c**ontact-**t**o-**M**idi' converter is used (CTM64 for short).

As recommended by the supplier of MIDI converter, a row of free contacts has to be foreseen in the keyboard. This means insertion of a new ON/OFF contact in each keying module of the upper keyboard. This solution has been discarded at once, too much complexity. Moreover, such original contacts are no more available.

To cope with this situation, it was necessary to develop a dedicated MIDI interface unit which role is to take the benefit of existing X-66 contacts on one end and provide on the other end 'free' contacts to drive the CTM64 MIDI converter.

The realization of this MIDI interface unit, wiring, installation of MIDI converter, etc.. requires adequate technical skill mostly in musical instruments and under no circumstances should be undertaken by unexperienced technicians.

This X-66 MIDI implementation has been divided into two sections :

- Part 1. THEORY & CONCEPT : concept, principle and basic description.
- Part 2. REALIZATION: realization of MIDI Interface unit, wiring, installation, tests and measurements.

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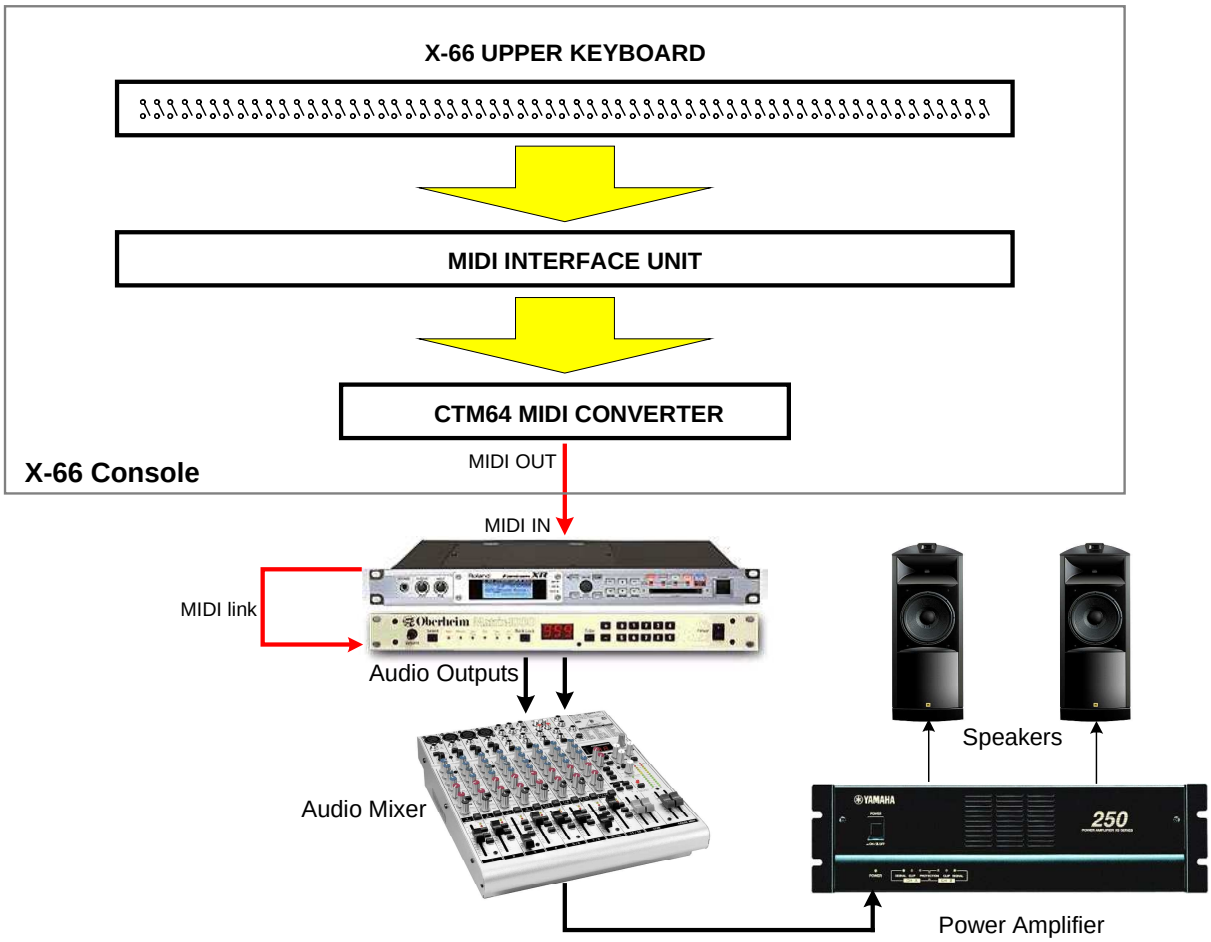
This information is for educational purposes only and no claims are made that this information will lead to any successful MIDI implementation.
Dan.Vigin assumes no responsibility to its use.

List of specific acronyms used can be found on Page 26.

PART 1. THEORY & CONCEPT

HOW TO START ?

The answer is "*by the beginning*", this means the block-diagram.



Block-Diagram : MIDI implementation

From top to bottom,

- X-66 contacts of upper keyboard (61 in total). Traps row of contacts is used.

- MIDI Interface unit to be realized and installed under the row of keying modules.

- The 61 ON/OFF contacts provided by the MIDI interface unit are driving directly the CTM64 MIDI converter.

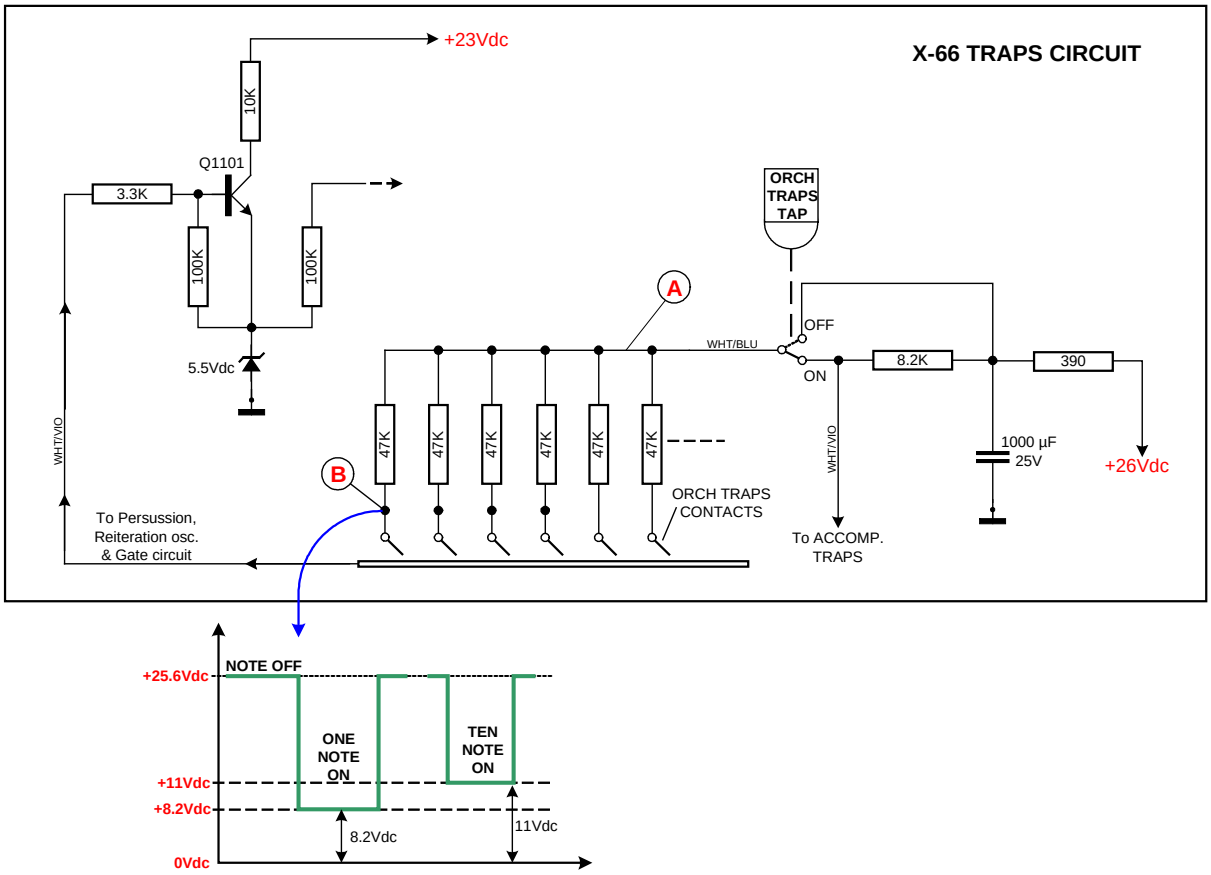
- MIDI OUT connector is linked to external MIDI instruments.

- Audio (analogue) signals from MIDI instruments are routed through any audio system i.e. audio mixer, power amplifier and speakers as usual.

1. Contacts of Upper Keyboard.

The upper keyboard of X-66 is equipped with 15 rows of contacts in which 13 of them are carrying analogue signals and therefore are unusable for MIDI implementation.
The PERCU row did not provide adequate signal either.
Fortunately, the remaining one is the ORCH.TRAPS row and does provide adequate DC voltages that will be exploited to trigger the interface unit.

Firstly, it is important to understand how this ORCH.TRAPS circuit is working.



Whether the ORCH. tap is on OFF or ON position, the voltage at Pt.A remains almost the same (+26Vdc on OFF and 25.6 Vdc on ON position).
When no key is depressed, the circuit is opened and the same voltage (+26Vdc) is available at Pt.B.

If one (1) key is played, the voltage at Pt.B drops from 26 Vdc to about 8.2 Vdc.
If ten (10) keys are played simultaneously, the voltage at Pt.B drops from 26 Vdc to about 11 Vdc (more 47 K resistors are put in parallel).

Since there is no capacitor is involved in this DC circuit, switching DC voltages are available at each contact (bottom of 47 K resistor) and will drive directly the input of the interface unit.

The ORCH.TRAPS tap has to be sacrificed and will become MIDI ON tap. That's the only unavoidable modification to be accepted beforehand.

It appears that very few X-66's organists are using this ORCH. tap during play.

Anyhow, for those who argue on this point, any technician can 're-wire' this ORCH. tap in its original condition in a couple of minutes.
Full wiring details are provided later on in the next pages.

2. MIDI Interface unit.

This MIDI Interface unit is unavoidable for the following reasons:

- beside the suppression of the ORCH.TRAPS feature, it was the intention to preserve the original performances of the X-66. Then the input circuit of this interface unit was designed in such way to avoid any deterioration of initial signals. This involves the use of high-impedance input circuits.

- the MIDI converter CTM64 (1) does not support any other signal than ON/OFF switching to be converted into MIDI data signals. Then the +26Vdc or +8Vdc voltages as seen in above Pt.1 are not usable as such without this interface unit.

Any interface unit is composed of at least two circuits : input and output.

2.1. Input circuits.

Two DC voltages are available from the ORCH.TRAPS contacts :
+ 25.6 Vdc when no key is depressed
+ 8 Vdc when one key is depressed

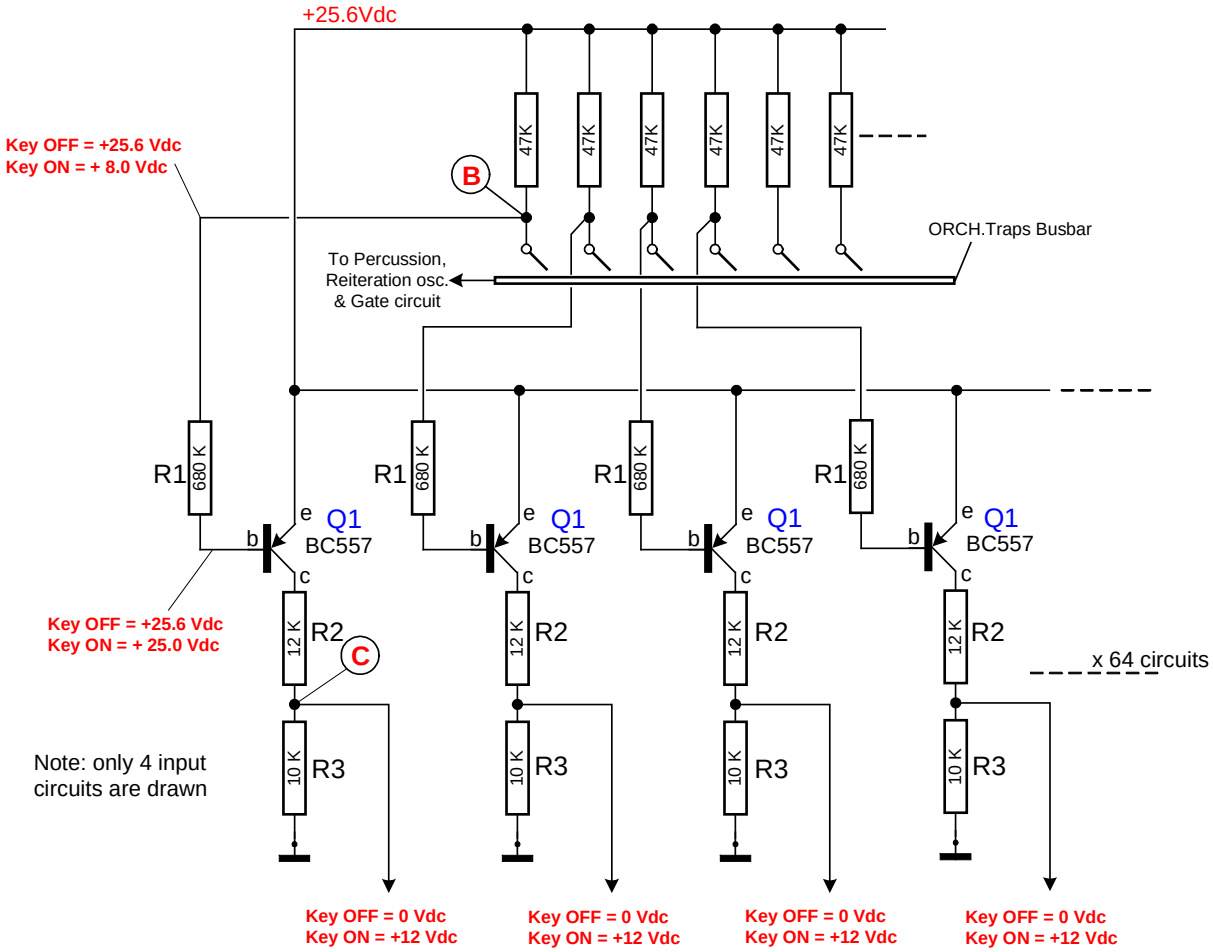
The simplest way is to use one PNP transistor (type BC557 or equiv.) mounted in reverse polarity to assure this basic function (see schematic diagram hereafter).

When applying a negative voltage on the Base of this transistor by comparison with its Emitter, this transistor becomes conductive (saturated).
When the voltage on the Base is the same as its Emitter, this transistor is blocked.

Therefore it operates as a simple ON/OFF switch, depending on the position of the ORCH.TRAPS contacts. That's exactly the purpose.

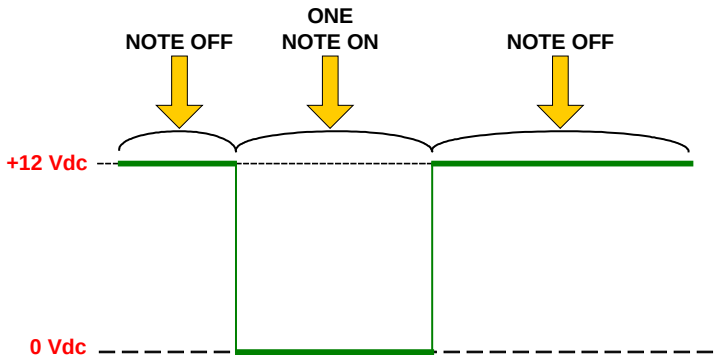
Two resistors are inserted in the Collector of this transistor and the +12 Vdc needed to command the Quad Bilateral Switch IC is available at the middle junction point.

(1) CTM64 / V4 – Contact-to-Midi converter from Doepfer Musikelectronic.
All details on : www.doepfer.com



MIDI Interface unit : Input circuits.

As a conclusion, the role of each 'branch' composed of Q1, R1, R2 & R3 of this input stage is simply to provide a voltage near +12 Vdc at Pt.C when the corresponding key is depressed and 0 Vdc when the same key is released.



DC voltages available at Pt.C

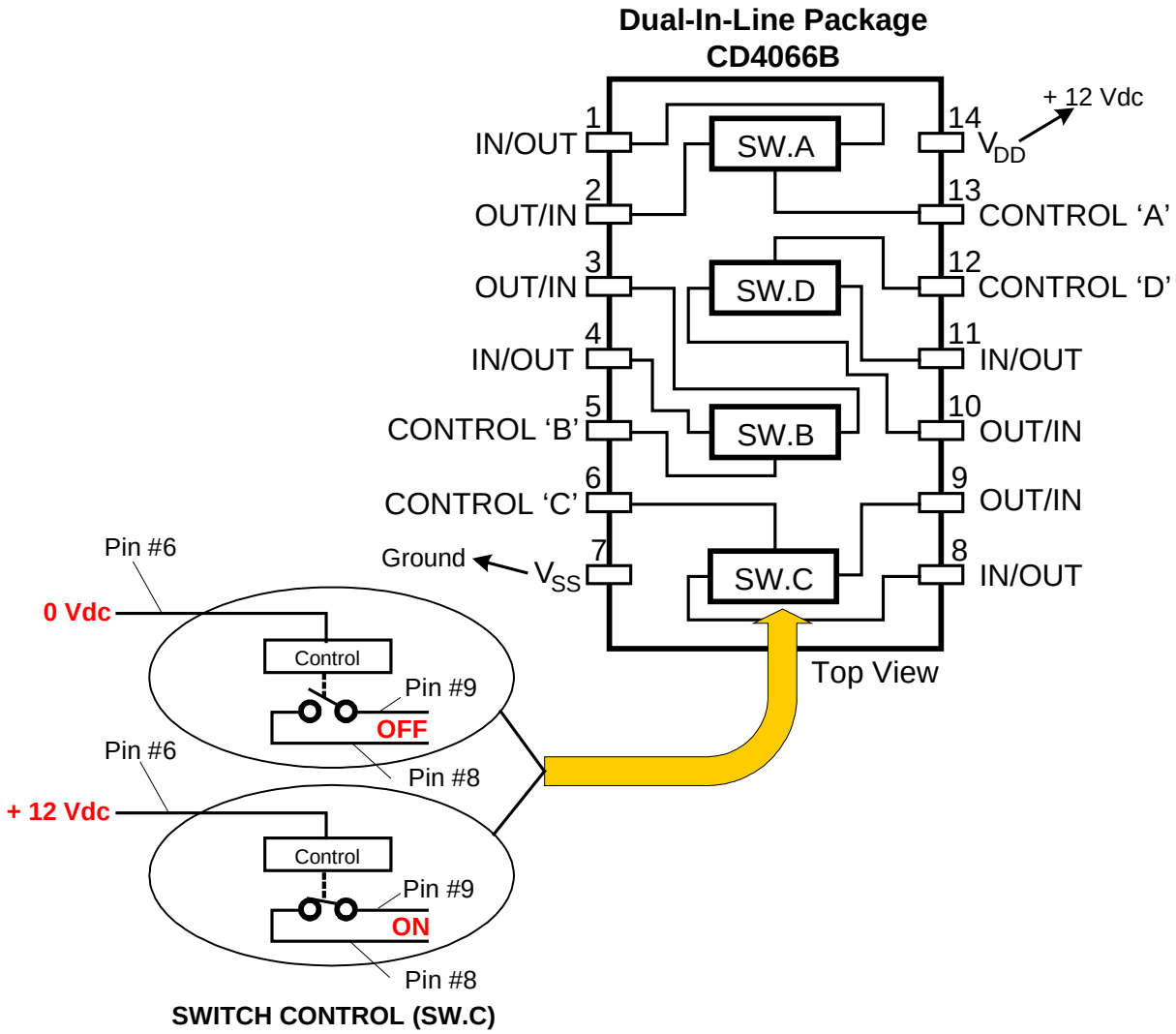
By doing so, the shape of the signal at Pt.C being perfectly 'square', it is now possible to trigger the output stage accordingly.

2.2. Output circuits.

As previously seen, the mechanical switches (or contacts) of the X-66 upper keyboard cannot be used as such to command the CTM64 MIDI converter unit. The function of the Input circuits is to convert available signals of ORCH.TRAPS row into switching signals able to drive Quad Bilateral Switches IC's (CD4066B). (See datasheets CD4066B in attachment for details).

This second mission of this MIDI interface is then to 'substitute' those mechanical contacts by static contacts found in this IC CD4066B. Several functional tests were conducted with those IC's and CTM64 converter with quite positive results since the "ON" resistance of CD4066B is rather low i.e. below 100 Ω.

Hereunder is the contents of this IC.



CD4066B - How it works ?

Quite basic. When a voltage of 0 Vdc is applied to the control pin of this IC, the internal switch remains 'OPEN' (extremely high impedance).
If a voltage of +12 Vdc is applied to the same control pin, the internal switch becomes 'CLOSED' at once (almost a short-circuit).

Since the behaviour of all those static switches will follow and will be exactly synchronized with each key depressed, it is now possible to connect each so-called 'static switches' to corresponding contact connectors (JP1~JP4) of the CTM64 MIDI converter.

Each IC CD4066B is composed of four bilateral switches. To cover the upper keyboard (5 octaves + 1 C-key), 16x IC's are needed. Three extra switches will be available (as spare..) if any.

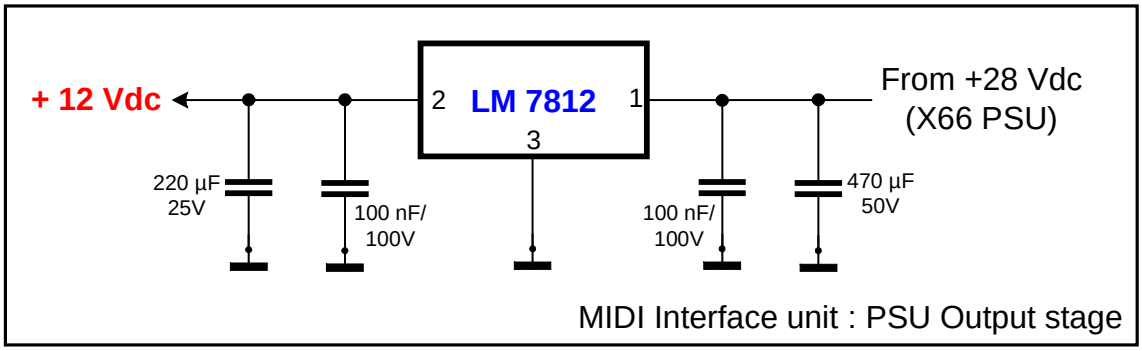
2.3 Schematic diagram.

The overall schematic diagram of the MIDI Interface unit can be found on the next page. The Input and Output stages have been simply put together.

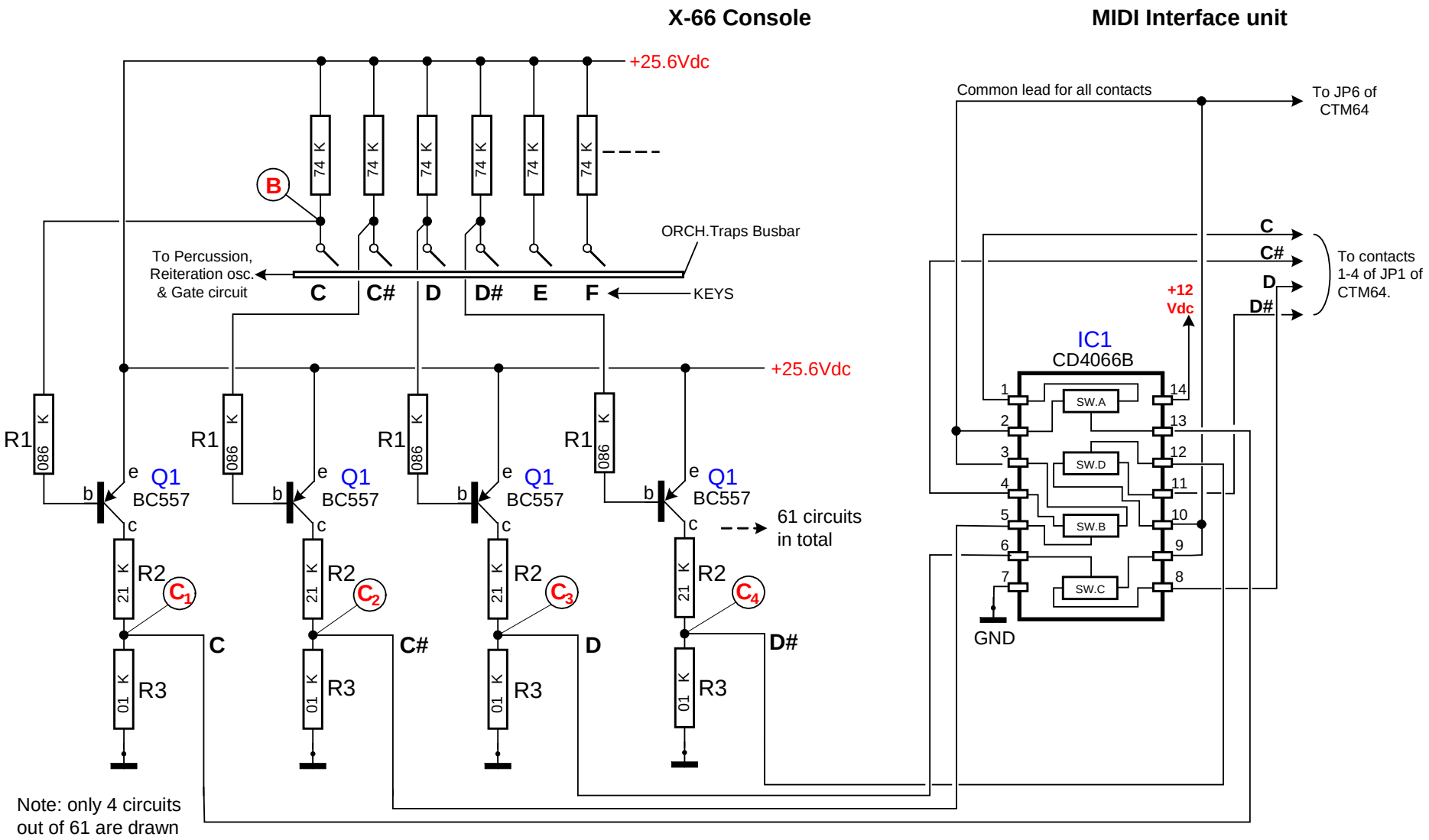
For easiness of understanding only 4 circuits out of 61 needed have been drawn.
All 61 circuits are identical.

The input section of the MIDI Interface unit does not require additional power supply. All transistors (Emitters) are connected together directly to the +25.6 Vdc available on common point of the 47 K resistors.

The output section composed of 16 IC's has to be powered with a voltage of +12 Vdc. One regulator LM7812 is simply connected to the +28 Vdc available in the X-66 power supply unit. See Interface PSU diagram hereunder for details.
No heatsink is required on the 7812 regulator.



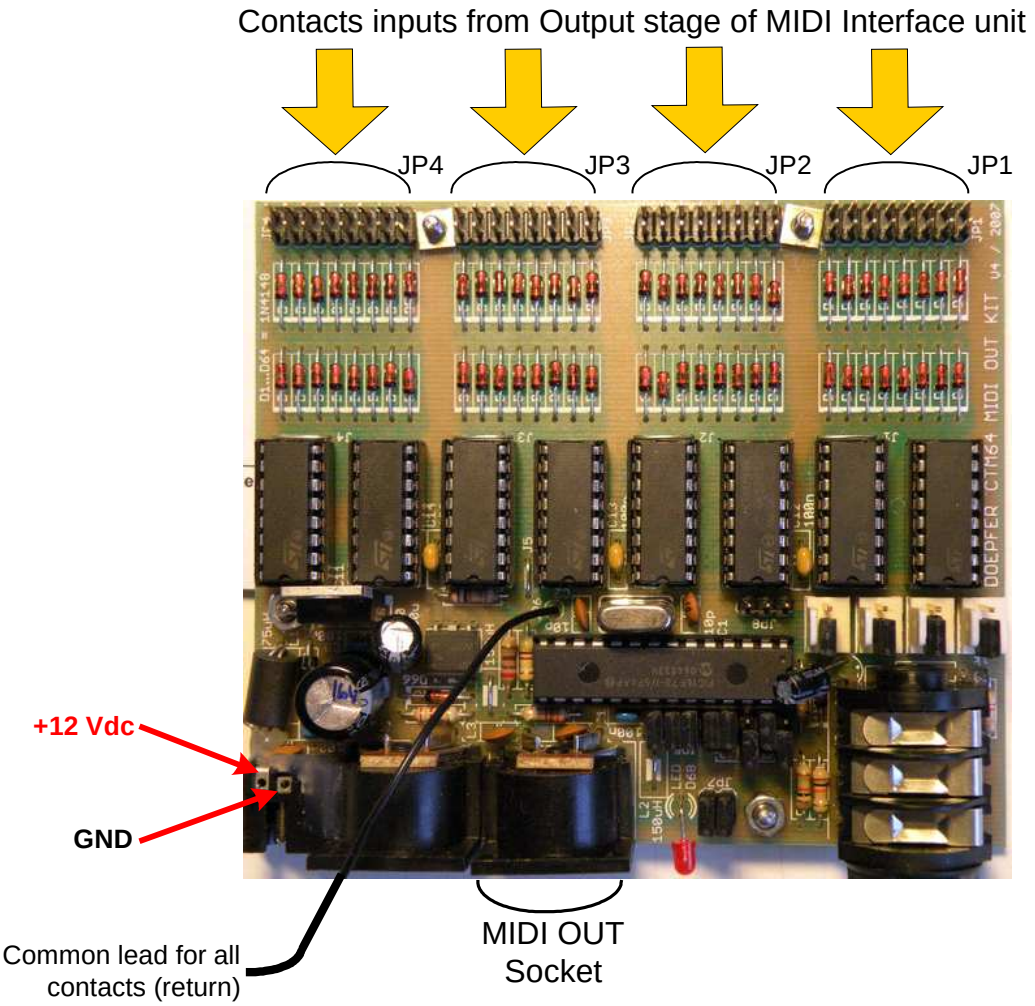
MIDI Interface unit : PSU Output stage



MIDI Interface unit : Overall diagram.

3. MIDI Converter CTM64 / Version 4 .

The CTM64 is an universal MIDI OUT converter delivered completely assembled and 'ready for use' from Doepfer Musikelektronic. It requires 64 " free contacts " to generate MIDI data (note ON/OFF). One 5-pin DIN MIDI OUT connector is installed on board allowing so connections with external MIDI equipment.



The installation manual can be found in Annex 'CTM64' (.pdf file). All information concerning the installation, configuration, extensions such as pitch bend, modulation, volume, after touch, etc... are clearly described in this manual.

Full information also are available on www.doepfer.com if needed.

4. Overall MIDI implementation.

All elements have been described and can now be connected together. Refer to the next drawing ' Overall Connecting Diagram '.

Each contact point (bottom of 47 K resistor) has to be linked to the Input section of the MIDI Interface unit in a sequential manner (61 connections in total).
16-leads flat cables are used for these connections.

All the Emitters of transistors BC557 are connected together to the +25.6 Vdc i.e. on the top of 47 K resistors. The input stage does not require other voltage supply.

The output stage composed of 16x IC's CD4066B has to be powered by a voltage of +12 Vdc provided by specific PSU board. To achieve this, the 'IN' voltage (+28 Vdc) is coming directly from the X-66 PSU directly.
It is not foreseen to feed the CTM64 converter with this +12 Vdc voltage.

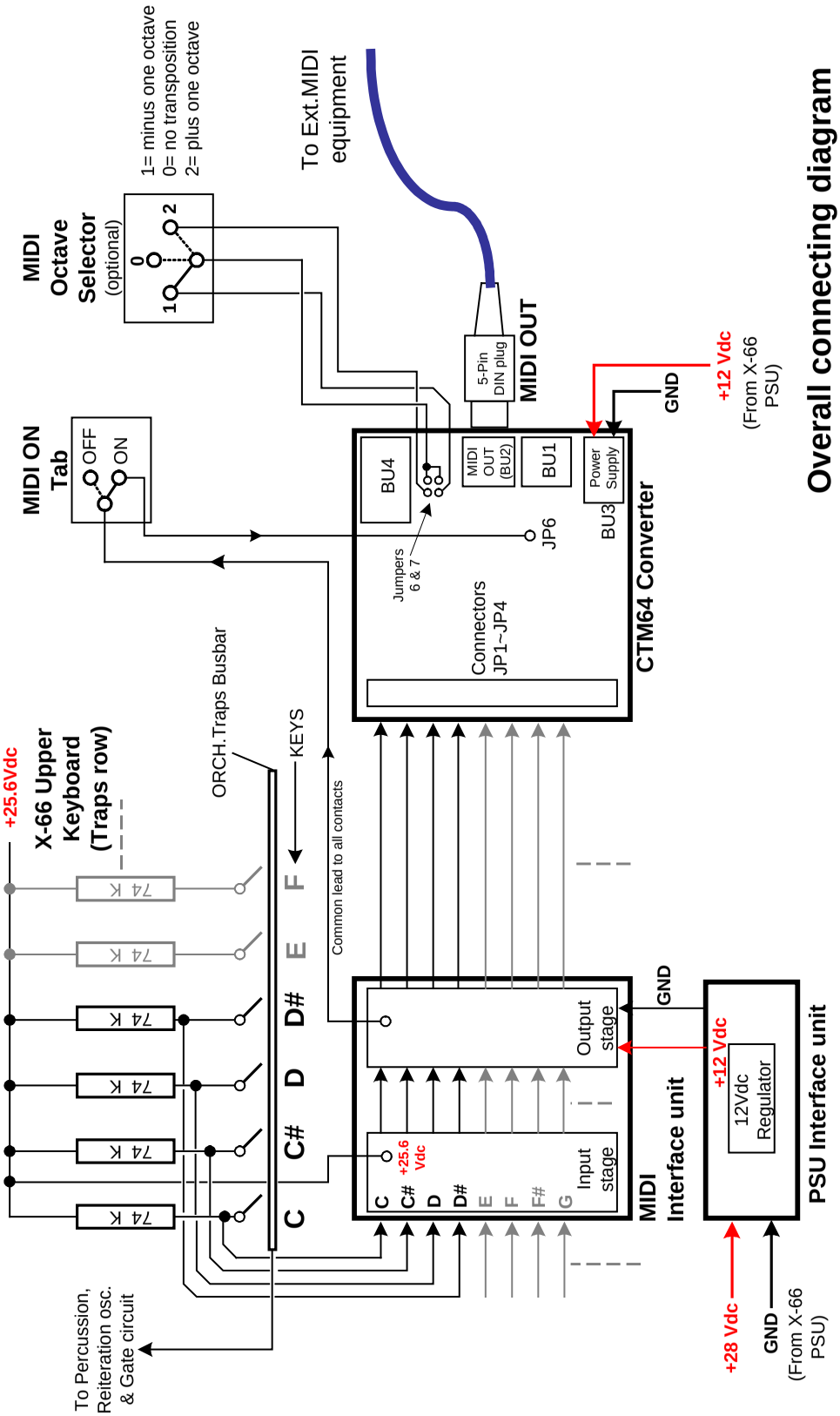
Each 'contact' of the output stage will be linked to the four connectors JP1 to JP4 always keeping the same logical sequence.
Flat cables are included in the CTM64 kit.
Since all static contacts of this output stage do have one row of contacts connected together, so-called 'return or common lead', this point will ensure the 'return' liaison between all contacts and the MIDI converter. If this connection is interrupted, no MIDI data will be available.
That's the reason why the MIDI ON switch (indeed it is the former ORCH. tap) has been inserted in that link. See special section on this point later on.

The CTM64 converter is powered separately by the +12 Vdc available from the X-66 PSU.

One Octave Selector Switch (type " I - 0 - I ") has been fixed under the keyboard nearby the Sforzando piston. This is an interesting feature that allows the player to transpose by +/- one octave the MIDI equipment. Quite easy to implement.

MIDI data are collected at MIDI OUT socket of CTM64 via one 5-pin DIN plug and cable to link external MIDI expanders or keyboards.
See also 'How to build your own MIDI cables'.

To be noted that both MIDI Interface unit and CTM64 converter are designed to handle 64 contacts from the keyboard. The X-66 keyboard has only 61 keys per manual. So, the three last 3 positions will be not connected and will be kept 'as spare' just in case....of course with adequate wiring change.


Overall connecting diagram
MIDI Octave Selector (optional)
1= minus one octave
0= no transposition
2= plus one octave
To Ext.MIDI equipment
MIDI ON Tab
OFF
ON
MIDI OUT
5-Pin DIN plug
+12 Vdc
(From X-66 PSU)
GND
CTM64 Converter
BU4
MIDI OUT (BU2)
BU1
Power Supply
BU3
JP6
Jumpers 6 & 7
Connectors JP1~JP4
ORCH.Traps Busbar
KEYS
C
C#
D
D#
E
F
Common lead to all contacts
+25.6Vdc
X-66 Upper Keyboard (Traps row)
74 K
MIDI Interface unit
Input stage
Output stage
+25.6 Vdc
GND
+12 Vdc
12Vdc Regulator
PSU Interface unit
+28 Vdc
GND
(From X-66 PSU)
To Percussion, Reiteration osc. & Gate circuit

CTM64 converter is also offering additional features (pitch-bend, modulation, volume, after-touch, etc..) that are left to the owner decision. Full details are found in the CTM64 User's Guide and are easy to implement.
The internal schematic diagram is not included with the CTM64 kit and is not relevant for the technician.

PART 2. PRACTICE

5. Realization and installation.

The theoritical part being seen, it is now time to build this MIDI Interface unit since it is not available as such on the market.

This chapter will cover the following elements:

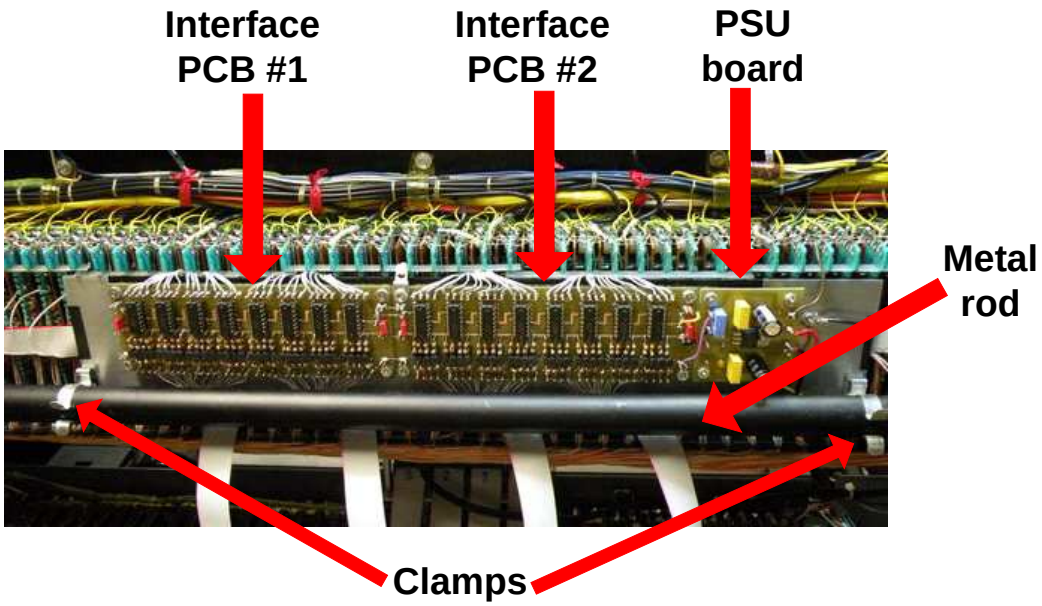
- *MIDI Interface unit (PCB and mechanical installation).*
- *Connecting keyboard to Input section.*
- *Connecting Output section to CTM64 converter.*
- *Installation of CTM64 and X-66 MIDI output.*
- *Final measurements, functional tests and conclusions.*

5.1. MIDI Interface unit.

The MIDI Interface unit has been designed specifically for the Hammond X-66 console and cannot be used for any other instrument.

It is composed of three PCB's : 2x MIDI Interface boards and 1x PSU.
Those PCB's are installed on a metal plate of 450 mm x 86 mm.
This metal plate is fixed with two clamps on the metal rod just behind the row of keying modules.

The reason to install this interface unit there is to reduce the lengths of flat cables as much as possible. Remember, the impedance of the input stage is in the range of 1 MΩ (quite high), so it has been always a good engineering practice to minimize the lengths of cables in such cases.



This MIDI Interface unit is mounted on clamps because it must pivot to allow easy wiring of each keying module.

PCB's of Interface unit.

Initially, it was decided to minimize the size of PCB's in order to insert them as close as possible from the keying contacts under the upper keyboard.

Due to the number of components involved, those PCB's were designed on double-sided copper board (double-sided epoxy board of 160 mm x 52 mm).
All 16 IC's are installed on DIL-14 sockets and resistors are mounted vertically to reduce space on PCB.

'IN' and 'OUT' connections are realized with inserted connecting pins.
Each PCB is composed of 8 IC's, 32 transistors and 96 resistors and some decoupling cap's of 100 nF as usual.

For easiness of cabling, both 'IN' and 'OUT' connecting pins are put "in line" and grouped by 4. First C-Key being on the left-hand side. The 3 last 'IN' connecting pins on right-hand side are not wired since there are only 61 keys on keyboard.

PCB layouts and translucent artwork films, components location, etc.. are provided in Annex. ' PCB artworks'. Some additional remarks about those PCB's artworks:

- The first artwork on top provides the copper side of PCB. Evidently when translucent artwork will be printed, it has to be inverted so that written indications appear in the correct way on the copper side.
- The second artwork exhibits the copper side at the components side since dual-side PCB's are needed for this Interface PCB. Similarly to above point, here also the translucent artwork has to be inverted to match with the first one. (quite easy for those who are familiarized in building PCB's).
- The third artwork simply shows the component location on the Components side.
- The fourth one is a single-sided copper board (52 mm x 52 mm) to accomodate components of the PSU.

Cabling components on those PCB's is not difficult but requires working method and patience.

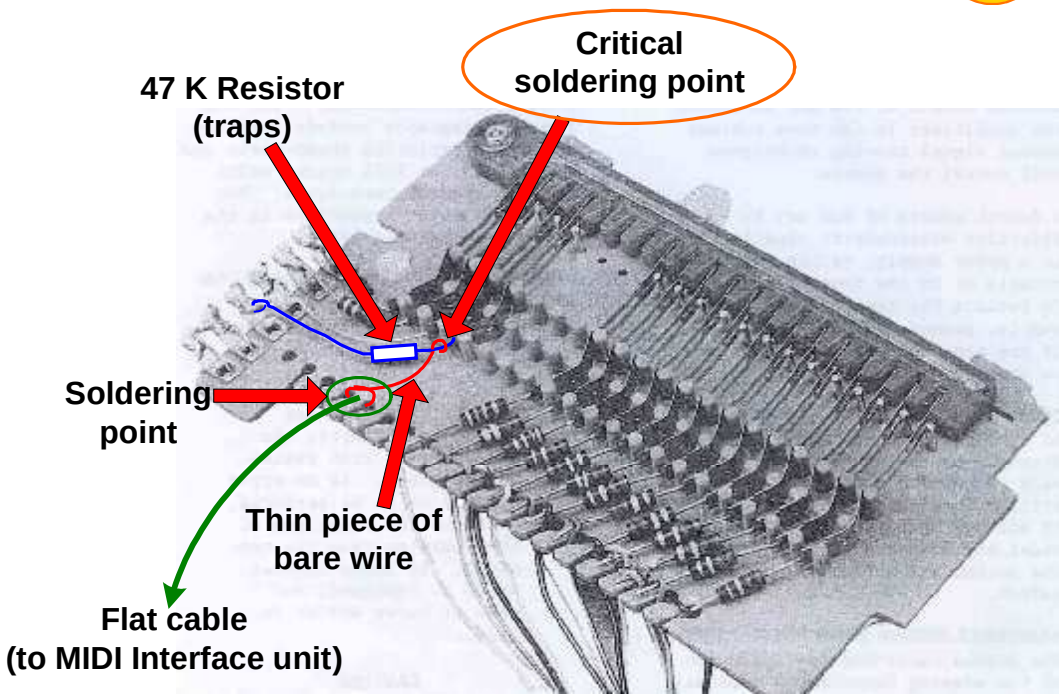
Each PCB is fixed with 6 mm metal spacers (4 pcs per PCB) on the metal frame. Inter-PCB's links are quite easy. Both sides of PCB are film coated to prevent from oxydation, corrosion, etc...

The Input stage of the MIDI Interface is auto-powered by the +25.6 Vdc (Traps voltage).

The Output stage of the MIDI Interface unit is powered by +12Vdc coming from the 7812 regulator (on PSU board). This 7812 regulator is fed directly by +28 Vdc of X-66 PSU as already mentioned.

Connecting 47K TRAPS resistors.

This operation is probably the most delicate in this X-66 MIDI project. In fact, as shown on shematic diagram, each lead of flat cable has to be soldered near the contact end of the 47 K resistor.



KEYING MODULE

All fasteners and bakelite separators have to be removed between keying modules to facilitate access to those 47 K resistors.

1. Prepare a little piece of single bare wire as shown on above sketch. Carefully and quickly solder this wire near the right hand of the 47 K resistor and wind the other end around a free plastic lug as indicated.
This operation is not easy and require adequate lighting ! Small 'dentist mirror' is helpful to control this critical soldering point. Afterwards, re-install bakelite separators and fasteners as original.

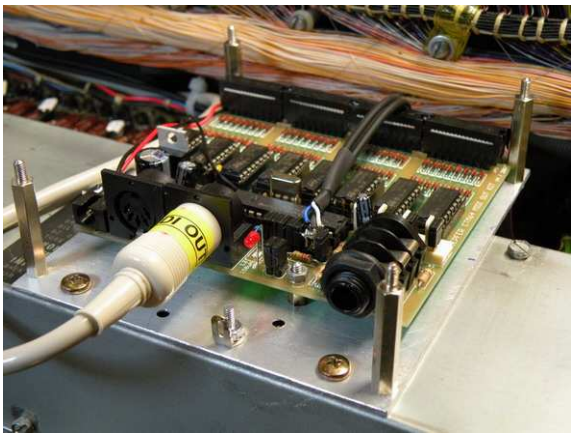
2. Later on when all 61 keying modules are so ready, solder corresponding lead of flat cables at that point. Since, solders have to done on plastic material, be very quick in doing this operation and pay special attention during cooling period. Make those 'IN' connections to MIDI Interface unit as short as possible.

Connecting OUTPUT cables.

The CTM64 converter is delivered with 4x 16-leads flat cables. This part of MIDI cabling is quite easy and has to be done in the logical sequence.
Lenght of flat cables is less important than for the Input section of MIDI Interface unit.

5.2 Installation of CTM64 Converter.

A recommended by Doepfer Musikelektronik, to minimize electromagnetic radiation that may affect the normal operation of X-66 console, the whole CTM64 unit has been shielded with a closed metal case. All information concerning installation and settings are clearly explained in the CTM64 User's Guide.



For easy access, the metal case of CTM64 is fixed on top of the Animator Assembly (Scanners unit) and fixed with two screws on the shield of scanners recovery amps and expression preamp boards.

Connections of CTM64 is quite easy and does not require any particular precaution. Refer to User's Guide CTM64 - Version 4.

One female 5-pole DIN socket (with locker) has been under the X-66 console to facilitate links with external MIDI units. Just a simple shielded point-to-point liaison.

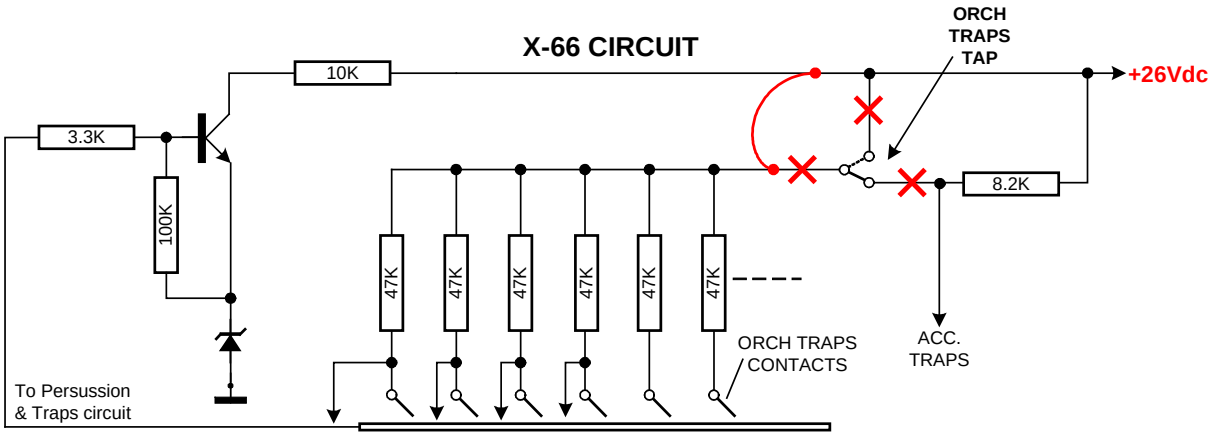
MIDI connection to external units.

5.3 Wiring TRAPS Tabs switches.

The ORCH. Traps Tab function has to be discarded and will be replaced by MIDI ON.

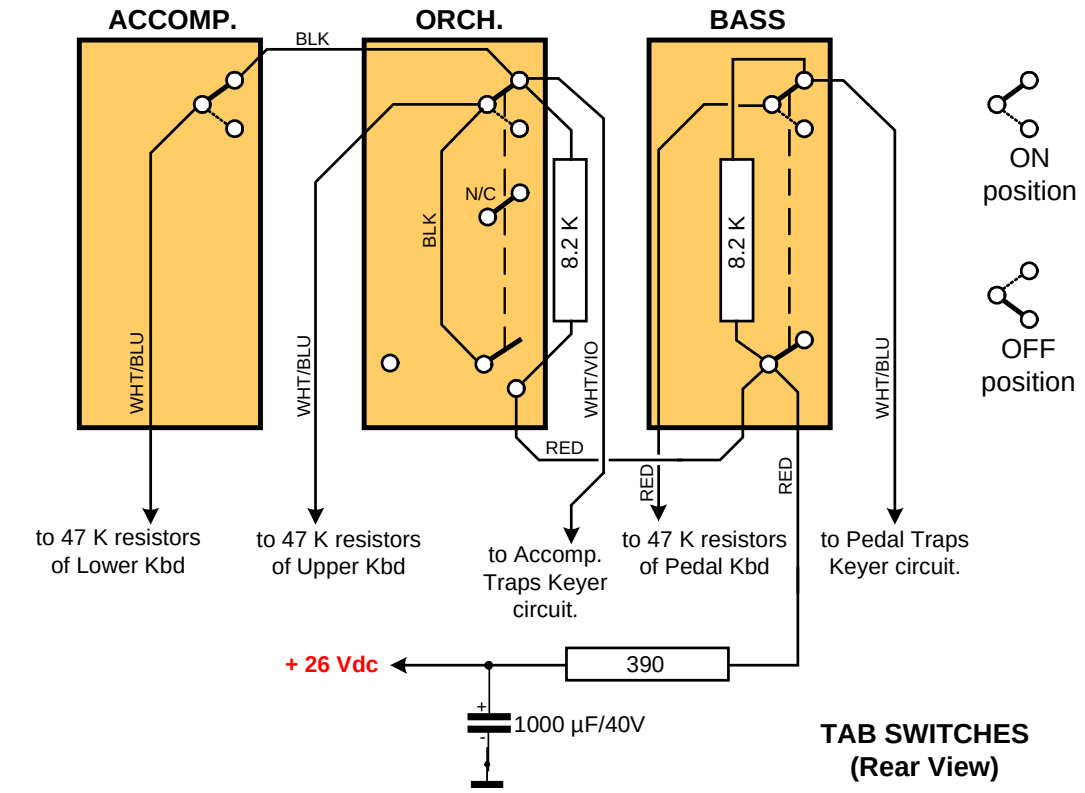
Evidently, this change implies some wiring modifications that are explained hereunder.

Basically, this modification is quite simple. The idea is to take benefit of the ORCH. Tab inverter switch to engage the MIDI function. This is done by switching ON or OFF the return common lead between the MIDI Interface unit and the CTM64 at JP6.

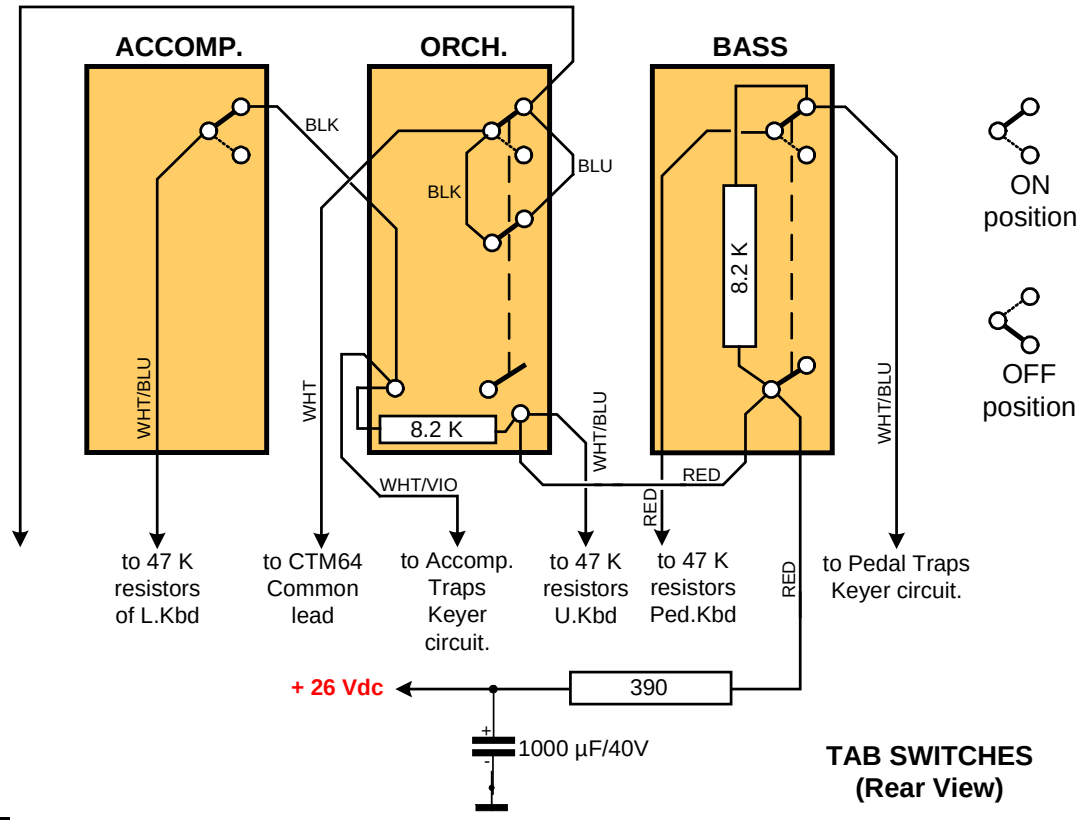


Refer also to 'Overall Connecting diagram' of Part #1.

ORCH. Traps Tap - Original wiring (rear side view).



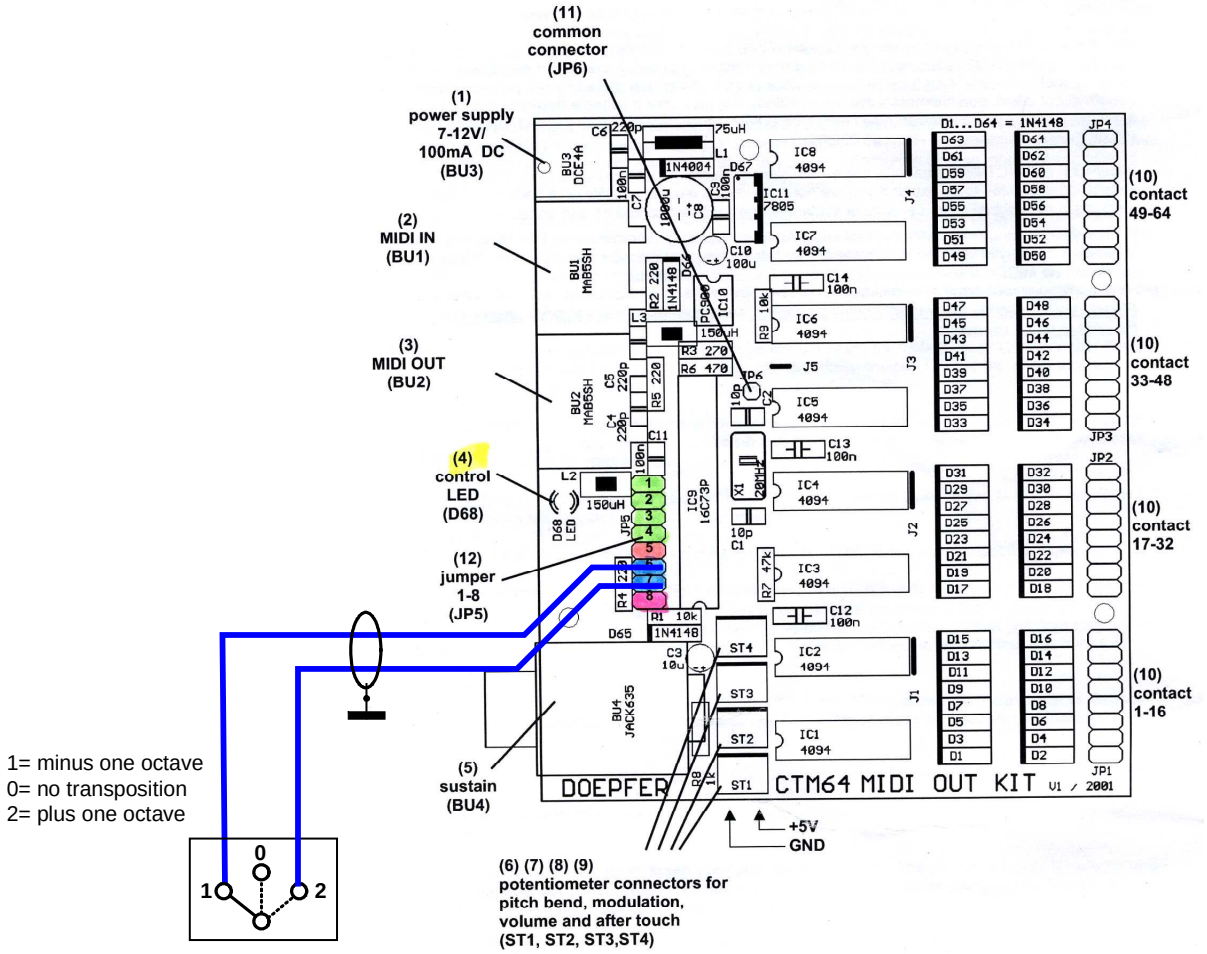
MIDI ON Tap - Wiring modifications (rear side view).



5.4 MIDI Octave selector.

This selector has been added near the Sforzando piston and is quite easy to implement. Current ' I - 0 - I ' switch is used. Since connections to the CTM64 are somewhat long, shielded cable has been used.

The 'hot' points of both jumpers 6 & 7 of JP5 are located near IC9 while the 'cold' points (ground) are on the other row. This outer row is grounded.



MIDI Octave Selector (optional)

5.5. Final Tests and measurements.

Functional tests.

After a thorought double-check (cabling, solders, grounding points, etc..), it is now time to switch ON the X-66 equiped with its MIDI interface unit. Great moment !

The MIDI interface and CTM64 remain switched ON when the X-66 console is powered since needed voltages are picked-up from the X-66 PSU.

One Roland expander was connected at MIDI OUT socket, Channel 1 selected on both CTM64 and MIDI expander.

Surprisingly, everything was directly operating on the first shot (it's not always the case..), all keys tried one by one, immediate response from the expander, wow !

Beside some settings of jumpers at CTM64 end (refer to CTM64 User's Guide), there is no other adjustment to be done. It works as such. Just play !

MIDI ON tap cancel the MIDI data in 'up' position and no output available at MIDI OUT. Beside the lack of ORCH.Traps, there is no other function affected by this MIDI implementation in terms of sound quality, features, noise level, crosstalk, interferences whatsoever.
No problem either in polyphonic playing under MIDI on upper keyboard.

The MIDI Octave selector works also normally and can be even switched during play without problem.

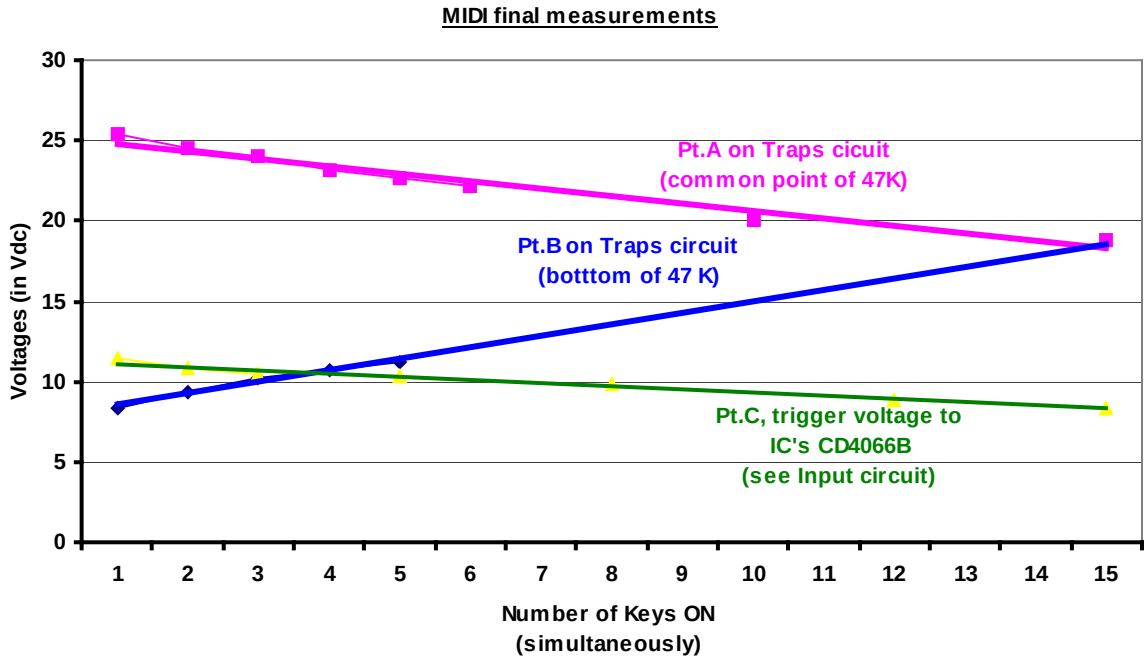
Final measurements.

To confirm the correct operation of this MIDI implementation, measurements have been conducted at three levels:

- Pt. A.: This voltage shows the voltage drops in function of the number of keys depressed (refer to Traps circuit of Part.1)

- Pt. B.: This voltage is increasing with the number of keys depressed, the number of 47K put in parallel is growing, so as the current involved. Quite normal.

- Pt. C.: This voltage represents the command voltages needed to trigger the IC's C4066B (refer to Input circuit of Part.1).



My conclusions.

With this MIDI implementation, it is now possible to drive from the Upper Keyboard of X-66 any external MIDI equipment providing so an infinity of additional sounds on top of the X-66 console and it works great.

Since, the idea was to keep the X-66 as original, basic ON/OFF contacts method was used on purpose (called contact-to-Midi) i.s.o. sensitive contacts with dual rubber contacts that modify the 'touching' of upper keyboard.

The result is that MIDI output level remains constant while playing and is not depending on the pressure or speed.
May be in the future, I will study the possibility to link the MIDI output level with the expression pedal of X-66.

Beside the octave selector, the other current MIDI features such as pitch bend, modulation, after touch, etc.. were not integrated on the X-66 while it is quite possible to do it.

It is my personal feeling that with the information provided, any technician having a sufficient expertise in musical instruments will be in position to duplicate this MIDI implementation.

If I did it, somebody else can do it as well, no question about it.

Dan. Vigin

List of specific Acronyms

CTM :	Contact-to-Midi
DIL.:	Dual-In-Line
DIN.:	Deutsche Industrie Norm
EXT.:	External
GND.:	Ground
IC.:	Integrated Circuit
KBD.:	Keyboard
MIDI :	Musical Instrument Digital Interface
ORCH.:	Orchestral (X-66)
PCB :	Printed Circuit Board
PNP.:	Positive-Negative-Positive (type of bipolar transistors)
PSU :	Power Supply Unit