MIDIbox TIA

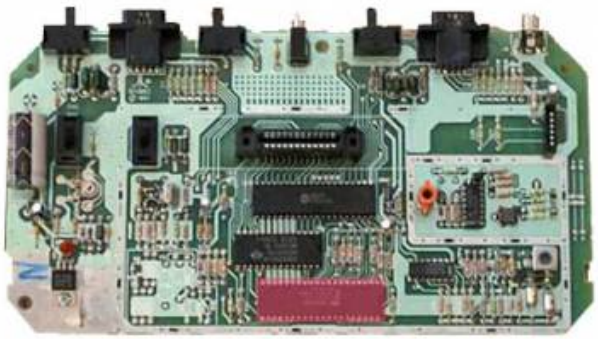
What is it?

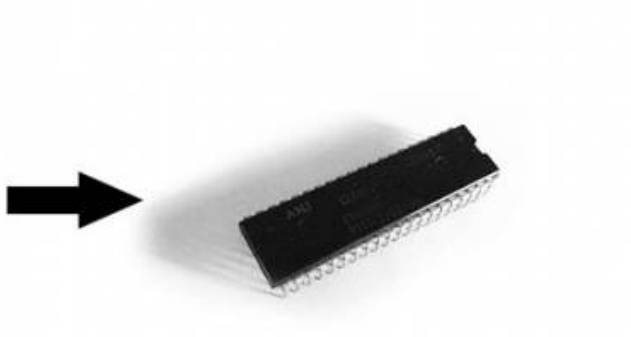
The Television Interface Adaptor (TIA) is the custom chip that is the heart of the Atari 2600 game console, generating the screen display, sound effects, and reading input controller.

- **Stella** = Name (by its maker) of Atari hardware design engineer Joe Decuir's bicycle
- **TIA** = **T**elevision **I**nterface **A**dapter

Where do i find this chip?

You can easily find an old and used console on the web. Atari 2600 on eBay
Atari 2600 Models and Clones
On the motherboard:





Have a look at 2600 Connection site to find it.
TIA = “Stella” = MM9031N = UM6525N = CO10444 = CO10444D (NTSC, U.S.A. & SECAM, France)
TIA = “Stella” = UM6526P1 = CO11903 (PAL, Europe + Australia + most of the rest of the world)

Why? and "What would be the point?"

I'm probably a bit nostalgic for a time I played the game console in the living room of my parent.
Need electronic sounds that have traumatized my childhood.
Midibox is the best way to integrate these original sounds in electronic music environment.

The point is it's fun, i can do it, it sounds great, it has a unique sound. Don't think it could only be useful for making chip-tunes/8-bit music, that's a limited horizon.
I love the sounds of sound chips and game controllers from the 70/80/90's but I don't make (or particularly like) video game music.
I make techno (minimal) and find the sounds from this source are perfect for that...

MIDIbox TIA Module

Introduction

The TIA is an MOS integrated circuit designed to interface between an eight (8) bit microprocessor and a television video modulator and to convert eight (8) bit parallel data into serial outputs for the color, luminosity, and composite sync required by a video modulator.

This circuit operates on a line by line basis, always outputting the same information every television line unless new data is written into it by the microprocessor.

When I started this project, there were two main structures of a MIDIbox, SEQ or SYNTH oriented.
My conclusion was that the skeleton and features of MB-SID version 1 were best suited to the TIA and its own possibilities.

Atari 2600 References

Atari 2600 hardware schematics PAL/NTSC
TIA technical information
TIA schematics

Firmware version 1 is devoid of Control Surface.
*“Full CS looks great, like on SID, but is also more expensive to build I think your solution with a controller patch works great, it's easy and intuitive to have it all there on the screen”*Eptheca

... Yes it's my choice , I've preferred to develop a MaxMsp[Cycling'74] patch to manage and control it, as one of my first desire was to get the beast in a game cartridge enclosure.
I decided to case it in a cartridge, because it makes this project a tiny one, easy to build and cheap. In short, an accessible start-up project, which need reasonable time to realize, share and present correctly.
So I focused all my attention to the Software Engine adaptation and the implementation of Sysex and CC#.

Moreover, this MaxMsp Patch has been declined in Midi Device for Live with Max4Live[ableton] , and now I access for complete automation of the box.
Max and Live do not lack of alternatives in terms of CS. Both Standalone and Device manager are iPad ready.

Like the SID Module, TIA is connected with a serial link to port J10 of the Core module via shiftregisters.
Module use 5v core power supply.

Firmware is only made for 18f4685. We need enough space in flash for the sampler option.

Like the Pokey, TIA is clocked to 3.58MHz(NTSC) or 3.54MHz(PAL). You can use an oscillator but my choice was to recycle the console parts, like Xtal and the couple of transistors which are on the atari motherboard.

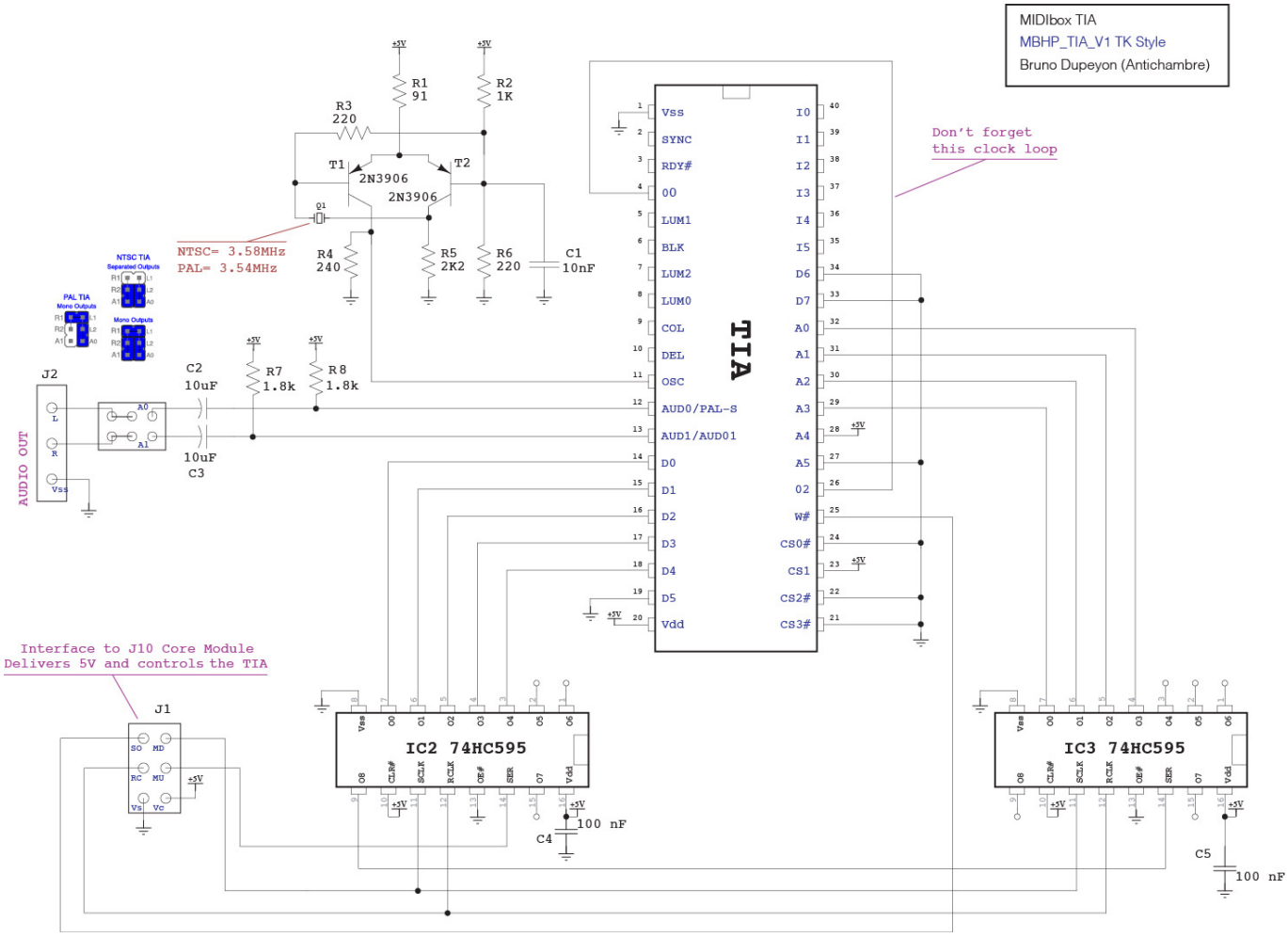
TIA and Shiftregisters

As seen in “How>Registers Address”, we don't need to use all adress and data pins.
Pins A5, D5, D6, D7, CS0#, CS2#, CS3# must be grounded.
Pins A4, CS1 must be connected to 5V.

We use only Address lines A0-A3, Data lines D0-D4 and WR# line.
Divided by 3 Clock output 00 must be connected to input 02.

Schematic

In TK Style:



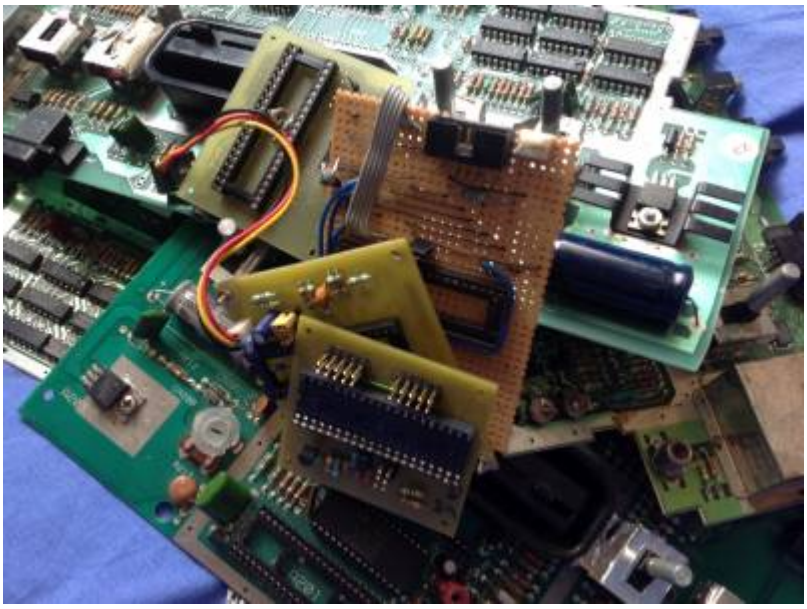
mbhp_tia_v1.pdf

Parts List

Part	Value	Type	Qty	Mouser Ref
IC1	TIA	UM6826P1/C010444D	1	/
IC2-IC3	74HC595N	74HC595N	2	595-SN74HC595N
T1,T2	2N3906	transistor-pnp	2	750-2N3906-G
Q1	3.58Mhz	XTAL	1	520-HCU357-17DNX
R1	91	resistor	1	291-91-RC
R2	1K	resistor	1	291-1K-RC
R3-R6	220	resistor	2	291-220-RC
R4	240	resistor	1	291-240-RC
R5	2k2	resistor	1	291-2.2K-RC
R7-R8	1K8	resistor	2	291-1.8K-RC
C1	10nF	Capacitor Ceram	1	
C2-C3	10µF	Capacitor Pol	2	647-USV1V100MFD
C4-C5	100nF	Capacitor Ceram	2	80-C412C104K5R
J1	CORE CON	JP3Q	1	
J2	AUD-CON	JP2E	1	
J3	AUD-CONF	JP3Q	1	

PCB files

I made a lot of breadboards and stripboards before first cartridge prototype.
It's really easy but i prepared an Eagle Project for people who want design . Maybe it will be usefull to replace the clock section by an Oscillator.



- Atari TIA Eagle Library
- mbhp_tia_v1 Eagle Project

**.sch is ready, *.brd is consistent but in airwires state... If somebody have done(or wanna do) this work, i will be happy to publish it and complete this section.*

.

TIA Setup

Necessary Hardware:

- MIDIbox CORE PIC 8bit.Remember, Only for 18F4685.
- MIDIbox TIA Module or equivalent.

Hardware Options

- Up to 8 BankSticks. 32K and 64K could be mixed (4 Banks per BS with 64 or 128 presets per Bank).
  Bank Name store and retrieve.
- LED Meter 2*4(cartridge version).

Connection to Core

TIA Module pin	Core pin	Pic pin nr
J1:Vs	ground	-
J1:SO	J10:SO	24

TIA Module pin	Core pin	Pic pin nr
J1:RC	J10:RC	23
J1:MU	J10:MU	29
J1:MD	J10:MD	28
J1:Vc	+5v	-

Features

Due to the TIA capabilities, the MIDIbox software provides almost the entire features of the synth engine. And it do it fine .

- Modulation Wheel.
- After-Touch.
- Volume for each Voice.
- Waveform select for each Voice.
- Transpose for each Voice.
- Pitch Range & Pitch Bend for each Voice.
- Delay for each Voice.
- Portamento for each Voice.
- Independents Constant Time Slide enable for portamento.
- Arpeggiator for each Voice
- Independents MIDI Sync Enable for LFOs/ENVs/ARPs.
- Master Volume.
- 2 independents Velocities (with CC# or/and Amplitude assign).
- 2 full independents and dedicated Envelopes with Modulation Type, MIDI Sync and curve assign. One by Voice (No internal envelope in a TIA). Assignable to Amplitude or pitch.
- 4 full independents LFOs with MIDI Sync.
- 2 full independents ENVs with MIDI Sync.
- 6*4 Matrix, LFOs/ENVs to amplitude or pitch.
- Keyboard Extended Option with note offset and note length values.
- GSA.
- MIDI Send Clock.

Synchronization

The 3.58 MHz oscillator also clocks a divide by three counter on this chip whose output (1.19 Mhz) is buffered to drive an output pad called 00. This pad provides the input phase zero clock to the microprocessor which then produces the system 02 clock (1.19 Mhz).

Data and addressing

Registers on this chip are addressed by the microprocessor as part of its overall RAM-ROM memory space. The attached table of read-write addresses summarizes the addressable functions. There are no registers that are both read and write. Some addresses however are both read and write, with write data going into one register and read data returning from a different register.
If the read-write line is low, the data bits indicated in this table will be written into the addressed write location when the 02 clock goes from high to low. Some registers are eight bits wide, some only one bit, and some (strobes) have no bits, performing only control functions (such as resets) when their

address is written. If the read-write line is high, the addressed location can be read by the microprocessor on data lines 6 and 7 while the 02 clock is high.

Two (2) independent audio generating circuits are included, each with programmable frequency, noise content, and volume control registers.

Voice 1 is Aud0 and Voice 2 is Aud1 in the Stella programmer's guide.

Audio Circuit

Synthesis:

There are two audio circuits for generating sound. They are identical but completely independent and can be operated simultaneously to produce sound effects through the TV speaker. Each audio circuit has three registers that control a noise-tone generator (what kind of sound), a frequency selection (high or low pitch of the sound), and a volume control.
Each audio circuit consists of parts described below:

Audio Output:

A few references of TIA have a separated output for each voice (pin 12 & 13).
In General, the two voices are added to the same output (pin 13), pin 12 became a special pin, is used for video carrier frequency modulation.
I think it's the oldest consoles(Six Buttons Model) which has separated outputs.

Separated outputs TIA models:

- C010444D-19

One Output TIA models:

- UM6526P1
- AMI C011903

Tell me yours

Registers Address

WRITE ADDRESS SUMMARY

6 bit address	Address Name	7	6	5	4	3	2	1	0	Function
00	VSYNC							1		vertical sync set-clear
01	VBLANK	1	1					1		vertical blank set-clear
02	WSYNC		s	t	r	o	b	e		wait for leading edge of horizontal blank
03	RSYNC		s	t	r	o	b	e		reset horizontal sync counter
04	NUSIZ0			1	1	1	1	1	1	number-size player-missile 0
05	NUSIZ1			1	1	1	1	1	1	number-size player-missile 1
06	COLUP0	1	1	1	1	1	1	1		color-lum player 0
07	COLUP1	1	1	1	1	1	1	1		color-lum player 1
08	COLUPF	1	1	1	1	1	1	1		color-lum playfield
09	COLUBK	1	1	1	1	1	1	1		color-lum background
0A	CTRLPF			1	1		1	1	1	control playfield ball size & collisions
0B	REFP0					1				reflect player 0
0C	REFP1					1				reflect player 1
0D	PF0	1	1	1	1					playfield register byte 0
0E	PF1	1	1	1	1	1	1	1	1	playfield register byte 1
0F	PF2	1	1	1	1	1	1	1	1	playfield register byte 2
10	RESP0		s	t	r	o	b	e		reset player 0
11	RESP1		s	t	r	o	b	e		reset player 1
12	RESM0		s	t	r	o	b	e		reset missile 0
13	RESM1		s	t	r	o	b	e		reset missile 1
14	RESBL		s	t	r	o	b	e		reset ball
15	AUDC0					1	1	1	1	audio control 0
16	AUDC1				1	1	1	1	1	audio control 1
17	AUDF0				1	1	1	1	1	audio frequency 0
18	AUDF1					1	1	1	1	audio frequency 1
19	AUDV0					1	1	1	1	audio volume 0
1A	AUDV1					1	1	1	1	audio volume 1
1B	GRP0	1	1	1	1	1	1	1	1	graphics player 0
1C	GRP1	1	1	1	1	1	1	1	1	graphics player 1
1D	ENAM0							1		graphics (enable) missile 0
1E	ENAM1							1		graphics (enable) missile 1
1F	ENABL							1		graphics (enable) ball
20	HMP0	1	1	1	1					horizontal motion player 0
21	HMP1	1	1	1	1					horizontal motion player 1
22	HMM0	1	1	1	1					horizontal motion missile 0
23	HMM1	1	1	1	1					horizontal motion missile 1
24	HMBL	1	1	1	1					horizontal motion ball
25	VDELP0								1	vertical delay player 0
26	VDEL01								1	vertical delay player 1
27	VDELBL								1	vertical delay ball
28	RESMP0							1		reset missile 0 to player 0
29	RESMP1							1		reset missile 1 to player 1
2A	HMOVE		s	t	r	o	b	e		apply horizontal motion
2B	HMCLR		s	t	r	o	b	e		clear horizontal motion registers
2C	CXCLR		s	t	r	o	b	e		clear collision latches

Those two audio generators use 6 registers:

- **AUDCx** (4bit), Waveform control(x2)
- **AUDFx** (5bit), Pitch control(x2)
- **AUDVx** (4bit), Volume control(x2)

AUDx registers adresses start @ **0x15** (21)
0x15= 0**1**0101
0x16= 0**1**0110
0x17= 0**1**0111
0x18= 0**1**1000
0x19= 0**1**1001
0x1a= 0**1**1010

So we need 4 bit of address only. And 5 bit max for data (AUDFx).
Data bit 7,6,5 and Adress bit 5 are cleared.
Adress bit 4 is set.

Waveform & Noise Control:

The noise-tone generator is controlled by writing to the 4 bit audio control registers (AUDC0, AUDC1). The values written cause different kinds of sounds to be generated. Some are pure tones like a flute, others have various “noise” content like a rocket motor or explosion.
This circuit contains a nine bit shift counter which may be controlled by the output code from a four bit audio control register(AUDC), and is clocked by the frequency select circuit. The control register can be loaded by the microprocessor at any time, and selects different shift counter feedback taps and count lengths to produce a variety of noise and tone qualities.
Even though the TIA hardware manual lists the sounds created by each value, some experimentation will be necessary to find “your sound”.

AUDC0 (AUDC1)

These addresses write data into the audio control registers which control the noise content and additional division of the audio output.

	D3	D2	D1	D0	Type of noise or division	
0	0	0	0	0	set to 1	Silent
1	0	0	0	1	4 bit poly	SAW
2	0	0	1	0	div 15 -> 4 bit poly	DISTO
3	0	0	1	1	5 bit poly -> 4 bit poly	ENGINE
4	0	1	0	0	div 2 : pure tone	SQUARE
5	0	1	0	1	div 2 : pure tone	Same as 4
6	0	1	1	0	div 31 : pure tone	BASS
7	0	1	1	1	5 bit poly -> div 2	PITFALL
8	1	0	0	0	9 bit poly (white noise)	NOISE
9	1	0	0	1	5 bit poly	Same as 7
10	1	0	1	0	div 31 : pure tone	Same as 6
11	1	0	1	1	set last 4 bits to 1	Silent
12	1	1	0	0	div 6 : pure tone	LEAD
13	1	1	0	1	div 6 : pure tone	Same as 12
14	1	1	1	0	div 93 : pure tone	BUZZ L
15	1	1	1	1	5 bit poly div 6	BUZZ H

These are 16 in number (4 bits). But some are the same or are silent. So only 10 waveforms are available.

Pitch Control:

Frequency selection is controlled by writing to a 5 bit audio frequency register (AUDF0, AUDF1).
The value written is used to divide a 30KHz reference frequency creating higher or lower pitch of whatever type of sound is created by the noise-tone generator.
Clock pulses (at approximately 30 KHz) from the horizontal sync counter pass through a divide by N circuit which is controlled by the output code from a five bit frequency register (AUDF). This register can be loaded (written) by the microprocessor at any time, and causes the 30 KHz clocks to be divided by 1 (code 00000) through 32 (code 11111). This produces pulses that are digitally adjustable from approximately 30 KHz to 1 KHz and are used to clock the noise-tone generator.
By combining the pure tones available from the noise-tone generator with frequency selection a wide range of tones can be generated.
On PAL/SECAM Atari models, sounds will drop a little in pitch (frequency) because of a slower crystal clock.

AUDF0 (AUDF1)

These addresses write data into the audio frequency divider registers.

D4	D3	D2	D1	D0	30KHz divided by
0	0	0	0	0	no division
0	0	0	0	1	divide by 2
0	0	0	1	0	divide by 3
...	...	...	...	...	...
1	1	1	1	0	divide by 31
1	1	1	1	1	divide by 32

5 bits so This registers are limited to 32 values
Value needs to be reversed!

Volume Control:

Volume is controlled by writing to a 4 bit audio volume register (AUDV0, AUDV1).
The shift counter output is used to drive the audio output pad through four driver transistors that are graduated in size. Each transistor is twice as large as the previous one and is enable by one bit from the audio volume register (AUDV). This audio volume register may be loaded by the microprocessor at any time. As binary codes 0 through 15 are loaded, the pad drive transistors are enabled in a binary sequence. The shift counter output therefore can pull down on the audio output pad with 16

selectable impedance levels.
Writing 0 to these registers turns sound off completely, and writing any value up to 15 increases the volume accordingly.

AUDV0 (AUDV1)

These addresses write data into the audio volume registers which set the pull down impedance driving the audio output pads.

				D3	D2	D1	D0	Audio Output Pull down current
				0	0	0	0	No output current
				0	0	0	1	lowest
				0	0	1	0	
				...	...	...	...	
				1	1	1	0	
				1	1	1	1	highest

16 levels (4 bits).

Precompiled setups in the FW:

```
 o setup_tia_base.hex        (TIA Base setup for
Module)
 o setup_tia_cartridge.hex   (TIA setup for
Cartridge version)
```

Details (What have been done?)

Amplitude Specifics

Unlike the SID, TIA does not have internal gate and envelope.

So I wrote a specific section for **TIA Amplitude** (volume) in tia_sw.inc.
TIA_SW_Amp function handles **AUDVx** registers, calculates Amplitude from Parameters:

- Master Volume.
- Voice Volume.
- GSA
- Velocity.
- Dedicated Envelope (to Amp).
- Modulation Matrix (to Amp).

Copy_Amp, Engine Value to TIA register (done after all other amplitude process) :

- 0 ≤ **AUDVx** ≤ 31$^{(4bit)}$
- 0 ≤ **AMP** ≤ 0x7f$^{(7bit)}$

AUDVx = **AMP** » 3

Amplitude:Volumes

Master Volume(CC#7) allow to increase or decrease general volume and keep the relative mixing between the two Voices (CC#9-10).
With V12 Volume (CC#8), single Volumes(CC#9-10) will be linked and equals.

- 0 ≤ Vx_VOLUME ≤ 0x7f(7bit)
- 0 ≤ MASTER_VOLUME ≤ 0x7f(7bit)

AMP = Vx_VOLUME * MASTER_VOLUME / 127

```
CC # | Hex | Description                                    | Range       |
Reset
=====+=====+================================================+=============+===
===
   7 | 07h | Master Volume (00h-7Fh)                        |  0-127: val |
127
-----+-----+------------------------------------------------+-------------+---
---
   8 | 08h | Voice 1/2 Volume                               |  1-127: val |
127
   9 | 09h | Voice 1 Volume                                 | see above   |
127
  10 | 0Ah | Voice 2 Volume                                 | see above   |
127
-----+-----+------------------------------------------------+-------------+---
---
```

Amplitude:Vx Gate

I recreated the Gate and its GSA (CC#19-21)
feature by software.

Gate Stay active option maintain the Gate High and allow to dig in Amplitude(useful when depth velocity or envelope are negatives).
GSA in Voice Mode Controller:

```
CC # | Hex | Description                                    | Range       |
Reset
=====+=====+================================================+=============+===
===
  19 | 13h | Voice 1/2 Mode                                 |             |
0
     |     |   Bit 0: Gate Stay Active on/off               |             |
```

```
  20 | 14h | Voice 1 Mode                                    | see above   |
0
  21 | 15h | Voice 2 Mode                                    | see above   |
0
-----+-----+-------------------------------------------------+-------------+---
---
```

I add a fade out section to avoid 'clicks' on abrupt amplitude fall down.
Adjust it in setup_tia_*.asm

```
    ;; Adjustable Gate fade out option:
    ;; to avoid click when envelope is off or envelope release is null.
    ;; Uses USER_Timer period N * 819 (us), default N=2 (1.638ms).
#define DEFAULT_TIA_GATE_FADEOUT   2
```

Amplitude:Vx Velocity

Velocity response for both voices Amplitude(CC#19-21). With optional CC# Assign(CC#43-45).

It will play Init value(CC#4-6) if Velocity input is less than it.

- 0 ≤ Vx_LAST_VEL ≤ 0x7f(7bit)
- 0 ≤ Vx_INIT_VEL ≤ 0x7f(7bit)

If Vx_LAST_VEL ≤ Vx_INIT_VEL then Vx_LAST_VEL = Vx_INIT_VEL

A negative depth value(CC#13-25) will reverse the effect, harder you play, lower it sounds.
It will play Init value(CC#4-6) if Velocity input is less than it.

- **GSA** Off
- 0 ≤ Vx_LAST_VEL ≤ 0x7f(7bit)
- - 0x3f(6bit) ≤ Vx_DEPTH_VEL ≤ + 0x3f(6bit)

If Vx_DEPTH_VEL > 0 then
AMP = **AMP** * [(Vx_LAST_VEL / 127) * (Vx_DEPTH_VEL / 63)]

If Vx_DEPTH_VEL < 0 then
AMP = **AMP** * [1 - [(Vx_LAST_VEL / 127) * (|Vx_DEPTH_VEL| / 63)]]

Velocity to Amplitude Enabler in Vx Mode Controller:

```
CC # | Hex | Description                                        | Range       |
Reset
=====+=====+===================================================+=============+===
===
  19 | 13h | Voice 1/2 Mode                                     |             |
0
     |     |   Bit 3: Velocity to Amplitude on/off              |             |
  20 | 14h | Voice 1 Mode                                       | see above   |
0
  21 | 15h | Voice 2 Mode                                       | see above   |
0
-----+-----+---------------------------------------------------+-------------+---
---
```

Velocity Controllers :

```
CC # | Hex | Description                                        | Range       |
Reset
=====+=====+===================================================+=============+===
===
   4 | 04h | Voice 1/2 Velocity Init Value                      |  0-127: val |
0
   5 | 05h | Voice 1 Velocity Init Value                        |             |
0
   6 | 06h | Voice 2 Velocity Init Value                        |             |
0
-----+-----+---------------------------------------------------+-------------+---
---
  13 | 0Dh | Voice 1/2 Velocity Depth                           |  0- 63: neg |
127
     |     | negative depth (0-63) inverts the effect           |     64: off |
     |     |                                                    | 64-127: pos |
  14 | 0Eh | Voice 1 Velocity Depth                             |             |
  15 | 0Fh | Voice 2 Velocity Depth                             |             |
-----+-----+---------------------------------------------------+-------------+---
---
  43 | 2Bh | Voice 1/2 Assign Velocity to Controller            |     0: off  |
0
     |     |                                                    | 1-127: Ctrl |
  44 | 2Ch | Voice 1 Assign Velocity to Controller              | see above   |
0
  45 | 2Dh | Voice 2 Assign Velocity to Controller              | see above   |
0
-----+-----+---------------------------------------------------+-------------+---
---
```

Velocity and GSA behaviour :\\

With **GSA enabled** (CC#19-21), in accordance with Depth sign (CC#8-10), velocity value will **increase/decrease Amplitude** value on noteOn and restore normal value on noteOff.

- **GSA** On
- 0 ≤ Vx_LAST_VEL ≤ 0x7f$^{(7bit)}$
- - 0x3f$^{(6bit)}$ ≤ Vx_DEPTH_VEL ≤ + 0x3f$^{(6bit)}$

If Vx_DEPTH_VEL > 0 then
AMP = **AMP** + (127 - **AMP**) * [(Vx_LAST_VEL / 127) * (Vx_DEPTH_VEL / 63)]

If Vx_DEPTH_VEL < 0 then
AMP = **AMP** - **AMP** * [(Vx_LAST_VEL / 127) * (|Vx_DEPTH_VEL| / 63)]

e.g. Positive Velocity Depth.

- **GSA** On
- **AMP** = 64
- Vx_DEPTH_VEL = **+ 32**
- Vx_LAST_VEL= 127

AMP = 64 + (127 - 64) * [(127 / 127) * (32 / 63)] ≈ 96

e.g. Negative Velocity Depth.

- **GSA** On
- **AMP** = 96
- Vx_DEPTH_VEL = **- 63**
- Vx_LAST_VEL= 82

AMP = 96 - 96 * [(82 / 127) * (63 / 63)] ≈ 34

Amplitude:Vx Envelope

TIA needs Envelopes to be a real synth and have its behaviour...
I chose to decrease LFOs number by 2 and add one dedicated envelope per voice.
Ok now, we've got 4LFOs and 4 ENVs...

For each 2 dedicated Envelopes (VxENV) :

- Envelope to Amplitude Enabler(CC#19-21).
- Depth parameter (CC#49-51).
- Curve Bender parameter (CC#52-54).

- Classic parameters Attack (CC#55-57), Decay (CC#58-60), Sustain (CC#61-63), Release (CC#64-66).
- Matrix Mixer Mode Option (CC#46-48).Lend a focus
- Curve Bender assign to Attack/Decay/Release (CC#46-48).
- Midi Sync Enabler (CC#46-48).

If enabled(CC#19-21) and Depth(CC#49-51) is not null then the Gate reset will be delayed by the envelope release.

- 0 ≤ **VxENV** ≤ 0x3f00(15bit)

= **AMP** * **VxENV**$_{HI}$ / 127

Envelope to Amplitude Enabler in Vx Mode Controller:

```
CC # | Hex | Description                                          | Range       |
Reset
=====+=====+======================================================+=============+===
===
  19 | 13h | Voice 1/2 Mode                                       |             |
0
     |     |   Bit 4: Enveloppe to Amplitude on/off               |             |
  20 | 14h | Voice 1 Mode                                         | see above   |
0
  21 | 15h | Voice 2 Mode                                         | see above   |
0
-----+-----+------------------------------------------------------+-------------+---
---
```

Envelope Depth :
A negative Depth(CC#49-51) value will reverse the effect.

e.g. Positive Depth. **AMP**

- **GSA** Off
- Vx_DEPTH_VEL = **+ 63**

e.g. Negative Depth.

- **GSA** Off
- Vx_DEPTH_VEL = **- 63**

Negative depth inverts the **VxENV** waveform.
And **AMP** will follow.

e.g. Negative Depth with GSA Enabled.

AMP

- **GSA** On
- Vx_DEPTH_VEL = **- 36**

```
CC # | Hex | Description                                          | Range       |
Reset
=====+=====+======================================================+=============+===
===
  49 | 31h | Voice 1/2 Envelope Depth                             |  0- 63: neg |
64
     |     | negative depth (0-63) inverts the waveform           |     64: off |
     |     |                                                      | 64-127: pos |
  50 | 32h | Voice 1 Envelope Depth                               | see above   |
64
  51 | 33h | Voice 2 Envelope Depth                               | see above   |
64
-----+-----+------------------------------------------------------+-------------+---
---
```

At the moment we have two 'dedicated' envelopes which behave like the other two, except that enable bits are into different registers and Vx_ENV can not modulate the other voice...
What will happen if I assign another mod via the voice modulation matrix?

From the Modulation Matrix:

- $-\ 0x7f00^{(15bit)} \leq$ **LFOx** $\leq +\ 0x7f00^{(15bit)}$
- $-\ 0x7f00^{(15bit)} \leq$ **ENV$_{Vx}$** $\leq +\ 0x7f00^{(15bit)}$
- $-\ 0xff00^{(16bit)} \leq$ **MODs** $\leq +\ 0xff00^{(16bit)}$

MODs = LFO1_VALUE **+** ... **+** LFO4_VALUE **+** ENV1_VALUE **+** ENV2_VALUE

e.g. Modulation Matrix LFO1 to Vx Amplitude is enabled.

- Vx_DEPTH_VEL = **+ 31 (mid pos)**

AMP = **AMP** * (**VxENV$_{HI}$** **+** **MODs$_{HI}$**)

Like the extra modulations mixer, it results in the addition of the dedicated envelope value and the Matrix Modulation result.
And it's not really what I wanted. As you can see, the MODS result alters the envelope. At the end of the release,

amplitude is not zero, which causes audio clicks.

My issue was to add two others Mixing modes...

Envelope Matrix Mixer Mode options:

So we've got the basic **A + B** Mixer Mode.

- $AMP_{Vx} = AMP * (VxENV_{Vx} + MODs_{Vx})$

Here the **A * B** Mixer Mode.

- $AMP_{Vx} = AMP * (VxENV_{Vx} * MODs_{HI})$

Here the **A + A * B** Mixer Mode.

- $AMP_{Vx} = AMP * (VxENV_{Vx} + VxENV_{HI} * MODs_{HI})$

```
CC # | Hex | Description                                          | Range       |
Reset
=====+=====+======================================================+=============+===
===
  46 | 2Eh | Voice 1/2 Envelope Options                           |             |
0
     |     |   Bit 0-1: Envelope Mixing Mode                      |             |
     |     |       0= Env + Modulation Matrix                     |             |
     |     |       1= Env * Modulation Matrix                     |             |
     |     |       2= Env + (Env * Modulation Matrix)             |             |
  47 | 2Fh | Voice 1 Envelope Options                             | see above   |
0
  48 | 30h | Voice 2 Envelope Options                             | see above   |
0
-----+-----+------------------------------------------------------+-------------+---
---
```

Envelope Curve and options :

```
CC # | Hex | Description                                    | Range       |
Reset
=====+=====+================================================+=============+===
===
  52 | 34h | Voice 1/2 Envelope Curve                       |   0-63: neg |
64
     |     | Note: Curve must be enabled separately         |      0: lin |
     |     | for Attack/Decay/Release parameter w/ CC#46    | 64-127: pos |
  53 | 35h | Voice 1 Envelope Curve                         | see above   |
64
  54 | 36h | Voice 2 Envelope Curve                         | see above   |
64
-----+-----+------------------------------------------------+-------------+---
---
  46 | 2Eh | Voice 1/2 Envelope Options                     |             |
0
     |     |   Bit 4: Use curve parameter to Attack         |             |
     |     |   Bit 5: Use curve parameter to Decay          |             |
     |     |   Bit 6: Use curve parameter to Release        |             |
  47 | 2Fh | Voice 1 Envelope Options                       | see above   |
0
  48 | 30h | Voice 2 Envelope Options                       | see above   |
0
-----+-----+------------------------------------------------+-------------+---
---
```

Envelope parameters :

```
CC # | Hex | Description                                    | Range       |
Reset
=====+=====+================================================+=============+===
===
  55 | 37h | Voice 1/2 Envelope Attack                      |  0-127: val |
0
  56 | 38h | Voice 1 Envelope Attack                        | see above   |
0
  57 | 39h | Voice 2 Envelope Attack                        | see above   |
0
-----+-----+------------------------------------------------+-------------+---
---
  58 | 3Ah | Voice 1/2 Envelope Decay                       |  0-127: val |
0
  59 | 3Bh | Voice 1 Envelope Decay                         | see above   |
0
  60 | 3Ch | Voice 2 Envelope Decay                         | see above   |
0
-----+-----+------------------------------------------------+-------------+---
---
  61 | 3Dh | Voice 1/2 Envelope Sustain                     |  0-127: val |
0
  62 | 3Eh | Voice 1 Envelope Sustain                       | see above   |
```

```
0
  63 | 3Fh | Voice 2 Envelope Sustain                      | see above   |
0
-----+-----+-----------------------------------------------+-------------+---
---
  64 | 40h | Voice 1/2 Envelope Release                    |  0-127: val |
0
  65 | 41h | Voice 1 Envelope Release                      | see above   |
0
  66 | 42h | Voice 2 Envelope Release                      | see above   |
0
-----+-----+-----------------------------------------------+-------------+---
---
```

Envelope Sync option :

```
CC # | Hex | Description                                   | Range       |
Reset
=====+=====+===============================================+=============+===
===
  46 | 2Eh | Voice 1/2 Envelope Options                    |             |
0
     |     |   Bit 3: Envelope Midi Sync on/off            |             |
  47 | 2Fh | Voice 1 Envelope Options                      | see above   |
0
  48 | 30h | Voice 2 Envelope Options                      | see above   |
0
-----+-----+-----------------------------------------------+-------------+---
---
```

Pitch Specifics

TIA pitch scale is poor (AUDFx, 32 values maximum).
I thought this box as an FX synth, so in addition to others sound modules. No matter that it monopolizes an entire keyboard channel in normal mode. My first idea was tu use the Splitter key which already exists, but they are not accessible via CC and not adapted to the TIA scale. So I add some specifics parameters for **TIA Frequency** (pitch) in tia_sw.inc.
Despite the size of AUDFx and the lack of frequency accuracy, the 16bit frequency registers were kept. I wanted this process valuable for other project, e.g. POKEY.

TIA_SW_Note, TIA_SW_Pitch and TIA_SW_Porta functions handle **AUDFx** registers, calculates Frequency from Parameters:

- Note(and Arpeggiator).
- Key Extended option.
- Transpose.
- Pitch Bend and Pitch Range.
- Portamento.
- Dedicated Envelope (to Pitch).
- Modulation Matrix (to Pitch).

Copy_Freq, Engine Value to TIA register (done after all other pitch process) :

- $0 \leq$ **AUDFx** $< 2^5$
- $0 \leq$ **FREQ** $< 2^{16}$

AUDFx = (255 - $\mathbf{FREQ_{HI}}$) » 3
Remember... AUDFx Value must be inverted.

Pitch:Key Extended Option

This feature is a bit enabler located in the Voice Mode Controller(CC#19-21).
In normal mode, it splits a keyboard in 2 ranges of Keys Length(CC#40-42), which start at their respective Note Offsets(CC#37-39), there's one range per Voice.
In Extended mode, the 32 notes scale of the TIA is expanded to the keyboard midi range (128 notes). So 4 Keys per value.
Voices can share same MIDI Channel.

Key extended Enabler in Vx Mode Controller:

```
CC # | Hex | Description                                          | Range       |
Reset
=====+=====+======================================================+=============+===
===
  19 | 13h | Voice 1/2 Mode                                       |             |
0
     |     |   Bit 2: Keyboard Extended on/off                    |             |
  20 | 14h | Voice 1 Mode                                         | see above   |
0
  21 | 15h | Voice 2 Mode                                         | see above   |
0
-----+-----+------------------------------------------------------+-------------+---
---
```

Key extended is off (normal mode).

- 1 ≤ Vx_KEY_OFFSET ≤ 127 (0=off)
- 0 ≤ Vx_KEY_LENGTH ≤ 31
- 1 ≤ Vx_NOTE ≤ 127

If Vx_NOTE ≥ Vx_KEY_OFFSET AND Vx_NOTE ≤ (Vx_KEY_OFFSET + Vx_KEY_LENGTH) then
$\mathbf{FREQ_{HI}}$ = (Vx_NOTE - Vx_KEY_OFFSET) « 3
$\mathbf{FREQ_{LO}}$ = 0

```
CC # | Hex | Description                                          | Range       |
Reset
```

```
=====+=====+================================================+=============+===
===
  37 | 25h | Voice 1/2 Key Offset                           | 0-127: val  |
24
  38 | 26h | Voice 1 Single Key Offset                      |             |
24
  39 | 27h | Voice 2 Single Key Offset                      |             |
60
     |     | Note: Inactive if Key Extended On              |             |
-----+-----+------------------------------------------------+-------------+---
---
  40 | 28h | Voice 1/2 Key Length                           | 0-31: val   |
31
  41 | 29h | Voice 1 Single Key Offset                      |             |
31
  42 | 2Ah | Voice 2 Single Key Offset                      |             |
31
     |     | Note: Inactive if Key Extended On              |             |
-----+-----+------------------------------------------------+-------------+---
---
```

- e.g. Default configuration.

- V1_Offset=24, Length=32.
- V2_Offset=60, Length=32.

- Voice 1 starts at offset 24(C0) and reacts to the range(C0 to G2).
- Voice 2 starts at offset 60(C3) and reacts to the range(C3 to G5).
- One key for each AUDFx Values.

- e.g. Voices can share same zone region or entire zone.

- V1_Offset=24, Length=32.
- V2_Offset=36, Length=20.

- Voice 1 starts at offset 24(C0) and reacts to the range(C0 to G2).
- Voice 2 starts at offset 36(C1) and reacts to the range(C1 to G2).
- Both sounds will be played on the shared region C1 to G2, only one in non-crossing region.

Key extended is on.

- 1 ≤ Vx_NOTE ≤ 127

$FREQ_{HI}$ = Vx_NOTE « 1
$FREQ_{LO}$ = 0

- e.g. V1 & V2 in KeyExtended mode.

- Voice 1 starts at offset 1(C#-2) and reacts to the range(CC#-2 to G8), 4 keys resolution.
- Voice 2 starts at offset 1(C#-2) and reacts to the range(CC#-2 to G8), 4 keys resolution.
- Four keys for each AUDFx Values.

- e.g. Only V1 in KeyExtended mode.

- V2_Offset=60, Length=32.

- Voice 1 starts at offset 1(C#-2) and reacts to the range(CC#-2 to G8).
- Four keys for each AUDF0 Values.
- Voice 2 starts at offset 60(C3) and reacts to the range(C3 to G5).
- One key for each AUDF1 Values.

Pitch:Vx Envelope

Downloads

Check it out from my playground on the svn!

Firmware:

- MIDIbox TIA v1c Firmware

Tools:

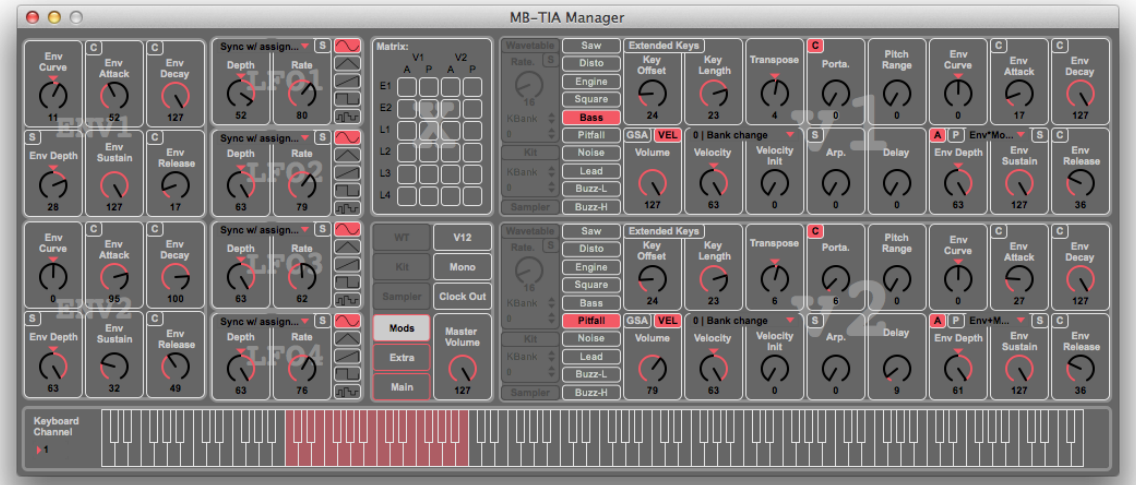
- MIDIbox TIA Interconnection Test Tool
- MIDIbox TIA Test Tone Tool
- MIDIbox TIA BankStick Check and Debug Tool
- Max Manager

Documentation:

- MIDIbox TIA CC# Implementation chart
- MIDIbox TIA Sysex Implementation

The MIDIbox TIA Manager

ASAP



* Max Manager

The MIDIbox TIA Cartridge Version

MB TIA Cartridge Forum Pictures

Building it!

You will need:

- A TIA chip.
- A game Cartrige with sticker and internal EPROM removed.
- The last version of the PCB.
- The last version of the aluminum backplane.
- Some components, wire and connectors.
- The last firmware.

The TIA chip

Find a TIA chip is already explain in "Where do i find this chip?" chapter above on this page
You may ask Psykhaze in MP, because he found a good provider for the UM6526P1.

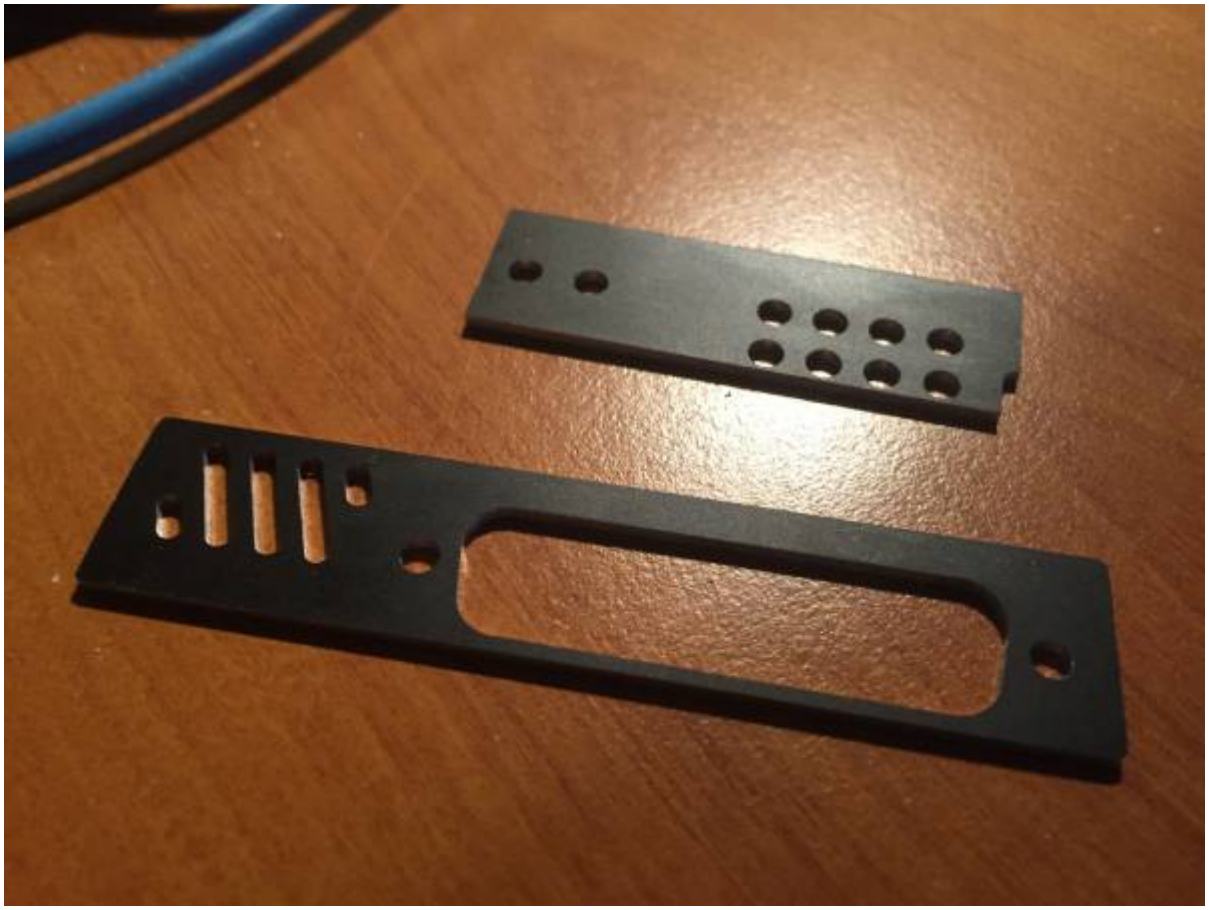
Which game cartridge?

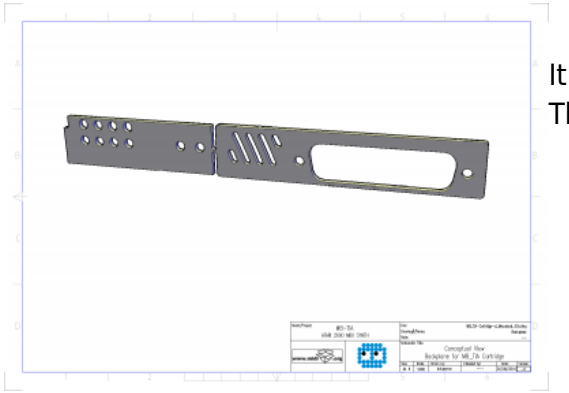
Any standard ATARI brand game like this one.
You will find a full list of the compatible games in the 'ATARI' section on AtariAge

- Remove the stickers and you will find a screw.
- Open the box and remove averything inside, just keep the 2 plastic parts of the box and the screw.
- Cut the two plastic clamps inside the top cover by bending it.
Note: **How to drill the led holes** is explained in the next 'backplane' chapter.

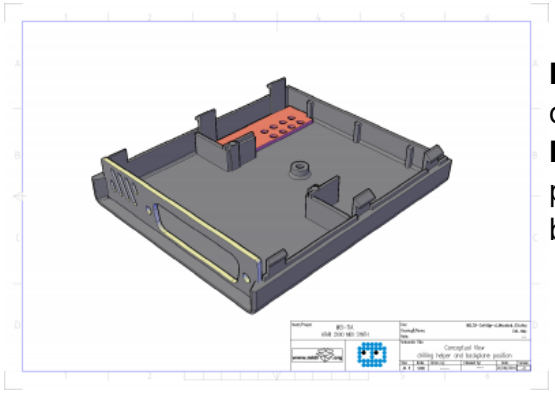
The aluminum backplane

dxf and fpd files





It's a 1.5mm thick aluminum plate.
There's **two part** which have to be separated



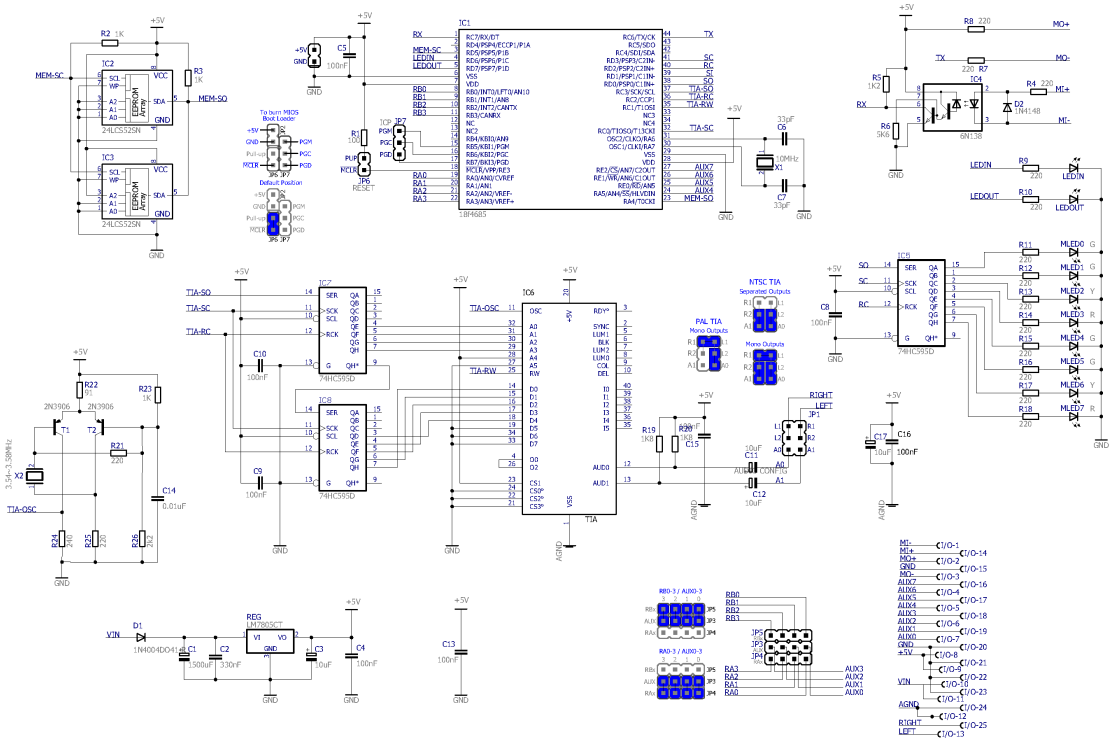
Right part is the backplane for the synth connector(a DB25 F).
Left is to help you **drilling the led holes**, just place it inside the top cover and use a 3mm drill bit:

PCB

This is **version 2**, there's some improvements since version 1.

- I solved a crossover issue.
- I removed the power switch which is hard to find.
- MIDI / AUDIO / POWER and EXPANSION share now the same connector, everything is on a DB25 Female.
- I changed some DIP package to SMD, don't worry it remains easy to solder.

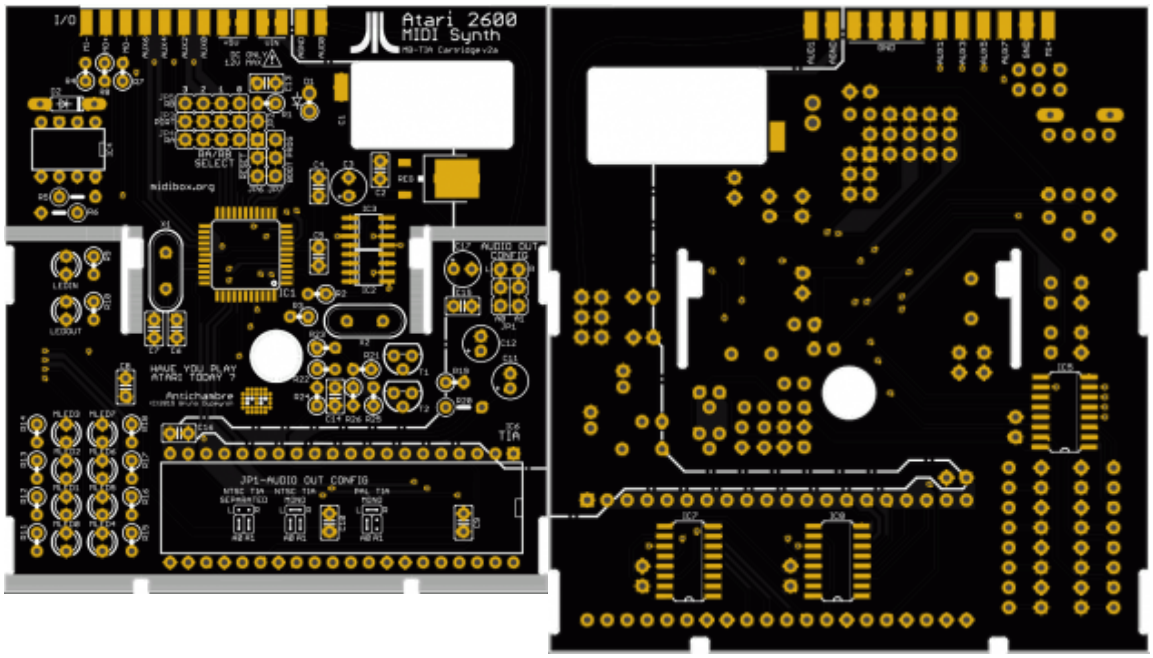
Schematic



Layout

Top layer...

Bottom layer, Seeed render.



Note: Because of the PIC package... If you haven't got any PIC Burner, I can solder the IC and burn the bootloader for you, just tell me.

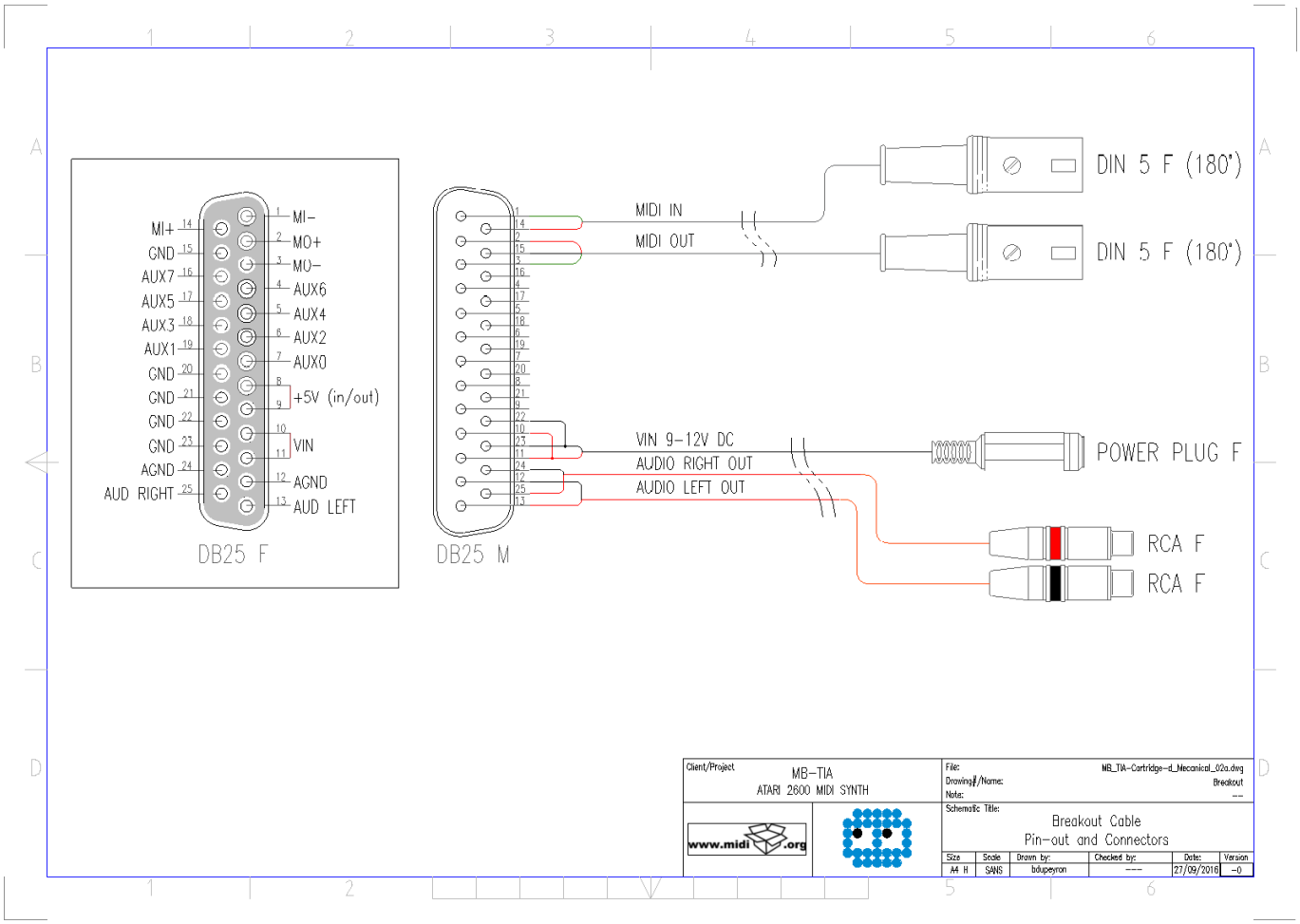
Cartridge Parts & BOM

Mouser BOM, corrected by yogi, (2016/12/21)
IC Socket for IC4 IC6 added, (2017/05/05)

Part	Value	Type	Qty
C1	1500uF	Polarized Capacitor	1
C2	330nF	Multilayer Ceramic Capacitors	1
C3,C17	10uF	Polarized Capacitor	2
C4,C5,C8,C9,C10,C13,C15,C16	100nF	Multilayer Ceramic Capacitors	8
C6,C7	33pF	Multilayer Ceramic Capacitors	2
C11,C12	10uF	Polarized Capacitor (Audio Grade)	2
C14	10nF	Multilayer Ceramic Capacitors	1
D1	1N4004	Diode	1
D2	1N4148	Diode	1

Part	Value	Type	Qty
I/O	SUB-D25 F Solder cup	1	
IC1	18f4685	1	
IC2,IC3	**24LC512**	Serial EEPROM	2
IC4	6N138	High Speed Optocoupler	1
IC5,IC7,IC8	74HC595D	8-bit Shift Register, output latch	3
JP1,JP2,JP3,JP4,JP5,JP6,JP7	–	header pin strip 40p	1
LEDIN,LEDOUT,MLED3,MLED7	Red	Led 3mm	4
MLED0,MLED1,MLED4,MLED5	Green	Led 3mm	4
MLED2,MLED6	Yellow	Led 3mm	2
R1	100	Resistor	1
R2,R3,R23	1K	Resistor	3
R4,R7,R8,R9,R10,R11,R12,R13,R14,R15,R16,R17,R18,R21,R25	220	Resistor	15
R5	1K2	Resistor	1
R6	5K6	Resistor	1
R19	1K8	Resistor	1
R20	1K8	Resistor	1
R22	91	Resistor	1
R24	240	Resistor	1
R26	2k2	Resistor	1
REG	7805DT	Positive Voltage Regulator	1
T1,T2	2N3906	PNP Transistor	2
X1	10MHz	Crystal	1
X2	3.54~3.58MHz	Crystal	1
IC Socket for IC4	DIP8	IC Support	1
IC Socket for IC6 TIA	DIP40	IC Support	1

Breakout Cable



Connector	Qty	Example
D-Sub 25 Male	1	Amphenol L717SDB25PVF @Mouser
Cover for D-Sub 25	1	–
Female Screwlock, washer and Nut	2	–
DIN 5pin Female	2	Switchcraft Inc. 06AL5FX @Digikey
RCA F Red	1	Amphenol Audio ACJR-RED @Mouser
RCA F Black/White	1	Amphenol Audio ACJR-BLK @Mouser
DC Power Plug F	1	CUI PR-002A @Mouser

And Some Wire.

Firmware

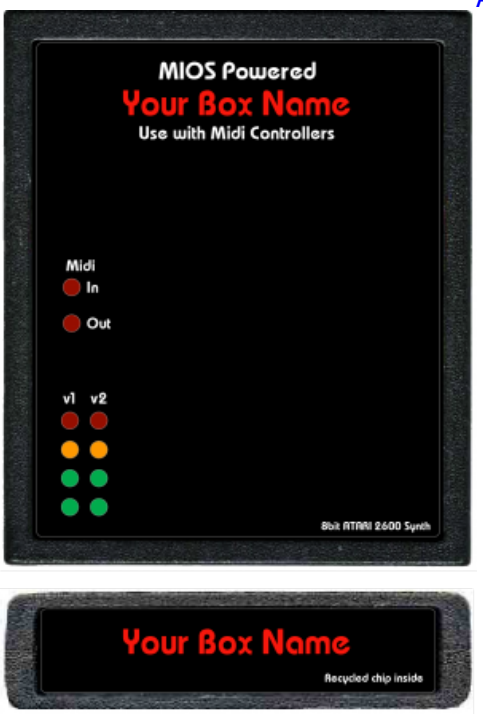
Refer to the download section on this page.
Base and Cartridge versions firmware are the same, only the asm setup differs.

Here the Hex file for cartridge version app.(Led Meter issue fixed!)

Customized Labels

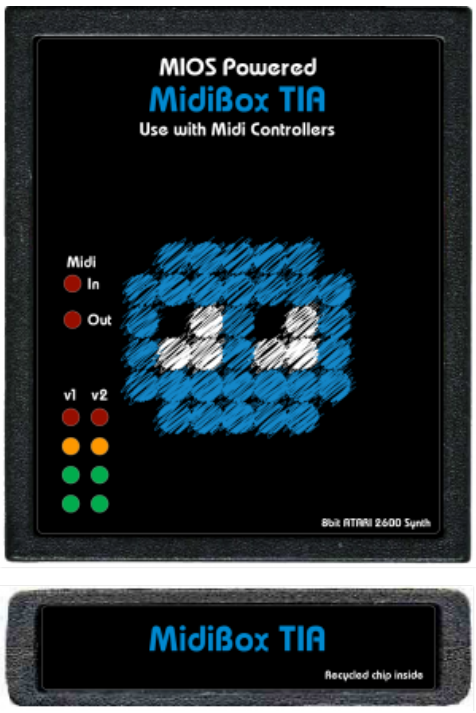
I've prepared an illustrator template file, inside you will find two model examples.
Just add your own bitmap or vecto, change the legend. And LABEL will be ready for printing.
There's cutout layer too, for printer with cutter head.

AI template file and Atari Fonts inside



Somes examples:

This is mine.



Mat already gave his own
He is an Atari lover AND a Metal

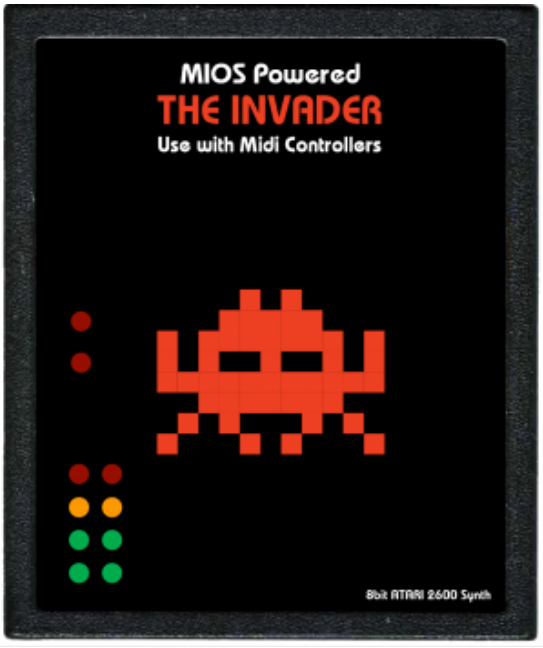
guitarist!

Gerald.

Scrubber.

Wired.

Djo.



Find the kit

Modular Addict

For any questions, informations or observations do not hesitate to contact me (Forum).
Antichambre.
You can also follow the thread on forum.