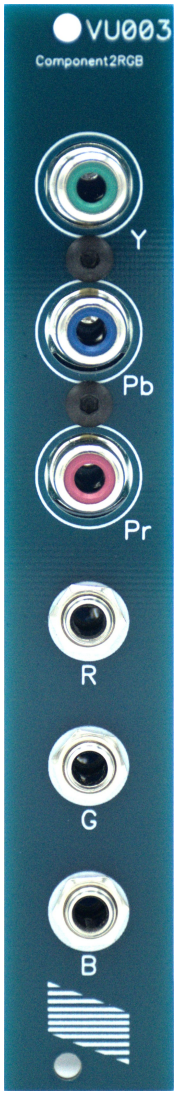
VU003
Component to RGB converter
User/Build Guide



VU003 is a Component/YPbPr to RGB colorspace converter, this allow to process a color video signal inside a DIY video modular system from a component video source.

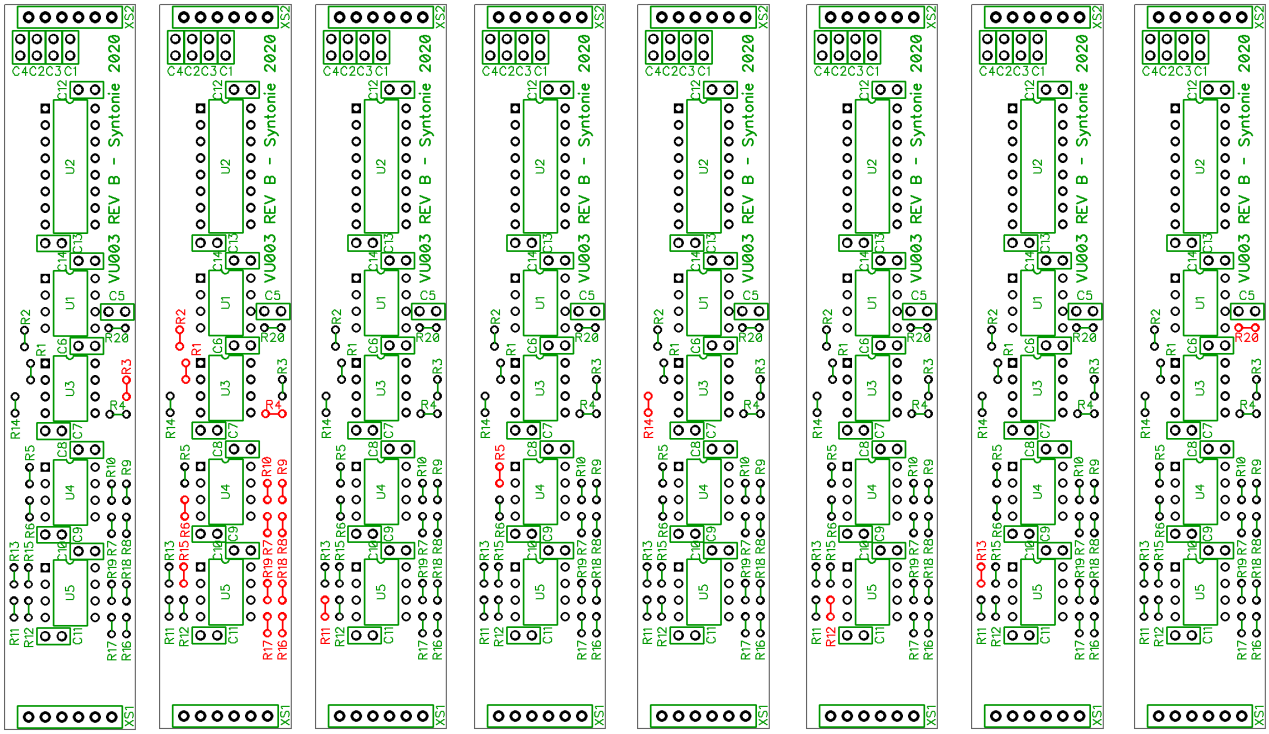
The basic setup requires a sync extractor/generator (LZX Cadet I) and a RGB encoder (LZX Cadet II).
Y is sent to the sync generator first, then sent to VU003, so the system is synced to the external video.
Since the Cadet I only handles 480i/576i, VU003 only work with SD component, also the sync extractor inside the module only takes care of SD sync (can probably be adapted).

Inputs: 0-700mV YPbPr, 75 ohms, RCA
Outputs: 0-1V RGB, 499 ohms, jack

– 4HP
– 28mA +12V
– 16mA -12V
– 0mA +5V
– 50mm deep

Mainboard build

Resistors



215R 499R 698R 768R 976R 1k 2.7k 680k

215R : R3
499R : R1, R2, R4, R6, R7, R8, R9, R10, R15, R16, R17, R18, R19
698R : R11
768R : R5
976R : R14
1k : R12
2.7k : R13
680k : R20

As you may have noticed, the resistors needs to be mounted vertically. Bend one of the lead along the body of the resistor, as close as possible (as another board will be mounted above this one).

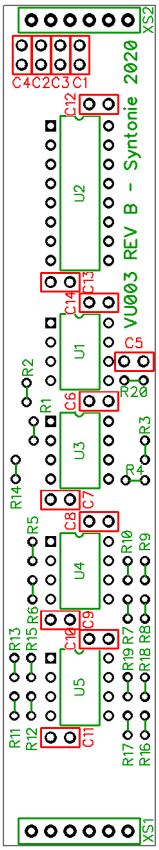
A good practice is to mount two resistors that are next to each horizontally head to tail, to avoid a short between the leads.

Another good thing to do is to place a few resistor and solder them instead of placing all of them and solder, as there will be a lot of leads crossing each other.

Check the picture at the end of this section to see how the resistors are mounted.

Mainboard build

Capacitors

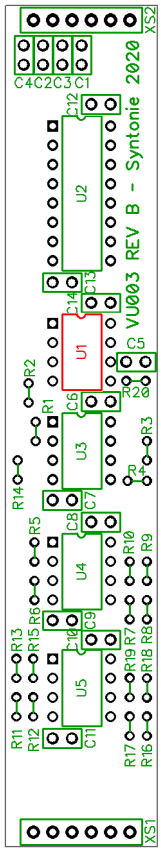


100nF

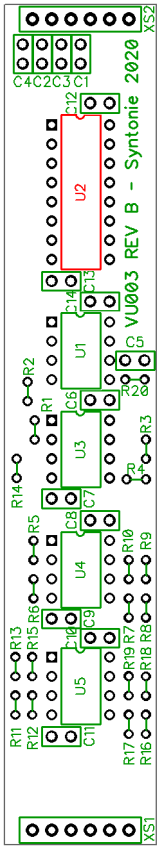
100nF : C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14

Mainboard build

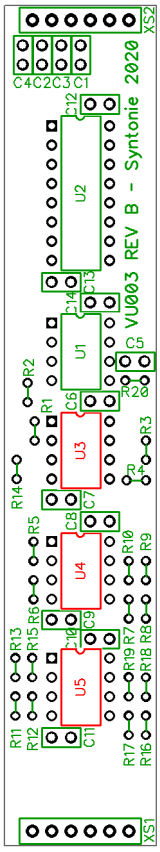
Semiconductors



LM1881



CD4053



LM6172

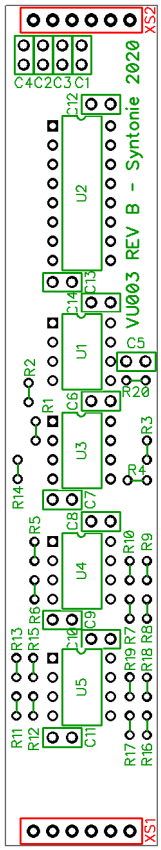
LM1881 : U1
CD4053 : U2
LM6172 :U3, U4, U5

All ICs are polarized, make sure that then notch on the chip matches the notch on the circuit board.

The kit include sockets for the ICs, you can use it or not, both have pro and cons, the socket allow to remove the chip easily, which can be useful for troubleshooting, however it can add unwanted capacitance on the IC pins.

Mainboard build

Connectors

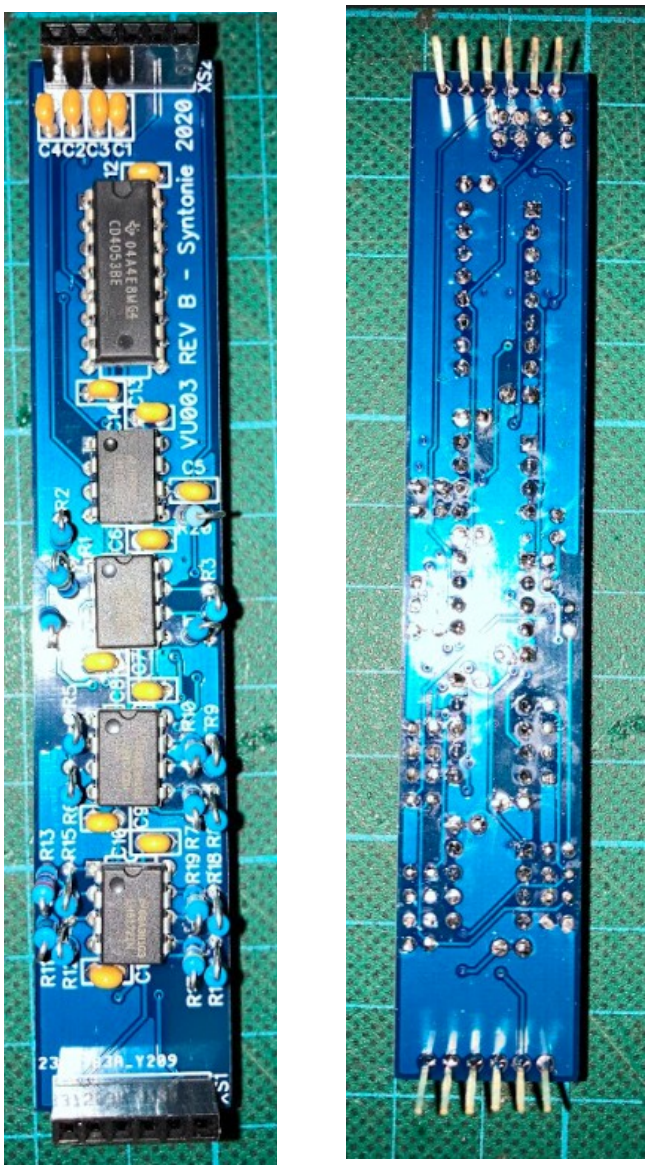


6 pin stackable connectors

XS1, XS2 : 6pin stackable connector

The box header (female plastic part) needs to be mounted on the component side, and the long pins on the solder side.

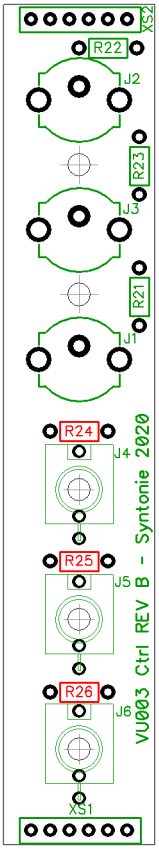
Mainboard build



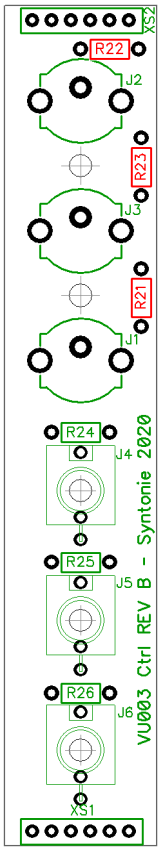
This is how the board should look once all the components are populated. Notice that the resistors are mounted head to tail. The connectors are soldered on the solder side of the board.

Controlboard build

Resistors



499R

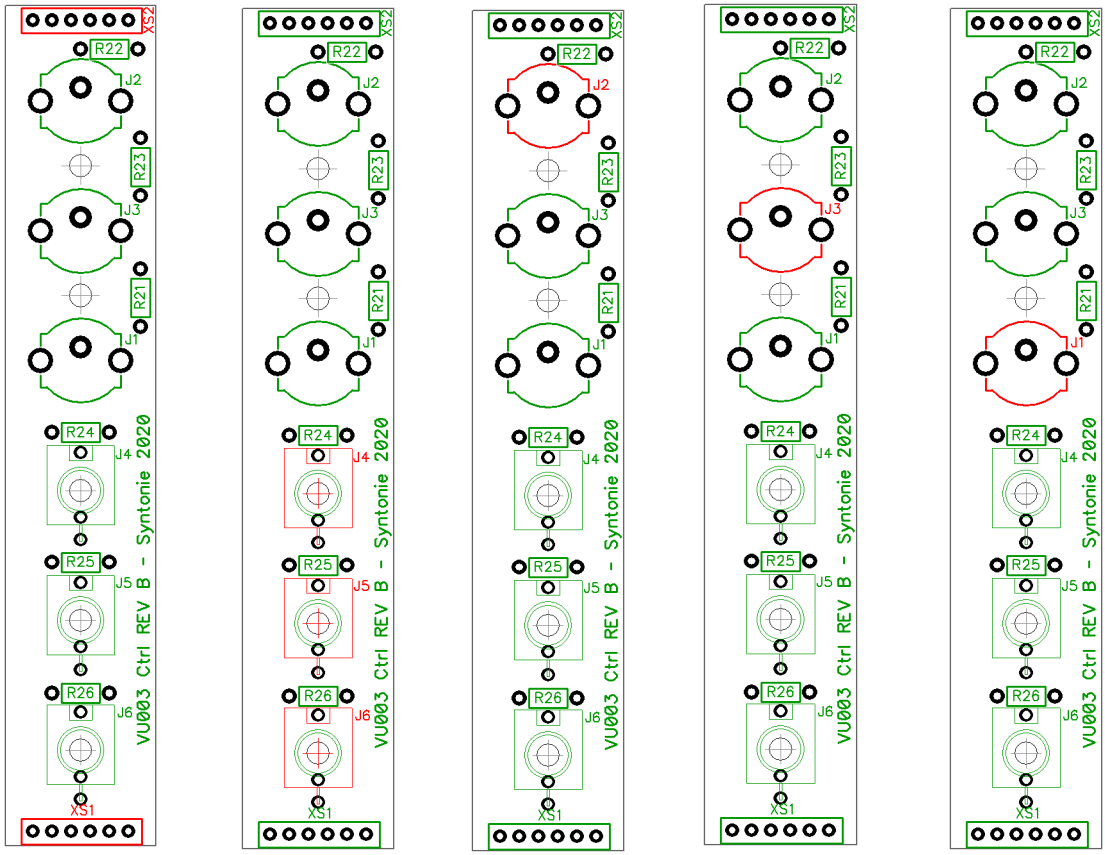


75R

499R : R24, R25, R26
75R : R21, R22, R23

Controlboard build

Connectors



6pin female | PJ398SM | Green RCA | Blue RCA | Red RCA

XS1, XS2 : 6pin female connector
J4, J5, J6 : PJ398SM
J2 : Green RCA
J3 : Blue RCA
J1 : Red RCA

The 6pin connectors needs to be mounted with the box header on the solder side, pins are soldered on the component side.

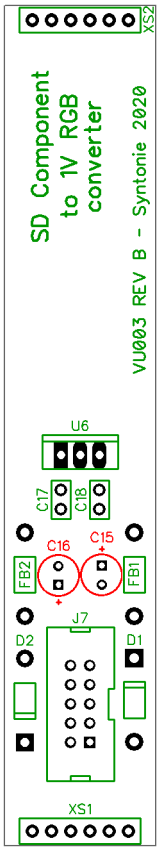
The 2x 10mm spacers can be mounted, they go on the component side of the board, as they will be used to secure the front panel to the controlboard.

Controlboard build

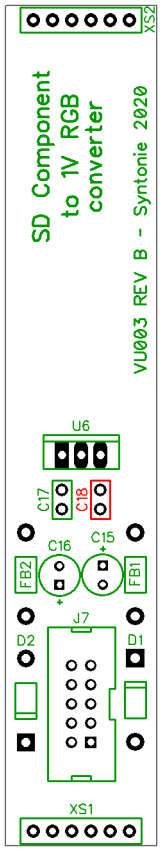
Now that the controlboard is done, let's move on to the power board. You can try fitting the controlboard to the mainboard now, but don't push the connectors all the way down yet, as it's a bit hard to disconnect afterwards.

Powerboard build

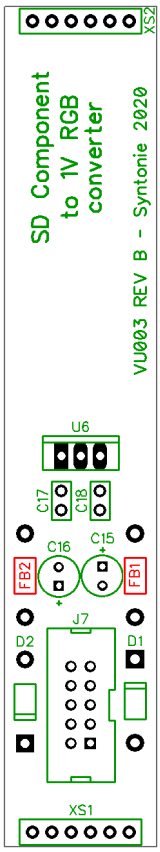
Capacitors/Ferrites



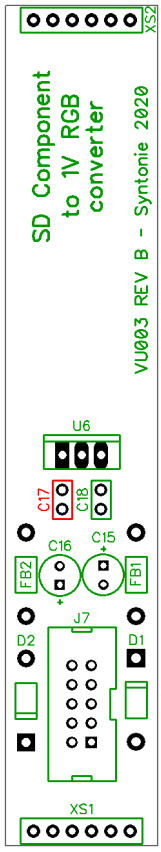
10uF



100nf



Ferrites



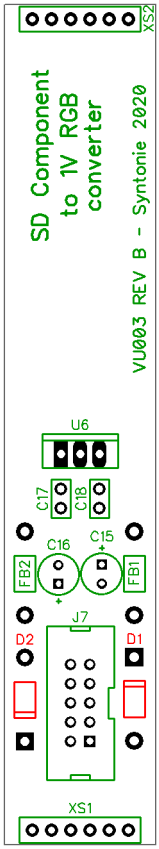
330nF

10uF : C15, C16
100nF : C18
Ferrites : FB1, FB2
330nF : C17

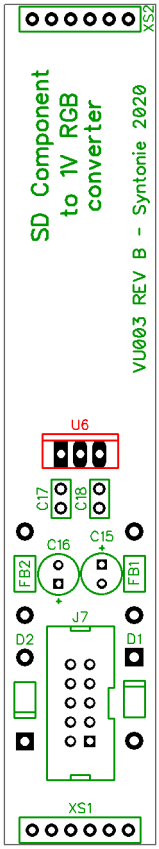
Note that the 10uF capacitors are polarized, the longer lead needs to match the square pad/plus sign on the circuit board.

Powerboard build

Semiconductors



1N4001



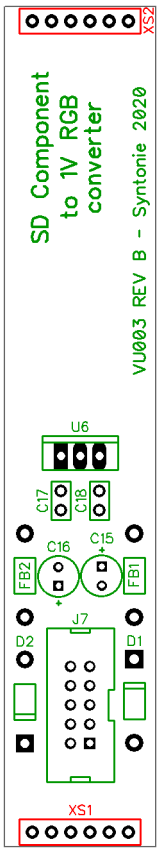
LM7805

1N4001 : D1, D2
LM7805 : U6

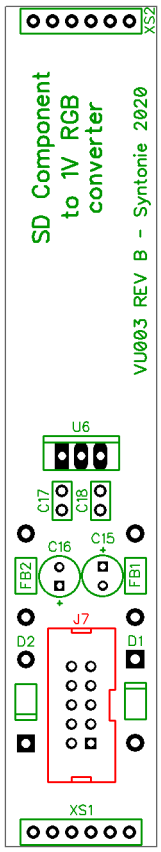
Diodes are polarized, make sure that the ring on the diode matches with the line on the circuit board.
LM7805 is polarized, the metal tabl should match the line one circuit board. You can lay the regulator flat to the board to save depth (see picture at the end of the section).

Powerboard build

Connectors



6pin male

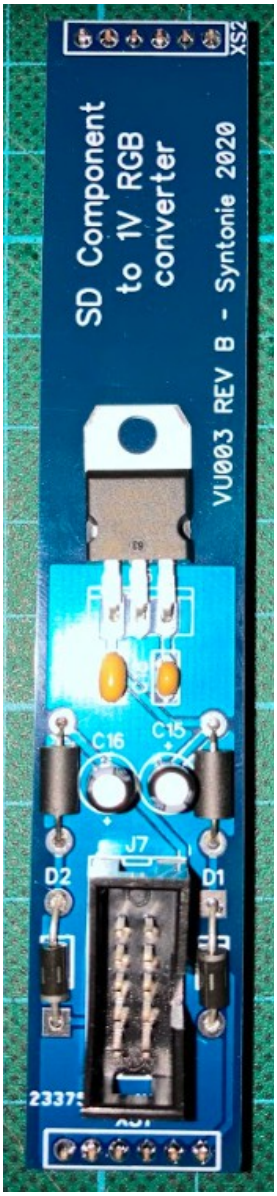


10pin IDC

XS1, XS2 : 6pin male connector
J9 : 10pin IDC connector

XS1 and XS2 long pins should be on the solder side of the board, and solder on the component side.
Make sure that the notch on the IDC connector matches the notch on the circuit board.

Powerboard build

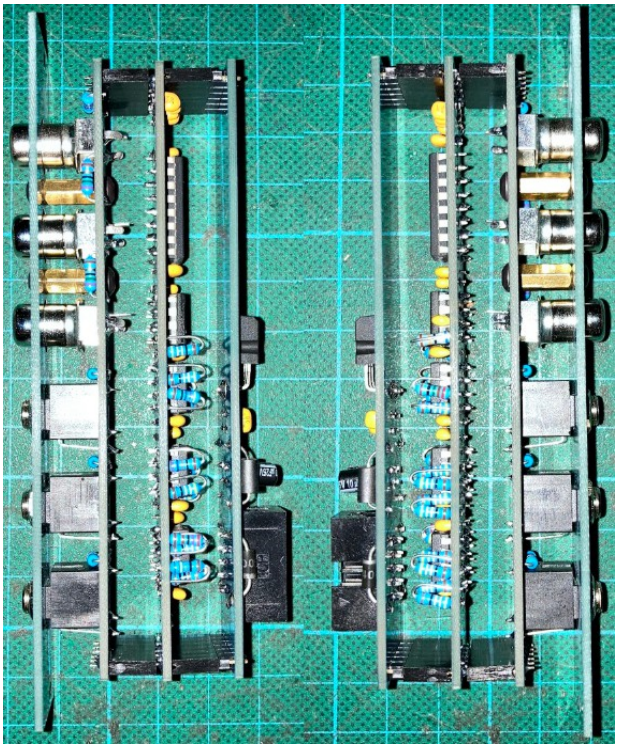


Now that all three boards are built, they can be connected together (again, don't push the control board and mainboard fully yet, it can be done once the module have been tested). You can fit the panel to test that the module is working properly.
Testing :

- Send Y signal from a component source to the Cadet Sync Gen
- Then send the buffered Y to VU003 Y input
- Connect Pb and Pr from the source to VU003 inputs
- Connect the R, G and B outputs from VU003 to R, G and B inputs of the Cadet RGB encoder.

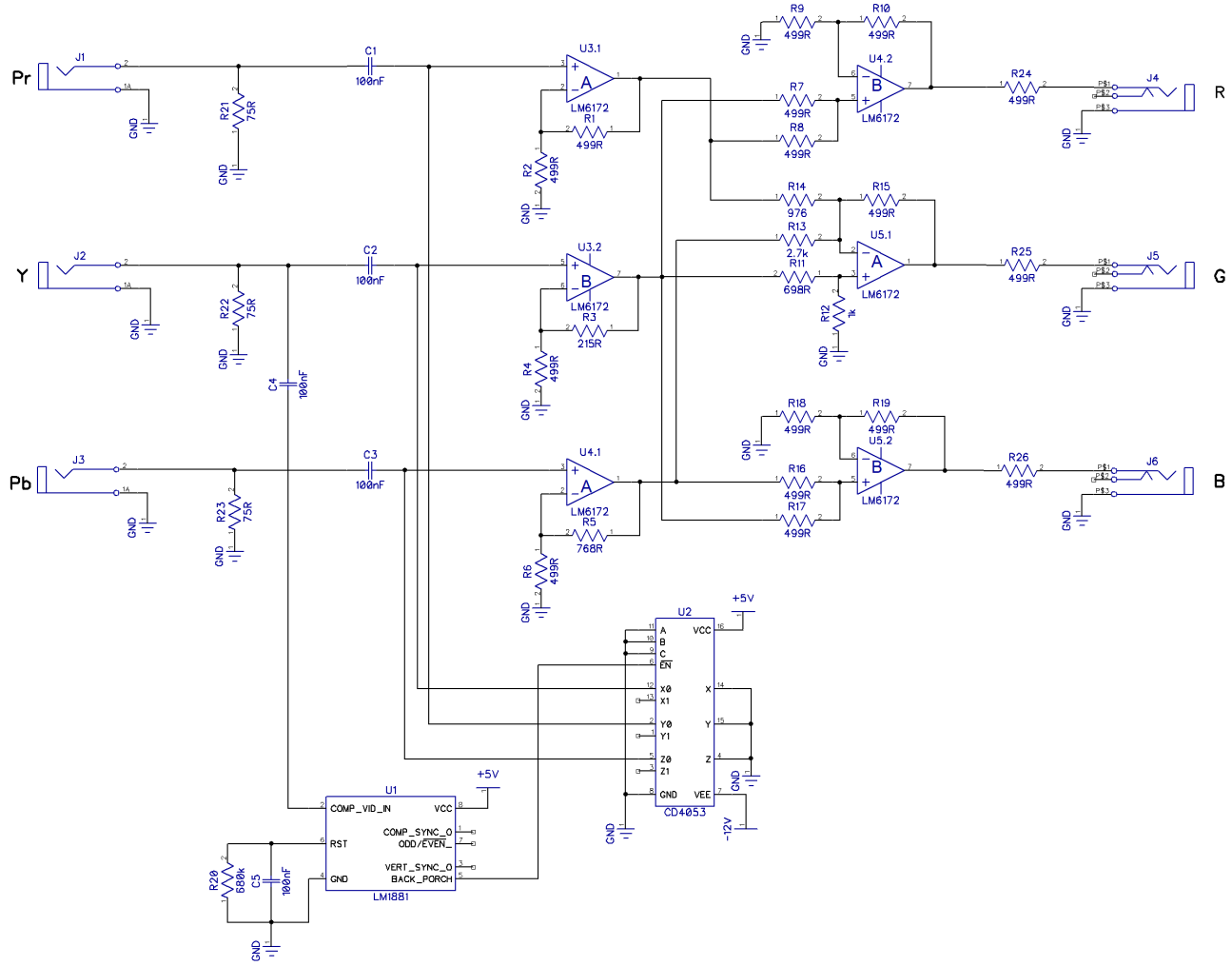
You can now push the controlboard and mainboard fully, if the boards are not perfectly parallel, you can bend the legs of the connector a bit so you can fit it completly.

If the connectors between the mainboard and powerboard feel a little loose, bending both the legs and box headers a bit outward of the boards will help.



This is how the boards looks like when assembled together.

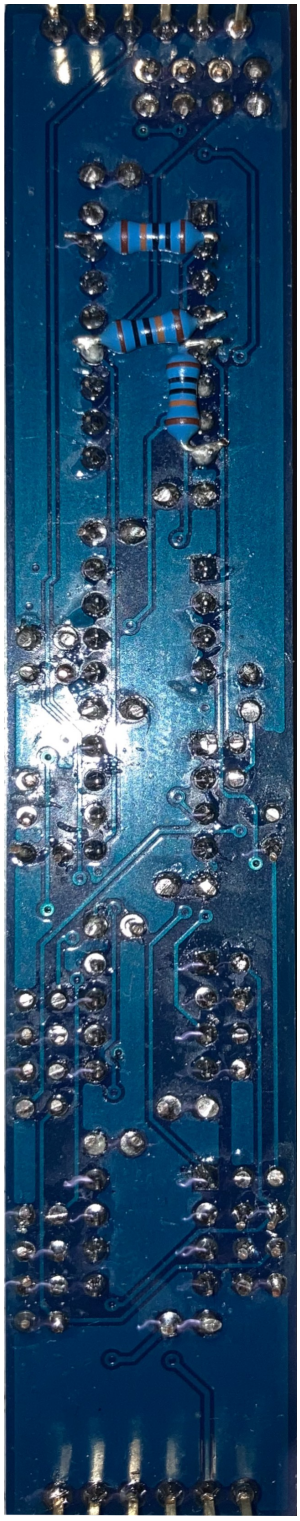
About the circuit :



R21, R22 and R23 are 75ohm input termination resistor, as per component video standard.
U1 and associated components extract the sync from Y.
C1 to C4 AC couples the signals at the inputs, so they removes DC offsets if any.
U2 is used for black level clamping : during backporch coming from U1, the 3 inputs will be pulled to ground.
U3.1 is a non-inverting amplifier with a gain of 2, convert Pr to R-Y.
U3.2 is a non-inverting amplifier with a gain of 1.43, scales 0.7V Y signal to 1V.
U4.1 is a non-inverting amplifier with a gain of 2.53, convert Pb to B-Y.
U4.2 is a non-inverting summer amplifier, Y and R-Y are added equally to produce Red.
U5.1 is a differential summer amplifier and performs *Y – 0.51(R-Y) – 0.186(B-Y)* to produce Green.
U5.2 is a non-inverting summer amplifier, Y and B-Y are added equally to produce Blue.
R24, R25, and R26 are 499ohm output termination resistors, as per LZX standard.

Modifications for Rev B/Rev C:

The circuit is missing 3x 100k resistor to ground just after C1/C2/C3, resulting in a DC offset being generated when no source is plugged in the YPbPr inputs, DC offset that is then replicated on the outputs.
Here is how the resistors can be placed :



It's not much of an issue when not placed as the DC offset at the output will go into a 100k resistor on the next module, though found about the issue with CBV002, and 8V into a 75R resistor make for a significative current over-consumption

Revisions log:

- **Rev B**: initial release
- **Rev C**: adds 11mm spacers
- **Rev D**: adds 3x 100k resistors to null DC offsets. (not released yet)

References :

- Linear Technology Application Note 57 – Video Circuit Collection - Color Matrix Conversion, Figure 19
https://www.analog.com/media/en/technical-documentation/application-notes/an57fa.pdf

- Video Demystified Fourth Edition – YCbCr Color Space, p.17
http://www.r-5.org/files/books/computers/algo-list/compression/Keith_Jack-Video_Demystified-EN.pdf

- labguysworld.com - YUV to RGB Color Matrix Project
http://www.labguysworld.com/YUV2RGB_Matrix.htm

- elm-chan.org - YUV2RGB
http://elm-chan.org/works/yuv2rgb/rw/yuv2rgb3.png

- LZX – Reference Designs
https://github.com/lzxindustries/lzxdocs/blob/master/Reference%20Designs/LZX%20Interface%20Examples%20RevA.pdf

- circuitjs simulation :
https://tinyurl.com/y4hxcgjx