Coaxial & Toslink Digital audio selector/splitter

Version 1.0

Dan - YO3GGX - yo3ggx@gmail.com

A few months ago I've brought a pair of MDR-DS6500 7.1 DD/DTS/PLIIx surround sound headphones from Sony (http://www.sony.ro/electronics/casti-cu-banda-de-fixare-pe-cap/mdr-ds6500). There is a Toslink (optical) input available for digital audio signals. I have several AV sources (6), some of them with RCA coaxial digital output, some of them with optical Toslink outputs. Searching for an appropriate digital audio selector I've found a few which only partially solve my problem and the price was too high for me (including shipping and taxes). One example is the Inday DA4X-R - http://www.inday.com/da4x/da4x.htm - but with only 4 audio-in channels.

Initially I've used the optical out from the TV to connect the headphones. Unfortunately most of the multichannel signals sent over HDMI to the TV were converted to PCM stereo, which was unacceptable for me.

At the end I've decided to build a digital audio selector myself, based on the following requirements:

- 4 coaxial digtal audio inputs;
- 4 optic digtal audio inputs;
- Two simultaneous optical digital audio outputs;
- Select the input using a push button;
- Display currently selected input using a 7-segments LED display;
- Powered from an USB port;
- Auto standby (when no signal at any input).

Based on my personal preferences, I took a few design decisions:

- Use mainly SMD components (1206 size);
- The PCB to be smaller than 100mmx80mm in order to be able to use the free version of Eagle Layout editor for design;
- Compact size (because of the 10 digital connections and the available ABS cases dimensions the final selector is not as small as expected)

Searching through the Internet, I've found some basic ideas about passing digital audio from coax to optic (see Bibliography).

With a small investment (less than $45) and some components which can be easily found in your junk box you can build your own digital audio selector/splitter. At the end, the device will look like in the following picture.

The components

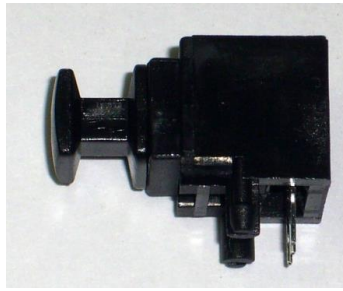First let's see where we can find the main components at a low price.

1. **RECEPT, COMBO, PHONO, TOSLINK, RX** (~ $6/pcs) at:
   http://ro.farnell.com/cliff-electronic-components/fc684206t/recept-combo-phono-toslink-tx/dp/2213314

2. **Transmitter EVERLIGHT PLT131** (~ $2.5/pcs.) at:
   http://www.ebay.co.uk/itm/261134092737

3. **ELS-816SURWA/S530-A3 EVERLIGHT 7 SEG NUMERIC DISPLAY, HYPER RED, 20.4 mm** (~ $1) at:
   http://www.conexelectronic.ro/produs.php?id=137641

4. **74ACT00SC, 74ACT CMOS, SMD, 4xNAND, SOIC14** (~ 0.5/pcs.) at:
   http://ro.farnell.com/jsp/search/productdetail.jsp?CMP=i-ddd7-00001003&sku=1014144

5. **CD4029BM - LOGIC, PRESET UP/DWN COUNTER, 16SOIC** (~ 0.8/pcs.) at:
   http://ro.farnell.com/texas-instruments/cd4029bm/logic-preset-up-dwn-counter-16soic/dp/1739742

6. **CD4028BM - LOGIC, DECODER CMOS BCD-DEC, 16SOIC** (~ $0.8/pcs.) at:
   http://ro.farnell.com/texas-instruments/cd4028bm/logic-decoder-cmos-bcd-dec-16soic/dp/1753401

7. **CD74HCT30M - LOGIC, 8-IN NAND GATE HS, 14SOIC** (~ $0.2/pcs.) at:
   http://ro.farnell.com/jsp/search/productdetail.jsp?CMP=i-ddd7-00001003&sku=1739958

8. **CD4543BMT - LOGIC, DECOD/DRIVER, 16SO** (~ $0.5/pcs.) at:
   http://www.conexelectronic.ro/produs.php?id=45972

9. **2N7002 - MOSFET, N, SOT-23** (~ $0.15/pcs.) at:
   http://export.farnell.com/fairchild-semiconductor/2n7002/mosfet-n-sot-23/dp/9845313

10. **Push-buton monostabil, galben,PCB, KS01-BV** (3 x 2.1 RON) la:
    http://www.adelaida.ro/product_info.php?products_id=8562 – galben
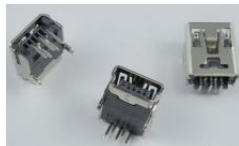   http://www.adelaida.ro/product_info.php?products_id=8560 – roșu

11. **BAV70 DIODE,SMALL SIG., 200MA, 75V, SOT-23** (~ $0.1/pcs.) at:
    http://ro.farnell.com/multicomp/bav70/diode-small-sig-200ma-75v-sot-23/dp/1621836

12. **Mini USB Female 5Pin PCB Socket Connector** (< $0.1/pcs.) at:
    http://www.ebay.co.uk/itm/180599038309

13. **10uf - 16v Tantalum SMD NRC106K16R** (~ $0.1) at:
    http://www.ebay.co.uk/itm/10uf-16v-Tantalum-SMD-NRC106K16R-Pack-10pcs-
    /300348384625?pt=UK_BOI_Electrical_Components_Supplies_ET&hash=item45ee28a571#ht_500wt_1054

14. **Plastic case 90x68x110mm Z-3A/B** (~ $3) at:
http://www.adelaida.ro/cutie-plastic-90x68x110mm-z-3a-b.html

The selector is composed from 3 main modules, interconnected using standard pin headers (2.54mm spaced):

1. Main module, containing Input logic, counter and BCD decoder
2. Display module, containing the 7 segments and BCD/7 segments decoder
3. Power and output module, containing optical outputs and USB power input.

Main Module

The schematic
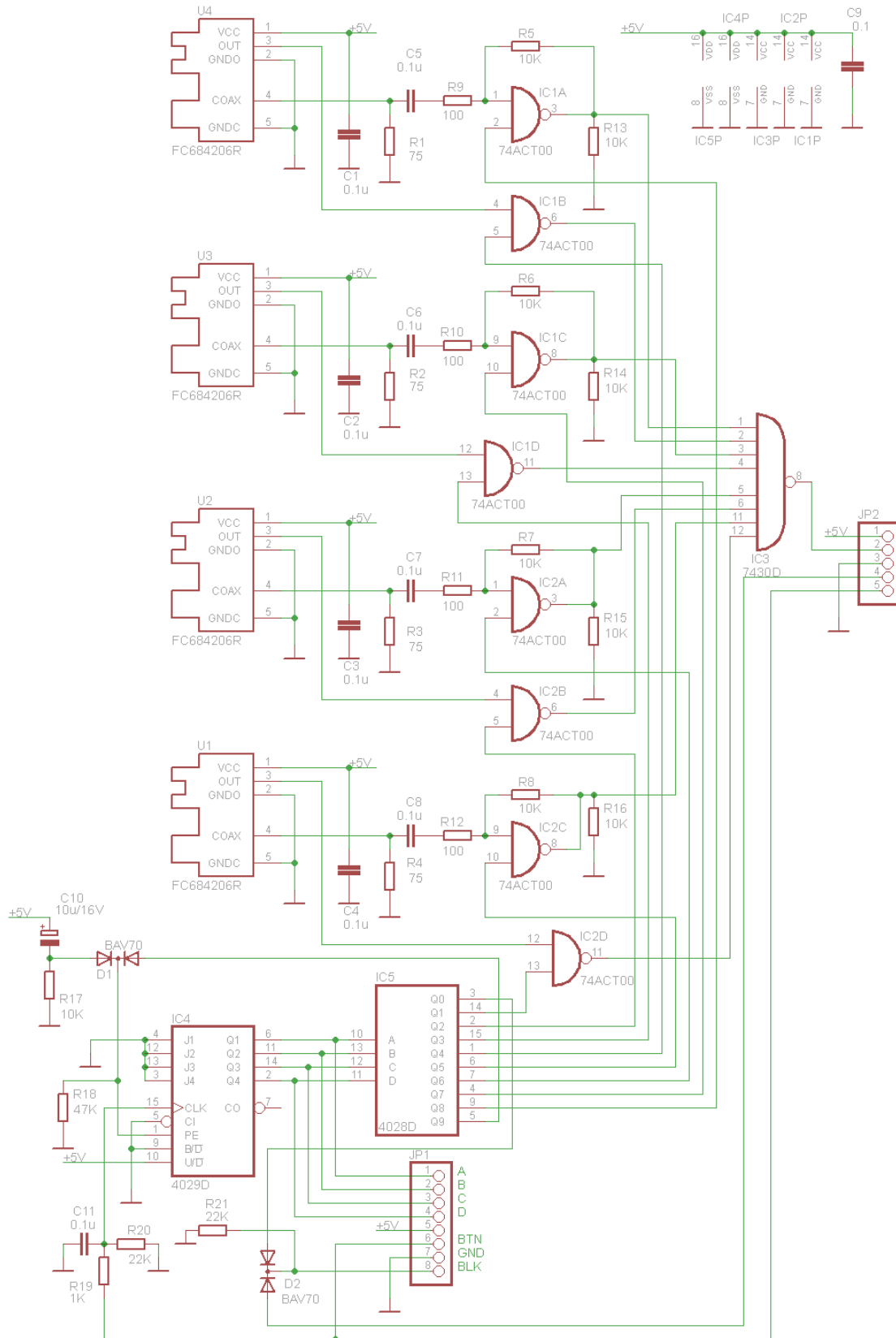
The schematic is composed from several main blocks:

- Digital audio combo receivers. This modules convert the optical or coaxial signals to pure digital signals (0-5V). A NAND gate (IC1A), together with R9, R5 and R13 act a Trigger Smith circuit used to convert each coaxial signal to the correct CMOS levels. A similar circuit is used for each coaxial input. The second input of the NAND gate is used to select only one of the inputs at one moment in time. When the input is not selected, the output of the NAND gate is at level '1'. All the 8 outputs are summed up in a 8-input NAND gate.
- The counter. This is built around a IC4 (CD4029) binary/decimal counter used in decimal mode. The clock is generated by the selector switch, filtered through C11, R20 and R19 for possible noise. The counter is used in UP mode.
- The binary/decimal decoder. This is built around IC5 (CD4028). Outputs 1-8 are used to select the corresponding input. Output 0 is used to blank the display (keep only the left dot) and output 9 is used to reset the counter (as we have only 8 digital audio inputs to select from). 0 means no input selected. The double diode (d2) act as an OR circuit, blanking the display when output 0 is selected or Auto Standby is activated.
- Auto reset at power up. R17 and C10 are used to reset the counter at circuit power up (always start with output 0 selected).
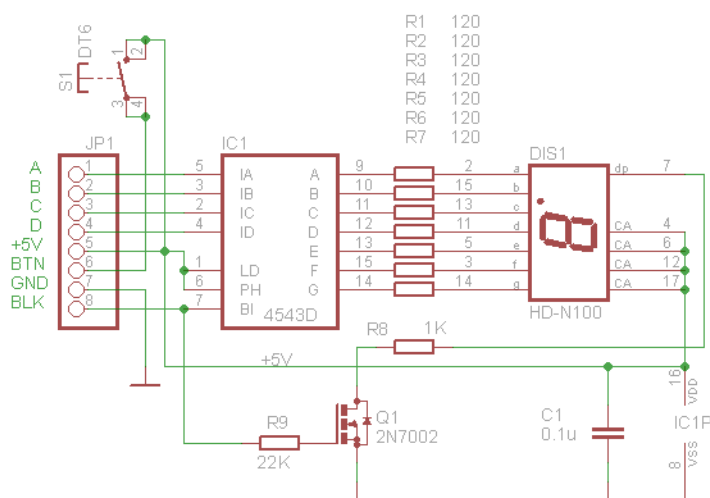
The list of parts (BOM):

Part	Value	Device	Package	Description
C1	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C2	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C3	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C4	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C5	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C6	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C7	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C8	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C9	0.1	C-EUC1206	C1206	CAPACITOR, European symbol
C10	10u/16V	CPOL-EUC/6032-28R	C/6032-28R	POLARIZED CAPACITOR, European symbol
C11	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
D1	BAV70	BAV70	SOT23	DIODE
D2	BAV70	BAV70	SOT23	DIODE
IC1	74ACT00	74AC00D	SO14	Quad 2-input NAND gate
IC2	74ACT00	74AC00D	SO14	Quad 2-input NAND gate
IC3	7430D	7430D	SO14	8-input NAND gate
IC4	4029D	4029D	SO16	Binary/decimal up/down COUNTER
IC5	4028D	4028D	SO16	BCD to decimal DECODER
JP1		PINHD-1X8	1X08	PIN HEADER
JP2		PINHD-1X5	1X05	PIN HEADER
R1	75	R-EU_R1206	R1206	RESISTOR, European symbol
R2	75	R-EU_R1206	R1206	RESISTOR, European symbol
R3	75	R-EU_R1206	R1206	RESISTOR, European symbol
R4	75	R-EU_R1206	R1206	RESISTOR, European symbol
R5	10K	R-EU_R1206	R1206	RESISTOR, European symbol
R6	10K	R-EU_R1206	R1206	RESISTOR, European symbol
R7	10K	R-EU_R1206	R1206	RESISTOR, European symbol
R8	10K	R-EU_R1206	R1206	RESISTOR, European symbol
R9	100	R-EU_R1206	R1206	RESISTOR, European symbol
R10	100	R-EU_R1206	R1206	RESISTOR, European symbol
R11	100	R-EU_R1206	R1206	RESISTOR, European symbol

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R12   100        R-EU_R1206       R1206      RESISTOR, European symbol
R13   10K        R-EU_R1206       R1206      RESISTOR, European symbol
R14   10K        R-EU_R1206       R1206      RESISTOR, European symbol
R15   10K        R-EU_R1206       R1206      RESISTOR, European symbol
R16   10K        R-EU_R1206       R1206      RESISTOR, European symbol
R17   10K        R-EU_R1206       R1206      RESISTOR, European symbol
R18   47K        R-EU_R1206       R1206      RESISTOR, European symbol
R19   1K         R-EU_R1206       R1206      RESISTOR, European symbol
R20   22K        R-EU_R1206       R1206      RESISTOR, European symbol
R21   22K        R-EU_R1206       R1206      RESISTOR, European symbol
U1    FC684206R FC684206R         CLIFF
U2    FC684206R FC684206R         CLIFF
U3    FC684206R FC684206R         CLIFF
U4    FC684206R FC684206R         CLIFF
```

Display Module

The schematic:

The schematic is composed from several main blocks:

- Binary/decimal decoder. Is built around IC1 (CD4543). This is used in LED mode, with common anode display. R1-R8 limit the current through the display and further protects the IC.
- Left dot driver. Q1 is used to light the left dot in the display when this is blank (0 output selected).
- Input selector switch – S1 (push switch).

The list of parts (BOM) for the module 2:

```
Part Value     Device       Package        Description

C1   0.1u      C-EUC1206     C1206         CAPACITOR, European symbol
DIS1 HD-N100 HD-N100         HDSP-Q        LED DISPLAY
IC1  4543D     4543D         SO16          BCD to 7-segment LCD DECODER
JP1            PINHD-1X8     1X08          PIN HEADER
Q1   2N7002    2N7002        SOT23         N-MOSFET 400mA  'S72'
R1   120       R-EU_R1206    R1206         RESISTOR, European symbol
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R2    120      R-EU_R1206      R1206          RESISTOR, European symbol
R3    120      R-EU_R1206      R1206          RESISTOR, European symbol
R4    120      R-EU_R1206      R1206          RESISTOR, European symbol
R5    120      R-EU_R1206      R1206          RESISTOR, European symbol
R6    120      R-EU_R1206      R1206          RESISTOR, European symbol
R7    120      R-EU_R1206      R1206          RESISTOR, European symbol
R8    1K       R-EU_R1206      R1206          RESISTOR, European symbol
R9    22K      R-EU_R1206      R1206          RESISTOR, European symbol
S1    DT6      DT6             DT6            ITT SWITCH
```

Output and power Module

The schematic:
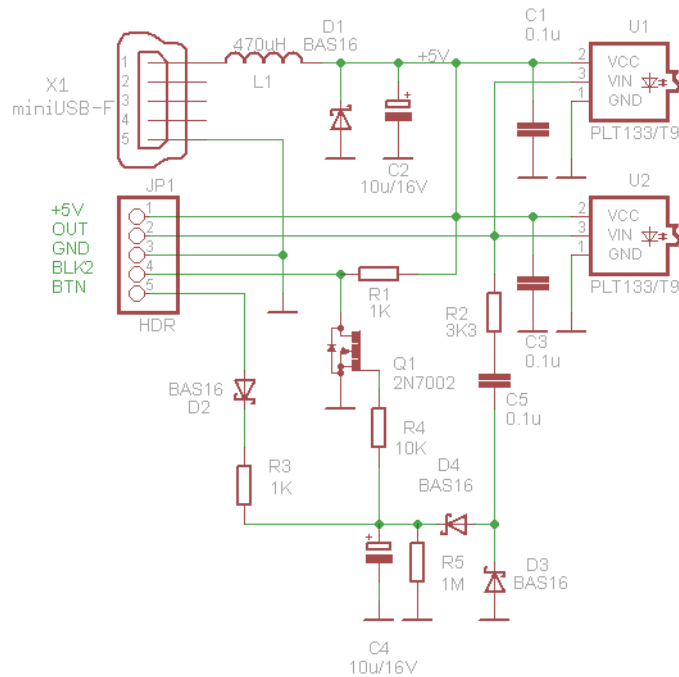
The schematic is composed from several main blocks:

- USB power input circuit. L1 and C2 are used to filter the noise over the power line. D1 is used to protect against power reversing. This is not normally possible as the connector does not allow this, but anyway.
- Digital signal detector. R2 and C3 are used to lower the load over the output circuit during the C4 charging time. D3 and D4 act as a rectifier for the digital signal and to charge the C4 capacitor. When no signal at the output, R5 is used to discharge C4. When a high level on C4 (caused by digital signal at the output or a press on the input selector button through D2 and R3), Q1 is used to reset the counter to 0 and to blank the display (only the left dot will light) in order to conserve power;
- Digital audio optical converters (U1 and U2).

The list of parts (BOM) for the module 3:

| Part	Value	Device	Package	Description
MF MPN OC_FARNELL OC_NEWARK				
C1	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C2	10u/16V	CPOL-EUC/6032-28R	C/6032-28R	POLARIZED CAPACITOR, European symbol
C3	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
C4	10u/16V	CPOL-EUC/6032-28R	C/6032-28R	POLARIZED CAPACITOR, European symbol
C5	0.1u	C-EUC1206	C1206	CAPACITOR, European symbol
D1	BAS16	BAS40	SOT23	Silicon Schottky Diodes
D2	BAS16	BAS40	SOT23	Silicon Schottky Diodes
D3	BAS16	BAS40	SOT23	Silicon Schottky Diodes
D4	BAS16	BAS40	SOT23	Silicon Schottky Diodes
JP1	HDR	PINHD-1X5	1X05	PIN HEADER
L1	470uH	L-USL1812	L1812	INDUCTOR, American symbol
Q1	2N7002	2N7002	SOT23	N-MOSFET 400mA 'S72'
R1	1K	R-EU_R1206	R1206	RESISTOR, European symbol
R2	3K3	R-EU_R1206	R1206	RESISTOR, European symbol
R3	1K	R-EU_R1206	R1206	RESISTOR, European symbol
R4	10K	R-EU_R1206	R1206	RESISTOR, European symbol
R5	1M	R-EU_R1206	R1206	RESISTOR, European symbol
U1	PLT133/T9	PLT133/T9	PLT133/T9	Photolink- FOptic Transmitter
U2	PLT133/T9	PLT133/T9	PLT133/T9	Photolink- FOptic Transmitter
X1	miniUSB-F	MINI-USB_SHIELD5P2-32005-601	32005-601	MINI USB-B R/A DIP 5pol.

How to build
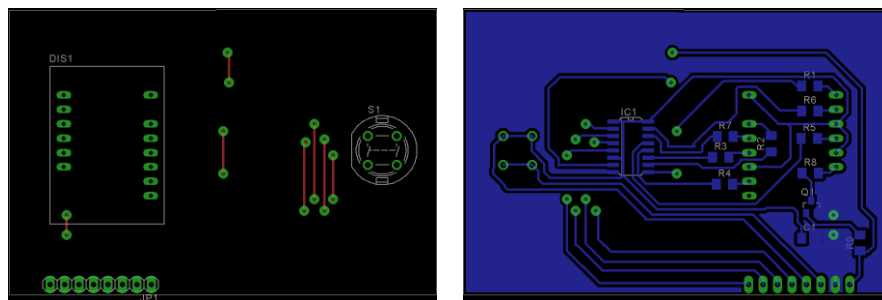
Create the 3 PCBs using the preferred method

NOTE: The Eagle files are available on request. Just send me an e-mail.

Both sides of the PCBs are presented in the following pictures (bottom side is in blue and mirrored).
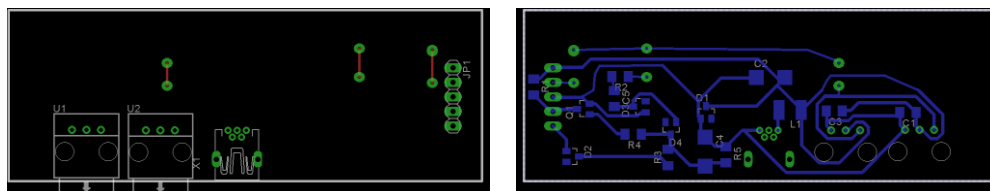
Module 1:
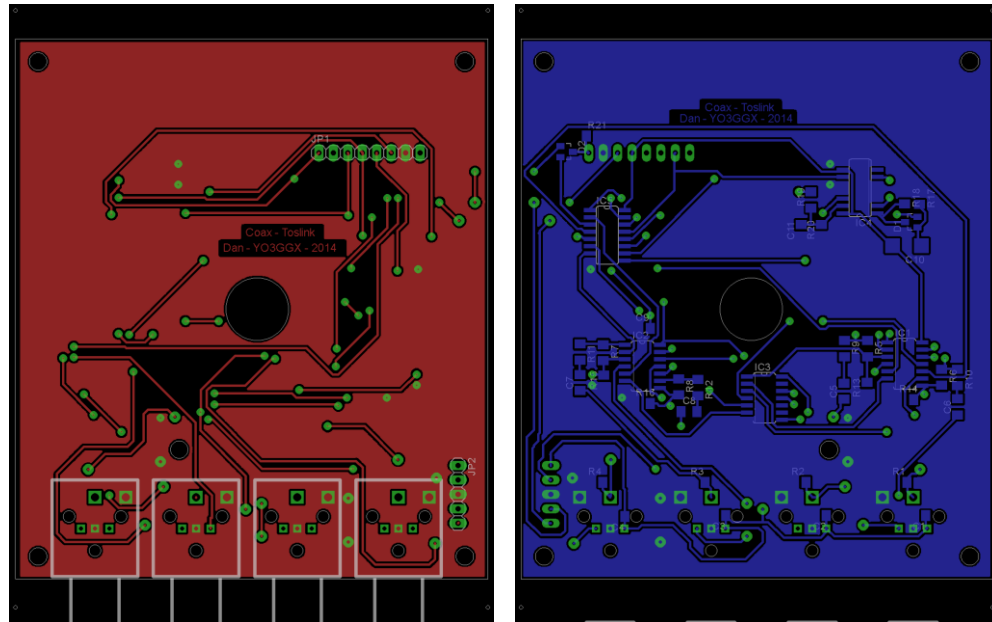
Module 2:

Module 3:

All the SMD components are placed on the bottom side (blue one).
You can use the proffered method to make the PCB. I've used the toner transfer method, using a laser printer, glossy photo paper and a GBC Docuseal 40 mini laminator.
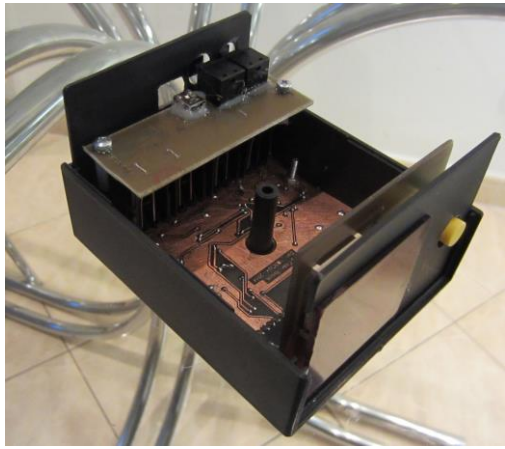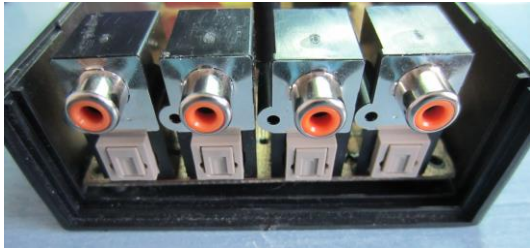Module 2 and 3 are using single side PCBs and straps on the top side.
This is how my PCBs looks like (both sides, without components).
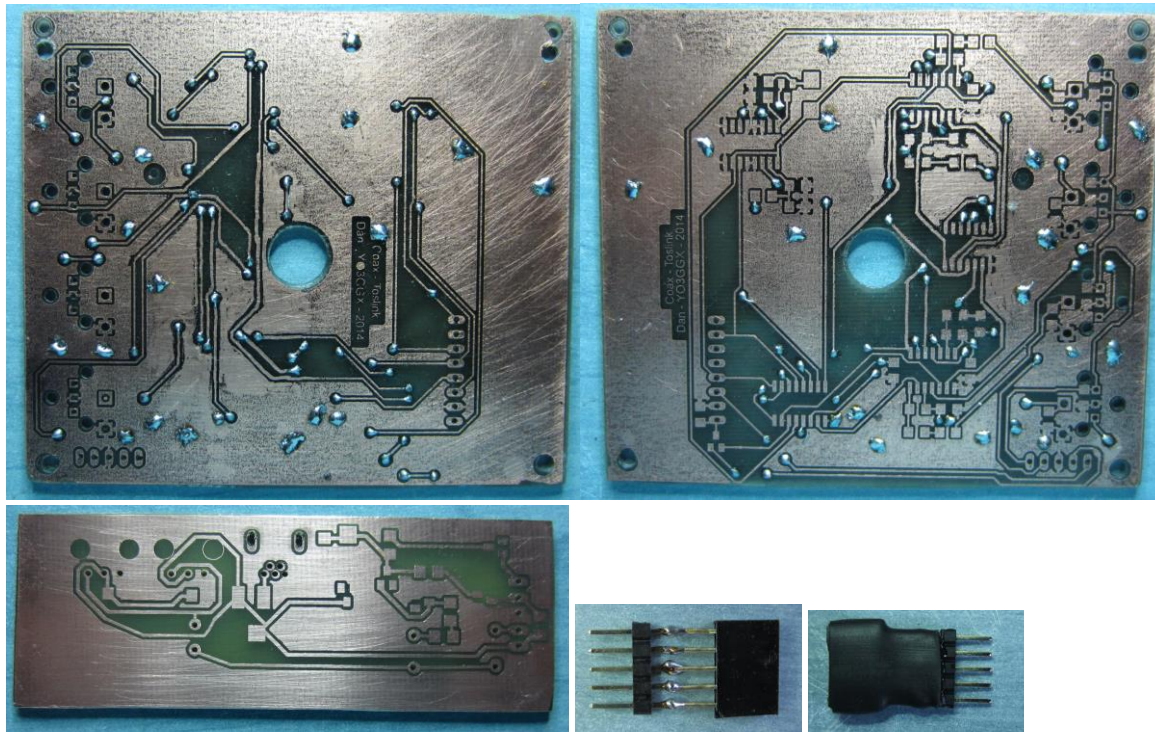
All the vias are manually connected on both sides using small pieces of wire.

Now some pictures all the components were placed and then PCBs mounted in the case.
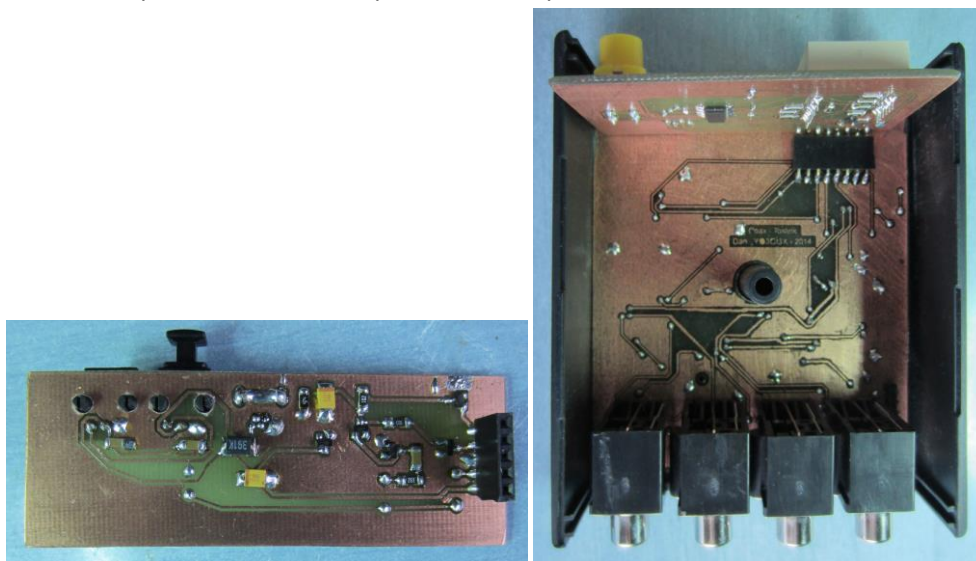
Bibliography

Craig's digital audio page	http://xse.com/leres/circuits/digitalaudio/
FC684206T datasheet	http://www.farnell.com/cad/1708371.pdf
ELS-816SURWA/S530-A3 datasheet	http://www.datasheets360.com/pdf/-7861650433073694165
74HCT30M datasheet	http://www.farnell.com/datasheets/1762693.pdf
74ACT00D datasheet	http://www.ti.com/lit/ds/symlink/sn74act00.pdf
CD4029BM datasheet	http://www.farnell.com/datasheets/1771253.pdf
CD4028BM datasheet	http://www.farnell.com/datasheets/1722660.pdf
CD4543 datasheet	http://www.farnell.com/datasheets/1762808.pdf
BAV70 datasheet	http://www.farnell.com/datasheets/1662687.pdf

Document History

Initial version of the document (v1.0).

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