Assembling the RPi-DAC (rev. 4)

For the parts - please see the list (BOM)

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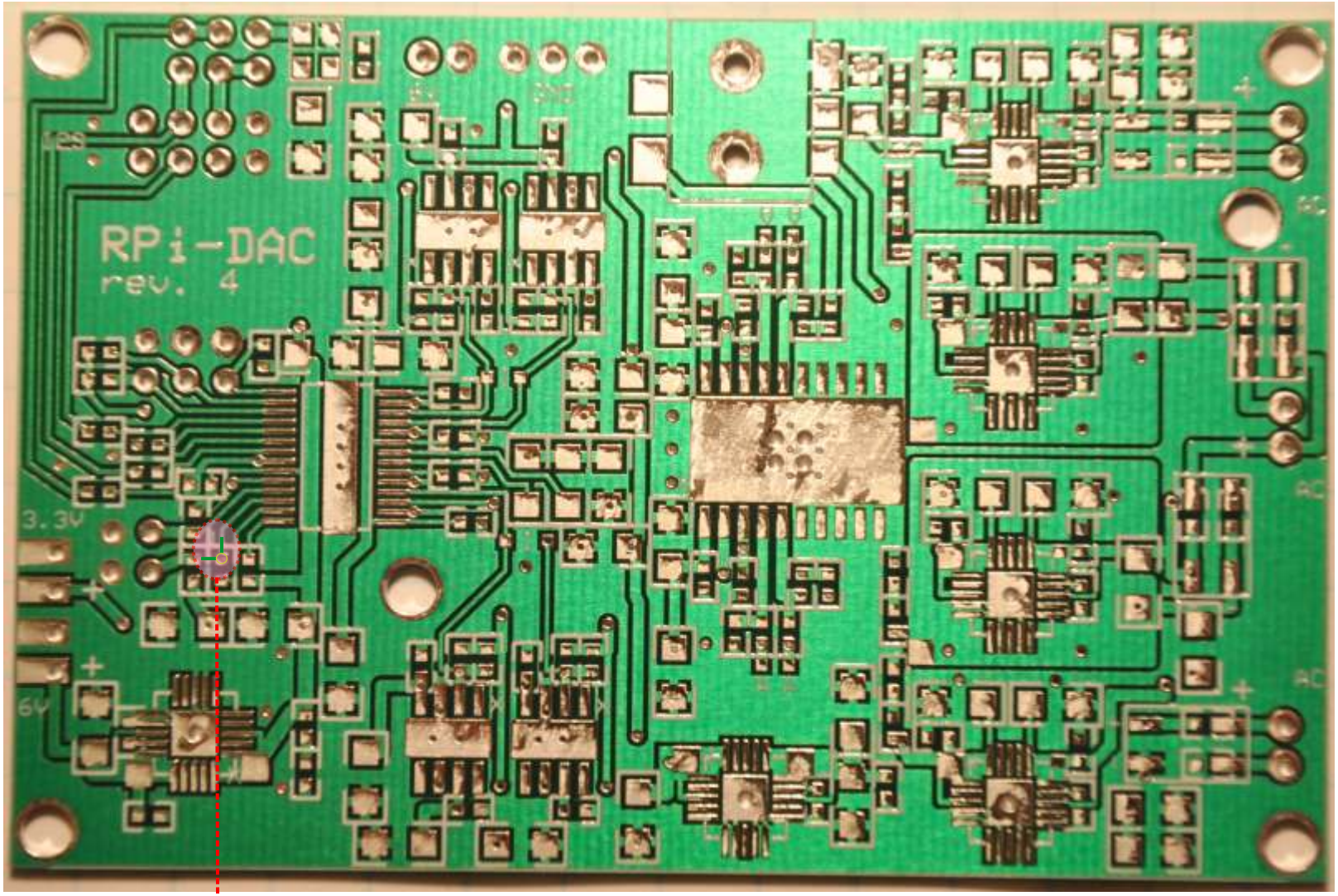
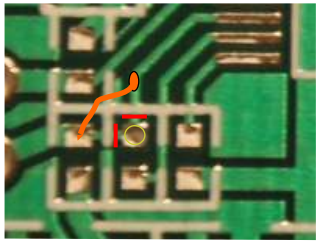
PCB Fix - before soldering parts





wire fix

cut traces

RPi-DAC

(rev. 4)

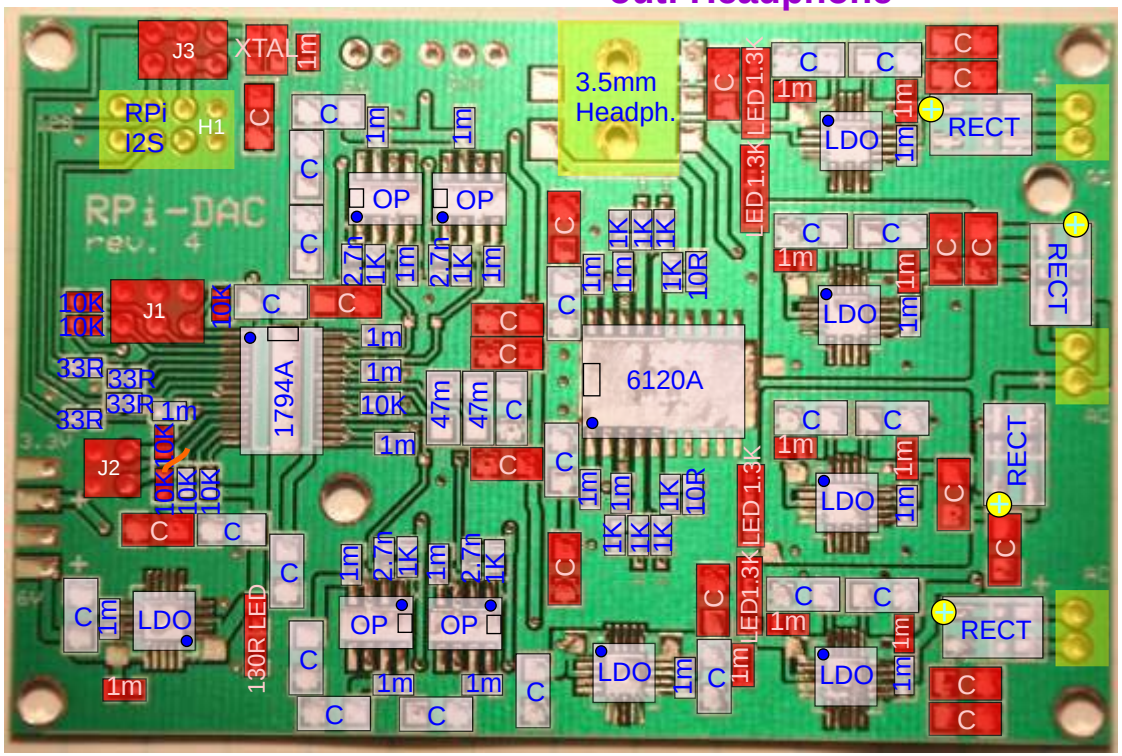
option 1:
AC input,
not using SPS

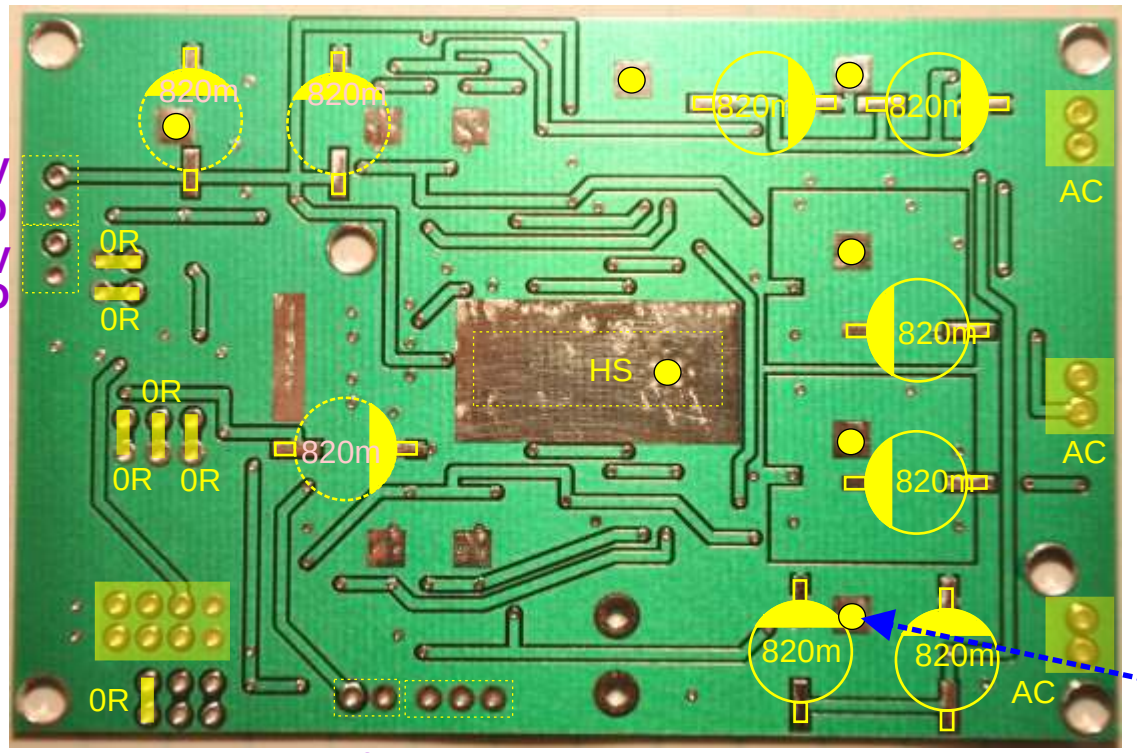
Top

option 3:
not J1, J2
use 0R

Bottom

out: Headphone





out: 6V
GND
out: 3.3V
GND

out: 6V GND

C	optional, not soldered
C	mandatory 22- 47m(24x)
OP	(optional) 22- 47m(17x)
LDO	LME49990 (4x)
RECT	TPS7A4700 (6x)
1794A	60V/2A Bridge (4x)
6120A	PCM1794A (1x)
47m	TPA6120A (1x)
1m	(2x)
1m	mandatory (23x)
2.7n	(optional: RF blocking, 11x)
1K	(with 4x 1K)
10K	(8x)
1K	(3x, 5x optional with 0R jumper)
33R	(4x, with 2.7n)
10R	(4x)
0R	(2x)
820m	(6x, or Header with Jumpers, J1..J3)
LED	(6x, backside, 3x optional)
	(optional) yellow/green (2.0V) (5x) plus R (10 mA)
H	(3x 2x1. 3x opt., 1x 3x1 optional)
H1	(female, 2x4 or I2S RPi)

IN: >6V AC / 8V DC

mount AC connectors on bottom side of PCB, if stacked with RPi or if using SPS

IN: >12V AC / 17V DC

use transformer with separate coils, no center tap for the + / - 15V

IN: >12V AC / 17V DC

solder PowerPad after LDOs mounted and checked

out: 6V GND

RPi-DAC

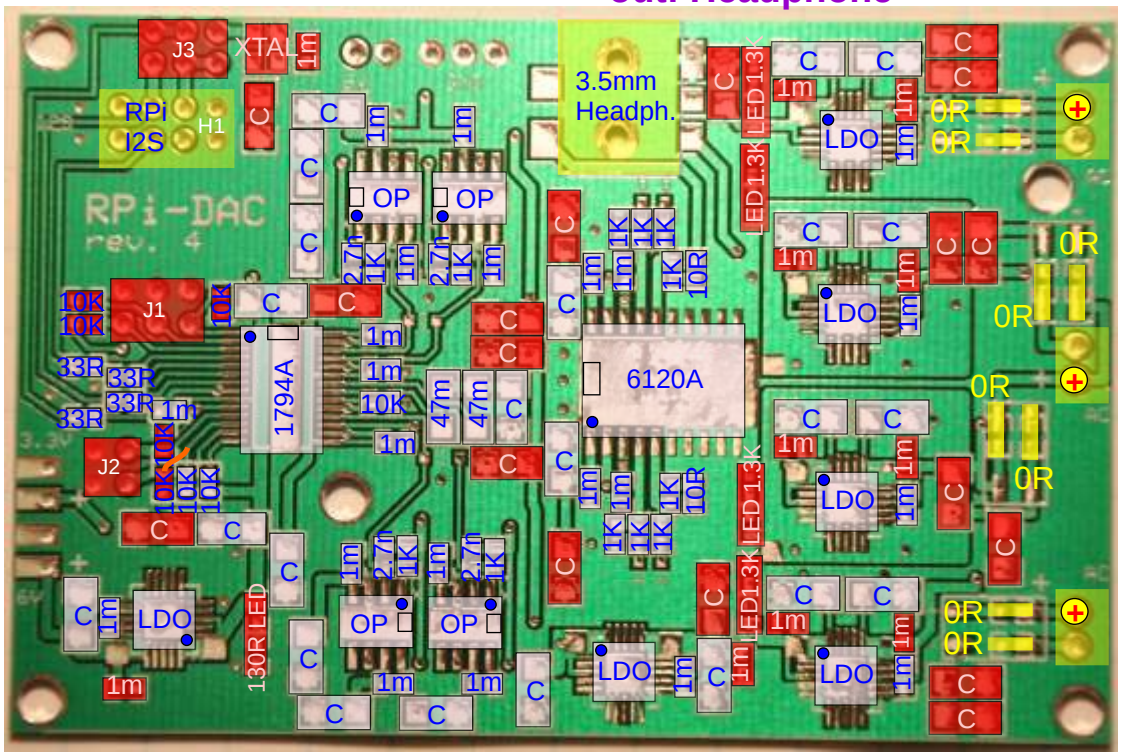
(rev. 4)

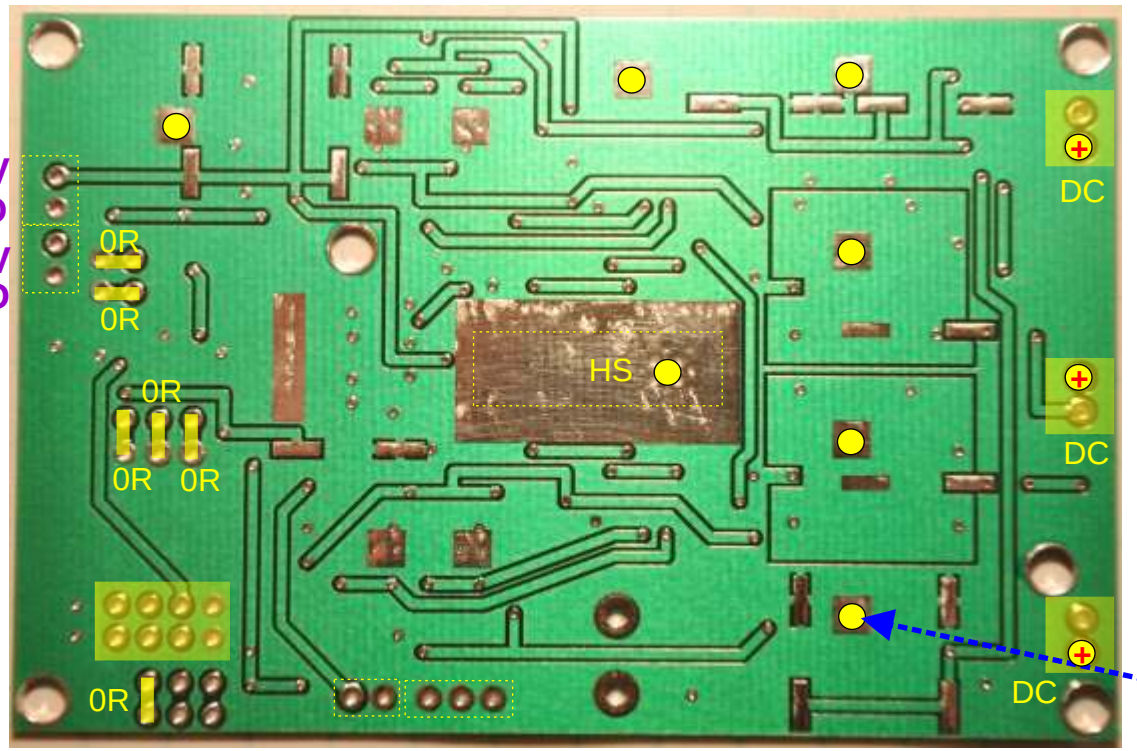
option 2:
DC input,
with SPS

Top

option 3:
not J1, J2
use 0R

out: Headphone





out: 6V
GND
out: 3.3V
GND

Bottom

out: 6V GND

C	optional, not soldered
C	mandatory 22- 47m(24x)
OP	(optional) 22- 47m(17x)
LDO	LME49990 (4x)
0R	TPS7A4700 (6x)
1794A	(8x, no RECT)
6120A	PCM1794A (1x)
47m	TPA6120A (1x)
1m	(2x)
1m	mandatory (23x)
2.7n	(optional: RF blocking, 11x)
1K	(with 4x 1K)
10K	(8x)
1K	(3x, 5x optional with 0R jumper)
33R	(4x, with 2.7n)
10R	(4x)
0R	(2x)
	(6x, or Header with Jumpers, J1..J3)
LED	(optional) yellow/green (2.0V) (5x) plus R (10 mA)
H	(3x 2x1. 3x opt., 1x 3x1 optional)
H1	(female, 2x4 or I2S RPi)

IN: 7V DC

mount AC connectors on bottom side of PCB, if stacked with RPi or if using SPS

IN: 16V DC

do not have common GND for the + / - 15V

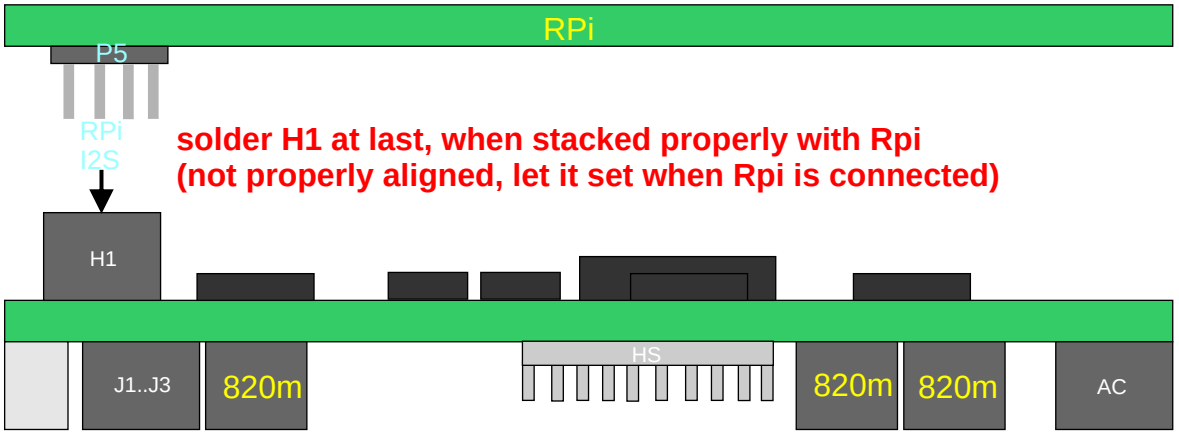
IN: 16V DC

solder PowerPad after LDOs mounted and checked

Order to solder the parts

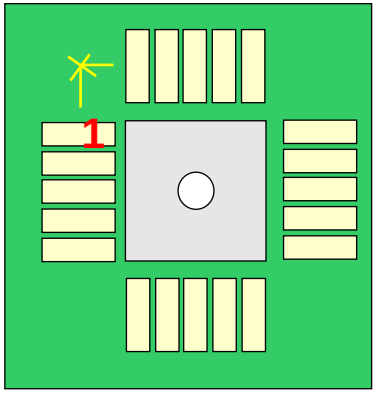
1. Solder the **LDOs with the related Caps and Rectifier first** (details about LDO soldering see next page)
2. After soldering LDOs - check the LDOs. Do it for every LDO independently after one soldered:
   apply AC or DC on AC connector (use a laboratory supply with current limiter)
   measure output voltage (pin 1 and 20)
   check if LDO regulates (keeps voltage quite constant on >15.6 V in, vary voltage on AC input)
   check if regulation is stable, not oscillating or changing voltage randomly (esp. not following Vin)
3. If all LDOs are working properly, all board internal voltages 3.3V, 5V, +15V (2x) and -15V (2x) are correct
   then solder all remaining passive parts (C and R, headers, jumpers connectors except H1)
4. Check voltages again (maybe also current, should be in range of the LEDs, in range of >10 mA).
5. Solder the active ICs as the last parts. Before doing it, you could cross check if the supply voltages are correct on the related IC pins.
   Solder the H1 female header (2x4) after all is ready to be stacked with RPi (see below).
6. If you provide now AC - **never let one +15 or -15V rail unpowered !** It will kill the OPs or AMP.
   +15 and -15V have to be there always together. Be careful not to shorten one rail.
7. When measuring voltages on soldered chips, esp. the AMP - be careful not to shorten a -15V or +15V with a neighbor pin. It will kill the AMP.
8. Connect the 0R (or set jumpers) and measure the output voltage on headphone connector. It should not have a high voltage (not in V, just few mV). Otherwise an OP could be dead or a shortcut on analog traces.
9. Testing the board in operation needs an I2S source: if you have an *USB to I2S* solution (e.g. XMOS), an FPGA (with design to generate I2S signal) or Raspberry Pi with extended Rasbian kernel (I2S driver) then you should be able to listen to sound on headphone connector.
   The suggested 0R (or jumpers) are for 24bit I2S. The sample rate is recognized automatically by the DAC (48/96/192 Khz). The SCK signal is jumper-ed to be derived from BCK (for RPi).

Stack with RPi



mount AC connectors on bottom side of PCB, when stacked with RPi

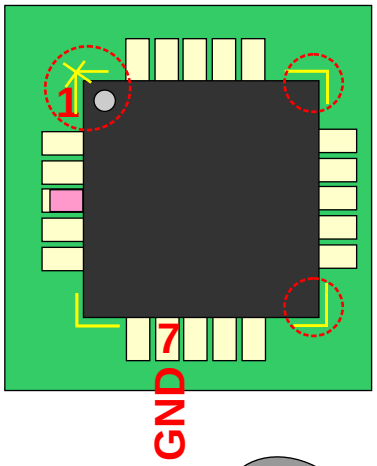
How to solder the LDOs (QFP)?



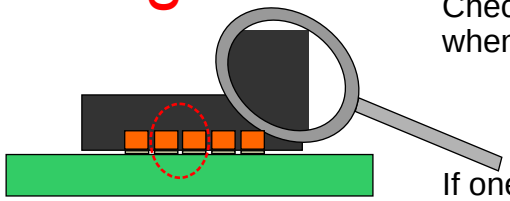
Soldering the LDOs is the most complicated task (QFP package, all connections under the package, also power pad). It is assume that soldering without head gun will be done.
Based on my experiences:

- use a magnifying glass, at best a microscope
- use SMD No-Clean Paste Flux (e.g. CHIPQUIK SMD291/10cc)
- keep the PCB clean, remove flux and dirt properly: I have seen LDO failing due to remaining flux. Use Isopropanol to “wash” the board

Put some solder on all pads, except the center power pad (quite same amount on all).



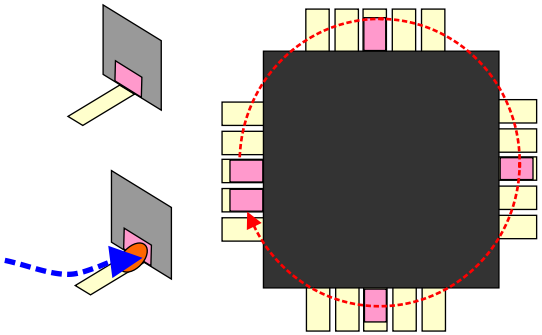
Check the pin 1 orientation (see drawing). Att: after “washing” hard to see the markers on package.
Provide the flux.
Place the LDO in approx. position.
Use magnifying glass or microscope to align the LDO. All four sides are important and the IC pads have to be above the PCB traces in a quite perfect position.
Solder just one pin. Provide solder so that it can flow a bit under the package or touch the small copper spot at the package side.



With just one pin soldered - check all pads on all sides under microscope. At best: turn the PCB a bit vertical in order to see the side of the package.
Check if the small copper pad on the side it almost exactly adjusted above the PCB. Check, when you would provide solder - could it shorten neighbor pins?

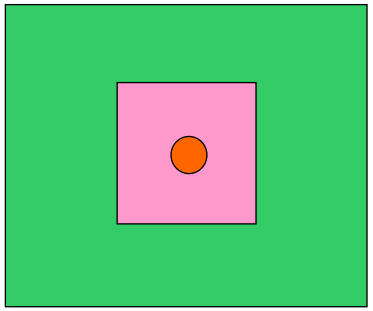
at all four sides

If one of the side is not properly aligned, use solder tool on soldered pin and move the package smoothly into right direction. The yellow markers can guide you but they might not be accurate enough to solder just after aligning package based on these.
The gap between package and the yellow silk screen masks should be quite the same on all corners.



If the LDO is properly aligned on all sides - solder all remaining pins. You should rotate, change to next side pin for pin in order to avoid thermal stress on the package.

Suggestion: use flux so that the solder can flow under the package. Always use the solder tool with movement towards the package, try to touch the small copper pad at the side and to connect the solder with it.
Check for shortcuts and flux/dirt between the pins.



Bottom

Power Pad

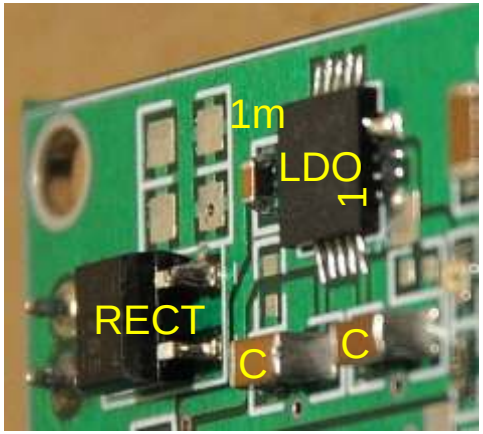
After all LDOs were soldered, checked and they work properly, you can (optional) solder the power pad. The power pad properly connected with the PCB is “just” for thermal reasons (e.g. if a high input voltage is provided on AC and a large heat dissipation due to large In-Out voltage difference, e.g. >1V).

You can provide solder from the backside of the PCB. Use a solder tool with a bit higher power (e.g 25W or 40W if you keep time short).

Provide enough solder so that it can flow in and through the hole.
The flux will evaporate and the solder in the hole might not be perfect.
Try several times until a nice result, the hole quite filled with solder. But avoid to overheat the PCB and IC, make breaks between trials.

Do not use too much solder, just to fill the hole. It could create shortcuts under the package which cannot be seen. There is no need to fill entire hole to the top (too much). Is the hole properly closed, even it looks like a valley, it should be fine.

Check the LDO again.



Check the LDOs

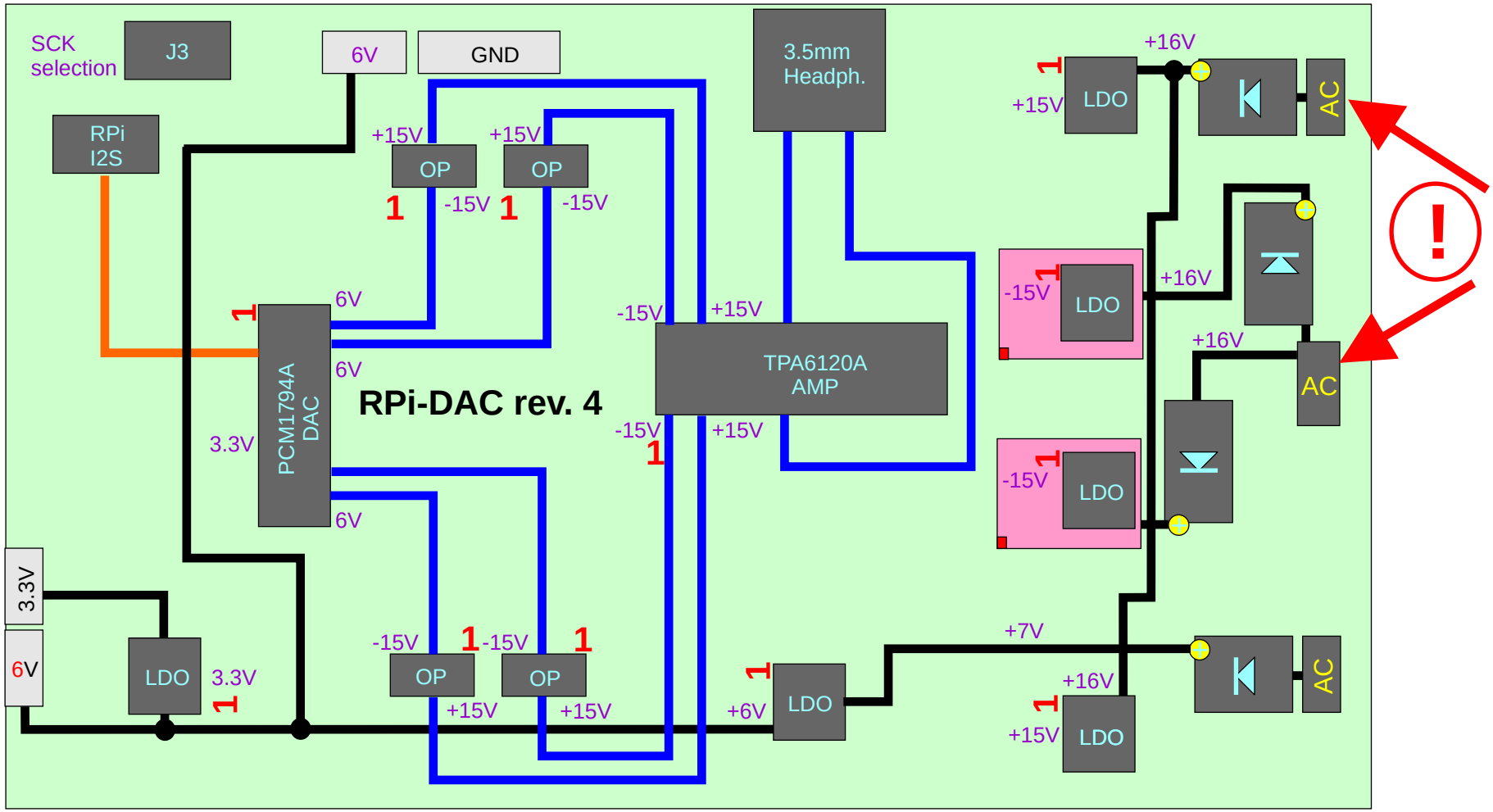
Best practice:
Measure the resistance on the pad traces against ground. It should be in the range of KOhms, except on those which are intended to be grounded.
Measure the resistance between neighbored pads: there should not be a shortcut (except: two pins are connected together for input, output or ground). Take it as a shortcut if you see a resistance in Ohm range, e.g, even ~100 Ohm.
Measure the resistance of the input traces (pad 15 + 16, 20 + 1) against ground. Especially the input resistance should be in Kohms.

When you power the LDOs, limit the current (~50 mA) and increase voltage smoothly from 0V until max. 20V. Check if the LDO limits the voltage at intended output voltage (+15V, -15V, +5V, +3.3V, with some acceptable tolerance, e.g. 14.7 .. 15.3V).
If the regulated output voltage is too slow then one of the voltage setting pads is grounded (shortcut). If it is too high or there is not a regulation with max. 20V input then voltage setting pins intended to be grounded are not connected properly. Try to resolder pads again.

Observe the output voltage if it is stable, esp. it is not following the input voltage (e.g, 20V resulting in 19V output, should stop at ~15V). The output voltage should not oscillate (jump). Often the 1mCap is not connected properly or some flux/dirt left between pads.

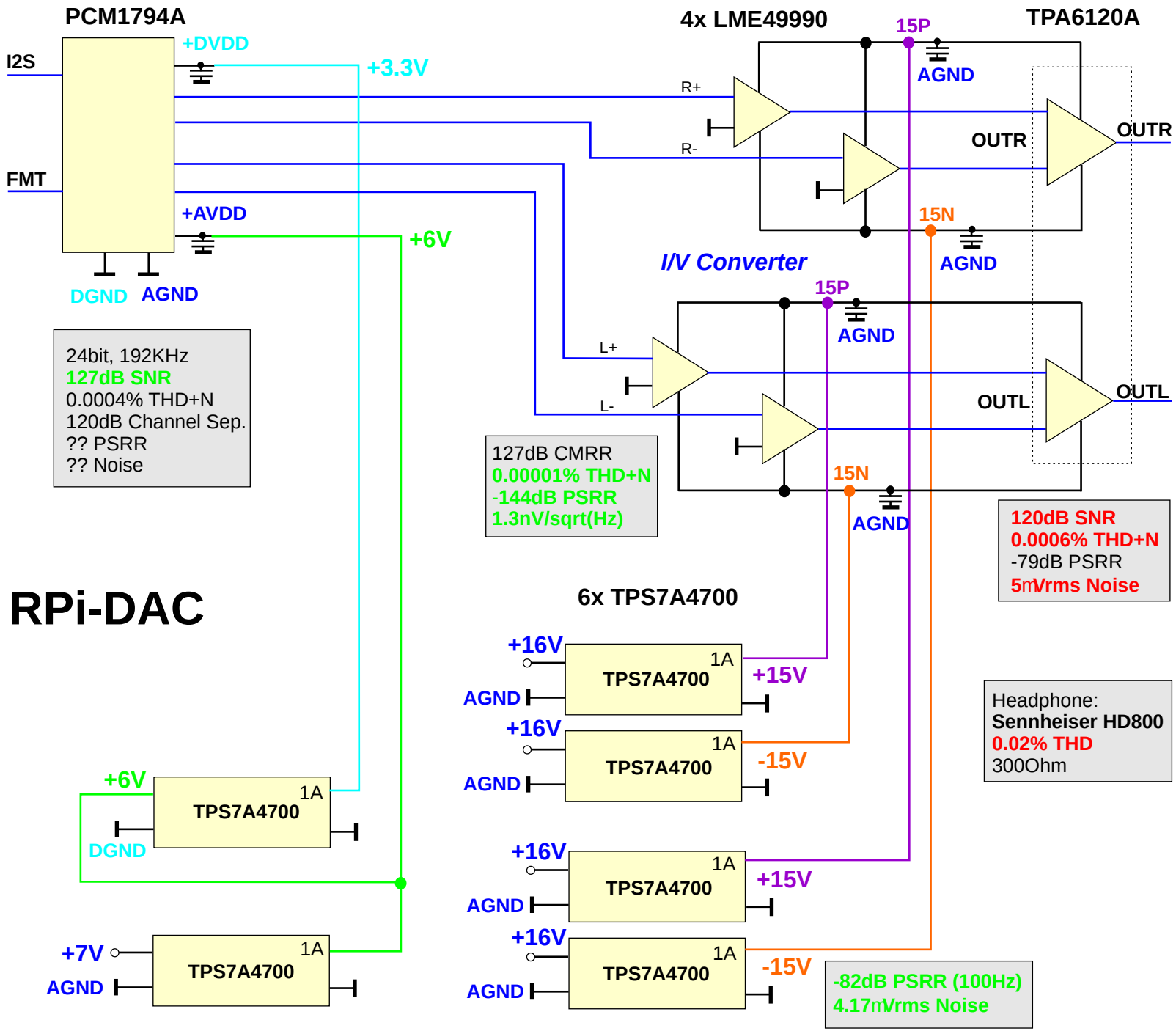
If something fails: try to resolder pads, check all again, remove flux and dirt. Check if all capacitors are connected properly, esp. the 1mand the 22mor 47mCaps at input and output. Watch out for weak solder spots or potential shortcuts. Check also the LDO package from the side with a microscope if there could be a short directly at the package corner, under the package.

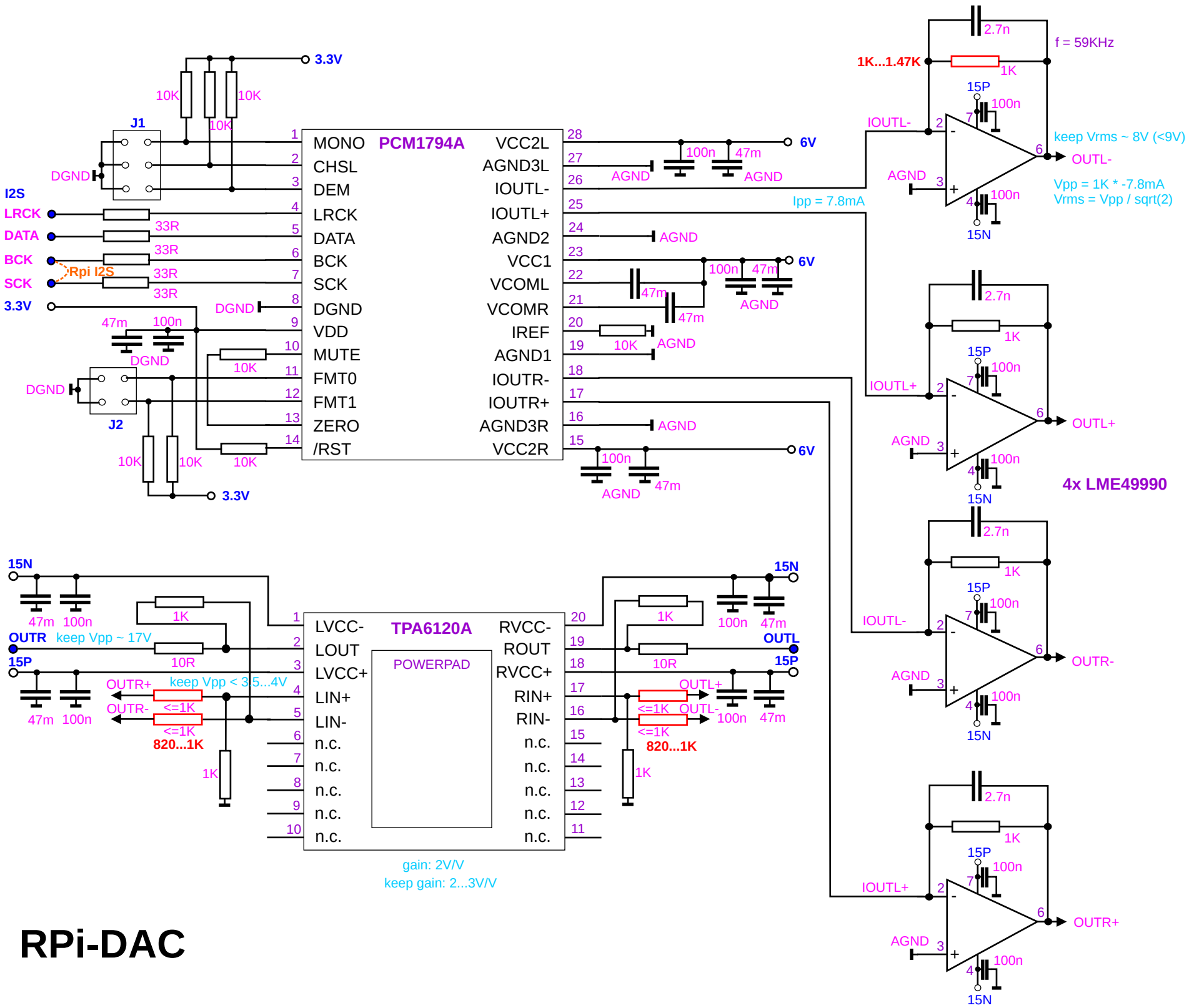
Block Diagram (PCB blocks)



After OPs and TPA6120 are soldered - always apply + and - 15V, never just one rail.
Use AC with separate coils (no center tap or DC without common GND).

For the schematics: please check out http://www.tjaekel.com/T-DAC/schematics.html


PCM1794A
I2S
FMT
+DVDD
+3.3V
+AVDD
+6V
DGND
AGND
24bit, 192KHz
127dB SNR
0.0004% THD+N
120dB Channel Sep.
?? PSRR
?? Noise
4x LME49990
TPA6120A
R+
R-
L+
L-
15P
15N
AGND
OUTR
OUTL
I/V Converter
127dB CMRR
0.00001% THD+N
-144dB PSRR
1.3nV/sqrt(Hz)
120dB SNR
0.0006% THD+N
-79dB PSRR
5mVrms Noise
RPi-DAC
6x TPS7A4700
+16V
+15V
-15V
+6V
+7V
1A
TPS7A4700
-82dB PSRR (100Hz)
4.17mVrms Noise
Headphone:
Sennheiser HD800
0.02% THD
300Ohm


PCM1794A
MONO
CHSL
DEM
LRCK
DATA
BCK
SCK
DGND
VDD
MUTE
FMT0
FMT1
ZERO
/RST
VCC2L
AGND3L
IOUTL-
IOUTL+
AGND2
VCC1
VCOML
VCOMR
IREF
AGND1
IOUTR-
IOUTR+
AGND3R
VCC2R
3.3V
6V
I2S
LRCK
DATA
BCK
SCK
Rpi I2S
J1
J2
33R
10K
47m
100n
2.7n
1K...1.47K
1K
15P
15N
f = 59KHz
keep Vrms ~ 8V (<9V)
OUTL-
Vpp = 1K * -7.8mA
Vrms = Vpp / sqrt(2)
Ipp = 7.8mA
OUTL+
OUTR-
OUTR+
4x LME49990
TPA6120A
POWERPAD
LVCC-
LOUT
LVCC+
LIN+
LIN-
n.c.
RVCC-
ROUT
RVCC+
RIN+
RIN-
OUTR
keep Vpp ~ 17V
OUTL
keep Vpp < 3.5...4V
<=1K
820...1K
gain: 2V/V
keep gain: 2...3V/V

RPi-DAC

Pictures