linear gain PIC-driven power amp protection board © Valery Zaichenko

Contents

Intro

This document describes functionality of the board and provides the details required to build it.

This is a second (refined) version of the board. Note that all the power active components are placed in a row on the right side of the board, making it easy to attach a common heatsink (just make sure they are insulated from the heatsink properly).

The board is driven by a PIC (ATMega chip on Arduino), providing unprecedented flexibility in operation algorithm, delays adjustment and indication options.

In as-built configuration, it protects the amplifier and the speakers against the following “troubles”:

1) DC offset at the output of the amplifier;
2) Over-current at the output stage;
3) Over-heating (2 sensors);
4) AC failure.

The board supports two types of switch-on triggering signals:

1) 12v trigger signal (most common practice);
2) Audiolab style trigger – shortened trigger input.

It is also possible to attach a power-on button, operating the same way as the 2-nd option above, though I use triggering from the previous stage and don’t have power-on switch in my build.

The board is always connected to mains, even during standby, whet the amplifier is off.

Heating relay is only used in case there are vacuum tubes in the circuit, otherwise it may be omitted (together with appropriate firmware amendment).

Operation

Default firmware operation algorithm is the following (soft-start sequence):

1) As soon as trigger signal comes in, or power-on switch is activated, the heating relay goes on, connecting the heating transformer to mains, and
   30 seconds delay is performed; **Power LED** is dimmed during soft-start (as well as in standby);
   This step is skipped if no heating required (no tubes in the amp).
   From this point, OPS over-current alarm is active.
2) In-Rush relay goes on, connecting the main power transformer to mains through the in-rush resistor;
   10 seconds delay is performed.
3) Power-On relay goes on, shortening the in-rush resistor and connecting the main power transformer directly to mains;
   2 seconds delay is performed.
4) The board checks if DC offset is fine for connecting the speakers.
   If it is ok, the speaker protection relays go on. **Power LED** goes bright, showing “Ready” state.

As soon as the soft-start sequence is complete, all alarms are monitored in the loop.

In case some alarm pops up, the board shuts down the amplifier in the following order:

1) Speaker protection relay off;
2) Power-on relay off;
3) 0.1 second delay;
4) In-Rush relay off;
5) Heating relay off.

Power LED indicates the reason of shut down:

- Intensive blinking (every 0.2 sec) – DC offset;
- 1 blink every 2 seconds – AC failure;
- 2 blinks every 2 seconds – overheat;
- 3 blinks every 2 seconds – OPS over-current.

The amp stays in this “Shutdown” state until you cycle the protection board mains power. After that, the board initializes and appears in “Standby” state, waiting for the trigger to begin the soft-start sequence.

Important Parts

Transformer

The one I use here is manufactured in Russia and it fits PCB perfectly, however it is possible to use any transformer giving 2 x 12-15 VAC, 500-1000 mA (the one I use is 800 mA). If the pin-out is different – simply place it on a chassis next to PCB and connect with wires.

Relays

Speaker protection relays – K1, K2: RT174012

http://www2.mouser.com/ProductDetail/TE-Connectivity/3-1393239-8/?qs=%2fha2pyFadugSrcMWG8rdM2UgLIrFMQouWyVORZf0MtmlrpXJ0mYvCg%3d%3d

Rated for switching up to 10A, 250VAC. Mounted on PCB.

Power control relays - In-Rush, Power-on, Heating-on: General Purpose Relays SPST-NO 12 VDC

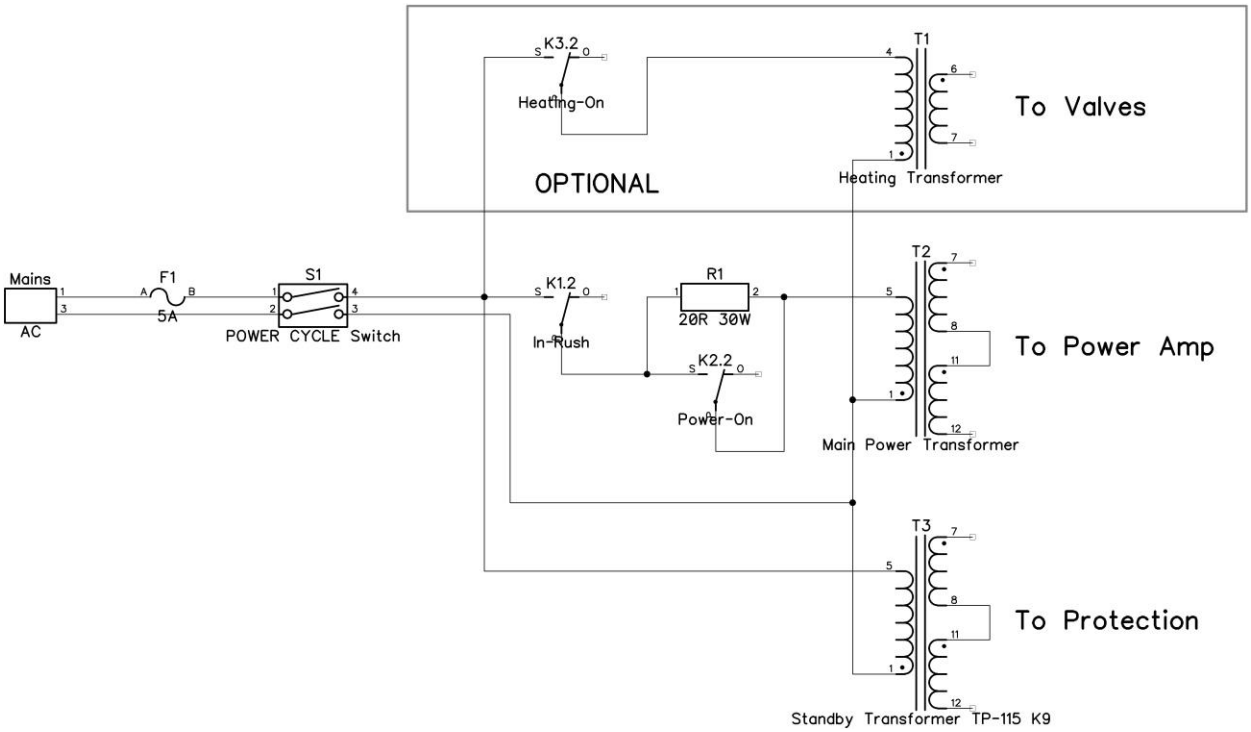
http://www2.mouser.com/ProductDetail/Omron-Electronics/G7L-1A-BUBJ-CB-DC12/?qs=sGAEpiMZZMtSzCF3XBhmW8TKJMszOoWJPzyM3OeVz5w%3d

These ones are rated for switching up to 30A, 240VAC. Mounted on Chassis.

In-Rush resistor

High power resistor - 20 ohm, 15-30W, mounted on a chassis and connected to the relay with the short wires. In use only during in-rush phase (some 10 seconds as part of the soft-start sequence).

Power relays arrangement

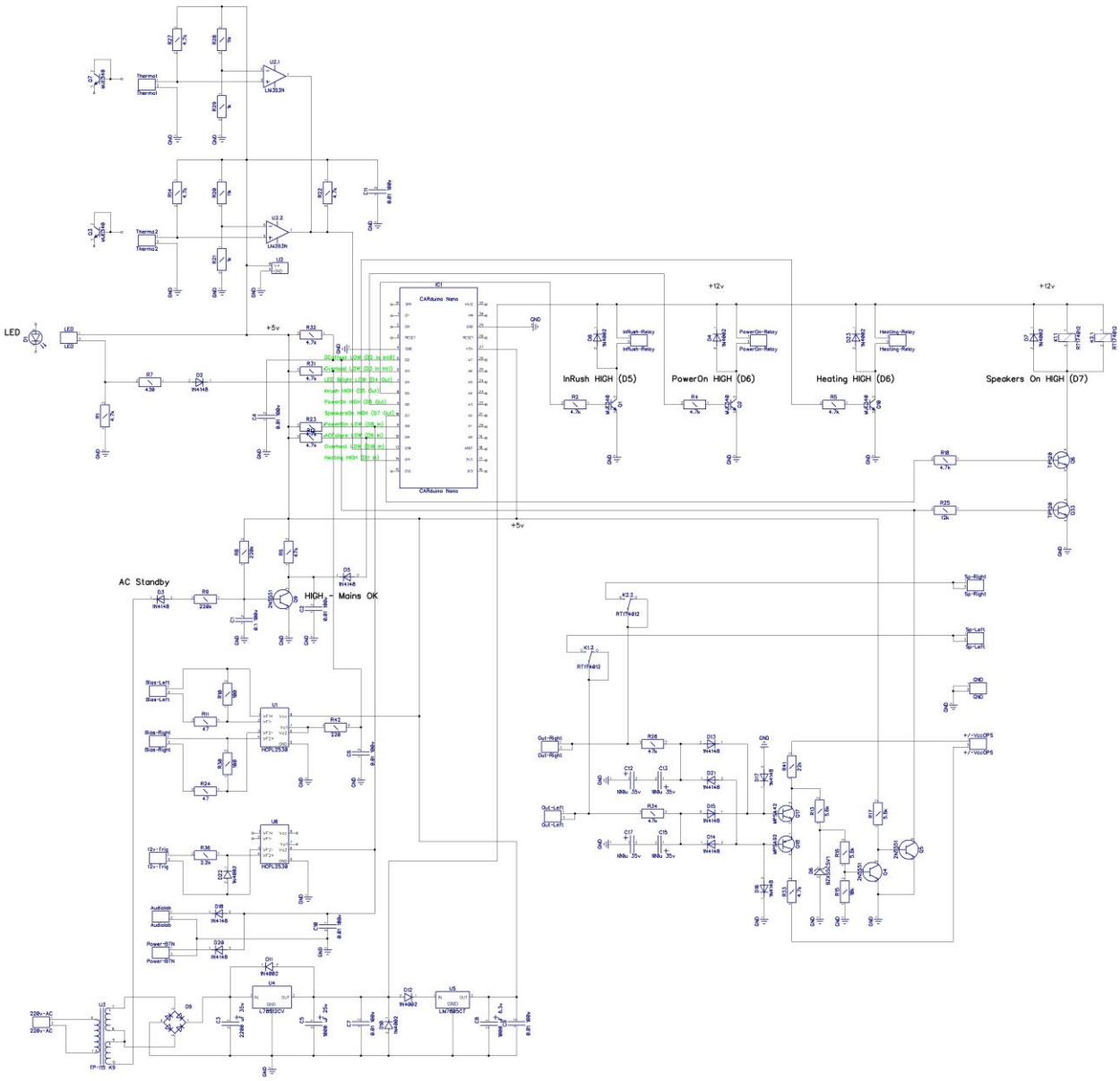


Optional part of the schematic is relevant in case you've got valves in the circuit.

BOM

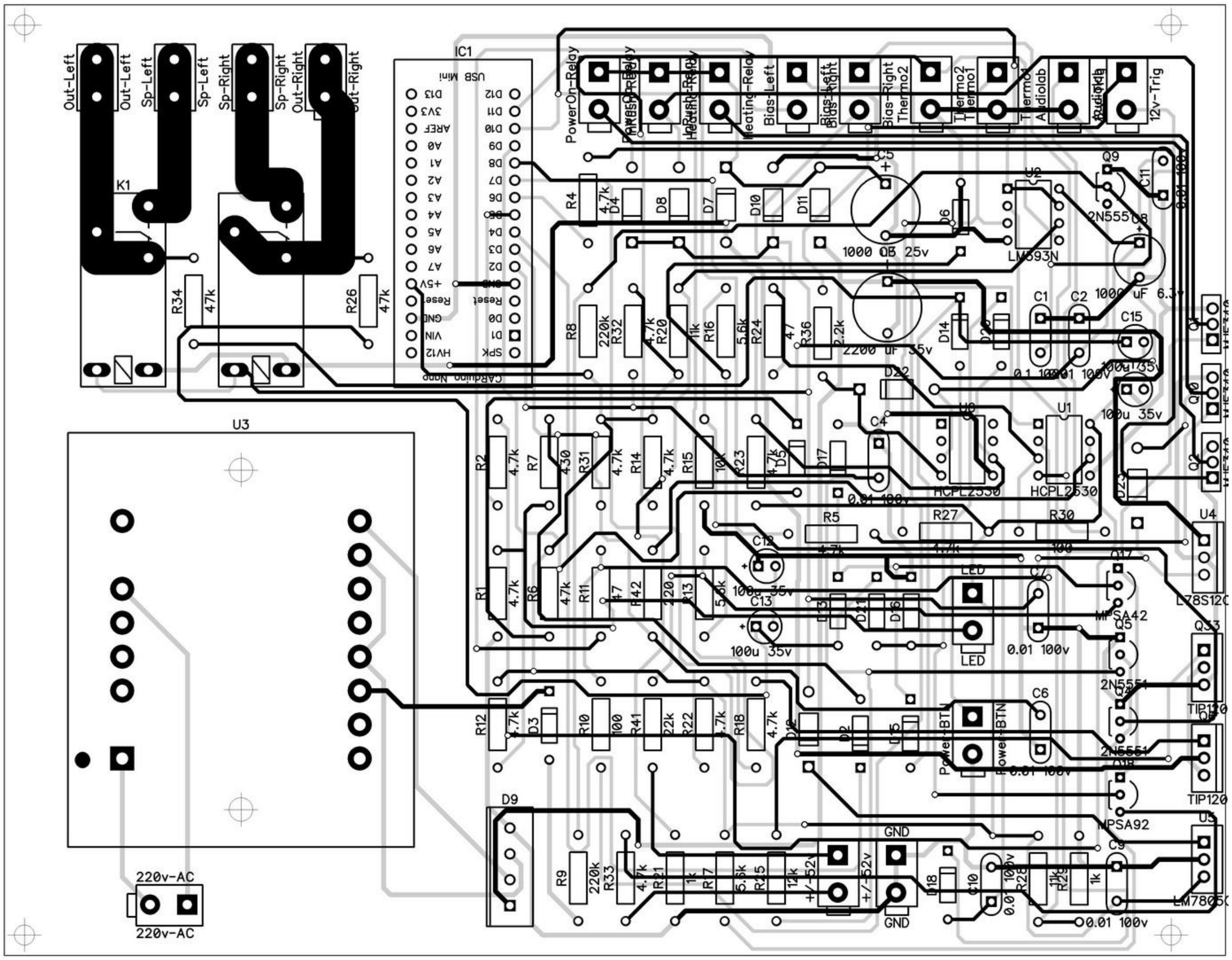
RefDes	Value	Name	Quantity	Manufacturer	Datasheet
2-pin plugs (Molex)	Male	2-pin 39-28-1043	18	Molex	http://www.molex.com/elqNow/elqRedir.htm?ref=http
C1	0.1 100v		1		
C2, C4, C6, C7, C9, C10, C11	0.01 100v		7		
C3	2200 uF 35v	Electrolytic	1		
C5	1000 uF 25v	Electrolytic	1		
C8	1000 uF 6.3v	Electrolytic	1		
C12, C13, C15, C17	100 uF 35v	Electrolytic	4		
D1		LED	1		
D2, D3, D5, D13, D14, D15, D16, D17, D18, D20, D21		1N4148	11		http://www.fairchildsemi.com/ds/1N/1N4148.pdf
D4, D7, D8, D10, D11, D12, D22, D23		1N4002	8		http://www.fairchildsemi.com/ds/1N/1N4001.pdf
D6		BZX55C5V1	1		
D9		2KBP02	1		
Heating-Relay		G7L-1A-BUBJ-CB-DC12	1	Omron	http://www2.mouser.com/ProductDetail/Omron-Electr
In-Rush Relay		G7L-1A-BUBJ-CB-DC12	1	Omron	http://www2.mouser.com/ProductDetail/Omron-Electr
Power-On Relay		G7L-1A-BUBJ-CB-DC12	1	Omron	http://www2.mouser.com/ProductDetail/Omron-Electr
IC1		Arduino Nano	1		May be substituted by Chinese clone (like CARduino or
K1, K2		RT174012	2		
LED	LED	Red LED	1		
Q1, Q2, Q3, Q7, Q10		MJE340	5		http://www.st.com/internet/com/TECHNICAL_RESOUR
Q4, Q5, Q9		2N5551	3		http://www.datasheetarchive.com/pdf-datasheets/Dat
Q6, Q33		TIP120	2		http://www.fairchildsemi.com/ds/TI/TIP31.pdf
Q17		MPSA42	1		http://www.fairchildsemi.com/ds/MP/MPSA42.pdf
Q18		MPSA92	1		http://www.fairchildsemi.com/ds/MP/MPSA92.pdf
R1, R2, R4, R5, R12, R14, R18, R22, R23, R27, R31, R32, R33	4.7k	1/4 W	13		
R6, R26, R34	47k	1/4 W	3		
R7	430R	1/4 W	1		
R8, R9	220k	1/4 W	2		
R10, R30	100R	1/4 W	2		
R11, R24	47R	1/4 W	2		
R13, R16, R17	5.6k	1/4 W	3		
R15	10k	1/4 W	1		
R20, R28	11k	1/4 W	2		
R21, R29	1k	1/4 W	2		
R25	12k	1/4 W	1		
R36	2.2k	1/4 W	1		
R41	22k	1/4 W	1		
R42	220R	1/4 W	1		
In-Rush Resistor	20R	30W	1		
Speaker Relay		2-pin 39-28-1043	2	TE Connectivity / Schrack	http://www2.mouser.com/ProductDetail/TE-Connectiv
Thermo1, Thermo2		MJE340	2		
U1, U6		HCPL2530	2		http://www.fairchildsemi.com/ds/6N/6N137.pdf
U2		LM393N	1		http://www.datasheetarchive.com/pdf-datasheets/Dat
U3		TP-115 K9	1		
U4		L78S12CV	1		http://www.st.com/internet/com/TECHNICAL_RESOUR
U5		LM7805CT	1		

Schematic



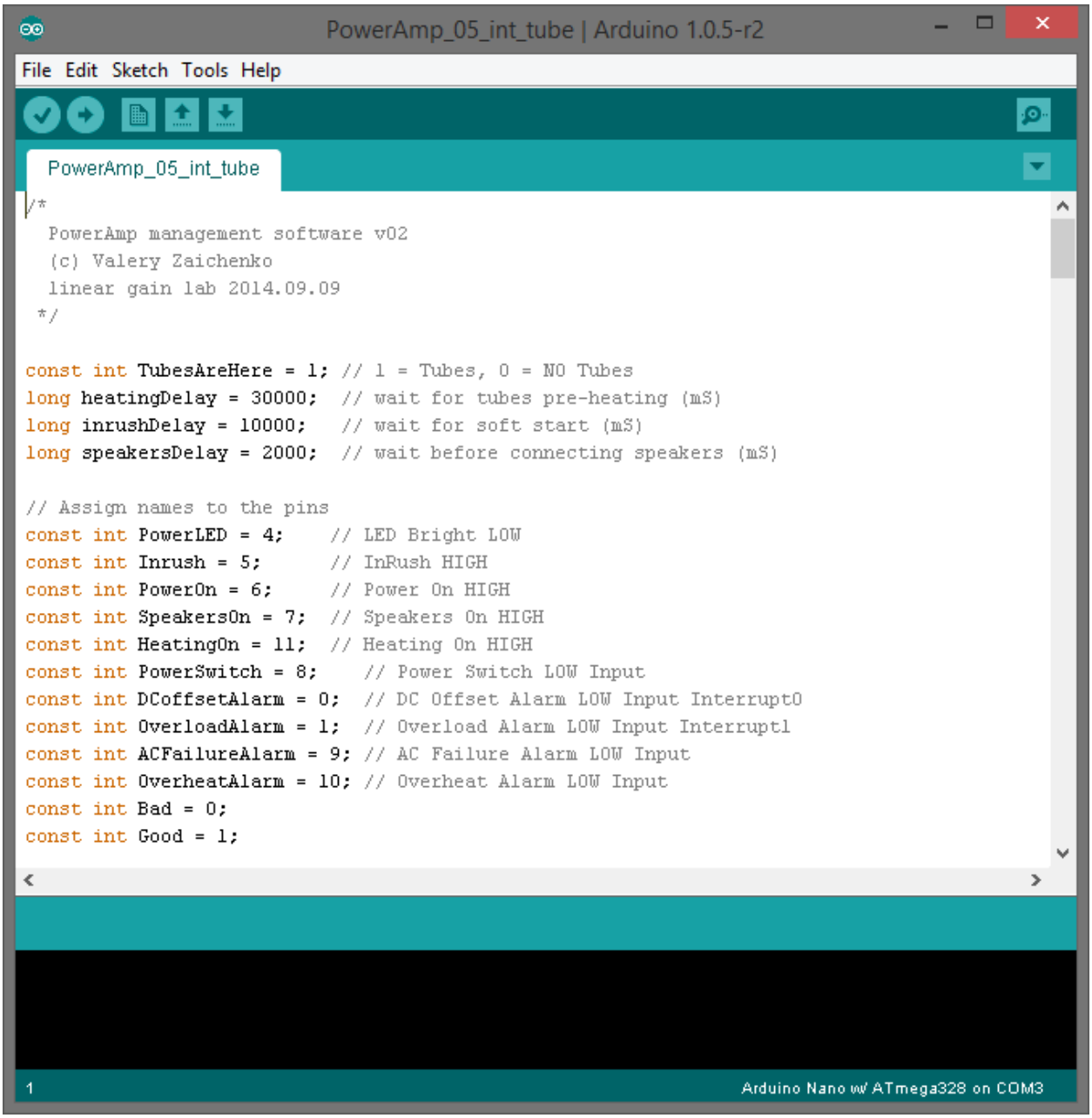
Voltage regulators and switching transistors are mounted on a common heatsink, placed on the right side of the board.

PCB Layout


Out-Left
Sp-Left
Sp-Right
Out-Right
K1
R34
47k
R26
47k
IC1
U3
220v-AC
PowerOn-Relay
Heating-Relay
Bias-Left
Bias-Right
Thermo2
Thermo1
Audiolab
12v-Trig
LM393N
1000 uF 25v
2200 uF 35v
HCPL2530
L78S12C
2N5551
MPSA42
MPSA92
TIP120
LM7805C
LED
PowerBTN
GND
D9

Firmware parameters

Depending on the amplifier design – with vacuum tubes or without them, firmware allows two modes of operation – with heating channel or without it. Also, all soft-start delays are adjustable. See the screenshot below (Arduino programming environment):



In the top section of constants you can see adjustable parameters (all delays – in milliseconds):

- TubesAreHere: “1” if you use the heating channel, “0” if you don’t;
- heatingDelay: startup pre-heating time;
- inrushDelay: time of in-rush (main transformer is connected to mains via R);
- speakersDelay: time between the moments when the amp is full powered-on and speakers are connected.

Gerbers and firmware are available on request.

Have a nice build! ;)

Cheers,
Valery