Chapter 7

forte 600 Operation Manual

rev 1.0 March 2024, by SP6GK

7.1 Introduction

Forte 600 is a linear solid state high frequency amplifier that operates from 1.8 to 30 MHz with maximum output power of 600 W. This amplifier utilizes two MRF300 LDMOS transistors in a push-pull class AB configuration, providing a robust power amplifier deck with good efficiency. Monitoring and controls of the amplifier are provided by a 32 bit STM32 microcontroller running a real-time operating system. Most important informations are displayed on LCD screen and LED bargraph.

7.2 Specification

- **Operating bands**[1]**:** 160, 80, 40, 30, 20, 17, 15, 12, 10 [m]
- **Output power:** 600 W CW max (no LPF) ≈400 W CW max (with LPF)
- **Input power:** 7 W maximum, P1dB ≈ 4 W
- **Worst case harmonic suppression:** -53.89 dBc at 21 MHz
- **Transmission modes:** CW, SSB, AM, FM, Digital
- **RF input and output ports:** 50 Ω unbalanced, Teflon SO-239
- **Connections:** IEC AC power connector, PTT - RCA phono,
  Analog band selection - RCA phono, ALC - RCA phono, Data - RJ-45.
- **AC power:** 200-240 V AC at 5 A max, Fuse 5 A 250 V slow
- **Weight:** 26 kg
- **Dimensions (W, H, D):** 455 x 260 x 430 [mm]

[1] 60 m is not covered because of limitations in allowed power on that band. 6 m band operation is possible and LPF is included, but this band was never tested.

7.3 Front Panel

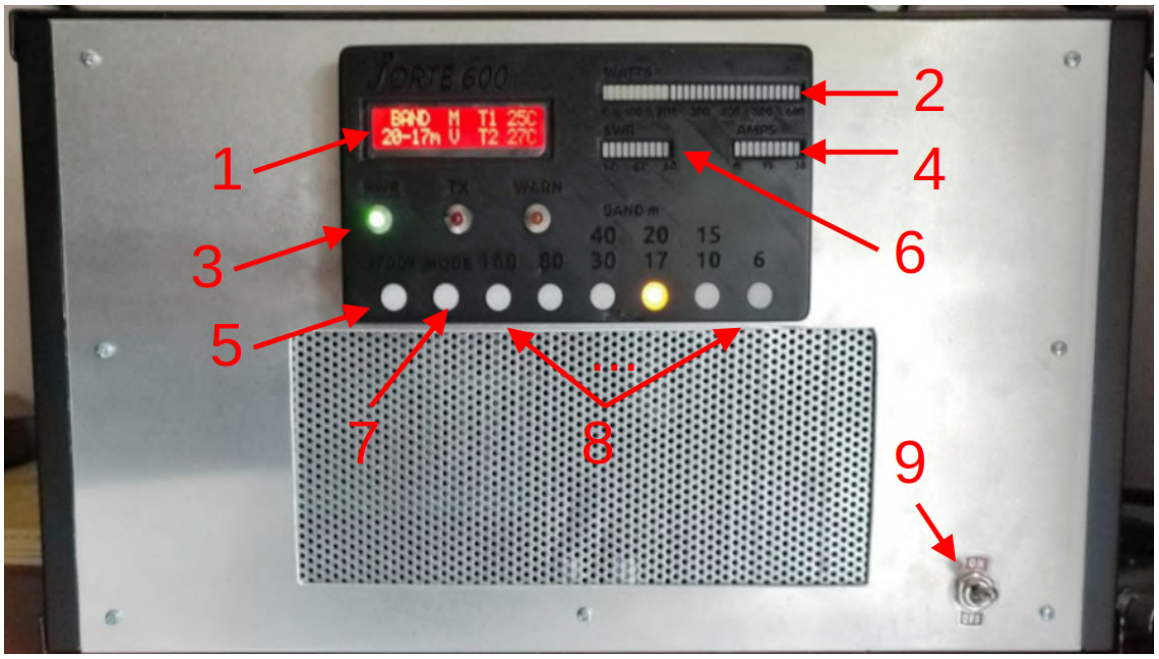


Figure 7.1: 1 - 16x2 Liquid Crystal Display (LCD), 2 - Output power bar graph, 3 - Status LEDs (from left to right: AC power (PWR), transmit mode (TX), fault detected (WARN)), 4 - Total drain current bar graph, 5 - Standby (STDBY) button, 6 - Standing Wave Ratio (SWR) bar graph, 7 - Band switching mode button (MODE), 8 - Manual band selection buttons, 9 - AC power switch

7.4 Rear Panel

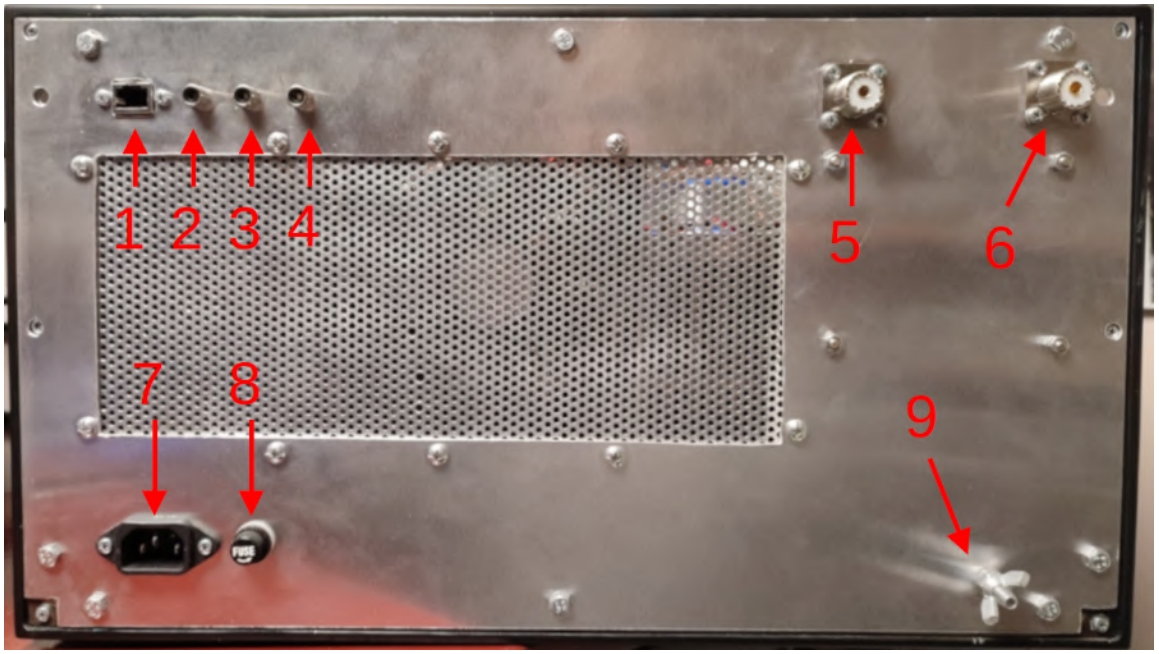


Figure 7.2: 1 - Digital band data, 2 - Analog band data, 3 - PTT, 4 - ALC (option), 5 - RF output, 6 - RF input, 7 - AC input, 8 - Fuse (slow 5 A), 9 - Ground

7.5 Installation and First Start

1. Ensure that the amplifier's AC switch is in the OFF position and that the power cable is disconnected.

2. Connect the PTT input of the amplifier to the transceiver's PTT output.

3. Connect a 50 Ω load or antenna to the RF output of the amplifier.

4. Leave the amplifier's input unconnected or terminate it with a 50 Ω load if possible.

5. Set the transceiver to LSB or USB mode on the 20 m band, and set the power level to minimum. Terminate the output of the transceiver into a 50 Ω load.

6. Connect the amplifier to the mains using an IEC cable.

7. Turn on the amplifier using the AC switch on the front panel.

8. When the amplifier goes through its startup procedure, a single one-second beep should sound, and after about 4 seconds, the front LCD should display the current band, temperature, and mode of operation.

9. Switch the amplifier to manual mode of band selection and switch to 20 m band. The button below 20/17 m should light up and LCD should show the same band.

10. Press the PTT on the transceiver side.

11. Observe the meters.

The amplifier should switch into transmit mode, and the LCD should display a drain current of 0.40 A and a drain voltage of 48 V. A difference of 0.04 A and 0.5 V from the nominal values is acceptable. The forward and reflected power should indicate 0 W.

If anything appears abnormal, please refer to Sec. 7.7.1. If the displayed values are correct, it indicates that the amplifier has also passed its self-test, and you can proceed to the next section.

7.6 Operation

In order to prepare the amplifier for normal operation after initial setup (Sec. 7.5), follow these steps:

1. Switch off the amplifier and transceiver.

2. Connect the RF output of the transceiver to the amplifier's input port using a 50 Ω coaxial cable.

3. (Optional but recommend) Choose one of the methods for automatic band selection from Sec. 7.6.1.

4. Switch on the transceiver and amplifier.

5. With the transceiver still in LSB or USB mode and with minimum output power, try changing the band to 15 or 40 m on the transceiver in receive mode. If one of the automatic band selection methods was used, the LPF section should switch automatically. Display should be updated, and you should hear the click of relays inside the amplifier.

6. Set the transceiver to CW and key the transmitter on one of the allowed bands while the 50 Ω output load or antenna is connected. Increased output power should be noted. At this stage input power of 1 W is recommended.

7. Release the CW key and increase power by 1 W or the minimal step on the transceiver. Remember that maximum input power is just 7 W.

8. Repeat step 6 until you reach 7 W of input power, at least 400 W should be observed at the output by now.

9. For normal SSB operation, it is recommended to use a maximum of 4 W of input power for linear operation.

NOTE: It is highly recommended to use automatic band switching if possible.
If manual band switching is selected and the operator forgets to change the amplifier settings, two cases might occur. Either the amplifier will transmit full power with a low-pass filter with too high of a cutoff, leading to illegal spurious emissions, or the cutoff of the LPF will be too low, resulting in the full power being reflected back to the transistors, which might shorten the lifespan of the output transistors or destroy them.

NOTE: Reduce the power further for transmission modes with high duty cycles.
Amplifier can work with high duty cycles, but its durability was not tested extensively since it heavily depends on the modulation type. For modes such as AM, FM, or digital modes, you should closely monitor the temperature. If it increases very quickly, you should lower the power. It is recommended to stay below 50° C.

7.6.1 Band Switching Modes

Forte 600 allows one of three band switching modes to be selected. The currently selected mode is indicated by a letter displayed under the 'M' letter on the LCD display when the amplifier is not in transmit state:

M : Manual

V : Voltage (analog)

B : Binary

In order to change the mode of band switching, press the MODE button on the front panel (7 in fig. 7.1). It allows you to cycle between modes. With each press, the mode will change in the following order:

Manual⟶ Voltage⟶Binary

After reaching the binary mode, the next press will cycle back to the Manual mode. The currently set band is displayed on the LCD screen, and the button representing the band is also illuminated by an LED. The amplifier will remember the last used mode even if power gets disconnected.

When the amplifier is in transmit mode, the option to change the band or band selection mode will be blocked until the amplifier returns to receive mode.

Manual Band Selection

Forte 600 allows for manual band selection by pressing any of the buttons on the front panel. To do this, set the mode to manual (M). If the manual mode was lastly selected, the amplifier will remember the last chosen band even if power was disconnected.

Automatic Band Selection

Forte 600 can also switch bands automatically if a connection between it and the transceiver is established. Two methods of automatic band switching are provided:

Analog Voltage Band Switching

This method utilizes a RCA phono jack at the back of the amplifier, where the center of the connector is the positive and the outer side is the ground. The amplifier measures the analog voltage on this connector and selects the band according to the voltage ranges presented in table 2.2.

Binary Band Switching

This method utilizes an RJ-45 connector at the back of the amplifier. For the pinout of the connector, see the schematic in Fig. 2.13. This amplifier uses a three bit binary to represent the necessary 6 bands of LPF. See table 2.1 for the assignment of bands.

When a cable with 3 bit binary data is connected to the amplifier, manual mode selection should not be used since the controller handling the manual selection uses the same 3 bit wide bus.

For transceivers using a 4 bit binary output to represent the current band, a translation layer needs to be provided for this version of the amplifier.

7.6.2 Stand By Mode

Pressing the STDBY button will cause the amplifier to be put into standby mode. If the amplifier is in standby mode, the STDBY button will light up green. In standby mode, the amplifier acts as a pass through connection between the antenna and the transceiver, and the PTT will have no effect on the amplifier. To return to normal operation, press the STDBY button once more. This mode should be used when antenna requires tuning to 50 Ω with extenral antenna tuning unit (ATU) that is connected after the amplifier.

7.6.3 Antenna Recommendation and ATUs

It is highly recommended to operate the amplifier with a maximum SWR of 1.8 if an output of more than 300 W is used. While the amplifier has many protections against high SWR and temperature, a good match is still necessary for efficient operation and to avoid the fail-safe mechanisms from tripping.

NOTE: When tuning the antenna, put the amplifier into standby mode and use the minimal power possible.
Do not attempt to measure the SWR input of the amplifier using sweep feature on your transceiver, out of band emission might occur.

7.7 Protection

Forte 600 includes a modern digital controller that provides real-time software protection against:

- High temperature, temperature sensor not detected
- Drain overcurrent and overvoltage
- Excessive input power
- Too high output reflection
- Too high output power
- Excessive LPF loss or reflection (wrong filter selection or filter damage)

In addition, there are also analog mechanisms to protect the amplifier from:

- Too high input power comparator - switches TX/RX
- Too high output SWR comparator - switches off bias and TX/TX
- Temperature compensating bias circuit - drain current is regulated as temperature increases to prevent thermal runaway and instability

If any abnormality is detected, the amplifier will be put in a warning mode (WARN LED will light up). The response of the controller depends on the fault or abnormality detected. An error code will be displayed on the LCD, and the buzzer will sound in a specific way. In case the user encounters a problem, the error code should be read and checked with the manual.

7.7.1 Error Codes

1. **MAX Id CURRENT!** Problem: Drain current has exceeded the maximal value.
   Note: This error has a counter, the controller has to detect this problem a few times in a limited time span to trigger the protection. This mechanism prevents noise from tripping the protection.
   Action taken by the amplifier: Disables the PA board, goes into RX, pauses for 10 s, and resets.

Recommended action for the user: Disconnect the power to the amplifier, open the top cover, disconnect the 48 V rail from the PA deck. Measure the resistance from drains to ground, it should be in the range of MΩ. Measure the resistance from the 48 V rail (on the controller 48 V output) to ground, it should be more than a few hundred Ω. If you did not find a short and readings are normal, connect the 48 V rail back to the PA board, connect the power, and turn on the amplifier. With the top cover removed, measure the 48 V rail on the input to the controller, it should be present in receive mode. With the amplifier connected to a matched load and no RF input, key down the amplifier into TX mode. The LCD panel should indicate a current of 0.4 A, and 48 V should be present at the drains. If up to this point, no abnormalities were detected, then the protection was most likely tripped by noise or improper operation, and the amplifier is good for use. Otherwise, troubleshoot the section close to where the abnormality was detected. See the section on difficulties for more details around current sensor.

2. **MAX Ud VOLTAGE!** Problem: Too high voltage detected on the 48 V rail.
   Note: This error has a counter, the controller has to detect this problem a few times in a limited time span to trigger the protection. This mechanism prevents noise from tripping the protection.
   Action taken by the amplifier: Disables the PA board, goes into RX, pauses for 10 s, and resets.
   Recommended action for the user: Switch off the amplifier, open the top cover, and disconnect the 48 V rail from the PA deck. Key down the amplifier and measure the voltage at the 48 V rail output from the controller, 48 V should be measured. If the voltage is too high, then the PSU is damaged otherwise measure values of the 48 V rail divider resistors.

3. **MAX TEMPERATURE!**
   Note: Reading on one of the temperature sensor has exceeded 65 $°C$
   Action taken by the amplifier: The amplifier disables the PA board, goes into RX mode, pauses for 30 seconds with fans sped up to the maximum, and then resets.
   Recommended action for the user: If the error did not occur rapidly and occurred when the amplifier was operated in a hot environment for a longer period of time, the recommended action is to wait until the temperature drops below $40°C$ before transmitting again. If the temperature rises too fast during normal operation (room temperature of 24°C and maximum P1dB input power into matched load for ICAS operation), the condition of the fans and thermal paste should be checked. If the temperature difference between T1 and T2 sensors is larger than 5 $°C$, it is highly recommended to check the mounting of temperature sensors to the transistors, the application of thermal paste might also be uneven.

4. **Out Power limit!**
   Note: Output power has exceeded 600 W
   Action taken by the amplifier Disables the PA board, goes into RX, pauses for 10 s, and resets.
   Recommended action for the user Check the amplifier according to startup guide again. Use lower input power, otherwise check the input attenuator and ouput couplers.

5. **In Power limit!**
   Note: Input power has exceeded 7 W
   Action taken by the amplifier: Disables the PA board, goes into RX, pauses for 10 s, and resets.
   Recommended action for the user: Lower the power output on the transceiver side. If it's not possible to set a lower output power, consider using an attenuator. If the error occurs even when the power is lower than 7 W, check the input coupler and its output voltage when 7 W of CW is applied.
   For a matched source with 7 W of input power the forward input voltage should be approximately 0.9 V.

6. **High out SWR!**
   Note: High standing wave ratio detected at the output of the LPF board (output of the amplifier to the antenna).
   Action taken by the amplifier: Disables the PA board, goes into RX, pauses for 10 s, and resets.
   Recommended action for the user: Check if the antenna is tuned properly. If so, switch off the amplifier, disconnect AC power. Desolder the coaxial cable from the PA deck to LPF, connect VNA to the input of the LPF and output of the amplifier (SO-239). Disconnect the RF input to the amplifier and terminate the transceiver. Connect the amplifier to AC and turn it on, key it down on the band where the error occurred. Perform S21 measurement of the LPF and RX/TX switch. If error occurred during antenna tuning with ATU, ensure standby mode is used while tuning. If error occurs on startup, check connections between LPF and controller board PCBs, make sure ADC inputs are not floating.

7. **High in SWR!**
   Note: The RF source is not well matched to 50 Ω.
   Action taken by the amplifier: Disables the PA board, goes into RX, pauses for 10 s, and resets.
   Recommended action for the user: If possible, check your input cable with a VNA. Switch off the amplifier and disconnect it from power. Disconnect the PA deck from the LPF board and connect the PA deck to the dummy load. Connect the VNA to the input port, only one port is necessary to perform the S11 measurement. Connect the amplifier to the power and switch it on. Measure the return loss in the range from 1 to 30 MHz, it should be better than -10 dB. Make sure that S11 sweep is made in the range of the selected LPF.

8. **Mismatch LPF!**
   Note: The PA deck board output coupler has detected a large reflection.
   Action taken by the amplifier Disables the PA board, goes into RX, pauses for 10 s, and resets.
   Recommended action for the user: If using manual band switching, ensure that the correct band is selected. When using automatic band switching, refer to the High SWR section and troubleshoot the LPF and RX/TX section.
   Make sure that the LCD is showing the same band as your transceiver.

9. **LOSS PWR in LPF!**
   Note: A large difference between input power to the LPF and output power from the LPF was detected. This might indicate damage in the LPF section.

Action taken by the amplifier: Disables the PA board, goes into RX, pauses for 10 s, and resets.
Recommended action for the user: Refer to the High in SWR error code and measure the S21 of LPF and RX/TX sections. Make sure insertion loss in pass band is close to that specified in technical documentation (Sec. 4.7.1).

10. **TEMP SENS ERROR**.
Note: The controller board did not detect at least two sensors on a One Wire bus.
Action taken by the amplifier: Disables the PA board, goes into RX, pauses for 10 s, and resets.
Recommended action for the user: Switch the amplifier off and disconnect it from power. Open the top lid and check the connections of the temperature sensors to the controller board. Temperature sensors are screwed on the top of the MRF300 packages.

NOTE: You can connect the ST-Link to the SWD port of the microcontroller and use the debug feature in a compatible IDE to step-by-step analyze what is happening with the amplifier. When debugging, proceed with caution if the PA deck is connected to the 48 V rail or RF input since real-time software protection might not be applicable.

7.8 In Case of Difficulty

Maximum drain current or drain voltage error code is detected upon a startup.

Check the connection of the other PCBs to the controller board. Ensure that the input to the ADC channels of the controller board is not floating with high input impedance. Such a situation will cause a large charge to accumulate on the ADC input, leading to a high input voltage being read, which can trigger the fail mechanism immediately during the startup check.

Exceeded drain voltage error occurs spontaneously during transmission.

Check the decoupling capacitors that filter the input to the ADC. High noise may be present on the drain voltage divider, potentially leading to false positive detection.

The LCD and bargraph display experience glitches during transmission.

Check the grounding of the front panel electronics. Use shields grounded on both sides of SPI and digital bus connections. Ensure that decoupling capacitors for the 5 V front panel regulator are properly mounted. Also, confirm that front panel cables are not routed close to the high-power RF path.

The temperature sensor reading is constant

It is possible that stray RF has corrupted the configuration of the DS18B20 thermometer. Ensure that sensors are connected properly with short grounded cable on both sides. Ensure that decoupling capacitors are not damaged.

7.9 Warnings

Electrical Hazard! This device operates on mains electricity, which can lead to lethal shock. Do not operate the device near water and avoid exposing it to moisture. Before performing maintenance and service, always remove the power plug.

Heat warning: During operation, certain parts of the device may become hot. To prevent damage, ensure proper ventilation around the vents of the device. Avoid placing the device near heat sources.

Cleaning: Use a soft, dry cloth to clean the exterior of the device. Do not use abrasive cleaners or solvents.

Environment Considerations: Dispose of the device responsibly according to local regulations. Do not dispose of it in regular household waste. Consider giving it to someone new to the hobby or keeping it for spare parts.

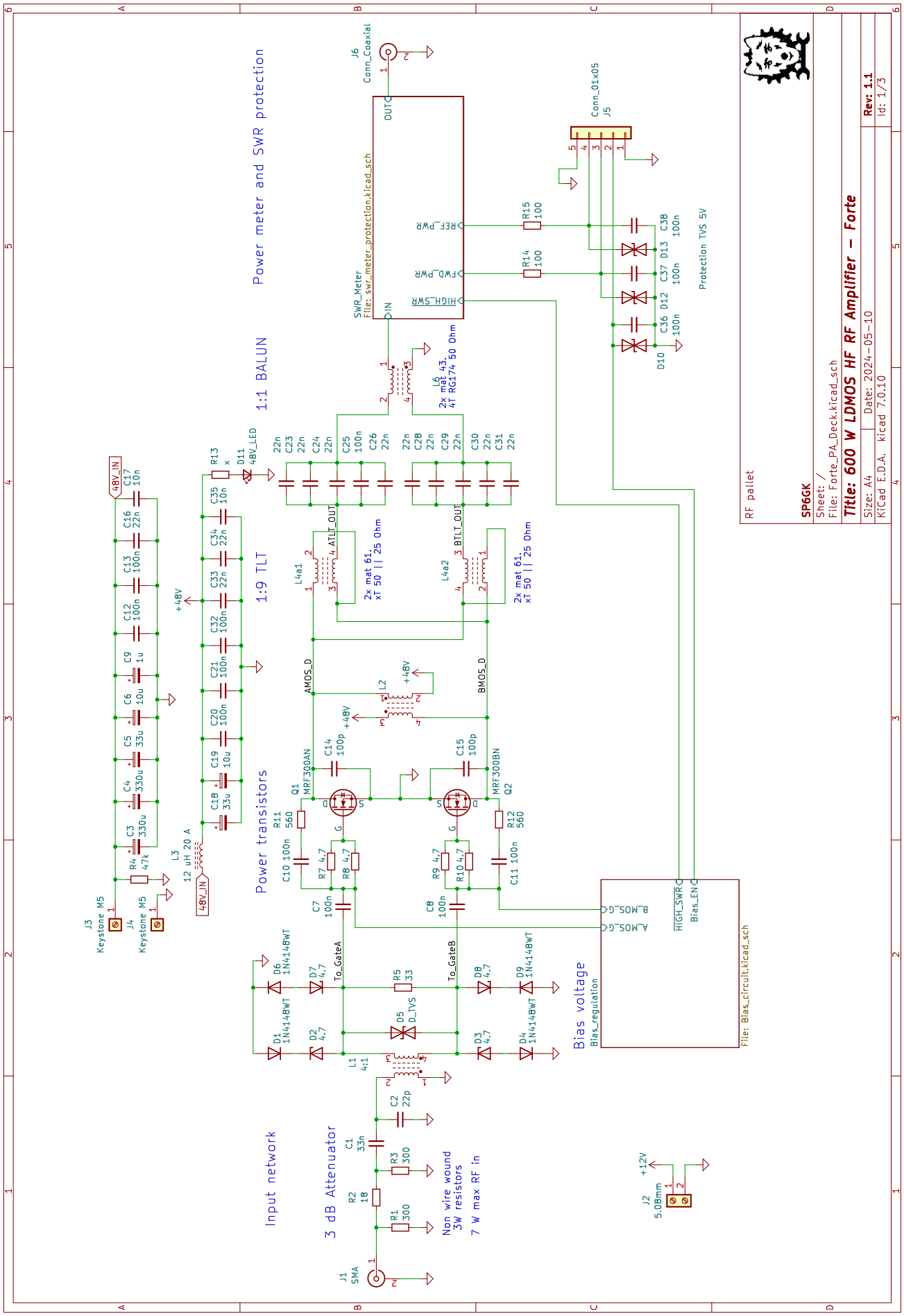
7.10 Service and Repair

It is your device, absolutely attempt to disassemble or repair it if you have the proper tools and knowledge. Schematics are provided below!
Remember about proper ESD protection!

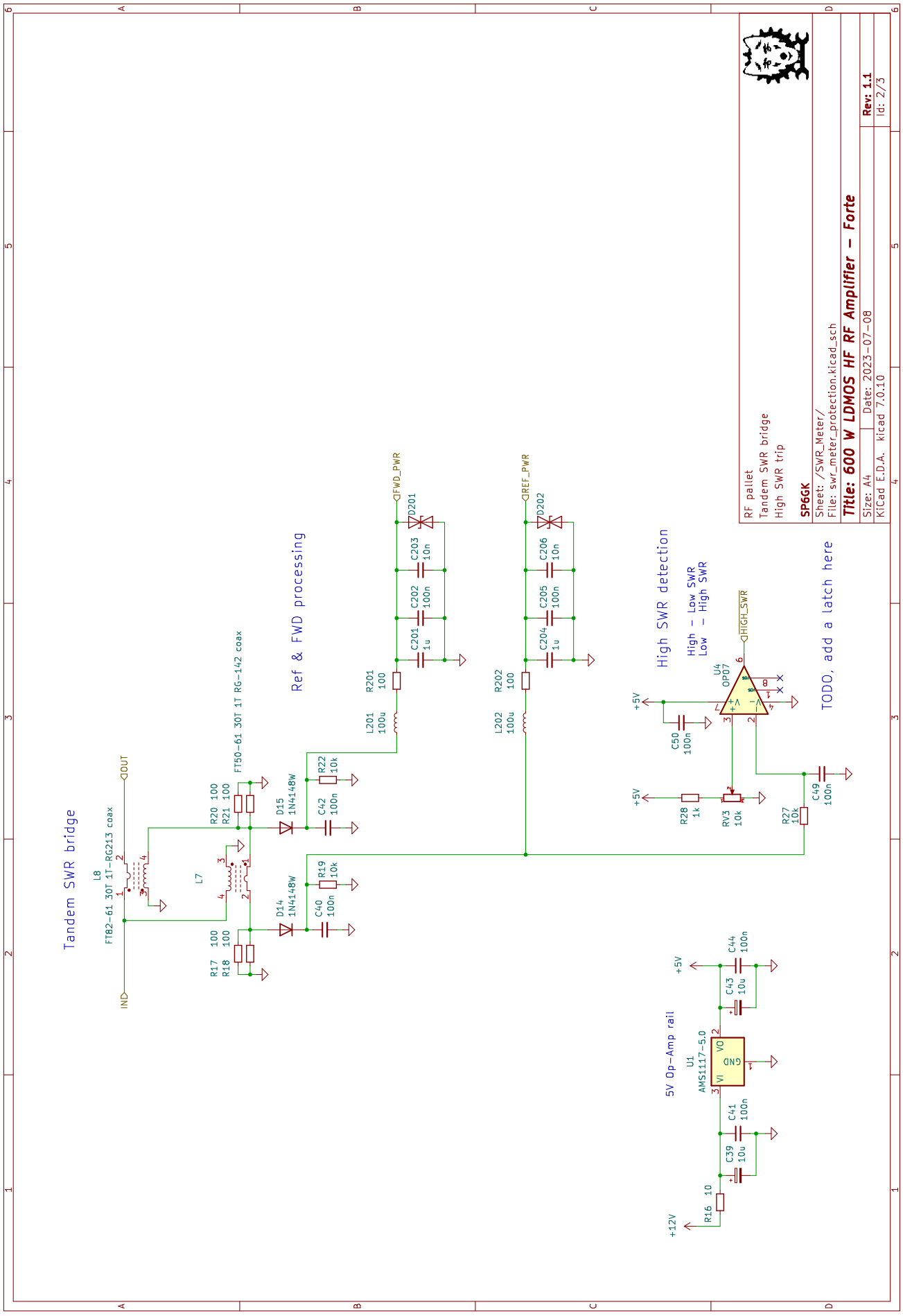
7.11 Schematics

Schematics follow on the next pages.

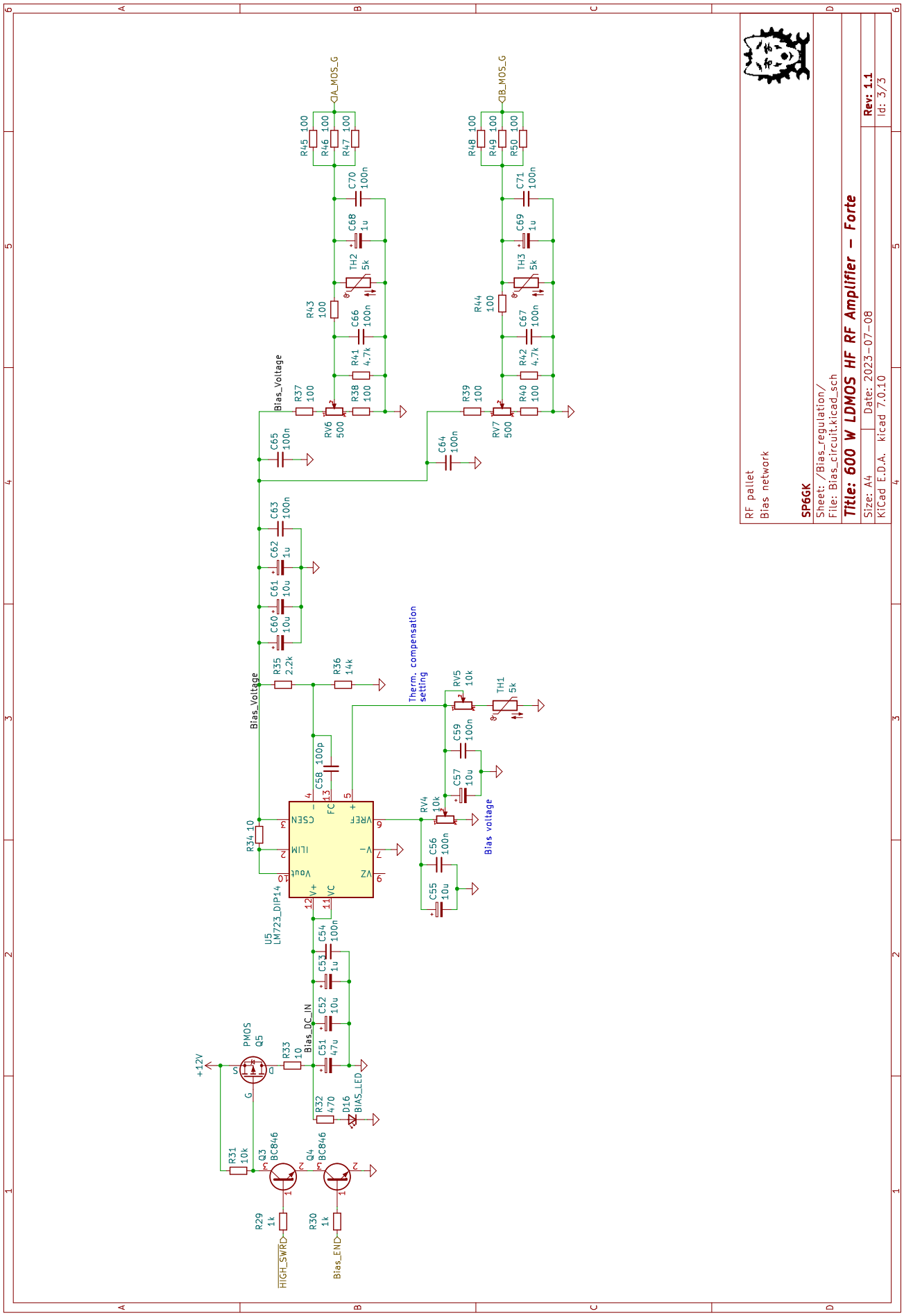
7.11.1 PA Board Main Schematic



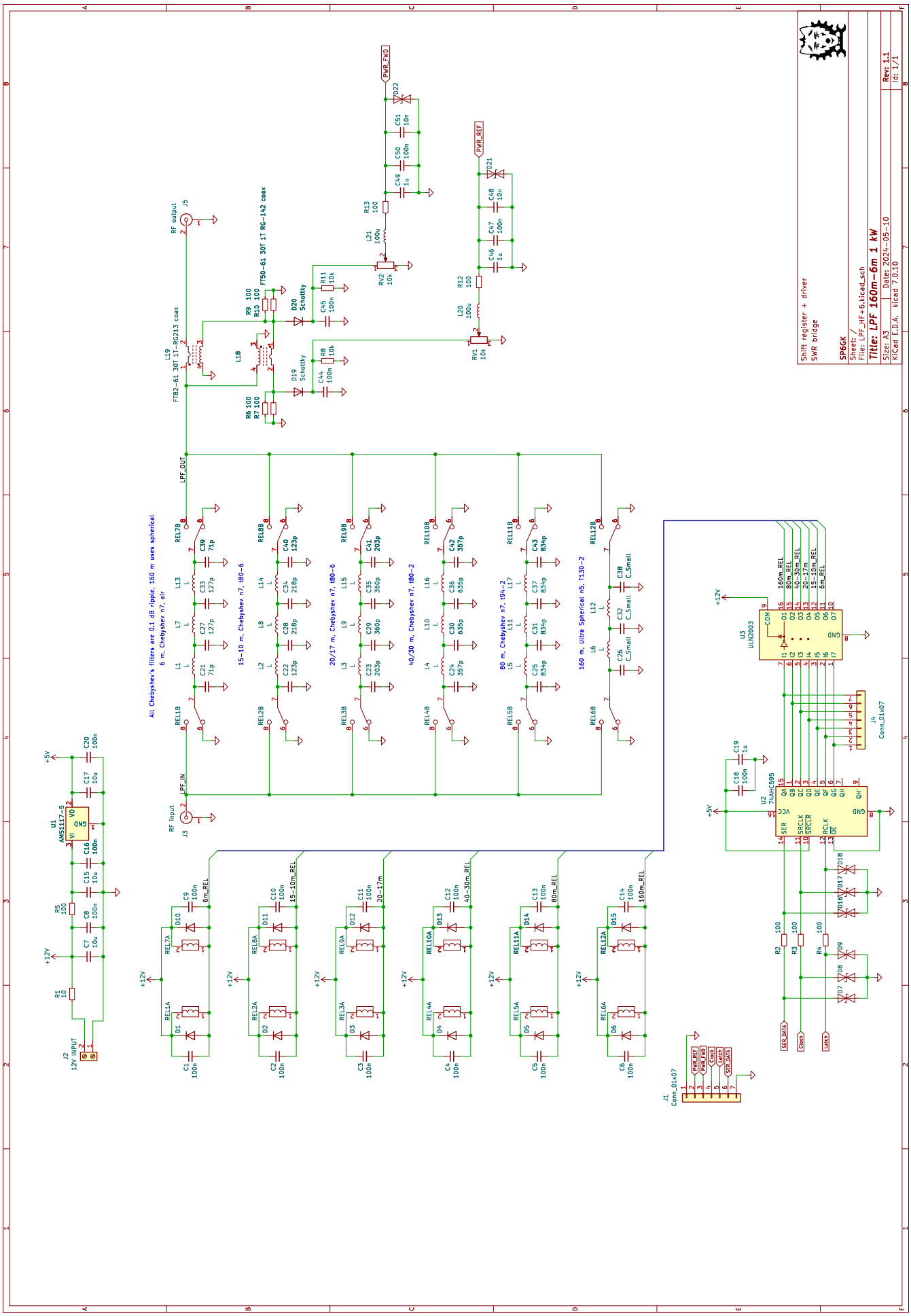
PA board Directional Coupler



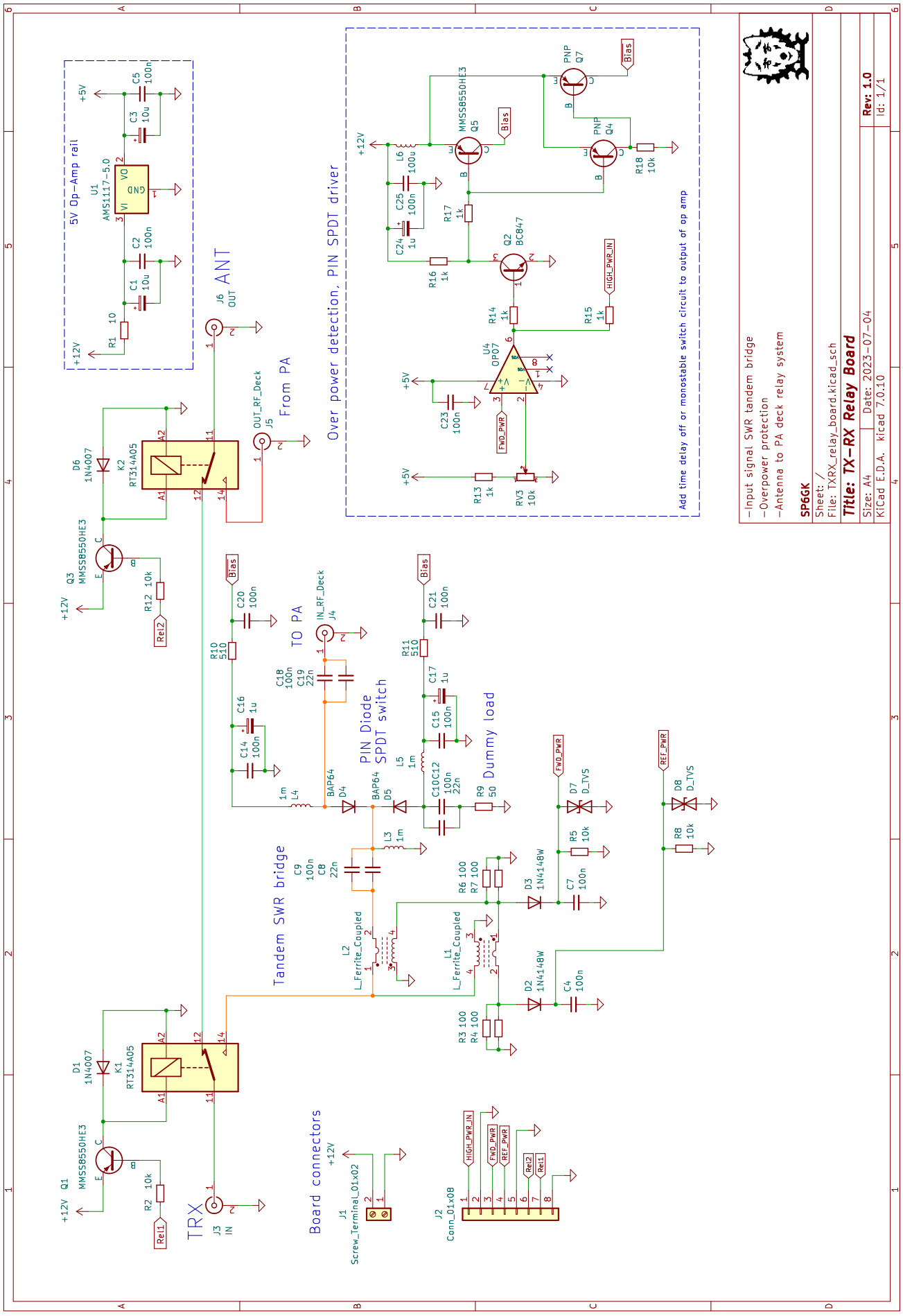
PA board Bias Circuit



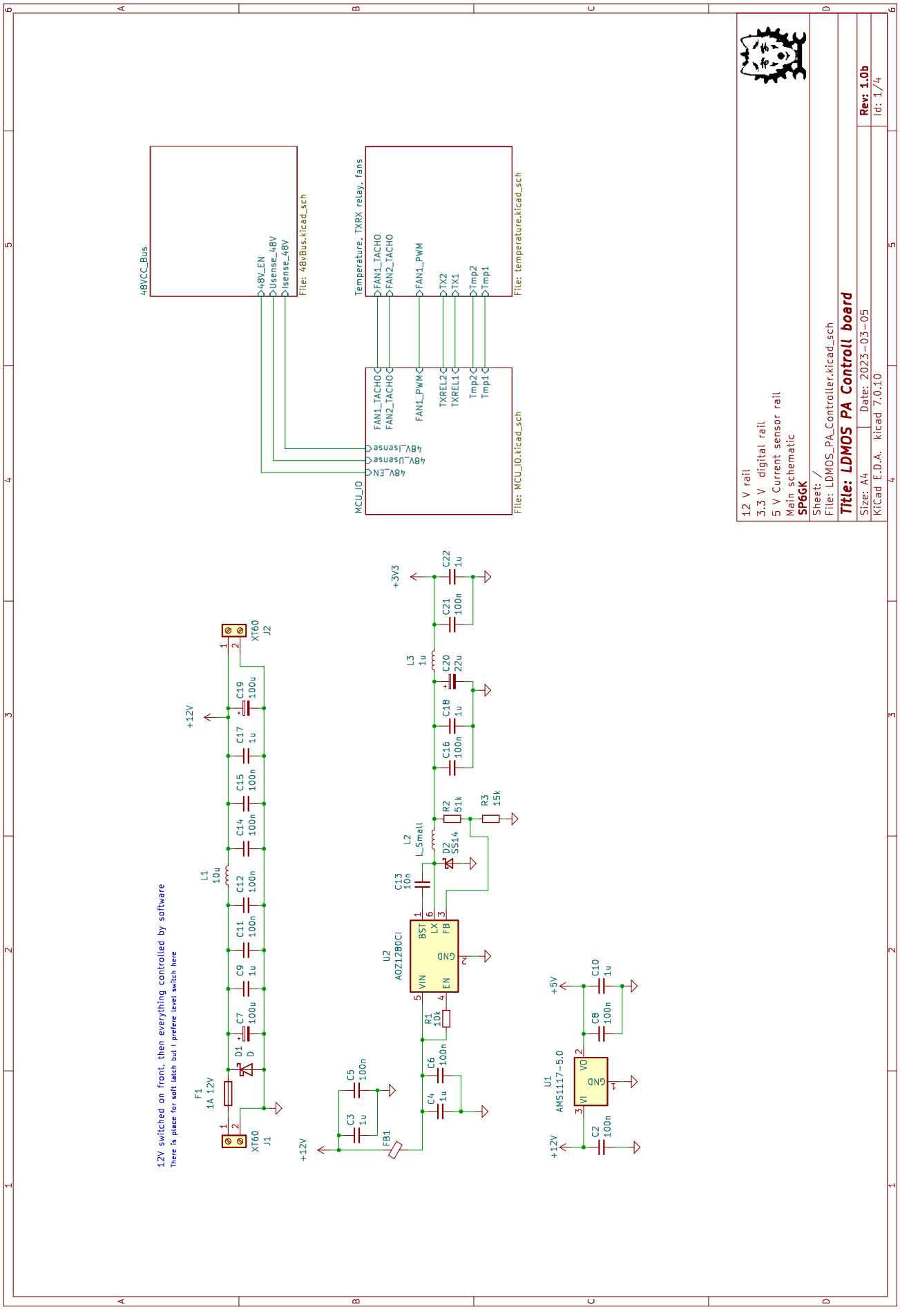
7.11.2 LPF Schematic



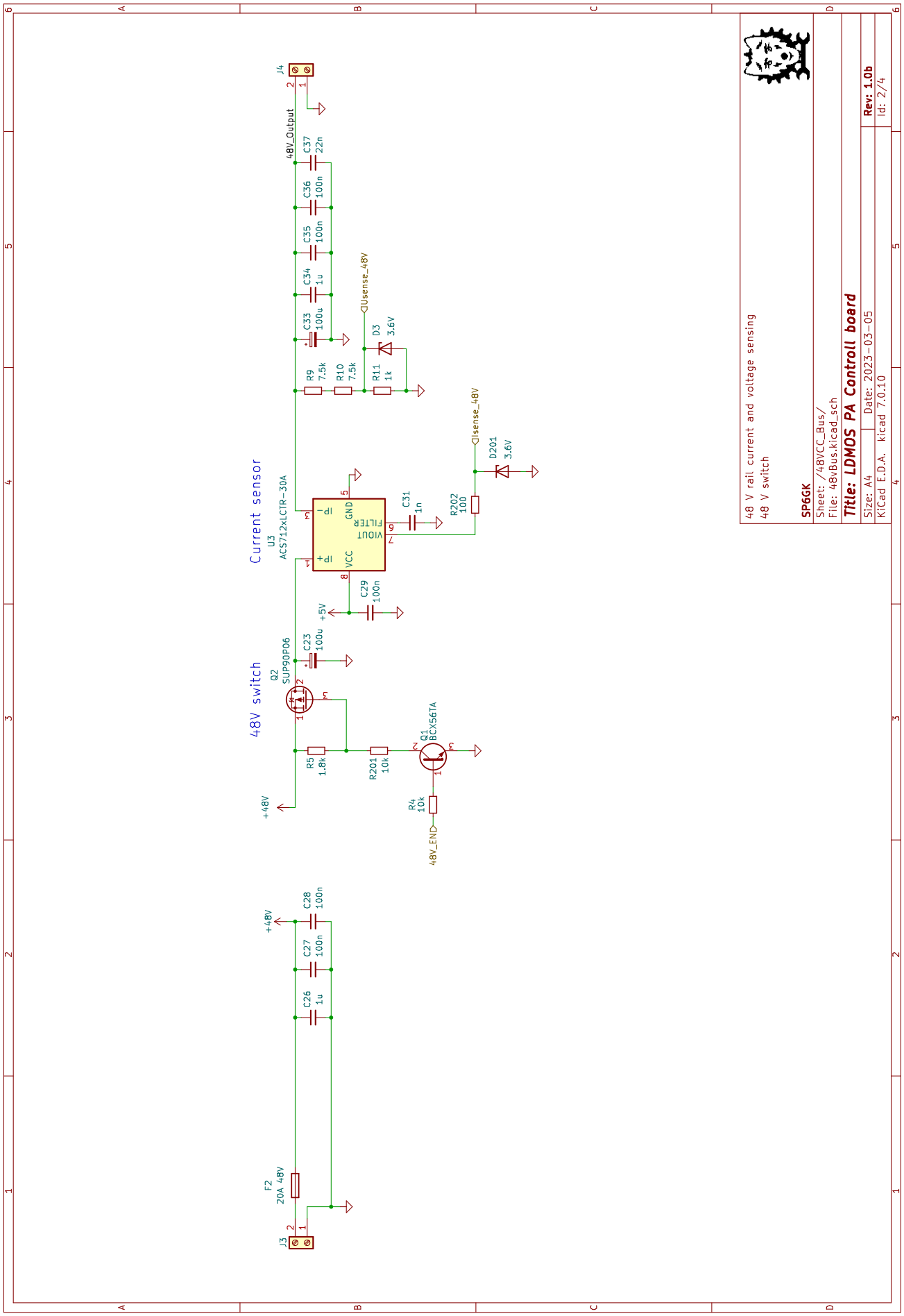
7.11.3 TX/RX Schematic



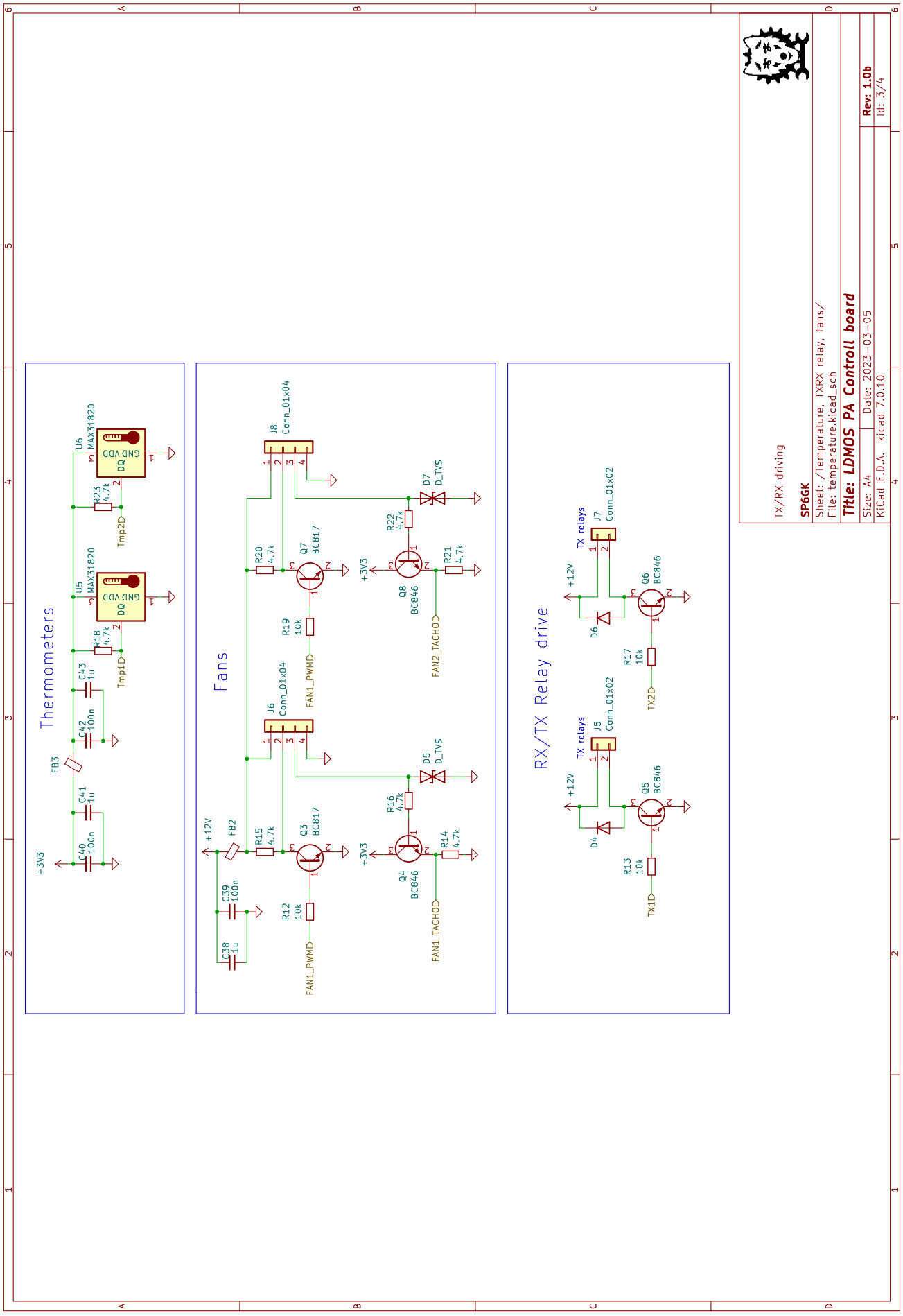
7.11.4 Controller Schematic



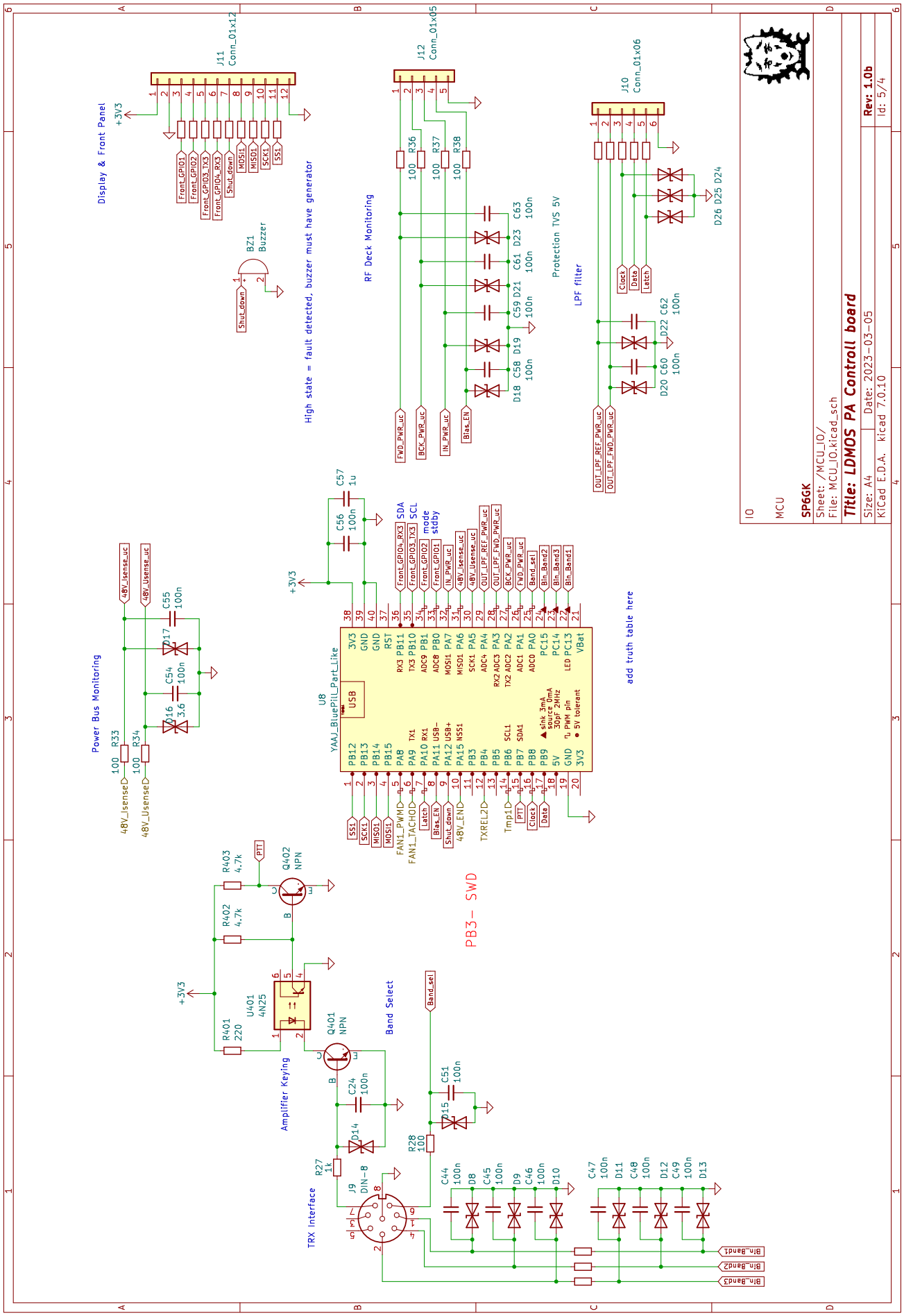
Controller Schematic, 48 V Rail



Controller Schematic, Temperature Sensors, Fans, Relays



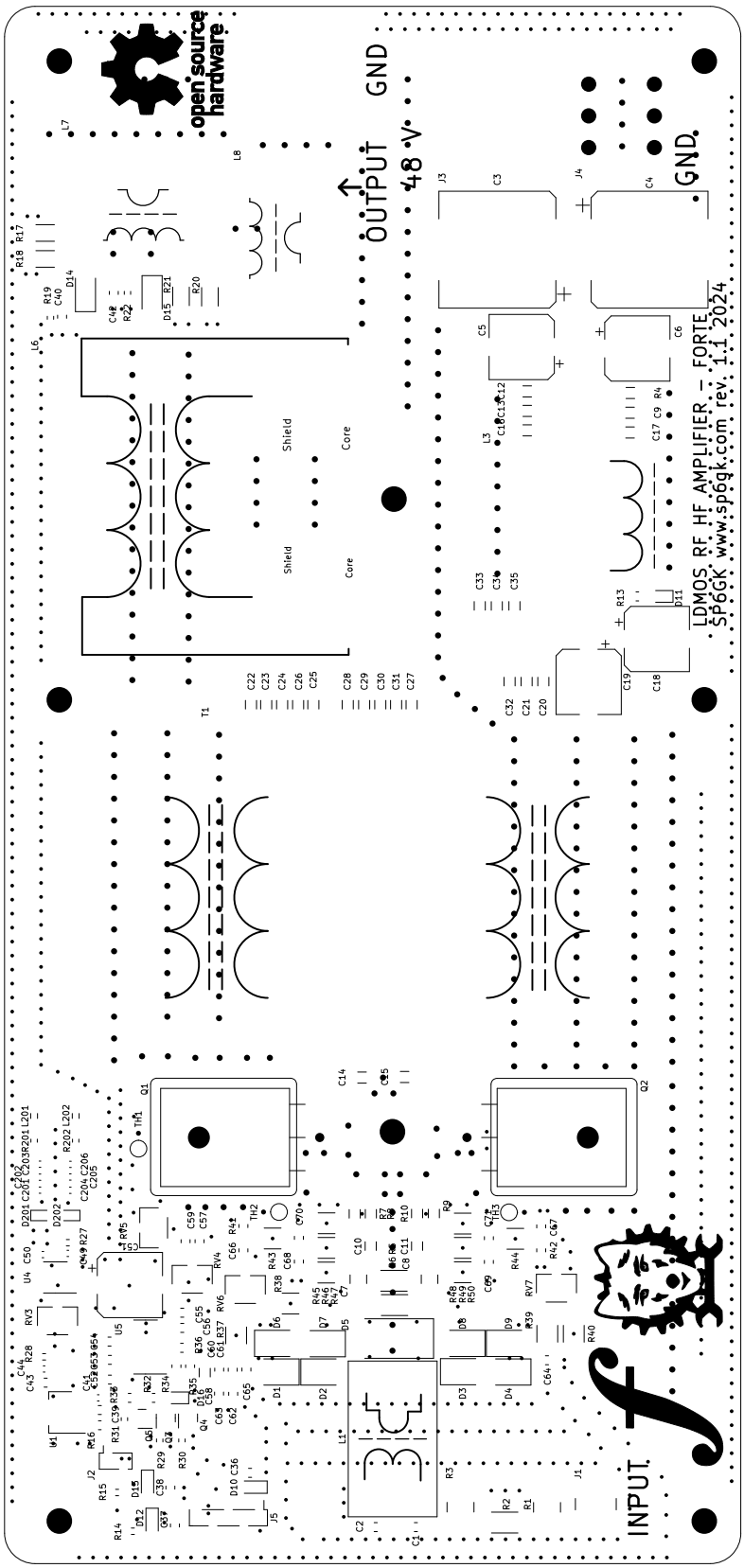
Controller Schematic, Microcontroller



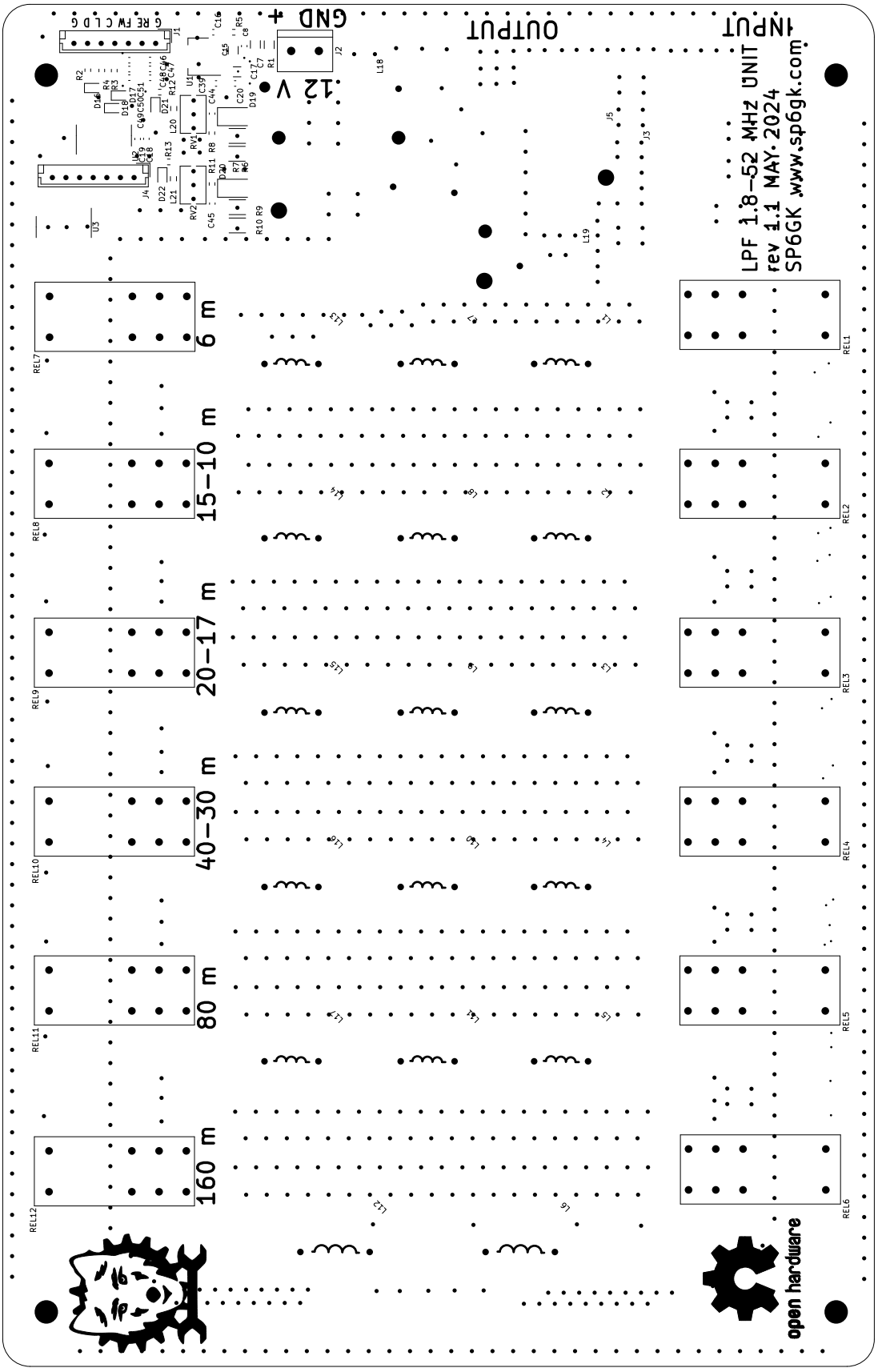
7.12 PCB Silkscreens

Presented silk screen layers are not to scale.

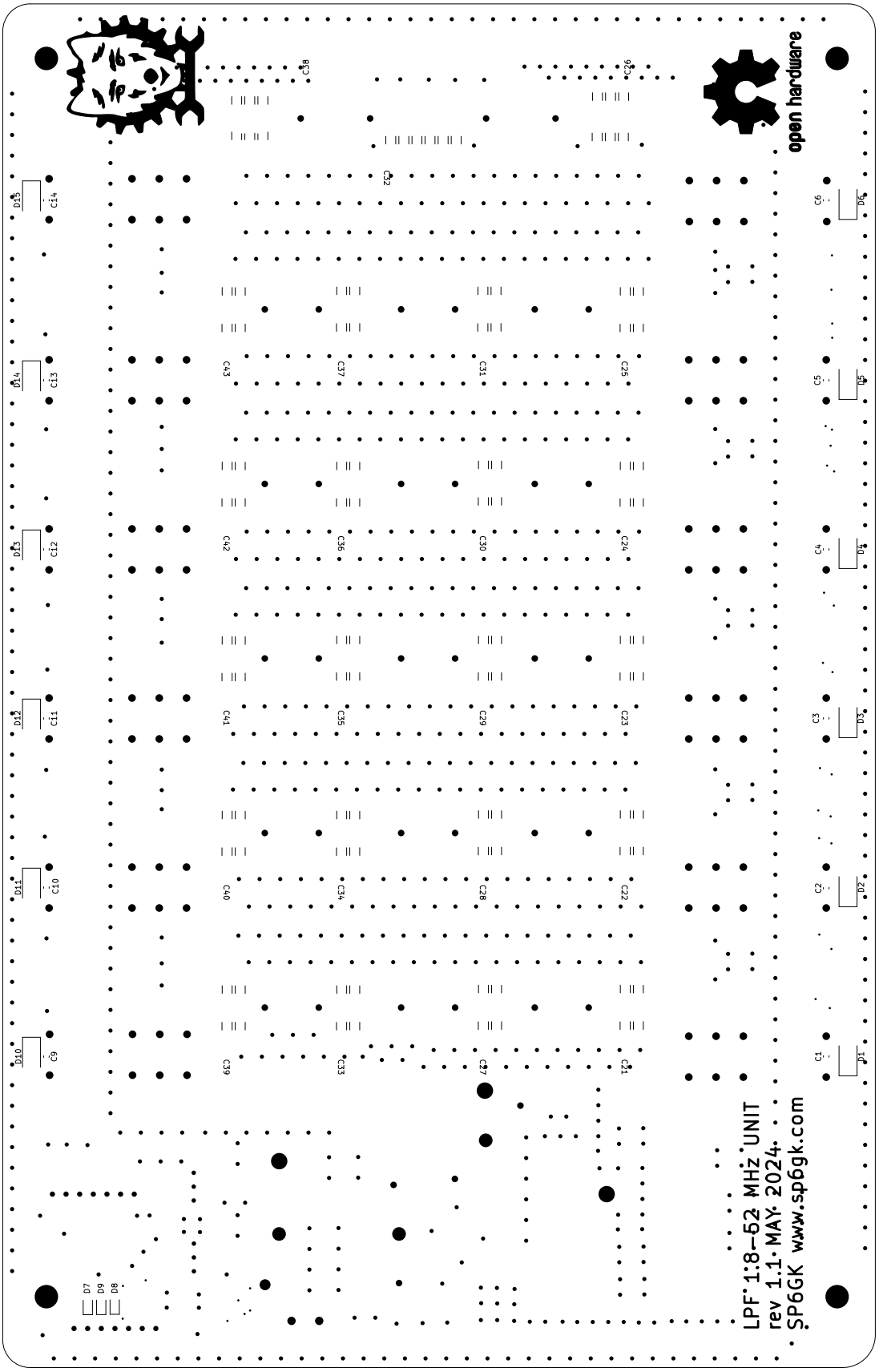
PA board Front Silkscreen



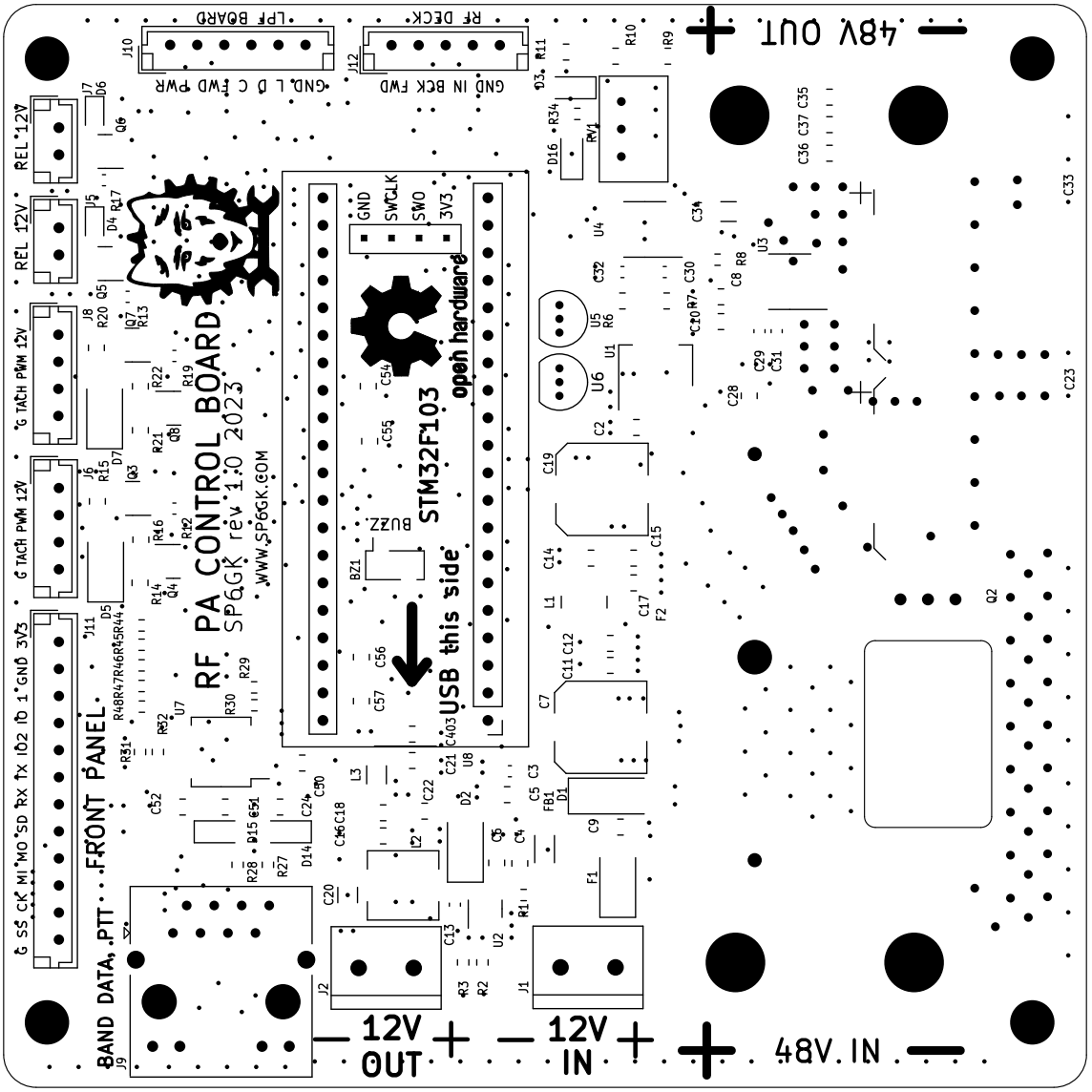
7.12.1 LPF Board Front Silkscreen



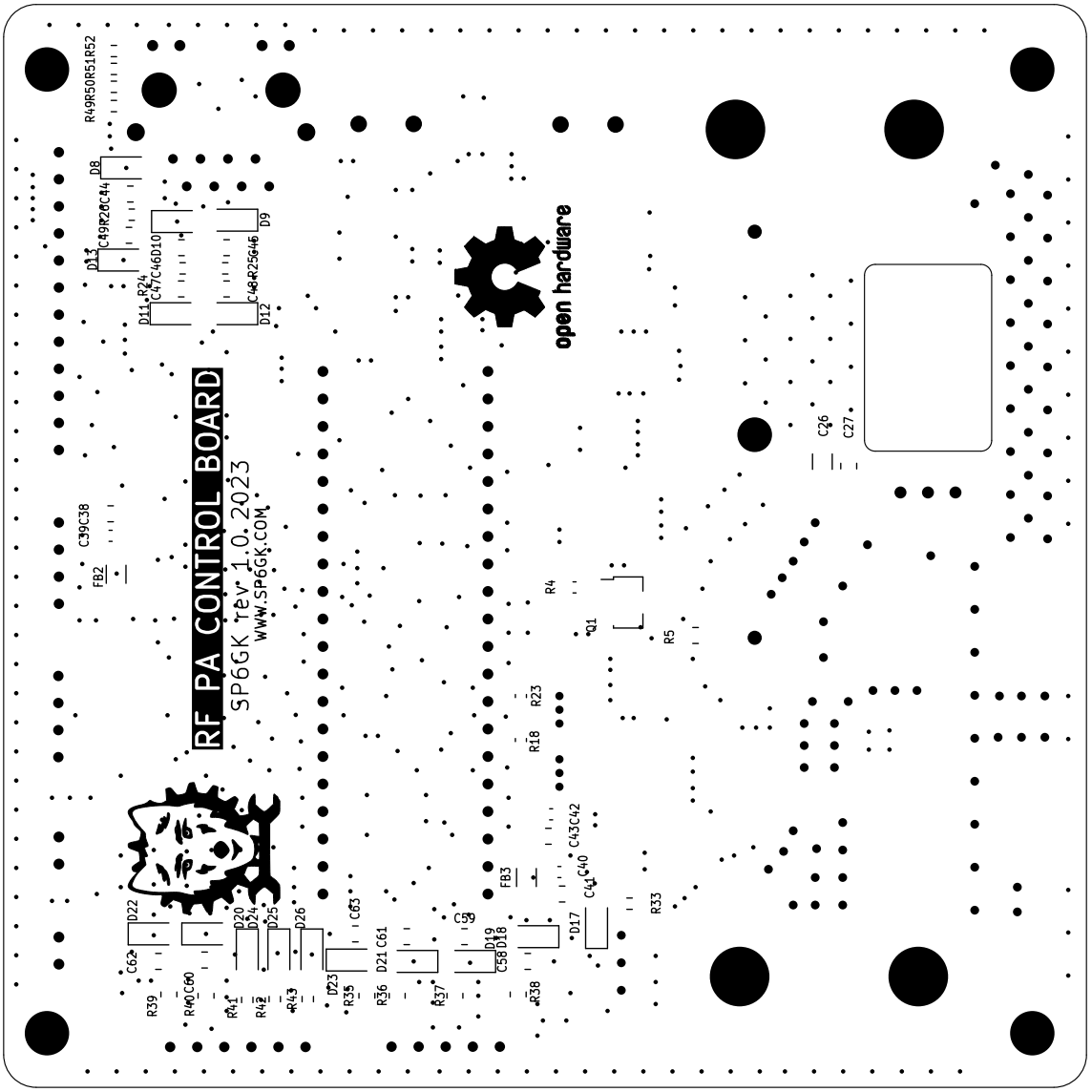
7.12.2 LPF Board Back Silkscreen



7.12.3 Controller Board Front Silkscreen



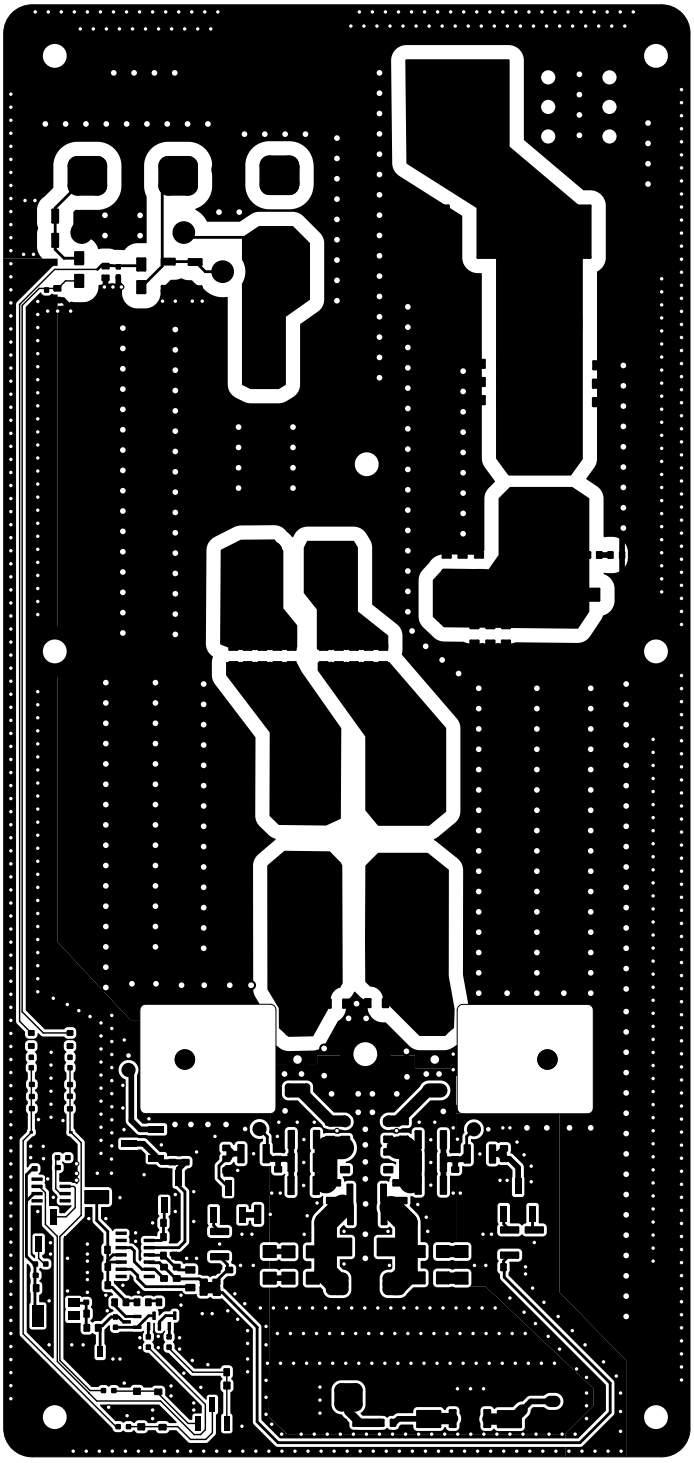
7.12.4 Controller Board Back Silkscreen



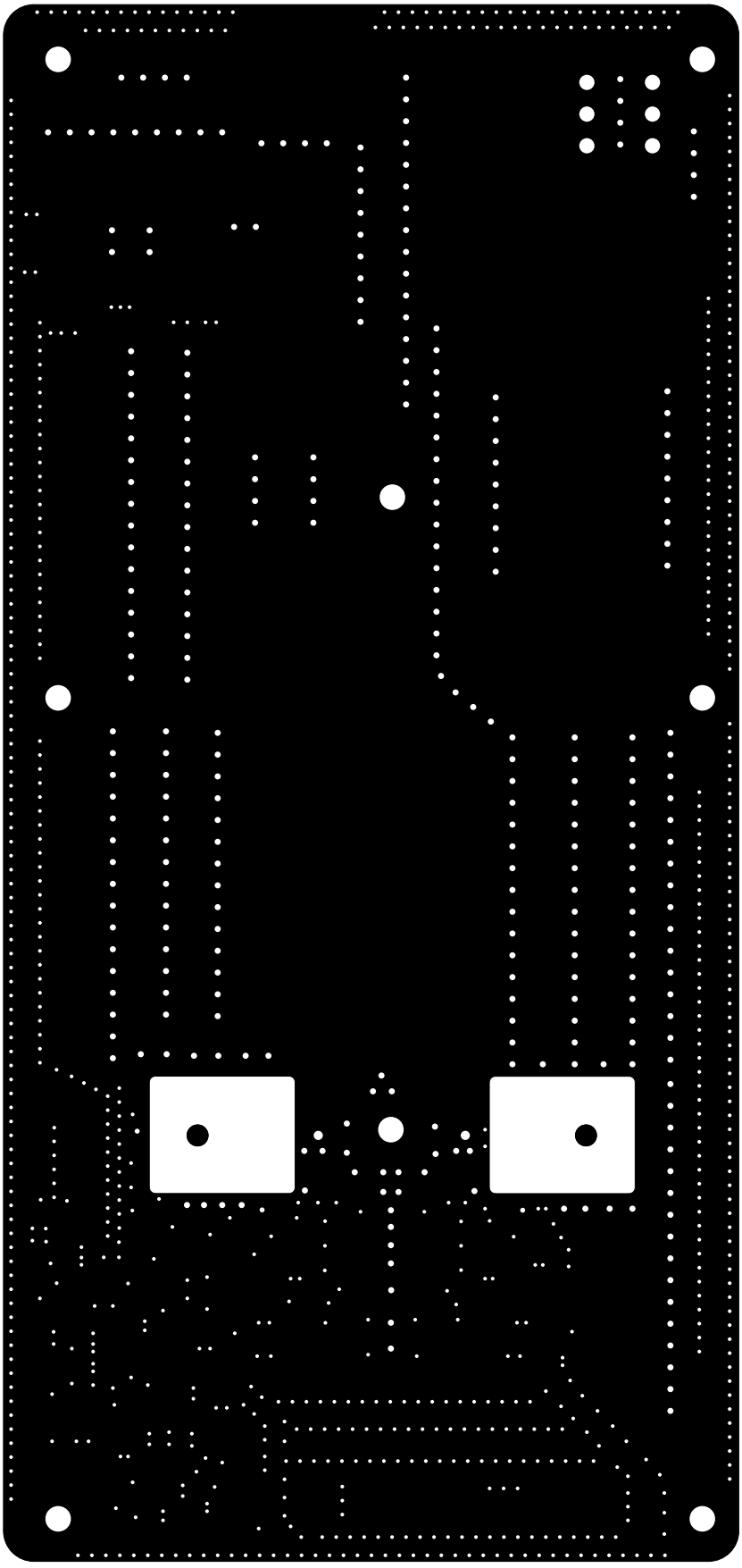
7.13 PCB Copper Layers

Presented copper layers are not to scale.

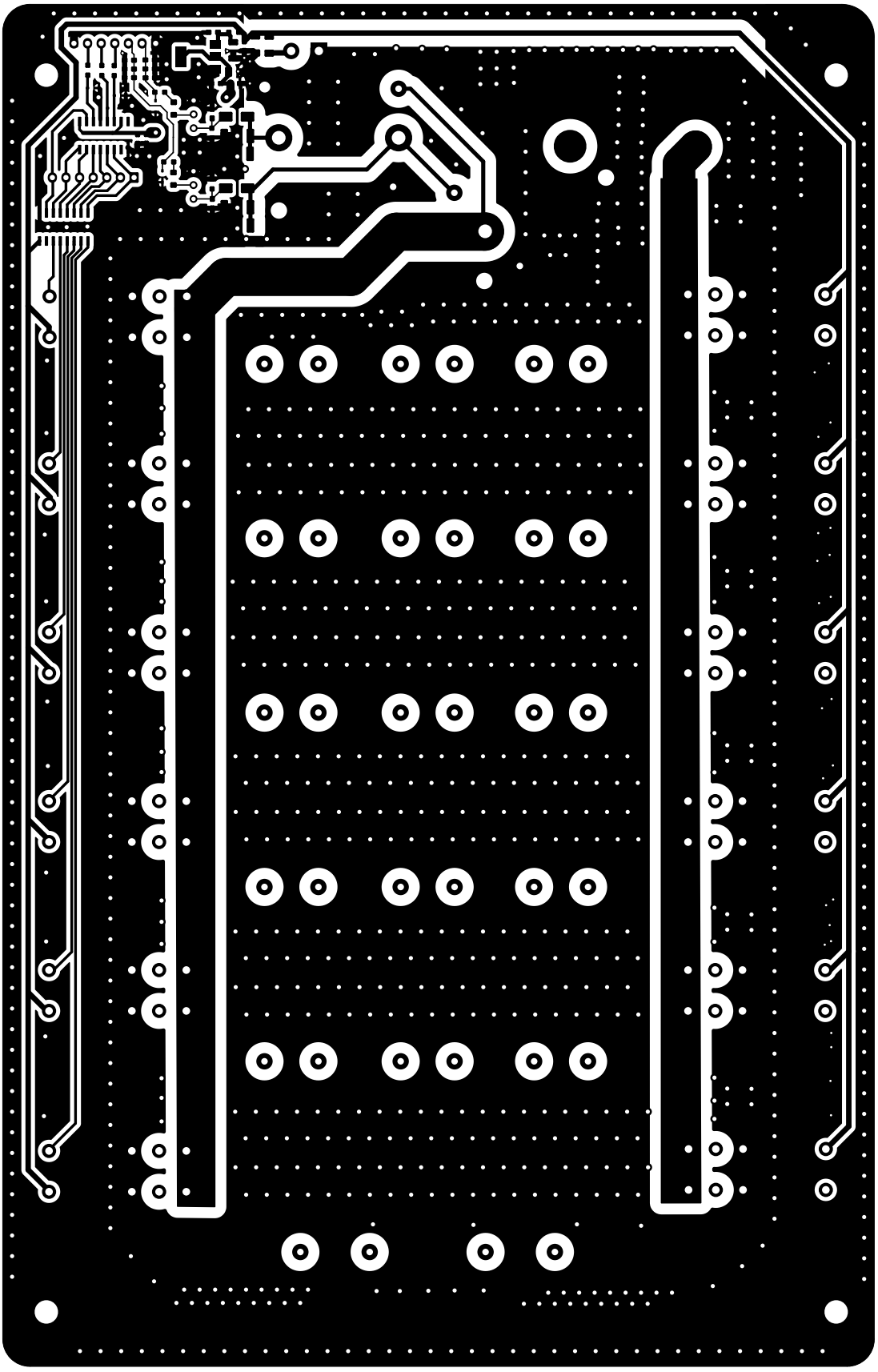
PA Board Front CU



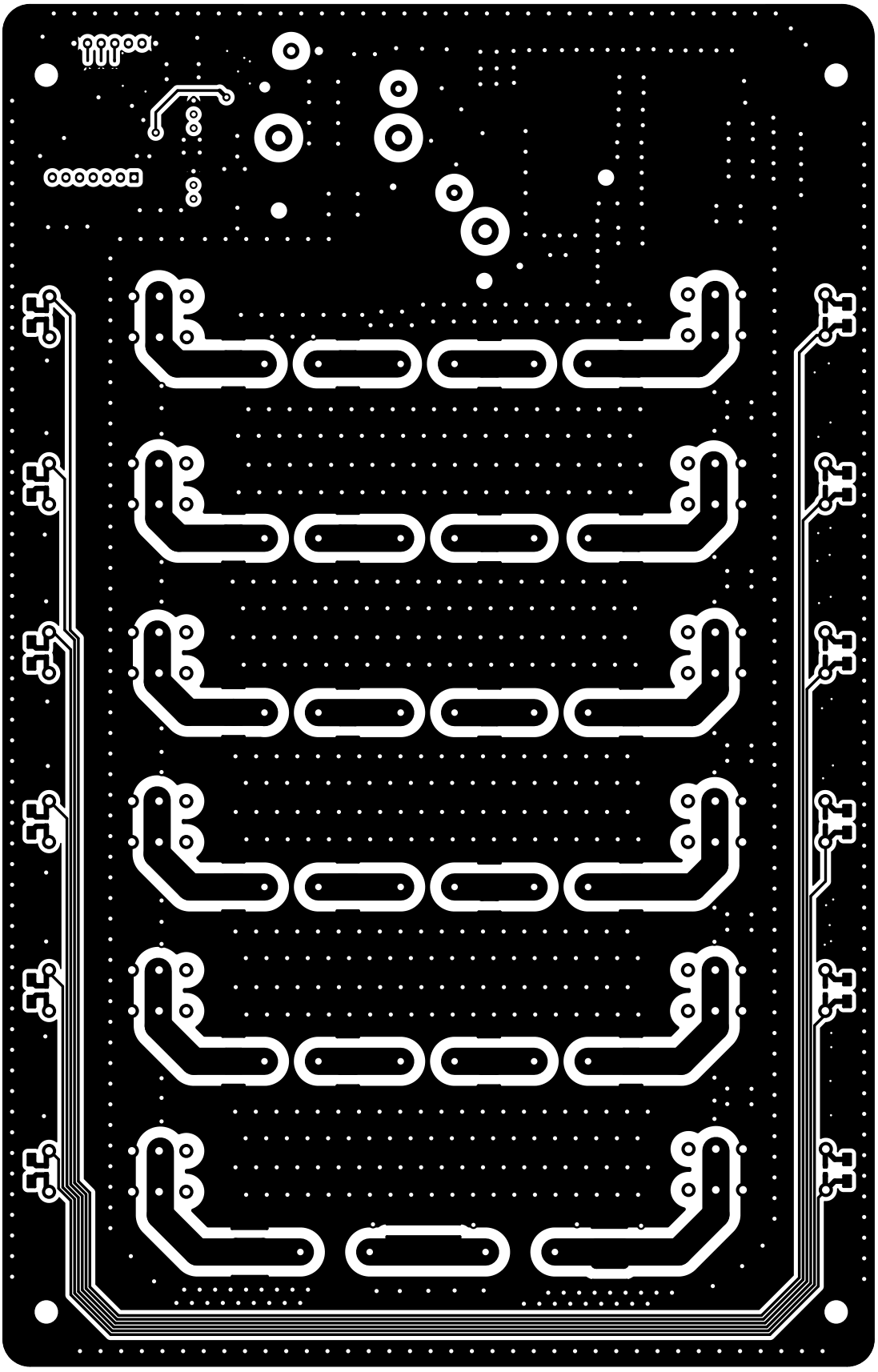
PA Board Back CU



7.13.1 LPF Board Front CU

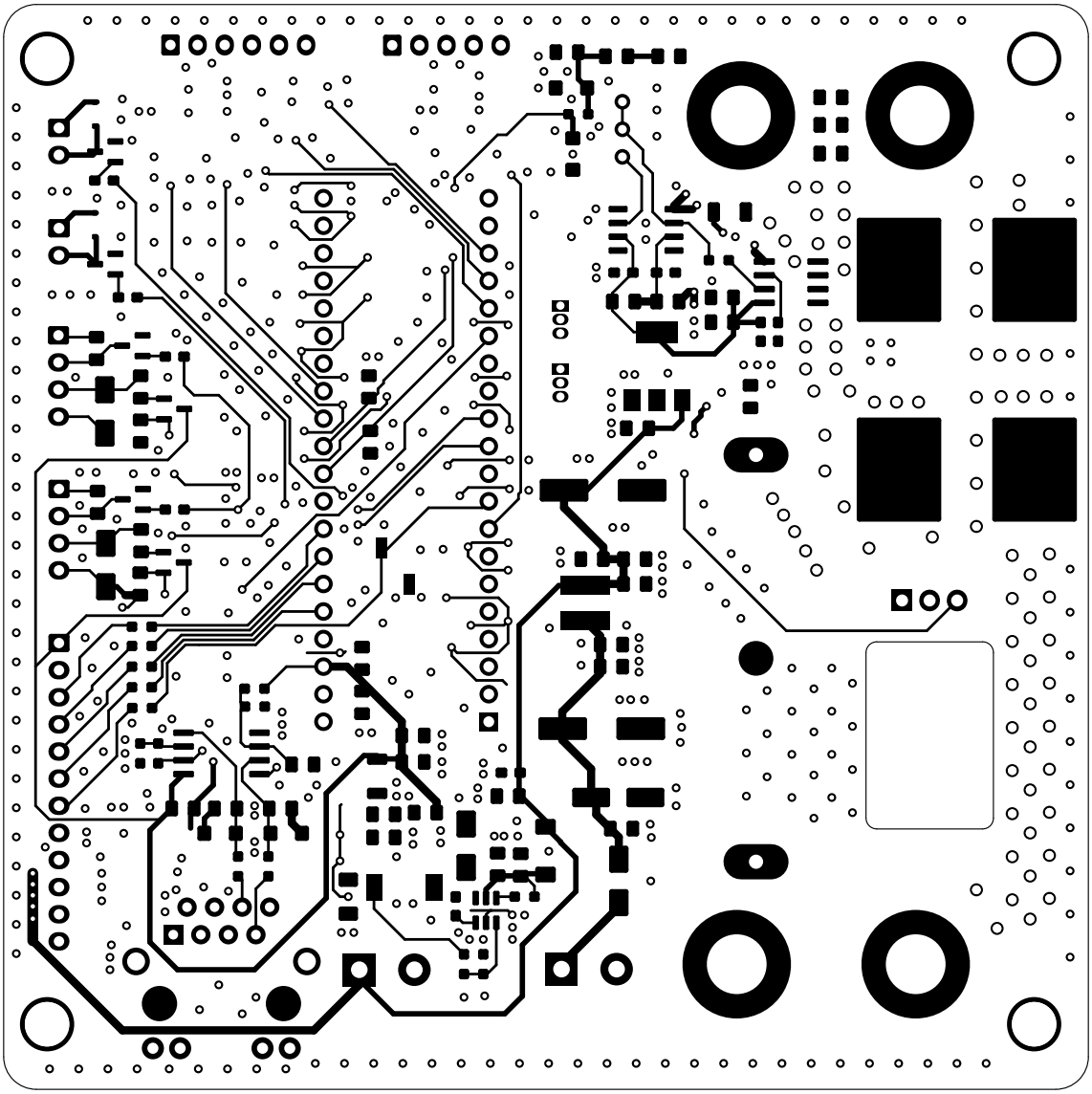


7.13.2 LPF Board Back CU

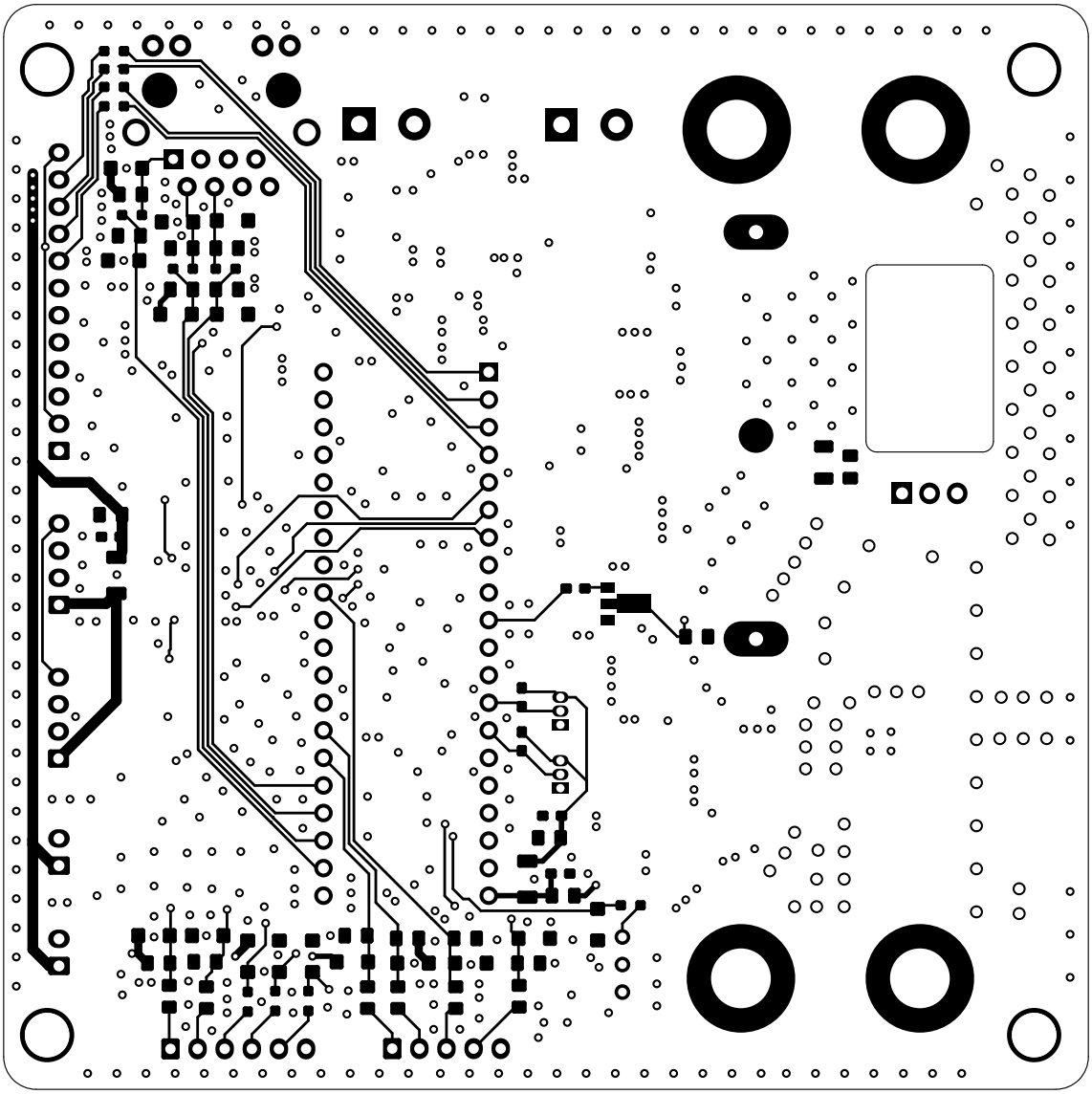


7.13.3 Controller Board Front CU

Copper ground pour is not included in order to increase the visibility of the traces.



7.13.4 Controller Board Back CU



7.14 BOM

7.14.1 PA Deck

References	Value	Footprint	Quantity
C36, C37, C38, C40, C42, C54, C56, C59, C63, C64, C65, C66, C67, C70, C71	100n, 25 V	0805	15
C16, C22, C23, C24, C26, C27, C28, C29, C30, C31, C33, C34	22n, 400 V	1206	12
C10, C11, C12, C13, C20, C21, C25, C32	100n, 400 V	1206	8
C39, C43, C52, C55, C57, C60, C61	10u, 25 V	0805	7
C41, C44, C49, C50, C202, C205	100n, 25 V	0603	6
C53, C62, C68, C69	1u, 25 V	0805	4
C14, C15, C58	100p, 1000 V	1206	3
C3, C4	330u, 63 V	CP_Elec_18x17.5	2
C5, C18	33u, 63 V	CP_Elec_10x10.5	2
C6, C19	10u, 63 V	CP_Elec_10x10.5	2
C7, C8	100n, 400 V	1210	2
C17, C35	10n, 100 n	1206	2
C201, C204	1u, 25 V	0603	2
C203, C206	10n, 25 V	0603	2
C1	33n, 50 V	0805	1
C2	22p, 50 V	0805	1
C9	1u, 63 V	1206	1
C51	47u, 25 V	CP_Elec_10x10.5	1
R37, R38, R39, R40, R43, R44, R45, R46, R47, R48, R49, R50	100, 2W Thin Metal	1812	12
R7, R8, R9, R10	4.7 0.25 W Thin Metal	1206	4
R14, R15, R201, R202	100	0603	4
R17, R18, R20, R21	100	2010	4
R19, R22, R27, R31	10k	0603	4
R16, R33, R34	10	0805	3
R28, R29, R30	1k	0603	3
R1, R3	300 3W Thin Metal	2816	2
R5, R6	33 3W Thin Metal	2512	2
R41, R42	4.7k	0805	2
R2	18 2W Thin Metal	2512	1
R4	47k	1206	1
R13	x	0805	1
R32	470	0805	1
R35	2.2k	0805	1
R36	14k	0805	1
L201, L202	100u	0805	2
L1	4:1	Binocular_trafo_small	1
L3	12 uH 20 A	EMI_inductor	1
L6	2x mat 43. 4T RG174 50 Ohm	Trafo_623-2661102002	1
L7	FT50-61 30T 1T RG-142 coax	FT82_trafo	1
L8	FT82-61 30T 1T-RG213 coax	FT82_trafo	1
D1, D4, D6, D9	1N4148WT	D_SMB	4
D2, D3, D7, D8	4.7	D_SMB	4
D12, D13	Protection TVS 5V	D_SMF	2
D14, D15	1N4148W	D_SMA	2
D201, D202	SD12_SOD323	D_SOD-323	2
D5	D_TVS	D_SMC_Handsoldering	1
D10	3.6	D_SMF	1
D11	48V_LED	0805	1
D16	BIAS_LED	0805	1
U1	AMS1117-5.0	SOT-223-3_TabPin2	1
U4	OP07	SOIC-8_3.9x4.9mm_P1.27mm	1
U5	LM723_DIP14	SO-14_3.9x8.65mm_P1.27mm	1
RV3, RV4, RV5	10k	Bourns_3269W_Vertical	3
TH1, TH2, TH3	5k	L6.3mm_D2.5mm_P2.54mm	3
Q3, Q4	BC846	SOT-23	2
RV6, RV7	500	Bourns_3269W_Vertical	2
Q1	MRF300AN	TO-247-3	1
Q2	MRF300BN	TO-247-3	1
Q5	PMOS	SOT-23	1
T1	1:9 TLT	TLT_Trafo	1
J3, J4	Keystone M5	M5_screw_terminal_Keystone	2
J1	SMA	SMA Vertical	1
J2	5.08mm	1x02 2.54mm	1
J5	Conn_01x05	1x05 2.54 mm	1

7.14.2 Controll Board

References	Value	Footprint	Quantity
C2, C5, C6, C8, C11, C12, C14, C15, C16, C21, C24, C27,C28, C35, C36, C44, C45, C46, C47, C48, C49, C50, C51, C52, C54, C55, C56, C58, C59, C60, C61, C62, C63	100n	0805	33
C4, C9, C10, C17, C18, C22, C38, C41, C43, C57, C403	1u	0805	11
C29, C30, C32, C39, C40, C42	100n	0603	6
C7, C19	100u	C_Elec_8x10.2	2
C23, C33	100u	CP_Elec_16x17.5	2
C26, C34	1u	1206	2
C3	1u	0603	1
C13	10n	0603	1
C20	22u	1206	1
C31	1n	0603	1
C37	22n	0805	1
R24, R25, R26, R27, R28, R33, R34, R41, R42, R43, R44, R45, R46, R47, R48, R49, R50, R51, R52	100	0603	19
R14, R15, R16, R20, R21, R22	4.7k	0805	6
R35, R36, R37, R38, R39, R40	100	0805	6
R4, R12, R13, R17, R19	10k	0603	5
R5, R11	1k	0805	2
R6, R7	10k	0805	2
R8, R31	4.7k	0603	2
R9, R10	7.5k	0805	2
R18, R23	4.7k	0603	2
R1	10k	0603	1
R2	51k	0603	1
R3	15k	0603	1
R29	2.3k	0603	1
R30	3.3k	0603	1
R32	5.6k	0603	1
L1	10u	Ferrocore_DLG-0403	1
L2	L_Small	L_6.3x6.3_H3	1
L3	1u	1206	1
D8, D9, D10, D11, D12, D13, D14, D15, D17, D19, D22, D24, D25, D26	D_TVS	D_SMF	14
D16, D18, D20	3.6	D_SMF	3
D4, D6	1SS355VM	D_SOD-323F	2
D5, D7	D_TVS	D_SMA	2
D21, D23	Protection TVS 5V	D_SMF	2
D1	D	D_SMA	1
D2	SS14	D_SMA	1
D3	3.6V	D_SMF	1
U5, U6	MAX31820	TO-92_Inline	2
U1	AMS1117-5.0	SOT-223-3_TabPin2	1
U2	AOZ1280CI	SOT-23-6	1
U3	ACS712xLCTR-30A	SOIC-8_3.9x4.9mm	1
U4	OP07	SO-8_3.9x4.9mm	1
U7	LM358	SO-8_5.3x6.2mm	1
U8	YAAJ_BluePill_Part_Like	YAAJ_BluePill_1	1
F1	1A 12V	D_SMA	1
F2	20A 48V	6.3x32mm	1
Q3, Q4, Q5, Q6, Q7, Q8	BC846	SOT-23	6
FB2, FB3	FerriteBead_Small	1206	2
BZ1	Buzzer	1x02_P2.54mm	1
FB1	FerriteBead_Small	1806	1
Q1	BCX56TA	SOT-89-3	1
Q2	AOB411L	TO-220-3_Vertical	1
RV1	20k	Bourns_3299W_Vertical	1
J1, J2	XT60	TerminalBlock_2_P5.08mm	2
J3, J4	Screw_Terminal_01x02	48Busfootprint	2
J5, J7	Conn_01x02	1x02_P2.50mm_Vertical	2
J6, J8	Conn_01x04	1x04_P2.50mm_Vertical	2
J9	DIN-8	RJ45SS74301-00x	1
J10	Conn_01x06	JST_EH_B6B-EH-A_1x06_P2.50mm_Vertical	1
J11	Conn_01x12	JST_EH_B12B-EH-A_1x12_P2.50mm_Vertical	1
J12	Conn_01x05	JST_EH_B5B-EH-A_1x05_P2.50mm_Vertical	1

7.14.3 TX/RX Relay Board

References	Value	Footprint	Quantity
C1, C3, C7, C9, C10, C11, C16, C17, C18, C20, C22, C24	100n	0603	12
C4, C6, C15	22n	0805	3
C5, C8, C14	100n	0805	3
C12, C13, C21	1u	0805	3
C19, C23	10u	0805	2
R1, R4, R7, R13, R20	10k	0603	5
R14, R16, R17, R18, R19	1k	0603	5
R2, R3, R5, R6	100	2010	4
R8, R10	100	0603	2
R11, R12	510	1206	2
R9	50	SMA_Vertical	1
R15	10	2010	1
L4, L6, L7	1m	1812	3
L1, L2	L_Ferrite_Coupled	FT82_trafo	2
L3, L5	L_Small	0603	2
L8	100u	1206	1
D1, D8	1N4007	D_SMA	2
D2, D3	Schottky	D_SMA	2
D4, D5	BAP64	D_SOD-323	2
D6, D7	D_TVS	D_SOD-323	2
U1	OP07	SOIC-8_3.9x4.9mm_P1.27mm	1
U2	AMS1117-5.0	SOT-223-3_TabPin2	1
Q1, Q2, Q5	MMSS8550HE3	SOT-23	3
K1, K2	RT314A05	Relay_SPDT_Schrack-RT1-16A-FormC_RM5mm	2
Q4, Q6	PNP	SOT-23	2
Q3	BC847	SOT-23	1
RV1	10k	Potentiometer_Bourns_3296W_Vertical	1
J1	Screw_Terminal_01x02	TerminalBlock_bornier-2_P5.08mm	1
J2	Conn_01x08	JST_EH_B8B-EH-A_1x08_P2.50mm_Vertical	1
J3	IN	SMA_Amphenol_901-144_Vertical	1
J4	IN_RF_Deck	SMA_Amphenol_901-144_Vertical	1
J5	OUT_RF_Deck	Coax_solder	1
J6	OUT	Coax_solder	1

7.14.4 LPF Board

References	Value	Footprint	Quantity
C1, C2, C3, C4, C5, C6, C8, C9, C10, C11, C12, C13, C14, C16, C18, C20, C39, C44, C45, C47, C50	100n	0603	21
C25, C31, C37, C43	834p	4x1206_2	4
C19, C46, C49	1u	0603	3
C26, C32, C38	C_Small	6x1206	3
C7, C17	10u	1206	2
C21, C39	71p	4x1206_2	2
C22, C40	123p	4x1206_2	2
C23, C41	203p	4x1206_2	2
C24, C42	357p	4x1206_2	2
C27, C33	127p	4x1206_2	2
C28, C34	218p	4x1206_2	2
C29, C35	360p	4x1206_2	2
C30, C36	635p	4x1206_2	2
C48, C51	10n	0603	2
C15	10u	1206	1
R2, R3, R4, R5, R12, R13	100	0603	6
R6, R7, R9, R10	100	2010	4
R8, R11	10k	0603	2
R1	10	0603	1
L1, L2, L3, L4, L5, L7, L8, L9, L10, L11, L13, L14, L15, L16, L17	L	T94-Inductor	15
L6, L12	L	T106-Inductor	2
L20, L21	100u	0805	2
L18	FT50-61 30T 1T RG-142 coax	T94-SWR_TRAFO	1
L19	FT82-61 30T 1T-RG213 coax	T94-SWR_TRAFO	1
D1, D2, D3, D4, D5, D6, D10, D11, D12, D13, D14, D15	1N4007	D_SMA	12
D7, D8, D9, D16, D17, D18, D21, D22	SD12_SOD323	D_SOD-323	8
D19, D20	Schottky	D_SMA	2
U1	AMS1117-5	SOT-223-3_TabPin2	1
U2	74AHC595	SO-16_3.9x9.9mm_P1.27mm	1
U3	ULN2003	SO-16_3.9x9.9mm_P1.27mm	1
REL1, REL2, REL3, REL4, REL5, REL6, REL7, REL8, REL9, REL10, REL11, REL12	RM85	RM85_Relay	12
RV1, RV2	10k	Potentiometer_Bourns_3266Y_Vertical	2
J1, J4	Conn_01x07	JST_EH_B7B-EH-A_1x07_P2.50mm_Vertical	2
J2	12V INPUT	TerminalBlock_bornier-2_P5.08mm	1
J3	RF input	Coax_Mount	1
J5	RF output	Coax_Mount	1