Sailmaking Plotter

User Manual and Technical Manual

Sailmaking Plotter User Manual

The plotter is controlled by a PC that runs the Microsoft DOS operating system and a sailmaking application called ProSail.

When the PC is turned ON, the DOS operating system will boot and a menu application will automatically start running. From the menu the user may enter DOS (select “8”) or enter ProSail.

< For Philip to write the rest !!! >

Sailmaking Plotter Technical Manual

Electronically the plotter forms an open-loop control system. The main components are a PC, a desk of electronics, and the plotter mechanical system.

Within those, the main components are a PC with digital-to-analog (D/A) converter cards that drive power amplifiers in a desk, which themselves drive X & Y axes motors, that incorporate position encoders that feed back to a handmade decoder PCB that feeds back to digital input cards in the PC. At the PC, additional digital outputs drive a relay output PCB in the desk, that control various plotter solenoids, etc. And various plotter sensors feed back to an opto-isolator PCB in the desk, that feeds back to additional digital inputs in the PC. The architecture is shown in Figure 1 and the wiring layout is shown in Figure 2.

The loop is only closed by software.

Software outputs digital values that determine the output voltages of the D/A converters, which drive the X & Y motors via the power amplifiers. Software then inputs the plotter X & Y positions and alters the D/A output voltages in order to achieve its aims.

A console on the plotter has lamps driven by digital outputs of the PC, and switches that are sensed by digital inputs of the PC. The console is used by the operator to enable motors, to zero ('home') the plotter X & Y arms, to start and stop plotting.

A variety of microswitch interlocks ensure the motors are disabled when position limits are exceeded. The interlocks do not brake the motors, so inertia may still cause a bang as the X or Y arm hits spring-loaded end-stops; hence such maneuvers should be avoided except when necessary for debugging faults. An emergency stop button on the console also disables the motors (and so can also be used to minimise overrunning limits during testing).

The plotter axes are counter-intuitive: the X axis is vertical (along the roll of sailcloth), and the Y-axis is horizontal. A third Z axis motor is also controlled by the PC to rotate the sailcloth as needed.

The PC is deliberately isolated from the network to eliminate security incidents. It also deliberately runs the DOS version for which the ProSail application was designed in order to avoid compatibility issues arising from operating system upgrades. The PC hardware is deliberately mounted on the desk top surface to minimize any dust intake, and extra forced ventilation ensures the internal temperatures remain low. With care the system should continue to work correctly for many tens of years.

The PC internal layout is shown in Figure 43:
Slot 1 (top): standard multi-I/O card for ProSail dongle
Slot 2: standard multi-I/O card for mouse
Slot 3: PCL-720 digital I/O card
Slot 4: unoccupied
Slot 5: PCL-726 D/A card
Slot 6: unoccupied
Slot 7: VGA display card
Slot 8: standard games port card

The game port card base address is adjustable, and is set to 0200H.
The PCL-720 digital I/O card base address is adjustable, and is set to 02A0H.
The PCL-726 D/A card base address is adjustable, and is set to 0300H.

< Need tables of I/O port usages >

< Need photos of plotter mechanical system >

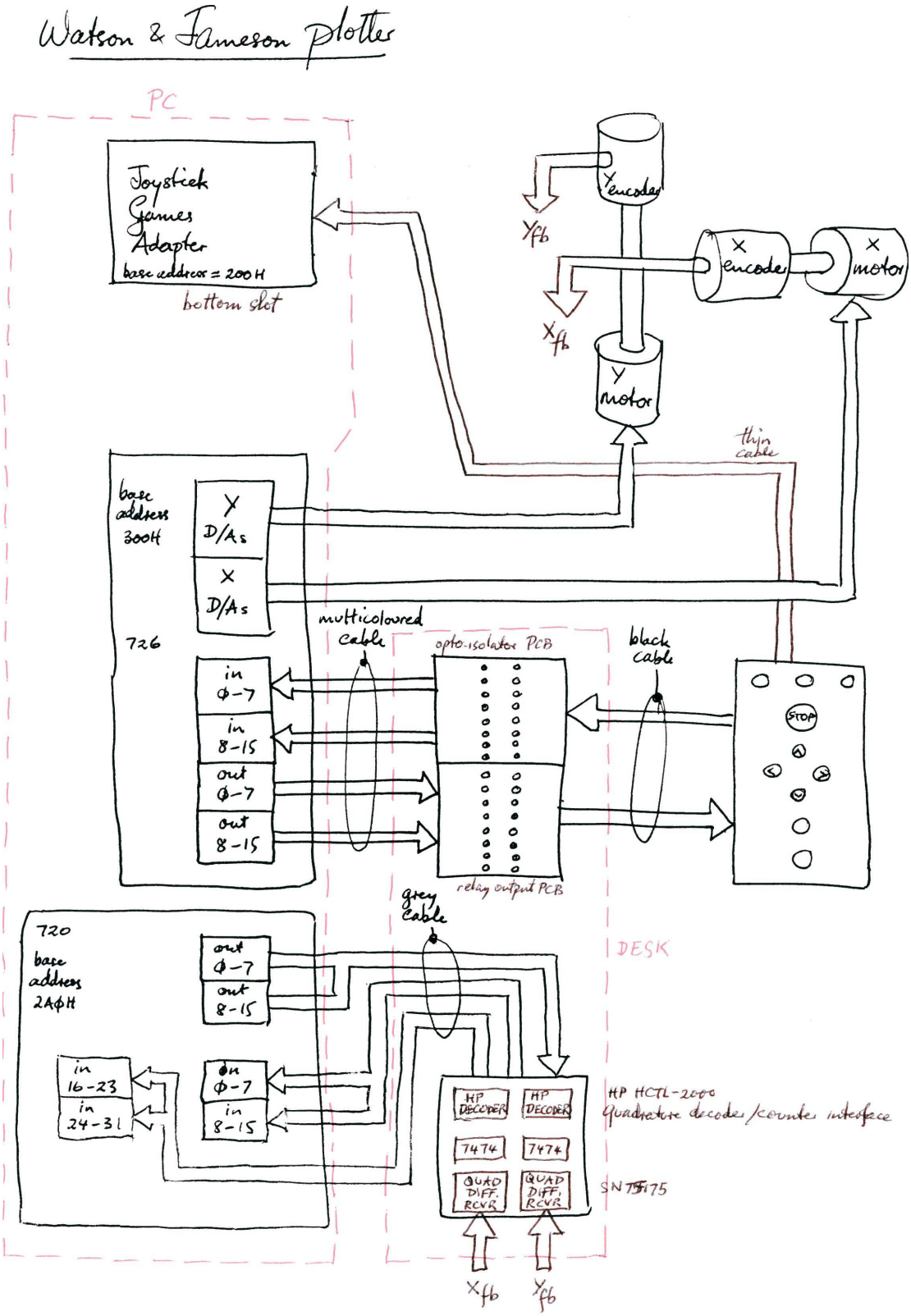


Figure 1: Plotter architecture

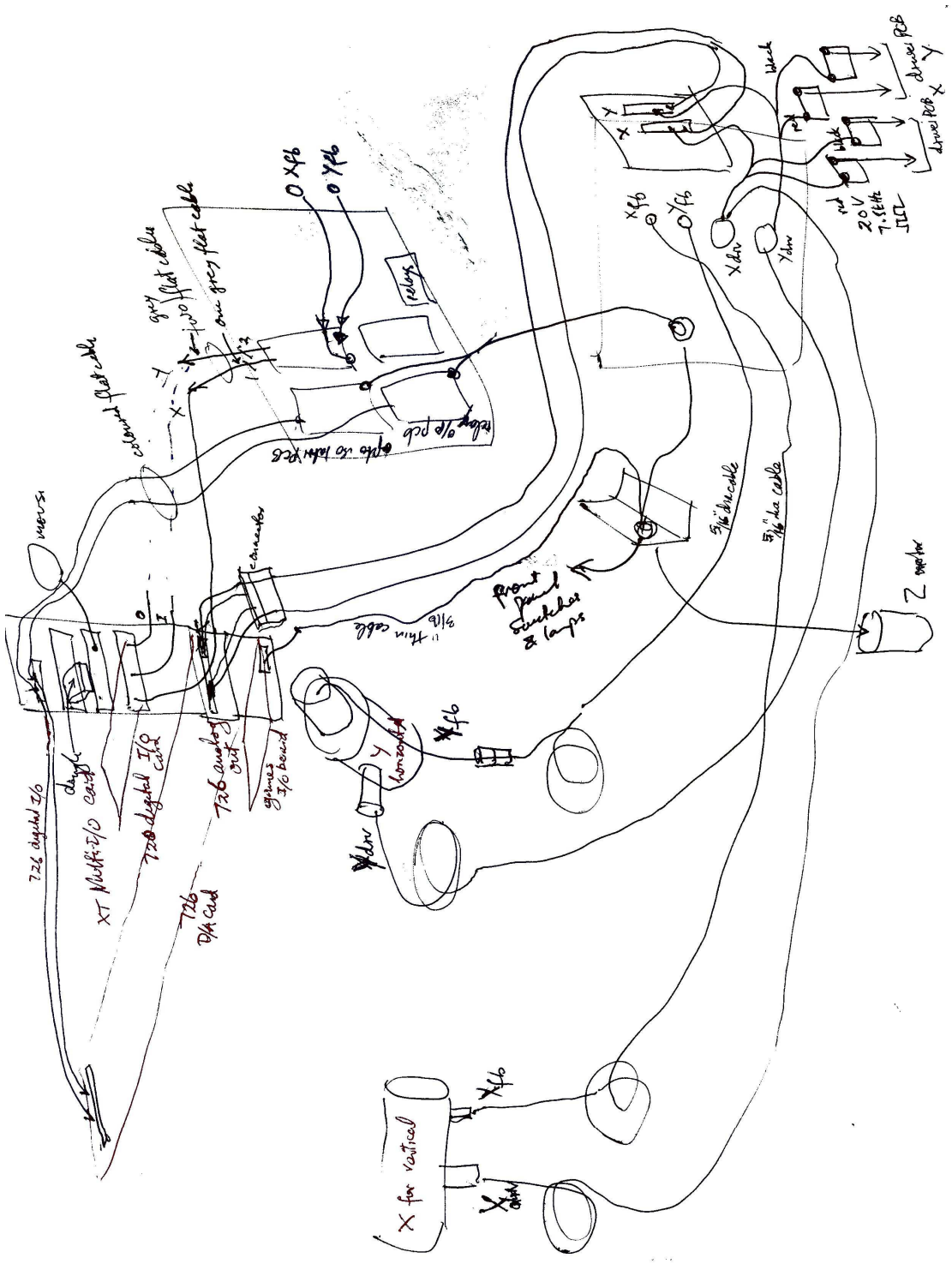


Figure 2: Plotter wiring layout

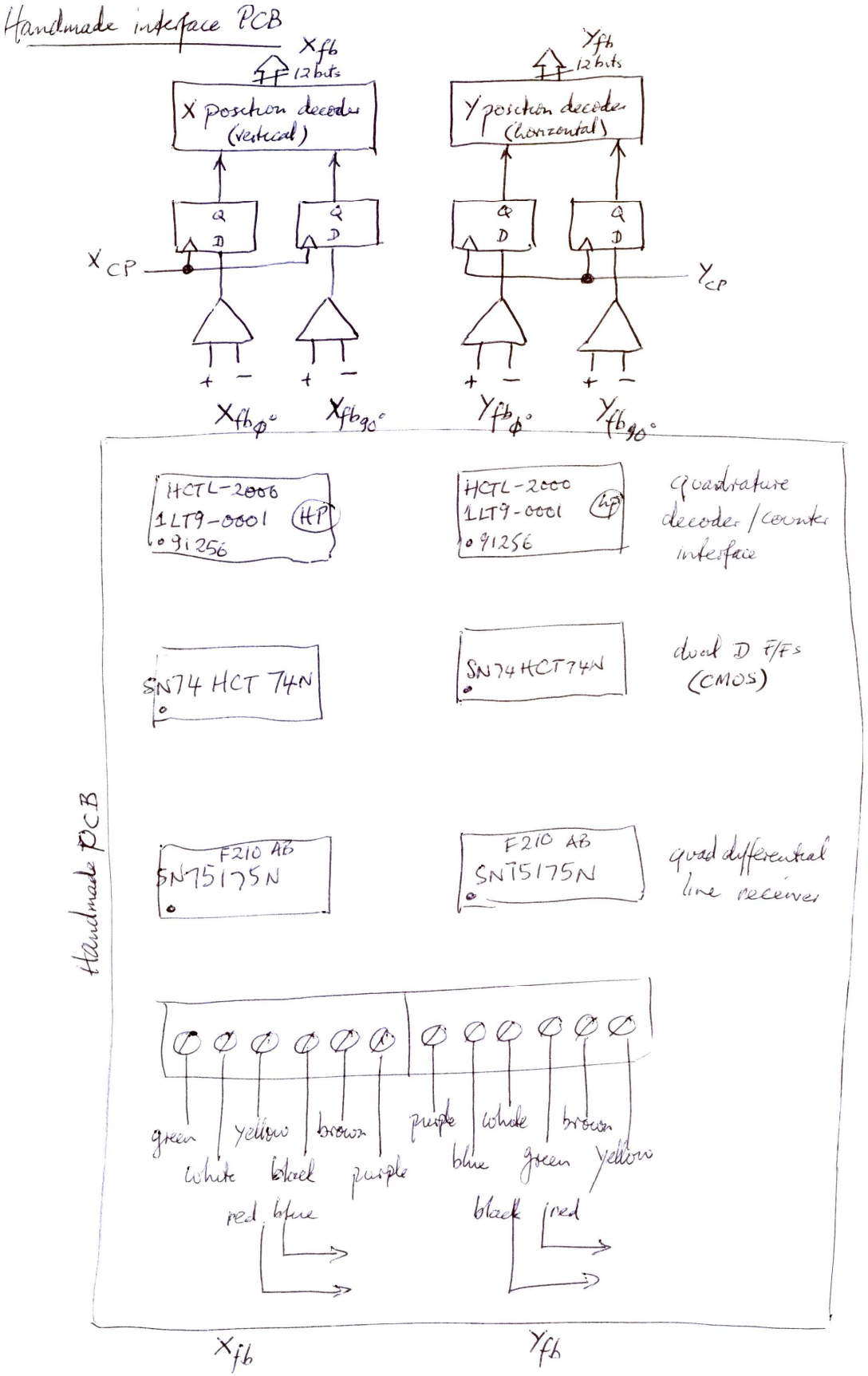


Figure 3: Handmade position decoder PCB.
(the PCB supports 3 axes, but the RHS axis is unused)

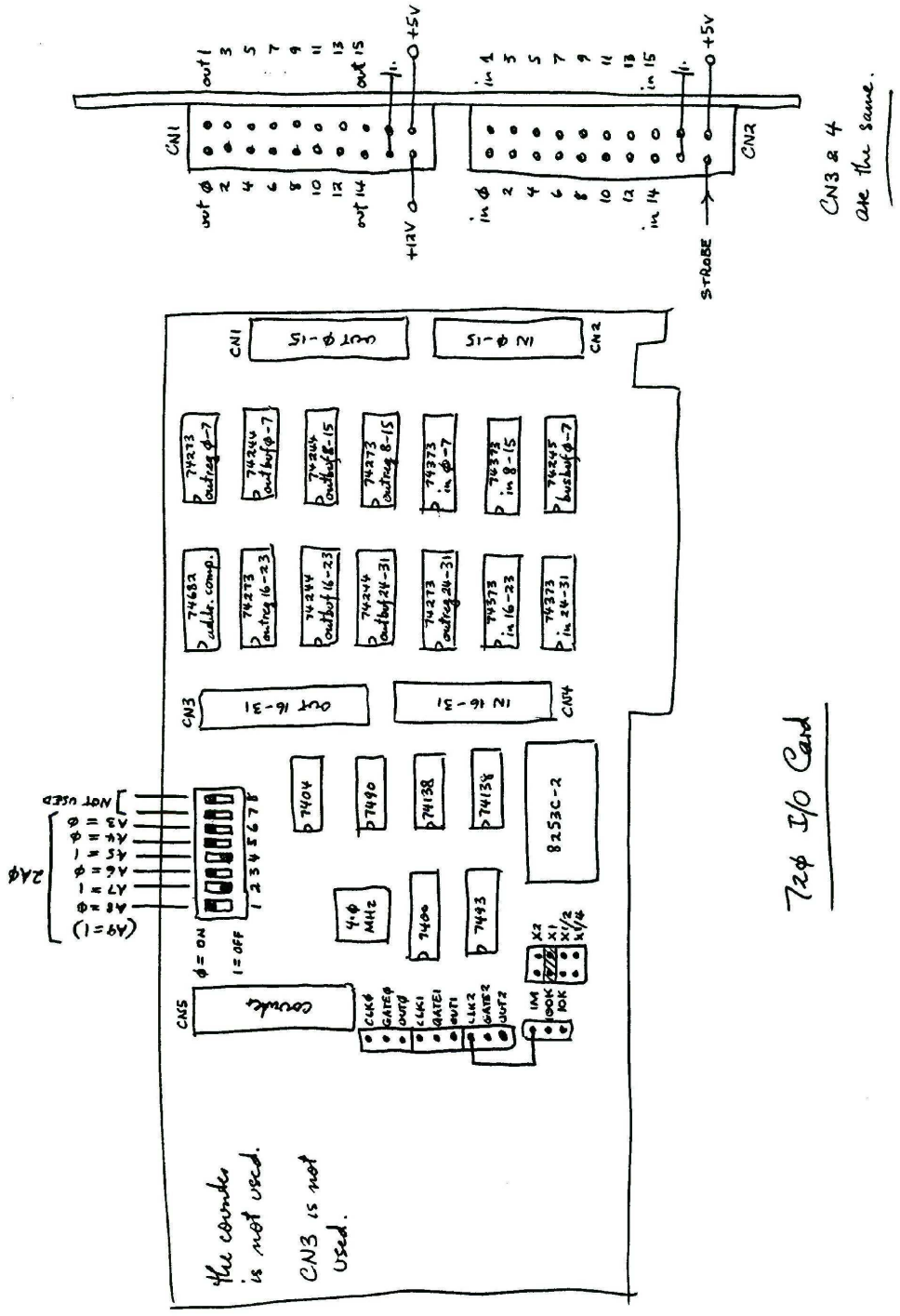


Figure 4: PCL-720 layout

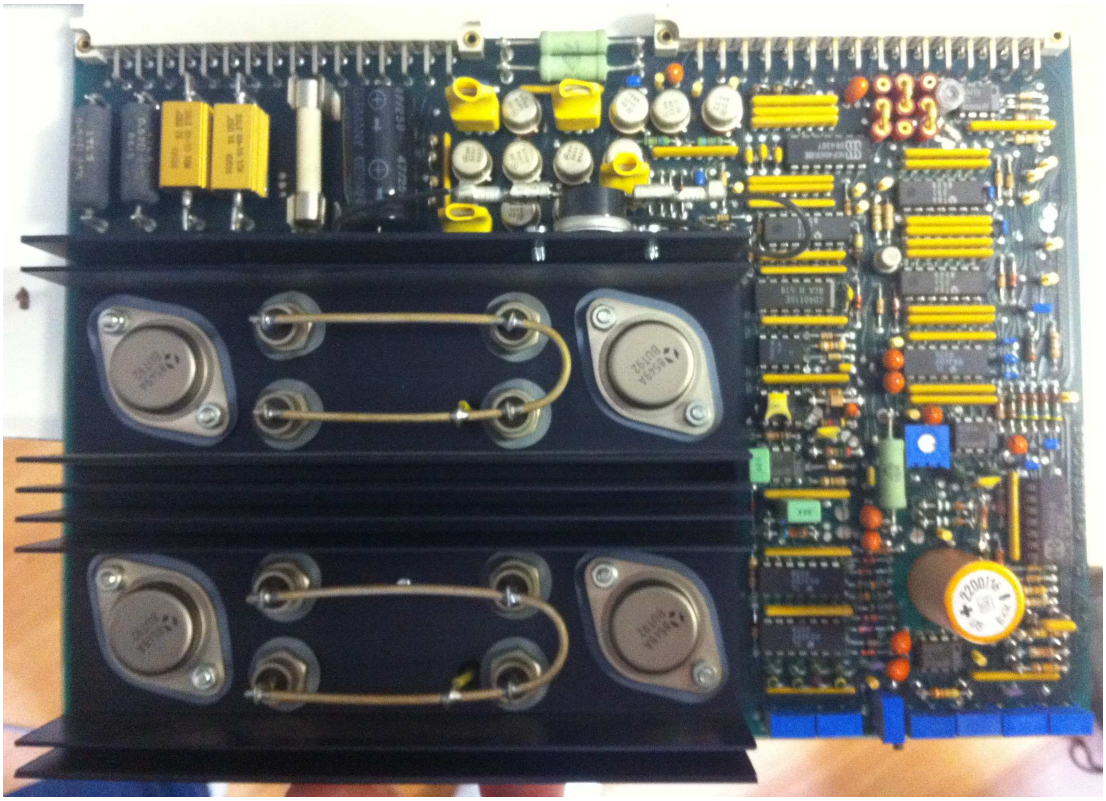


Figure 5: Power amplifier PCB.

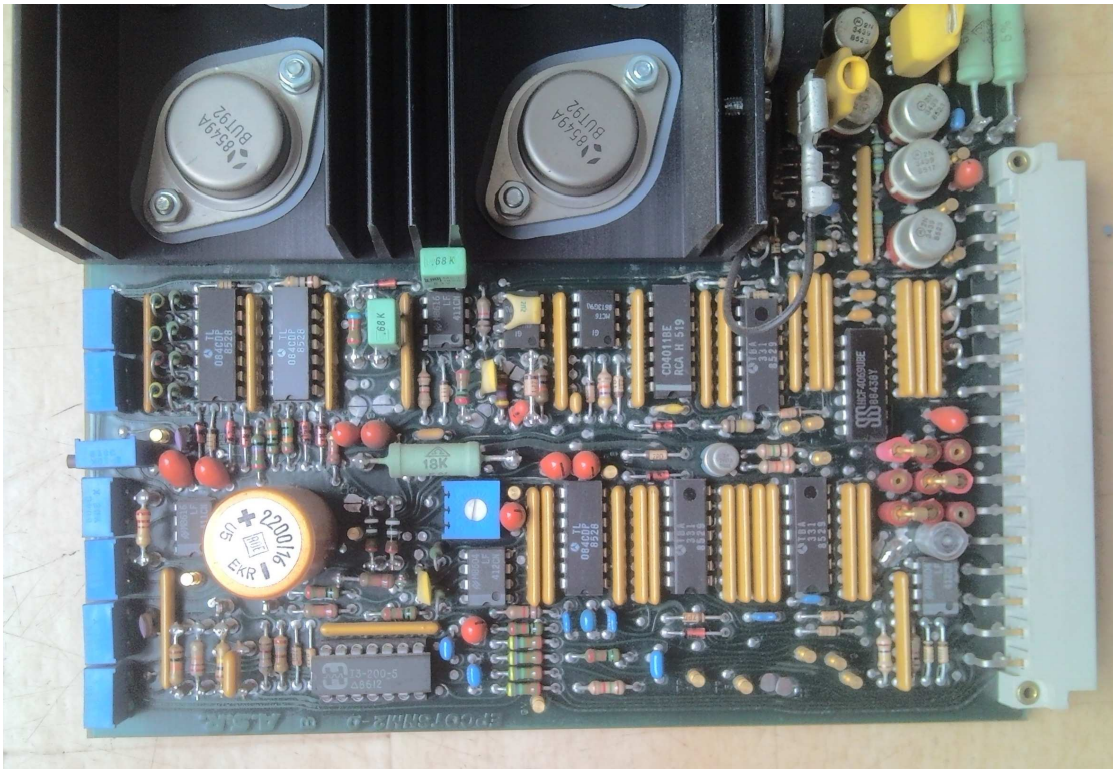


Figure 6: Power amplifier PCB left hand side.

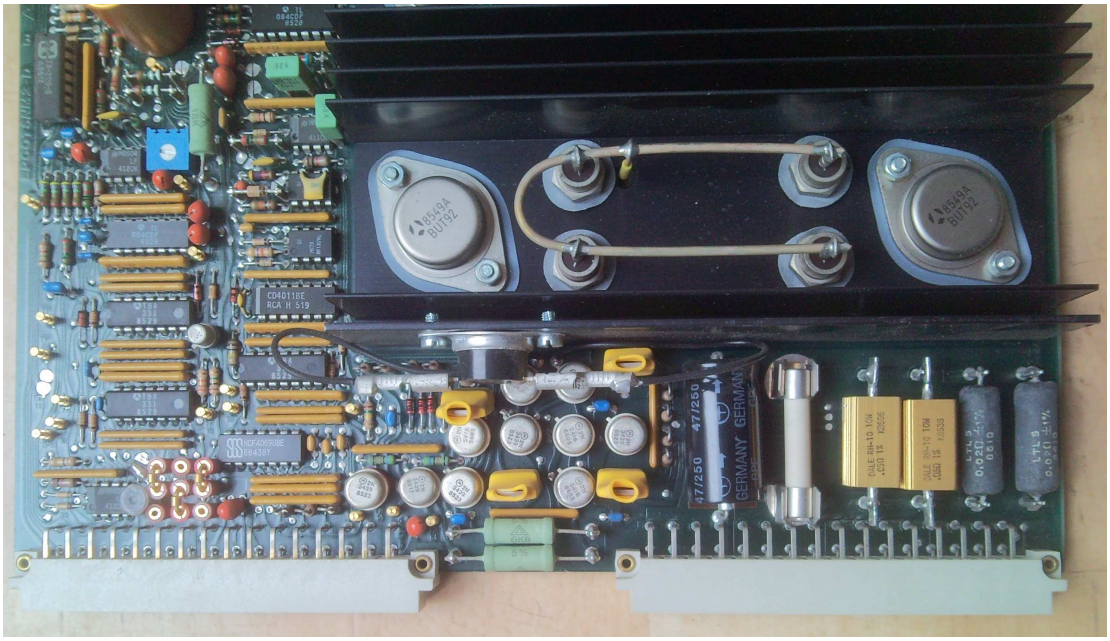


Figure 8: Power amplifier PCB lower edge

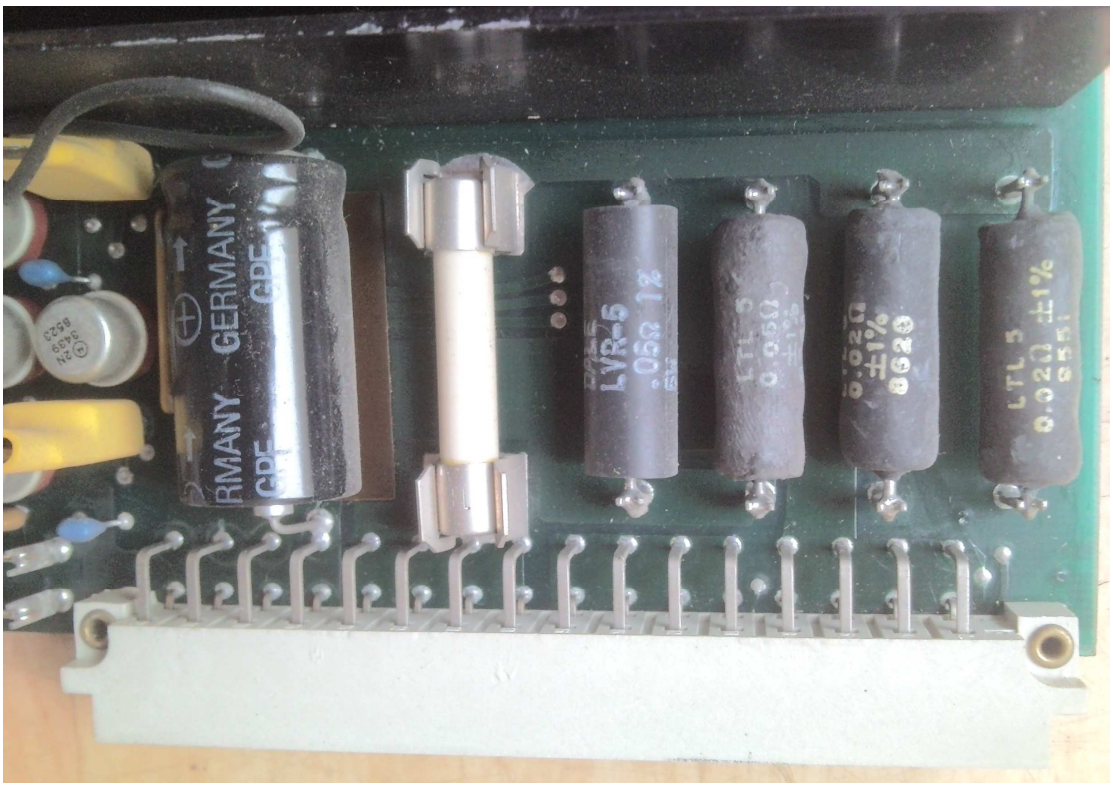


Figure 17: Power amplifier PCB lower right closeup

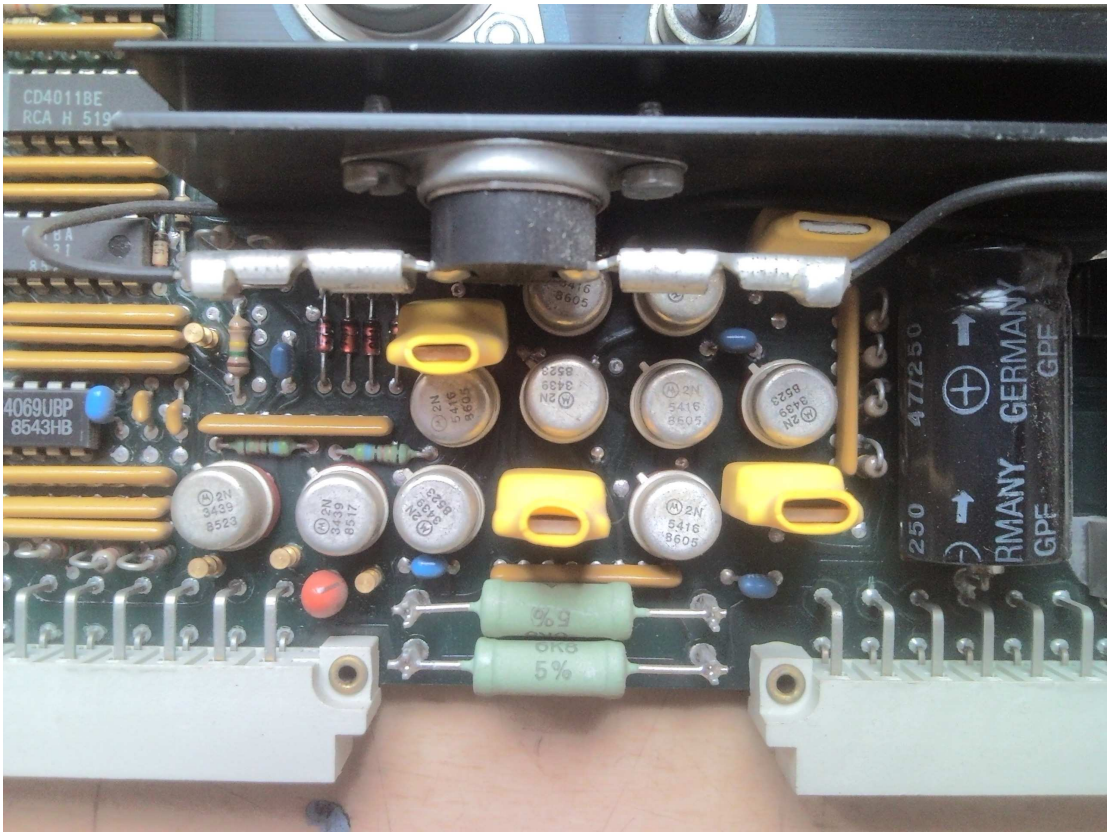


Figure 10: Power amplifier PCB lower middle.

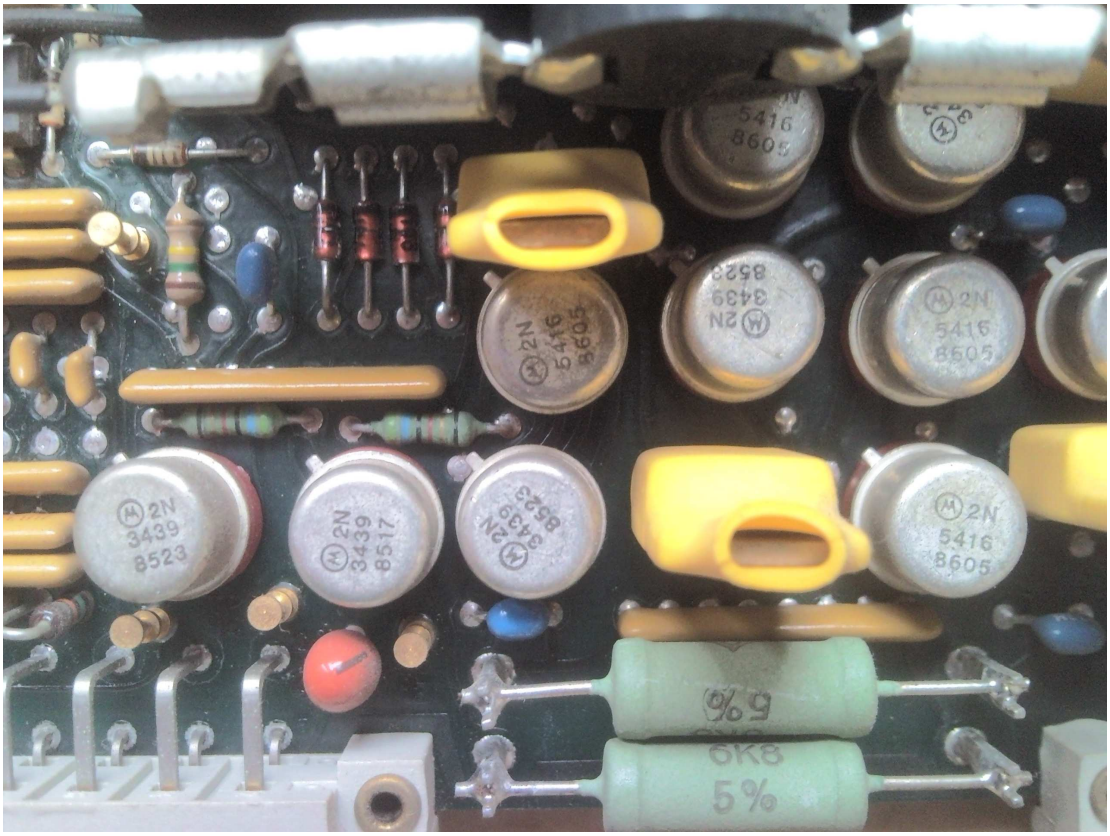


Figure 11: Power amplifier PCB lower middle closeup.
(transistors are Motorola 2N3439 and 2N5416)

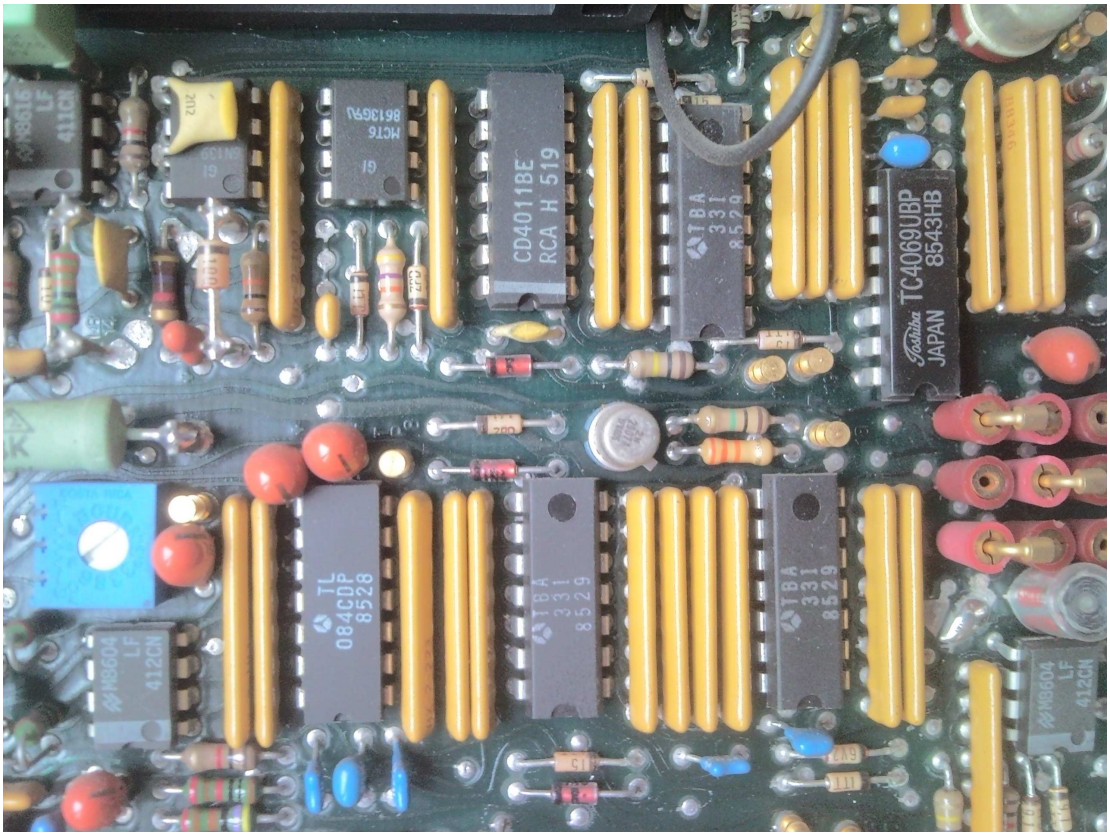


Figure 12: Power amplifier PCB lower left.

Top row:
(a) National Semiconductor LF411CN JFET-input operational amplifier
(b) General Instruments MCT6 Dual Phototransistor Optocouplers
(c) RCA CD4011BE CMOS quad 2-input NAND gate
(d) Thomson-CSF TBA331 transistor array
(e) Toshiba TC4069UBP hex inverter

Middle row:
(a) 2N2907A transistor

Bottom row:
(a) National Semiconductor LF412CN dual JFET-input operational amplifier
(b) TL084CDP quad JFET-input general-purpose operational amplifier
(c) Thomson-CSF TBA331 transistor array
(d) Thomson-CSF TBA331 transistor array
(e) National Semiconductor LF412CN dual JFET-input operational amplifier

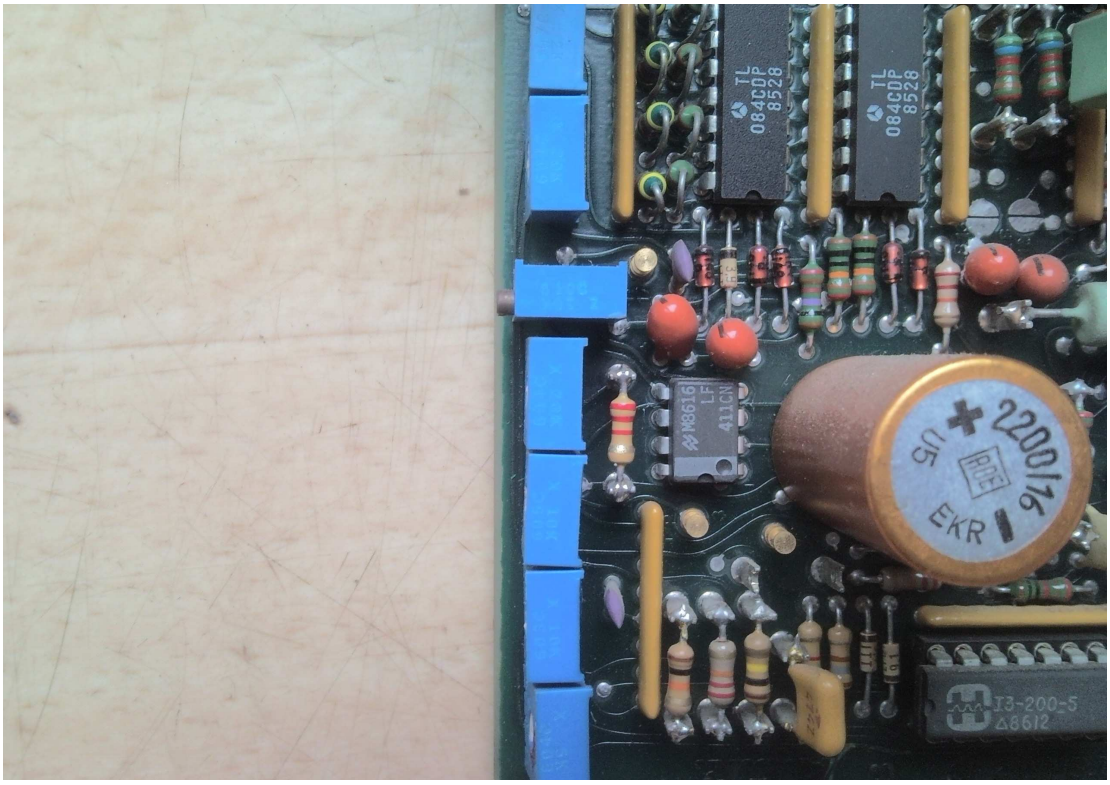


Figure 16: Power amplifier PCB upper right

ICs:

(a) TL084CDP quad JFET-input general-purpose operational amplifier

(b) National Semiconductor LF411CN JFET-input operational amplifier

(c) Harris Semiconductor J3-200-5

Figure 24: Power amplifier PCB power transistors
(all Thomson-CSF BU192)

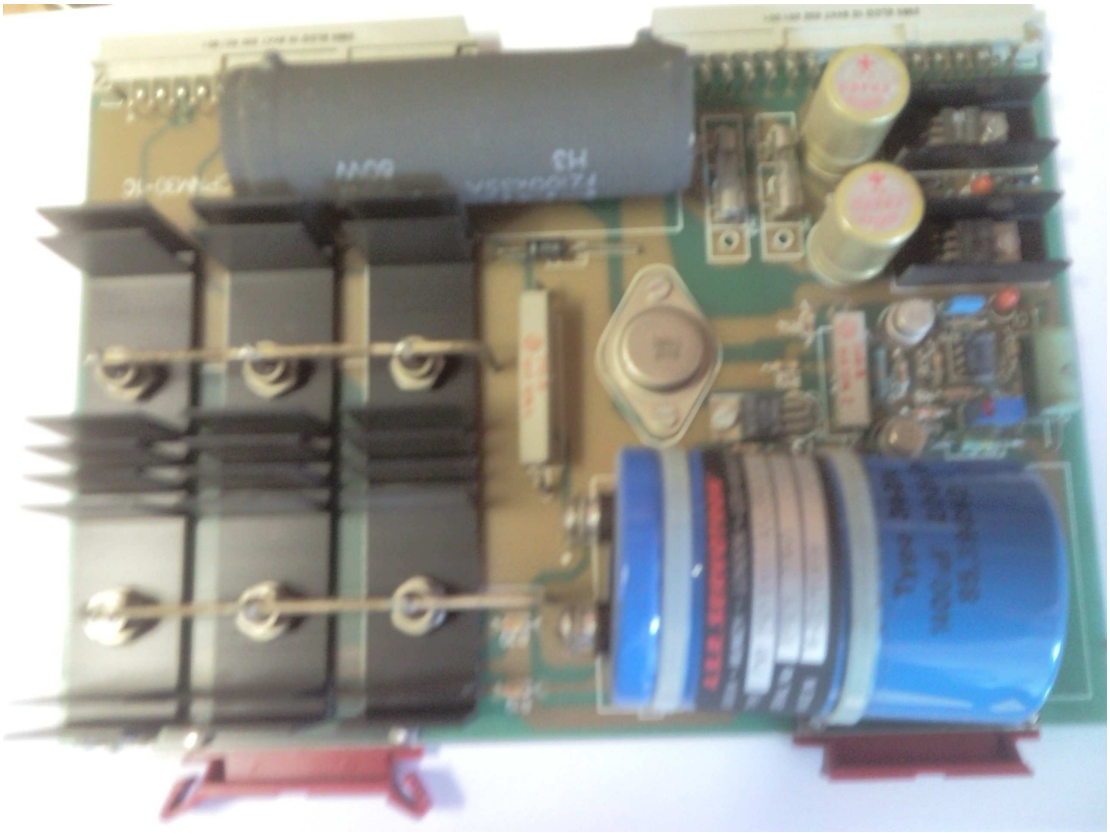


Figure 25: Power amplifier power supply unit (PSU) PCB

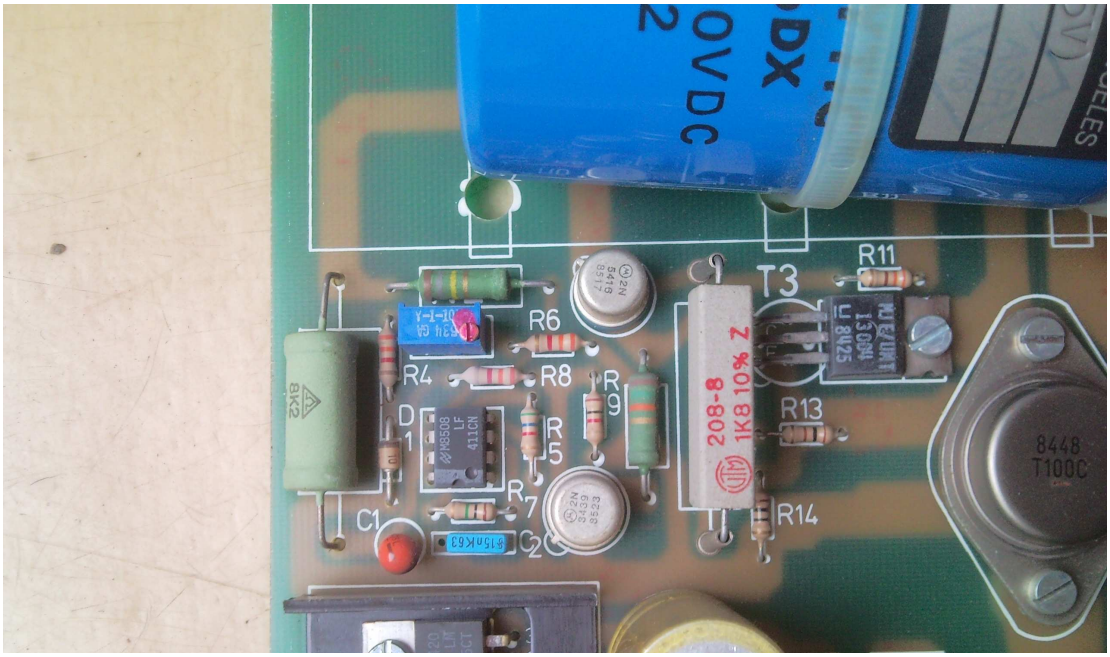


Figure 26: Power amplifier PSU voltage regulator
(Motorola 2N5416 and 2N3439 transistors)
(MJE/UMT 13004 TO220 NPN silicon power transistor)
(unknown T100C TO3 device)
(National Semiconductor LF411CN JFET-input operational amplifier)

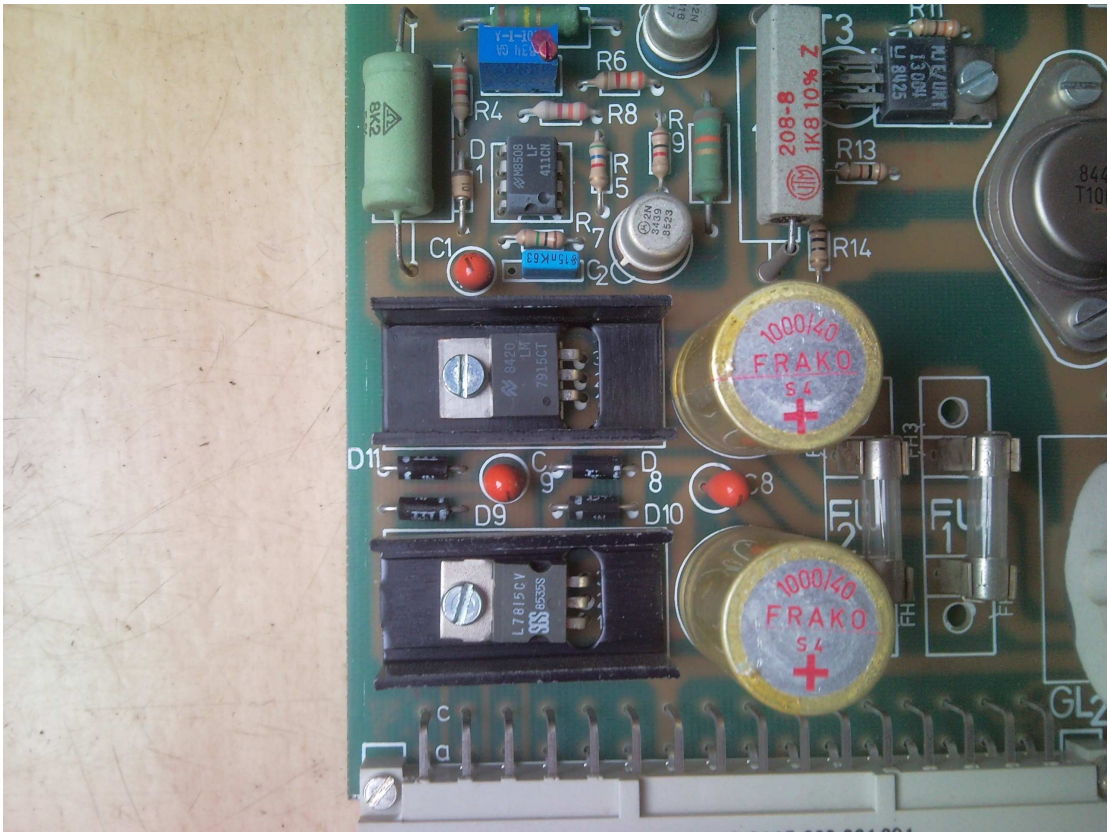


Figure 27: Power amplifier PSU voltage regulators and fuses
(National Semiconductor LM7915CT voltage regulator)
(SGS L7815CV voltage regulator)

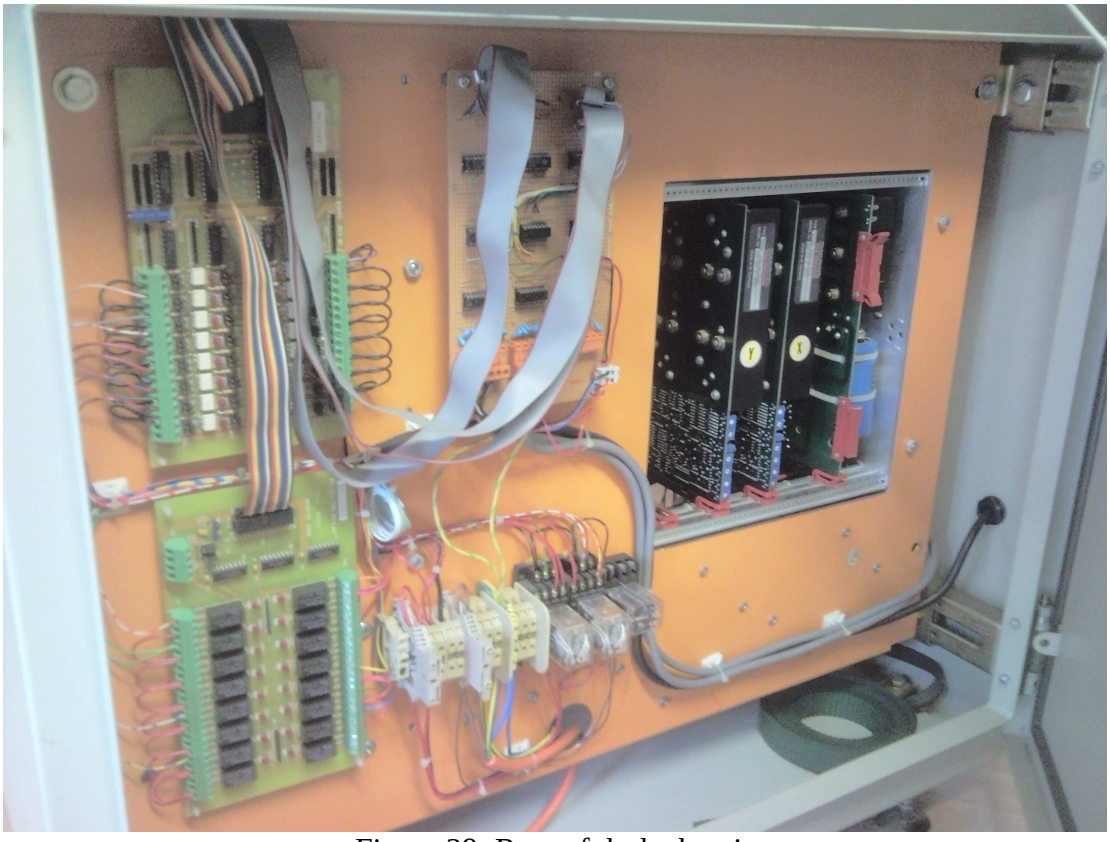


Figure 29: Rear of desk chassis

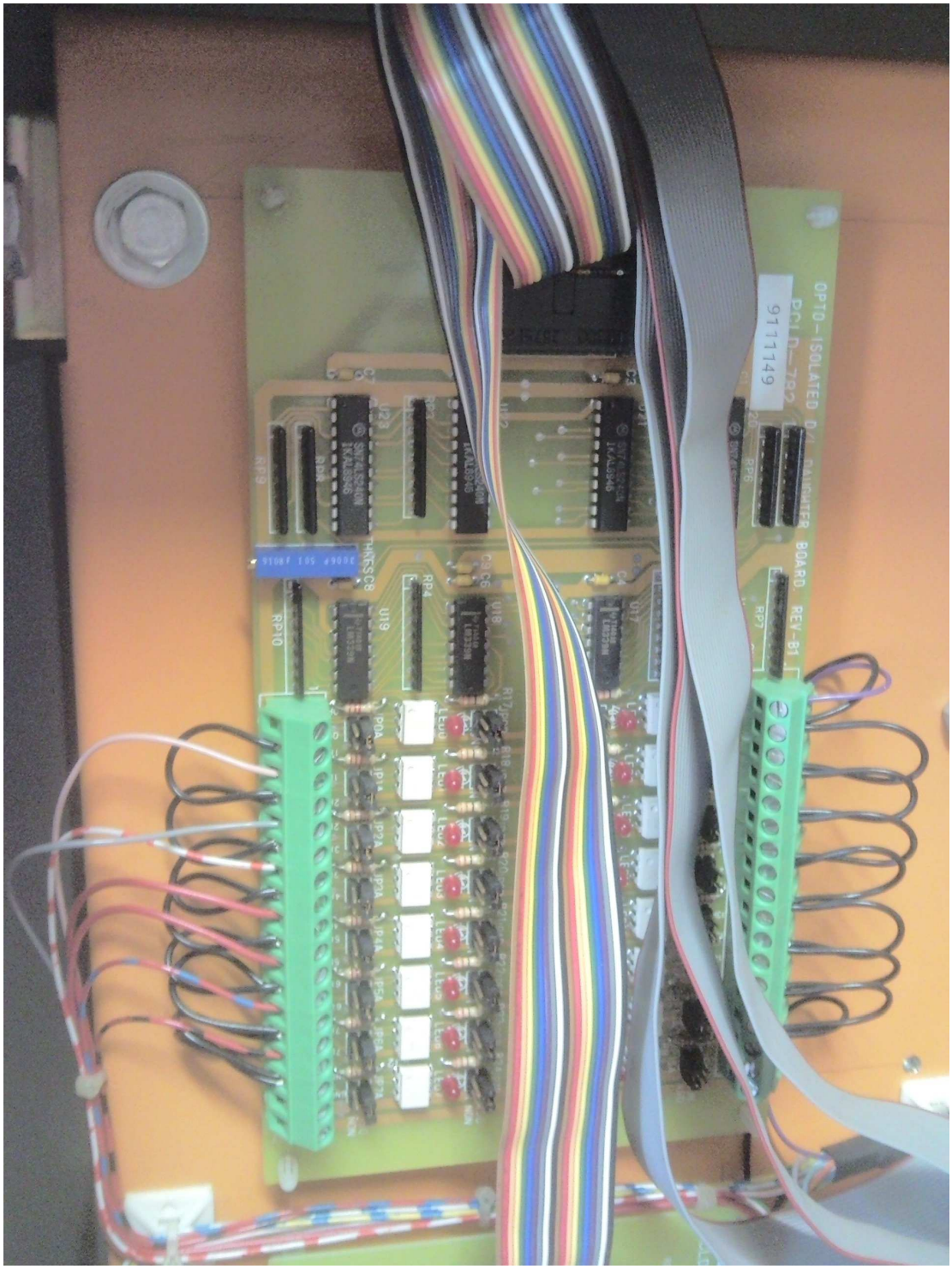


Figure 30: PCLD-782 opto-isolator input PCB

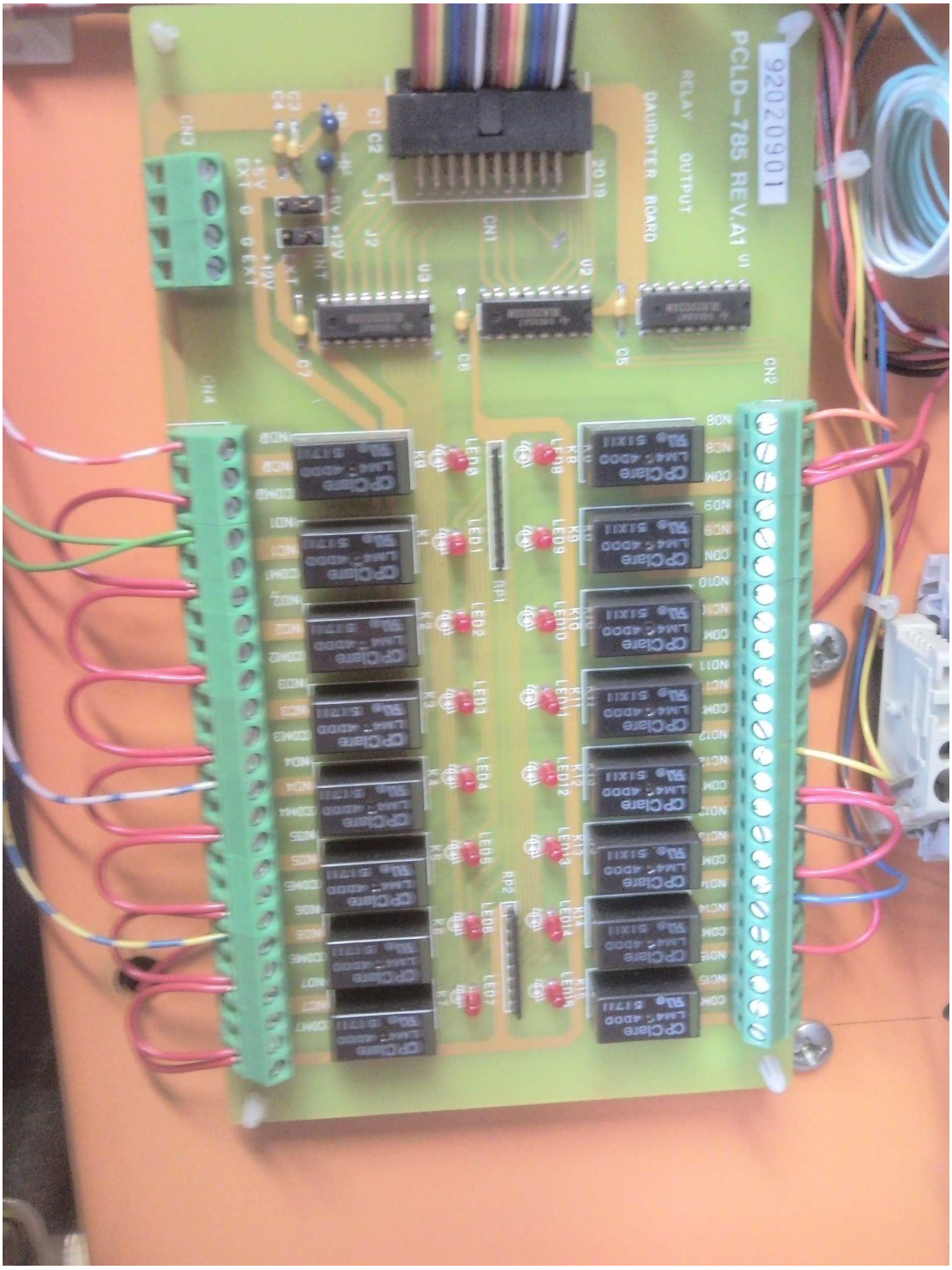


Figure 31: PCLD-785 relay output PCB

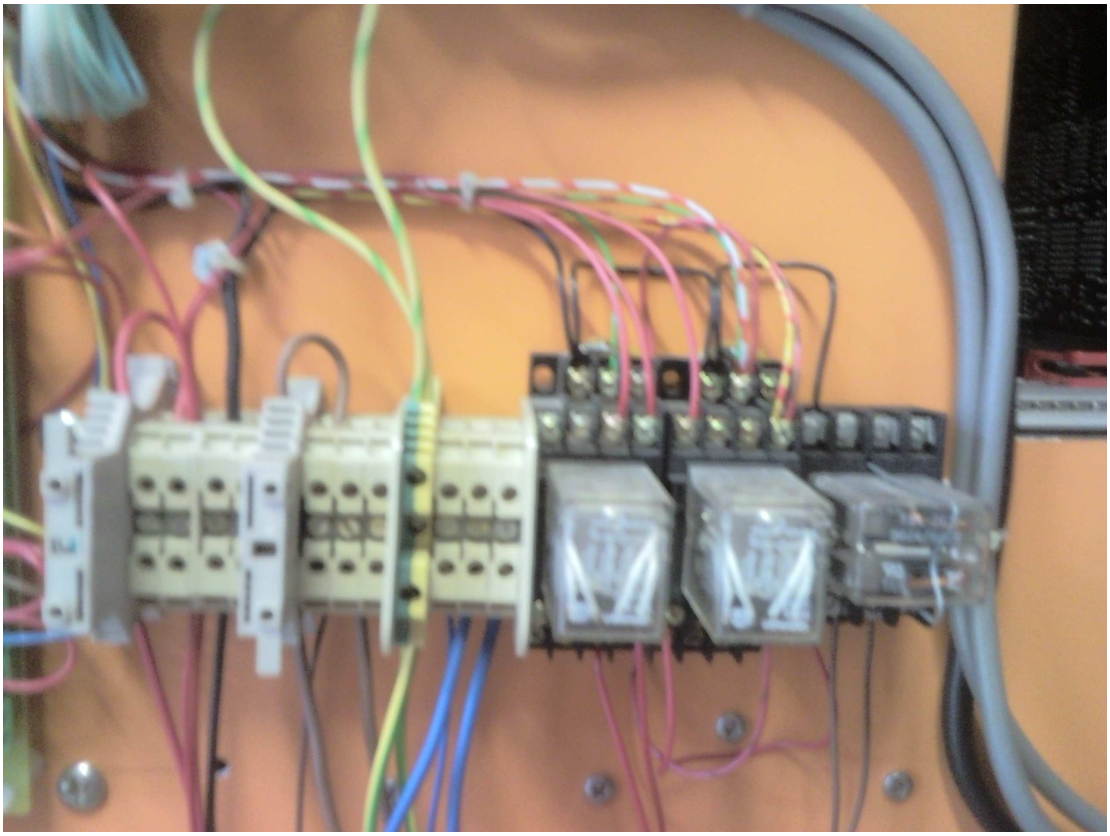


Figure 32: Control relays

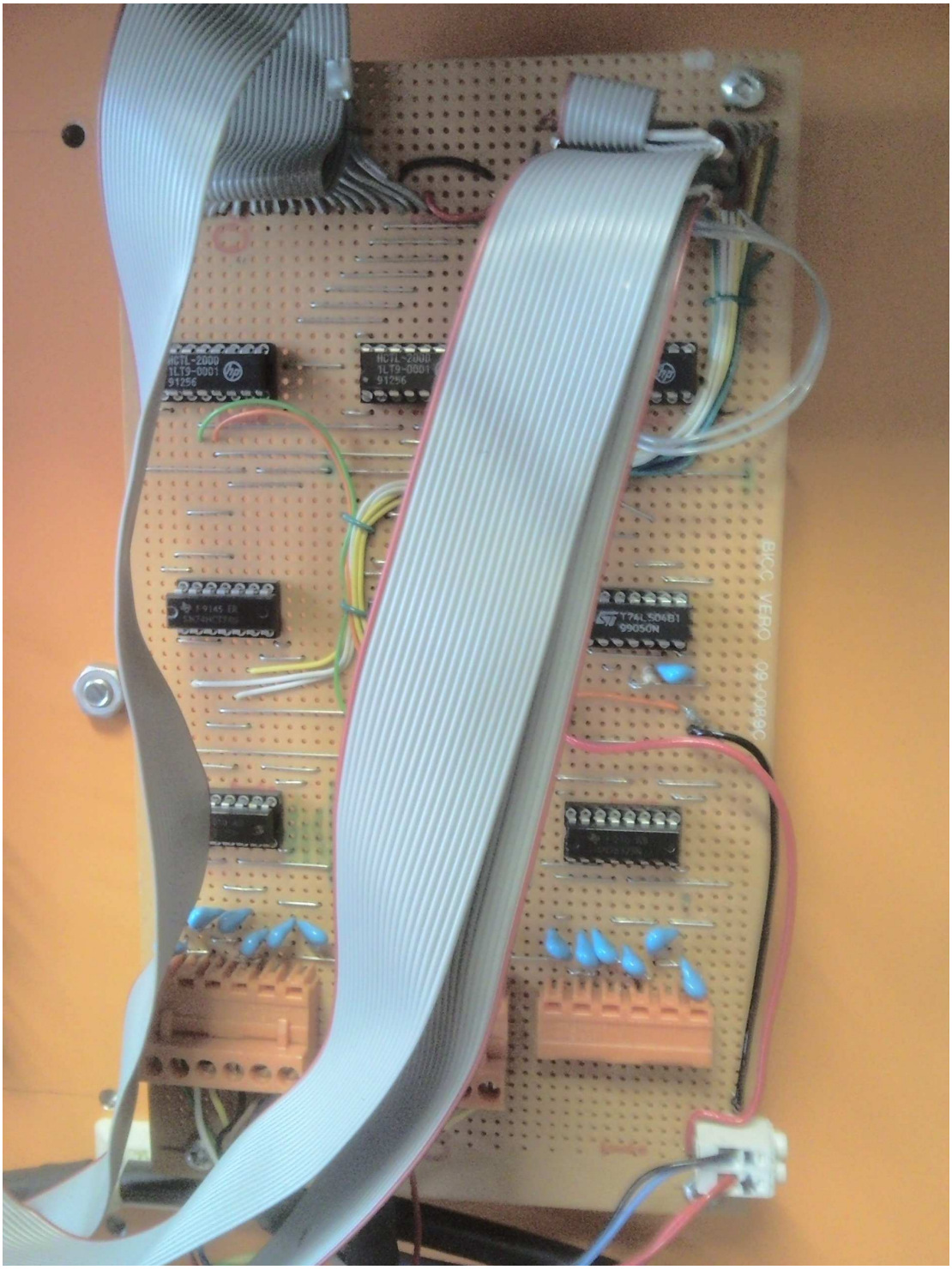


Figure 33: Handmade position decoder PCB

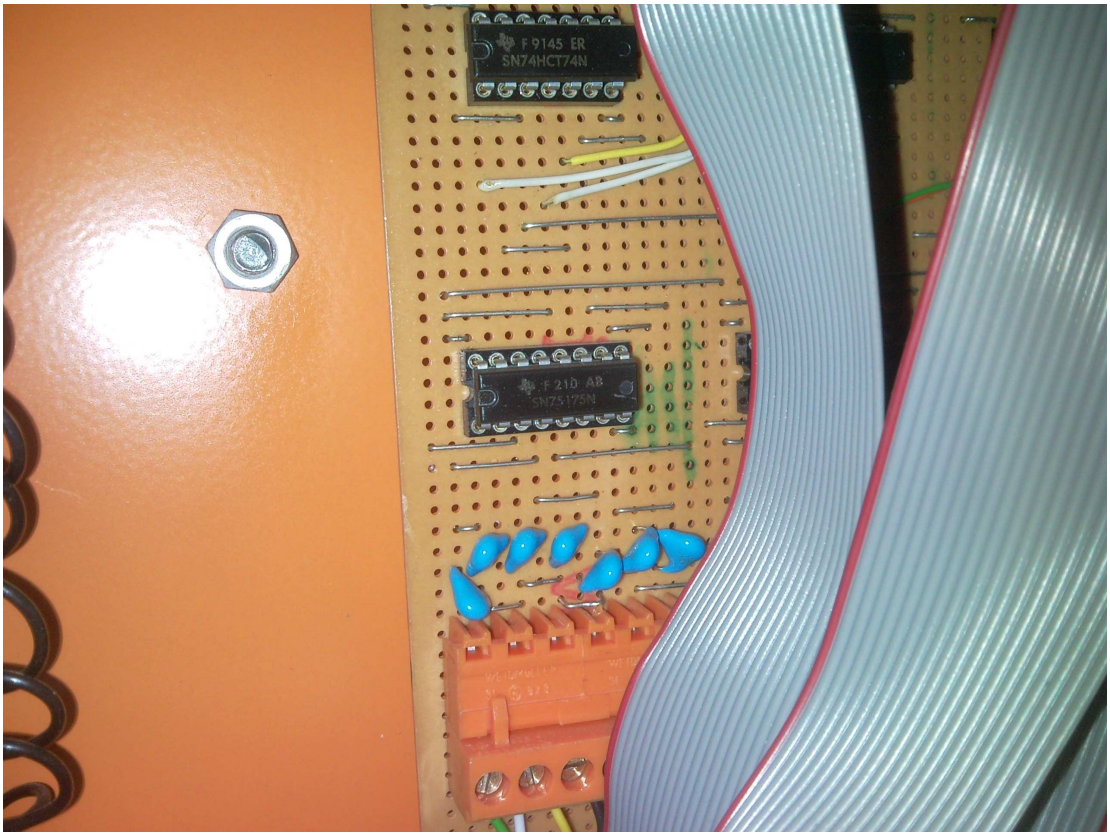


Figure 44: Handmade position decoder PCB.

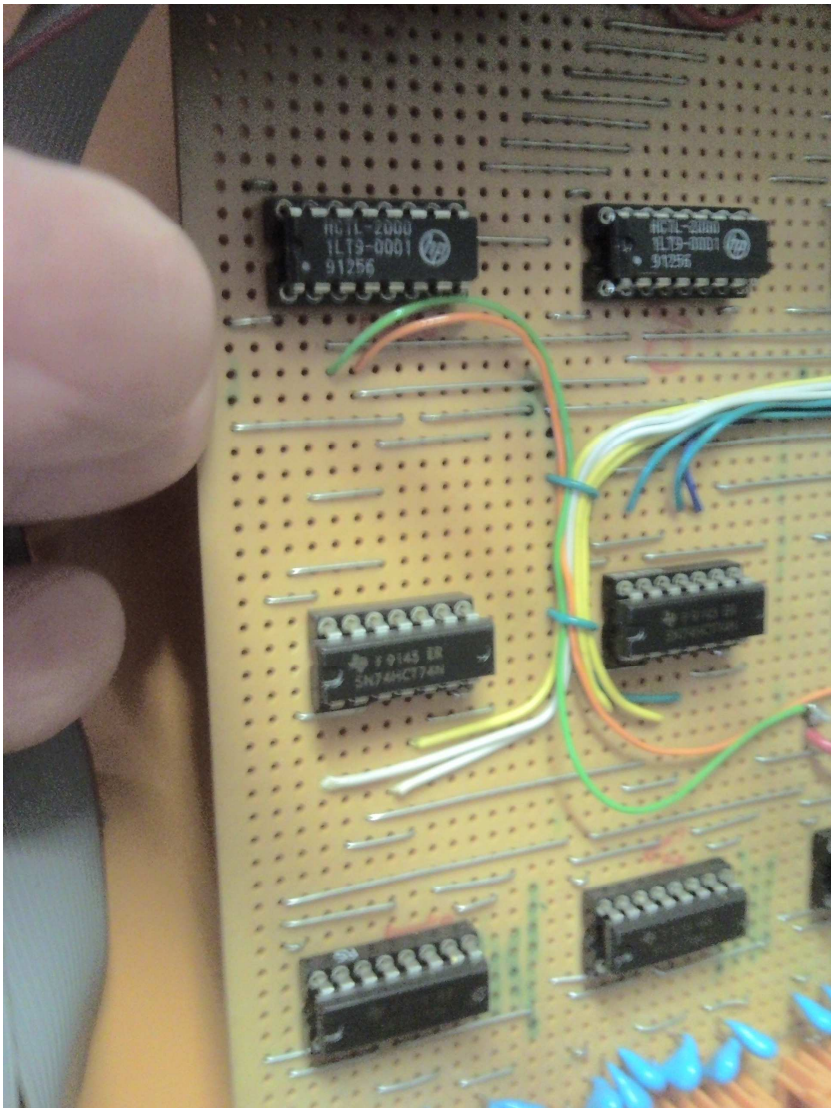


Figure 45: Handmade position decoder PCB.

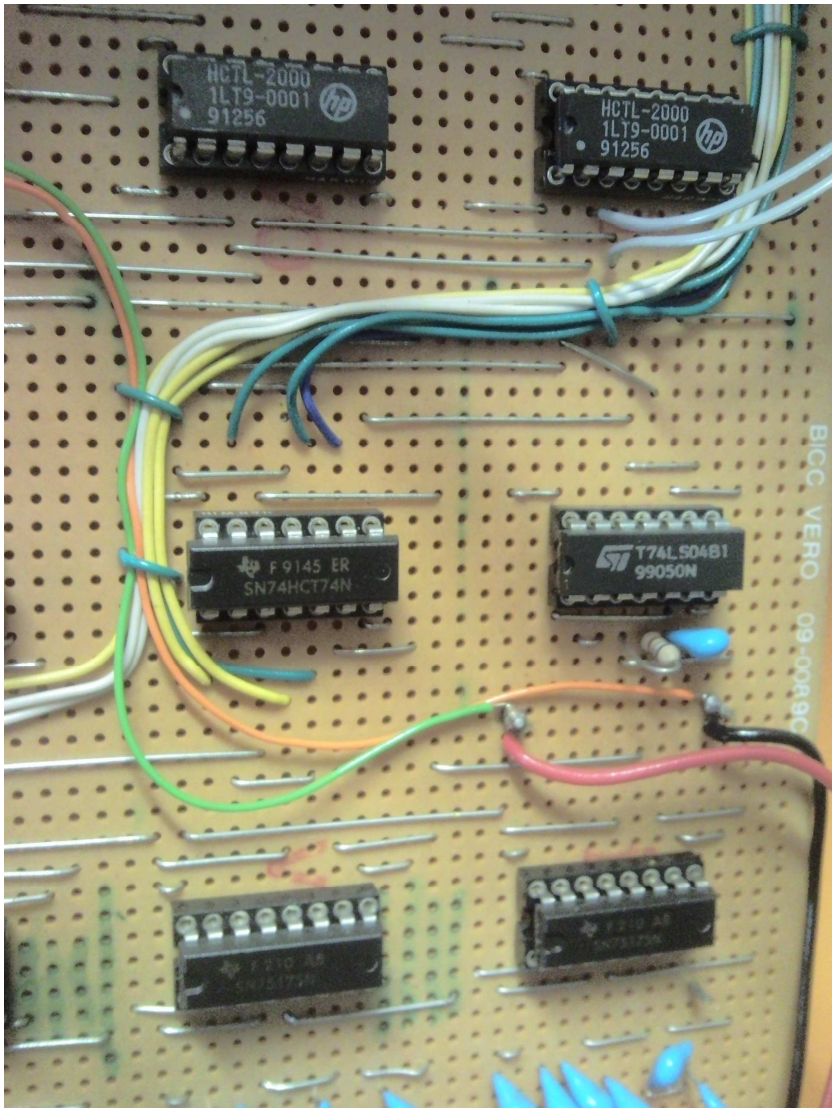


Figure 46: Handmade position decoder PCB.

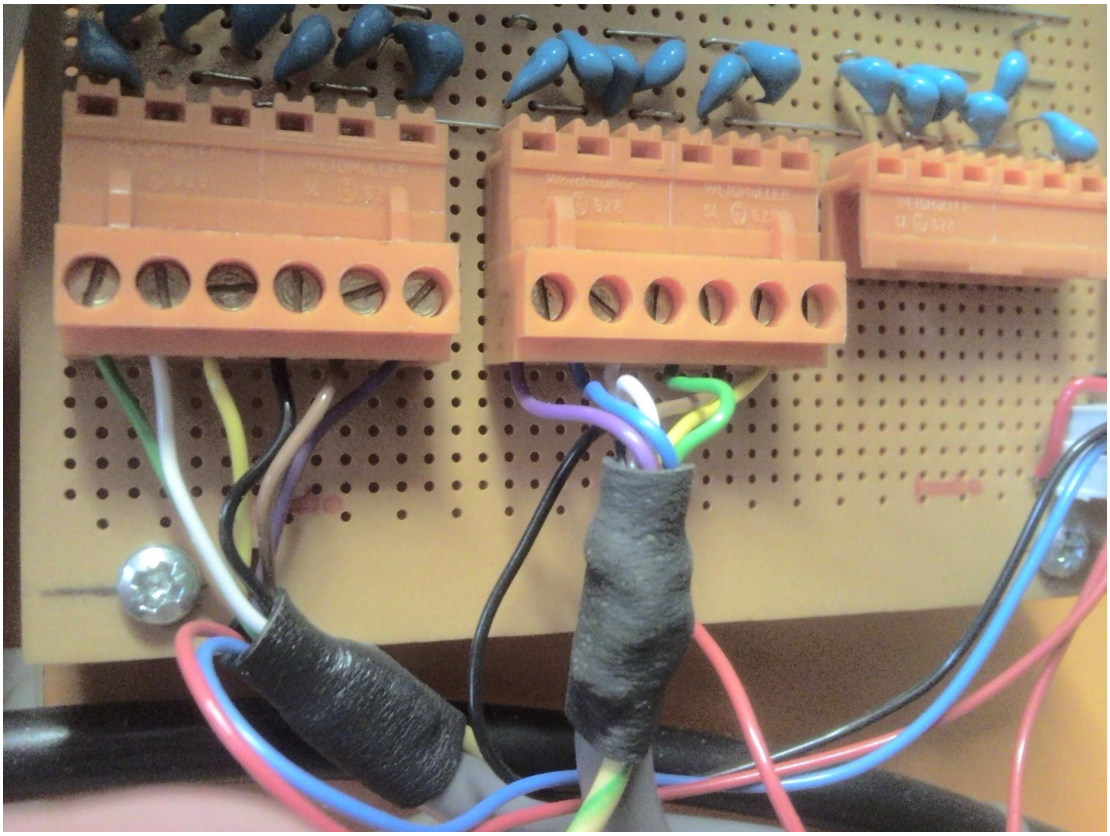


Figure 47: Handmade position decoder PCB incoming connections from position encoders. X axis on left, Y axis on right.

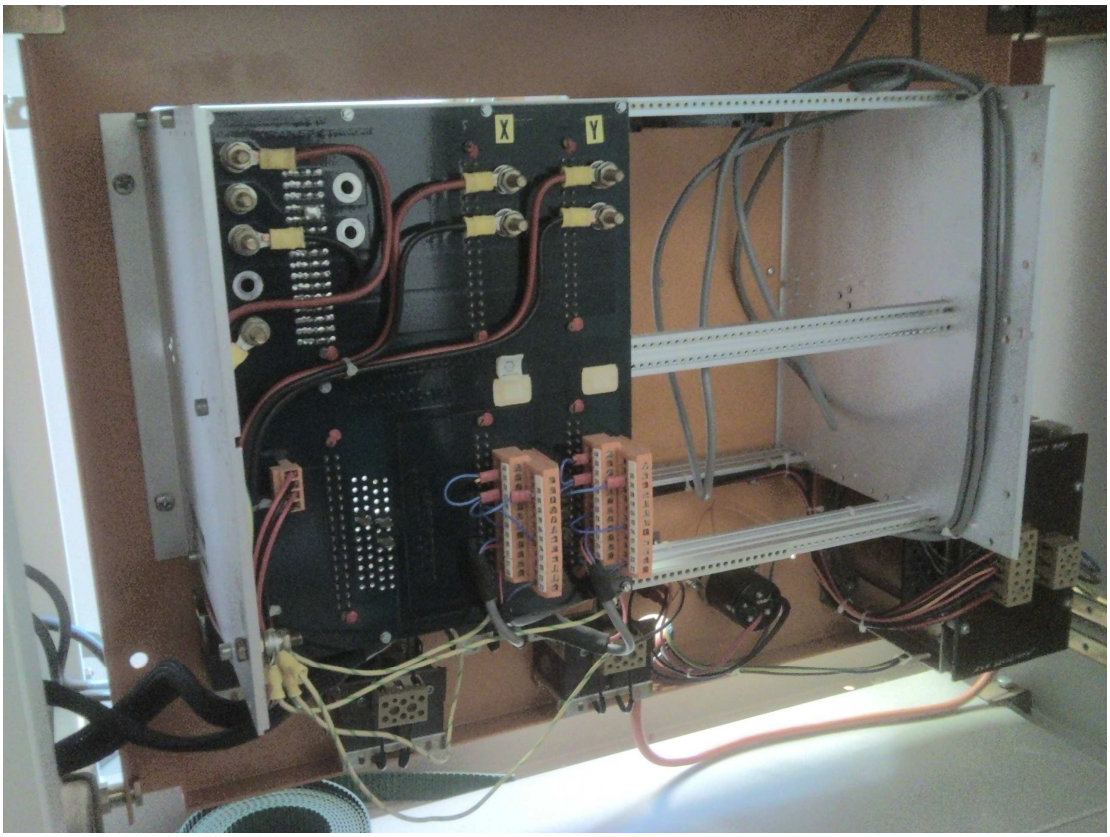


Figure 34: Front of desk chassis (backplane for power amplifier PCBs)

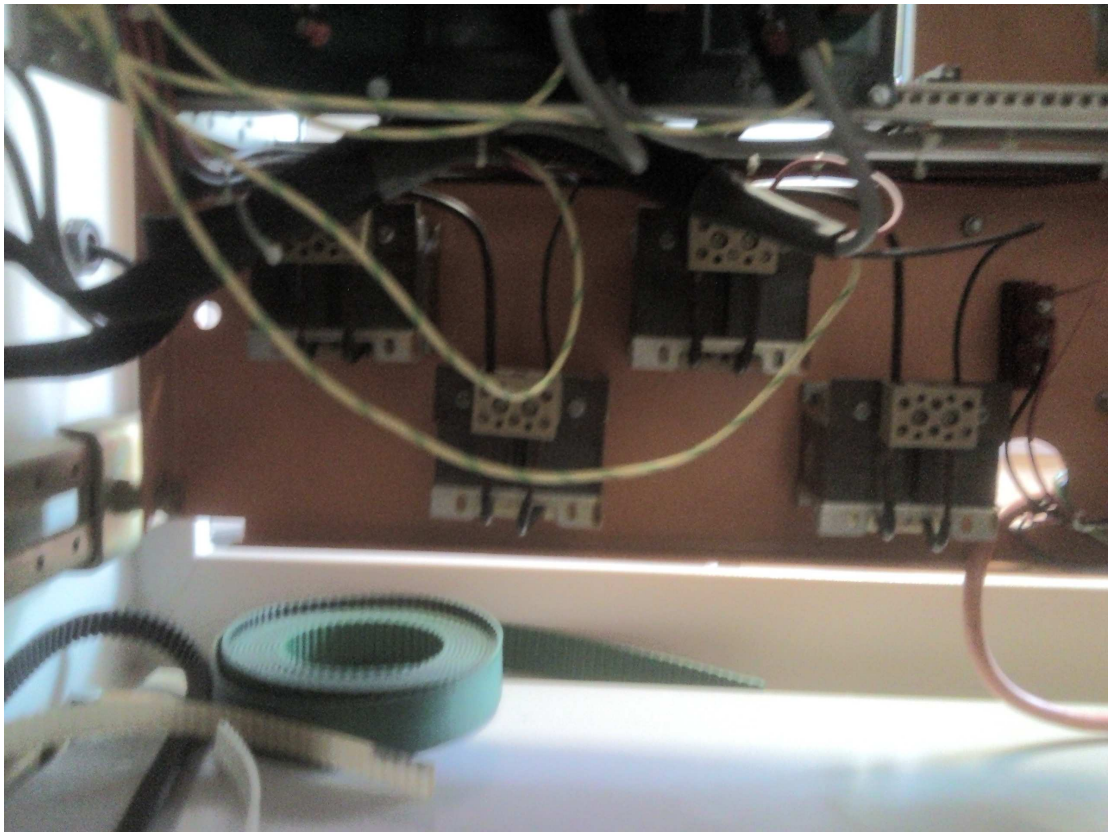


Figure 35: Inductors (chokes) below front of desk chassis

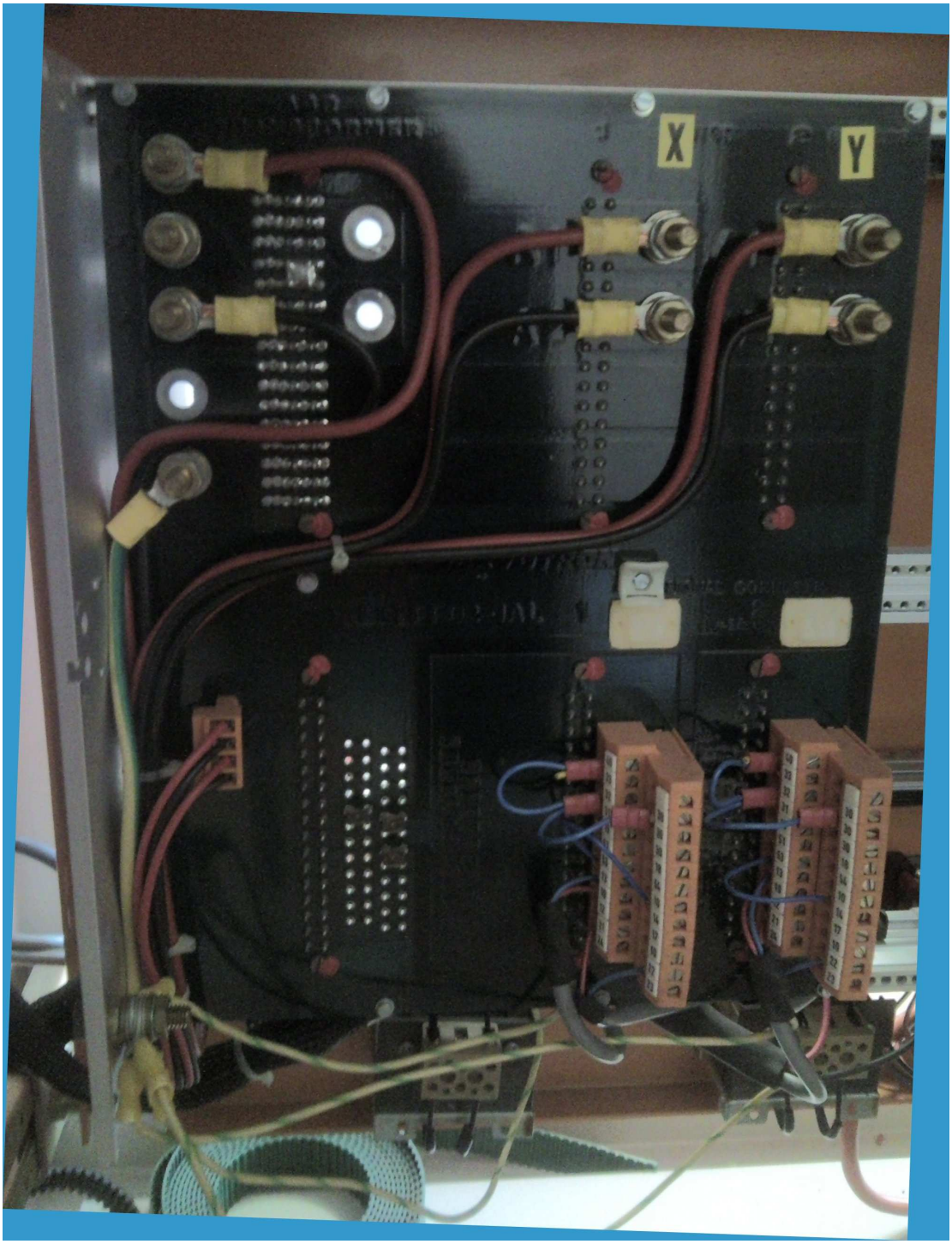


Figure 36: Backplane
D/A voltages connect at bottom of terminator blocks.

Figure 37: Rear of PC

Figure 38: Rear of PC

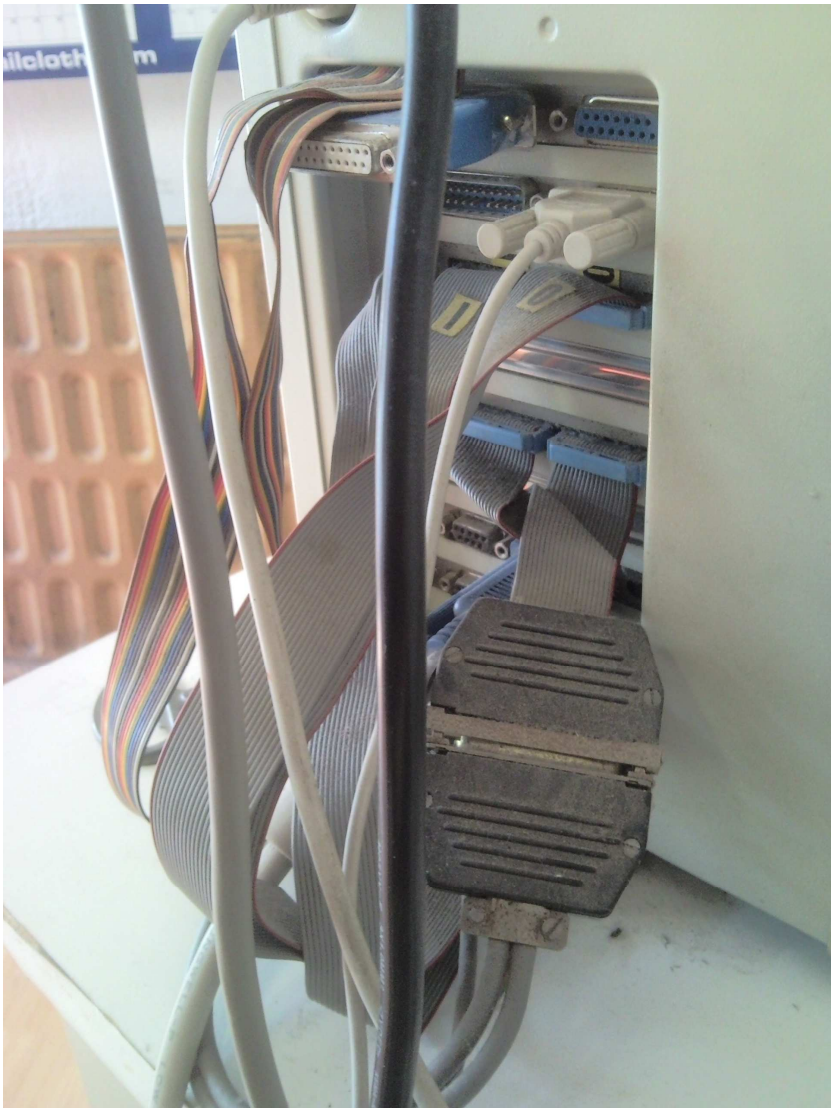


Figure 39: Rear of PC, showing D/A voltage output to octagonal metal connector.

Figure 40: Rear of PC, showing D/A voltage outputs.

Figure 41: Rear of PC, showing position decoder inputs (gray flat cables marked “I”).

Figure 42: Rear of PC showing games card input at bottom.

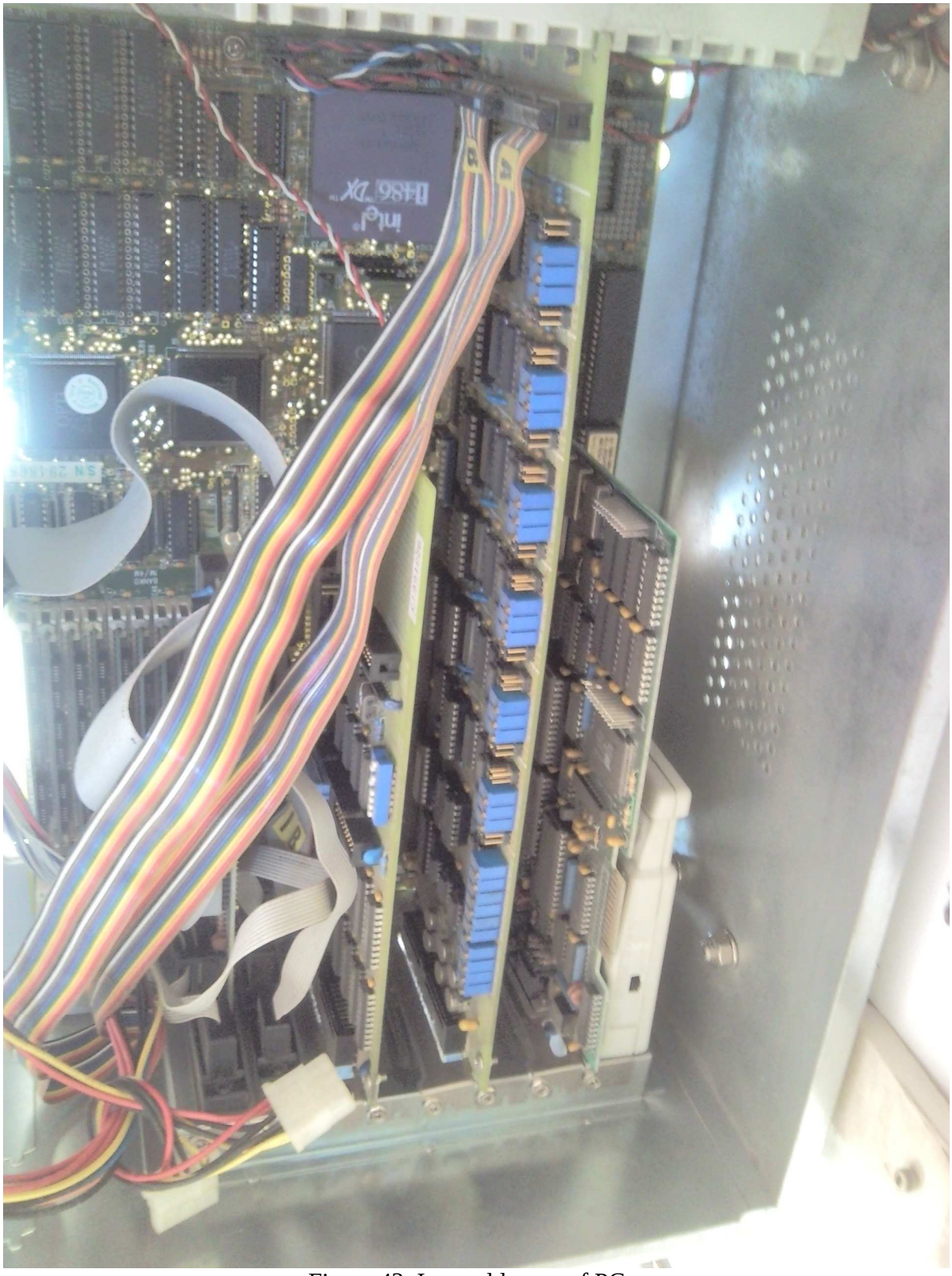


Figure 43: Internal layout of PC.

The multicoloured flat cables connect to the relay output PCB and the opto-isolator input PCB. The gray flat cables connect to the handmade position decoder PCB.

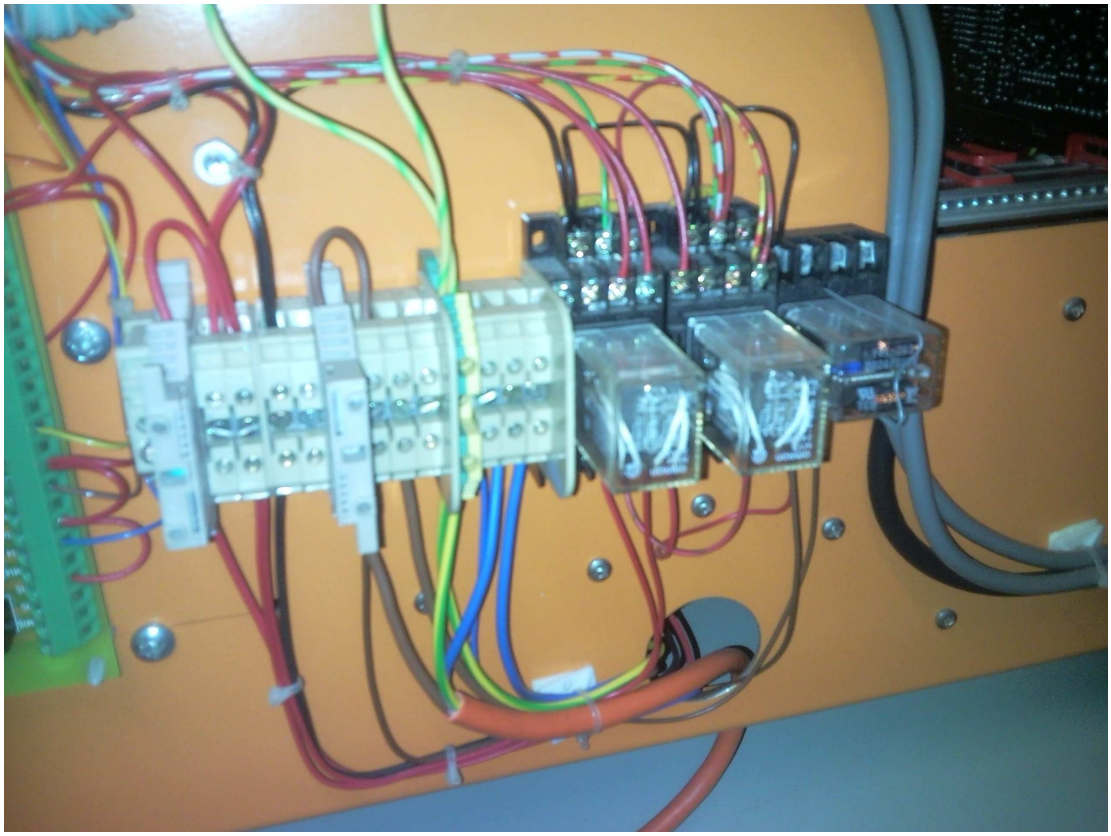
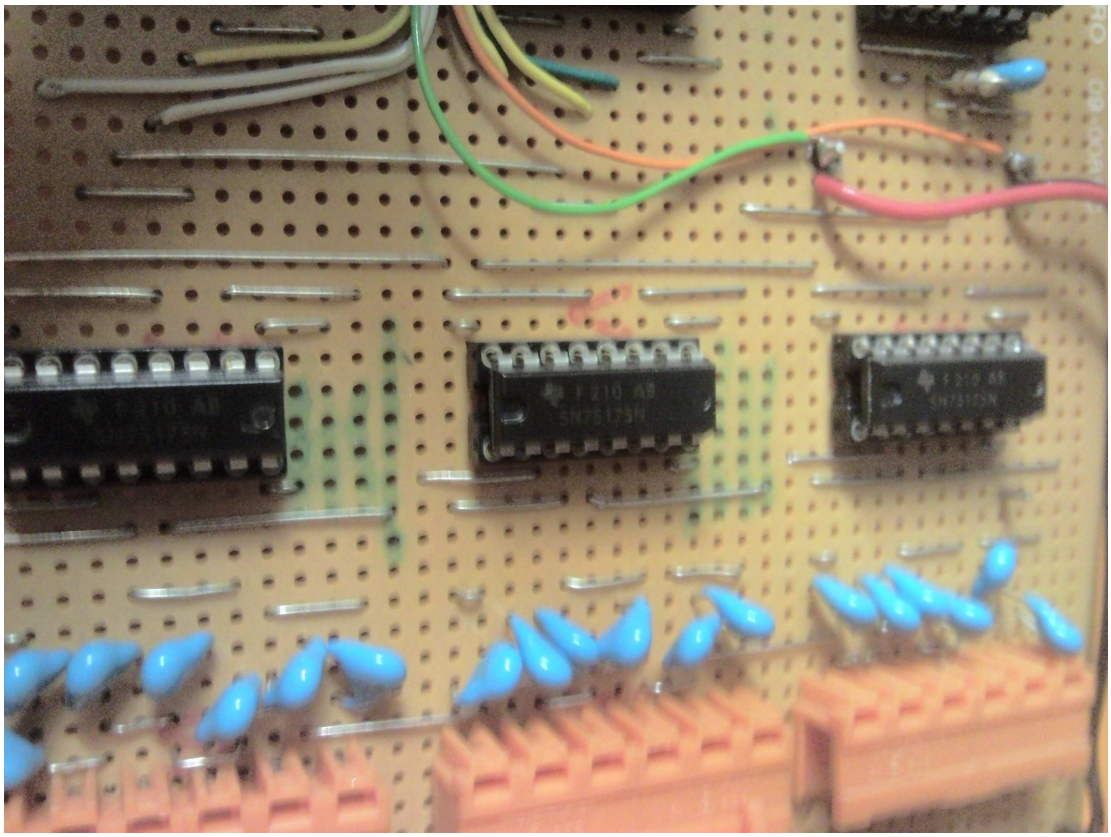


Figure 44: xxx.



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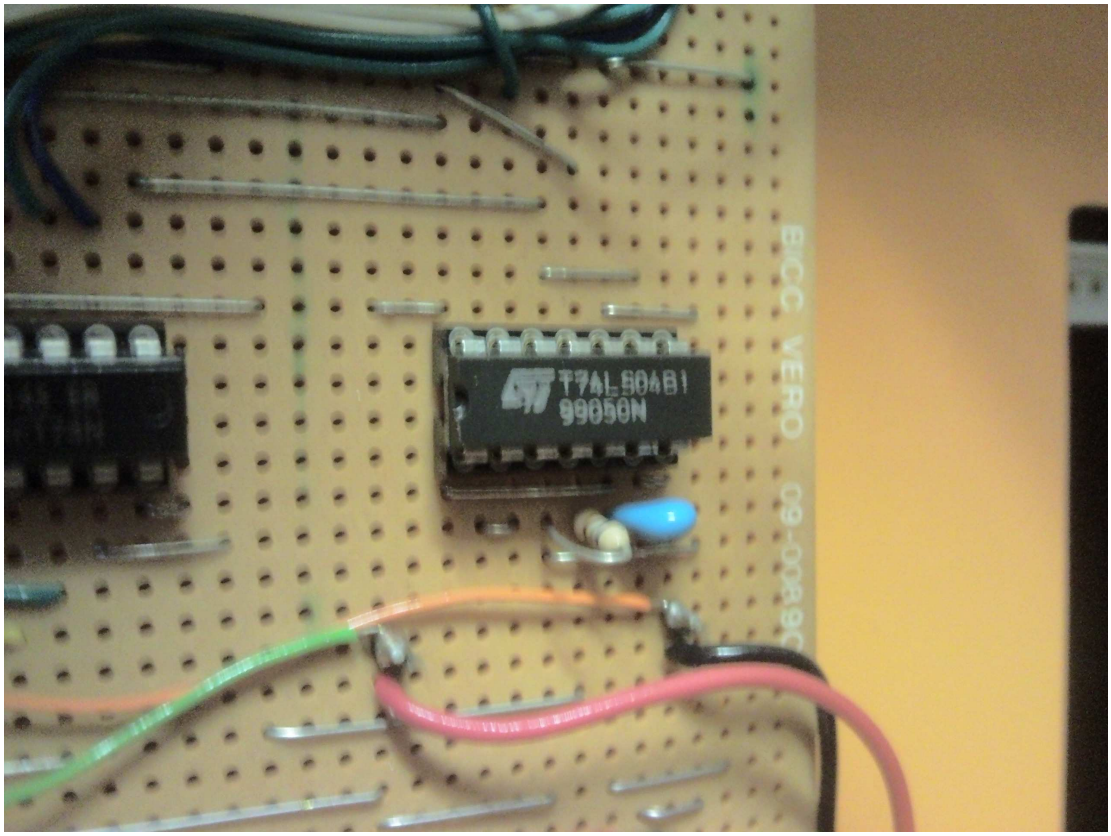

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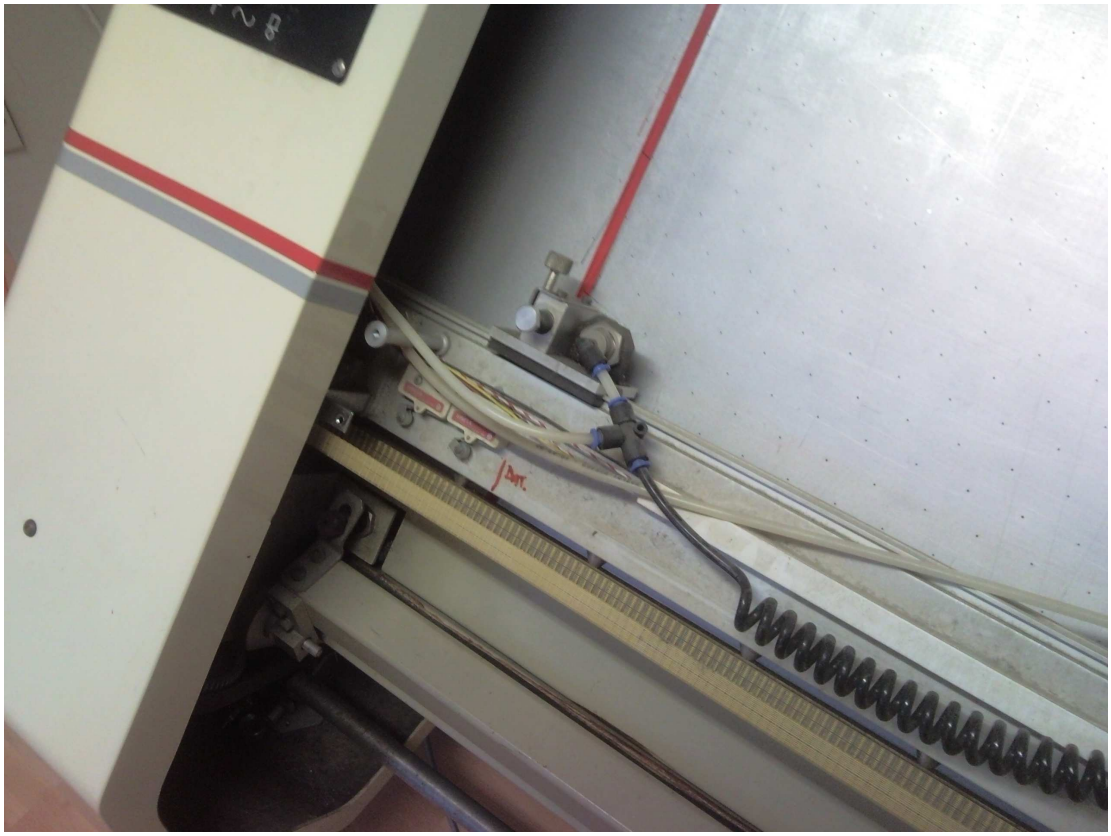

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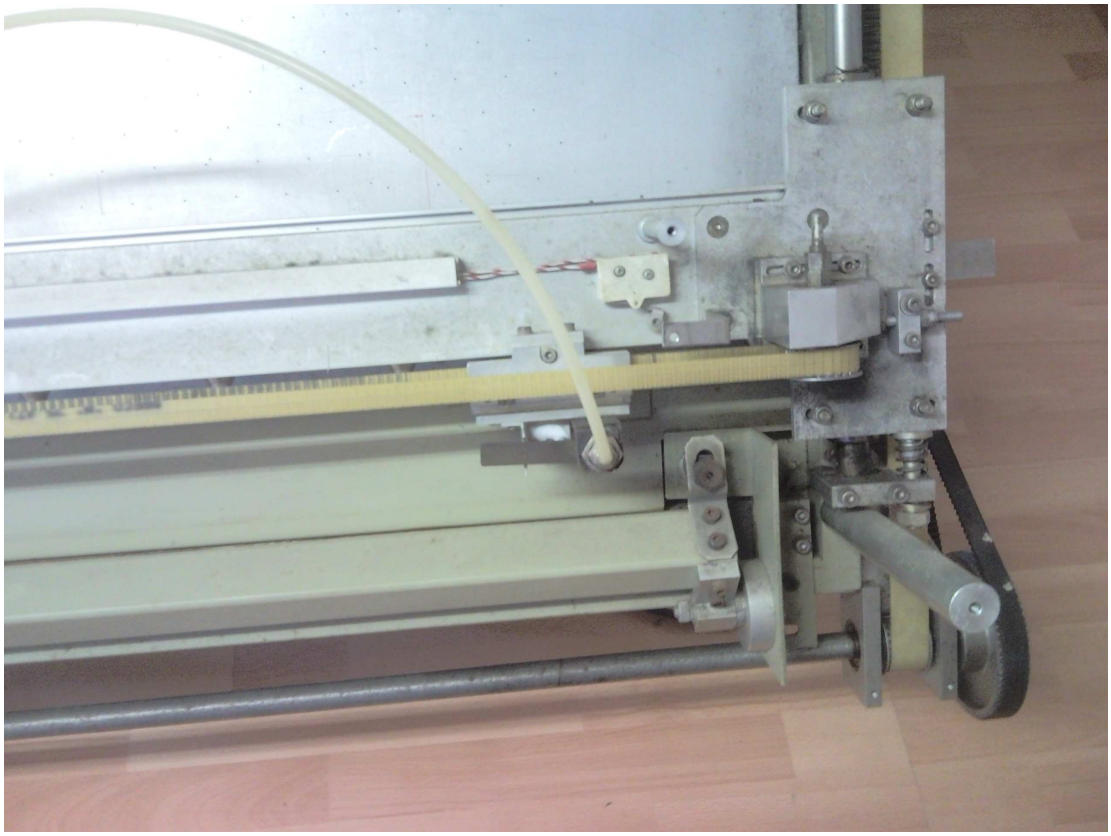

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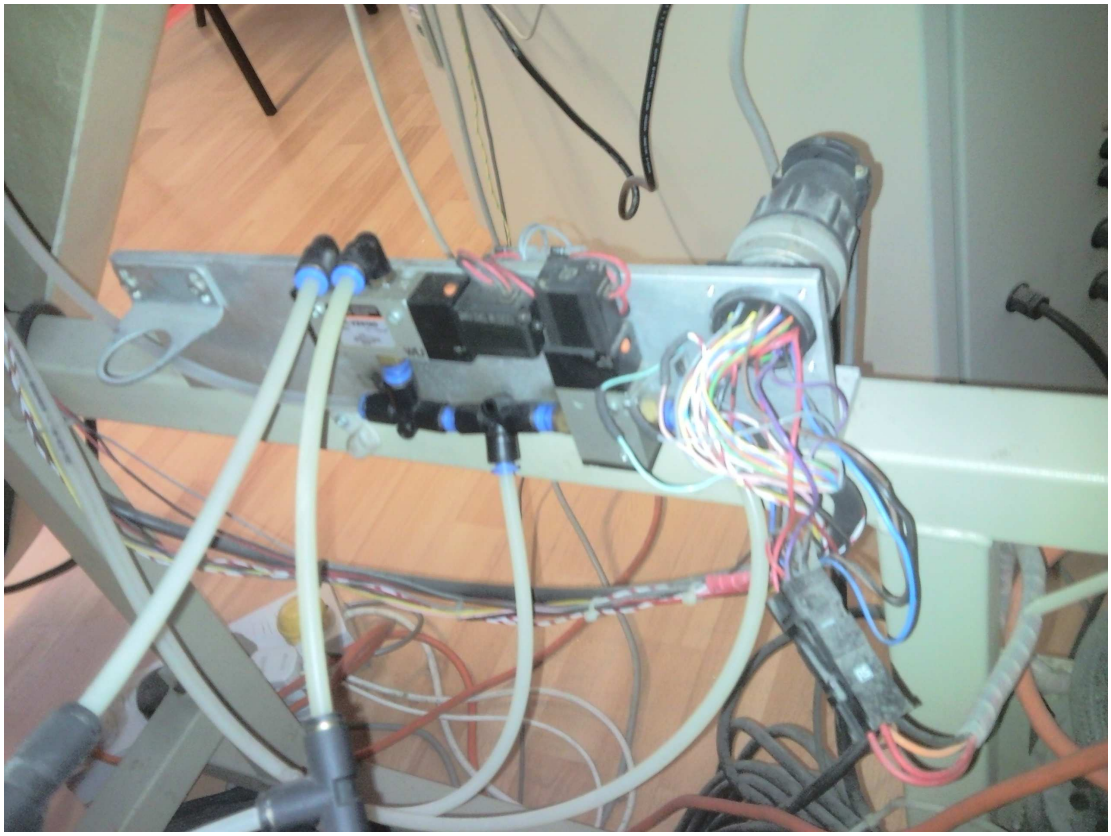

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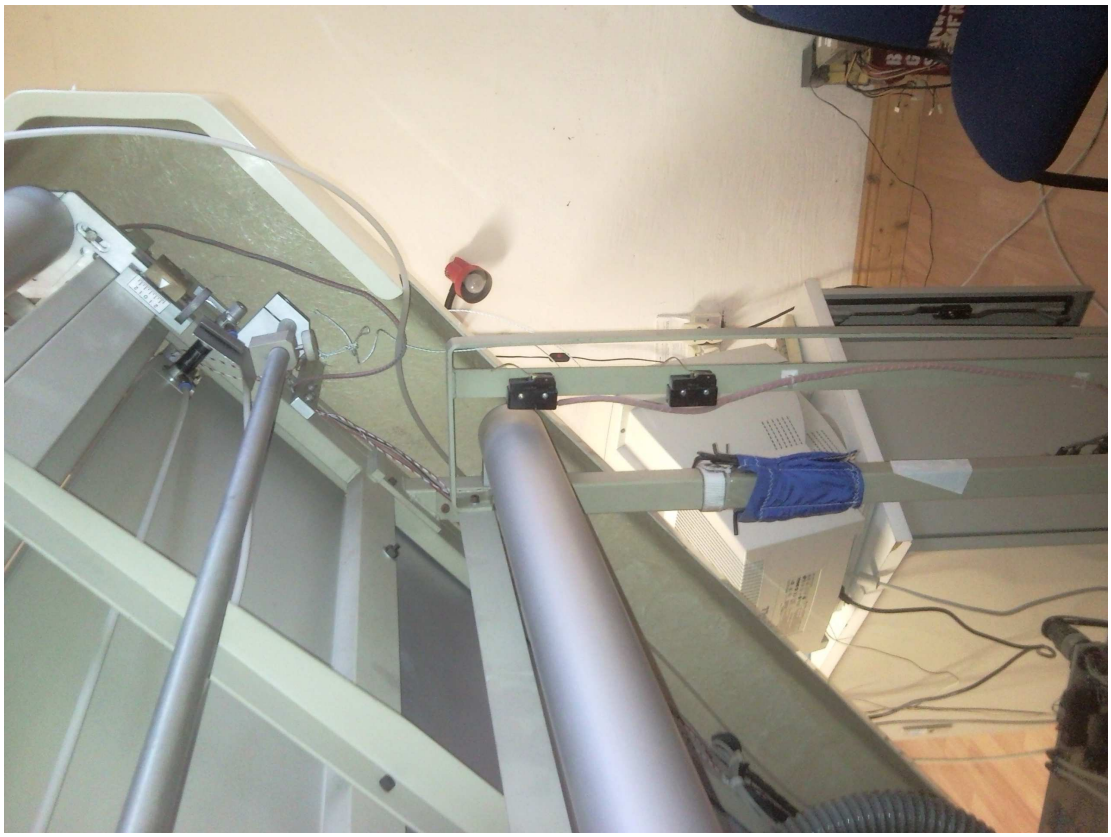

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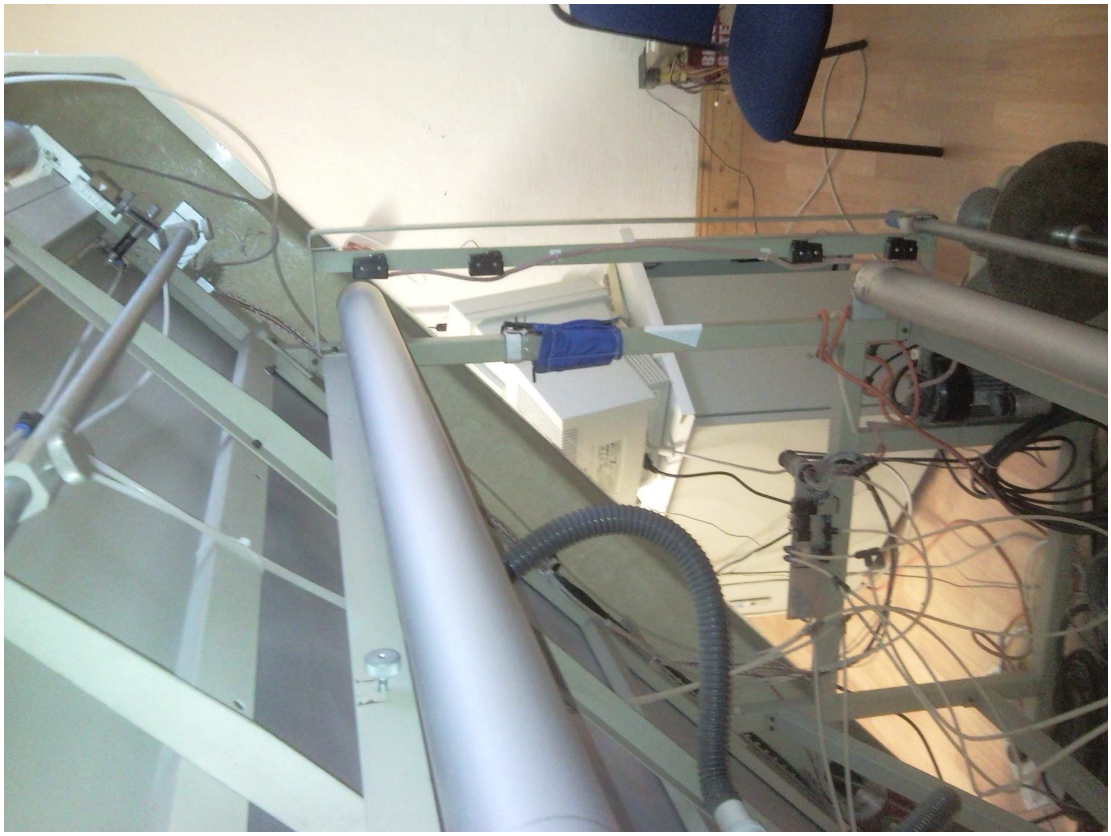

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