BiSON Birmingham Solar-Oscillations Network

TECHNICAL REPORT NO. 344

The Mount Controller: A Digital Autoguider for Las Campanas

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2011 May 26

This technical report series is published by:

THE UNIVERSITY OF BIRMINGHAM

High-Resolution Optical-Spectroscopy Group

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Abstract

Some technical information on the Mount Controller is presented.

Contents

1 Introduction

The Mount Controller is the first digital, solar autoguider in the Birmingham Solar-Oscillations Network (BiSON). This report describes the device that contains main board MC-MAIN-2 and was sent to Las Campanas [1] in 2011 January.

2 Unit Design

The Mount Controller, like many other units, is housed in an aluminium 19-inch rack case with its own internal power supplies.

Because there are a lot of connectors on the rear panel of the mount controller, this unit uses a 2U rack case rather than the usual 1U case.

2.1 The Front Panel

The front panel of the Mount Controller is shown in Figure 1.

On the left there is the HiROS standard power switch. Underneath the power switch is an LED that is illuminated when the +24 V power that is used for motor slewing is present. Next there is a Power LED board that shows that the other power rails are active. On the Mount Controller these rails are +12 V, +5 V, and −12 V.

Next there are two Generic LED boards which show the status of various parameters for the stepper motors. There is one board for the RA motor and a separate one for the DEC motor.

Finally on the right of the unit is the standard RS-232 LED board. This board shows the status of the Rx and Tx lines of the RS-232 serial communications interface. The red LED indicates that the line is low whilst the green LED indicates that the line is high.

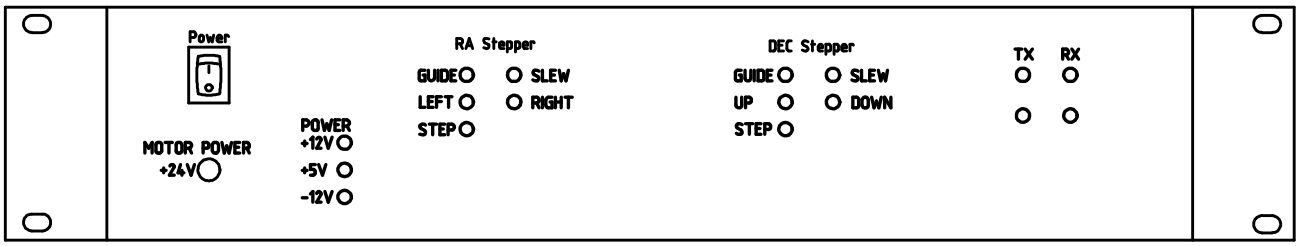


Figure 1: The Front Panel of the Mount Controller.

2.2 The Rear Panel

Figure 2 shows the layout of the rear panel of the Mount Controller. On the left of the unit is the case fan. In the centre of the rear panel are a number of D-type connectors. These connectors connect the mount encoders, fine and coarse autoguider, mount limit switches, and stepper motors to the Mount Controller.

Finally on the right there is the mains power inlet. Underneath this there is the connection for the serial port to the computer.

2.3 Internal Layout

The main case of the Mount Controller contains a Main pcb and two smaller power supply PCBs. There is also some din rail terminal that distributes the AC power to the power supplies. The internal layout is shown in Figure 3. Components fitted to the front and rear panels have been omitted for clarity.

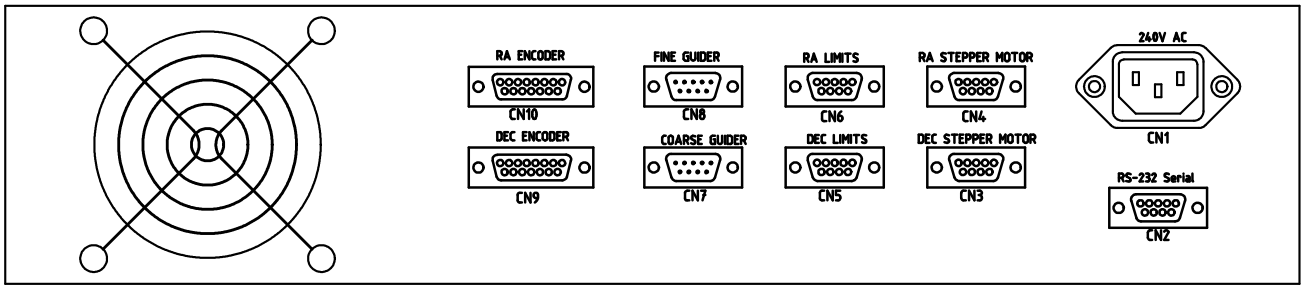


Figure 2: The Rear Panel of the Mount Controller.

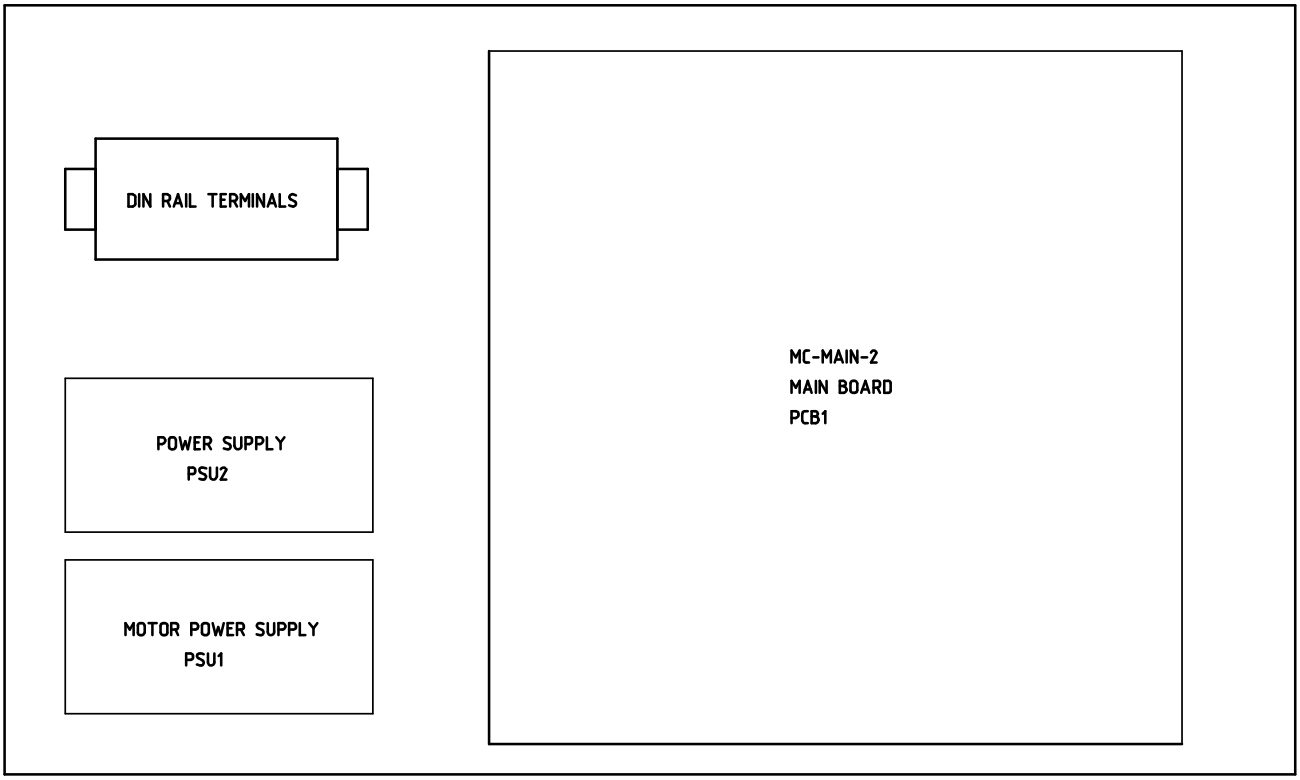


Figure 3: The Internal Layout of the Mount Controller.

2.4 Parts List

The parts list for the Mount Controller is too large to fit in a single table. Hence it has been split into several smaller tables according to component type. These tables are summarized in Table 1. A spare parts kit is also supplied.

Table 1: Mount Controller — Case Parts Lists

Component Type	*Table*	*Page*
PCB Sub Assemblies	2	4
Case	3	5
Spare Parts Kit	4	6

Table 2: Parts List — PCB Sub Assemblies

Name	Part Number	Description (SSM)
PSU1	FEC 144-1237	24-V 4.6-A 100-W Open Frame PSU
PSU2	FEC 117-6970	Triple Output 40-W Open Frame PSU
PCB1	HiROS MC-MAIN-2	Main Board Assembly
PCB2–PCB3	HiROS PWR-LED-4	Power-LED Board Assembly
PCB4–PCB5	HiROS GEN-LED-1	Generic LED Board Assembly
PCB6	HiROS 232-LED-3	RS232-LED Board Assembly

Table 3: Parts List — Case

Name	Part Number	Description (SSM)
—	RS 584-227	Rack Case 2 U × 84 HP × 254 mm
SW1	RS 664-553	Green Visirocker Switch
CN1	RS 238-794	IEC Inlet Filter 6-A
CN2–CN4	Rapid* 15-0150	9-pin Female D-Type Connector
CN5–CN6	RS 642-4907	9-pin Female Low-profile IDC D-Type Connector
CN7–CN8	RS 642-4834	9-pin Male Low-profile IDC D-Type Connector
CN9–CN10	RS 642-4890	15-pin Male Low-profile IDC D-Type Connector
FAN1	CPC CS13345	Akasa 80-mm Cooling Fan
LED1	Rapid* 56-0440	Yellow 5-mm Low-current LED
—	Rapid 55-0260	5-mm LED Mounting Bezel
—	FEC 150-221	Mini DIN-Rail Grey Terminal (10)
—	FEC 150-222	Mini DIN-Rail Blue Terminal (10)
—	FEC 150-223	Mini DIN-Rail Earth Terminal (10)
—	FEC 150-229	Mini DIN-Rail End Cover (10)
—	FEC 150-233	Mini DIN-Rail End Stop (10)
—	FEC 150-234	10-Way Jumper Kit for DIN-Rail Terminal
—	FEC 177-126	0.5-m Mini Top-hat DIN Rail
—	FEC 150-235	Blank 5 × 5 Marker Strips pk100
—	Rapid 37-0825	80-mm Fan Finger Guard
—	RS 211-0907	IEC Inlet Insulating Boot (5)
—	FEC 769-277	Heatshrink Boot 28-mm
—	Rapid* 15-0365	D-type 8-mm Female Screwlock Kit
—	Rapid* 33-3525	M3 × 12 Hexagonal Spacers pk25
—	Rapid* 33-4210	M3 × 6 Panhead Pozidriv Screw pk100
—	Rapid* 33-4260	M3 × 6 Pozidriv Countersunk Screw pk100
—	Rapid* 33-4200	M2.5 × 6 Pozidriv Panhead Screw pk100
—	Rapid* 33-1715	M4 Nuts pk100
—	Rapid* 33-1765	M4 Washer pk100
—	Rapid* 33-2975	M4 × 20 Pozidriv Panhead Screw pk100
—	Rapid* 33-2977	M4 × 25 Pozidriv Panhead Screw pk100

*These items are available from Physics Stores.

Table 4: Parts List — Spare Parts Kit

Part Number	Description (SSM)
Rapid 87-1945	Conductive IC Storage Box
Rapid 73-3206	PIC16F877-20P Microcontroller
Rapid 82-0148	MAX232CPE RS-232 Line Driver IC
Rapid* 82-0054	TL074 Quad Op-amp IC
Rapid 47-0156	ZVN2106A n-channel MOSFET
Rapid 47-0174	ZVP2106A p-channel MOSFET
RS 426-991	CP82C55A parallel I/O IC
Rapid 82-0198	L297 Stepper Motor Driver IC
Rapid 82-0202	L298N Dual Full-bridge Driver IC
Rapid* 83-0380	4049 Hex Inverter IC
Rapid* 83-0382	4050 Hex Buffer IC
Rapid* 83-0414	4081B Quad 2-Input AND IC
FEC 117-5735	AQZ202 PhotoMOS Relay 60-Vdc 3-A
Rapid 08-1200	1.8-pF Ceramic Capacitor 2.5-mm

*These items are available from Physics Stores.

3 System Design

The Mount Controller main unit sits at the heart of a larger system. The main unit will be located in the main electronics crate whilst the mount will be sitting up in the dome section of the building. Obviously cables are needed to connect the main unit to the mount.

Thus a system diagram of the whole Mount Controller system is required. The system diagram for the Mount Controller is too large to fit onto a single drawing and so it has been split up into smaller logical blocks. The drawings that make up the system diagram are summarized in Table 5.

Table 5: Mount Controller — System Diagram

Mount Controller Subsystem	*Figure*	*Page*
Encoders and stepper motors	4	8
Limit switches	5	9
Telescopes	6	10

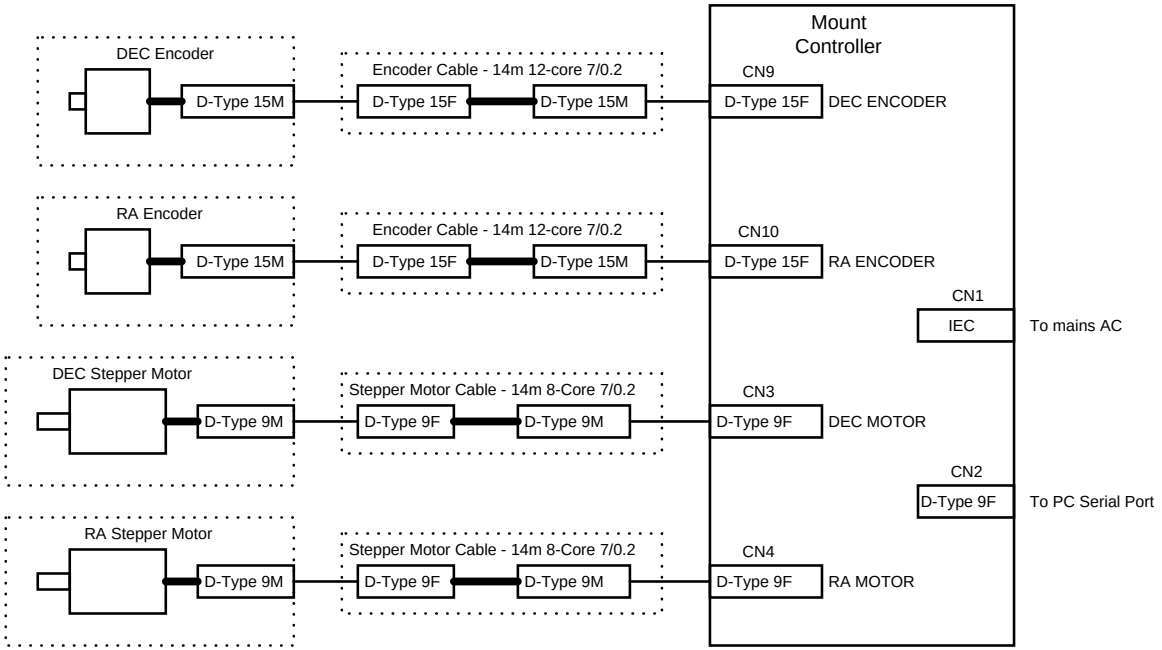


Figure 4: The encoders and stepper motors.

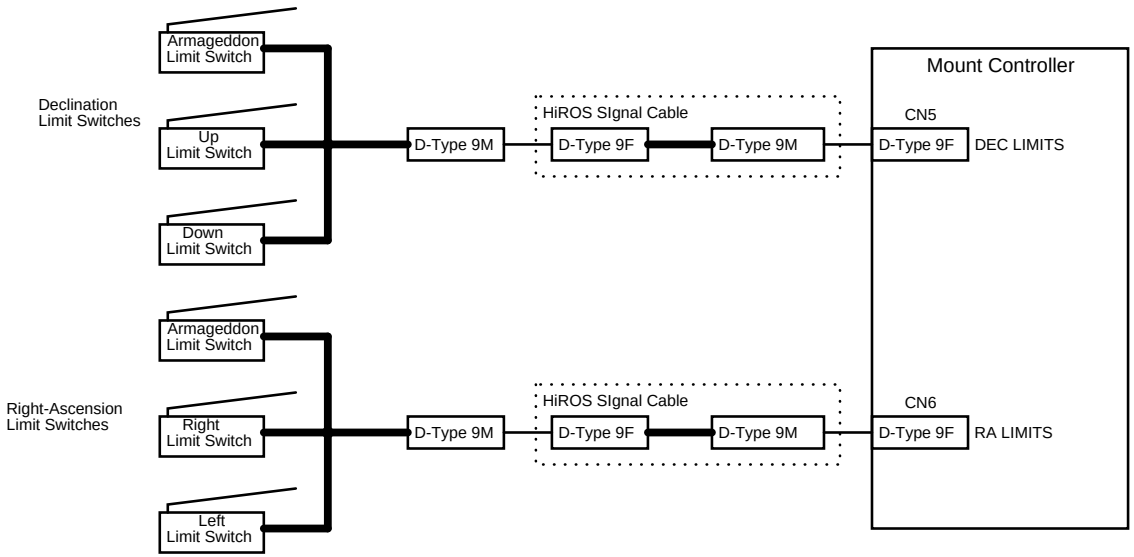


Figure 5: The limit switches.

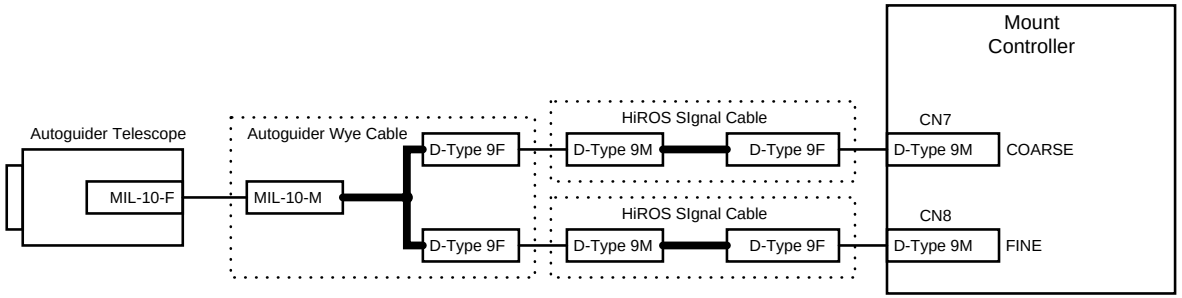


Figure 6: The telescopes.

4 External Cable Assemblies

All of the external cables that are needed for the Mount Controller are summarized in Table 6.

Table 6: Mount Controller External Cable Assemblies

4.1 HiROS Signal Cable

The majority of signals have to travel from a remote sensor to some instrument. Because of this it was decided to adopt a standard cable that is used on any system that requires signals to travel over a considerable distance.

The HiROS signal cable is this standard cable. It is basically a network cable that has D-Type connectors fitted on each end. The cable is made up of four twisted pairs of 7/0.2-mm wires. The cables come in a variety of different lengths and several different outer sheath colours are available including yellow, blue, and red.

Figure 7 shows how the cable is connected internally.

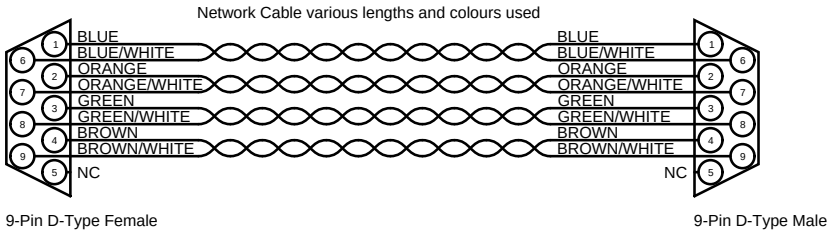


Figure 7: The HiROS signal cable.

4.2 Telescope Wye Cable

The Telescope Wye Cable is used to split the fine and coarse quadrant photodiode signals into two separate branches because they use different connectors on the rear of the Mount Controller. The autoguider telescopes used in our stations are all wired differently. The telescope wye cable will be adjusted at each station to compensate.

Figure 8 shows the telescope wye cable in Birmingham. Figure 9 shows the telescope wye cable in Las Campanas.

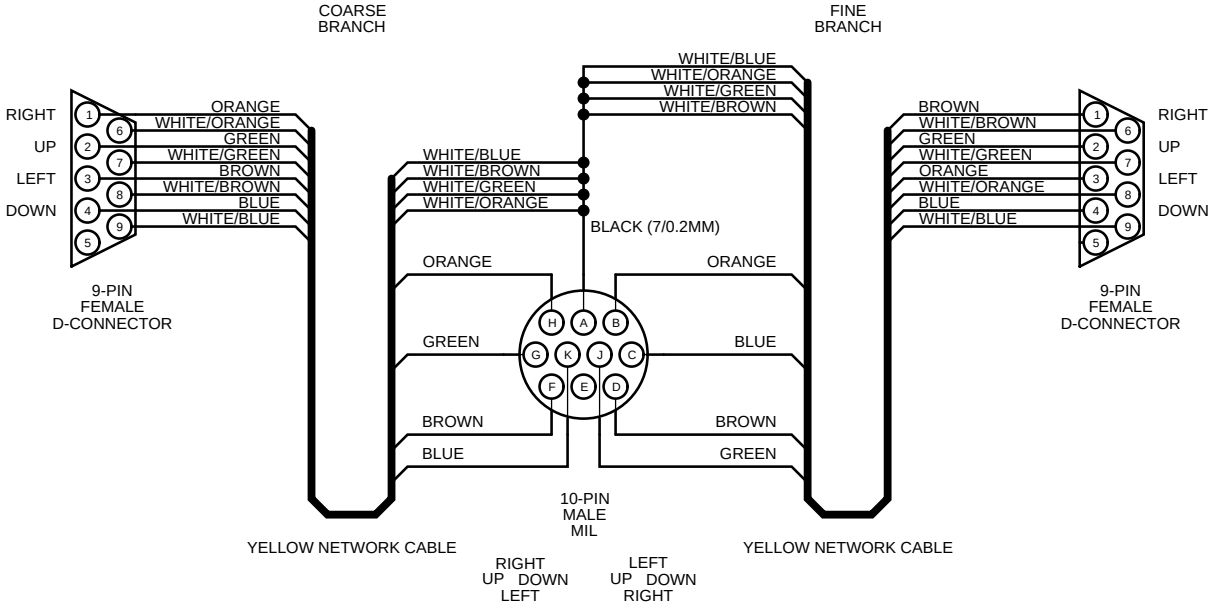


Figure 8: The telescope wye cable in Birmingham.

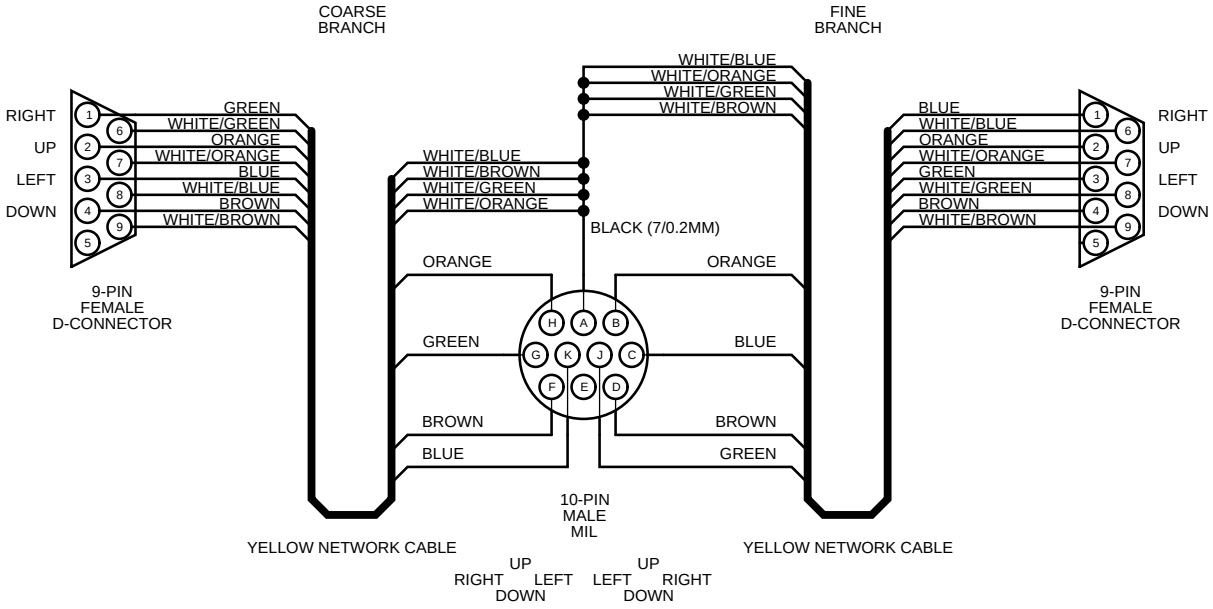


Figure 9: The telescope wye cable in Las Campanas.

4.3 Stepper Motor Wiring

The Mount Controller uses two McLennan 23HSX-202 stepper motors with an IP057-M02 50:1 gearhead to alter the position of the mount in both right ascension and declination.

The stepper motors come pre-wired with eight wires connecting to the coils of the motor. This configuration allows the user to configure the stepper motor in a number of different ways. A 9-pin D-Type connector is fitted to the stepper motor and the wiring configuration is set on the main board of the Mount Controller.

Figure 10 shows how both the RA and DEC stepper motors are wired.

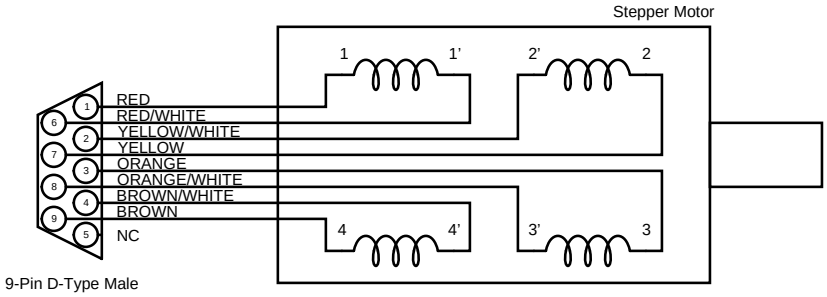


Figure 10: Stepper motor wiring.

4.4 Stepper Motor Cable

The Stepper Motor Cable is the long cable that connects the stepper motors to the Mount Controller main unit. Figure 11 shows how the cable is connected internally.

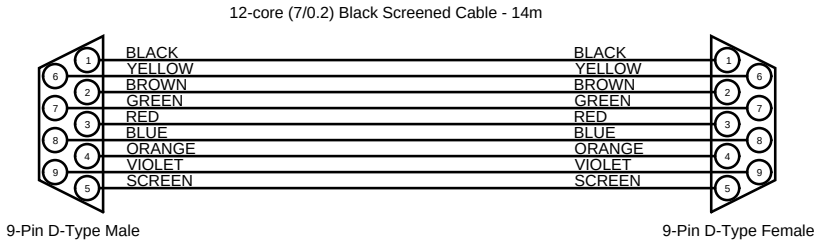


Figure 11: The stepper motor cable.

4.5 Mount Encoder Wiring

There are two encoders used on the mount, one for RA and one for DEC. Both encoders are wired in exactly the same way and this is shown in Figure 12.

4.6 Mount Encoder Cable

The Mount Encoder Cable connects the RA and DEC encoders fitted on the mount to the Mount Controller. Figure 13 shows how the cable is connected internally.

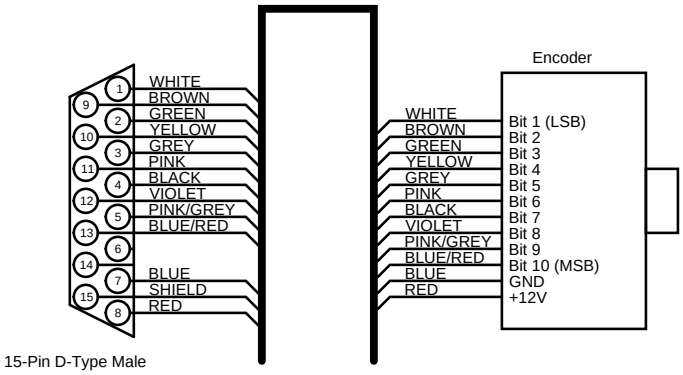


Figure 12: The mount encoder wiring.

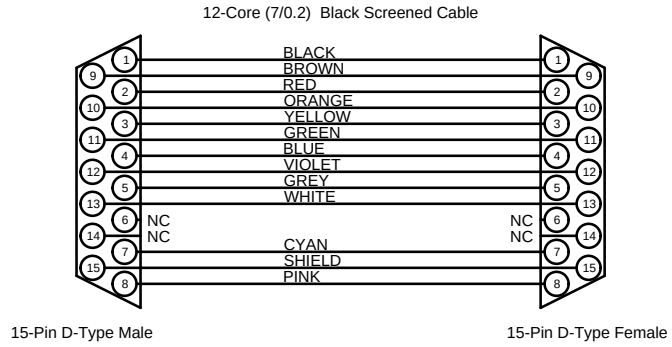


Figure 13: The mount encoder cable.

4.7 Limit Switches

There are a total of six limit switches fitted to the mount. There are separate limits for up, down, left, and right which tell the computer that the mount has reached the appropriate limit.

Then there are two special limit switches one each for RA and DEC called "Armageddon" limits. The "Armageddon" limit switches kill the power to the associated stepper motor when the mount has been driven past the normal limit. The computer cannot recover if either of the "Armageddon" limit switches has been activated. This is because there is obviously a problem with the limit switch that the computer uses and there is a serious risk of damage to the mount.

All six mount limit switches are wired in exactly the same way and this is shown in Figure 14.

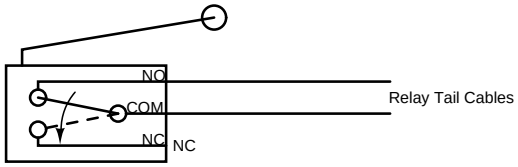


Figure 14: The limit switches.

4.8 Limit Switch Tails

All six mount limit switches are wired in exactly the same way and this is shown in Figure 14.

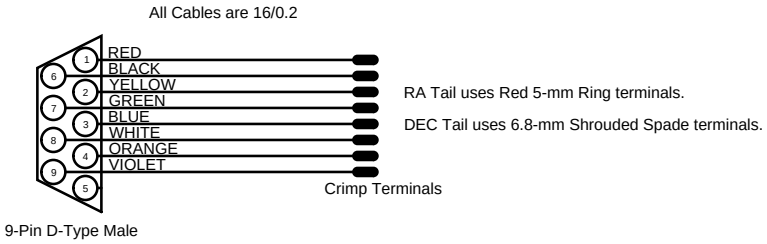


Figure 15: Limit switch tails.

4.9 Parts List

The parts that are needed to make all of the external cable assemblies are given in Table 7.

Table 7: Mount Controller — External Cable Assembly Parts

Part Number	Description (SSM)
McLennan 670 001150	10-bit Encoder
McLennan 23HSX202	Stepper Motor
McLennan IP057-M02	50:1 Gearbox
Rapid* 15-0525	9-Pin Female D-Type Connector
Rapid* 15-0500	9-Pin Male D-Type Connector
Rapid* 15-0530	15-Pin Female D-Type Connector
Rapid* 15-0505	15-Pin Male D-Type Connector
RS 442-2016	10-pin Male MIL Connector
Rapid 33-1003	Red 5-mm Ring Terminal pk100
Rapid 33-11062	Red 6.3-mm Shrouded Spade Terminal pk100
RS 544-3402	D-Type Connector Hood 9-Pin (10)
RS 544-3418	D-Type Connector Hood 15-Pin (10)
Rapid* 19-4424	Yellow 10-meter Network Cable
FEC* 119-0267	12-Core 7/0.2 Black Screened Cable 100m Reel
Rapid* 02-0205	8-Core 7/0.2 Black Screened Cable 100m Reel
FEC* 715-232	4-Core 7/0.2 Black Screened Cable 100m Reel
Rapid* 01-0935	Red 16/0.2 Cable 100m Reel
Rapid* 01-0900	Black 16/0.2 Cable 100m Reel
Rapid* 01-0950	Yellow 16/0.2 Cable 100m Reel
Rapid* 01-0915	Green 16/0.2 Cable 100m Reel
Rapid* 01-0905	Blue 16/0.2 Cable 100m Reel
Rapid* 01-0945	White 16/0.2 Cable 100m Reel
Rapid* 01-0925	Orange 16/0.2 Cable 100m Reel
Rapid* 01-0940	Violet 16/0.2 Cable 100m Reel

*These items are available from Physics Stores.

5 Internal Wiring

The Mount Controller uses a single main board and then there are connectors and panel-mounted display boards used to make up the entire system. This means that the unit requires internal wiring using cable assemblies. This section of the report describes all of the internal wiring of the Mount Controller.

5.1 Internal Wiring Diagrams

The wiring diagram for the Mount Controller is too large to fit onto a single page and therefore it has been split up into smaller logical blocks.

Table 8 summarizes the individual drawings that make up the internal wiring diagram for the Mount Controller.

Table 8: Internal Wiring Diagram

Drawing	*Figure*	*Page*
AC Power Supplies	16	18
DC Power Supplies	17	19
Coarse and fine autoguiders	18	20
Stepper motors	19	21
RS-232 communications interface	20	22
Limit switches	21	23
Mount encoders	22	24

The internal RS-232 cable was damaged and had to be replaced in Las Campanas. No 4-wire cable was available. Figure 20 in page 22 shows the replacement cable that was made.

5.2 Internal Wiring Parts

The parts to complete the internal wiring of the Mount Controller have been split up into separate tables for cables and connectors.

The tables that make up the parts list for the internal wiring are summarized in Table 9.

Table 9: Internal Wiring Parts Lists

Drawing	*Figure*	*Page*
Cables	10	25
Connectors	11	26

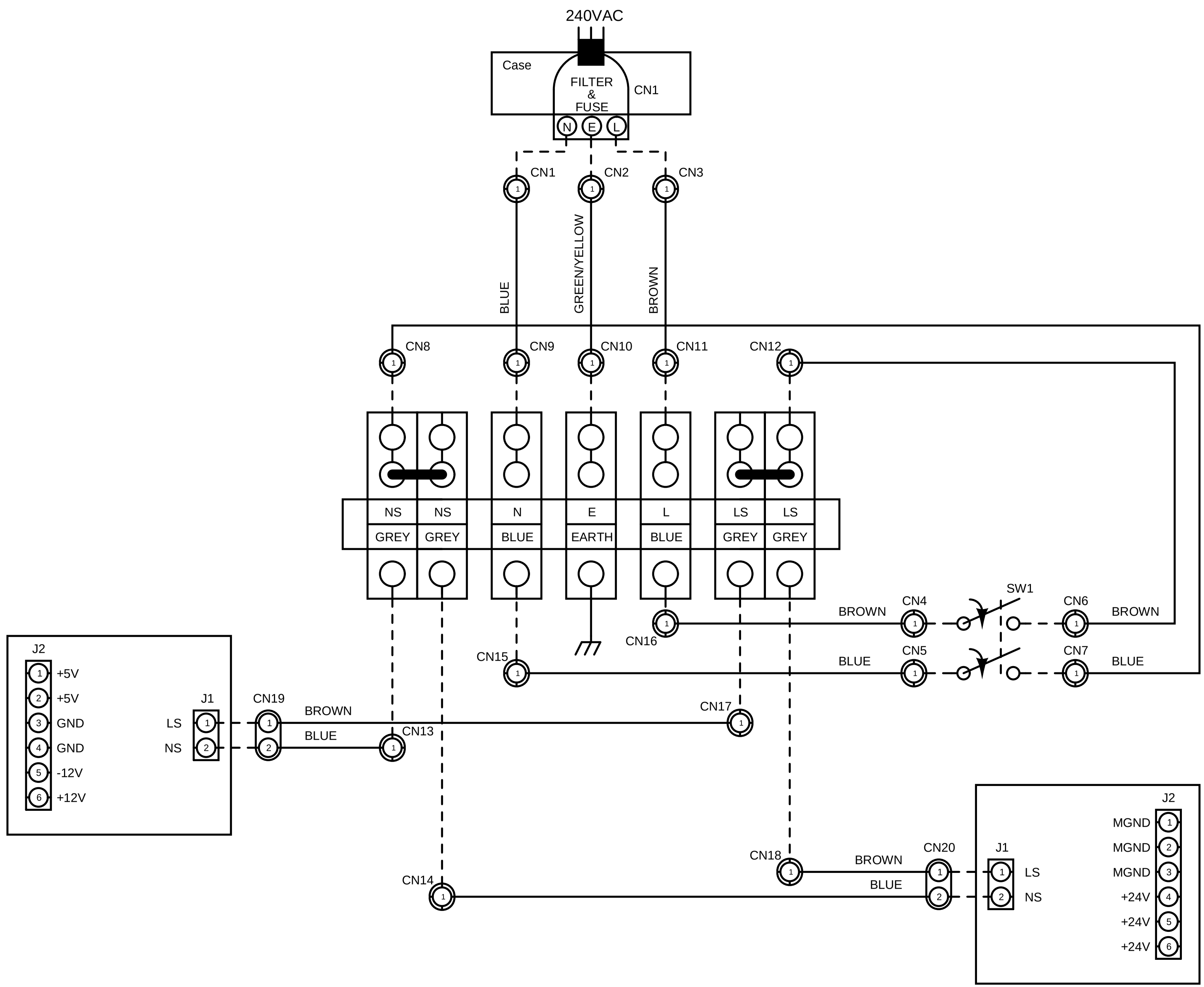


Figure 16: The AC power supplies.

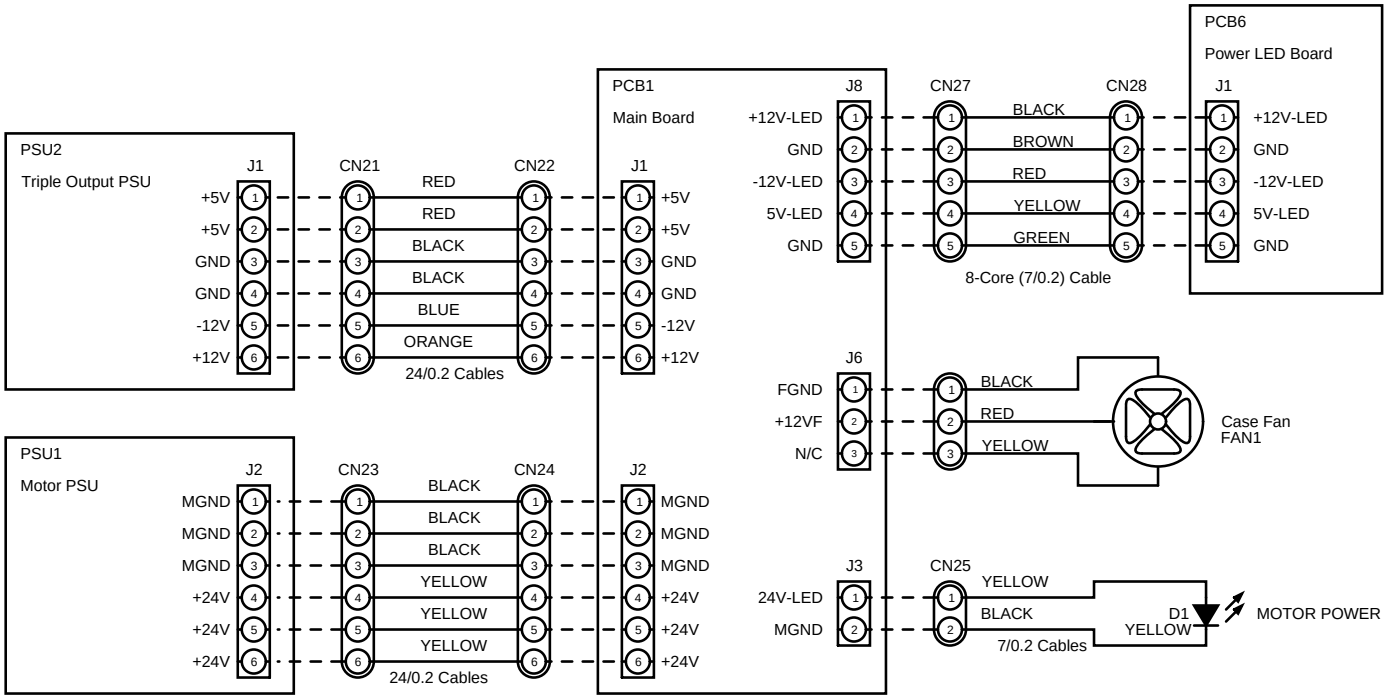


Figure 17: The DC power supplies.

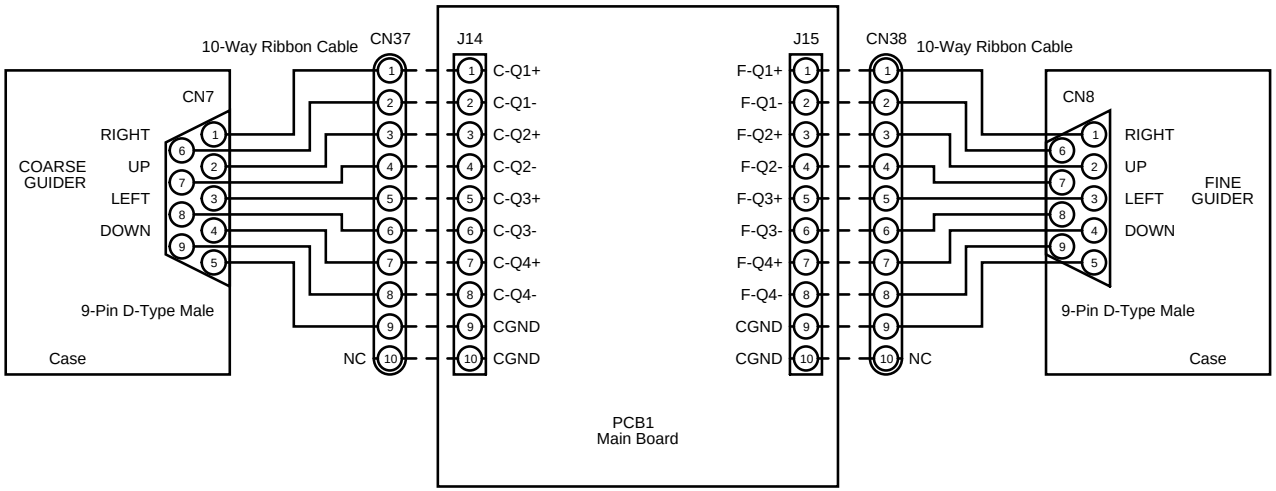


Figure 18: The coarse and fine telescopes.

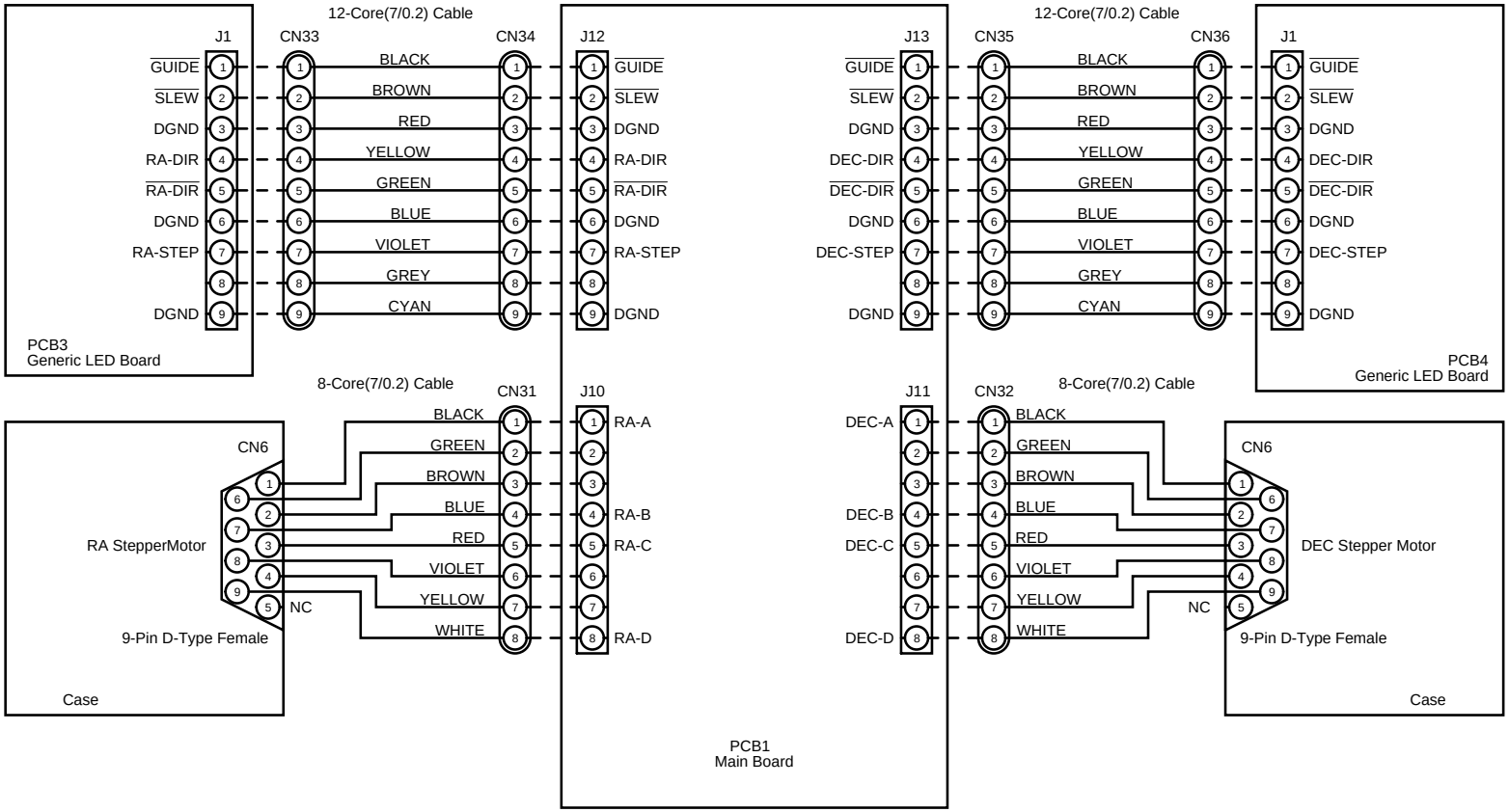


Figure 19: The stepper motors.

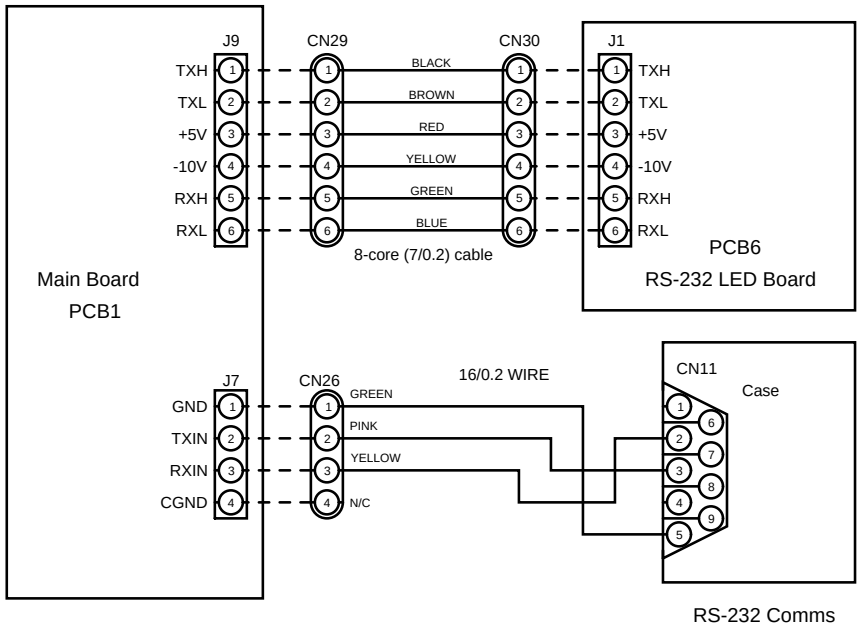


Figure 20: The RS-232 communications interface.

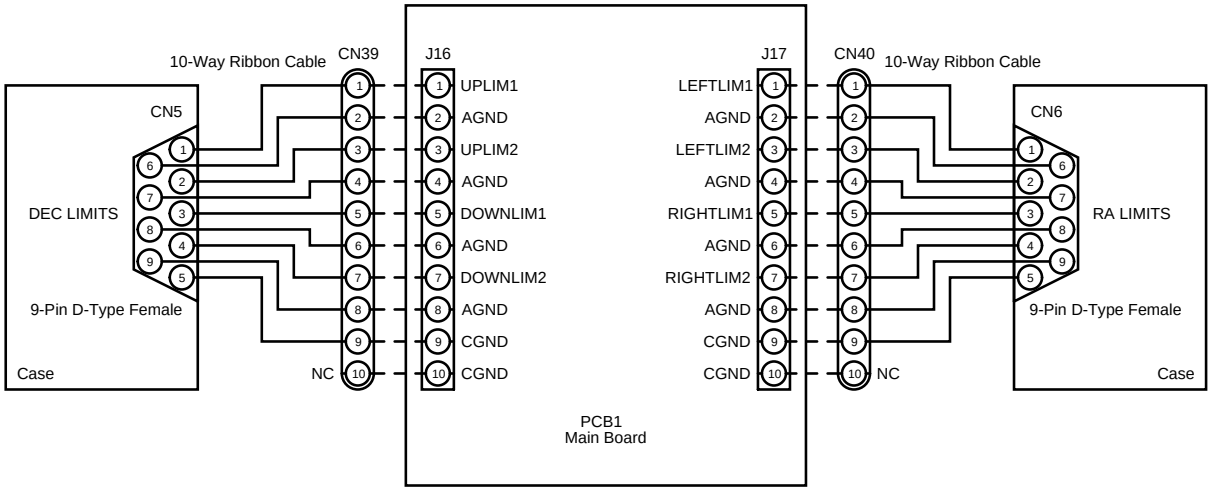


Figure 21: The limit switches.

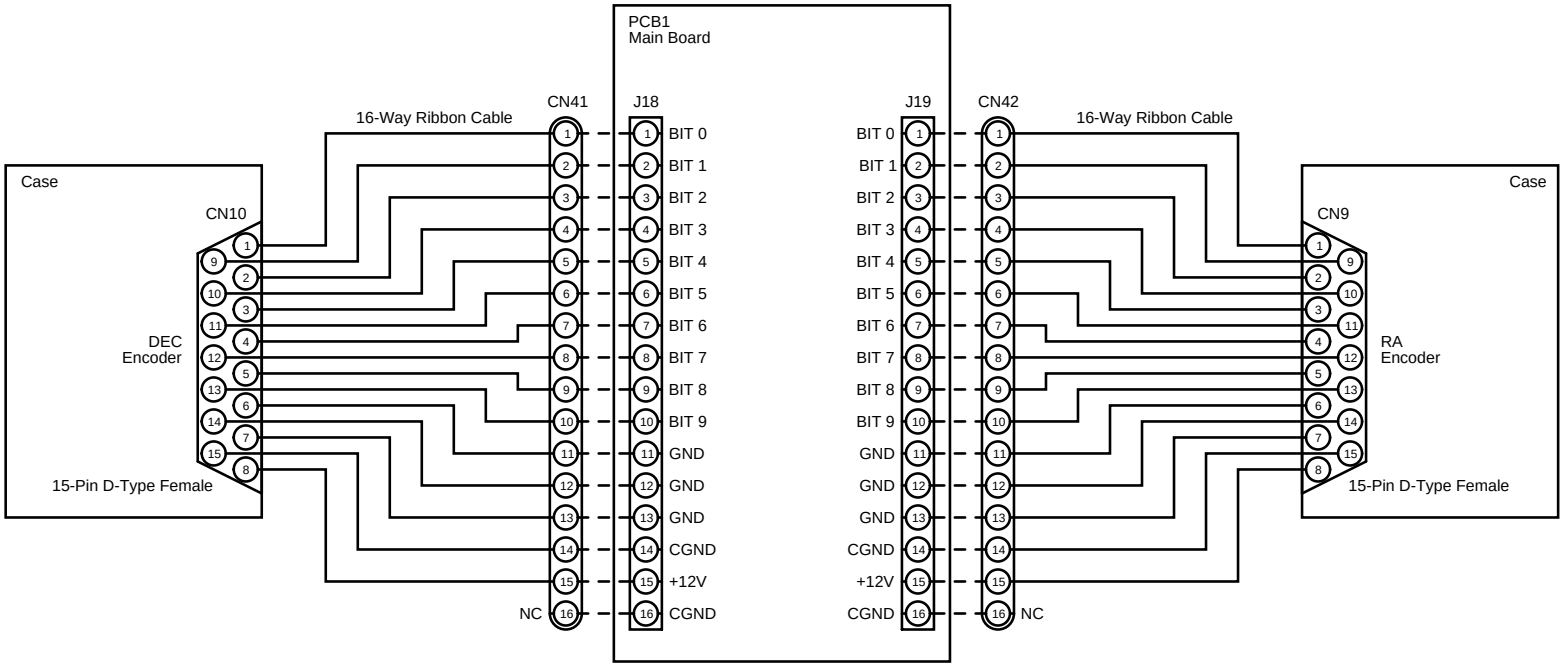


Figure 22: The mount encoders.

Table 10: Internal Wiring Parts List — Cables

Part Number	Description (SSM)
Rapid 01-0256	2-Core (32/0.2) Mains Cable 100m Reel
Rapid* 01-0282	3-Core (32/0.2) Mains Cable 100m Reel
FEC* 119-0255	4-Core (7/0.2) Screened Black Cable 100m Reel
FEC* 119-0171	8-Core (7/0.2) Screened Black Cable 25m Reel
Rapid* 01-1461	10-Way Coloured Ribbon Cable 30.5m Reel
Rapid* 01-1464	16-Way Coloured Ribbon Cable 30.5m Reel
Rapid* 01-0450	7/0.2 Yellow Cable 100m Reel
Rapid* 01-0400	7/0.2 Black Cable 100m Reel
Rapid* 01-1100	24/0.2 Black Cable 100m Reel
Rapid* 01-1135	24/0.2 Red Cable 100m Reel
Rapid* 01-1105	24/0.2 Blue Cable 100m Reel
Rapid* 01-1150	24/0.2 Yellow Cable 100m Reel
Rapid* 01-1125	24/0.2 Orange Cable 100m Reel

*These items are available from Physics Stores.

Table 11: Internal Wiring Parts List — Connectors

Name	Part Number	Description (SSM)
CN1–CN3	Rapid* 33-0660	Red Insulated 6.8×0.8 Female Terminal pk100
CN4–CN7	Rapid* 33-0650	Red Uninsulated 4.8×0.8 Female Terminal pk100
CN8–CN18	Rapid 33-1368	Yellow 1-mm Bootlace Ferrule pk100
CN19–CN20	Rapid 22-2500	0.156" 2-Way Crimp Housing
CN21–CN24	Rapid 22-2520	0.156" 6-Way Crimp Housing
CN25	Rapid 22-0905	2-Way Molex KK Crimp Housing
CN26	Rapid 22-0915	4-Way Molex KK Crimp Housing
CN27–CN28	Rapid 22-0920	5-Way Molex KK Crimp Housing
CN29–CN30	Rapid 22-0925	6-Way Molex KK Crimp Housing
CN31–CN32	Rapid 22-0930	8-Way Molex KK Crimp Housing
CN33–CN36	Rapid 22-2355	9-Way Molex KK Crimp Housing
CN37–CN40	Rapid* 19-0300	10-Way IDC Socket
CN41–CN42	Rapid* 19-0305	16-Way IDC Socket
—	Rapid 22-1098	Molex KK Crimp Terminal pk1000
—	Rapid 22-2576	0.156" Crimp Terminal pk1000

*These items are available from Physics Stores.

6 Main Board

Most of the electronics needed by the Mount Controller are contained on the Main board. This section of the report describes the design and construction of the Main PCB of the Mount Controller.

6.1 Schematic Diagram

The schematic diagram for the Main board of the Mount Controller is too large to fit onto a single page. Hence the schematic has been split up onto several pages, with each page being a logical block of the whole design. Table 12 shows all the pages that make up the schematic for the Main board.

Table 12: Mount Controller Main Board Schematics

Drawing	*Figure*	*Page*
Hierarchical block diagram	23	28
External power supply input	24	29
Power supply decoupling — analog	25	30
Power supply decoupling — digital	26	31
Programmable peripheral interface	27	32
Mount encoders	28	33
Coarse telescope	29	34
Fine telescope	30	35
Stepper motor power and control circuits	31	36
Stepper motor LED board driver circuit	32	37
RA stepper motor driver circuit	33	38
DEC stepper motor driver circuit	34	39
Limit switches	35	40
RS-232 serial communications interface	36	41

6.2 Circuit Design and Description

The schematic diagram has been split up into several logical blocks as summarized in Table 12 on Page 27. It makes sense to describe the circuit operation of these sub-blocks individually in this order.

6.2.1 Hierarchical Block Diagram

The hierarchical block diagram is given in Figure 23 on Page 28. This diagram shows all of the sub-circuits in the design of the Mount Controller. The diagram also shows some of the connectors that are also used on the Main board.

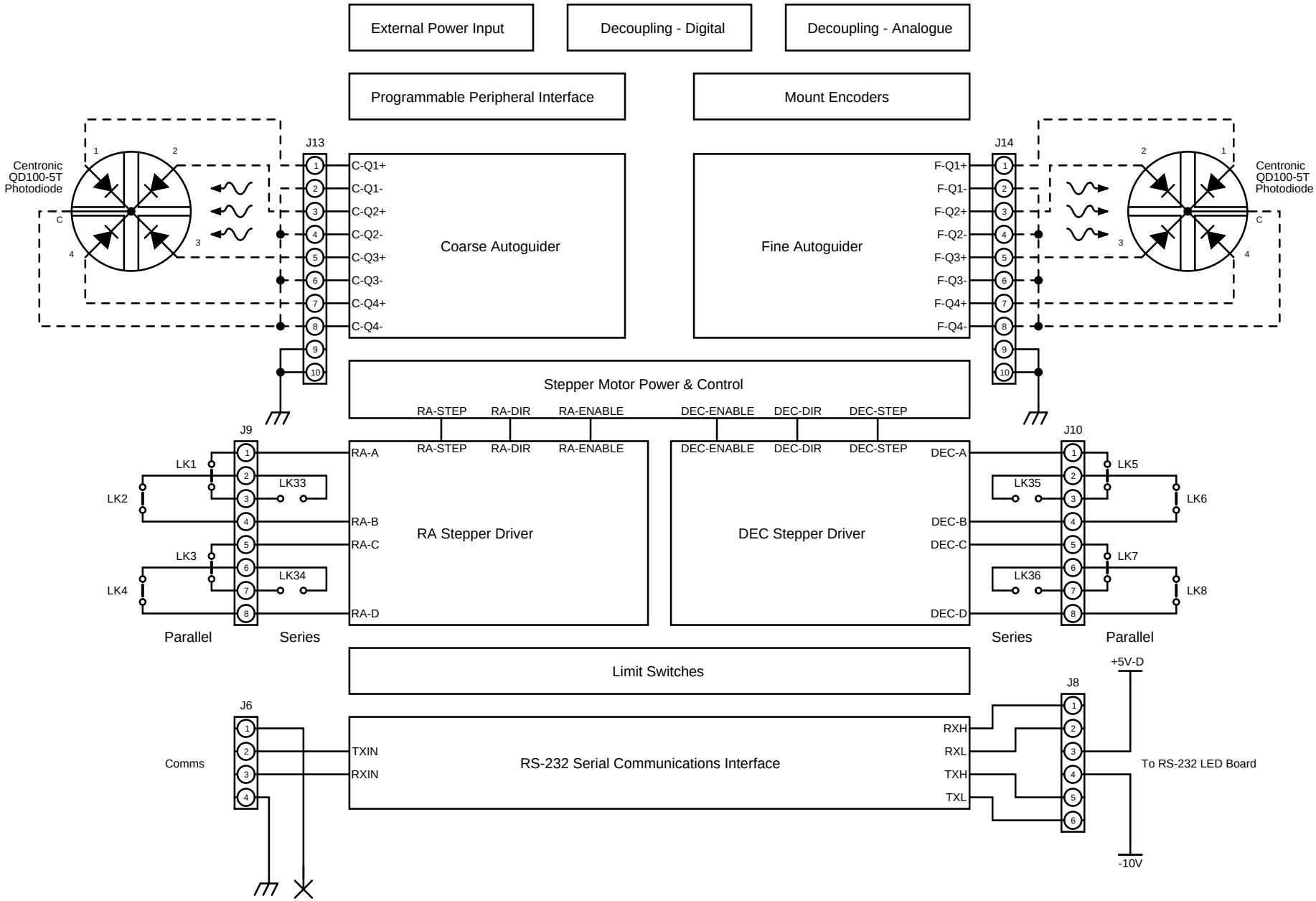


Figure 23: Hierarchical block diagram. Steppers usually wired in parallel.

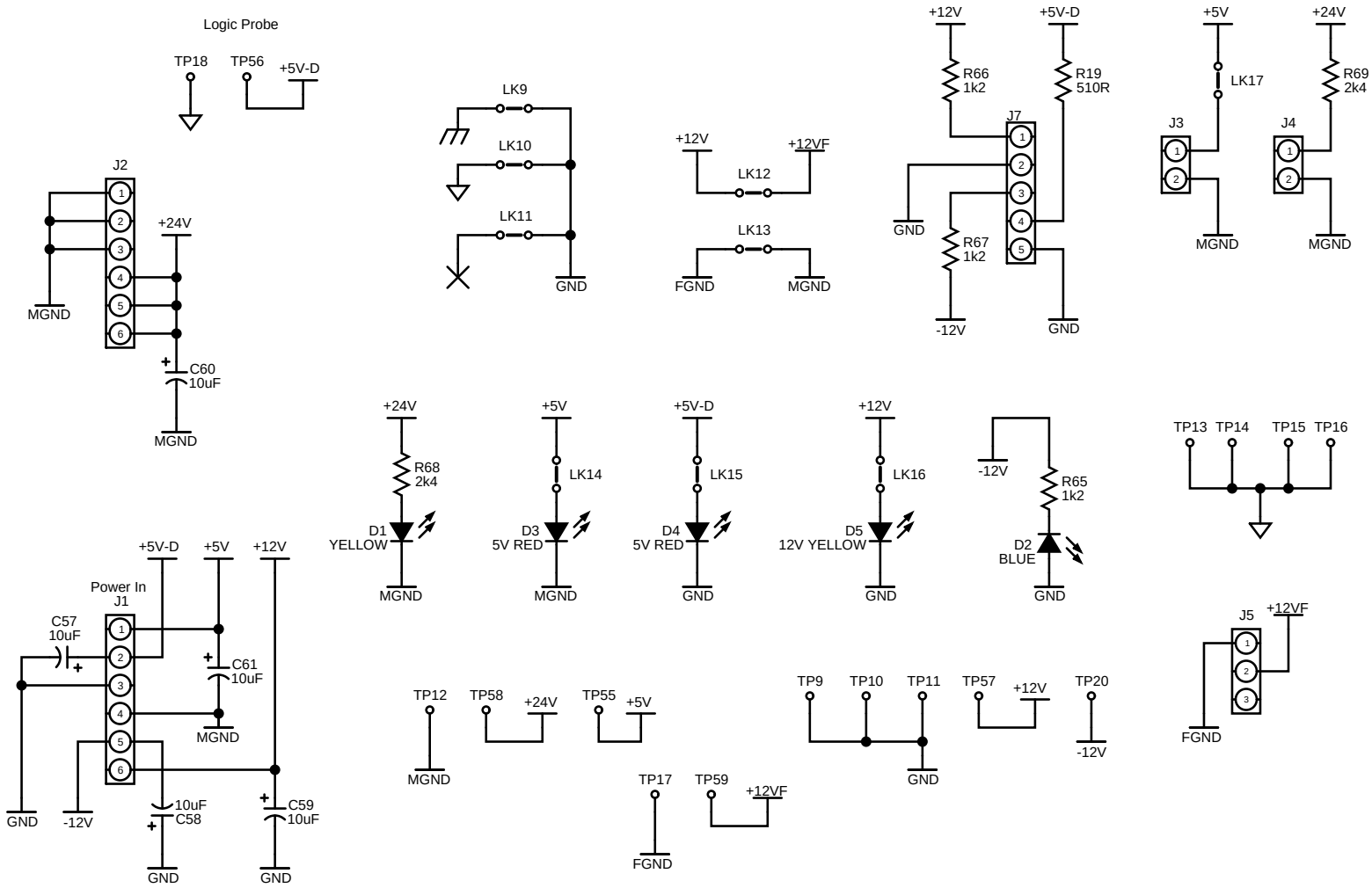


Figure 24: External power input.

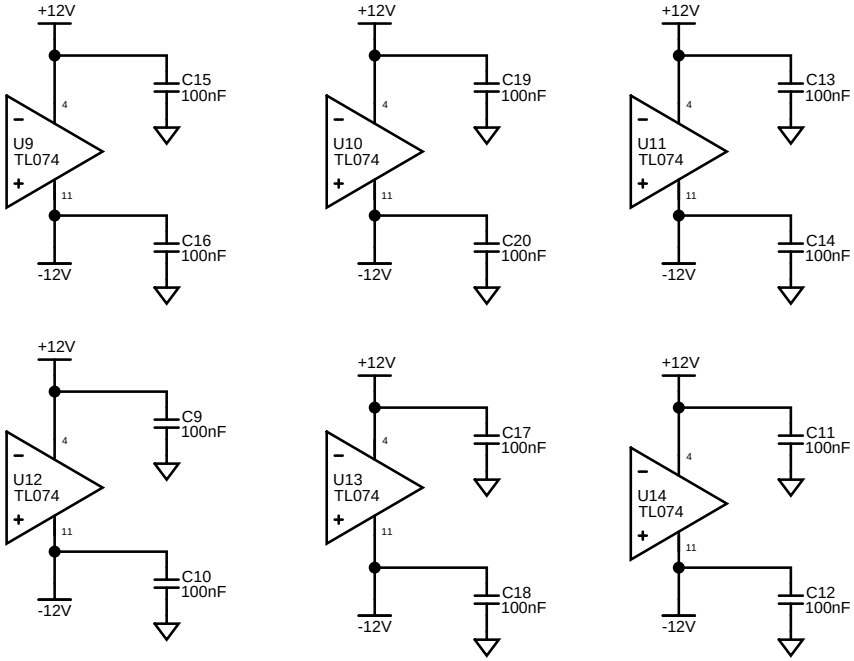


Figure 25: Power supply decoupling — analog.

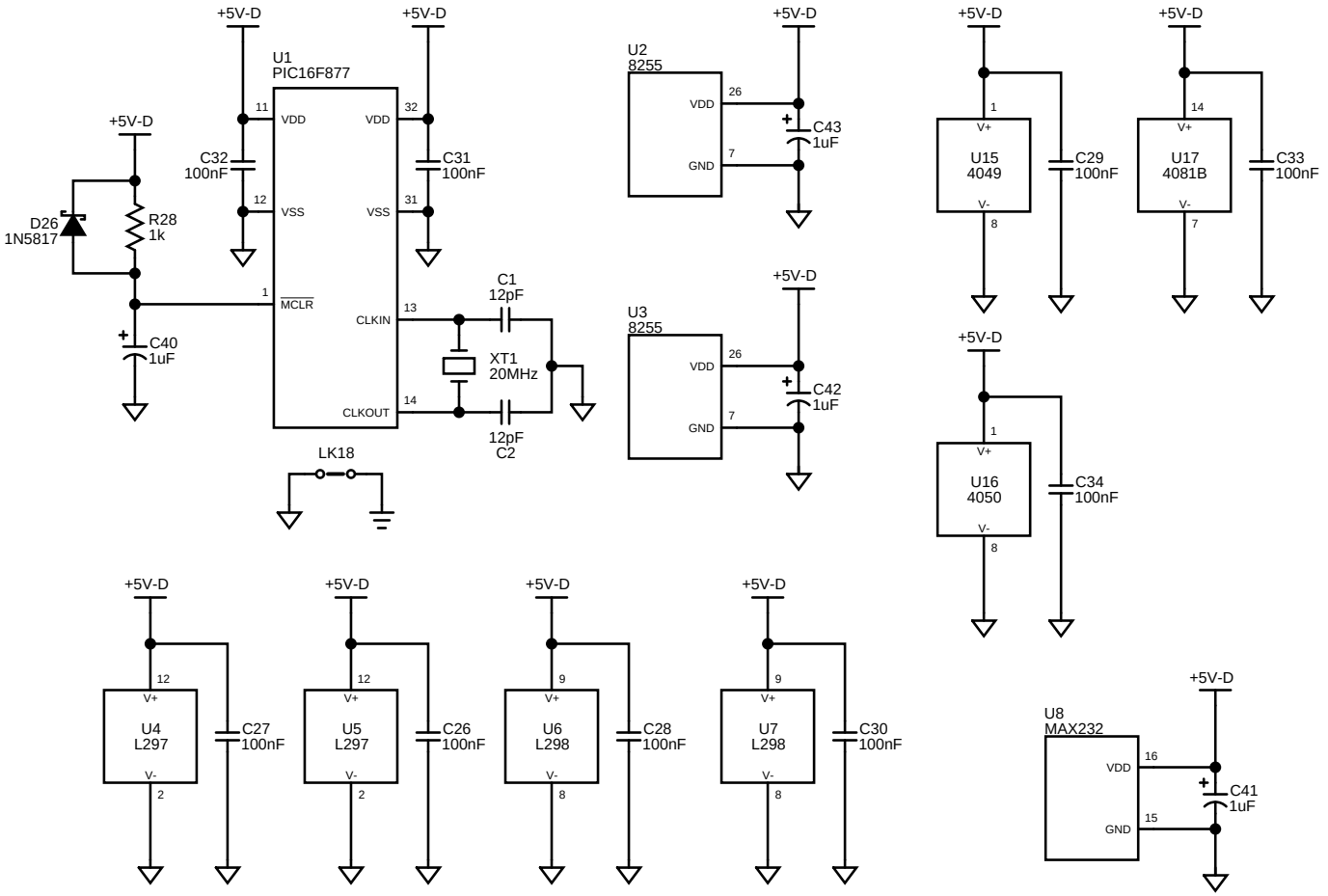


Figure 26: Power supply decoupling — digital.

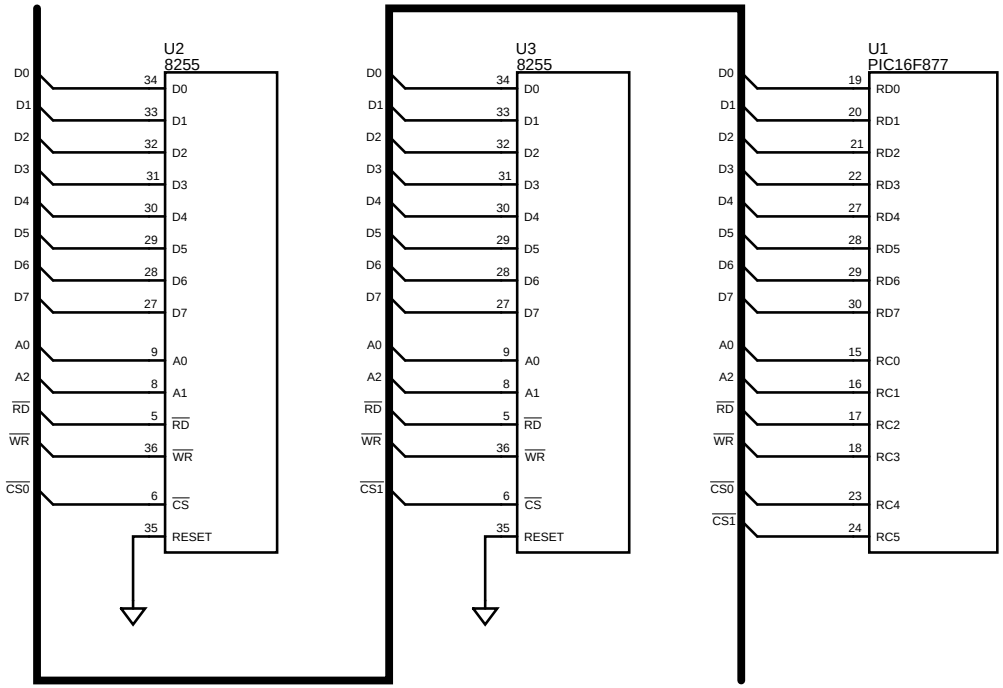


Figure 27: The programmable peripheral interface.

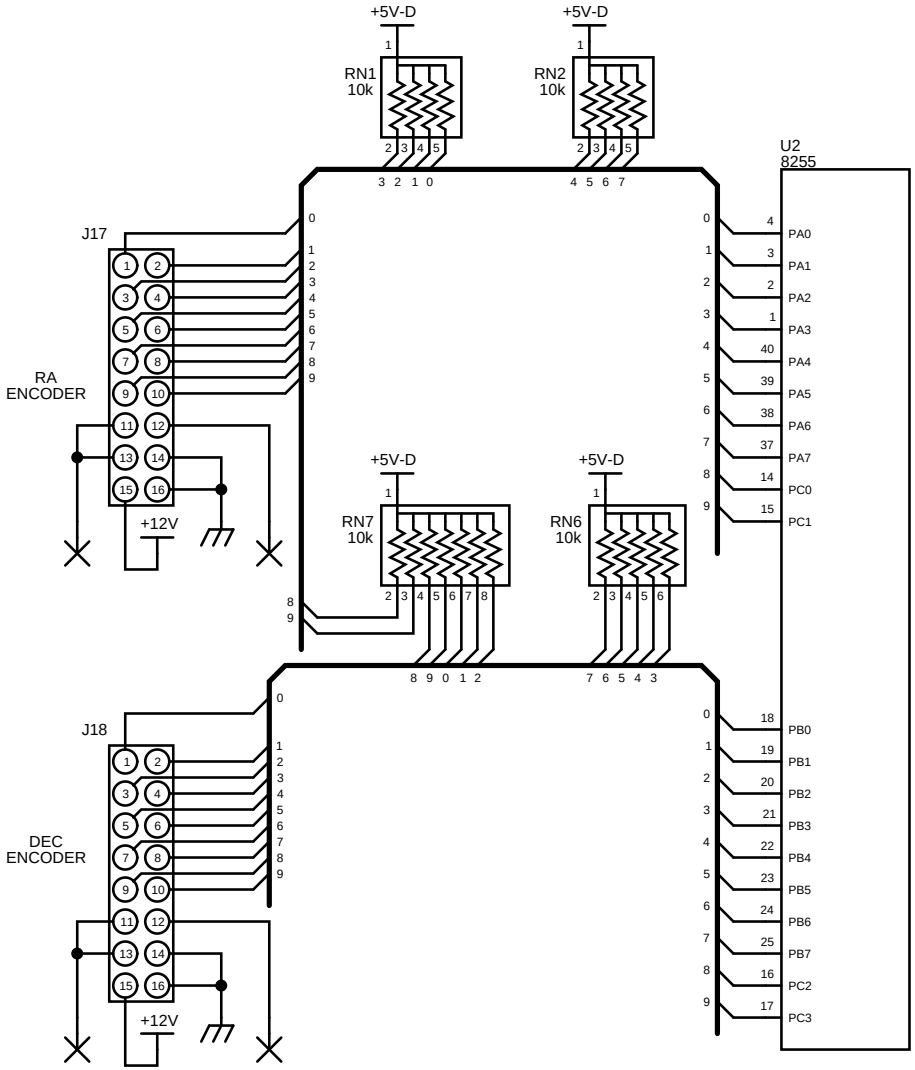


Figure 28: The mount encoders.

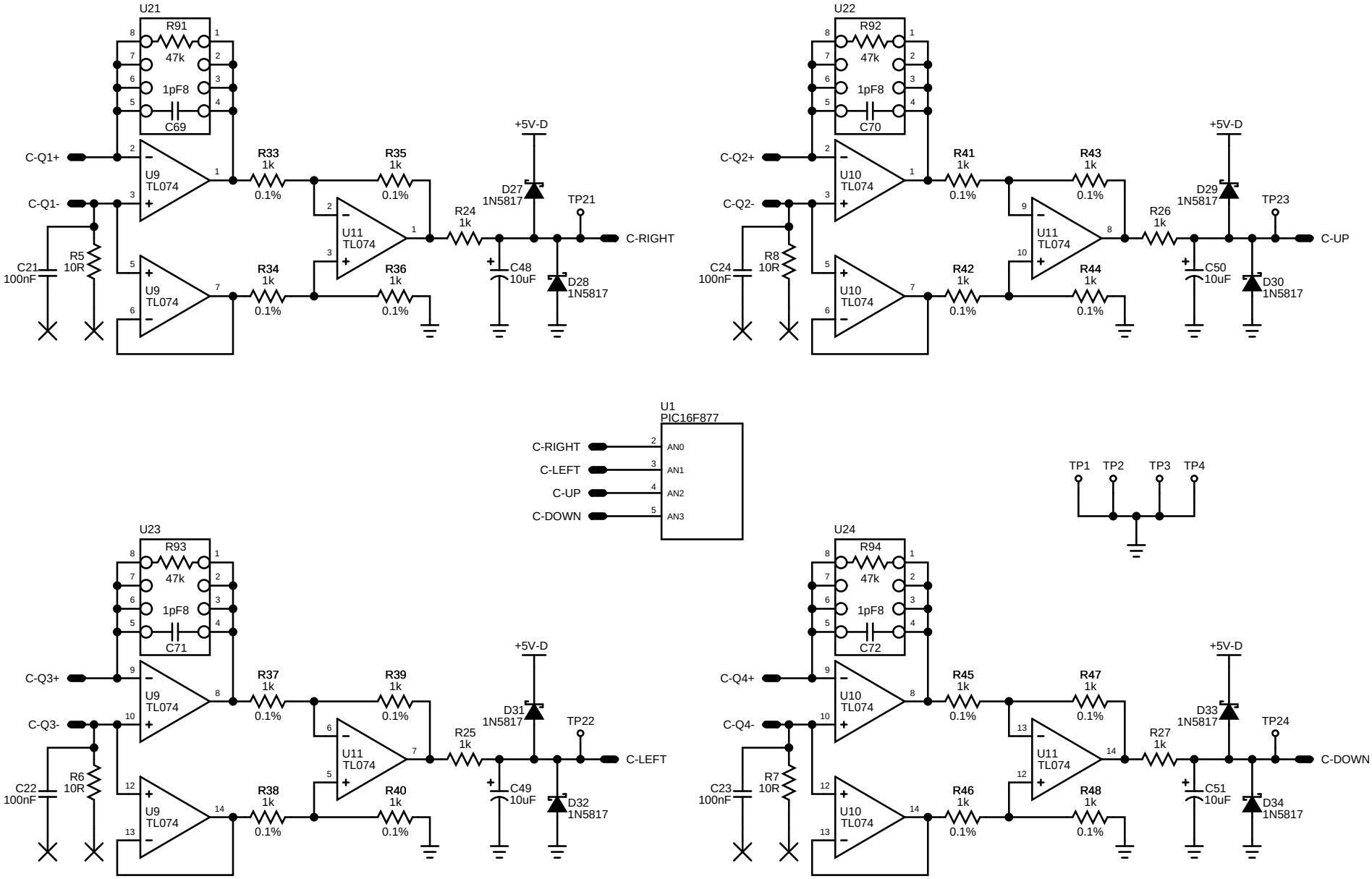


Figure 29: The coarse telescope inputs.

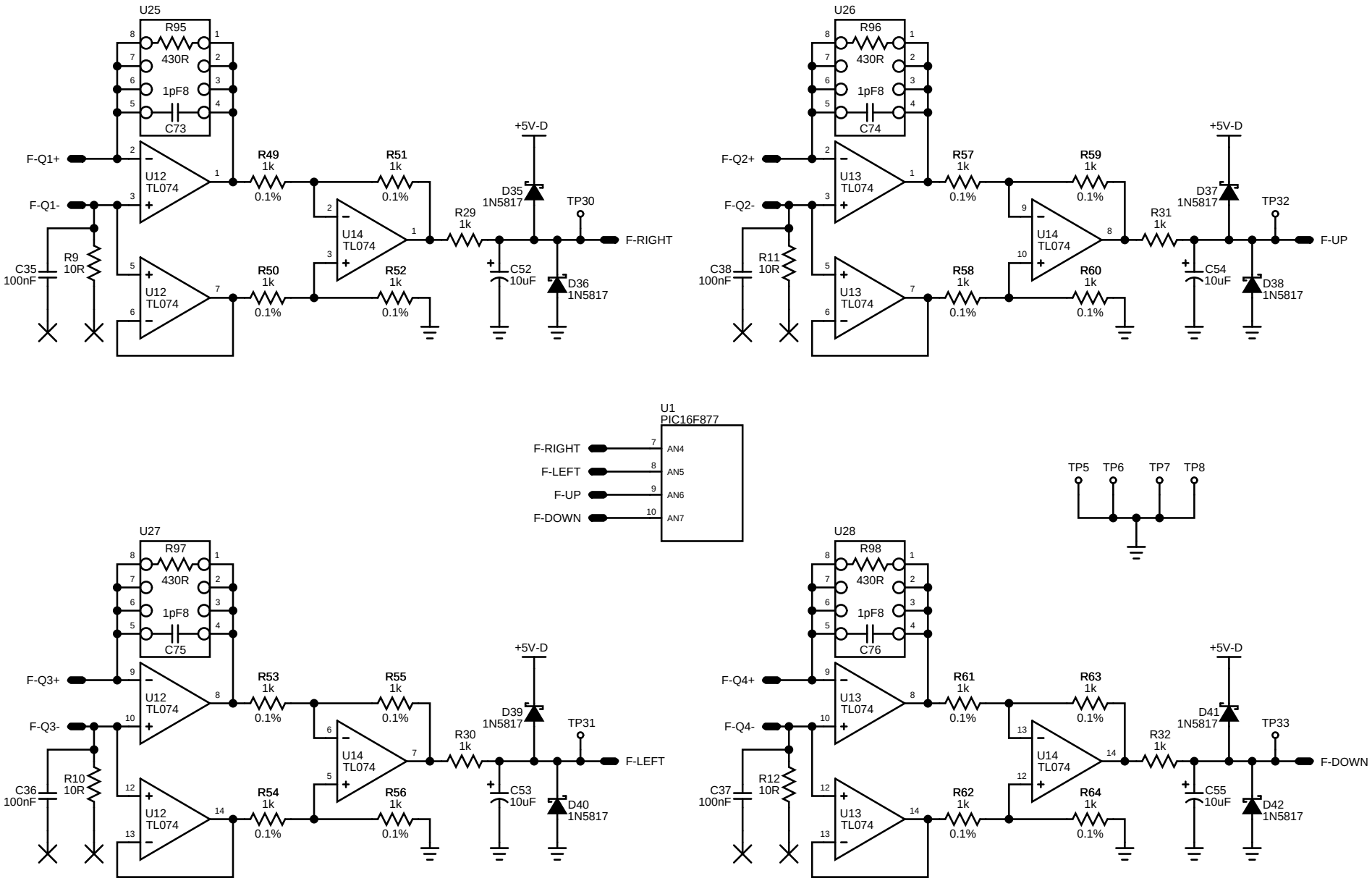


Figure 30: The fine telescope inputs.

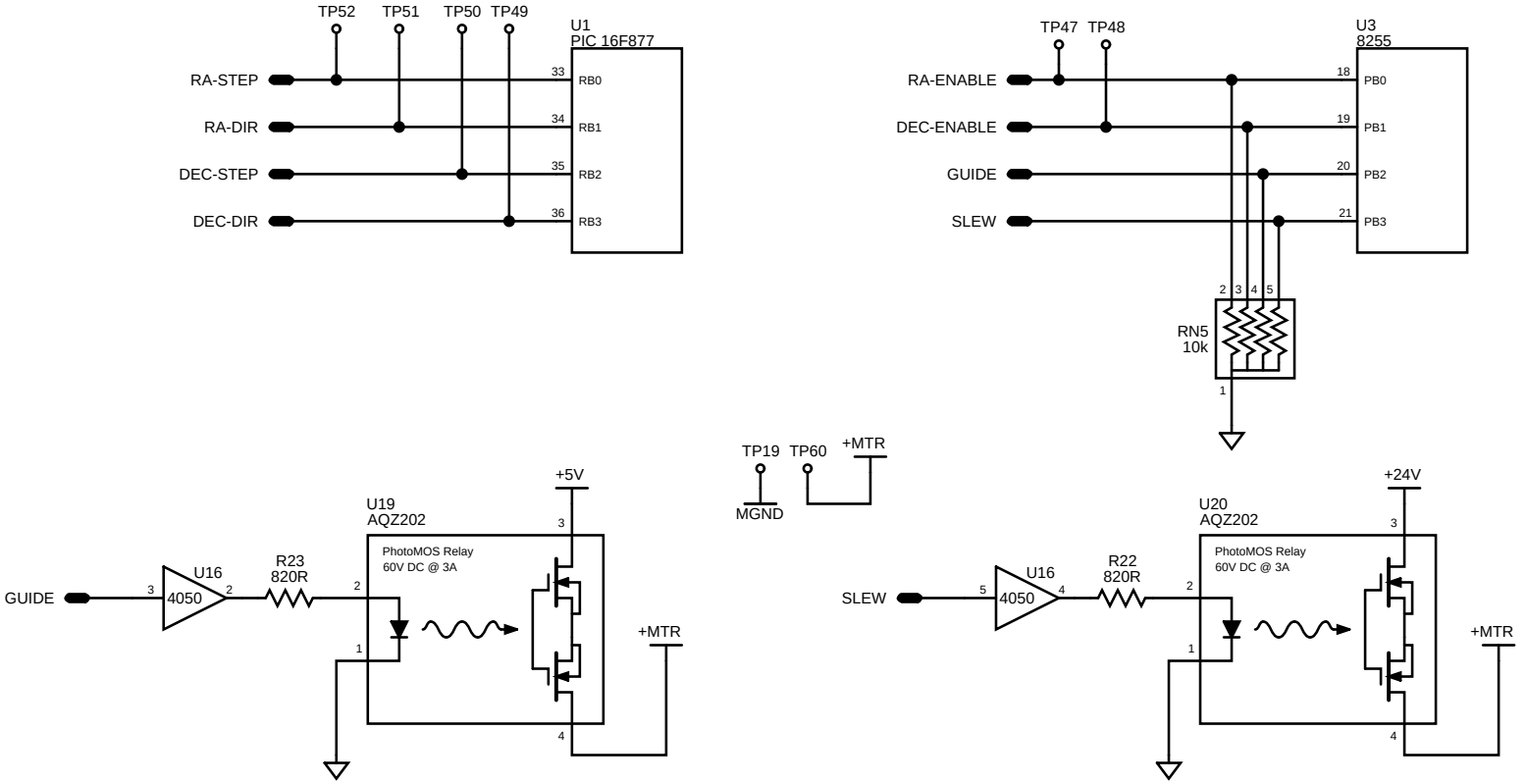


Figure 31: The stepper motor power and control circuits.

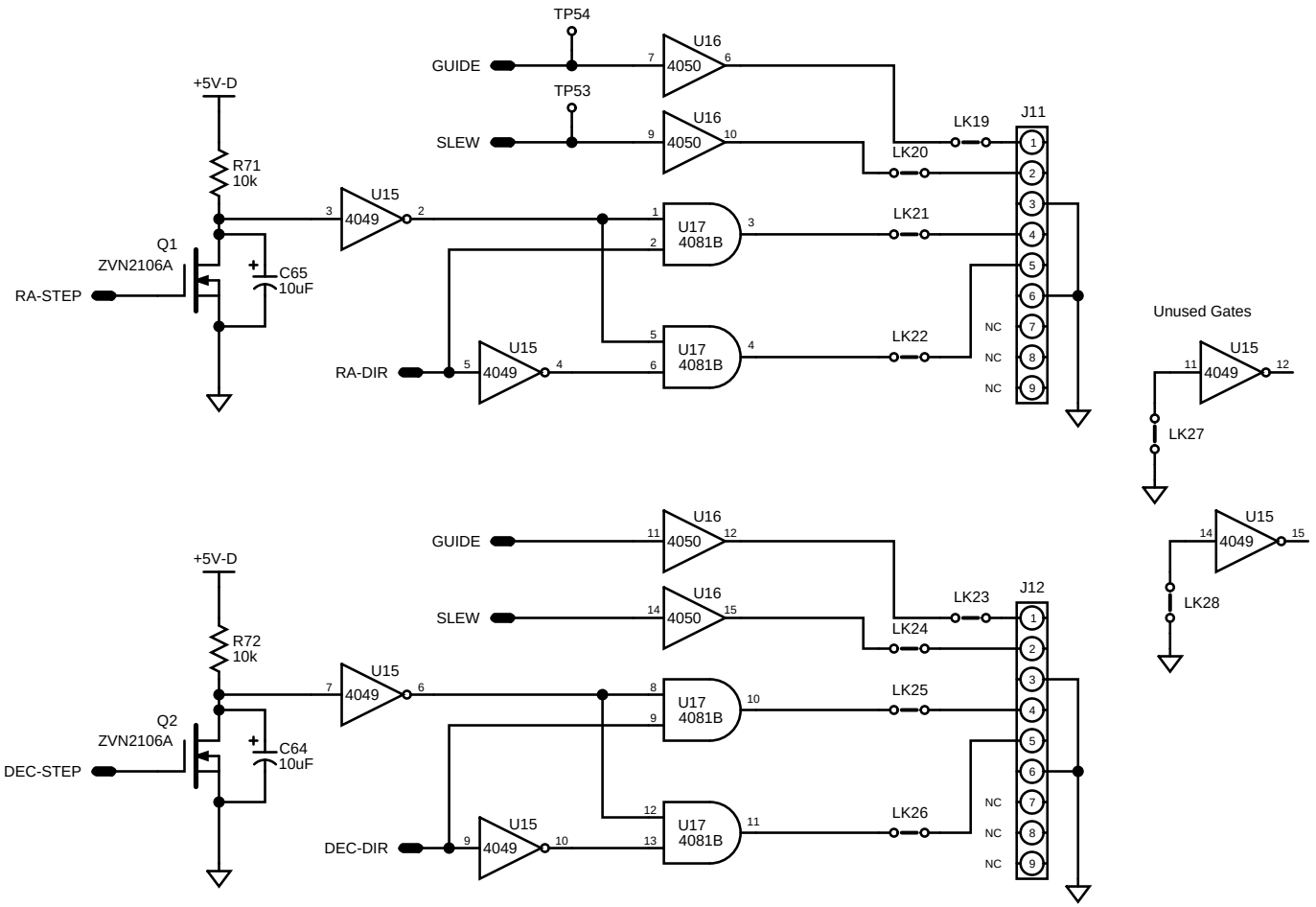


Figure 32: Stepper motor LED board driver circuit

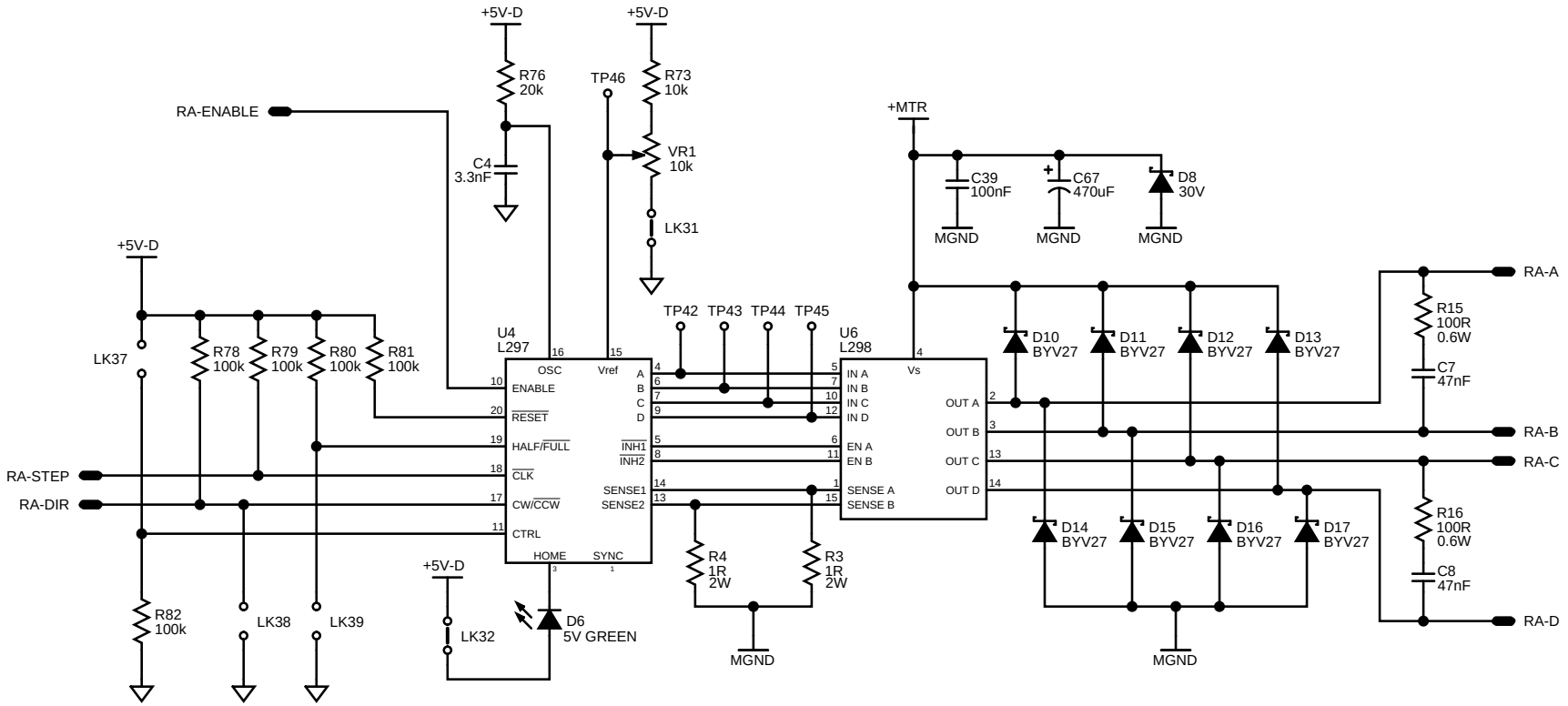


Figure 33: The RA stepper motor driver circuit.

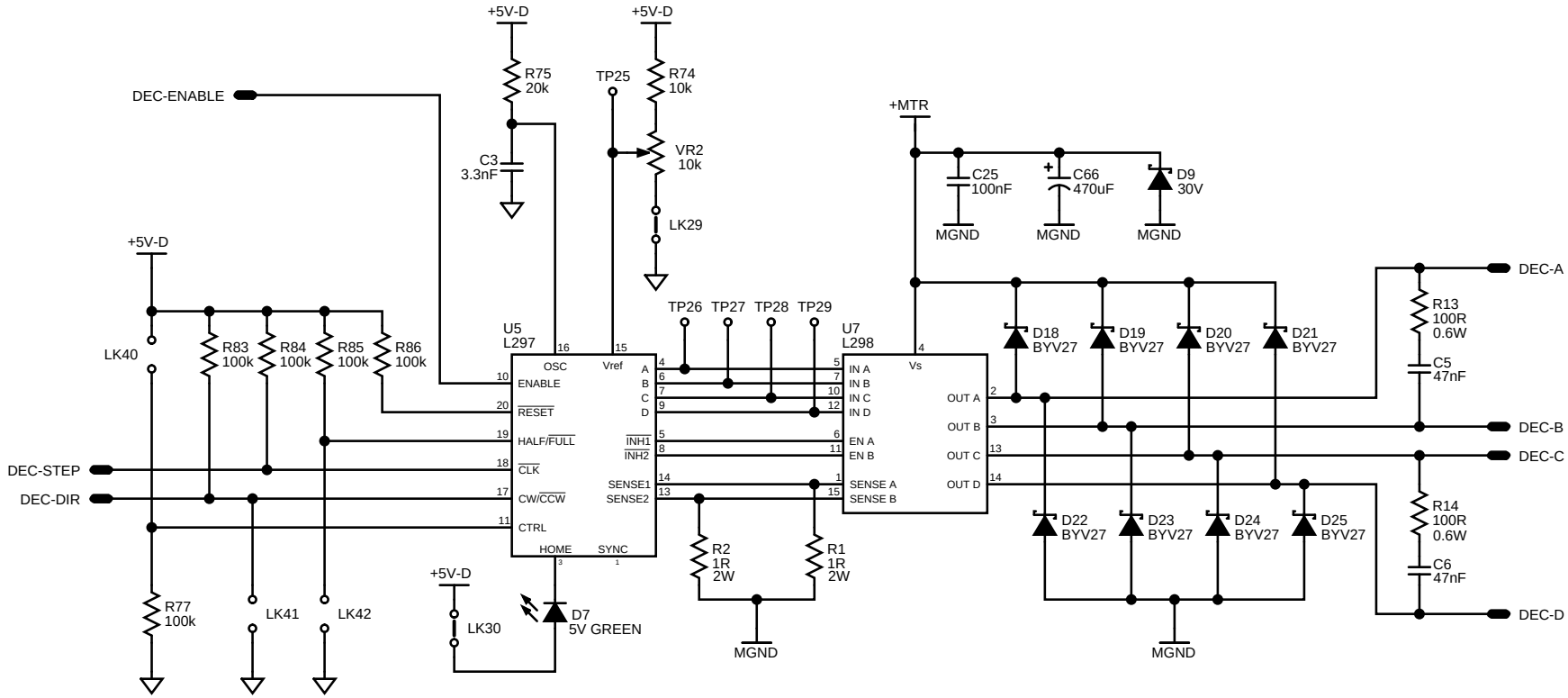


Figure 34: The DEC stepper motor driver circuit.

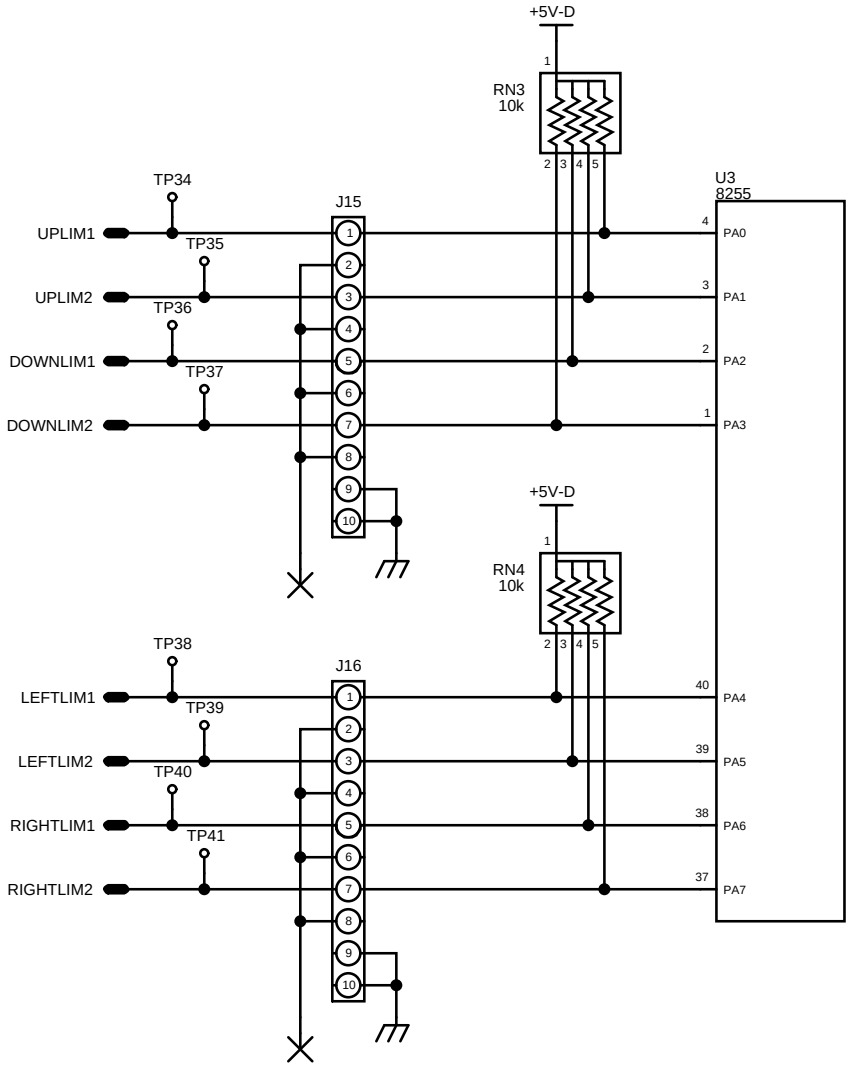


Figure 35: The limit switches.

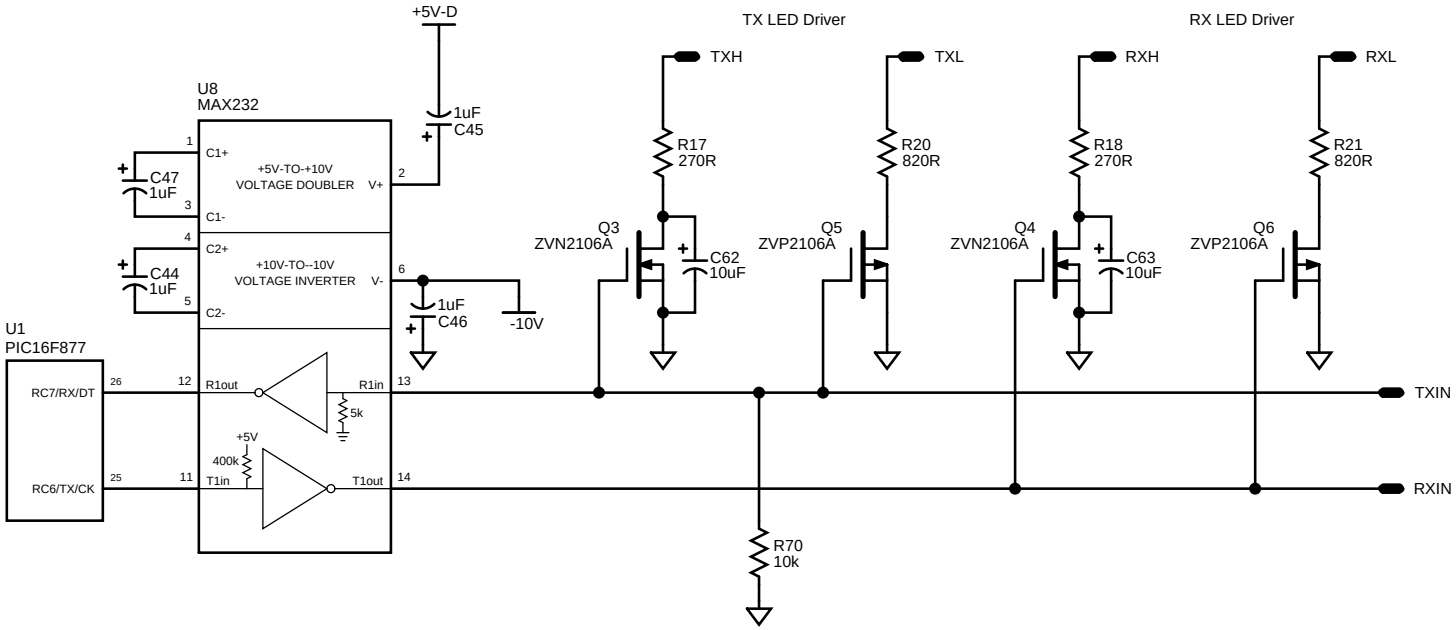


Figure 36: RS-232 serial communications interface.

6.2.2 External Power Input

The external power input schematic is given in Figure 24 on Page 29. The Mount Controller uses several power rails and all of these rails are provided by two commercial power supplies. One supply provides the power for the stepper motors and the other provides all of the other rails needed by the electronics.

The schematic shows the connectors which connect the external power supplies to the Main board. There are also connections to the case mounted LEDs that show that the power rails are working. There are also LEDs fitted to the Main board that show the power rails are working. The +5 V and +12 V LEDs that are fitted to the Main board have the resistor fitted within the LED and hence do not need a resistor. This is why 0-Ω links are fitted to the board. If the LED fails then by changing the link a standard LED can be used.

The schematic also contains various test points on the power rails and also shows how all the different grounds are tied together.

6.2.3 Power Supply Decoupling

The Mount Controller contains a mixture of analog and digital components, and all these components need decoupling capacitors on the power supply pins. Figure 25 on Page 30 shows the decoupling arrangement for the analog devices. Figure 26 on Page 31 shows the decoupling for the digital components. The circuits for the PICs $\overline{\text{MCLR}}$ and clock pins is also shown.

6.2.4 Programmable Peripheral Interface

The Mount Controller is a highly complex system and as a result it requires a lot of I/O lines to be connected to the PIC microcontroller. The PIC that is used on the Mount Controller doesn't have enough I/O lines itself. To provide additional lines of I/O, a programmable peripheral interface (PPI) is used. The PPI has an 8-bit data bus and requires 4 bits for control purposes. The PPI can provide a total of 24 lines of I/O. The 8255 PPI IC is the device that is used to do the I/O expansion on the Mount Controller.

On the Mount Controller there are two 8255s; they share the data lines of the PPI. To ensure that the data goes to the correct device, the chip select lines have to be used.

Figure 27 on Page 32 shows how the data bus is connected to the two 8255s.

6.2.5 Mount Encoders

There are two encoders fitted to the mount that the Mount Controller reads, one for declination (DEC) and one for right-ascension (RA). Both the RA and DEC encoders are the same 10-bit unit.

Figure 12 on Page 14 shows the encoder circuit The PIC reads the DEC and RA through $U2$.

6.2.6 Stepper Motor Power and Control Circuits

The stepper motor power and control circuits are given in Figure 31 on Page 36.

The stepper motors on the mount are driven in two modes — guiding and slewing. In guiding mode, the motors are moved a step at a time in order to rack the sun. To do this the motors are powered from a +5-V supply. Slewing is used when the mount has to be moved quickly to a position; for example, to return to the sunrise position after sunset. To do this, the motors are run very quickly and with a much higher voltage — in this case +24 V. To switch between the +5-V and +24-V supplies, two photomos relays are used.

The STEP and DIR signals have to change very quickly and so they are connected directly to the PIC. The ENABLE, GUIDE, and SLEW signals generally change far less frequently and so they are connected to an 8255 which is slower in switching as the device has to be set up by the PIC.

All of the stepper motor signals are displayed on the front panel of the case via a LED board. The LEDs on this board are all +5 V variants and hence no resistor is needed. A standard LED can be used as there are 0-Ω links on the board that can be changed for a resistor if needed. There are separate display boards for the RA and DEC stepper motors.

6.2.7 Stepper Motor Driver Circuits

The Mount Controller uses the same circuit for the RA and DEC stepper motor drivers. Figure 33 on Page 38 for the RA stepper driver and Figure 34 on Page 39 for the DEC stepper circuit.

6.3 PCB Layout

The Mount Controller Main board is a four layer PCB and as a result the manufacture of this PCB is subcontracted out to a professional manufacturer. Because the PCB is being made externally it will have a proper silkscreen on the board which will make the population of the board and fault finding easier.

Table 13 summarizes the various layers that make up the Mount Controller Main board.

Table 13: Mount Controller PCB Layers

Drawing	*Figure*	*Page*
Component Side Tracks (Layer 1)	37	44
Internal Layer Tracks (Layer 3)	38	45
Internal Layer Tracks (Layer 4)	39	46
Component Side Tracks (Layer 2)	40	47

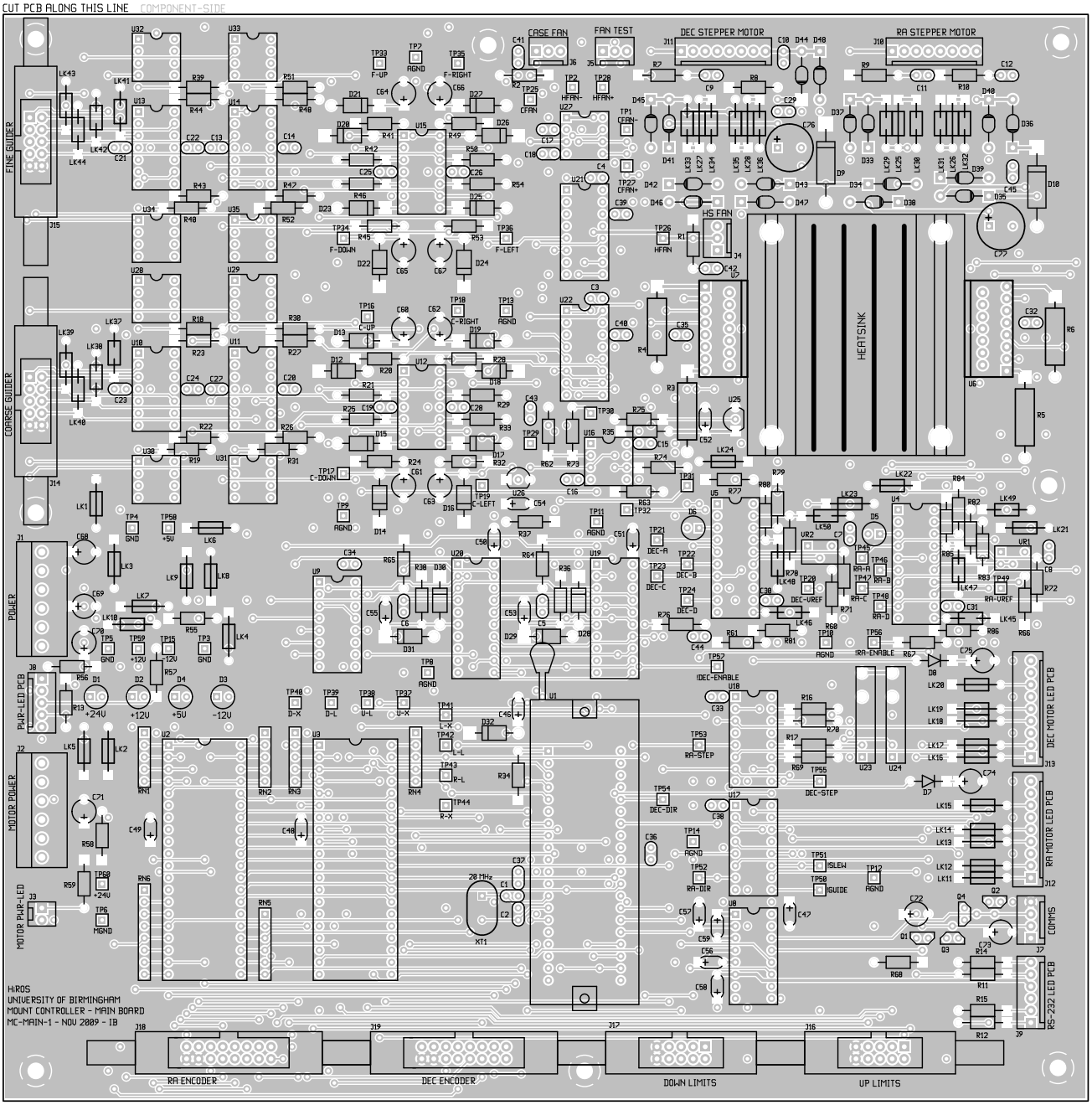


Figure 37: Silkscreen and component-side tracks (Layer 1) of the Main PCB.

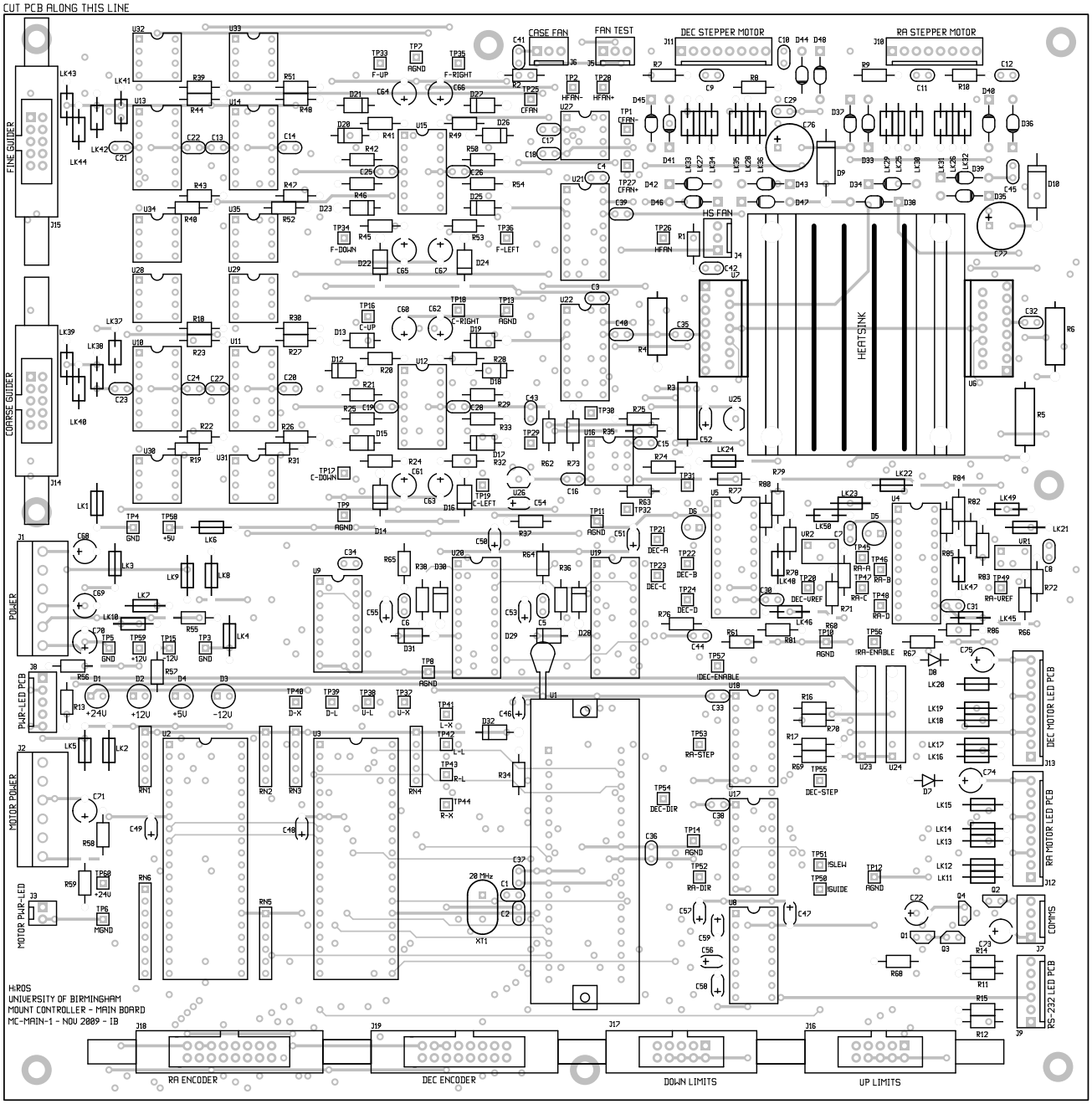


Figure 38: Silkscreen and internal tracks (Layer 3) of the Main PCB.

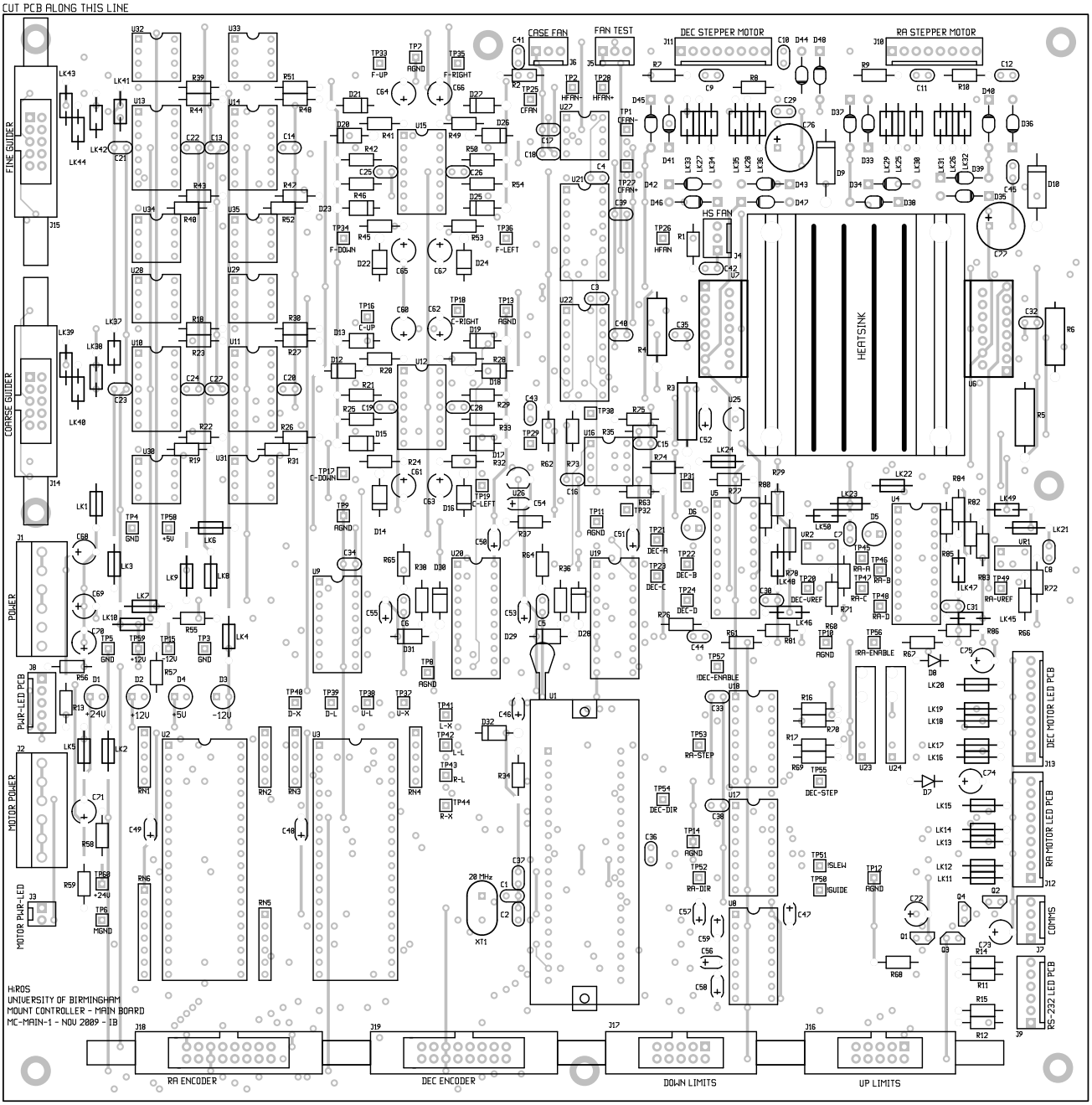


Figure 39: Silkscreen and internal tracks (Layer 4) of the Main PCB.

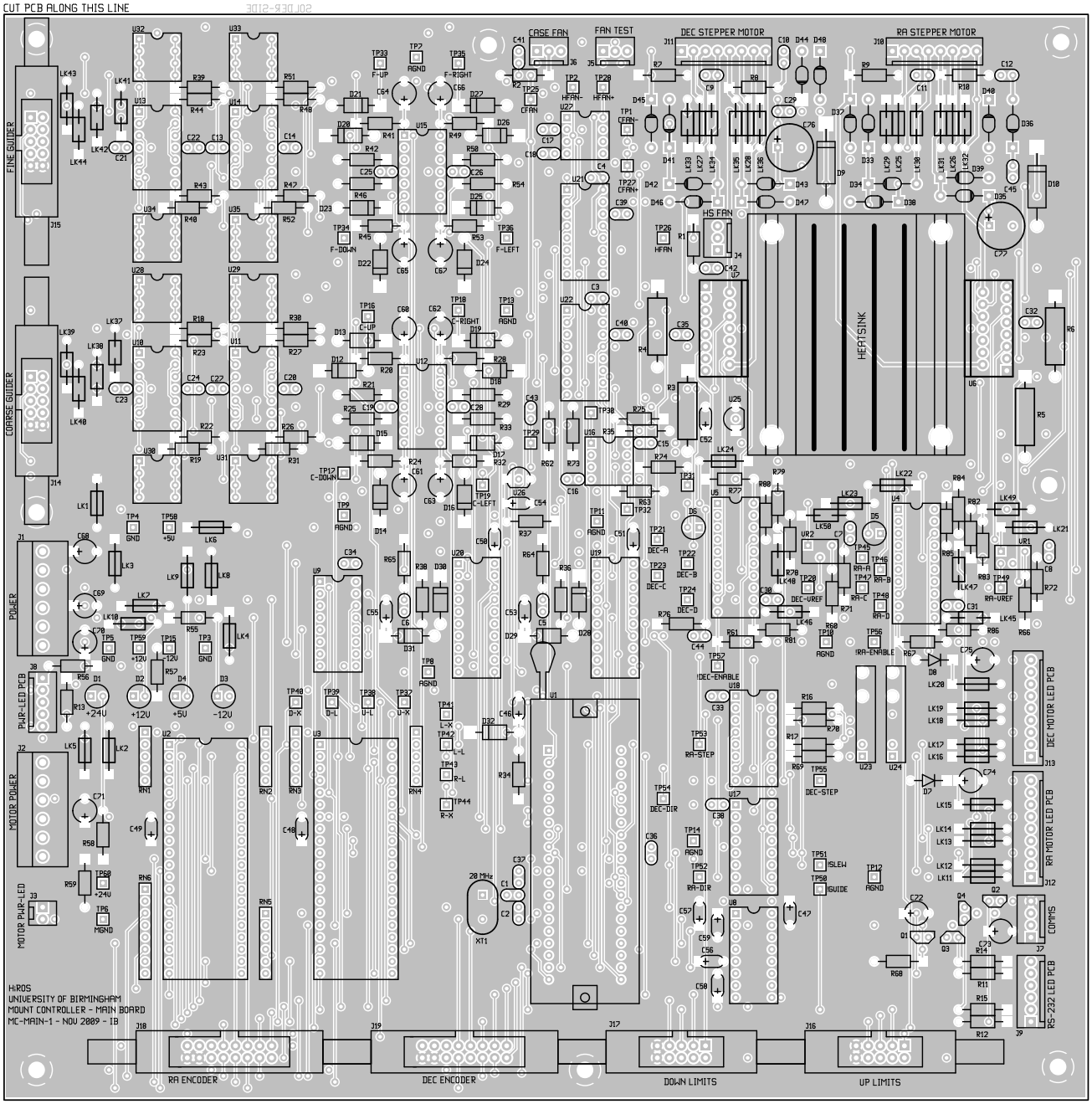


Figure 40: Silkscreen and solder-side tracks (Layer 2) of the Main PCB.

6.4 PCB Assembly Notes

The following points need to be noted when assembling the Mount Controller Main board.

- All LEDs are mounted on 3-mm LED spacers.
- The short leg of the LEDs is the cathode.
- The main board can be configured to ensure that the stepper motors have either series or parallel connection of the motor coils. The various configurations are summarized in Table 14.
- U_1 is mounted in a ZIF socket.
- U_6 and U_7 are mounted on a substantial heatsink. The heatsink assembly is shown in Figure 41.

Table 14: Mount Controller Stepper Motor Coil Configurations

Motor	*Coil Configuration*	*Made Links*	*Open Links*
RA	Series	25–26	29-32
RA	Parallel	29–32	25-26
DEC	Series	27–28	33-36
DEC	Parallel	33–36	27-28

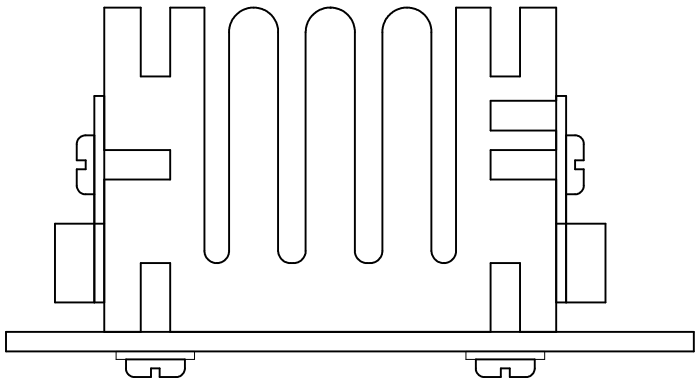


Figure 41: Assembly drawing of the heatsink onto which the stepper motor driver ICs are mounted.

6.5 PCB Blunders & Enhancements

The following list details all of the blunders and enhancements that were found with the MC-MAIN-2 PCB during testing.

- C_{51} PCB ident needs rotating.

- Instead of having two GEN-LED boards the autoguider directions should be shown on a cross arrangement of LEDs.
- Design a new front panel board that can allows the cross configuration of guider signals or six discrete LEDs.
- Change the layout of the front panel LED board connectors so that a cross LED board can be used.

6.6 Parts List

The parts list for the Mount Controller is too large to fit in a single table, and so it has been split up into smaller tables according to component type. The parts list tables are summarized in Table 15.

Table 15: Mount Controller Main Board — Parts Lists

Drawing	*Figure*	*Page*
Resistors	16	50
Capacitors	17	50
Configuration Parts	18	51
Semiconductors	19	51
Connectors and Testpoints	20	52
Miscellaneous	21	53

Table 16: Main PCB Parts List — Resistors

Name	Part Number	Description (SSM)
R1–R4	Rapid 62-6700	1-Ω 2-W Power Resistor PR02 Series pk10
R5–R12	Rapid* 00-0000	10-Ω 0.25-W 1% MR25 Resistor pk100
R13–R16	Rapid 62-7446	100-Ω 0.6W MRS25 Resistor pk100
R17–R18	Rapid* 62-0784	270-Ω 0.25-W 1% MR25 Resistor pk100
R19	Rapid* 62-0802	510-Ω 0.25-W 1% MR25 Resistor pk100
R20–R23	Rapid* 62-0817	820-Ω 0.25-W 1% MR25 Resistor pk100
R24–R32	Rapid* 62-0824	1-kΩ 0.25-W 1% MR25 Resistor pk100
R33–R64	Rapid 63-1236	1-kΩ 0.4-W 0.1% Precision Resistor
R65–R67	Rapid* 62-0827	1.2-kΩ 0.25-W 1% MR25 Resistor pk100
R68–R69	Rapid* 62-0849	2.4-kΩ 0.25-W 1% MR25 Resistor pk100
R70–R75	Rapid* 62-0897	10-kΩ 0.25-W 1% MR25 Resistor pk100
R76–R77	Rapid* 62-0917	20-kΩ 0.25-W 1% MR25 Resistor pk100
R78–R86	Rapid* 62-0964	100-kΩ 0.25-W 1% MR25 Resistor pk100
RN1–RN5	Rapid 63-0265	10-kΩ 4-Commoned SIL Resistor Network
RN6	Rapid 63-0300	10-kΩ 5-Commoned SIL Resistor Network
RN7	Rapid 63-0125	10-kΩ 7-Commoned SIL Resistor Network
VR1–VR2	Rapid 68-1112	10-kΩ Multiturn Potentiometer PV37W Series
LK1–LK32	FEC 933-9027	0-Ω Link MCF Series (50)
LK33–LK42	—	Depopulated SOT Link

*These items are available from Physics Stores.

Table 17: Main PCB Parts List — Capacitors

Name	Part Number	Description (SSM)
C1–C2	Rapid 08-0895	15-pF Ceramic Capacitor 2.5-mm
C3–C4	Rapid 08-0913	3.3-nF Ceramic Capacitor 2.5-mm
C5–C8	Rapid 08-1030	47-nF Ceramic Capacitor 2.5-mm
C9–C39	Rapid 08-1015	100-nF Ceramic Capacitor 2.5-mm
C40–C47	Rapid* 11-0688	1-μF Tantalum Capacitor 5-mm 35-V
C48–C65	Rapid* 11-0698	10-μF 35V Tantalum Capacitor 5-mm 35-V
C66–C67	Rapid 11-0360	470-μF 85°C Electrolytic Capacitor 35-V

*These items are available from Physics Stores.

Table 18: Main PCB Parts List — Configuration Parts

Name	Part Number	Description (SSM)
R91–R94	Rapid* 62-0942	47-kΩ 0.25-W 1% MR25 Resistor
R95–R98	Rapid* 62-0795	430-Ω 0.25-W 1% MR25 Resistor
C69–C76	Rapid 08-1200	1.8-pF Ceramic Capacitor 2.5-mm

*These items are available from Physics Stores.

Table 19: Main PCB Parts List — Semiconductors

Name	Part Number	Description (SSM)
U1	Rapid 73-3206	PIC16F877-20P Microcontroller
U2–U3	RS 426-991	CP82C55A parallel I/O IC
U4–U5	Rapid 82-0198	L297 Stepper Motor Driver IC
U6–U7	Rapid 82-0202	L298N Dual Full-bridge Driver IC
U8	Rapid 82-0148	MAX232CPE RS-232 Line Driver IC
U9–U14	Rapid* 82-0054	TL074 Quad Op-amp IC
U15	Rapid* 83-0380	4049 Hex Inverter IC
U16	Rapid* 83-0382	4050 Hex Buffer IC
U17	Rapid* 83-0414	4081B Quad 2-Input AND IC
U19–U20	FEC 117-5735	AQZ202 PhotoMOS Relay 60-Vdc 3-A
Q1–Q4	Rapid 47-0156	ZVN2106A n-channel MOSFET
Q5–Q6	Rapid 47-0174	ZVP2106A p-channel MOSFET
D1	Rapid 56-0410	Yellow 3-mm Low-current LED
D2	Rapid 55-1465	Blue 3-mm Low-current LED
D3–D4	Rapid 56-1400	Red 5-V 3-mm LED
D5	Rapid 56-1460	Yellow 12-V 3-mm LED
D6–D7	Rapid 56-1405	Green 5-V 3-mm LED
D8–D9	FEC 988-4963	30-V Transient Suppressor Diode
D10–D25	FEC 146-9372	BYV27 Ultrafast Recovery Diode
D26-D42	Rapid 47-2564	1N5817 1-A 20-V Schottky Power Diode

*These items are available from Physics Stores.

Table 20: Main PCB Parts List — Connectors

Name	Part Number	Description (SSM)
J1–J2	Rapid 22-2610	6-Way 0.156" Vertical Pin Header
J3–J4	Rapid 22-0950	2-pin Molex KK Vertical Pin Header
J5	Rapid 22-0955	3-pin Molex KK Vertical Pin Header
J6	Rapid 22-0960	4-pin Molex KK Vertical Pin Header
J7	Rapid 22-0965	5-pin Molex KK Vertical Pin Header
J8	Rapid 22-0970	6-pin Molex KK Vertical Pin Header
J9–J10	Rapid 22-0975	8-pin Molex KK Vertical Pin Header
J11–J12	Rapid 22-2395	9-pin Molex KK Vertical Pin Header
J13–J16	Rapid* 19-0250	10-Way IDC Vertical Header
J17–J18	Rapid* 19-0255	16-Way IDC Vertical Header
TP1–TP19	Rapid 17-1810	Black Testpoint pk100
TP20	Rapid 17-1817	Blue Testpoint pk100
TP21–TP54	Rapid 17-1820	Green Testpoint pk100
TP55–TP56	Rapid 17-1815	Red Testpoint pk100
TP57–TP60	Rapid 17-1819	Yellow Testpoint pk100

*These items are available from Physics Stores.

Table 21: Main PCB Parts List — Miscellaneous

Name	Part Number	Description (SSM)
XT1	Rapid 90-3259	20-MHz Crystal
—	Rapid 38-0610	HC-49 Crystal Mouning Pad
—	Rapid 38-0750	3 mm × 3 mm LED Spacer pk25
—	Rapid* 22-1720	8-pin Turned Pin DIL IC Socket
—	Rapid* 22-1721	14-pin Turned Pin DIL IC Socket
—	Rapid* 22-1722	16-pin Turned Pin DIL IC Socket
—	Rapid* 22-1724	20-pin Turned Pin DIL IC Socket
—	Rapid* 22-1730	40-pin Turned Pin DIL IC Socket
—	Rapid 22-1580	40-pin ZIF IC Socket
U21–U28	Rapid 22-1707	8-pin DIL Component Header 0.3”
—	FEC 177-011	46 × 50 × 33 — 4.9°K/W Heatsink
—	Rapid 33-3150	N°4 × 6.5 Self-tapping Screw pk100
—	Rapid 33-3155	N°4 × 9.5 Self-tapping Screw pk100
—	Rapid 33-5064	M3 Nylon Washer pk100
—	Rapid 38-3034	T-Pad 1500 Thermal Pad 100 × 100
—	Beta† MC-MAIN-2	Mount Controller Main PCB

*These items are available from Physics Stores.
†Price quoted does not include shipping.

7 Power LED Board

The Power LED Board is a generic board that is used on virtually every unit that is designed and built by HiROS. The Power LED Board contains up to three LEDs that are illuminated when the power supply levels are present. The PCB is fitted to the front panel of the unit using a self-adhesive PCB pillar.

On the Mount Controller unit all three LEDs are present and these indicate that the +12 V, +5 V and −12 V power rails are present.

7.1 Schematic Diagram

The schematic diagram for the Power LED board is shown in Figure 42.

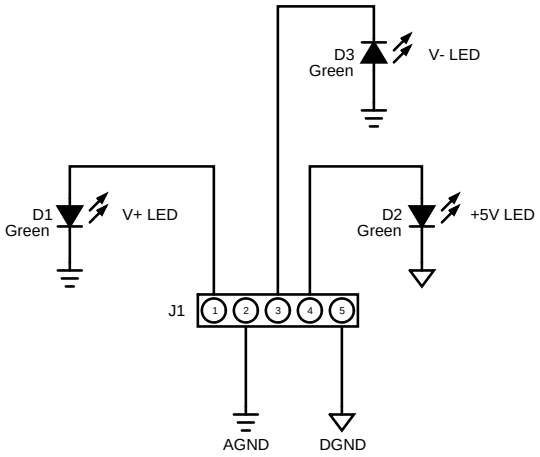


Figure 42: Schematic diagram of the Power LED Board. All of the LEDs are mounted on 7.6-mm LED spacers.

7.2 PCB Layout

The component layout and solder-side tracks are shown in Figure 43. The board is single sided and is made by an outside contractor.

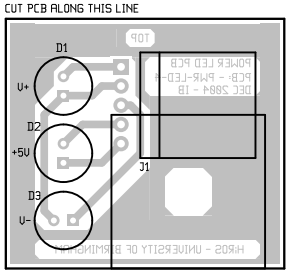


Figure 43: Power LED Board component layout and solder-side tracks.

7.3 PCB Assembly Notes

The following points need to be noted when assembling the Power LED board.

- $D_1 - D_3$ are mounted on 7.6-mm LED spacers.
- The short leg on the LED is the cathode.
- PCB is secured to the front panel of the unit by a self-adhesive PCB pillar.
- PCB should be cleaned with Ambersil PCB cleaner (RS 558-041) after soldering to remove light flux residue and general grime. For more stubborn flux contamination use Ambersil flux remover (RS 558-007).
- PCB should be coated with three coats of PCB lacquer (Rapid 87-0670) to electrically insulate the tracks.

7.4 Parts List

Table 22 shows all of the parts that are required to build the Power LED board.

Table 22: Power LED Board — Parts List

Name	Part Number	Description (SSM)
J1	Rapid 22-1020	5-pin Molex KK Right-angled Pin Header
D1–D3	Rapid 56-0435	Green Low Current 5-mm LED
—	Rapid 38-0770	5 mm × 7.6 mm LED Spacer pk25
—	Rapid 33-2135	Self-Adhesive PCB Pillar 9.5-mm pk25
—	Beta† PWR-LED-4	Power LED PCB (7)

†PCB is below minimum order area and therefore multiple PCBs must be ordered.

8 Generic LED Board

The generic LED board was designed as a general purpose board that can be fitted to the front panel of units that are designed and built by HiROS. The generic LED board can contain up to six LEDs.

The Mount Controller uses two of these PCBs to show the status of the DEC and RA stepper motor control signals.

8.1 Schematic Diagram

The schematic diagram for the Generic LED boards as used on the Mount Controller is shown in Figure 44.

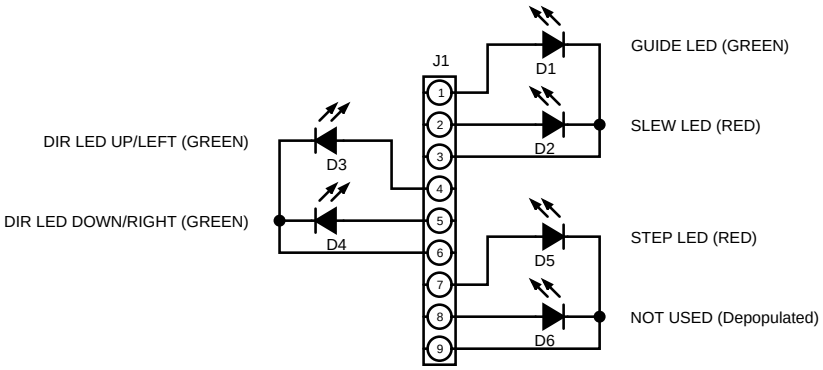


Figure 44: Schematic diagram of the Generic LED Board.

8.2 PCB Layout

The component layout and solder-side tracks are shown in Figure 43. The board is single sided and is made by an outside contractor.

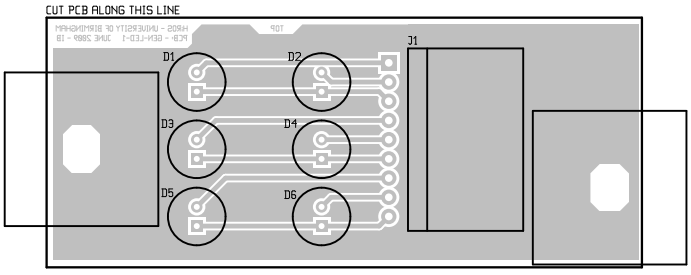


Figure 45: Generic LED Board component layout and solder-side tracks.

8.3 PCB Assembly Notes

The following points need to be noted when assembling the Generic LED board.

- $D_1 - D_5$ are mounted on 7.6-mm LED spacers.
- D_6 is depopulated.
- The short leg on the LED is the cathode.
- PCB is secured to the front panel of the unit by self-adhesive PCB pillars.
- PCB should be cleaned with Ambersil PCB cleaner (RS 558-041) after soldering to remove light flux residue and general grime. For more stubborn flux contamination use Ambersil flux remover (RS 558-007).
- PCB should be coated with three coats of PCB lacquer (Rapid 87-0670) to electrically insulate the tracks.

8.4 Parts List

Table 23 shows the parts required to build one of the Generic LED boards.

Table 23: Generic LED Board — Parts List

Name	Part Number	Description (SSM)
J1	Rapid 22-2425	9-pin Molex KK Right-angled Pin Header
D1, D3, D4	Rapid 56-1505	Green 5-V 5-mm LED
D2, D5	Rapid 56-1500	Red HE 5-V 5-mm LED
D6	—	Depopulated 5-mm LED
—	Rapid 38-0770	5 mm × 7.6 mm LED Spacer pk25
—	Rapid 33-2135	Self-Adhesive PCB Pillar 9.5-mm pk25
—	Beta† GEN-LED-1	Generic LED PCB (2)

†PCB is below minimum order area and therefore multiple PCBs must be ordered.

9 The RS-232 LED Board

The RS-232 LED Board is a generic board that is used on every unit that uses an RS-232 serial interface.The RS-232 LED board sits behind the front panel and holds four LEDs. These LEDs show the state of the RS-232 lines. The left column is for the TxD line and the right column is for the RxD line. The red LEDs on the bottom are illuminated when the corresponding line is low. The green LEDs on the top are illuminated when the line is high.

9.1 Schematic Diagram

The schematic diagram for the RS-232 LED board is given in Figure 46

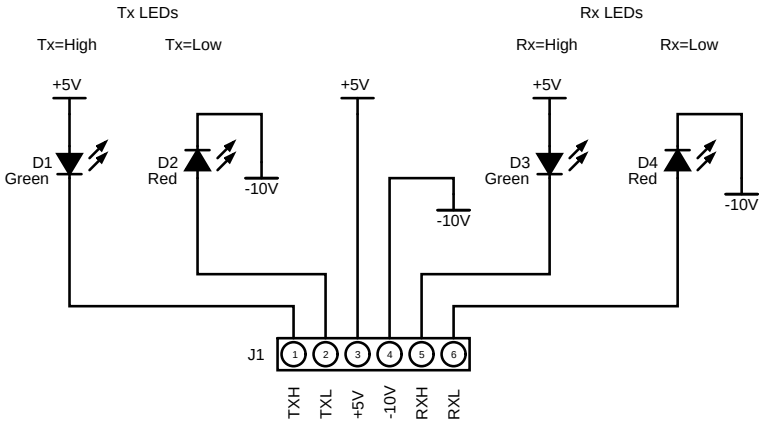


Figure 46: Circuit drawing of the RS-232 LED Board. All of the LEDs are mounted on 7.6-mm LED spacers.

9.2 PCB Layout

The RS-232 LED board is a single-sided board and the component silkscreen and solder-side tracks are given in Figure 47.

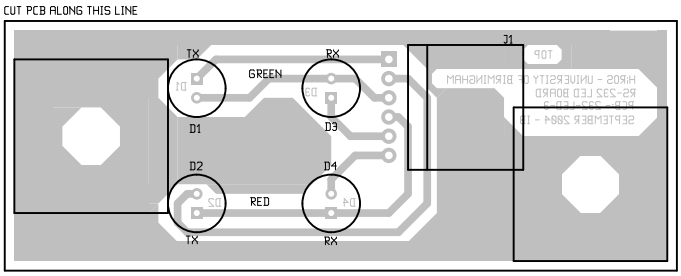


Figure 47: LED Board component layout and bottom-side tracks.

9.3 PCB Assembly Notes

The following points need to be noted when assembling the RS-232 LED board.

- $D_1 - D_3$ are mounted on 7.6-mm LED spacers.
- The short leg on the LED is the cathode.
- PCB is secured to the front panel of the unit by using a self-adhesive PCB pillar.
- PCB should be cleaned with Ambersil PCB cleaner (RS 558-041) after soldering to remove light flux residue and general grime. For more stubborn flux contamination use Ambersil flux remover (RS 558-007).
- PCB should be coated with three coats of PCB lacquer (Rapid 87-0670) to electrically insulate the tracks.

9.4 Parts List

The parts list for the RS-232 LED PCB is given in Table 24.

Table 24: RS-232 LED Board — Parts List

Name	Part Number	Description (SSM)
D1, D3	Rapid 56-0435	Green Low-current 5-mm LED
D2, D4	Rapid 56-0430	Red Low-Current 5-mm LED
J1	Rapid 22-1025	6-Way Right-angled Molex KK Pin Header
—	Rapid 38-0770	5 mm × 7.6 mm LED Spacer pk25
—	Rapid 33-2135	Self-Adhesive PCB Pillar 9.5-mm pk25
—	Beta† RS-232-3	RS-232 LED Board PCB (3)

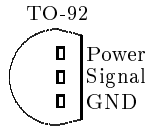
†PCB is below minimum order area and therefore multiple PCBs must be ordered.

10 Component Pin-outs

The component pin-out figures have been grouped together in several figures and these are summarized in Table 25.

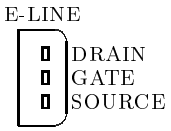
Table 25: Component Pin-Out Diagrams

Drawing	*Figure*	*Page*
TO-92 Devices	48	60
E-line Devices	49	60
8-pin DIL Devices	50	61
14-pin DIL Devices	51	61
16-pin DIL Devices	52	61
20-pin DIL Devices	53	61
Stepper Motor Driver IC — L298	54	62
40-pin DIL Devices	55	62

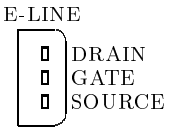


(a) LM35

Figure 48: Pin-out diagrams of devices using the TO-92 package.



(a) ZVN2106



(b) ZVP2106

Figure 49: Pin-out diagrams of devices using the E-line package.

11 Mechanical Drawings

There are several mechanical drawings that are associated with the Mount Controller and these are summarized in Table 26.

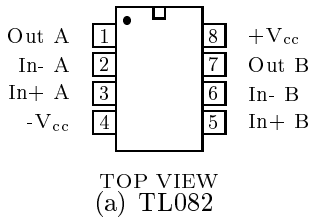


Figure 50: Pin-out diagrams of devices that use the 8-pin DIL package.

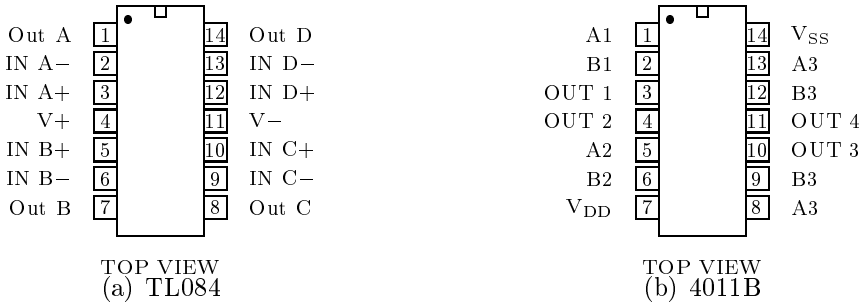


Figure 51: Pin-out diagrams of devices that use the 14-pin DIL package.

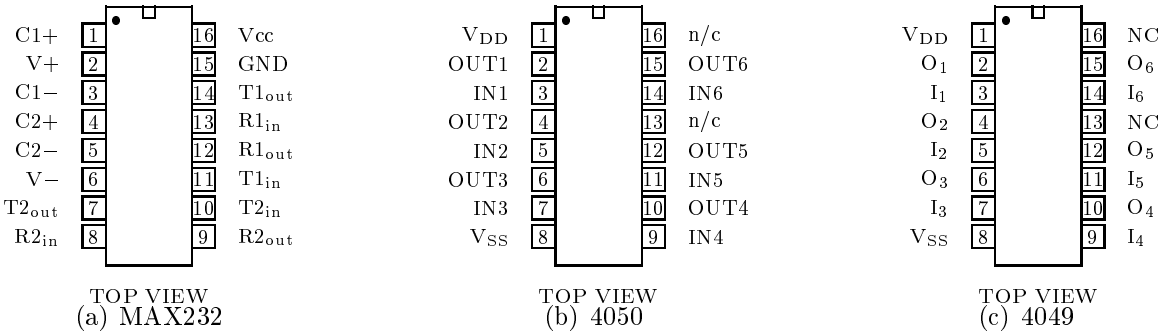


Figure 52: Pin-out diagrams of devices that use the 16-pin DIL package.

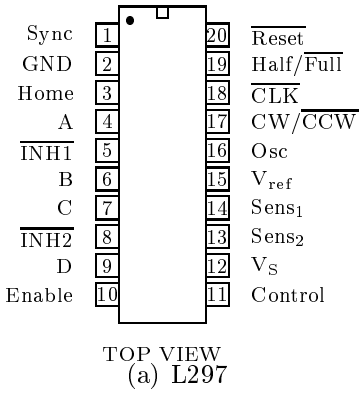
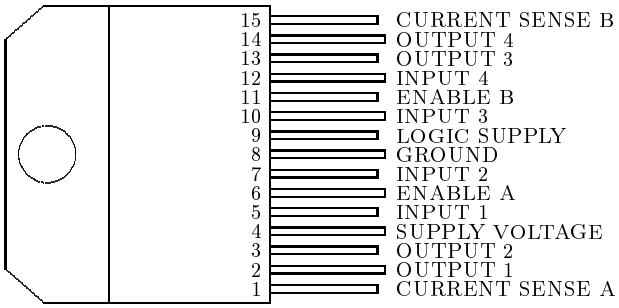


Figure 53: Pin-out diagrams of devices that use the 20-pin DIL package.

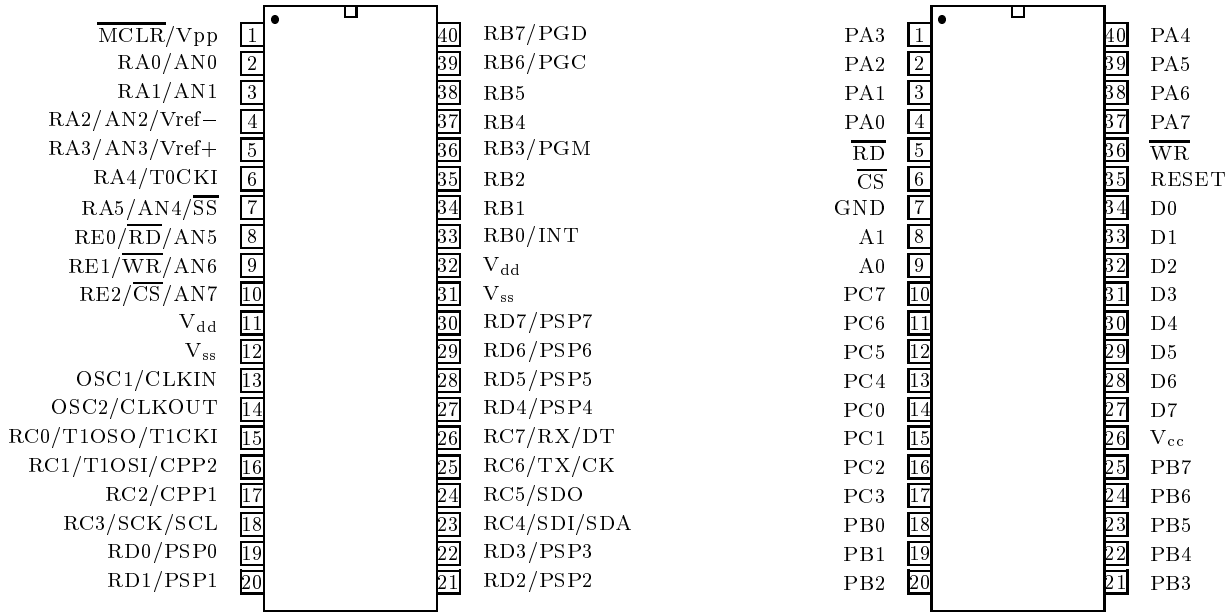
Table 26: Mechanical Drawings

Drawing	*Figure*	*Page*
Modified Heatsink	56	62
Mount Controller Front Panel	57	63
Mount Controller Rear Panel	58	64



(a) L298

Figure 54: Pin-out diagrams of the stepper motor driver IC.



(a) PIC18F877 (b) 82C55

Figure 55: Pin-out diagrams of devices that use the 40-pin DIL package.

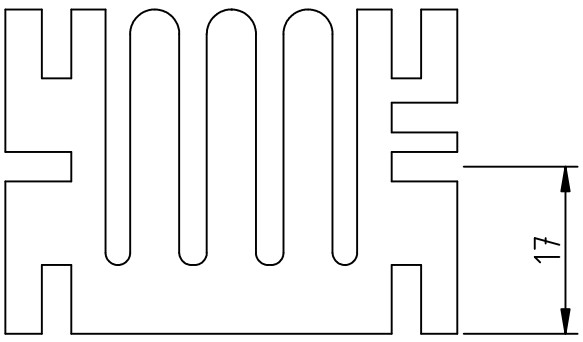


Figure 56: Mechanical drawing of the modified heatsink.

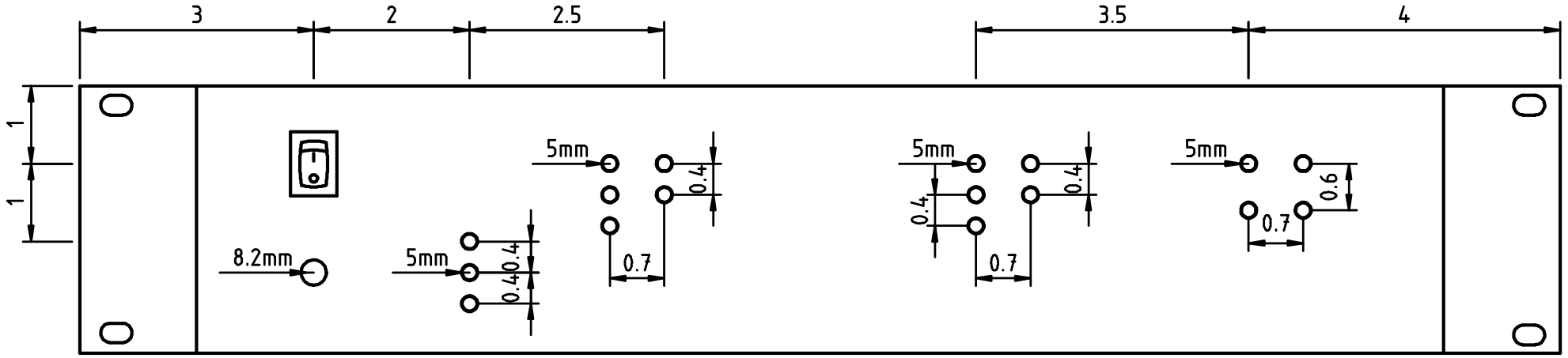


Figure 57: Mechanical drawing of the front panel of the Mount Controller.

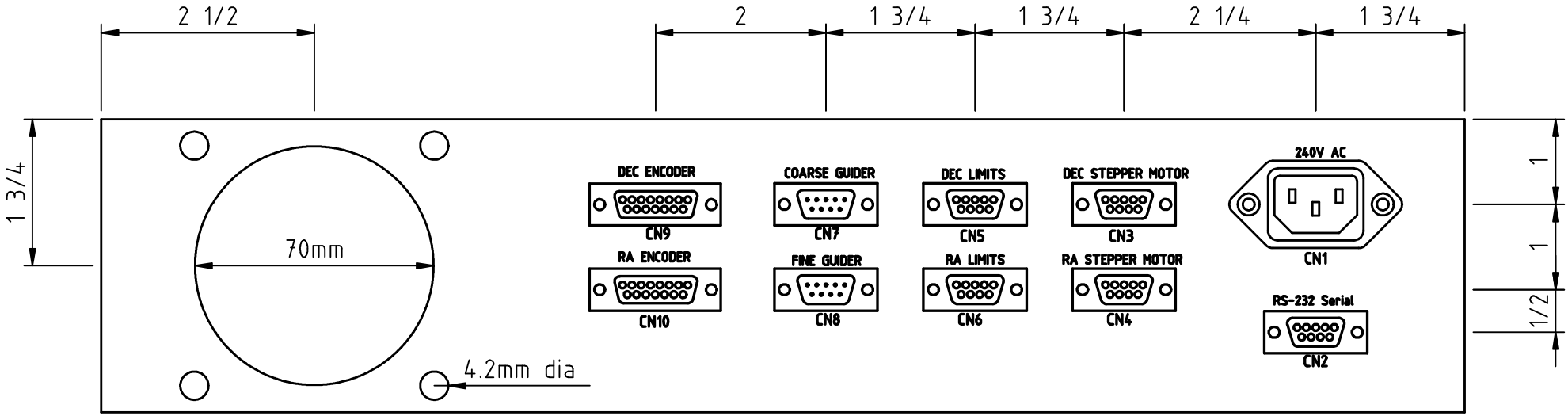


Figure 58: Mechanical drawing of the rear panel of the Mount Controller.

References

[1] Brek A. Miller. The installation of a digital autoguider in Las Campanas in 2011 March. *BISON Technical Report Series,* Number 343, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, May 2011.