



# EUROPEAN SOUTHERN OBSERVATORY

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral  
Europäische Organisation für astronomische Forschung in der südlichen Hemisphäre

## LA SILLA OBSERVATORY

### APEX POINTING TELESCOPE ELECTRONICS

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## 1. INTRODUCTION

The Atacama Pathfinder Experiment (APEX) radio telescope antenna requires an optical refracting telescope both for pointing and collecting positional data for doing pointing models.

The APEX Pointing Telescope (APT) is a heavy duty optical piece including; CCD TV camera, focusing mechanism, objective's protection lid and the necessary coarse and fine adjusting screws for alignment of their optical axis with respect to the antenna. The APT will be remotely controlled via Ethernet. Both the electronics and the telescope will be subject to extreme climatic conditions with an operating temperature range of -25°C to +35°C.

### 1.1. PURPOSE AND SCOPE

This document describes the electronics used for controlling the APT. Including the schematic diagrams, control/status bits assignation and installation instructions. Shall be considered as an electronic - software installation and service manual.

### 1.2. REFERENCE DOCUMENTS

[RE1] None

### 1.3. APPLICABLE DOCUMENTS

[AP1] ADAM-6000 User's Manual

### 1.4. ACRONYMS & ABBREVIATIONS

APEX	Atacama Pathfinder Experiment
APT	APEX Pointing Telescope
PI	Proportional Integral

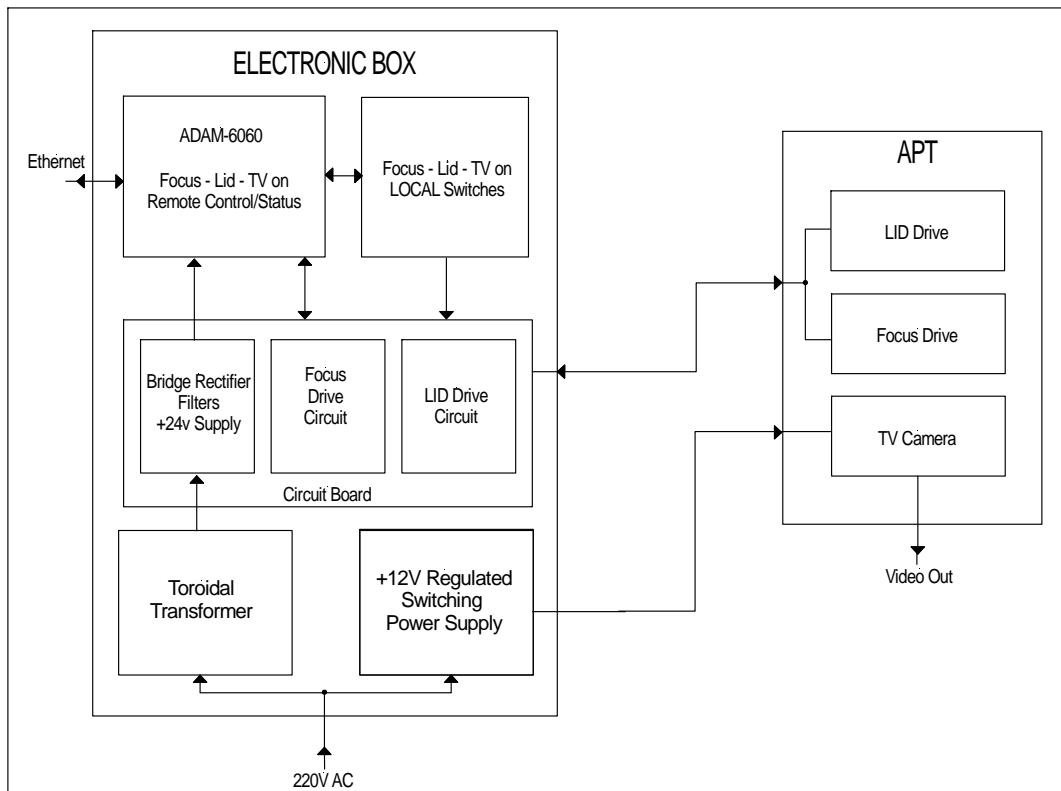
## 2. DESCRIPTION

### 2.1. OVERVIEW

The APT electronics is housed inside a single metallic box and comprises:

- I. Two DC power supplies; 24V unregulated for the ADAM, focus drive and lid drive, 12V regulated for the TV camera.
- II. ADAM-6060 Ethernet relay module for remotely controlling and reading the status of the focus, protection lid and TV camera power. Please refer to [AP1] and 5.3.

- III. Focus driving circuit comprising a simple bridge power amplifier together with a Proportional Integral (PI) circuit for closing a velocity loop. Three sealed relays are used for selecting fast/slow gain resistors, applying the plus or minus velocity reference and switching on/off. The advantage of this circuitry is that the focus could be moved at low speed with full motor torque and thus overcoming friction effectively. Please refer to 5.2 for further details.
- IV. Protection lid driving circuit comprising three sealed relays and two 1N4007 diodes. Two PNP inductive limit sensors drives the open and close stop relays, the third relay is wired for inverting the polarity of the 24V supply feeding the lid motor and is driven by the open/close command. Please refer to 5.4 for further details.

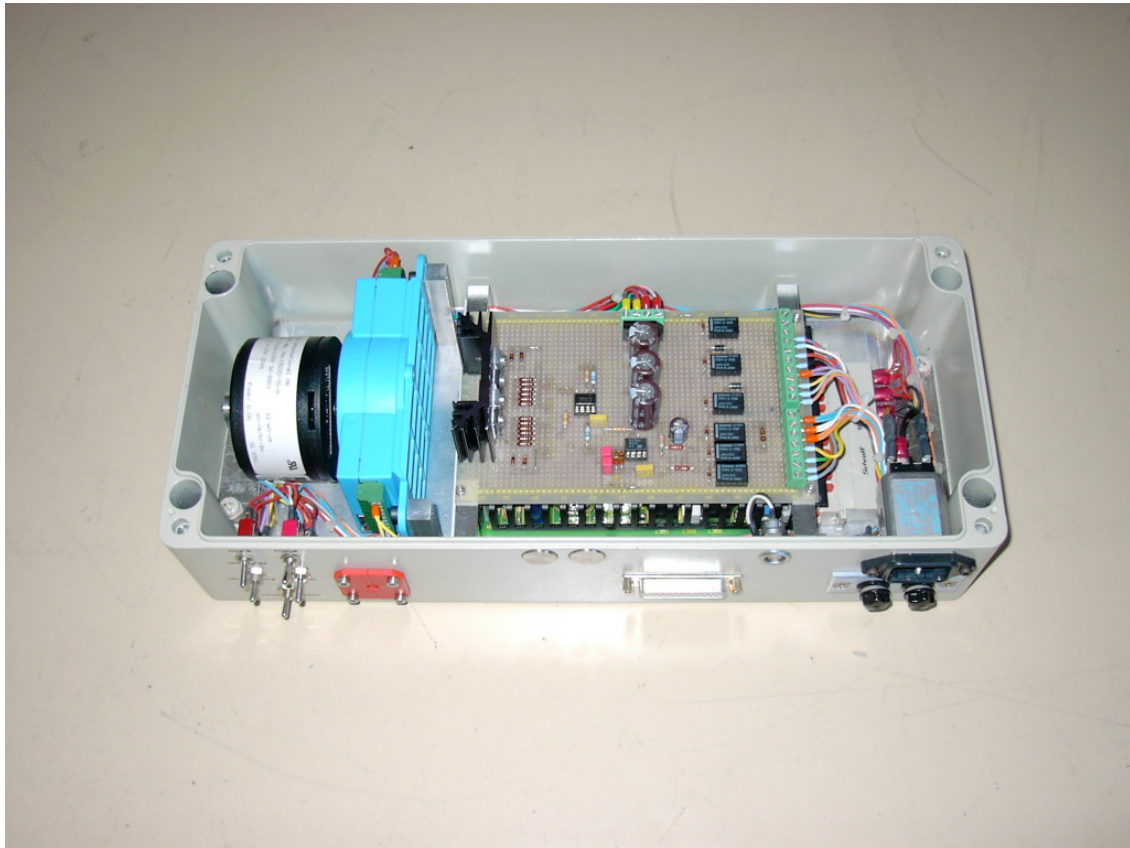


**Figure 1 : Block Diagram**

## **2.2. COMPONENTS**

The main components inside the box are as follows:

- I. Circuit board with three terminal-blocks for; power, focus and lid connections. These terminal blocks provide the necessary connections for the onboard unregulated +24V bridge rectifier and filter, focus drive circuit and the protection lid drive circuit.
- II. Regulated +12V switching power supply for the TV camera.
- III. ADAM-6060 Ethernet relay module. Please refer to [AP1].
- IV. 20VA toroidal transformer for the unregulated +24V supply.
- V. 220V line plug-filter.
- VI. Line fuses for the +12V and +24V supplies.
- VII. Three groups of miniature toggle switches for local operation of the focus, lid and TV camera power on/off.
- VIII. RJ-45 Ethernet cable inlet strain relief and seal.
- IX. DB-25 female Cannon connector for the focus and lid function signals.
- X. Lemo chassis #1 2 pin connector for the TV camera power.



**Figure 2 : Electronic box without cover**

### **2.3. ADAM-6060 BITS ASSIGNATION**

The APT remote control is based on an Ethernet ADAM-6060 relay module. The ADAM-6060 internal relays DO0, DO1, DO2, DO3 and DO4 are used for commanding the focus drive, objective protection lid drive and TV camera power. Bits DI0, DI1, DI2 and DI3 are used for monitoring the cover and TV camera power status.

The tables below summarize the relay and input bits allocation for each function.

<b>STATE</b>	<b>DO0</b>	<b>DO1</b>	<b>DO2</b>
STOP	Off	X	X
MOVE CW SLOW	On	Off	Off
MOVE CW FAST	On	On	Off
MOVE CCW SLOW	On	Off	On
MOVE CCW FAST	On	On	On

**Table 1 : Focus Drive (refer to note #1 next page)**

STATE	DO3
CLOSE	Off
OPEN	On

**Table 2 : Lid Drive**

STATE	DI0	DI1	DI2
CLOSE REMOTE	Off	On	Off
OPEN REMOTE	On	Off	Off
CLOSE LOCAL	Off	On	On
OPEN LOCAL	On	Off	On

**Table 3 : Lid Status (refer to note #2 next page)**

STATE	DO4
CAMERA OFF	Off
CAMERA ON	On

**Table 4 : TV Camera Power**

STATE	DI3
TV REMOTE	On
TV LOCAL	Off

**Table 5 : TV Camera Status (refer to note #3 next page)**STATES

Off = DON relay not energized - DIN connected to iso-GND.

On = DON relay energized – DIN open.

X = Don't care.

NOTES

- I. CW or CCW rotation of the eccentric wheel as seen from the top when the camera cover is removed.
- II. REMOTE means that the cover can be commanded via DO3. LOCAL means that the cover status is only available but the command is via the local switch.
- III. REMOTE means that the TV camera can be switched on and off via DO4. LOCAL means that the TV camera is switched on locally.



## **2.4. INTERCONNECTION CABLES**

The electronics box and the telescope are interconnected by two 1.2 meter cables:

- I. Focus and lid drives cable fitted with 25pin male Cannon D-Sub connectors at both ends.
- II. TV camera power cable attached to the APT on one end and fitted with a LEMO cable 2pin #1 connector.

Additionally standard RJ-45 Ethernet and power cables are used for connecting the net and mains to the box.

At the telescope side a short 75 $\Omega$  coaxial cable terminated with a BNC connector is attached to the APT. This is the TV camera video output.

## **3. INSTALLATION**

### **3.1. ELECTRONICS BOX MECHANICAL FIXATION**

Fix the box near the telescope allowing access for easy cover removal and local switches manual activation.

Drill four M5 threaded holes on the desire mounting surface. The arrangement and distance between centres of the mounting holes is engraved on the back of the box and corresponds to 340mm X 110mm.

When locating the box bear in mind that the length of the interconnection cables to the telescope is 1.2 meters.

### **3.2. ADAM-6060 IP SETTING**

For the initial setting use any windows PC using a crossed UTP cable between the PC and the ADAM-6060. Plug the box to the mains. Install the ADAM Ethernet I/O Utility Software and set the desire net parameters. For further details please refer to [AP1].

### **3.3. CONNECTIONS & TESTING**

Provided that the box is properly mounted proceed with the following connections;

- I. Plug the DB-25 Cannon connector cable at the telescope and box ends. Screw the fixations of both connectors by hand without over-tightening. Route the cable neatly and secure it with cable ties where possible.
- II. Plug the LEMO #1 connector cable to the box. Route the cable neatly and secure it with cable ties where possible.
- III. At the box remove the four M3 Allen screws that hold the red plastic pieces at the right side of the switches. Pull out the red pieces, connect the RJ-45

- Ethernet cable into the ADAM, fit the plastic pieces and screw them back in place. Route the cable neatly and secure it with cable ties where possible.
- IV. Use a 75 $\Omega$  BNC connector cable of the desire length for the video. After connection of the cable using a 75  $\Omega$  adapter route it neatly and secure it with cable ties where possible.
  - V. Plug the box to the mains. Route the power cable neatly and secure it with cable ties where possible. Please be aware that the box has no power switch.

Test the focus, lid and TV camera power using the local switches. Switch the lid back to remote and turn the TV camera off, now you are ready for commanding the APT remotely.

## 4. ENVIRONMENTAL TESTING

### 4.1. OVERVIEW

We partially simulated the extreme environmental conditions by using a freezer capable of reaching -33°C after ~2 hours with the APT + electronics energized and coming from an ambient temperature of ~+20°C. The freezer has no temperature setting so we found necessary to leave the door partially open to stabilize at approximately -20°C. Two 12 hour thermal cycles where performed. Both cycles started from ambient temperature down to -20°C and -33°C. In both cases everything was energized including the TV camera.



Figure 3 : APT in the freezer after 12 hours at -33°C



Figure 4 : Measuring the temperature

#### **4.2. ELECTRONICS BOX**

The electronics box endured the tests without problems.

#### **4.3. FOCUS MECHANISM**

At  $-33^{\circ}\text{C}$  the focus mechanism was stuck, the current limit of the bridge amplifier was reached. Raising the temperature to  $-25^{\circ}\text{C}$  it started to move very slowly, at  $-15^{\circ}\text{C}$  it was operative.

Clearly the problem is due to the hardening of the lubricating grease. The grease will be replaced by a special type to improve the behaviour at low temperature. Still to decide what to do with the sealed ball bearings used, we suspect the grease inside them also hardens.

#### **4.4. LID MECHANISM**

At  $-33^{\circ}\text{C}$  the lid mechanism was stuck with the clutch slipping when operated. At  $-20^{\circ}\text{C}$  it was operative getting stuck occasionally when opening.

We observed that both the rubber seal of the lid was hardened and the tension of the driving clutch was relaxed. Clearly the clutch tension-bolt loose tightening at low temperature.

The clutch tension was readjusted and a blocking mechanism will be added to the tension-bolt. The rubber seal compression will be reduced and a special Teflon spray

will be applied to the rubber for protection. The closed position holding magnet must be completely clean of any grease or oil to avoid sticking at low temperatures.

#### **4.5. TV CAMERA**

At -33°C the TV camera was found dead. The camera did not recover until the temperature was rise to 0°C.

We found that the camera operates normally down to -20°C (as specified) provided that is powered on when the temperature is > -2.5°C, any attempt to power cycle at temperatures < -2.5°C will render it inoperative, in the sense that we get out of sync lines in the TV screen.

#### **4.6. OPTICS**

It was not possible to test the optics at low temperatures due to condensation and ice formation. As soon as the APT was moved from the freezer to the optical bench we have a layer of ice over the optics.

### **5. CIRCUIT SCHEMATIC DIAGRAMS**

The circuit schematic diagrams are listed below and annexed to this document as six A4 format drawings.

#### **5.1. APT Terminal Blocks and DC Supply (board)**

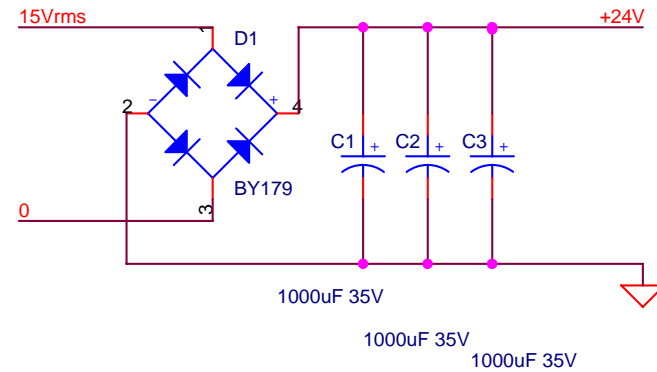
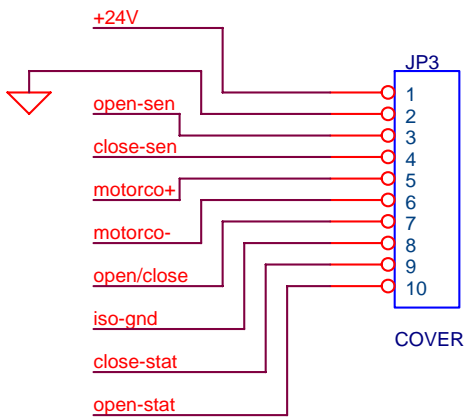
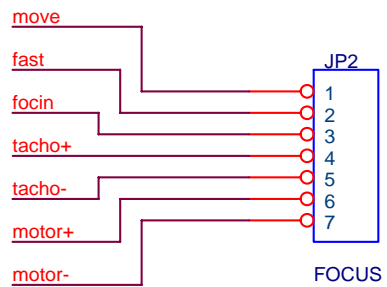
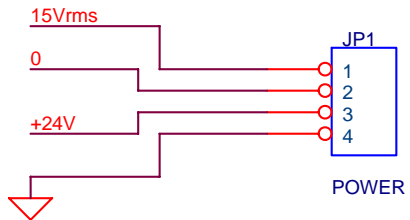
#### **5.2. APT Focus Drive Circuit (board)**

#### **5.3. APT Power Supply, NET and Local Control**

#### **5.4. APT Protection Lid Drive Circuit (board)**

#### **5.5. APT Telescope Cabling**

#### **5.6. APT Cables**



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Title: **APT Terminal Blocks and DC Supply (board)**

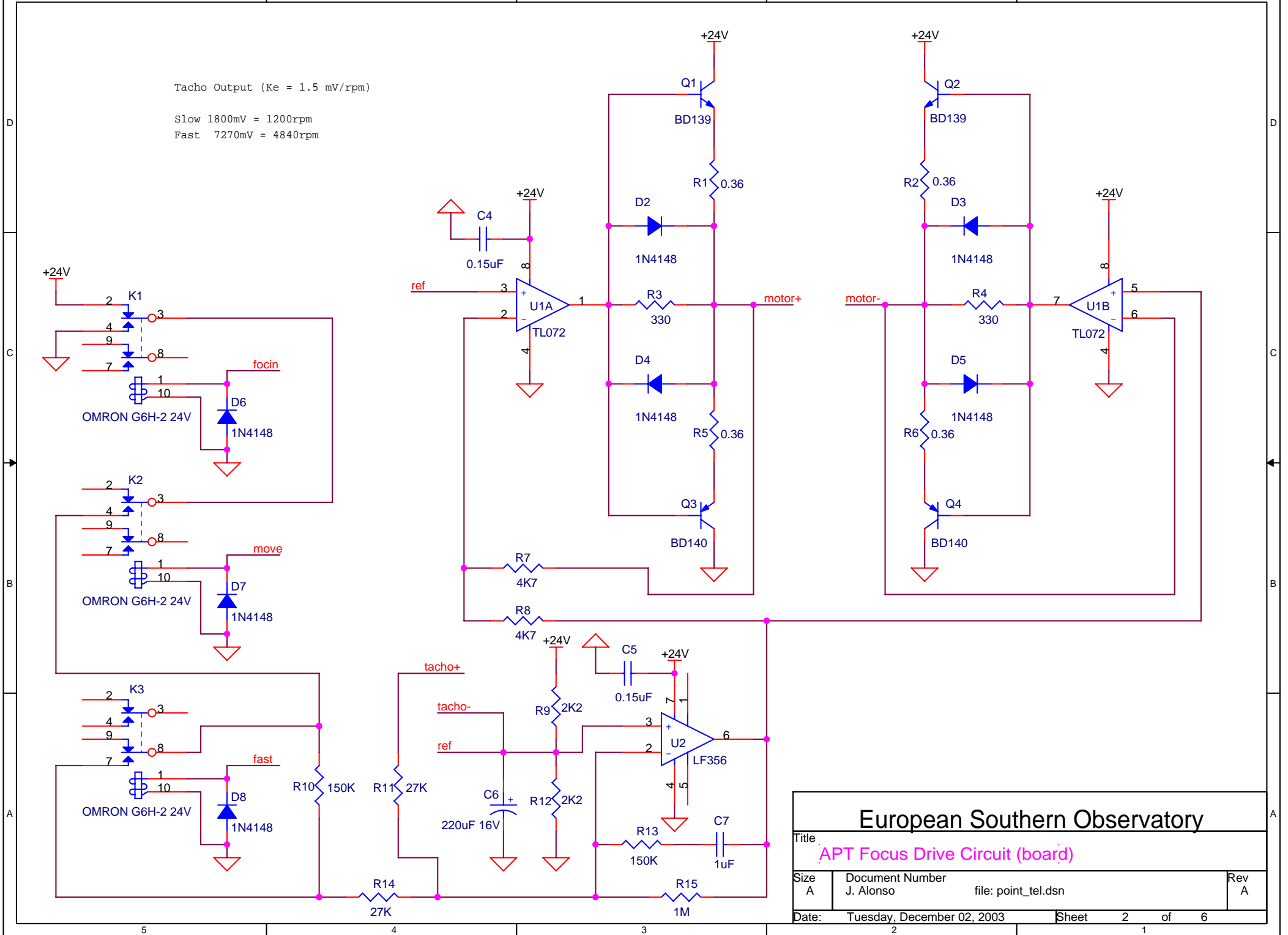
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Tacho Output ( $K_e = 1.5 \text{ mV/rpm}$ )

Slow  $1800\text{mV} = 1200\text{rpm}$

Fast  $7270\text{mV} = 4840\text{rpm}$

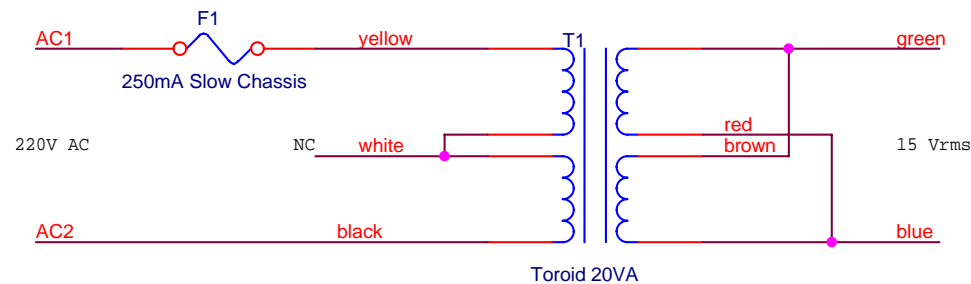
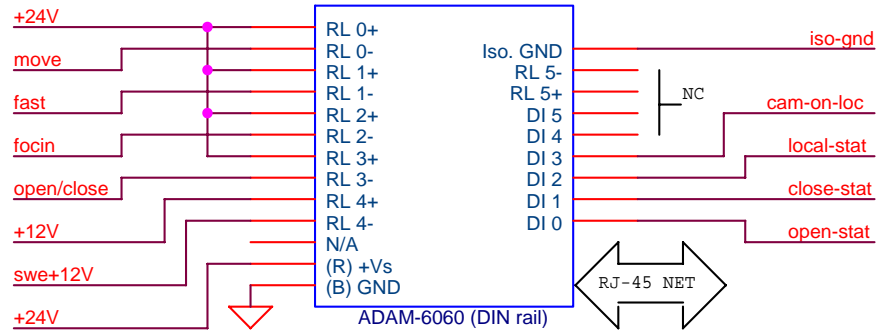


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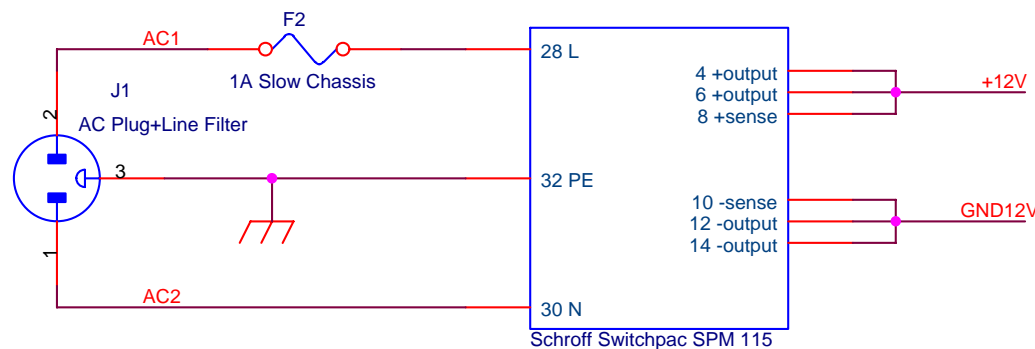
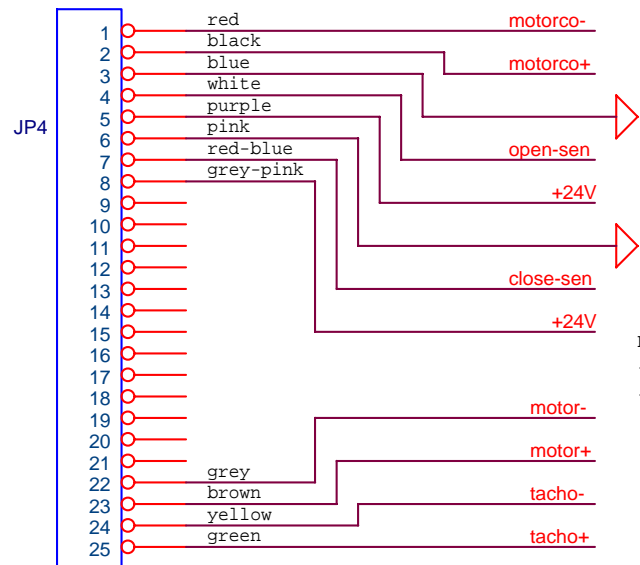
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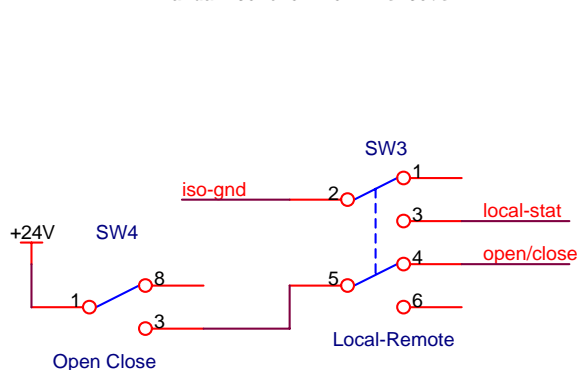
DB25 Female Chassis Mount



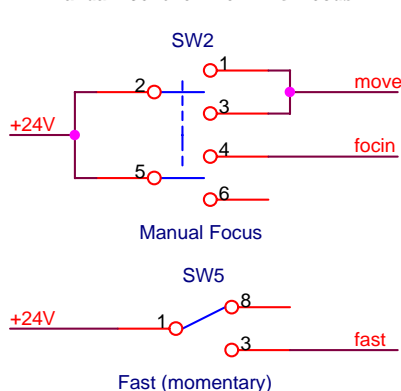
NOTES

- Use heat shrinkable tube for all the connections at the DB25.
- Mount nut type fixation for the DB25.

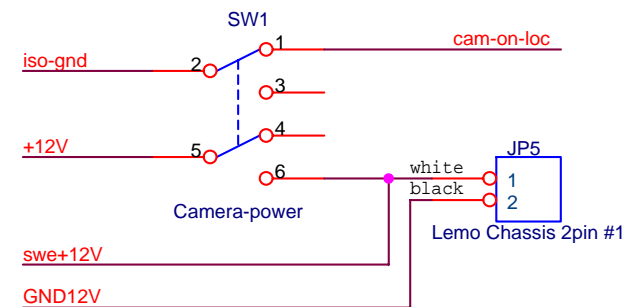
Manual Control For The Cover



Manual Control For The Focus

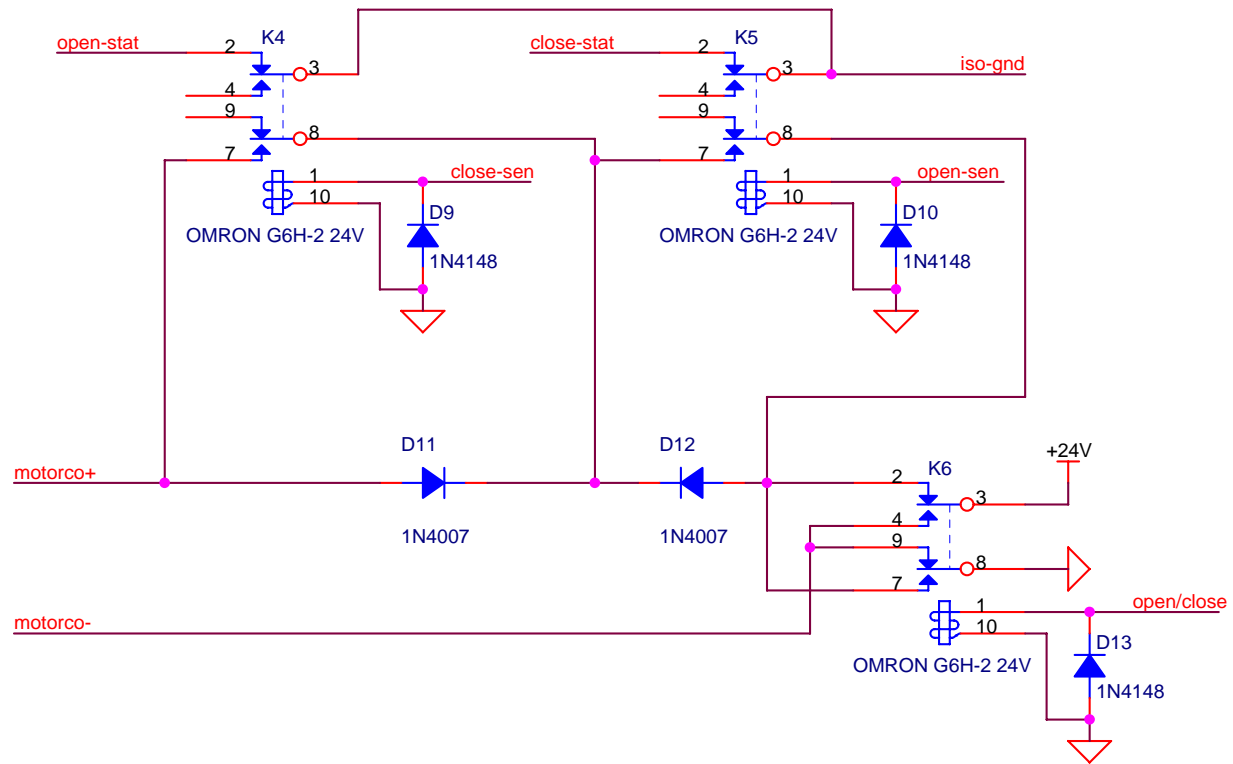


Manual Power For The TV Camera



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APT Power Supply, NET and Local Control		
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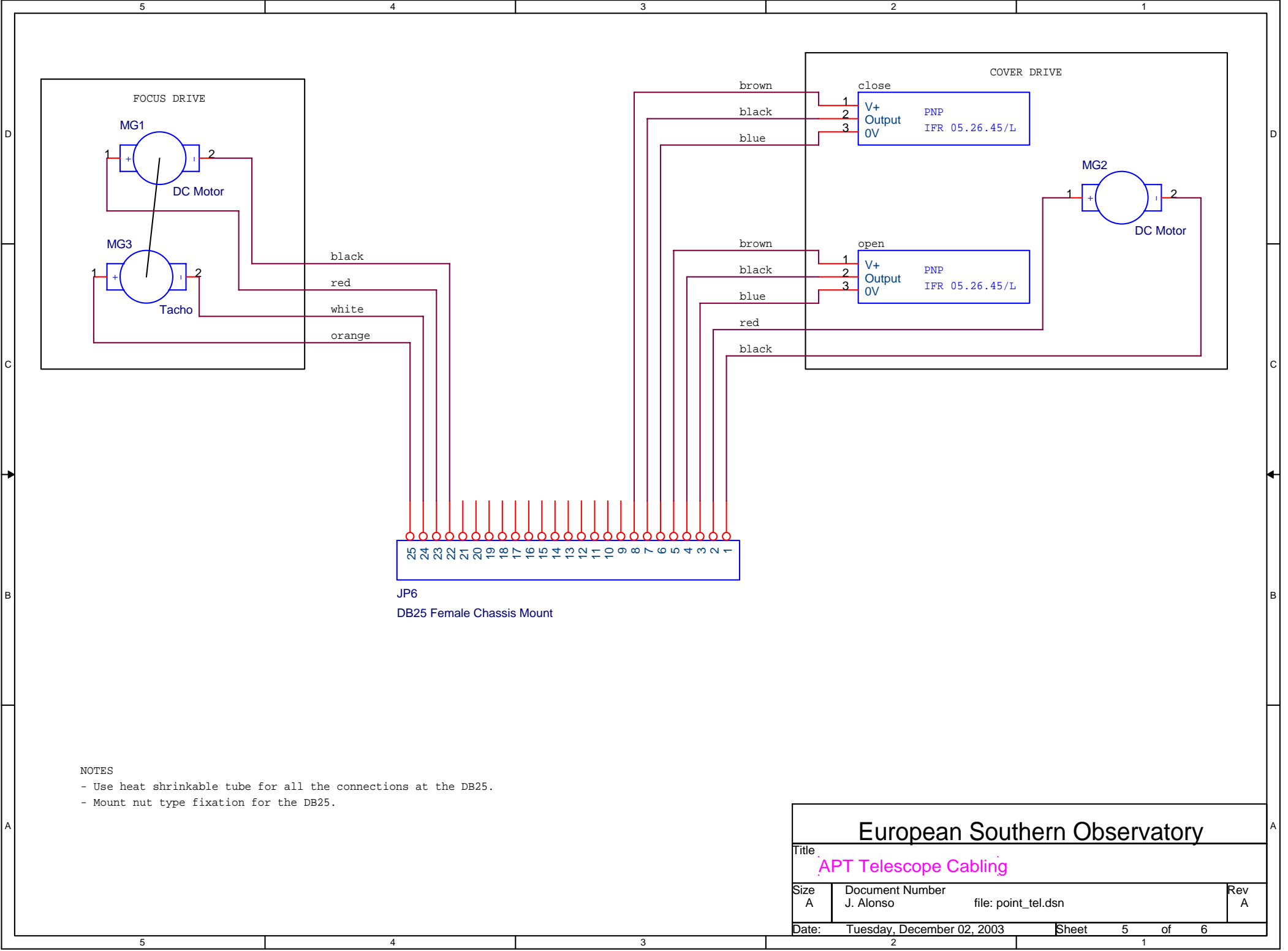
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Title  
APT Protection Lid Drive Circuit (board)

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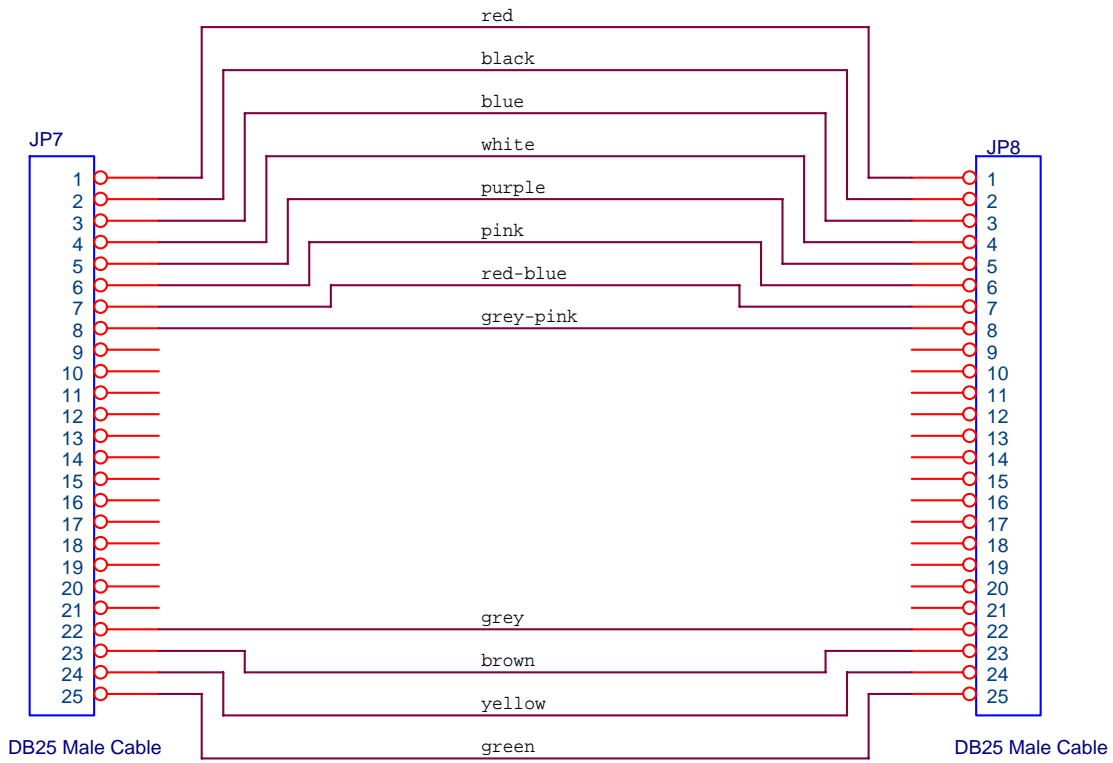




NOTES

- Use heat shrinkable tube for all the connections at the DB25.
- Mount nut type fixation for the DB25.

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<b>APT Telescope Cabling</b>		
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- NOTES
- Use heat shrinkable tube for all the connections at both DB25 and the LEMO.
  - Mount screw type fixation covers for the DB25.
  - Connect cable shield at both DB25 covers.
  - Lenght 1.2m
  - Manufacture one of each type.

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