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The Installation of the Sutherland Temperature Controllers in 2007 August

Ian Barnes

The University of Birmingham, Edgbaston, Birmingham B15 2TT

2008 January 15

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High-Resolution Optical-Spectroscopy Group

School of Physics and Astronomy
The University of Birmingham
Edgbaston, Birmingham B15 2TT, United Kingdom
Telephone: +44-121-414-4551 FAX: +44-121-414-1438

The Installation of the Sutherland Temperature Controllers in 2007 August

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Abstract

Details of the trip to Sutherland to install new temperature controllers and replace the damaged water tank are presented.

Contents

1 Introduction

Sutherland uses a large water tank to cool the spectrometer. However all the water from the tank leaked out and the tank was damaged beyond repair by the heater element melting the plastic wall of the tank.

The temperature controllers that were installed at the station were also struggling to keep the oven at the right temperature during cold weather.

Ian Barnes visited Sutherland in August/September 2007 to install a brand new temperature controller system and to replace the damaged water tank. Ian was on site from August 20 until September 5.

The complete list of tasks that were due to be undertaken was as follows:

- Install new Temperature Controllers [1].
- Replace front filter mount on Fred.
- Replace the damaged water tank.
- Replace float switch and look at installing a second device.
- Install V-F Power Box [2].
- Install new oscilloscope.
- Modifications to the DIO splitter card [3].
- Replace external temperature sensor.
- Install mains controller [4].
- Investigate the poor quality of magnetic data.
- Investigate poor instrument sensitivity.

2 Front Filter Mount

On the last station visit to Sutherland [5] it was noticed that the front filter mount on Fred was damaged. The retaining ring that held the red filter in place was bent and also had a damaged thread.

A new front filter mount was made that had the red filter mounted at an angle. This was fitted to the front of Fred. There are some nylon screws that ensure that the red filter cannot fall out of the mount and these were fouling on the heat shield. The problem was identified as the screw heads and these were cut off.

This means that removing the red filter for cleaning is rather tricky but the mount was only fitted as a temporary measure as new front filter mounts have been designed and one of these will be fitted on the next station visit to Sutherland.

Following the installation of the new filter mount it was necessary to check the alignment of the beam as the new mount may well have affected the optical path.

3 DIO Splitter Re-configuration

The allocation of the I/O channels on the PCI DIO card needed to be reorganized following the installation of the Mains Controller [4]. The reconfiguration of the DIO card also meant changes to the dassie were necessary.

Originally the tank relay box which controls the cooler, heater, pump and extractor fans was connected to DIO Port 3B. The tank float switch was connected to Port 2B. It was decided therefore to move the tank relay box signals to Port 2B so that all the I/O lines associated with the dassie were grouped together.

The I/O lines of Port 3B which were previously occupied by the tank relay box were then used to connect to the Mains Controller.

Following the changes to the DIO allocation in Sutherland, the DIO Splitter [3] report has been re-published to reflect the changes.

3.1 DIO Splitter Cables

Apart from the standard 37-way interface cables there are four other cables that are associated with the DIO splitter card in Sutherland. The drawings of these cables have been placed in the appropriate sections of this report.

Table 1 summarizes the cable drawings and where you can find them.

Table 1: DIO Splitter Cables

Drawing	*Figure*	*Page*
Mains Controller Cable	1	5
Tank Relay Box Cable	5	11
Cylinder Float Switch Cable	11	14
Ball Float Switch Cable	14	16

4 Mains Controller Installation

In the past HiROS has had a few problems with some devices latching up into bad states. The only was to get these units to recover is to power cycle them. Given the fact that the stations are overseas getting someone to the affected device can be rather time consuming. Therefore a device which the computer could control was needed that could perform the power cycle. This device is the Mains Controller.

The Mains Controller [4] can switch the power to eight separate devices. In Sutherland the Mains Controller currently only controls the Temperature Controllers.

4.1 Mains Controller Channel Configuration

The channel configuration for the Mains Controller in Sutherland is given in Table 2.

Table 2: Channel Allocation of the Sutherland Mains Controller

Mains Controller Channel	*DIO Port*	*System*
0	3B0	Temperature Controller
1	3B1	—
2	3B2	—
3	3B3	—
4	3B4	—
5	3B5	—
6	3B6	—
7	3B7	—

4.2 Mains Controller Scripts

There are a number of scripts that are associated with the Mains Controller. These scripts are located in the */home/zoo/bin/* directory.

There are scripts to turn individual channels of the Mains Controller on and off. These are named *mainsX_on* and *mainsX_off*, where X is the channel number which is in the range 0–7.

4.3 Mains Controller Cable

The Mains Controller Cable connects the Mains Controller to the DIO Splitter Card. Figure 1 shows the cable that is used in Sutherland.

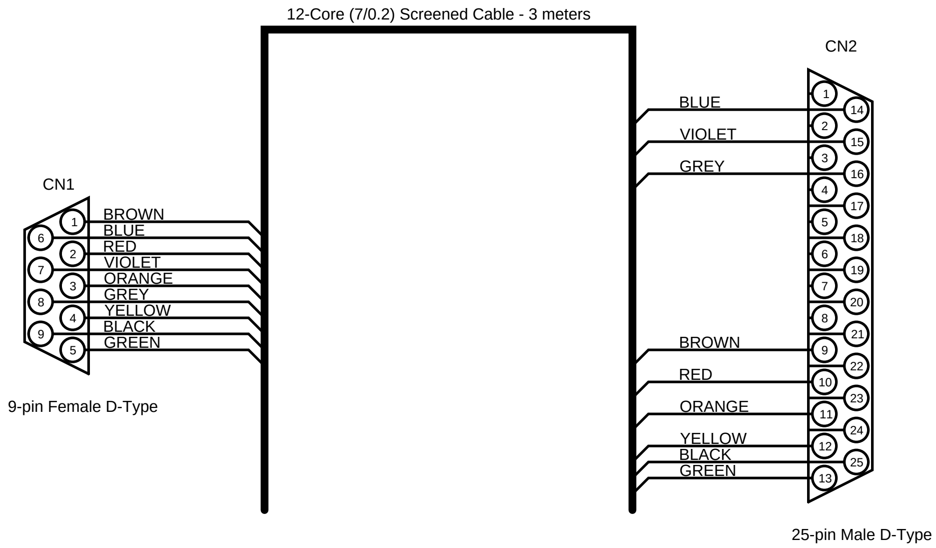


Figure 1: The Mains Controller Cable.

5 Sutherland Temperature Monitor Re-configuration

The changes to the wiring of the tank temperature probes and the retirement of the old temperature controllers meant that there were quite a few changes to the temperature monitor system.

The temperatures of the port and starboard detectors, the oven and interference temperature will now be monitored and logged by the new temperature controllers. There is no need to use the temperature monitor to monitor these parameters.

This has meant that the channel allocation of the Sutherland Temperature Monitor has changed as has the system wiring.

5.1 Channel Configuration

The temperature-monitor can monitor up to 16 separate channels. The channels on the Sutherland Temperature Monitor have been allocated as shown in Table 3. The lizard writes one set of temperature readings to the temperature file (*/home/zoo/Results/st*yymmdd.*dat*) every thirty seconds. The component corresponding to each column in this file are also shown in Table 3.

Table 3: Sutherland Temperature Monitor Channels

Channel	*Temperature File Column*	*Description*
0	1	Water Tank Temperature — Top
1	2	Water Tank Temperature — Bottom
2	3	Spectrometer Base Plate Temperature
3		—
4		—
5		—
6		—
7		—
8		—
9	4	Dome Ambient Temperature
10	5	Room Ambient Temperature
11	6	External Ambient Temperature
12	7	Cloud Detector Voltage
13		—
14		—
15		—

5.2 Temperature Monitor Rear Panel

Following the changes to the Sutherland Temperature Monitor the labels on the rear panel of the unit have also changed. Figure 2 shows the rear panel of the Sutherland Temperature Monitor.

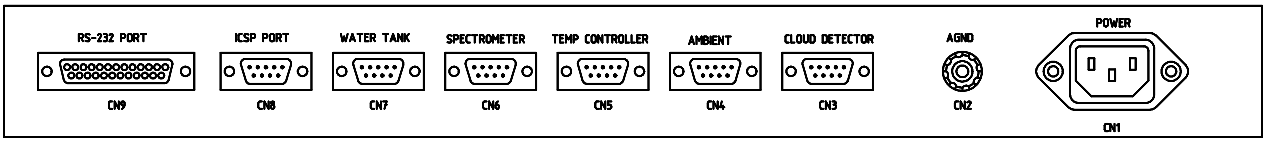


Figure 2: The Sutherland Temperature Monitor Rear Panel.

5.3 External Temperature Sensor

When the Sutherland Temperature monitor was installed an LM35 was used to measure the ambient temperature outside the dome. At the time concern was expressed as the LM35 was only protected from the elements by heat-shrink. It was expected to get damaged by water at some point. However the LM35 managed to survive but it was replaced on this trip.

The LM35 was potted inside a thermocouple pocket which makes the probe water resistant. A mounting bracket and cover was also made and these were used to mount the temperature probe on the exterior wall of the dome.

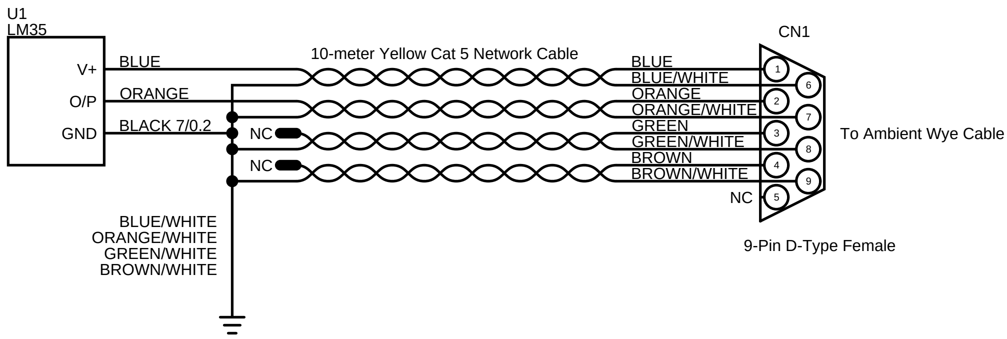


Figure 3: The External Temperature Probe.

All of the parts needed to make the exterior temperature probe are given in Table 4

Table 4: External Temperature Probe Parts List

Name	Part Number	Description (SSM)
U1	Rapid 82-1002	LM35DZ Temperature Sensor IC
CN1	Rapid* 15-0525	9-Pin Female D-Type Connector
—	RS 544-3402	D-Type Connector Hood 9-Pin (10)
—	Rapid* 19-4424	Yellow 10-meter Network Cable
—	FEC 673-961	Thermocouple Pocket
—	RS 552-668	Thermal Potting Compound
—	HiROS	Mounting bracket and Cover Assembly

*These items are available from Physics Stores.

5.4 System Diagram

Following the changes to the Sutherland Temperature Monitor the system diagram as shown in BTR-277 is now incorrect. Figure 4 shows the system diagram for the Sutherland Temperature Monitor System.

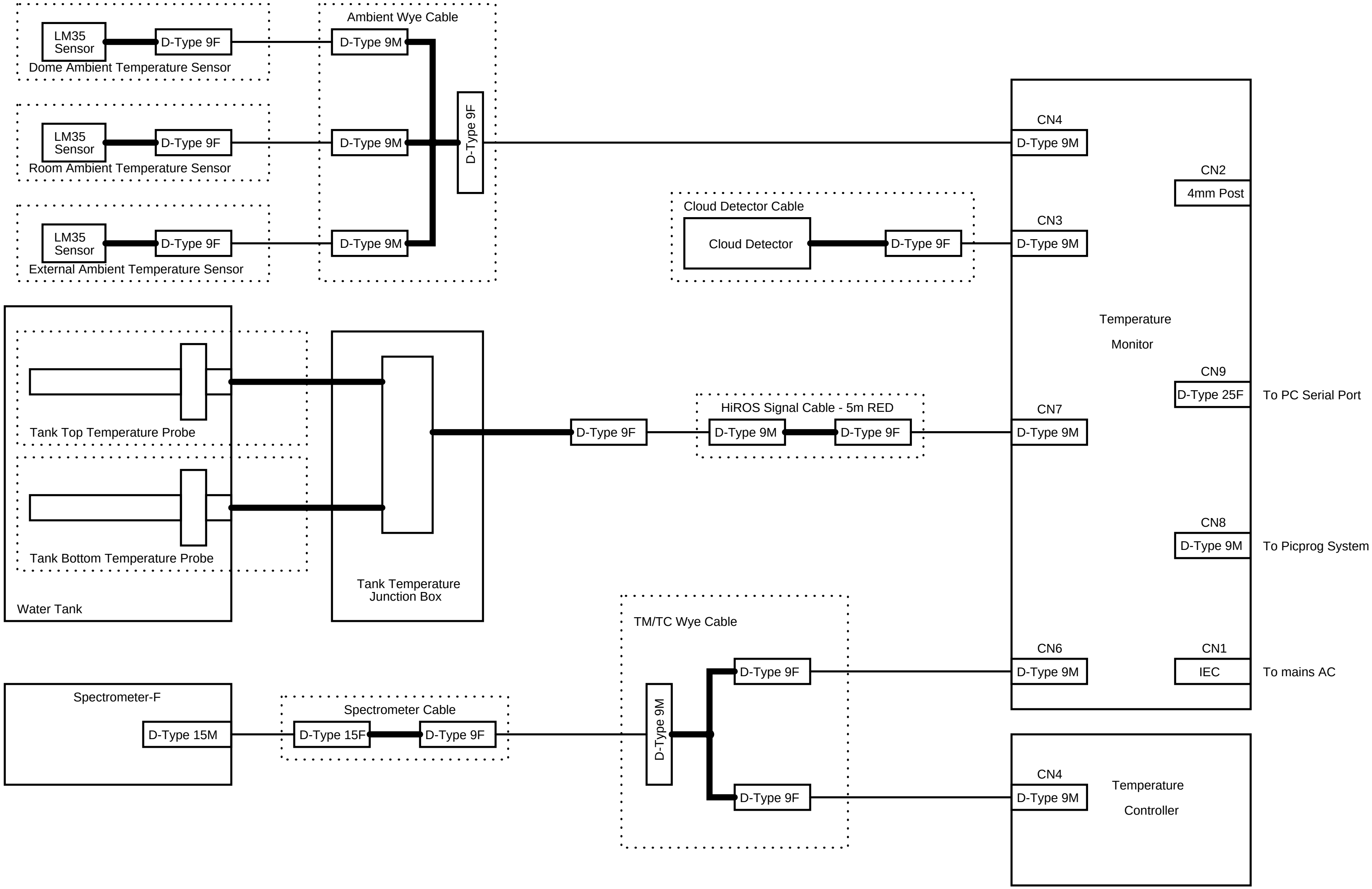


Figure 4: The Sutherland Temperature Monitor System.

6 Water Tank Installation

In Sutherland, Fred is cooled using water that is held in a large 1500-litre water tank. The existing tank sprung a leak and the computer sensed that the water temperature was low and turned the heater on. Because the water had leaked from the tank, the heater melted the plastic of the tank and eventually fell out and was swinging on its cable.

The tank was a complete write-off and had to be replaced. Fortunately the water tank is readily available in Sutherland. The old tank was stripped of all the fittings and components and the new tank was put in place.

6.1 Changes to the Water Tank

The new water tank is practically identical to the last tank that we used. However the design of the lid has changed slightly on this version, and in fact this is an improvement. The lid now has two holes that locate over two pillars on the tank. A couple of clips go through the pillars that prevent the lid from being blown off in windy conditions.

There are however, quite a number of changes to the ancillary equipment that is added to the tank. These changes are summarized below:

- The water return pipes mounted in brass pipe fittings to prevent the pipes from moving around.
- The hole in the top of the tank which was previously used for the water return pipes has been blocked off.
- A stop tap has been added to the tank so that the water can be easily turned off. This means that the water can be stopped very easily now.
- The heater element has been placed lower in the tank than before.
- The heater element is now more powerful as it is rated at 1.5kW instead of 1kW.
- A ball type float switch has been added which gives us two sensors monitoring the water level within the tank.
- The tank temperature sensors are now mounted from the top of the tank rather than from the side. Changing these sensors in the event of failure was pretty tricky and involved getting wet.
- A new filter has been fitted to the pump as the old one was damaged. The new filter is a different design as the old filter is no longer available.

6.2 Tank Relay Box Cable

The Tank Relay Box cable carries the control signals from the computer via the DIO splitter card to the tank relay box. The tank relay box controls the extractor fans, water heater, water cooler unit and water pump.

Figure 5 shows how the tank relay box cable is wired.

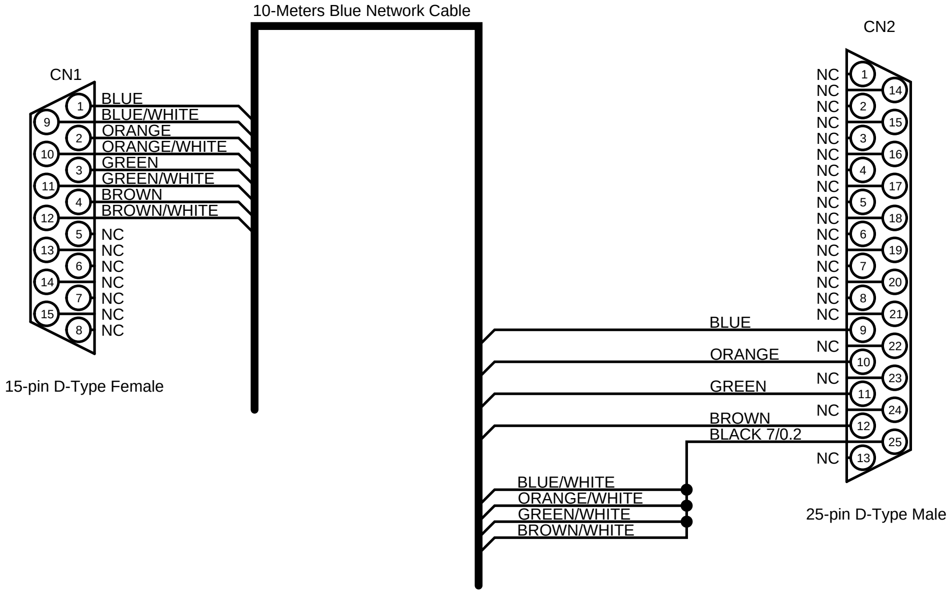


Figure 5: The Tank Relay Box Cable.

6.3 Water Tank Control (Dassie) Scripts

The dassie is the animal that controls the water tank in the Sutherland Zoo. The dassie reads various parameters from the temperature monitor and the DIO card. It then uses these inputs to control the temperature of the water in the tank and also the temperature in the room.

The dassie has a number of different devices that can be operated according to the status of the input temperatures. The devices that the dassie controls include:

- Water Pump.
- Water Cooler.
- Tank heater.
- Extractor Fans.

Since the Dassie outputs changed ports on the DIO splitter card the scripts that controlled the various outputs also had to be modified. These scripts are located in the */home/zoo/bin/* directory.

6.4 Tank Temperature Sensing System

On the original water tank the temperature sensors were fitted into the side of the tank. This meant that changing the probes due to failure was a tricky operation. Whilst removing the probes from the old tank it was also noticed that the turning motion needed to unscrew the probes from their fittings was damaging the cable where it came out of the thermocouple pocket.

In order to make changing the probes easier and to prevent damage to the cable, it was decided to mount the probes from the top of the tank and use the cable to hang the probe at the correct depth.

Figure 6 shows the tank temperature system block diagram.

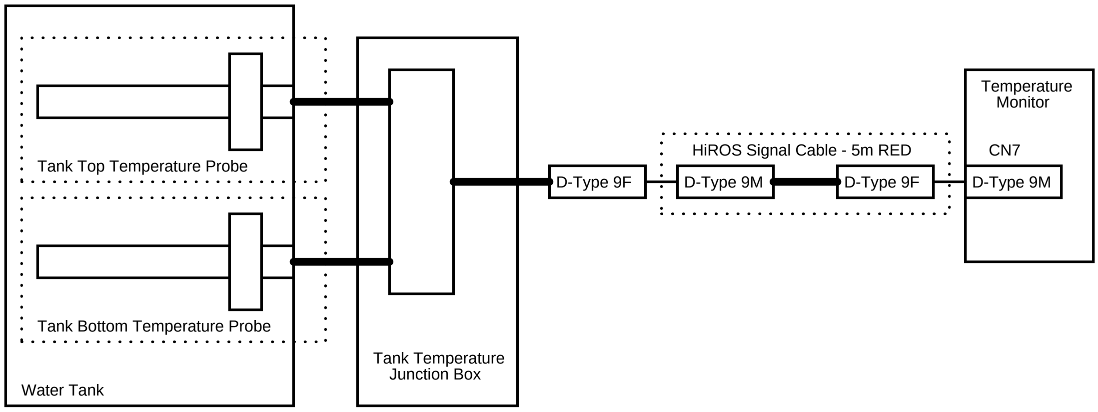


Figure 6: The Tank Temperature System Block Diagram.

6.4.1 Tank Temperature Probes

Currently the probes are housed in 350-mm long thermocouple pockets. Since the probes are now mounted from the top of the tank there is no need for them to use such a long metal probe. Due to the damage to the wiring the probes will be replaced on the next trip. The new probes will use the 100-mm metal probe instead of the 350-mm version.

Both of the temperature probes have identical wiring and this is shown in Figure 7.

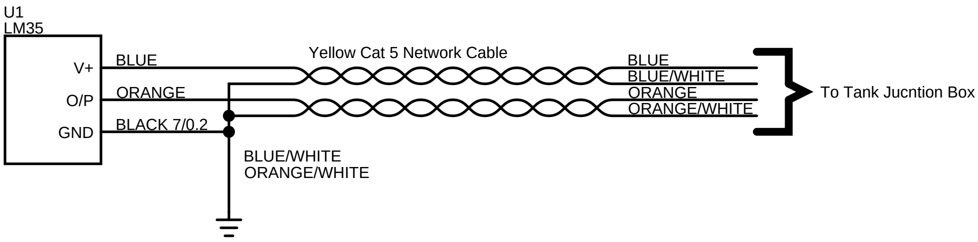


Figure 7: The Tank Temperature Probe Wiring.

6.4.2 Tank Temperature Junction Box

The Tank Temperature Junction Box is simply a die-cast box mounted on the top of the water tank that contains the wiring for the temperature probes. A separate cable gland for each temperature probe secures the cable allowing the depth that the probe sits to be set.

Each temperature probe uses two of the four twisted-pairs of a network cable. All of the signals from both probes can therefore be combined and transmitted down a single network cable.

In order to combine the signals into one cable terminal block was used. Figure 8 shows the internal wiring of the temperature junction box.

6.4.3 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.

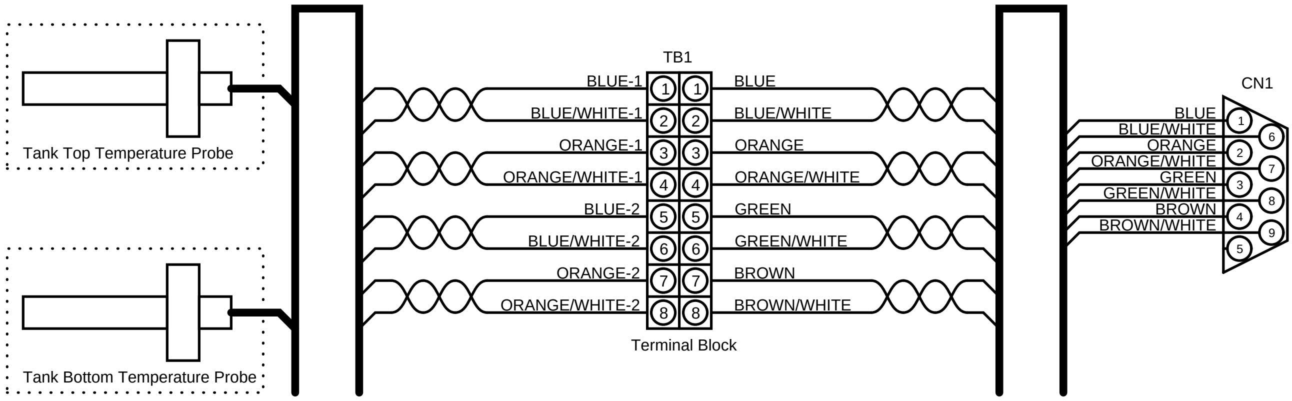


Figure 8: The Tank Temperature Probe Junction Box Wiring.

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 4 twisted pairs of 7/0.2 wires. The cables come in a variety of different lengths and several different outer sheath colours are available including yellow, blue and red.

Figure 9 shows how the cable is connected internally.

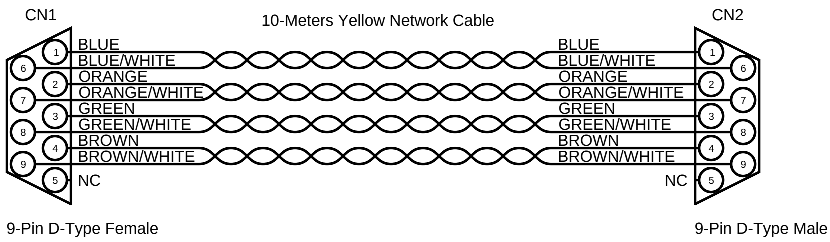


Figure 9: The HiROS Signal Cable.

6.5 Cylinder Float Switch

The old tank used a float switch to indicate that the water was low. However this sensor did not sense that the water had leaked out of the tank and thus the tank was melted by the heater element which was trying to heat the water that wasn't there.

It was expected that the float switch had failed however when the unit was tested it was found to be working properly. The reason for the failure of the float switch was eventually found. There was a wiring mistake and the sensor was connected to the wrong input on the DIO card, this is why the computer did not see that the water level was low.

Even though the sensor that was fitted to the old tank was still working perfectly the metal ring that acts as a mechanical stop was badly corroded and disintegrated when touched. The sensor was scrapped and a new one was fitted to the replacement tank.

The cylinder float switch has two switches inside as shown in Figure 10. The upper switch indicates that the water in the tank is at a high level whilst the other switch indicates a low water level. The inputs on the DIO card are pulled high by pull-up resistors and when the appropriate contact on the float switch is opened by the float passing the corresponding level, the signal goes low.

The sensor is mounted through the top of the tank and a die-cast box. Figure 11 shows the wiring of the cylinder float switch.

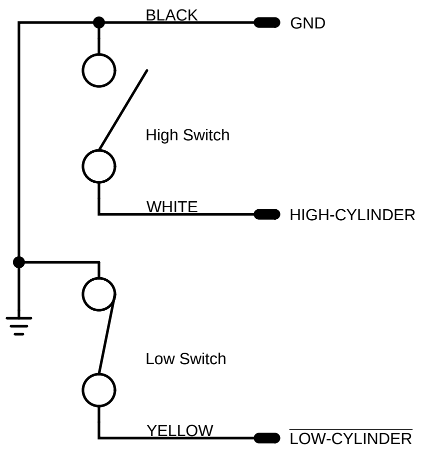


Figure 10: The Cylinder Float Switch — Internal Circuit Diagram.

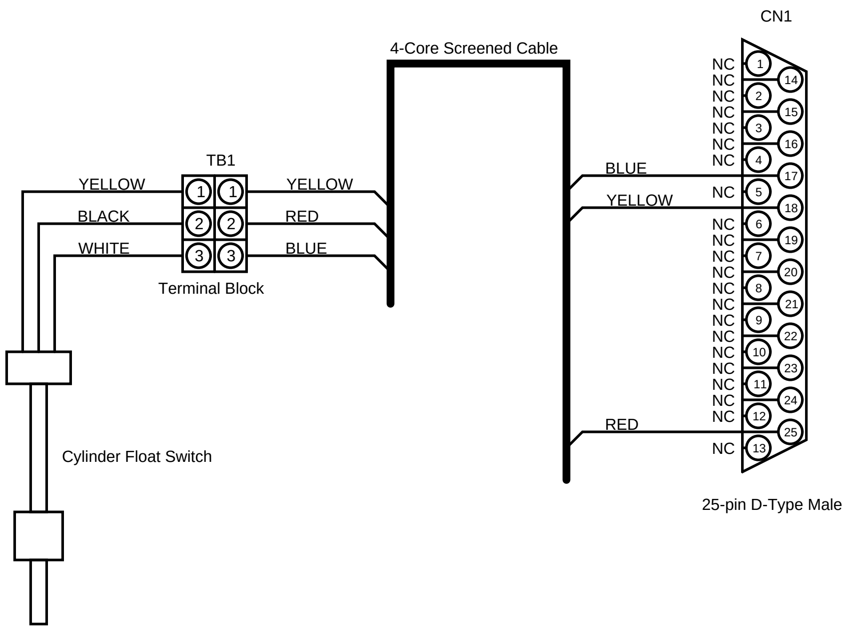


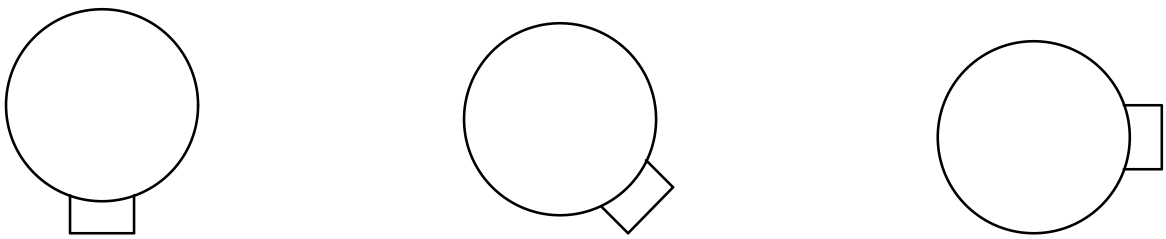
Figure 11: The Cylinder Float Switch Wiring.

6.6 Ball Float Switch

Following the suspected failure of the cylinder float switch it was decided to install a second float switch in the tank. Instead of fitting a second cylinder type float switch it was decided to fit a totally different type of sensor altogether.

The ball float switch looks like the ballcock out of a toilet with a cable coming out of it. The cable is tethered at a specific length and the ball will float on the water with the cable just hanging loose. As the water drops the cable gets pulled tight and eventually it tips the ball past its horizontal axis and the switch changes state.

Figure 12 shows how the position of the ball switch changes as the water level decreases towards the alarm point. In Figure (a) there is plenty of water in the tank and the ball switch is floating on top of the water, this is the "high" water position. In Figure (b) the water level has dropped and the ball is now starting to pull the cable taught. This state can be called the "medium" water position. In Figure (c) the water level has dropped even further and the cable has pulled so tight as it has pulled the ball to the horizontal position. This causes the changeover switch to change state and this can be detected by the computer.



(a) High (b) Medium (c) Low

Figure 12: The three different states of the Ball Float Switch.

Figure 13 shows the equivalent circuit for the ball switch that is fitted in the tank at Sutherland.

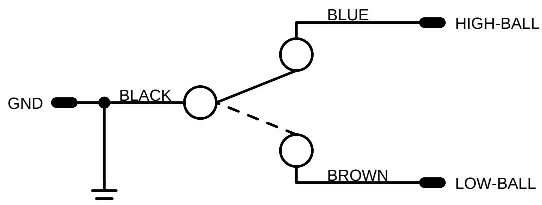


Figure 13: The Ball Float Switch — Internal Circuit Diagram.

The sensor is mounted through a die-cast box on the lid of the water tank. Inside the box there is a cable clamp which is used to clamp the cable of the sensor at the appropriate alarm point. Figure 14 shows the wiring of the ball float switch.

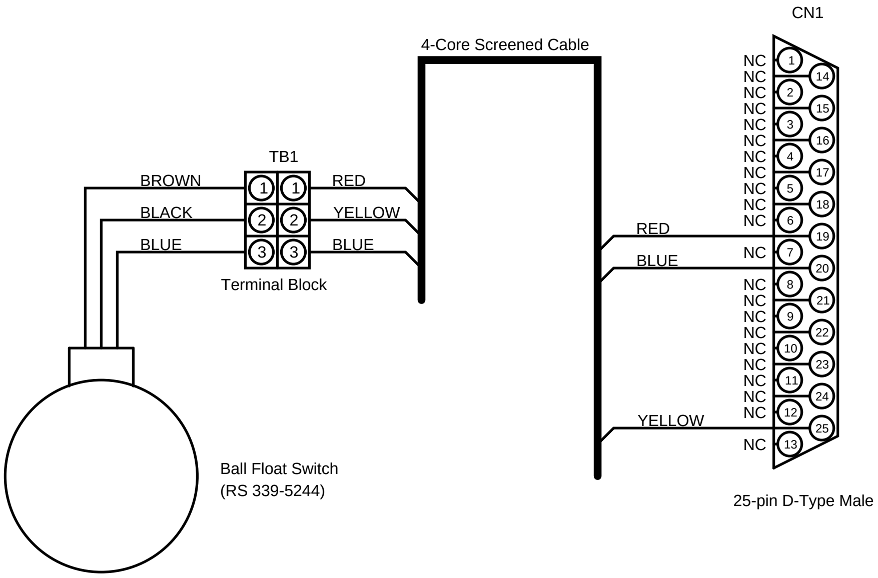


Figure 14: The Ball Float Switch Wiring.

7 Temperature Controller Installation

The temperature controllers in Sutherland have been struggling for quite some time. During the last trip to Sutherland it was found that a voltage reference had stopped working and a temporary fix was made.

The temperature controllers simply didn't have enough power to heat the oven during cold spells of weather at the station. It was therefore decided to replace the temperature controllers with a brand new design.

7.1 Temperature Controller Configuration

The Sutherland Temperature Controllers [1] control the temperatures of the following spectrometer components:

- Port Detector.
- Starboard Detector.
- Interference Filter.
- Oven.

The temperature controller is controlled by the iguana program. The iguana writes out two temperature files, one for the daytime temperatures (*/home/zoo/Results/sw*yymmdd.*dat*) and one for the nighttime temperatures (*/home/zoo/Results/sx*yymmdd.*dat*). Table 5 shows how the channels are allocated in both of these files.

Table 5: Sutherland Temperature Controller Channels

Channel	*Temperature File Column*	*Description*
0	1	Oven
1	2	Starboard Detector
2	3	Port Detector
3	4	Interference Filter (IF)
4	5	Heatshink Drive Board A
5	6	Heatsink Drive Board B
6	7	Case Rear
7	8	Case Front

7.2 System Diagram

Figure 15 shows the system diagram for the Sutherland Temperature Controller System.

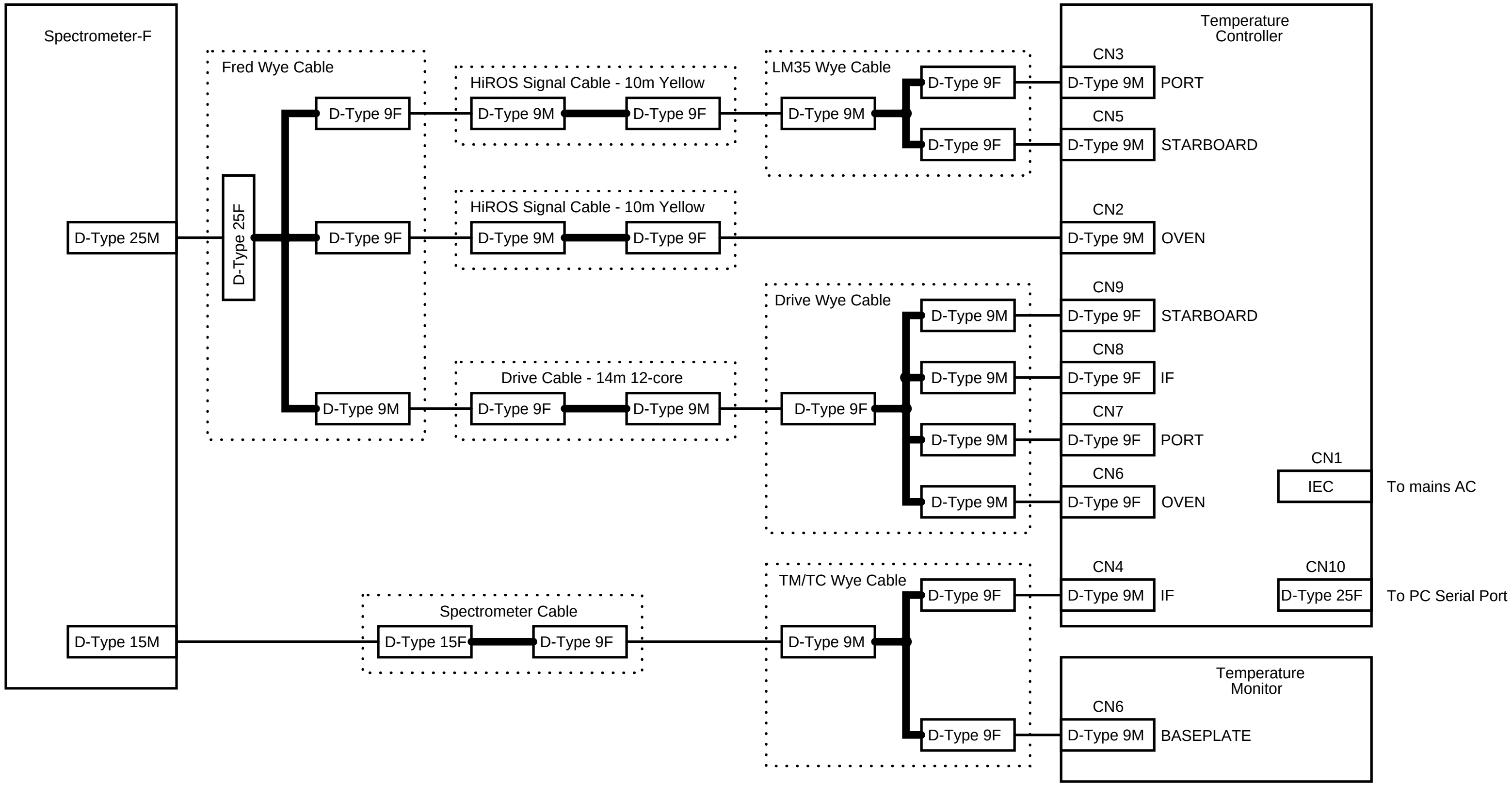


Figure 15: The Sutherland Temperature Controller System.

8 V/F Power Box Installation

The V/F Converters inside Fred were receiving their power from a bench power supply unit. This takes up a lot of space in the timber rack and it was decided to design a new power supply box in a 1U case to save shelf space in the rack.

Thus the V/F Power Box [2] was designed. The installation was very straight forward indeed as it was a case of removing the current power supply and connecting the V/F Power Cable to the new V/F Power Box. A quick check that the power rails were present on the correct pins and job done.

The V/F Power box was left in-situ for a day and the data was analyzed. The data had gone completely haywire. The fault was traced to a problem with the +5V rail. Basically a 100-mA regulator was used to provide the +5 V rail for the electronics inside Fred, and this device could not provide enough current and hence the voltage was dropping too low at around +3.5 V. Figure 16 shows the +5 V regulated supply as it was designed on the Power board within the V/F Power Box.

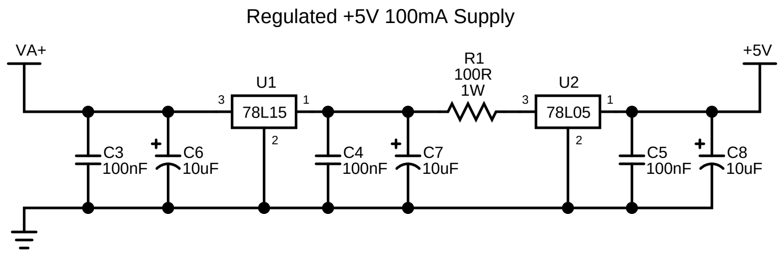


Figure 16: The +5 V Regulated Power Supply as used on the POWER-1 PCB, which is used within the Sutherland V/F Power Box.

To fix the V/F Power Box a new +5 V regulated supply was created on a small piece of veroboard and connected to the POWER-1 PCB. The new circuit used a voltage regulator that can supply a maximum current of 1 A. Figure 17 shows the circuit diagram of the new circuit that was used.

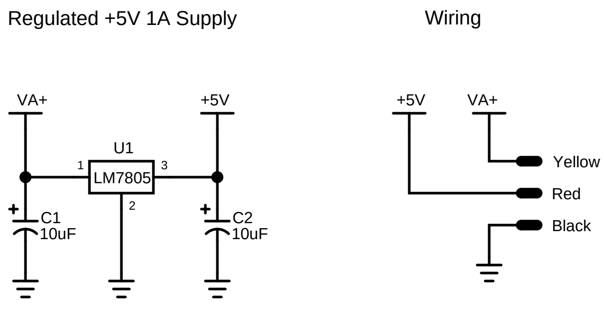


Figure 17: The new 1 A +5 V regulated power supply built to replace the on-board circuit.

The modifications to the POWER-1 PCB are given below:-

- Depopulated U1, U2 and R1.
- Connect yellow wire on veroboard to U1-3.
- Connect black wire on veroboard to U1-2.

- Connect red wire on veroboard to U2-1.

The veroboard circuit was tested and tested with no load and also with the V/F converters connected and the output of the voltage regulator was steady at a constant +5 V. A new PCB should be designed for the Sutherland V/F Power Box and installed on the next visit to the station.

9 Data Quality Improvements

The quality of the data coming out of Sutherland prior to this trip has not been very good, and improving the data quality was one aim of this trip. Some of the work already documented in this report will help to improve the data quality.

The main improvement will come about because of the replacement of the water tank and temperature controllers. The old units did not have enough power to get the optical components to the correct temperature during cold conditions. Therefore the temperature of the water in the tank was kept at a reasonable level. Losing all of the water in the tank therefore seriously affected the data quality during the winter months when it is pretty cold in Sutherland.

Having the front filter at an angle is also an improvement that has been made on this trip. The alignment could also improve data quality and so fitting the new front filter mount and realigning the beam should add to the data quality.

The data from the Magnetic Pockels-Cell was particularly bad. A Pockels-Cell scan would hopefully fix this up although the problem was quickly identified at the start of the procedure — the magnetic Pockels-Cell Driver was not turned on!

Scans of both the velocity and magnetic Pockels-Cells were completed and the associated drivers were set at the levels that maximized the ratio.

References

[1] Ian Barnes. The Sutherland Temperature Controllers. *BISON Technical Report Series,* Number 295, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, January 2008.

[2] Ian Barnes. The Sutherland V/F Power Box. *BISON Technical Report Series,* Number 298, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, January 2008.

[3] Ian Barnes and Brek A. Miller. Interface C: Another DIO splitter. *BISON Technical Report Series,* Number 299, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, January 2008.

[4] Ian Barnes. The Mains Controller. *BISON Technical Report Series,* Number 297, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, January 2008.

[5] Ian Barnes and Brek A. Miller. The grand opening of the Sutherland Zoo. *BISON Technical Report Series,* Number 276, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, October 2006.

[6] Ian Barnes. Temperature-monitor unit for Sutherland. *BISON Technical Report Series,* Number 277, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, October 2006.