Visible & Infrared Survey Telescope for Astronomy

IR CAMERA

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1 Introduction

1.1 Scope

This document describes the thermal control of the LOCSAG units, the alterations made to the original design to customise its use for VISTA, and the voltage setpoints required for various target temperatures.

1.2 Acronyms and Abbreviations

CCD	Charge Coupled Device
EMC	Electromagnetic Compatibility
ESO	European Southern Observatory
LOCSAG	Low Order Curvature Sensor AutoGuider
TCCD	Technical CCD
TEC	ThermoElectric Cooler
SDSU	San Diego State University (controller)

1.3 Applicable Documents

[AD1] Wavefront Sensors Autoguider Wiring Diagram, VIS-DES-UOD-06042-0014, Issue 0.5, 21 Nov 2005.

[AD2] Wavefront Sensors Curvature Sensors Wiring Diagram, VIS-DES-UOD-06042-0013, Issue 0.5, 21 Nov 2005.

2 TCCD Controller Thermal Control

2.1 Description

The thermal control circuitry for the VISTA TCCD controllers is contained on the ARC78 Power Control Board. This board is a custom design built to ESO requirements and uses a MAX1979 chip in a feedback loop.

The MAX1979 operates by providing an output current that is proportional to the difference between two voltages present at inputs *FB+* and *FB-*. If *FB+* is greater than *FB-*, the device sources output current to the connected TEC or heater. *FB-* is a set point generated by a variable resistor connected to a reference voltage (generated by the MAX1979). This potentiometer is mounted on the front panel of the TCCD controller to allow the user easy access. *FB+* is the voltage generated by the temperature sensor.

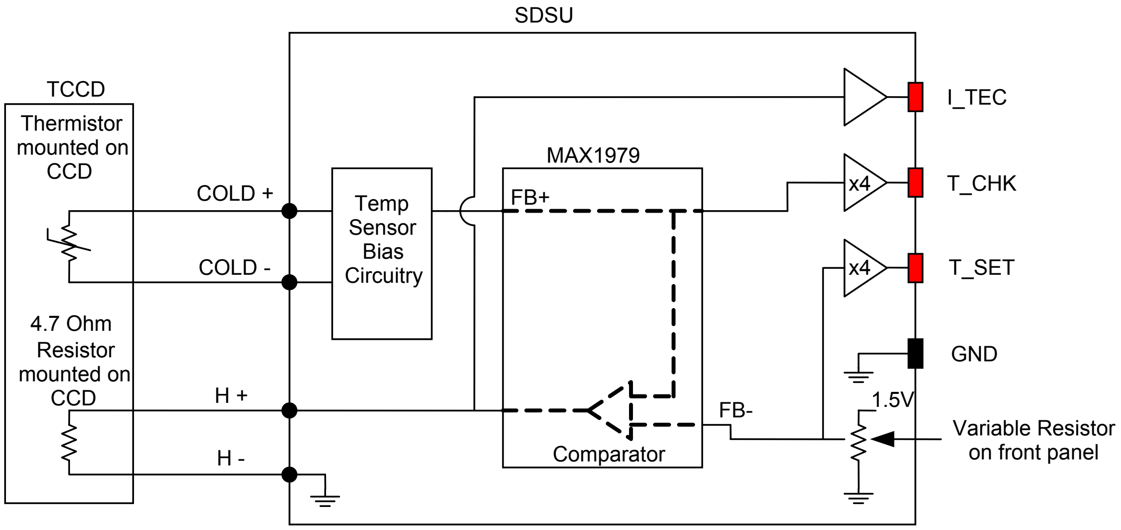

Figure 2-1: Functional Diagram of thermal control with VISTA connections shown

Three temperature sensors can be used: a thermistor, a transducer (AD590) and a diode. The MAX1979 chip is intended to be used with a thermoelectric cooler, but can be used with a heater – the difference being that with a TEC, more current means more cooling and a reduction in temperature, and vice versa with a heater. Each sensor type requires different bias conditions and each board contains all the circuitry required for all modes. The mode is selected by altering the configuration of 5 jumpers, found next to the power connector: JP16, SW4, SW3, SW2, JP15. The board shown is ARC78 Rev1B and some controllers contain ARC78 Rev1C, which have slightly different layout, but the position of the jumpers remains the same.

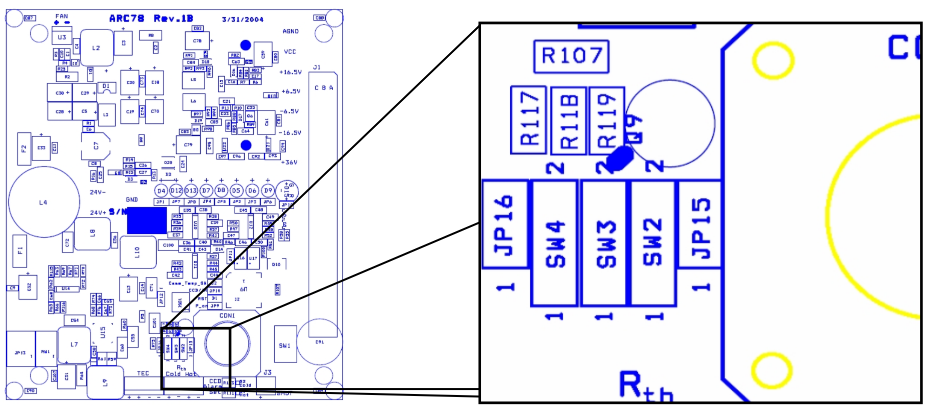

Figure 2-2: Location of sensor configuration jumpers

There are four voltages available on the front panel of the controller, in the form of sockets for 4mm banana plus. These are *GND*, *T_SET*, *T_CHK* and *I_TEC* which allow the user to easily read and adjust the inputs to the comparator and check the current flowing into the heater. The two temperature voltages, *T_SET* and *T_CHK*, present on the front panel have been amplified by a gain of 4, and the *I_TEC* voltage is an approximate one-to-one representation of the current flowing through the heater i.e. 1V = 1A.

The thermal control is activated by the *TEC_START* software command, but this has been bypassed by the inclusion of a jumper on JP12 which automatically provides power to the MAX chip when the ARC78 is powered on.

LED D15 on the ARC78 provides a visual indication to the user of the current state of the thermal loop. If the setpoint is higher than the sensor voltage (FB- > FB+) then the LED is green, if lower (FB- < FB+), then it is red and if at the correct temperature (FB- = FB+) there is no light.

2.2 *VISTA mode of operation*

Each VISTA TCCD's ceramic package has a hole on the side into which a thermistor with a negative temperature coefficient is potted using a thermal epoxy. On the underside of the device there is a recess that allows a TO-220 resistor to be mounted to act as a heater. This allows the temperature of the device to be known and then controlled by varying the heater power. The thermistor is soldered onto the flex and the signals are available at the Micro-D connector.

This causes a problem as when the board is configured for use with a thermistor temperature sensor, it assumes a TEC device is present and thus the feedback loop is positive:

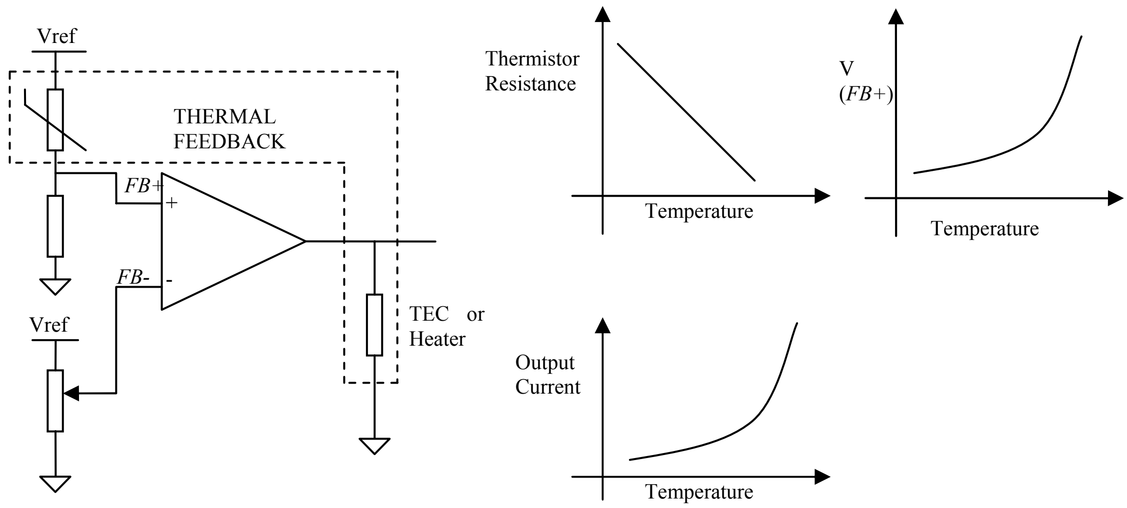

Figure 2-3: Thermal Control Feedback Loop

As the temperature increases, the resistance of the thermistor decreases and therefore the voltage V(*FB+*) increases. Thus the output current flowing through the TEC increases, thereby cooling the device and reducing the temperature: negative feedback. But if a heater resistor were used, the increased current would result in increased heating and increased temperature: positive feedback.

To correct this, either the thermistor or heater resistor must be replaced or the circuit modified. The latter is the only option available, and the easiest way to produce the required response is to swap the positions of the thermistor and resistor in the potential divider. This is done by the following three steps:

1) Remove the fixed resistor in the potential divider: R68 (4.99k)
2) Configure the jumpers as shown to connect SW3-3 to SW2-3, this connects *Thermistor+* to *FB+*
3) Attach a resistor between *FB+* and *Vref*. This is most easily done by connecting between JP16-1 and SW2-1. This then acts as the fixed resistor in the divider.

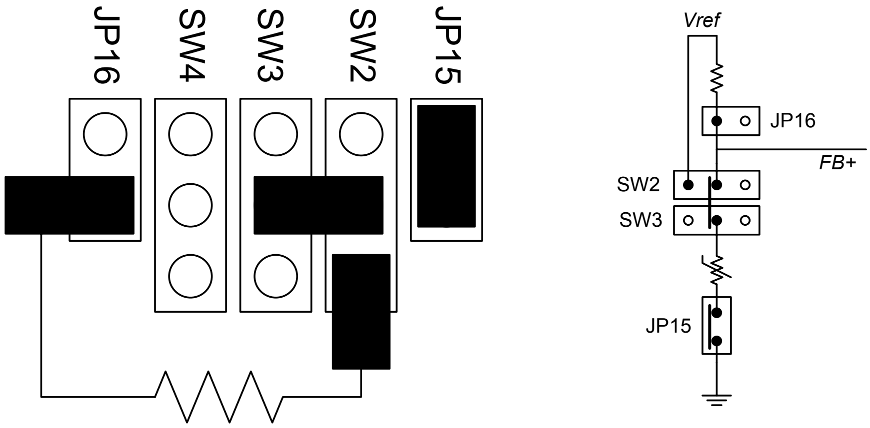

Figure 2-4: VISTA jumper configuration and diagram of resulting circuit

The value of this new resistor is determined by the thermistor's temperature response. The operating temperature of the TCCDs for VISTA is lower than normal and thus the thermistors are operating at the extreme of their range. The graph below plots the resistance of the thermistor on the left-hand Y axis, and the output voltage *FB+* for varying values of fixed resistor on the right-hand axis. Both are versus temperature for the range 160 to 230K. From the graph it is clear that a 5k resistor is too small, and that both the 50k and 100k offer a wide range of voltages for the target temperature. The 50k was chosen as it provided a better response at warmer temperatures.

Due to the use of the thermistor in a potential divider, it is imperative that all thermistors used in VISTA have the same response; else it would be necessary to calibrate every controller to a specific TCCD. The manufacturers of the thermistor, YSI, quote a 0.2 degree device interchangeability.

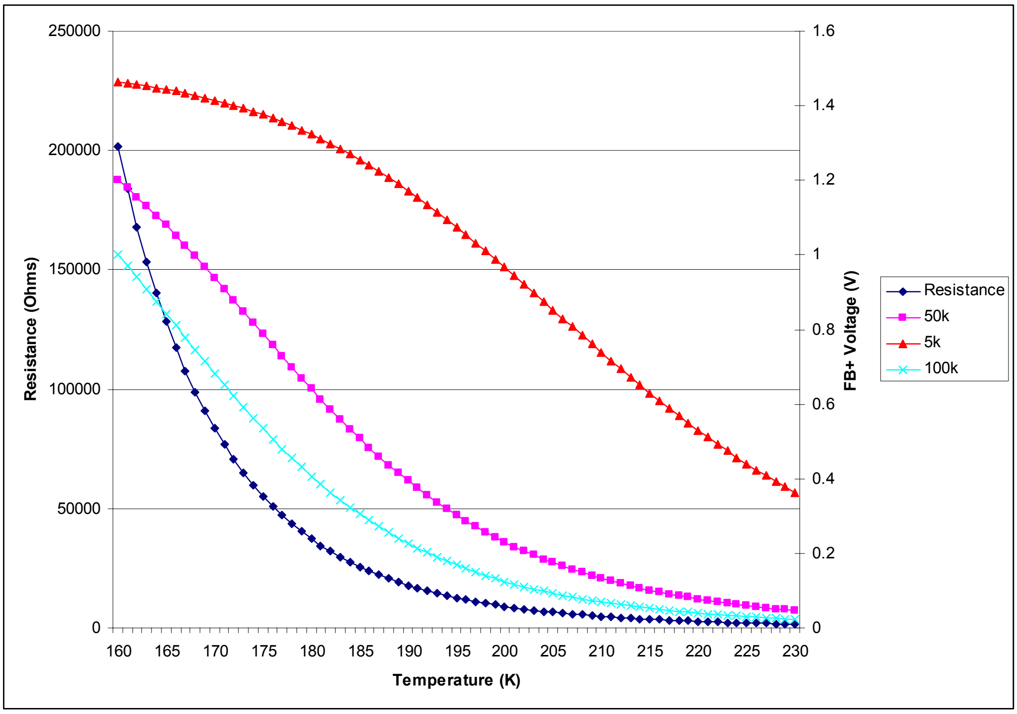

Figure 2-5: Graph showing variation of thermistor resitance and feedback voltage with temperature

A simplified table showing the setpoints for various temperatures and the LED conditions is provided.

Desired Temperature (K)	T_SET (V)
160	4.8
165	4.3
170	3.8
175	3.2
180	2.6
185	2

LED is	CCD is
Green	Too hot
Red	Too cold
Off	Correct

Table 2-1: TemperatureSetpoints

3 TESTING

3.1 Results from AIT-4b

During AIT4b tests were run by GFW to verify that the thermal control system was working. Attached are his results.

		LCU end, RHS SDSU (+Y AG)		LCU end, LHS SDSU (+Y CS)		SCP end, RHS SDSU (-Y CS)		SCP end, RHS SDSU (-Y AG)			
Date	Time	TCHK	ITEC	TCHK	ITEC	TCHK	ITEC	TCHK	ITEC	L/S 218	
7/02/06	14h30	5.06V (led red)	1.266V	5.06V (led red)	0.656V	5.05V	0.690V	5.05V	1.233V	106K	COLD
	15h45	3.81V (led off)	1.238V	3.82V (led off)	0.646V	5.04V	0.683V	5.04V	1.207V	153K	COLD
8/02/06	12h30	4.24V (led red)	1.233V	3.75V (led off)	0.639V	5.04V (led red)	0.682V	5.04V (led red)	1.205V	154.5K	COLD
9/02/06	09h30	4.16V (led red)	1.229V	3.83V (led off)	0.643V	5.04V (led red)	0.681V	5.04V (led red)	1.205V	154.3K	WARMING UP
	10h45	3.81V (led off)	0.48V to 1.2V	3.83V (led off)	0.13V to 0.643V	4.91V (led red)	0.679V	5.04V (led red)	1.201V	162.7K	WARMING UP
	14h30	3.81V (led off)	0.718V to 0.738V	3.78V (led off)	0.013V to 0.641V	3.83V (led off)	0.013V to 0.675V *	3.81V (led red)	0.27V to 1.189V *	176.6K	WARMING UP
10/02/06	10h45	0.176V (green)	0.012V	0.105V (green)	0.013V	0.396V (green)	0.013V	0.115V (green)	0.013V	239.0K	WARMING UP

Table 3-1: Results of thermal control tests from AIT-4b Feb 2006

Notes :

1. TSET measured 3.8V for all 4 SDSUs and was not adjusted.
2. During AIT-4b, approx 8W was applied to the WFS thermal protection resistors. When the WFS temp was seen to rise on the Lake Shore 218, as the result of turning on the SDSUs (afternoon of 7/02/06), the WFS thermal protection heating was switched off.
3. Camera warmup was started at 08h30 on 9/02/06 and the WFS thermal protection resistor heating was turned on again.
4. * the higher voltage was present for several minutes with only short periods, of a few seconds, at the lower voltage.

Guy Woodhouse 10 Feb 2006

3.2 Discussion of Results

There are several conclusions to be drawn from these results:

1) The thermal control system does work as the system does stabilise to 3.8V, the value set by TSET
2) The +Y LOCSAG has enough thermal power to raise the system from cold but it appears –Y does not (-Y only raises to ~154K)
3) The +Y AG does not appear to stabilise until camera warms, although this may just be aliasing due to infrequent sampling.
4) The Lakeshore temperatures suggest that the theoretical setpoints are approximately correct but need to be tuned accordingly.
5) It appears that the –Y AG thermistor is functioning correctly, suggesting that earlier problems with this monitoring the temperature of this device stemmed from the bias circuitry in the controller.
6) The variation in ITEC seen at 14h30 on the 9th illustrates the changing heater current, and also should be noted that the LED remains off, thus the LED cannot be taken as a measure of heater status.
7) The steady state of ITEC in +Y AG suggests the loop may have closed… how long the other systems take to stabilise, or if they stabilise, requires a longer test run.
8) The stability of the system would require tracking of the TCHK voltage and the Lakeshore reading
9) 8W of heater power for the TPS is insufficient to keep the detectors at temperature significantly warmer than the WFS plate.
10) Further tests should also include the WFS plate data in order to build up a complete picture of the thermal system.

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