BiSON
Birmingham
Solar-Oscillations
Network

TECHNICAL REPORT NO. 62

The Trip to Las Campanas During the Big Snowstorm of 1997 August

Brek A. Miller
The University of Birmingham, Edgbaston, Birmingham B15 2TT

1997 November 12

This technical report series is published by:

THE UNIVERSITY
OF BIRMINGHAM

High-Resolution Optical-Spectroscopy Group

School of Physics and Space Research
The University of Birmingham
Edgbaston, Birmingham B15 2TT, United Kingdom
Telephone: +44-121-414-4568 FAX: +44-121-414-4577

The Trip to Las Campanas During the Big Snowstorm of 1997 August

Brek A. Miller

The University of Birmingham, Edgbaston, Birmingham B15 2TT

1997 November 12

Abstract

I had to make many repairs to the electronics, the damage looks like it was caused by a lightning strike. Work was hampered at first by high winds, and then by heavy snowfall. A small group of people were trapped on the mountain: The roads were out, the phone lines down, the electricity supply cut, and the Internet connection was not working. But through it all, not one single volcano erupted.

1 El Niño

On 1997 July 16, something major happened to the shutter control circuits. Much damage was done to the electronics. The problem may have been a lightning strike near the dome. It would appear that a high-voltage spike traveled into the dome through the rain detector, destroying electronics along its path all the way to the solid-state relays controlling the shutter.

I arrived on site on August 14 and stayed until August 25. Ordinarily, this would have been more than enough time to complete all of the work that I would have liked to have done, however Mother Nature had other plans for me on this trip.

I began work on the morning of Friday, August 15. During the day the wind speed reached 50 mph. This was the sustained wind speed, not the gusts. And it was cold. The dome is not very air tight so with winds at that speed, the interior temperature pretty much stays the same as the exterior temperature. I did manage to find enough of the problems with the shutter circuit to at least get things working.

On Saturday, August 16, the winds picked up. The recorded speeds during the day were 70 mph climbing to 75–80 mph by evening. I had trouble just walking to the dome. By the end of the day I still had not found all of the problems with the electronics.

I woke up Sunday morning to silence; finally the wind had died down. I opened the door to my room only to find everything covered in snow. Now getting to the dome was even more difficult than before. While the wind had died down, it was still blowing at 20 mph. The snow was still falling — in large lumps of ice which sting when they hit you at 20 mph. It snowed all through Sunday. There was no hope of getting down off the mountain, though the locals tried desperately to keep the road open between the lodge and the 100-inch dome. By midday the snow had forced them to give up and we were all trapped in the lodge. Our dome is only a quarter of a mile from the lodge so I could still get to work, but I did not really want to make the trip at night, so I confined my working hours to daylight. The average snowfall was probably only about 18 inches, but the wind made it much deeper in places.

On Monday, August 18, the locals opened the road to the telescopes, but there was no hope of getting through the 30-km, snow-covered dirt road down off the mountain. The electricity supply from the national grid failed, but luckily they still have their old diesel generators, so we still had power. This was fortunate because the heat in the lodge relies on the electricity supply. We lost the telephones and Internet connection as well, though the phones were restored after only a couple of days.

We learned from television news broadcasts that even if we could get down off the mountain, we still could not get home because the Pan American Highway was washed out in five different places between us and the offices at La Serena. It was one of the worst storms seen in this area, thousands of people were left homeless. In one place, a mudslide covered an entire building site.

I first saw the sun on Wednesday, August 20. The first people to get through from La Serena made it on Friday, August 22. Though passage was not guaranteed at that point. Even after I left on Monday, August 25, the Pan American Highway was still closed to traffic in one direction in the mornings and to traffic in the other direction in the afternoons. I left one day early just to be sure of making it back to La Serena before my flights.

At some point during the trip there were some minor tremors. Miguel Roth joked that the only thing that did not happen to us was a volcanic eruption. Since I left there has been a major earthquake in the La Serena area, though there still has not been any volcanic activity.

2 Shutter Control

The shutter-control section of the relay box is shown schematically in Figure 1 on the facing page. The shutter motor is controlled by three solid-state relays. SSR_4 controls power to the windings that drive the shutter up, SSR_5 controls power to the windings that drive the shutter down. SSR_6 controls the power to SSR_4 and SSR_5 and is normally closed. The circuit is designed so that SSR_6 will open if both the SHUTTER DOWN and SHUTTER UP lines are true at the same time. This hopefully prevents the motor from being driven in both directions at the same time.

In order to check the states of the solid-state relays, one first tries to measure the voltage on output pins 1. Assuming that SSR_6 is closed, one would naïvely expect to see 0 V on pin 1 of

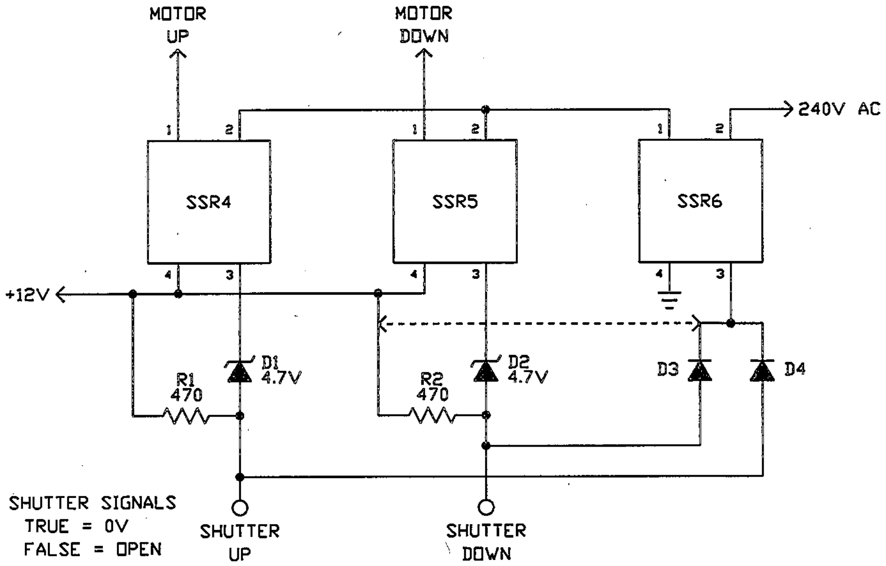

Figure 1: The shutter-control section of the relay box. I added the jumped indicated by the broken line to overcome the problem with the 4.7-V Zener diode, for which there was no spare.

SSR_4 when it is open and 240 V when it is closed. In fact, someone has already installed three 240-V, green, neon lights to pins 1 of SSR_4, SSR_5, and SSR_6. As it turns out, these lights are pretty much useless.

What you actually observe is this: If SSR_6 is open, there will be 0 V on all output pins. However, when SSR_6 is closed, things are a bit different. In this case there is always 240 V on pin 1 of SSR_6. If both SSR_4 and SSR_5 are open, both output pins will be at 0 V. However, if SSR_5 closes, the output of SSR_5 will be at 240 V while the output of SSR_4 will be 263 V. The situation is reversed if SSR_4 is closed instead of SSR_5. If all three solid-state relays are closed, all output pins are at 240 V. This last state is not supposed to happen, but it did.

This odd behaviour is actually not odd at all. The two output wires for MOTOR UP and MOTOR DOWN are not independent. They both connect to windings inside the shutter motor and so it is not unexpected to find an induced voltage in one winding when power is applied to the other. This means that the green lights installed on the output pins of the solid-state relays do not give an accurate picture of what is happening. Because I felt they were not very useful, and because I had suspected they may be the cause of the problems, I removed them from the circuit completely. It turns out that they were not the cause of the problem.

The symptoms I first observed were as follows. With the relay box set to automatic and with both SHUTTER DOWN and SHUTTER UP signals at false, the shutter would drive up. Setting SHUTTER DOWN to true caused the motor to stall and hum. It also caused the lights in the dome to dim. Clearly, both the up and down windings in the motor were being powered at the same time. If allowed to remain in this condition, the motor would eventually trip out the thermal cutout. The problem was that SSR_4 was always closed. I replaced SSR_4.

However, SSR_4 was only part of the problem. Now the new symptoms were as follows. With both SHUTTER DOWN and SHUTTER UP signals at false, neither shutter motor was powered. Setting SHUTTER UP to true would drive the shutter up, however setting SHUTTER DOWN to true would drive the motor in both directions. I traced this problem to diode D_1 on the input of SSR_4 — it was short circuit.

Why did this cause a problem? The answer is not obvious from a first look at the circuit drawing. We need to understand why D_1 and D_2 are required. Assume for the moment that both D_1 and D_2 are short circuit. The two pull-up resistors R_1 and R_2 are meant to keep pins 3 of SSR_4 and SSR_5 at +12 V when the inputs are open circuit. However, the two inputs are connected through SSR_6 to ground, thus pins 3 of SSR_4 and SSR_5 are not at +12 V but are instead slightly lower. They are normally at a voltage that is just above the threshold at which the solid-state relays close, so everything is ok. Now when one of the two inputs is grounded, the corresponding relay closes. However, now only half the original current flows through the input side of SSR_6 so the voltage at pin 3 of SSR_6 goes down slightly. This causes the voltage on the relay side of the pull-up resistors on the other solid-state relay to go down slightly too. It falls to just below the relay threshold and the other relay closes too. The 4.7-V Zener diodes ensure that the voltage on pin 3 stays above the threshold for the relay.

Although I identified the bad diode, I was unable to find a replacement. There were no Zener diodes of any value in both our dome and in the Las Campanas electronics workshop. As a temporary fix, I replaced D_1 with a short circuit and added a jumper as shown in Figure 1. This holds pin 3 of SSR_6 at +12 V all of the time thus keeping SSR_6 permanently closed. It also prevents any voltage drop across R_1 and R_2 and this keeps SSR_4 and SSR_5 open when the corresponding inputs are open circuit.

The drawback to this solution is that we no longer have protection against trying to drive the motor both ways at the same time. However, in all of our years of operation, the dome-control modules have never tried to drive the motors both ways at the same time. This has to do with the design of the dome-control modules and is not software dependent. The software can not drive the motors both ways even it wanted to.

3 Weather Module

I found much damage to the weather module. It appears that there may have been a lightning strike on the dome itself. We have a lightning-protection box installed on the incoming power line, but there is no protection against a direct strike.

We now believe that a lightning strike on or near the dome induced a large voltage spike on the rain detector. The pulse traveled into the dome and arrived at the weather module where the most damage was done. The weather module has control over the shutter signals sent to the shutter-control section of the relay box. It looks like the spike traveled through these lines into interface module #3 where three traces were vaporized. Then it traveled from there to the relay box where a 4.7-V Zener diode and SSR_4 were damaged (See Section 2 on page 2).

Within the weather module itself, chips #1 and #2, 4069 hex inverters, were not working; chip #4, a 4073 dual three-input AND gate, was not working; a VN10LM transistor on the shutter-control lines had split in half; the reed relay, also on the shutter-control lines, was stuck in the open position; and two traces on the PCB that carry shutter-control signals were vaporized. There were no spare reed relays, so I removed it from the circuit. The relay is normally supposed to be closed, connecting the shutter-control signals to the relay box. It is held closed by the 5-V power-supply line. If the 5-V power supply is lost, the relay opens grounding the shutter-control line causing the shutter to drive down.

I had one other problem with the weather module, and it had to do with the cloud detector. The photodiode is connected to the front panel through a pair of 2-mm banana plugs. One of them is connected to ground, the other used to be connected to the cloud-detector circuits added to the weather module. I found that this connection had been broken. Now, the photodiode signal from the front panel connects directly to pin z14 on the back of the module. Pin z16 on the back of the module connects to the cloud-detector circuits. I also found two new wire-wrap connection on the main-crate backplane:

$$\mathrm{XZz14} \longleftrightarrow \mathrm{WAb28}$$
$$\mathrm{XZz16} \longleftrightarrow \mathrm{WAb27}$$

where XZ is the weather module and WA is the stellar autoguider. The automated stellar photometer (ASP) needs access to the cloud detector circuit because it needs to open the dome at night, a time when the cloud detector is sure to be tripped.

The problem that I found was that the ASP control box was holding the dome closed even when the cloud detector was not tripped. Turning the box on and then off again seemed to fix things. There are no circuit drawings for the ASP control box in Las Campanas, but Peter Monks's Thesis [1] will be available shortly.

4 Other Damaged Electronics

There was more damage to be found in the rest of the system. Chips #5 in both stepper-motor drivers were not working. They are listed as 4069 hex inverters, however HEF 40106 chips were installed instead. There were no spare 40106s in the dome, so I used 4069s. Both VN10LM output transistors in the dome-control module were blown. They were replaced with spare transistors found in the dome. Chip #11, a 74 HCT 191 dual four-bit counter, in the gate module was not working. *There were no spares!* Luckily I was able to find two of them on an old gate module in the dome.

The white, euro-style terminal block on the RA stepper-motor assembly had disintegrated. This terminal block contains the connections for the stepper motor and associated limit switches. There were no spare terminal blocks in the dome, however Hernan Solis was able to give me a replacement black terminal barrier strip. In the past we have found that color is important to plastic cable ties: Black ones are UV resistant while white ones become brittle and crumble after exposure to sunlight.

5 Water Circulator

There was a problem with the water circulator control electronics. The heating element was on all of the time. I removed the control board, found a problem, fixed it, replaced the board, and discovered that it still did not work. I have removed the board and disconnected the heater. The board has been brought back to Birmingham where it will be repaired and returned to Las Campanas.

The compressor in the water circulator has long since failed. On a previous (unreported) trip it was disconnected from the control electronics. All that remained was the pump and the heater. Now the thermostatic control over the heater has been lost so we are left with just the pump.

6 UPS

The UPS has also failed. The was originally reported by Peter Monks [2]. Richard Lines later tried to fix it on an (unreported) trip, but decided it was beyond hope. I removed the broken PCB on this visit in the hope that we might return it to the manufacturer for repair only to discover that the damage was more extensive that had been originally suspected. There really is no hope of getting this unit working again.

7 Computer

Hernan Solis informed me before my visit that he was having problems with the floppy disk drive. I brought a new one with me and installed it in the computer.

I also brought with me an Ethernet card and installed that in the computer too. I changed its I/O address from `0x300` to `0x320` to avoid a conflict with the DIO card.

There is a fiber-optic cable coming into our dome, but nothing has been connected to the end of it yet. They have also not attached the far end of the cable to anything yet either. We hope to have a full Internet connection inside the dome in the next few months.

8 Dome Encoder Calibration

Hernan Solis removed the shutter encoder and installed the spare when he could not get the shutter to behave correctly. I put the old encoder back in the system and found that nothing was wrong with it. The misbehaviour of the shutter can be explained by the problems described in Sections 2 and 3.

Table 1: Shutter Calibration Constants

	ratio	*offset*
Old values	−620	995
New values	−574.842	1000

I centered the encoder and calibrated it using the method described elsewhere [3]. The changes to the calibration constants is shown in Table 1.

In addition, I changed the azimuth encoder offset from 522 to 512 and then moved the encoder body to reposition the dome. This centers the dome encoder.

9 Software

I made many changes to the software on this trip. Firstly, I added all of the Internet-support code and programs that are currently in use at Mount Wilson, Sutherland, and Narrabri. The computer is not yet connected to the Internet, but we expect a full Internet connection to be present in the dome within a few months. The Ethernet card is already configured and installed in the computer. It would have been nice to get things ready so that all the local people have to do is plug us in. However, they were not able to assign us an Internet address while I was there, so a few minor changes will have to be made to the software before things are running. It is possible to have these changes made without the need for a visit.

Secondly, QSOOSY was having some difficulty with running out of memory. I removed all of the modem-support code from QSOOSY and things seemed to work well. There is no modem in Las Campanas. A telephone has been placed in the dome, but it is not yet connected to anything.

Thirdly, I changed all of the code relating to multiple instruments. In 1994 when Chris Underhill and Peter Monks travelled to Las Campanas to install Ivan and the ASP [4], Chris added some code to handle these extra devices. At roughly the same time I developed similar code in Carnarvon to handle Jabba concurrently with Mark V. Our philosophies were completely different. The one major drawback, in my opinion, in the code that Chris wrote was that it changed the system clock each day in order to trick the compacting routine into doing the right thing. The system clock was later reset using the GPS time service. I thought this was a bad idea and completely replaced Chris's code with my own.

There may still be a problem with running out of memory in Las Campanas. On the morning that I left, the computer crashed with a hard-disk write error. I rebooted the computer and all was well. I left the mountain but before I could even leave the country I had received word that the computer was stuck again. Eventually, Hernan, Emilio, and Patricio were able to get it working again. The solution seemed to be to repeatedly turn the computer off and on again until it comes up in a good state. Sometimes it comes up in a bad state and the behaviour is random. Sometimes it comes up in a good state and all works well — until the next power failure.

Because of the hard-disk write error that I observed before leaving the mountain, I at first assumed that the problem was a bad hard disk. While this still may be the case, it is also possible that there are problems with insufficient memory. Or perhaps there is a problem on the motherboard of the computer itself. It may be as simple as a loose adaptor card.

10 Temperatures

There are sixteen temperatures measured and logged by the system. They are shown in Table 2 on the next page.

11 Things Needed

Some of the things that could be taken to the station on the next visit are shown in Table 3 on page 10.

12 Flooded 4.2-kV Junction Box

As my trip drew to a close, the weather began to improve. As the temperature came up, the snow started to melt. Some of this water found its way into the conduit containing the power-distribution line between our dome and the Japanese radio telescope. That section of conduit is higher than our dome and the water ran down the conduit into our junction box.

The power for the mountain used to be generated at the power house — a building about half way between the lodge and the 100-inch dome. Las Campanas is now connected to the national grid. The old generator room now houses the new motor/generator. Chile is nationally supplied with 50-Hz power just like the United Kingdom. However, Las Campanas used to generate power at 60 Hz because all of their equipment is imported from the United States. To convert 50-Hz power to 60-Hz power, the observatory employs a motor/generator. A very large, AC synchronous motor is connected the national grid. This is connected mechanically to very large AC generator that supplies power to the whole observatory.

Power is distributed as three 4.2-kV phases along several spur lines from the power house. One line runs from the power house to the lodge, then to our dome, and finally to the Japanese radio telescope beyond us. That line is composed of three high-voltage conductors surrounded by a grounded shield. There is a junction box about eight meters from our dome. In this box, one of the three 4.2-kV phases is split off and, along with a wire to the grounding shield, is connected to our 4.2-kV-to-240-V step-down transformer that housed in a metal box above ground about one meter from the junction box.

Table 2: Temperature Read-Out System

Channel	*QSOOSY.BI Symbol*	*Chris's New* Symbol*	*Keithley Channel*	*Display Abbrev.*	*Scale*†
0	AMBTEMP		1	Am	10
1	IFTEMP		0	IF	10
2	OVENTEMP		2	OB	5
3	SPECTEMP		12	Sp	10
4	TOPTEMP		15	OT	5
5	STARTEMP		16	SD	10
6	PORTTEMP		17	PD	10
7	AMB2TEMP		18	A2	10
8	DECDLIM	NAIFTEMP	22	IF2	11
9	DECULIM	NAOVENTEMP	21	OT2	5.6
10	HALLIM	NASTARTEMP	19	SD2	11
11	HARLIM	NAPORTTEMP	20	PD2	11
12	AZLOCK	PHDETTEMP	26	PHD	56.61168
13	ALTLOCK	PHBRIDGE	27	PHB	100
14	ALLIM	H2OTEMP	28	H2O	5.65
15	AZRLIM	TBA	29	TBA	100

*These new symbols were added to `QSOOSY.BI` by Chris Underhill to describe the temperature-monitoring channels. The names that Chris chose are pretty good descriptions of what the channels actually monitor. Symbols beginning with NA- refer to Ivan, which used to contain a sodium cell; symbols beginning with PH- refer to the ASP.

†The Keithley readings are converted first into a voltage and then into a temperature. A scale of 10 mV/°C is assumed for all sensors for historical reasons. `THERMO.BAS` allows each channel to be assigned a calibration correction constant. Each temperature is divided by this correction constant. My temperatures module for Spectrometer H supplied temperature signals at 100 mV/°C for all except the oven channels, which were 50 mV/°C. This corresponds to correction constants of 10 and 5 respectively. Richard Lines temperature controllers output temperature signals with similar gains, but there is an additional effect of 10% because of the output-impedance of the controllers. Hence the corresponding correction constants are 11 and 5.6. Chris has made some fine adjustments to these constants.

As the snow melted, our junction box filled with water and the exposed 4.2-kV connections became submerged. As current flowed, the water began to heat up and eventually started to boil. It boiled rather vigorously. Steam rose into the transformer enclosure and a strange, sickly sweet odor not uncharacteristic of PVC travelled up through the conduit into the dome. When I walked outside, I thought the transformer was on fire. Luckily it was just steam pouring out of the box, not smoke.

The power was turned off and the box drained. The next afternoon the box flooded again. We repeated the draining operation and this time poked holes in the junction box. The holes allow the water running down the conduit from the Japanese radio telescope to drain. This is not an ideal solution. The conduit and the junction box are sealed and are meant to be water tight. Poking holes in a water tight box should never be considered a permanent solution. I was

Table 3: Thing to Take to Las Campanas

Small Adjustable Wrench	
2.5-mm Drill Bit	
15-pin D-Connectors	
240-V, 60-W, Edison-Thread Light Bulbs	
4.7-V Zener Diodes	
Terminal blocks	
AMP 01 FX	Autoguider
VN 10 LM	Transistor
TO 99	Autoguider
AD 642 JH	Autoguider
AD 647 KH	Autoguider
LM 2917	Frequency Counter (IN 2917)
4069	Hex inverter
4070	Dome-control module
4073	Dual three-input AND gate
HEF 4077	XNOR gate
4098	Stepper controller
HEF 40106	Hex inverter
4510	Scaler
MCI 4534	Scaler chip (we have two)
74 HCT 08	two-input AND gate
74 HC 74	dual D-type flip flop
74 HCT 191	dual four-bit counter
74 HCT 4002	four-input NOR gate
7505	Dome-control module
ICL 7530	Dome-control module
7805	Mount-encoder module
RS 301-858	PXO-600 crystal oscillator
RS 349-355	Reed relay for weather module

promised that on the next shift, the electrician would come up and fix things.

I do not know if that was done. However on 1997 September 25 lightning struck the 4.2-kV supply line melting our step-down transformer. We have been without power since then.

References

[1] Peter D. Monks. *Development of a Photoelectric Photometer and the Study of Stellar Oscillations.* PhD thesis, University of Birmingham, 1996.

[2] Brek Miller. Various trips to stations in 1995. *BISON Technical Report Series,* Number 48, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, April 1996.

[3] Brek A. Miller. A description of the automated solar-observatory encoder system. *BISON Technical Report Series,* Number 60, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, November 1997.

[4] Pete D. Monks, Chris J. Underhill, and George R. Isaak. Two trips to Las Campanas to install a second spectrometer and an automated photometer: 1994 November 12 to December 13 and 1995 March 7 to March 23. *BISON Technical Report Series,* Number 40, High-Resolution Optical-Spectroscopy Group, Birmingham, United Kingdom, June 1995.