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Subject: Whircam testing

Below are the results of a series of tests performed on whircam to try and derive a cause for the charring of constantine wires in the clock harness in the detector housing.

These tests were based on the assumed ohmic heating of all or some of the 18 conductors sufficient to cause complete loss of the enamel insulation and charring (through evaporation) of the silk protection thread.

The tests were carried out in an attempt to discover the source of the current by creating fault scenarios and then trying to eliminate these possible causes.

1.0 Starting with the known, final conditions we have:
1.1 Whircam failed when it was noticed that the images in movie mode where no longer produced. No whircam error was reported by the system; cooling, electronics, software were all shown as normal.
1.2. At the time of the failure, the telescope was low on the horizon and was in the process of instrument rotation limits testing. After the failure the telescope was moved to zenith.
1.3 The instrument was left in normal mode for a period of at least 4 hours after the fault occurred, at which time the detector temperature had risen from nominally 30K to 114K and the cold shield from 70K to 85K. At this point the instrument was shutdown normally.
1.4 After dismounting whircam and during subsequent inspection it was found that the constantine portion of the 18 conductors in the array clocks cable leading from the optical table thrust plate to the detector array pcb where charred black. These wires did not appear to be shorted to either the detector housing or to each other.
1.5 Two bond wires on the InSb array where also found to be lifted from their bond pads (Fast phase 1 clock and fast sync). They did not show the normal ball ends that occur from fusing through over current.
1.6 It was observed that the clearance hole in the optical table was small enough to allow the second stage cold finger too touch the optical table.

Suppositions that can reasonably be derived from conditions 1.3 and 1.4. are:
1.7 That the fault is persistent
1.8 That the damage caused by heating in the array clocks cable was the cause for the elevated temperatures observed before shutdown.

2.0. Electronic Testing
2.1. Conclusions
Without considering influences external to whircam, the only sources of current that could be dissipated through the array clock cable are from the clock drives themselves, the bias supplies, or the preamp sub assy. All of these have been tested and found functional.

Considering influences external to whircam, the possibility of causing a potential difference between the cryostat and electrical ground exists, however, the path of any current delivered would not include the array clock cable. It would flow in the low impedance paths of the cable shields.

No cause of the damage observed to the array clock cable can be found at this stage.

We await the report from SBRC detailing the condition of the array before attempting any further analysis.

2.2 Testing

2.2.1 Fault Scenario 1

That the cold finger did touch the optical table causing a current to flow, from a difference in potential of the cryostat with respect to the alice clock ground, through the cold finger to the array to the array pcb and to the alice controller clock board ground.

2.2.2 Modifications to the ground wiring that tie the alice / whircam cable shields together at the preamp box assure that there can be no difference of potential between cryostat and alice.

2.2.3 Although it is likely that the cold finger touched the optical table due to the displacer sagging at the telescope altitude when the fault occurred, and this would lead to the array warming up, this condition would not have persisted when that telescope was driven to zenith. This would have removed the heat load and so cannot explain the elevated temperatures found at shutdown.

2.2.4 Fault Scenario 2

That one or several clock drivers in the alice controller failed causing, at worst case, +15v DC drive to the array. This potential would lead to a current flow from the alice clock driver, through a 91 ohm resistor, through the (approx) 1 ohm constantine portion of the clock cable, on to the array pcb, through a zener diode, back through the constantine ground return, to the power supply ground of the clock driver board.

2.2.5 The max current to flow in this scenario is 170 ma which would have caused over 2.5 watts to be dissipated in the 91 ohm resistor. This would have caused destruction of this resistor which is not the case.

2.2.6 The clock drives where checked and verified to be their correct values.

2.2.7 Fault Scenario 3

That one or more of the bias supplies to the array became, at worst case, +15v thus forward biasing the protection zener on the array pcb and feeding current to the clock ground via the clock cable ground portion of the array clocks cable. (this is possible via the modificati on to the grounding scheme)

2.2.8 The bias supplies pass through a low pass filter on the array pcb which requires that the 170 ma current would pass through a 100 ohm resistor, thus distroying this. This was not apparent.

2.2.9 The ground return conducters in the array clocks cable are in parallel so the load would be shared by 9 separate conducters thus minimizing any ohmic heating.

2.2.10 The bias voltages were checked with the alice controller functioning and found to be at their correct values.

2.2.11 Fault Scenario 4

That the normal dynamic load on the clock drivers creates ohmic heating in the constantine portion of the array clocks cable which cannot be thermally dissipated via conduction to the array pcb. This would lead to a temperature rise of sufficient degree over time to cause degradation of the wire insulation enamel and silk.

2.2.12 A numerical analysis was done to determine if a short circuit current of 170ma (worst case clock driver failure) could damage the wire. It was found that for a simple model of pure thermal conduction through a 5cm length of constantine wire a temperature rise of 614K can be achieved in 4 hours, sufficient to cause the observed damage. This is a dissipation of approx 30mw which puts this finding is in some conflic t with the dissipation measured in the next paragraph.

2.2.13 A destructive test was carried out on a representative portion of constantine wire to determine the temperature and dissipation required to cause the degree of damage observed. The temperature reached was approx 570K to achieve charring in free air and approx 300 mw in vacuum for the beginning of degradation to occur. The normal dissipation was calculated for a 0.5 sec movie mode readout and found to be approx 7nw considering 100pf pmos gate capacitance which is magnitudes short of the required value (this value should be checked !).

To the best of our knowledge all auxillary circuits (temp monitoring, displacer drive electronics, filter wheel drives, etc) have been tested for galvanic isolation from the array electronics.


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