# Spectrometer Calibrator (SCAL)

# Interface Control Document

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# Update history

| Date | Version | Remarks |
|---|---|---|
| 7/9/01 | 1.0 | First issue for DDR |
| 6/02/02 | 2.0 | Issue for IBDR. |
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# List of Acronyms

| Term | Meaning | Term | Meaning |
|---|---|---|---|
| AD | Applicable Document | IR | Infrared |
| ADC | Analogue to Digital Converter | IRD | Instrument Requirements Document |
| AIV | Assembly, Integration and Verification | IRTS | Infrared Telescope in Space |
| AME | Absolute Measurement Error | ISM | Interstellar Medium |
| AOCS | Attitude and Orbit Control System | JFET | Junction Field Effect Transistor |
| APART | Arizona's Program for the Analysis of Radiation Transfer | ISO | Infrared Space Observatory |
| APE | Absolute Pointing Error | LCL | Latching Current Limiter |
| ASAP | Advanced Systems Analysis Program | LIA | Lock-In Amplifier |
| ATC | Astronomy Technology Centre, Edinburgh | LVDT | Linear Variable Differential Transformer |
| AVM | Avionics Model | LWS | Long Wave Spectrometer (an instrument used on ISO) |
| BDA | Bolometer Detector Array | MAC | Multi Axis Controller |
| BFL | Back Focal Length | MAIV | Manufacturing, Assembly, Integration and Verification |
| BRO | Breault Research Organization | MCU | Mechanism Control Unit = HSMCU |
| BSM | Beam Steering Mirror | MGSE | Mechanical Ground Support Equipment |
| CBB | Cryogenic Black Body | M-P | Martin-Puplett |
| CDF | Cardiff, Department of Physics & Astronomy | NEP | Noise Equivalent Power |
| CDMS | Command and Data Management System | NTD | Neutron Transmutation Doped |
| CDMU | Command and Data Management Unit | OBS | On-Board Software |
| CDR | Critical Design Review | OGSE | Optical Ground Support Equipment |
| CEA | Commissariat a l'Energie Atomique | OMD | Observing Modes Document |
| CMOS | Complimentary Metal Oxide Silicon | OPD | Optical Path Difference |
| CoG | Centre of Gravity | PACS | Photodetector Array Camera and Spectrometer |
| CPU | Central Processing Unit | PCAL | Photometer Calibration source |
| CQM | Cryogenic Qualification Model | PFM | Proto-Flight Model |
| CVV | Cryostat Vacuum Vessel | PID | Proportional, Integral and Differential (used in the context of feedback control loop architecture) |
| DAC | Digital to Analogue Converter | PLW | Photometer, Long Wavelength |
| DAQ | Data Acquisition | PMW | Photometer, Medium Wavelength |
| DCU | Detector Control Unit = HSDCU | POF | Photometer Observatory Function |
| DDR | Detailed Design Review | PROM | Programmable Read Only Memory |
| DM | Development Model | PSW | Photometer, Short Wavelength |
| DPU | Digital Processing Unit = HSDPU | PUS | Packet Utilisation Standard |
| DSP | Digital Signal Processor | RAL | Rutherford Appleton Laboratory, |
| DQE | Detective Quantum Efficiency | RD | Reference Document |
| EDAC | Error Detection and Correction | RMS | Root Mean Squared |
| EGSE | Electrical Ground Support Equipment | SCAL | Spectrometer Calibration Source |
| EM | Engineering Model | SCUBA | Submillimetre Common User Bolometer Array |
| EMC | Electro-magnetic Compatibility | SED | Spectral Energy Distribution |
| EMI | Electro-magnetic Interference | SMEC | Spectrometer Mechanics |
| ESA | European Space Agency | SMPS | Switch Mode Power Supply |
| FCU | FCU Control Unit = HSFCU | SOB | SPIRE Optical Bench |
| FIR | Far Infrared | SOF | Spectrometer Observatory Function |
| FIRST | Far Infra-Red and Submillimetre Telescope | SPIRE | Spectral and Photometric Imaging Receiver |
| FOV | Field of View | SRAM | Static Random Access Memory |
| F-P | Fabry-Perot | SSSD | SubSystem Specification Document |
| FPGA | Field Programmable Gate Array | STP | Standard Temperature and Pressure |
| FPU | Focal Plane Unit | SVM | Service Module |
| FS | Flight Spare | TBC | To Be Confirmed |
| FTS | Fourier Transform Spectrometer | TBD | To Be Determined |
| FWHM | Full Width Half maximum | TC | Telecommand |
| GSFC | Goddard Space Flight Center | URD | User Requirements Document |
| HK | House Keeping | UV | Ultra Violet |
| HOB | Herschel Optical Bench | WE | Warm Electronics |
| HPDU | Herschel Power Distribution Unit | ZPD | Zero Path Difference |
| HSDCU | Herschel-SPIRE Detector Control Unit | | |
| HSDPU | Herschel-SPIRE Digital Processing Unit | | |
| HSFCU | Herschel-SPIRE FPU Control Unit | | |
| HSO | Herschel Space Observatory | | |
| IF | Interface | | |
| IID-A | Instrument Interface Document - Part A | | |
| IID-B | Instrument Interface Document - Part B | | |
| IMF | Initial Mass Function | | |

# Table of Contents

# 1. Scope

The purpose of this document is to define the interfaces between the spectrometer calibrator (SCAL) and SPIRE.
The intention of this document is to present all interface information available at a given release date and will be updated as and when changes to the design are made under configuration control.

# 2. Documents

## 2.1. Applicable documents

All applicable documents are listed in the AD chapter of the CIDL (HSO-CDF-LI-029).

# 3. Mechanical Interface

The SCAL assembly will bolt directly to a baffle, provided by MSSL, which also houses SM8B (see Figure 1, Figure 2 and Figure 3). To ensure adequate heat sinking, provision will be made for the attachment of a thermal strap.

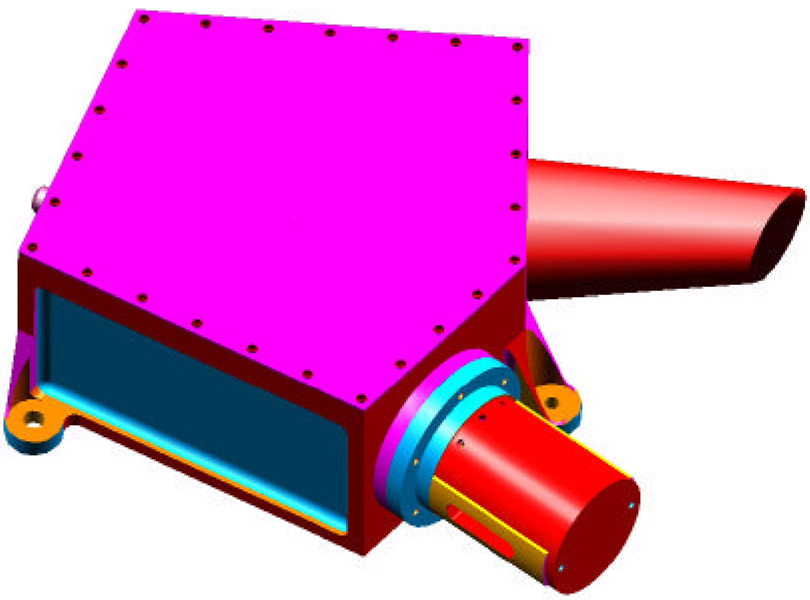

**Figure 1** Isometric view of SCAL interface to baffle.

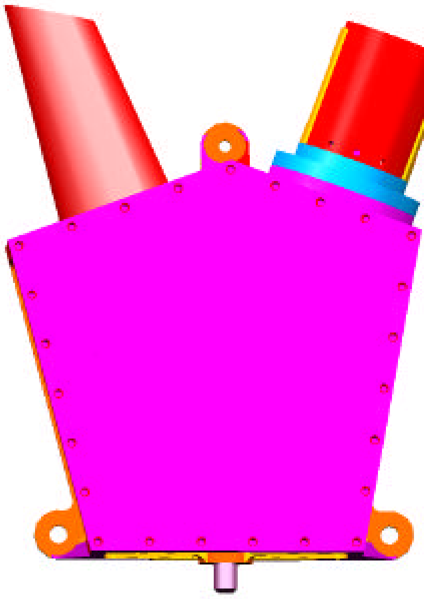

**Figure 2** Plan view of SCAL and baffle.

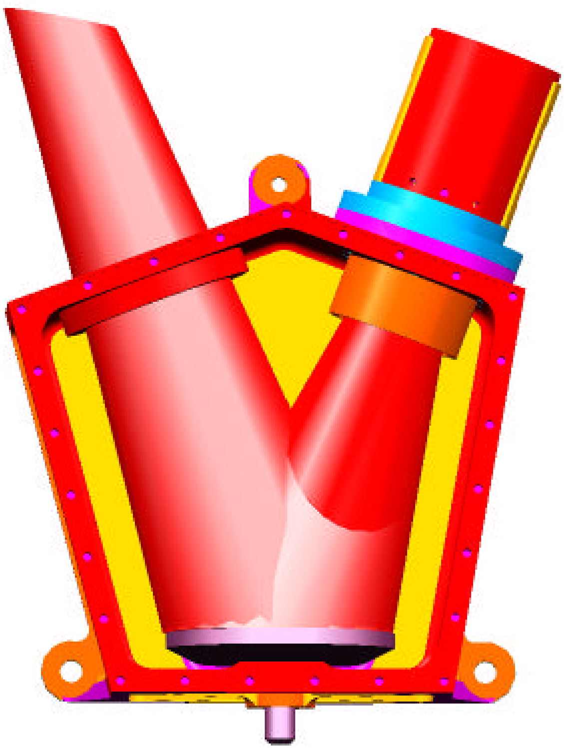

**Figure 3** Plan view of SCAL and baffle. Top cover has been removed to show SM8B and beams.

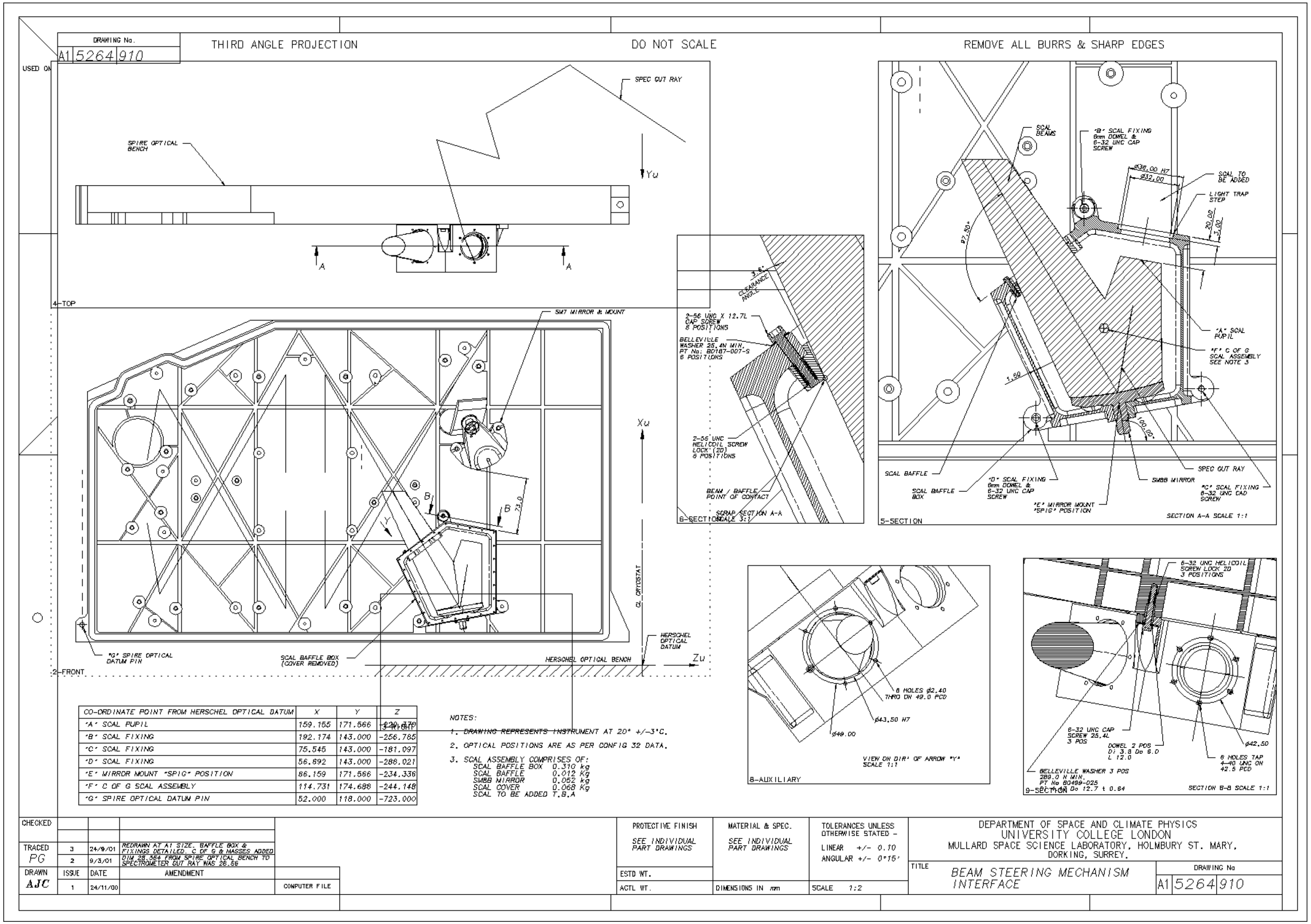


Figure 4 SCAL-structure interface drawing

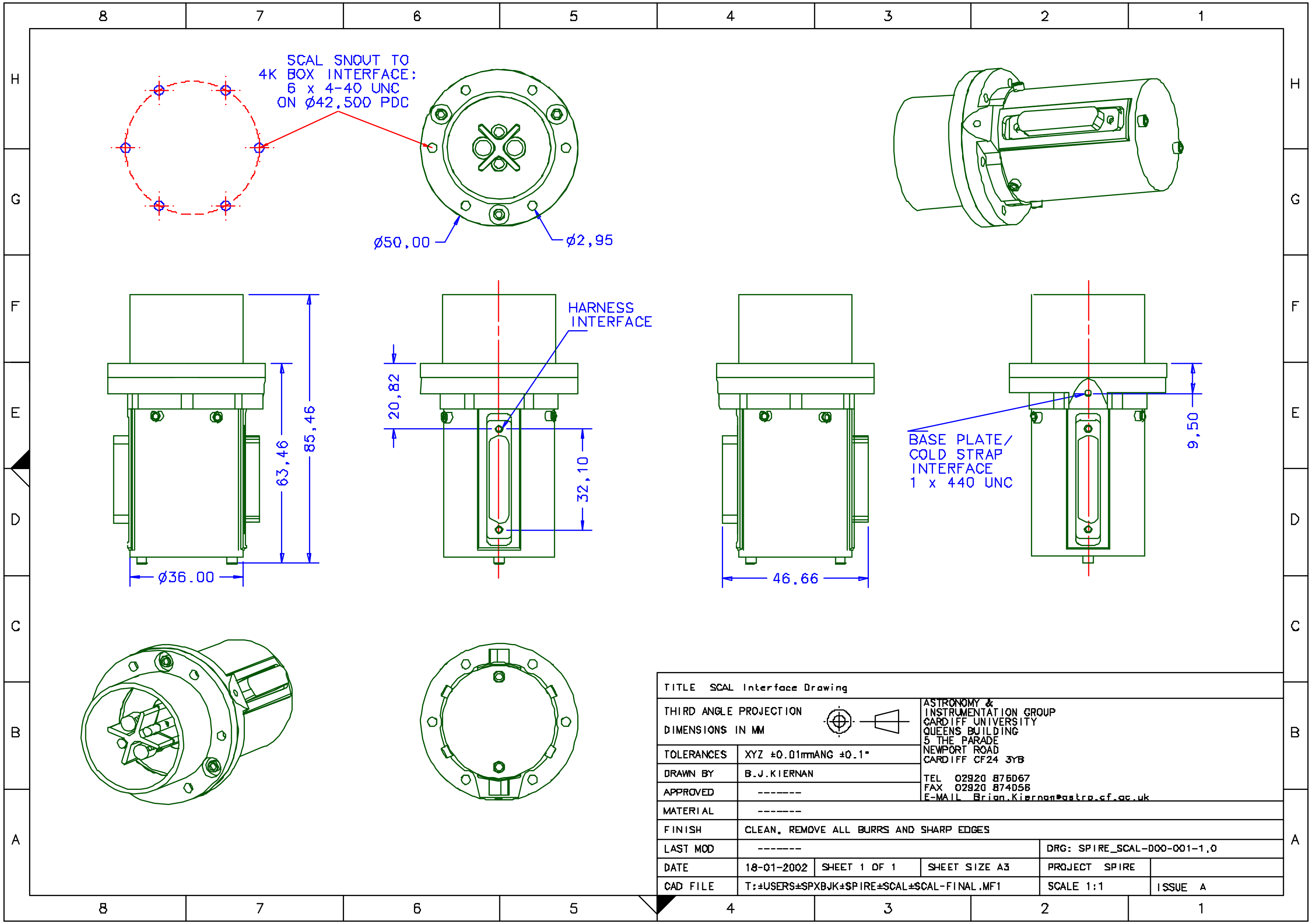


Figure 5 SCAL interface drawing

### 3.1. Mass

The current mass estimate for the entire SCAL assembly is 126.2 g.

### 3.2. Centre of Gravity

### 3.3. Resonance

A full mechanical analysis is in progress.

# 4. Thermal Interface

There is no direct thermal interface between SCAL and the SPIRE optical bench, as SCAL is mounted off the SCAL/SM8 baffle. In the unlikely event that heat sinking through the baffle to the SOB proves insufficient, provision is made for a thermal strap from the SCAL baseplate directly to the SOB. A thermometer on the SCAL baseplate will monitor the temperature of the SCAL interface.
The SCAL interface surface will be aluminium alloy, grade 6061, coated with electroless nickel (nominally 10 microns) and gold (nominally 5 microns). The interface surface provides a precision central hole and six mounting holes, tapped 4-40 UNC, with locking inserts.

### 4.1. Contact force

### 4.2. Surface Area

# 5. Optical Interface

The SCAL sources are placed at a pupil at the second input port to the FTS. The SCAL_A and SCAL_B sources fill 4% and 2% respectively of the pupil area, and are coated with a high (99%) emissivity finish. The rest of the pupil area is at the temperature of the SPIRE optical bench (SOB), and coated with the same high emissivity finish.

# 6. Electrical Interface

### 6.1. Heater Impedance

The nominal impedance of all SCAL source heaters is 500 Ω.

### 6.2. Maximum Drive Current

Maximum power is specified as 5mW (goal - TBC), but we may want to run at higher power. Therefore we have allowed for a maximum power dissipation of 15mW. Assuming a 500 Ω heater resistor, this gives a required drive current of 5.5mA.

### 6.3. Adjustability of Drive Current

12-bit resolution (minimum) is required in the range 0 – 5.5mA. This will give a minimum of 2275 adjustment steps in the target operating range.

### 6.4. Required Maximum Drive Voltage

The required maximum drive voltage, assuming a 30 Ω harness impedance in each direction, is 3.08 V. The voltage drop across the heater in this situation will be 2.75 V.

### 6.5. Drive Current Stability

The required repeatability for calibrator radiant power is 1%.

The stability and repeatability of the drive current should be within 5µA or 0.5% of the drive current, whichever is the greater.

### 6.6. Power Supply Redundancy

Separate power supplies are required for each SCAL heater – 2 prime, 2 redundant. Completely independent circuits will drive the prime and redundant SCAL heaters.

### 6.7. Thermometer Details

The thermometers to be used in the heater bodies are Lakeshore Cernox 1030 sensors.

### 6.8. Requirements on Thermometry Accuracy

The warm electronics requirements for the SCAL thermometers are:

(1) Constant current drive

(2) Drive current in the range 10 – 30 µA. Currents above this range may cause unacceptable self-heating.

(3) 16-bit ADC resolution.

(4) Stability: 1% on drive current required, driving through resistances of (500+2000)Ω (2kΩ from two harness wires), up to ~35kΩ.

### 6.9. Connector Pin-Outs and Harness Definition

A schematic of the SCAL harness is shown in Figure 6. This harness, to be supplied by Cardiff with SCAL, is isothermal, and runs between SCAL and the RF filter box. All conductors will be made from copper, and the harness length and routing is to be defined by MSSL. The pin allocation for the MDM37 PSB connectors (prime and redundant) is illustrated by Figure 7, and wiring details of the SPIRE cryoharness, C10, are shown in Table 1 and Figure 6.

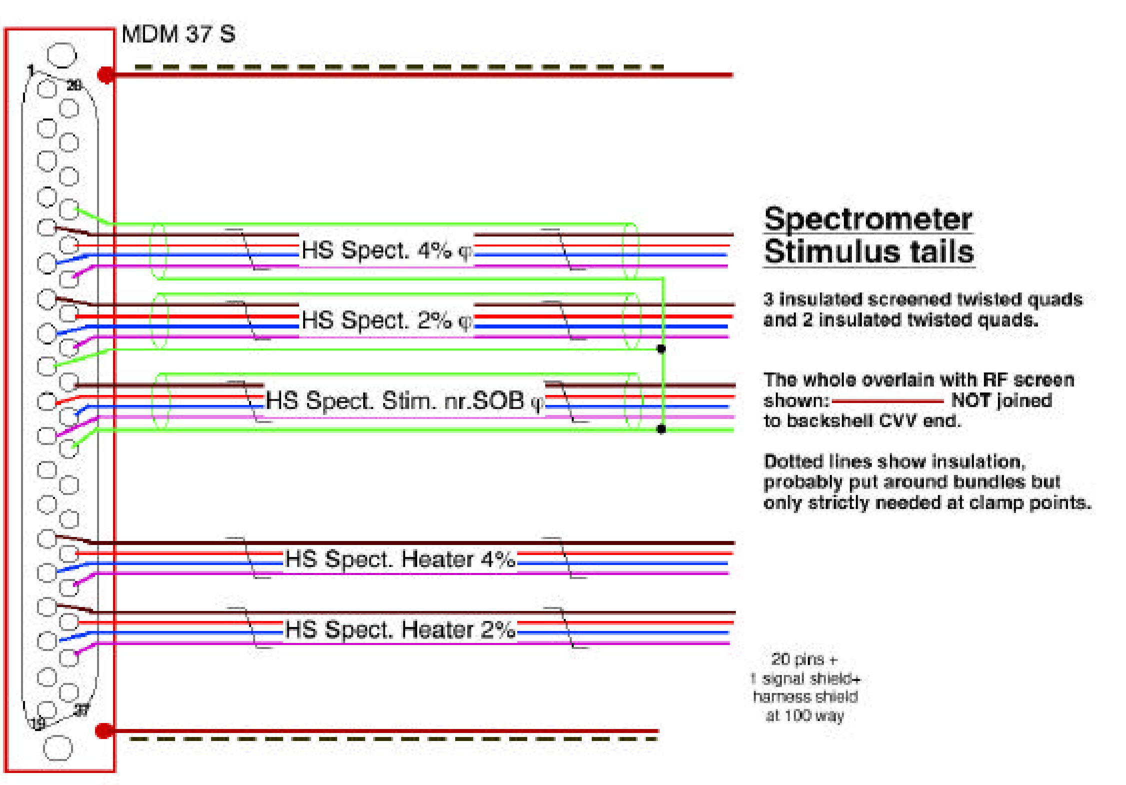


**Figure 6** Schematic of SCAL harness wiring scheme. The same scheme is used for prime and redundant harnesses.

**Table 1** Wiring details for SPIRE cryoharness, C10.

| **Function** | **37way J21** | **Max. current** | **Wire lay-up** | **Max Ohms** | **100way #10** |
|---|---|---|---|---|---|
| HS Spect. 4% temperature I+ **SCAL_A** | 5 | 1 µA | Insulated screened twisted quad | 1000 | |
| HS Spect. 4% temperature V+ | 6 | N/A | | 1000 | |
| HS Spect. 4% temperature V- | 24 | N/A | | 1000 | |
| HS Spect. 4% temperature I- | 25 | 1 µA | | 1000 | |
| HS Spect. 4% temperature shld* | 23 | N/A | | N/A | |
| HS Spect. 2% temperature I+ **SCAL_B** | 7 | 1 µA | Insulated screened twisted quad | 1000 | |
| HS Spect. 2% temperature V+ | 8 | N/A | | 1000 | |
| HS Spect. 2% temperature V- | 26 | N/A | | 1000 | |
| HS Spect. 2% temperature I- | 27 | 1 µA | | 1000 | |
| HS Spect. 2% temperature shld* | 9 | N/A | | N/A | |
| HS Spect. Stim near SOB temperature I+ | 10 | 1 µA | Insulated screened twisted quad | 1000 | |
| HS Spect. Stim near SOB temperature V+ | 11 | N/A | | 1000 | |
| HS Spect. Stim near SOB temperature V- | 28 | N/A | | 1000 | |
| HS Spect. Stim near SOB temperature I- | 29 | 1 µA | | 1000 | |
| HS Spect. Stim near SOB temperature shld* | 30 | N/A | | N/A | |
| HS Spect. 4% heater I+ **SCAL_A** | 14 | 9 mA | Twisted quad | 30 | |
| HS Spect. 4% heater V+ | 15 | 9 mA | | 30 | |
| HS Spect. 4% heater I- | 33 | 9 mA | | 30 | |
| HS Spect. 4% heater V- | 34 | 9 mA | | 30 | |
| HS Spect. 2% heater I+ **SCAL_B** | 16 | 7 mA | Twisted quad | 30 | |
| HS Spect. 2% heater V+ | 17 | 7 mA | | 30 | |
| HS Spect. 2% heater I- | 35 | 7 mA | | 30 | |
| HS Spect. 2% heater V- | 36 | 7 mA | | 30 | |

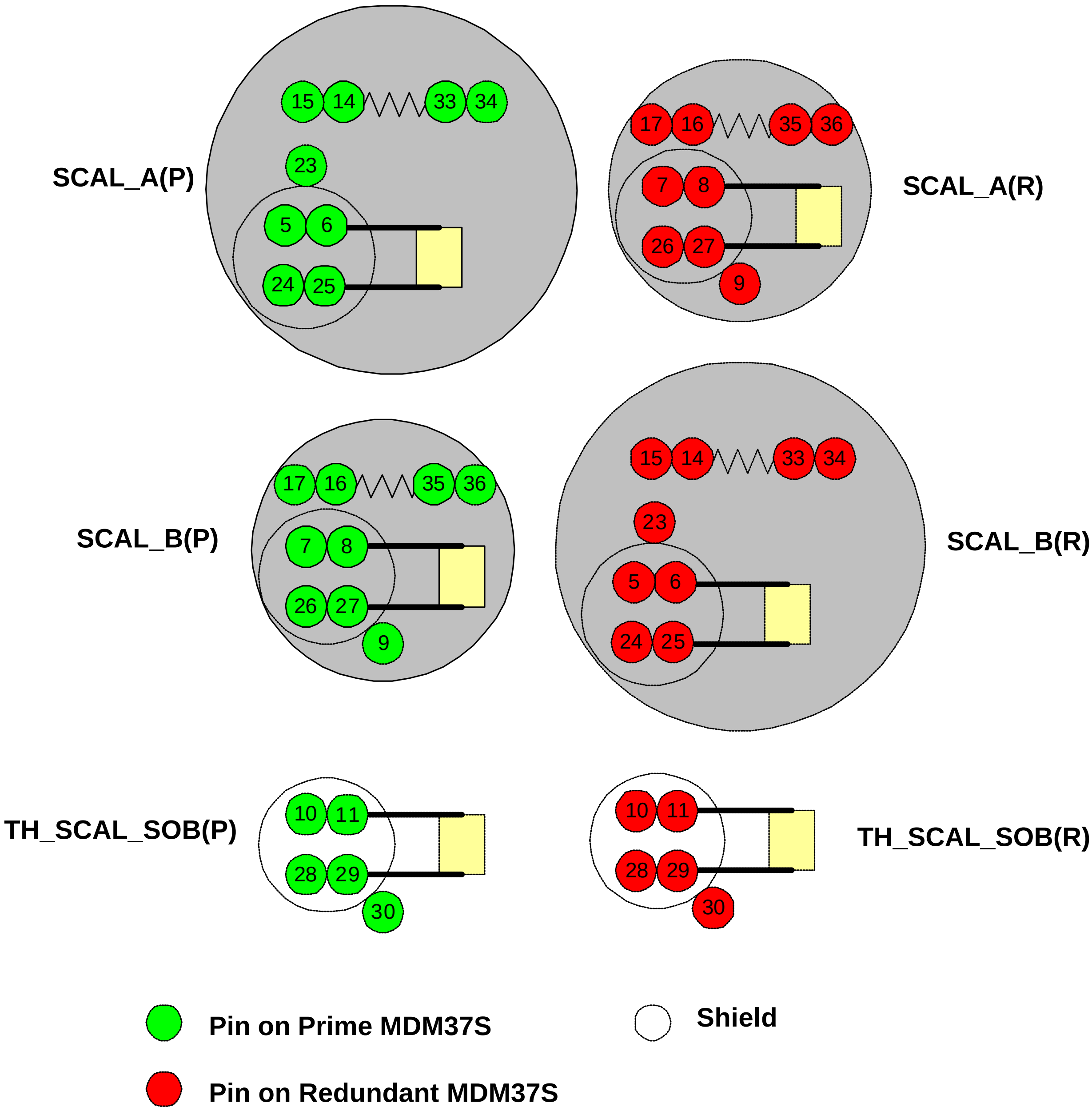


**Figure 7** Schematic of pin allocation on SCAL prime and redundant connectors

# 7. Data Interface

The following information applies to both prime and redundant sources.
SCAL has two heated sources, each with its own thermometer. These sources are labelled as SCAL_A and SCAL_B.
Normal operation of SCAL will involve the continuous application of a specified drive current for the duration of the "on" state to each of the heater sources. Each heater source may be run independently, or together at different commanded current levels.
Each source needs to be controlled via a feedback loop.

## *7.1. Commands*

| Command ID | IFSI Designation | Name | Description |
|---|---|---|---|
| SCAL_A1 | | SCAL_A on/off | Switches SCAL_A drive circuit on/off |
| SCAL_A2 | | SCAL_A current level | Sets SCAL_A current level |
| SCAL_A3 | | SCAL_A read | Reads thermometer on SCAL_A |
| SCAL_B1 | | SCAL_B on/off | Switches SCAL_B drive circuit on/off |
| SCAL_B2 | | SCAL_B current level | Sets SCAL_B current level |
| SCAL_B3 | | SCAL_B read | Reads thermometer on SCAL_B |
| SCAL_SOB1 | | SCAL_SOB read | Reads thermometer at SCAL interface. Note – this command may be incorporated in the general SPIRE housekeeping. |

## *7.2. PID parameters*

The time constants stated in this table are those predicted for heating the sources to ~50K for good matching of the nominal telescope spectrum (80 K, 4% emmisivity)

| | | |
|---|---|---|
| SCAL_A | Time constant (90% rise time) | 15 minutes (TBC) |
| | Current drive | 0-5.5mA with 12-bit resolution |
| | Thermometer readout | Cernox-1030 thermometer – calibration will be supplied |
| SCAL_B | Time constant (90% rise time) | 10 minutes (TBC) |
| | Current drive | 0-5.5mA with 12-bit resolution |
| | Thermometer readout | Cernox-1030 thermometer – calibration will be supplied |

It may be necessary to reduce the warm up time by applying a warm-up sequence with a higher peak current. This should be provided for by the use of an OBS script in the DPU.