Calibrators

Electrical Interface Requirements

For approval

Draft

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13th March 2001	1.0	Draft - Awaiting approval from SAp

Table of Contents

1. Scope

This document describes the electrical requirements for PCAL and SCAL, and defines the cryoharness requirements.

2. Documents

2.1. Applicable documents

	Title	Author	Reference	Date
AD1	Calibrators software interface requirements	P.Hargrave	SPIRE-QMW-PRJ-………	13/03/01

2.2. Reference documents

	Title	Author	Reference	Date

2.3. Glossary

PCAL	Photometer CALibrator		
SCAL	Spectrometer CALibrator		

3. Subsystem overview

3.1. Photometer Calibrator - PCAL

The purpose of the photometer calibrator is to provide a repeatable signal for monitoring of detector health and responsivity for ground testing and in-flight operation. It is NOT an absolute calibrator, but may be useful as part of the overall calibration scheme. The baseline design consists of a thermal source inside an integrating cavity, the body of which will be at 4K. The cavity will have a light pipe output with a 1-mm diameter aperture. The calibrator will be located behind the beam steering mirror (M4) at an image of the telescope secondary mirror. The fraction of M4 area obscured will be 0.2%. The limit on the calibrator aperture is set by the ratio of the telescope secondary to primary mirror diameters.

3.2. Spectrometer Calibrator - SCAL

The purpose of the spectrometer calibrator is to null the telescope emission by mimicking its spectrum and brightness in the second input port of the FTS. The telescope is assumed to be at 80-K with overall wavelength-independent emissivity $\varepsilon = 0.04$. The overall emissivity of the system is assumed to be uncertain by a factor of 2 (actual value will not be known before launch). The baseline design, shown in figure (1), is the use of a heated black plate, together with a "hot" source in an integrating cavity with light pipe, to uniformly illuminate the pupil. A neutral density filter may be used to dilute the emission. The calibrator will be located at the second input port to the FTS, at an image of the telescope pupil (diameter = 30 mm). Throughout this document, the heated plate will be referred to as SCAL-flood, and the "hot" PCAL type source shall be referred to as SCAL-point.

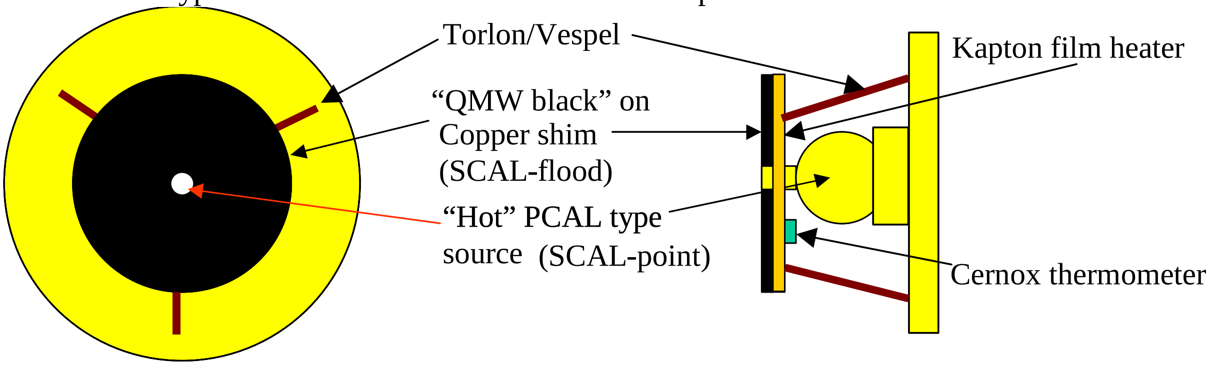

Figure 1 Schematic of spectrometer calibrator (SCAL)

4. Electrical requirements

These requirements have been derived assuming device impedances in the range 200Ω - 500Ω, and a harness impedance of 30Ω.
At the interface review (November 2000) it was agreed that current drive for PCAL and SCAL would be used.

4.1. Current drive

4.1.1. Maximum drive current

4.1.1.1. PCAL & SCAL point

Maximum power is specified as 2mW (goal), but we may want to run at higher power. Therefore we have allowed for a maximum power dissipation of 10mW. Allowing for the case of a 200Ω device, this gives a required drive current of 7mA.

4.1.1.2. SCAL flood

Maximum power is specified as 5mW (goal), but we may want to run at higher power. Therefore we have allowed for a maximum power dissipation of 15mW. Allowing for the case of a 200Ω device, this gives a required drive current of 9mA.

4.1.2. Adjustability of the drive current

4.1.2.1. PCAL & SCAL point

12-bit resolution (minimum) is required in the range 0 – 7mA. This will give a minimum of 1170 adjustment steps in the target operating range.

4.1.2.2. SCAL flood

12-bit resolution (minimum) is required in the range 0 – 9mA. This will give a minimum of 2275 adjustment steps in the target operating range.

4.1.3. Required maximum drive voltage

4.1.3.1. PCAL & SCAL point

Assuming worst case (R=500Ω), the maximum drive voltage is 3.9V when delivering 7mA. The maximum expected voltage drop across the devices is 3.5V. This voltage drop should be read with 16-bit ADC resolution (4-wire measurement).

4.1.3.2. SCAL flood

Assuming worst case (R=200Ω), the maximum drive voltage is 5.0V when delivering 9mA. The maximum expected voltage drop across the devices is 4.5V. This voltage drop should be read with 16-bit ADC resolution (4-wire measurement).

4.1.4. Time constant (PCAL)

The time constant associated with a PCAL current drive step should be less than 6ms.

4.1.5. Drive current stability

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. This requirement applies to both the PCAL and SCAL (point and flood) drives.

4.1.6. Safety limits on the drive current

The specifications on what the warm electronics can provide will be such that the power dissipation in the calibrator can get very high, depending on the final value of the device impedance. Therefore, we require provision for the placement of a set-on-test resistor in the warm electronics, the value of which will be determined by the final value of the calibrator impedances.

4.2. Power supply redundancy

4.2.1. PCAL & SCAL point

Two completely independent power supplies and circuits are required for PCAL and SCAL point – 1 prime, 1 redundant.

4.2.2. SCAL flood

A separate power supply is required for each SCAL heater – 1 prime, 1 redundant. Completely independent circuits will drive the two SCAL heaters.

5. Harness Requirements

5.1. PCAL

5.1.1. BSM Harness

Four copper wires are required, as part of the BSM harness. Four stand-offs will be provided to the rear of PCAL to ease integration to the BSM.

5.1.2. BSM/PCAL Cryo-harness

Four brass wires with one shield are required. Each wire should present an impedance of <30Ω between PCAL and the warm electronics.
Maximum levels will not exceed 4.0V at 10mA.

5.2. SCAL Cryoharness Requirements

A summary of the SCAL cryoharness and power supply requirements is shown in Figure 2 and Table 1 below.

Figure (3) shows the actual wiring scheme that will be used in SPIRE. This is extracted from AD? (SPIRE wiring harness definition – J.Delderfield)

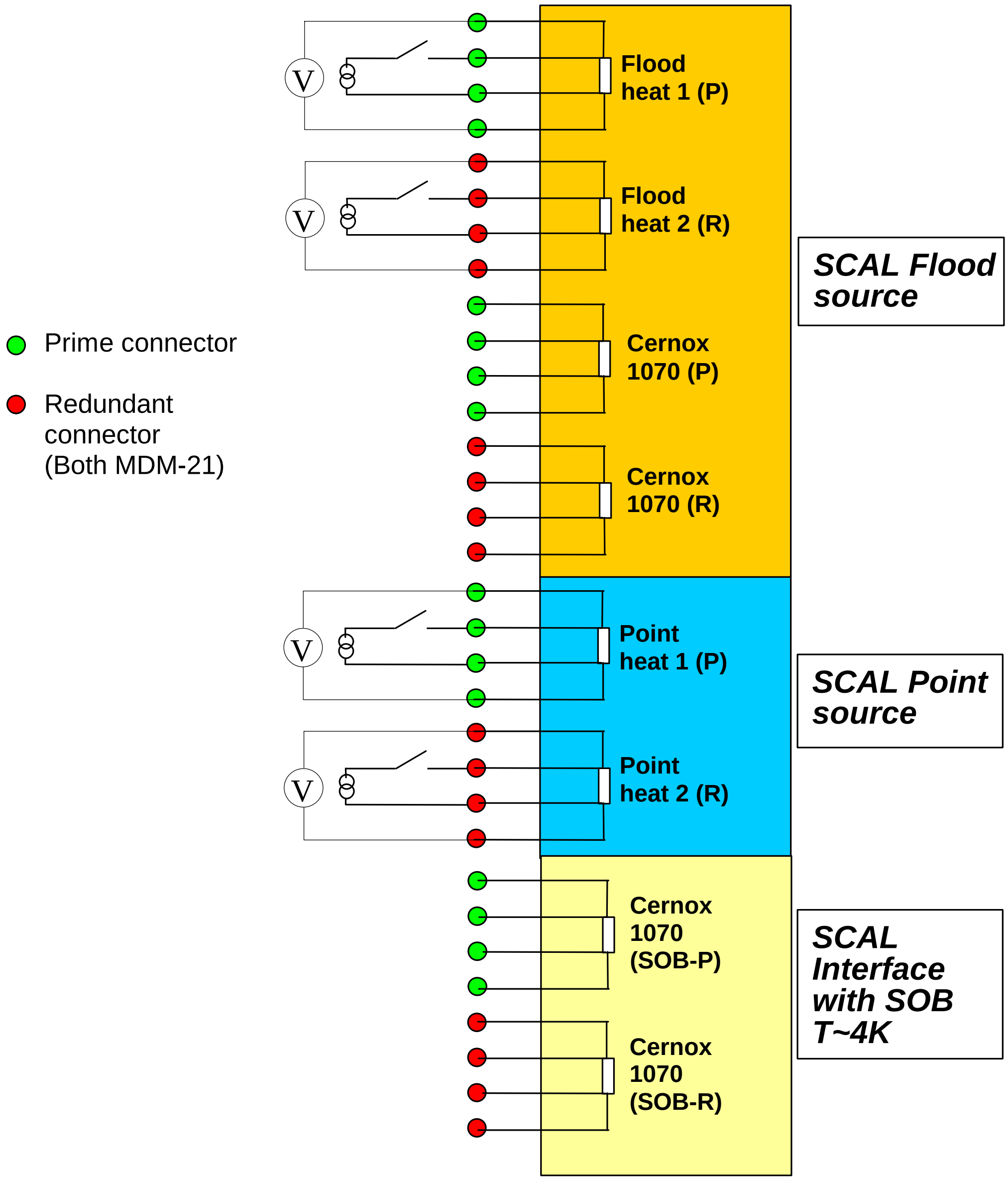

Figure 2 SCAL cryoharness requirements. P=Prime, R=Redundant

Table 1 SCAL cryoharness requirements

	No. of conductors	No. of shields	Ω max per conductor	Max Current (mA)	Max Volts (V)	Duty Cycle(1)	Remarks
Heater (prime)	4	0	30	11.5	5.0	0.5	Brass
Heater (redundant)	4	0	30	11.5	5.0	0	Brass
SCAL_therm (prime)	4	0.5	1000	0.01		1	SS
SCAL_therm (red.)	4	0.5	1000	0.01		1	SS
Base_therm (prime)	4	0.5	1000	0.01		1	SS
Base_therm (red.)	4	0.5	1000	0.01		1	SS
SCAL point (prime)	4	0	30	10	4.0	0.5	Brass
SCAL point (redundant)	4	0	30	10	4.0	0.5	Brass

(1) Duty cycle is the fraction of SPIRE time for which the circuit is active.

The total number of conductors is 34 (without robust wiring), which are shared equally between prime and redundant systems. Therefore it is proposed that the SCAL cryoharness comprises a 37-pin MDM going to two 21-pin MDM connectors, one prime and one redundant. This constitutes a change to the original harness definition which was a 37-pin MDM going to two 15-pin MDM connectors.

To Be Updated
FTS BB entries changed

	No. of Cond. Pins	No. of shield pins	Max.allowed Conductor Res.(Ohms)	Mean Current (A)/cond.	Peak Current (A)/cond.	Remarks	Cernox Type or Connect.ID
AUXILIARY PRIME 10	*Total Pins in use=*			*98*	*[69therm]*		
Spect JFET chassis therm	4	0.25	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
Phot JFET chassis therm	4	0.25	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
FSFPU chassis therm	4	0.25	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
~~Photometer 2K box~~	~~4~~	~~0.25~~	~~1000~~	~~2.50E09~~	~~2.50E09~~	~~Scr. Tw. Quad~~	~~CX-1050~~
Spectrometer 2K box	4	0.33	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
M3,5,7 Optical Subbench	4	0.33	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
Input Baffle Therm	4	0.34	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
30	28	2	37 way connector			All therm	*DCU J9*
FTS BB Flood Heater	2	0	30	3.00E03	3.00E03	Twisted Pair	
FTS BB Flood Heater(rob.)	2	0	30	3.00E03	3.00E03	Twisted Pair	
FTS BB Flood Therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
FTS BB case mt. SOB I/F therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
FTS BB Point Stimulus	2	0	30			Twisted Pair	
15	14	1	37 way connector to two 15 ways			9therm+6	DCU J13+9
Pump heater	2	0	10	3.00E02	3.00E02	Twisted Pair	
Pump heater(rob.)	2	0	10	3.00E02	3.00E02	Twisted Pair	
Pump therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
Evap. diag. heater	2	0	10	0.00E+00	0.00E+00	Twisted Pair	
Evap. therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1030
Shunt therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1030
Pump heat SW heater	2	0	10	1.60E03	1.60E03	Twisted Pair	
Evap. heat SW heater	2	0	10	1.60E03	1.60E03	Twisted Pair	
Pump heat SW heater(rob.)	2	0	10	1.60E03	1.60E03	Twisted Pair	
Evap. heat SW heater(rob.)	2	0	10	1.60E03	1.60E03	Twisted Pair	
Pump heat SW therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
Evap. heat SW therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
35	34	1	37 way connector			21therm+14	DCU J11+9
Shutter Actuator	2	0	10			Twisted Pair	
Shutter Heater	2	0	10			Twisted Pair	
Shutter Actuator Therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
Shutter Vane Position	4	1	1000	2.50E09	2.50E09	Scr. Tw. Quad	
Shutter Actuator Therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
18	16	2	25 way connector			9therm+9	DCU J15+9
DRIVES PRIME 11	*Total Pins in use=*		*100*	*[19therm]*			
SMEC drive coil	2	1	10	8.00E03	8.00E03	Scr. Tw. Pair	
SMEC drive coil(rob.)	2	1	10	8.00E03	8.00E03	Scr. Tw. Pair	
SMEC drive coil volts	2	1	1000	2.50E09	2.50E09	Scr. Tw. Pair	
SMEC posn sensors	19	1	1000	1.00E04	1.00E04	TBD	
SMEC home/limit switches	18	1	1000	1.00E03	1.00E03	TBD	
SMEC Mechanism Temp	4	1	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
SMEC Launch Latch	2	0	10			Scr. Tw. Pair	
BSM Launch Latch sensor	2	0	1000			Twisted Pair	
SMEC/SOB I/F therm	4	1	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
62	55	7	two 37 way connectors			10thm+20+19+13	DCU J17+21
BSM chop drive coil	2	0.5	10	0.010	0.050	Scr. Tw. Pair	
BSM jiggle drive coil	2	0.5	10	0.010	0.050	Scr. Tw. Pair	
BSM chop drive coil(rob.)	2	0.5	10	0.010	0.050	Scr. Tw. Pair	
BSM jiggle drive coil(rob.)	2	0.5	10	0.010	0.050	Scr. Tw. Pair	
BSM chop posn. Sense	5	1	100	1.00E04	1.00E04	TBD	
BSM jiggle posn. Sense	5	1	100	1.00E04	1.00E04	TBD	
BSM therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
BSM Launch Latch	2	0	10			Twisted Pair	
BSM Launch Latch sensor	2	0	1000			Twisted Pair	
Phot. BB Point Stimulus	2	1	30			Twisted Pair	
BSM/SOB I/F therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
38	32	6	37 way connector			9therm+28	DCU J19+21

	No. of Cond. Pins	No. of shield pins	Max.allowed Conductor Res.(Ohms)	Mean Current (A)/cond.	Peak Current (A)/cond.	Remarks	Cernox Type or Connect.ID
AUXILIARY REDUNDANT 12	*Total Pins in use=*			*98*	*[69therm]*		
Spect JFET chassis therm	4	0.25	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
Phot JFET chassis therm	4	0.25	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
FSFPU chassis therm	4	0.25	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
~~Photometer 2K box~~	~~4~~	~~0.25~~	~~1000~~	~~2.50E09~~	~~2.50E09~~	~~Scr. Tw. Quad~~	CX-1050
Spectrometer 2K box	4	0.33	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
M3,5,7 Optical Subbench	4	0.33	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
Input Baffle Therm	4	0.34	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
30	28	2	37 way connector			All therm	DCU J10
FTS BB Flood Heater	2	0	30	3.00E03	3.00E03	Twisted Pair	
FTS BB Flood Heater (rob.)	2	0	30	3.00E03	3.00E03	Twisted Pair	
FTS BB Flood Therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
FTS BB case mt. SOB I/F therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
FTS BB Point Stimulus	2	0	30			Twisted Pair	Unused?
15	14	1	See L.H.S.			9therm+6	DCU J14+10
Pump heater	2	0	10	3.00E02	3.00E02	Twisted Pair	
Pump heater (rob.)	2	0	10	3.00E02	3.00E02	Twisted Pair	
Pump therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
Evap. diag. heater	2	0	10	0.00E+00	0.00E+00	Twisted Pair	
Evap. therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1030
Shunt therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1030
Pump heat SW heater	2	0	10	1.60E03	1.60E03	Twisted Pair	
Evap. heat SW heater	2	0	10	1.60E03	1.60E03	Twisted Pair	
Pump heat SW heater(rob.)	2	0	10	1.60E03	1.60E03	Twisted Pair	
Evap. heat SW heater(rob.)	2	0	10	1.60E03	1.60E03	Twisted Pair	
Pump heat SW therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
Evap. heat SW therm	4	0.2	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
35	34	1	37 way connector			21therm+14	DCU J12+10
Shutter Actuator	2	0	10			Twisted Pair	
Shutter Heater	2	0	10			Twisted Pair	
Shutter Actuator Therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
[Shutter Vane Position]	4	1	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
Shutter Actuator Therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
18	16	2	25 way connector			9therm+9	DCU J16+10
DRIVES REDUNDANT 13	*Total Pins in use=*			*100*	*[19therm]*		
SMEC drive coil	2	1	10	0.00E+00	8.00E03	Scr. Tw. Pair	
SMEC drive coil(rob.)	2	1	10	0.00E+00	8.00E03	Scr. Tw. Pair	
SMEC drive coil volts	2	1	1000	2.50E09	2.50E09	Scr. Tw. Pair	
SMEC posn sensors	19	1	1000	1.00E04	1.00E04	TBD	
SMEC home/limit switches	18	1	1000	1.00E03	1.00E03	TBD	
SMEC Mechanism Temp	4	1	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
SMEC Launch Latch	2	0	10			Scr. Tw. Pair	
BSM Launch Latch sensor	2	0	1000			Twisted Pair	
SMEC/SOB I/F therm	4	1	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
62	55	7	two 37 way connectors			10thm+20+19+11	DCU J18+22
BSM chop drive coil	2	0.5	10	0.010	0.050	Scr. Tw. Pair	
BSM jiggle drive coil	2	0.5	10	0.010	0.050	Scr. Tw. Pair	
BSM chop drive coil(rob.)	2	0.5	10	0.010	0.050	Scr. Tw. Pair	
BSM jiggle drive coil(rob.)	2	0.5	10	0.010	0.050	Scr. Tw. Pair	
BSM chop posn. sense coil	5	1	100	1.00E04	1.00E04	TBD	
BSM jiggle posn. sense coil	5	1	100	1.00E04	1.00E04	TBD	
BSM therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1050
BSM Launch Latch	2	0	10			Twisted Pair	
BSM Launch Latch sensor	2	0	1000			Twisted Pair	
Phot. BB Point Stimulus	2	1	30			Twisted Pair	Unused?
BSM/SOB I/F therm	4	0.5	1000	2.50E09	2.50E09	Scr. Tw. Quad	CX-1070
38	32	6	37 way connector			9therm+28	DCU J20+22

Notes:
1. All screens insulated and no currents to be returned via above listed screens. The 100 CW connectors are in the middle of this run. For end tails at FCU and FPU see Block diagram.
2. Outside of each of these cables to be separately r.f. screened in addition to wires shown in the tables and these screens joined to connector backshells
3. Mean current per conductor when that side (prime or redundant) is active..shall be zero in unpowered side. When 4 wires are used, 2 for current and 2 for voltage sense, mean current = half conditioning current (x fraction of time energised).
4. Peak current per conductor is for "derating" sizing and is the worst case for any one conductor in group over a timescale of 5 mseconds.
5. "(rob.)" means robustness and spells out that the harness includes duplicate wires for critical functions, permitting some wire breakages without forcing prime to redundant side switching
…such wires drive the same heater/coil as others, although might initially measure volts and amps rather than having identical function.
6. Fraction numbers of pins for shields means that sometimes more than one insulated signal ground shield terminates on a given pin.
7. If drive wires, which should be heavily filtered to remove unnecessary high frequencies anyway, are required by FIRST to be screened, these screens cannot pass through the number of pins available and should be chassis/backshell terminated.
8. The above listing applies from the FSFPU RF Filter outputs to the DCU warm electronics, excepting that the "tails" at the DCU end are partitioned to suit its connectors I.e. temperature sensors are regrouped.
The choice of material and its gauge to keep below the required overall impedance end-to-end are to be specified by the harness supplier, the specification applying in the case of the cryostat running at working temperature.
This suggests stainless steel for many of the conductors in the cryogenic element of the harness and brass for the remainder of them, plus brass for all the conductors in the other element outside the 100-way CW connectors.

Figure 3 SPIRE wiring harness definition – extracted from AD? (J.Delderfield)

6. SCAL temperature stability requirements

In deriving these requirements, we have made the following assumptions:

(1) Cernox 1070 thermometer with properties close to generic example in Lakeshore catalogue.
(2) Required temperature measurement range = 4 K – 80 K
(3) Nominal operating temperature range = 15 – 20 K (to match dilute 80 K telescope Rayleigh-Jeans telecope spectrum).
(4) Goal temperature accuracy & stability = 1% in nominal range, 2% at 80 K. Note: this is not stated in the IRD, but internally decided.

Based on these assumptions, we have created a MathCad spreadsheet (Cernox_spec.mcd) to analyse the corresponding warm electronics requirements for the SCAL thermometers, which 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.

Note that there is no strong requirement on the time constant of the SCAL heater drive current (could be several seconds).