Photometer Calibrator (PCAL)

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

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

2. Documents

2.1. Applicable documents

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

3. Subsystem Description

3.1. General overview

PCAL is an electrically heated thermal source of submillimetre radiation, the purpose of which is to provide a repeatable signal for monitoring the health and responsivity of the SPIRE detectors. It is not required to provide absolute calibration or uniform illumination of the array, although it may be used as part of the overall calibration scheme in flight.

PCAL will be located at the position of a hole in the centre of the Beam Steering Mirror (BSM), which is at a pupil image. Although PCAL is optimised for the photometer, it can also be viewed by the FTS detector arrays. The thermal source will be positioned behind the mirror with a light pipe connecting the aperture in the mirror to a cavity in which the source is mounted, as shown in Figure 1. The BSM will be switched off when PCAL is operating, and some clearance will be needed to ensure the BSM does not foul on the light pipe when chopping. The location of PCAL and the BSM in the photometer opto-mechanical layout is shown in Figure 2

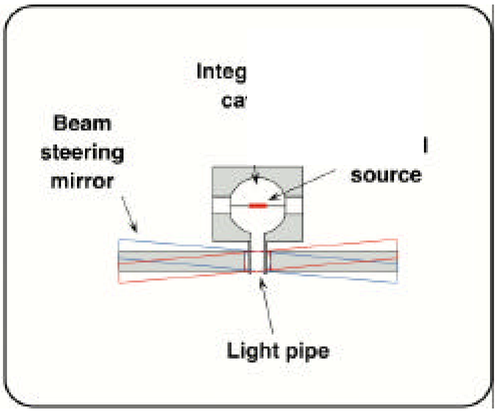

Figure 1: Conceptual design of PCAL

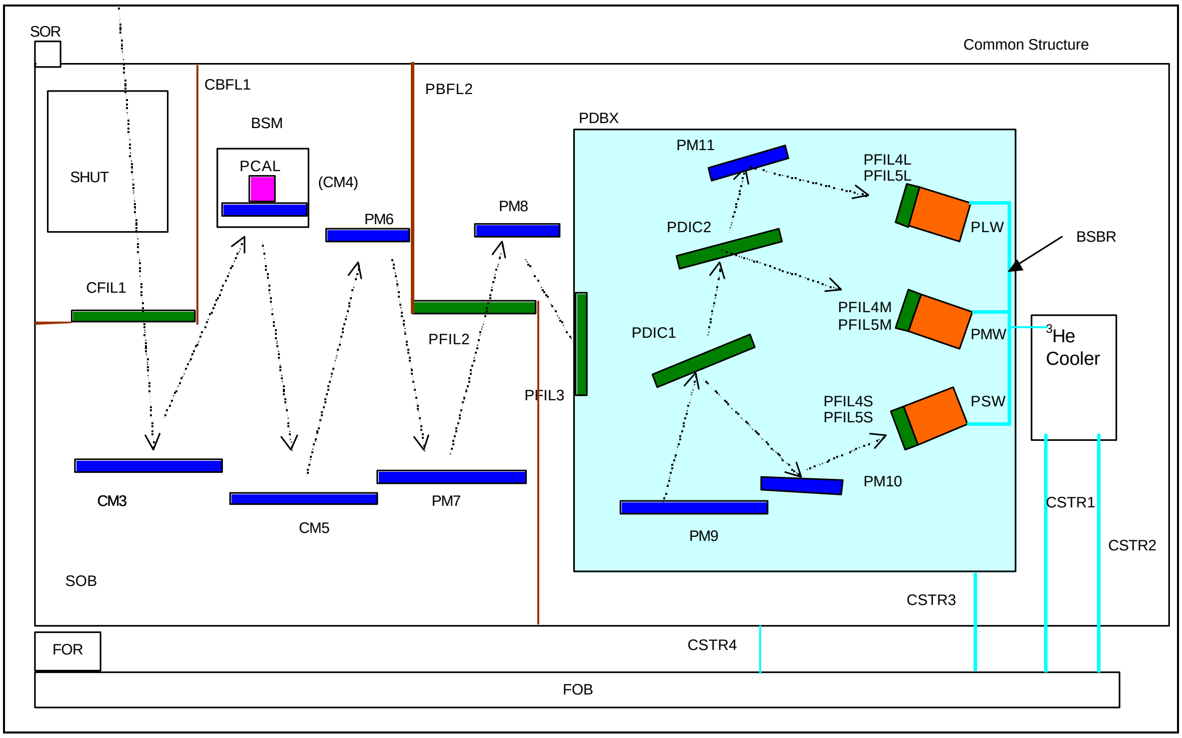

Figure 2: Location of the BSM and PCAL in the SPIRE FPU

4. Mechanical Interface

4.1. Inputs

PCAL receives input vibrations from the BSM structure, at a high level during launch and at a low level during operation (spacecraft micro vibration environment).
The analysis in this section has been carried out by the ATC for the BSM structure.

4.1.1. Resonance

The principal resonant modes of the structure and the two suspended masses are presented below. A full analysis of the combined system is to be completed.

The BSM structural interface forms a stiff body. The first twelve structural modes were determined by finite element analysis

FEA prediction for Response of structural interface		Approximate assembly response (see scale factor)
Mode	Frequency (Hz)	Frequency (Hz)
1	688	433
2	864	544
3	1781	1121
4	2715	1710
5	3058	1926
6	3284	2068
7	3345	2106
8	3614	2276
9	3957	2492
10	4097	2579
11	4677	2945
12	5185	3265
	mass of structure	291
	mass of assembly	734
	scaling for resonance	0.630

Table 1: Structural Interface Principal Modes

4.1.2. Scale factor

Pending a full resonant modes analysis, we may note that since the stiffness of the structural interface design remains unchanged, the assembly natural frequency scales as:

$$f_n = \frac{v\ (k/m)}{2\ ?}$$

hence, $f_{n(assy)} / f_{n(struct)} = v(\ m_{struct} / \ m_{assy})$

The mass of the structure used for the FEA modes search was calculated at 291gm, and the full assembly mass (excluding contingency, the baseplate and fasteners below the structure base) is predicted at 734 gm . This yields a scaling factor of ~ 0.63, used in Table 1.

4.1.3. Assumptions

As the structural response remains above 250 Hz it may be assumed to be stiff for subsequent analysis of the SPIRE structure and for transmission of SPIRE optical bench motion to PCAL.

4.2. Outputs

There are no mechanical outputs to the structure from this subsystem.

4.3. Interface drawings

The PCAL space envelope and agreed interface with the BSM is shown in Figure 3. At the time of writing, small modifications to the design of PCAL are in progress, but there will be no deviation from the agreed envelope and interface.

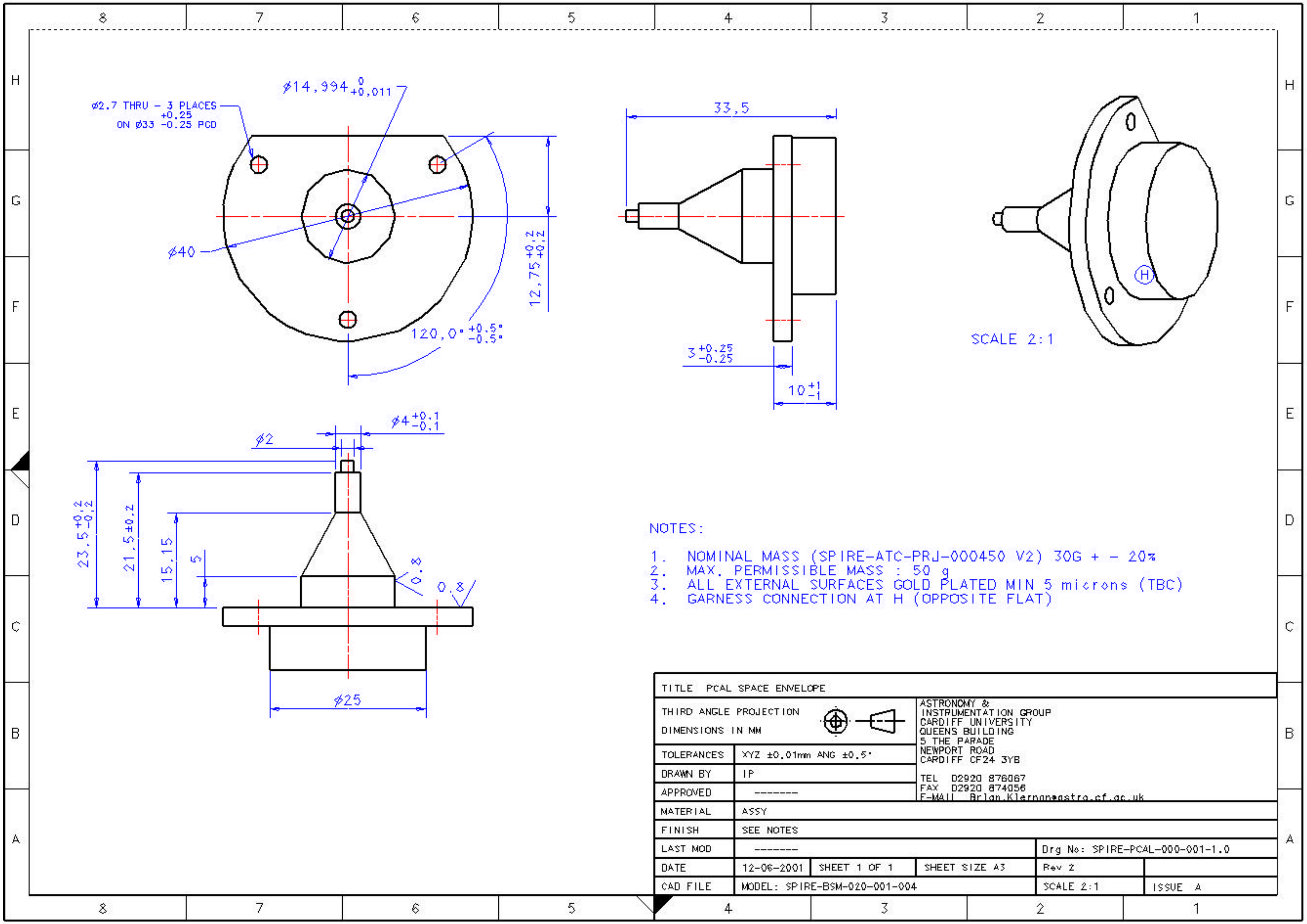

Figure 3 Volume envelope and interface for PCAL.

5. Thermal Interface

Cooling of PCAL is provided by contact to the BSM structure bulkhead

5.1. Finish

The BSM-PCAL interface surface on the BSM will be aluminium alloy, grade 6082, coated with electroless nickel (nominally 10 microns) and gold (nominally 5 microns). The interface surface provides a precision central hole and three mounting holes, tapped M2.5, with locking inserts. The PCAL interface surface will be aluminium alloy, grade 6061, coated with 10 microns of nickel and 5 microns of gold.

5.2. Surface Area

The contact surface area of the baseplate is TBD

5.3. Contact Force

At the contact face an approximate contact force of 1380 N (TBC) will be developed by three M2.5 socket head screws torqued to 0.23 (TBC) N-m

6. Optical Interface

7. Electrical Interface

7.1. Harness details

PCAL will be supplied to ATC with four wires to be integrated as part of the BSM prime harness. This harness will be duplicated for the redundant systems. The prime and redundant PCAL sub-harnesses will be greater than 300mm long and subsequently cut to length for integration to the BSM. The PCAL wiring will consist of an insulated, screened, twisted quad sub-harness. The maximum harness impedance requested for PCAL is 10 Ohms per wire. A schematic of the BSM prime connector wiring is shown in Figure 4. The redundant wiring will be an exact copy of this harness.

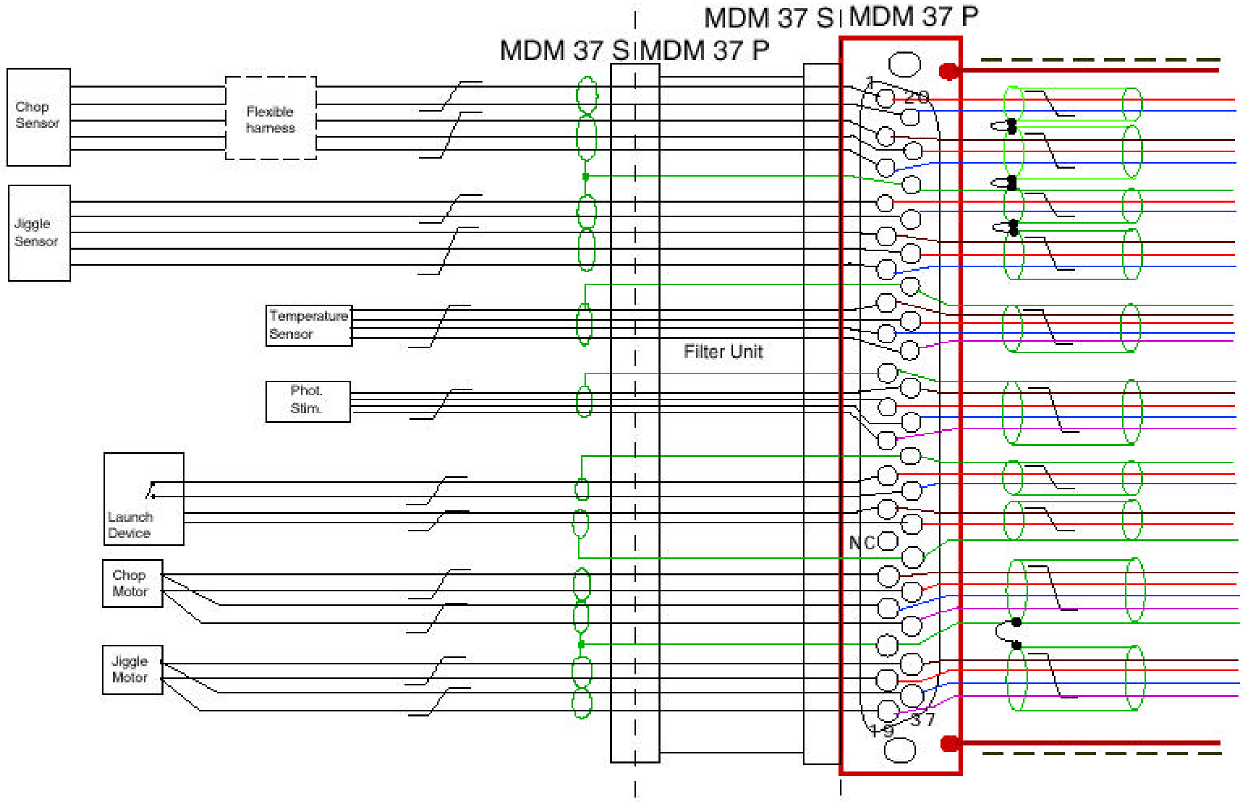

Figure 4 Details of BSM/PCAL harness (C11).

7.2. Electrical drive requirements

Current drive for PCAL in a four-wire configuration was agreed at the interface review in November 2001. The following specifications are derived to allow for final device impedances in the range 200-500 Ω:-

7.2.1. Maximum drive current

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.

7.2.2. Drive current adjustability

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.

7.2.3. Maximum drive voltage

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.

7.2.4. Time constant

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

7.2.5. 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.

7.2.6. 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 impedance.

7.2.7. Power supply redundancy

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

8. Data Interface

Normal operation of PCAL will involve the application of a pre-determined sequence of commands based on an OBS script under DPU control. Envisaged frequency of operation is no more than once per hour for a period of ~10 seconds.

Table 2 Summary of software commands needed to control PCAL

Command ID	Name	Description
PC1	On/Off	Switches PCAL drive circuit on/off
PC2	Current level	PCAL will be driven by a 12-bit DAC over the range 0 to 7mA. Therefore the software should allow for the commanding of 4096 current levels in the range 0 to 7mA.