

SPIRE

SUBJECT: Operating the SPIRE Instrument

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Glossary

AOT	Astronomical Observation Template
BSM	Beam Steering Mirror
DCU	Detector Control Unit
DPU	Digital Processing Unit
DRCU	Detector Readout and Control Unit
FCU	Focal Control Unit
FTS	Fourier Transform Spectrometer
HK	Housekeeping
IF	Instrument Function
MCU	Mechanism Control Unit
OBS	On-Board Software
PCAL	Internal calibrator for the Photometer
POF	Photometer Observatory Function
S/C	Spacecraft
SCAL	Internal calibrator for the FTS
SCU	Sub-system Control Unit
SMEC	Spectrometer Mechanism
SOF	Spectrometer Observatory Function
SPIRE	Spectral and Photometric Imaging Receiver

1. INTRODUCTION

The document "Operating Modes for the SPIRE Instrument" [AD-1] describes the instrument operating modes required to implement the types of observations for realising the science objectives of SPIRE.

The purpose of this document is to provide a description of the set of SPIRE instrument commands to be used in the Herschel ground segment and to be executed by the On-board Software (OBS) in order to carry out science observations. A typical science observation with SPIRE will consist of a number of Observatory Functions executed sequentially. An Observatory Function will itself consist of Instrument Functions, Data Configurations and S/C functions. Each component of an Observatory Function will be interpreted and expanded by the OBS into individual sub-system level commands before being sent to the appropriate DRCU sub-unit (viz. DCU, MCU and SCU).

This document also describes the types of science telemetry that needs to be generated in various operating modes. The actual structure and contents of the SPIRE telemetry packets are covered in [RD- 4].

1.1 Scope

The current document only discusses those instrument commands required for implementation of the Observatory Functions as described in [AD-1]. Future versions will describe the complete set of instrument operations, such as cooler recycle, memory checking and the switching between other modes. [It has been found that the implementation of these commands may place requirements on the DRCU-DPU interface and so this preliminary version of the document is issued in order to ensure that these requirements are considered.](#)

In this document the elaboration of Observatory Functions [AD-1] is confined to just the Instrument Functions and Data Configurations. The Spacecraft Functions necessary for the definition and execution of these Observatory Functions are identified and named, but not discussed here and it is assumed that they will be implemented as described in the Annexe "FIRST Pointing Modes" of [AD-3].

1.2 Assumptions

- For photometry observations all chop-throws will be performed in the Y direction. We assume that it will not be possible to change the orientation of the S/C arbitrarily to allow observers to specify their own chop positions on the sky (e.g. in terms of RA and Dec).
- At present there are no anomaly actions defined for the failure of an Observatory Function.
- It is further assumed that the execution of OBS commands will be independent of spacecraft triggers.
- The ISO observing strategy led to internal calibration measurements being routinely performed during each individual observation. A similar approach is also available for SPIRE observations but the Observatory Functions are designed in such a way that these calibrations can be performed outside the context of an observation. Consequently separate Observatory Functions exist for calibration.

2. DOCUMENTS

2.1 Applicable Documents

AD-1	Operating Modes for the SPIRE instrument	SPIRE-RAL-DOC-000320	3.0	4 th Jan 2002
AD-2	Herschel/Planck Packet Structure Interface Control Document	SCI-PT-ICD-07527	2/0	12 th July 2001
AD-3	Herschel/Planck Instrument Interface Document (IID Part A)	SCI-PT-IIDA-04624	2/0	31 st July 2001

2.2 Reference Documents

RD-1	DRCU Interface Control Document	Sap-SPIRE-CCa-25-00	0.5	17 th Oct 2001
RD-2	MCU Design Description	LAM/ELE/SPI/000619	2	12 th April 2001
RD-3	SPIRE Design Description	SPIRE-RAL-PRJ-000620	0.1	1 st Sept 2000
RD-4	SPIRE Data Interface Control Document	SPIRE-RAL-DOC-001078	1.0 (Draft 1)	15 th Jan 2001

3. OBSERVATORY FUNCTIONS

The detailed structure of an Observatory Function is illustrated schematically in Figure 1, with the flow of execution going from the top of the page to the bottom of the page.

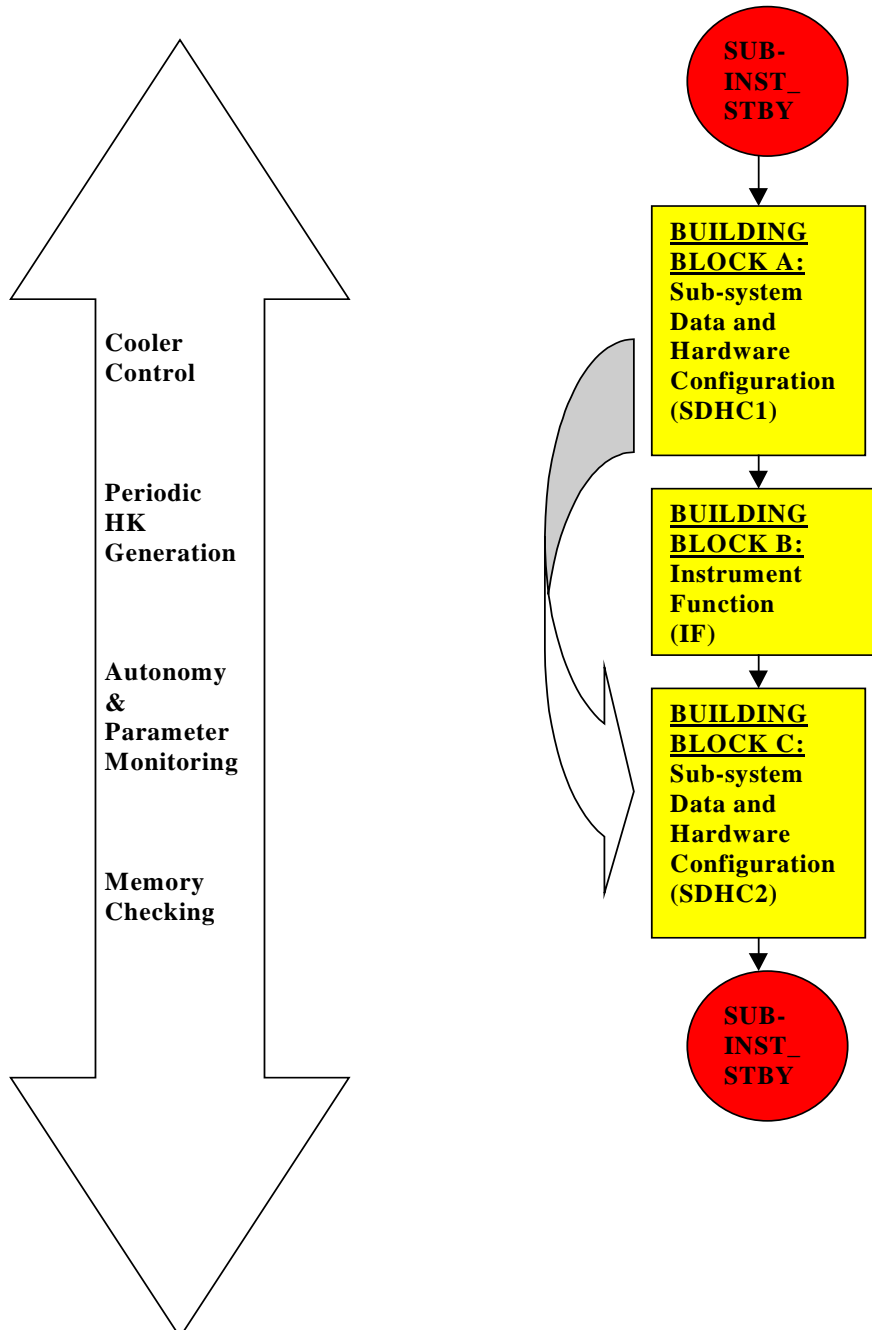


Figure 1: Structure of a SPIRE Observatory Function. The flow of execution is from top to bottom.

3.1 Nomenclature

- SPIRE Observatory Functions are designed to have all the functionality needed to perform complete astronomical observations (viz. AOTs) with the Photometer or the Spectrometer, including internal calibration. These Observatory Functions will consist of a sequence of Building Blocks, which can in principle comprise of both S/C and instrument commands. A BB is the key component of an Observatory Function like Photometer chopping, FTS scanning or internal calibration. In the Herschel ground segment each Observatory Function will have an Observation Identifier (ObsId) associated it.
- Each rectangular block in the diagram represents a BB. In the ground segment each BB has a BB Identifier (BBId) associated with it which simplifies the task of relating the down-linked telemetry with up-linked telecommands.
- Separate Observatory Functions are also available for performing internal calibration outside the context of an astronomical observation.
- Each BB includes sending commands to the DRCU sub-units, i.e. DCU, MCU and SCU. The sub-unit commands listed here have been take from [RD-1] where possible. These commands are prefixed with the name of the intended recipient of the DRCU sub-unit, e.g. DCU: SET_PHOTO_BIAS_FREQ.
- Parameters which the DPU has to set up are prefixed with the letters 'DPU'. DPU:SAMPLE_COUNT, for example, could be used by the OBS to tag sample numbers to detector data as received from the DCU.
- The BBs referring to S/C functions such as nodding, raster mapping and line scanning could span one or more instrument building blocks or may even last the duration of an Observatory Function.

3.2 Structure of an Observatory Function

A brief explanation of all the constituent steps of an Observatory Function, as shown in Figure 1, is now given.

3.2.1 SUB-INST_STBY mode

This is the assumed standby state of the instrument at the start of an Observatory Function. For observations with the Photometer SPIRE will start and end in the PHOT STBY mode whilst for Spectrometer observations it will start and end in the SPEC_STBY mode. The instrument will switch from REDY to either PHOT STBY or SPEC STBY *before* the start of an Observatory Function. **In order to maximise observation efficiency and to minimise unnecessary switching of instrument states it is desirable to group together observations according to sub-instrument in use, i.e. Photometer or Spectrometer.**

3.2.2 Building Block Definitions

As shown in Figure 1, and as explained below, each Observatory Function could potentially consist of three different types of Building Blocks for each type of instrument operation, i.e. BBs of types A, B and C. If an observation was to consist of a Photometer internal calibration called PCAL and Photometer chopping operation called CHOP then the Observatory Function could comprise the BBs shown in Figure 2.

PCAL A	PCAL B	PCAL C	CHOP A	CHOP B	CHOP C
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Figure 2: An example Observatory Function showing the component Building Blocks

BBs of type B will always exist whereas types A and C will depend on the kind of operation to be performed with the instrument. All the SPIRE BB definitions and implementations are described in Section 7.

3.2.2.1 Building Block A: Sub-system Data and Hardware Configuration (SDHC1)

This BB is designed to

- select the housekeeping parameters to be sampled and their sampling rates
- configure the sub-systems for the Instrument Function to be executed
- switch on power to the mechanisms or sub-systems needed for the execution of the Instrument Function

For example, we may need to set up the instrument for a Photometer internal calibration measurement or for chop operations.

3.2.2.2 Building Block B: Instrument Function (IF)

This BB covers the instrument operations that have to be performed to carry out the actual scientific measurement part of the Observatory Function, including any internal calibration. A Photometer Observatory Function may consist of PCAL for performing a Photometer internal calibration measurement and CHOP for Photometer chop operations.

3.2.2.3 Building Block C: Sub-system Data and Hardware Configuration (SDHC2)

Sets up the data and hardware configuration of the instrument prior to the switching off of some mechanisms. The sampling rates of the detectors and the position of a mechanism can be selected here. This BB involves configuring the instrument for the end of an Observatory Function. The switching-off of power to the appropriate mechanisms also happens here.

3.2.3 SUB-INST_STBY

The instrument ends up in the sub-instrument STBY mode of the Observatory Function, i.e. PHOT STBY or SPEC STBY.

3.2.4 Other Tasks

During the execution of an observatory function there will be a number of other tasks which will be active throughout. These are also shown in Figure 1 and include:

- Active cooler control
- Periodic HK generation
- Monitoring of parameters
- Memory checking

4. MODE TRANSITIONS

Figure 3 shows a diagram of the SPIRE operating modes (same as Figure 3-1 in [AD-1]) and the various procedures for switching between these modes. As stated earlier the instrument will switch from the Ready mode (REDY) to Photometer standby (PHOT STBY) or Spectrometer standby (SPEC STBY) mode before the execution of Observatory Functions. The generic Observe mode (OBSV) in this figure corresponds to any one of the Observatory Functions to be discussed in Sections 5 and 6.

The building blocks required for switching from the REDY mode to PHOT STBY or SPEC STBY are described in Sections 7.1 and 7.2. Building blocks for the remaining mode transitions shown in Figure 3 are TBW.

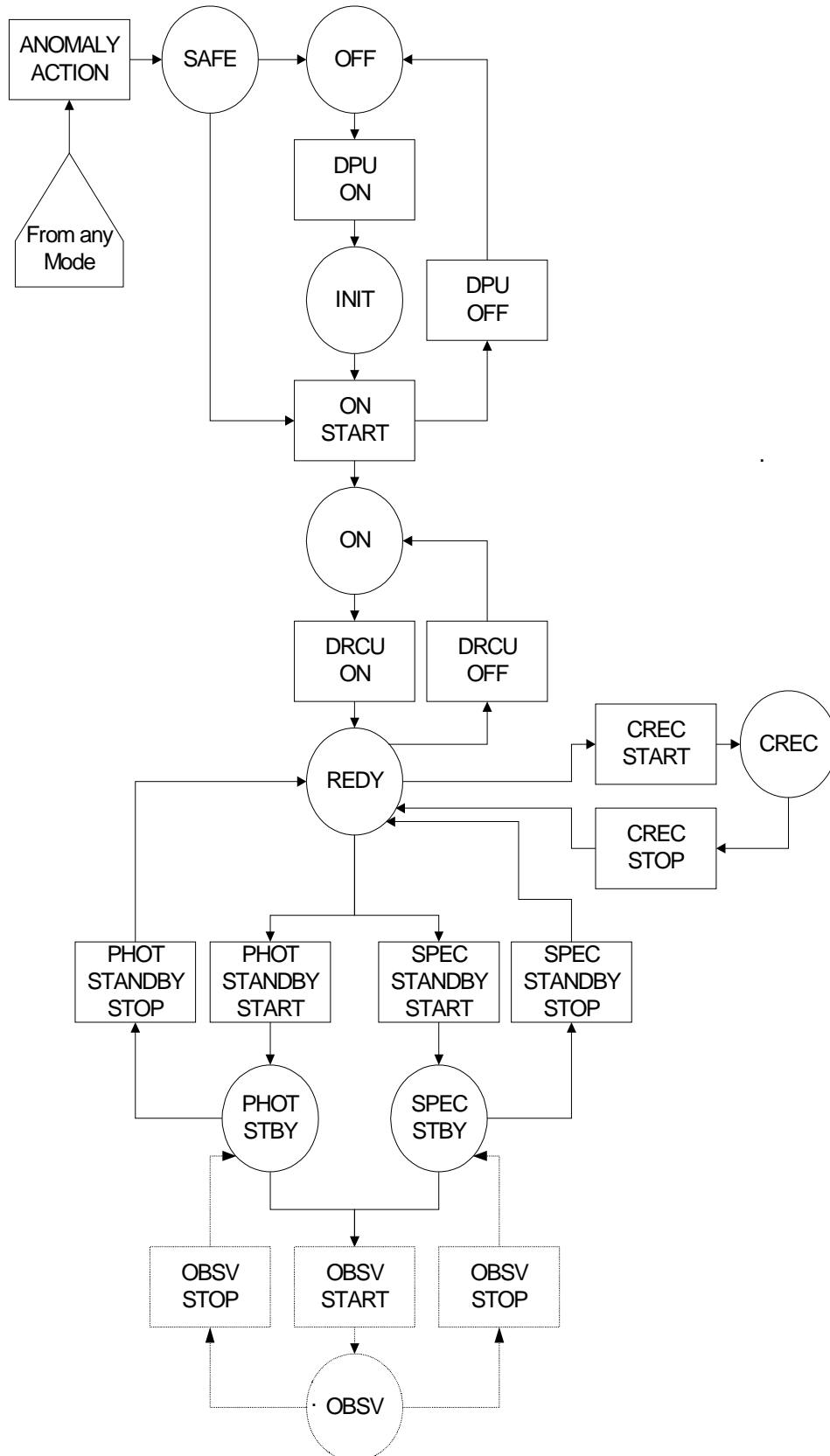


Figure 3: Logical transition flow between SPIRE operating modes. This diagram is taken from [AD-1].

5. PHOTOMETER OPERATIONS

5.1 POF1: Chop Without Jiggling

This is the simplest of the Photometer Observatory Functions. Its structure is expected to become a key component of other POFs, to be discussed later in this document. The high level operations to be performed in POF1 are as follows:

- 1) **TPOINT:** Point the telescope at the astronomical source
- 2) **PHOT_DAQC:** Set the Photometer Data Acquisition configuration
- 3) **PCAL:** Internally calibrate the Photometer *if necessary*
- 4) **CHOP:** Perform a series of chop cycles on the source while taking BDA data
- 5) **TNOD:** Nod the telescope and wait to settle
- 6) Repeat steps 4-5 as necessary
- 7) **PCAL:** Internally calibrate the Photometer *if necessary*
- 8) Repeat steps 4-7 as required
- 9) **PHOT_SDHC_RESET:** Reset the Photometer Data and Hardware Configuration

where **TPOINT**, **PHOT_DAQC**, **PCAL**, etc are the BBs in this POF. This scenario assumes that the BSM does not have to be switched off for PCAL operations (RD-3) and that Photometer calibration can be performed in the context of an astronomical observation.

- The OBS has to keep track of the number of chop cycles and the number of nod cycles.
- It is expected that the BDA data samples will be labelled with the sample number by the DCU.
- How do we select parameters to be sampled from SCU? Can they also be labelled with the sample number within the frame?

5.2 POF2: Seven-Point Jiggle Map

POF2 is intended for observing isolated compact sources with inaccurate co-ordinates or if the telescope pointing proves to be unreliable. In principle this POF should simply consist of POF1 being executed at each of the seven jiggle positions. It is envisaged that the jiggle sequence will be repeated a number of times to build up the required integration time. This is preferable to just performing a large number of chop cycles at each jiggle position and only visiting each jiggle position once. The order in which the jiggle positions are to be visited is TBD. (One possibility being discussed is that the BSM will return to the central jiggle position after visiting each of the other six jiggle positions). The parameters for the map will be read from a jiggle table stored in the OBS (see Section 8.2). The general sequence of steps is as follows:

- 1) **TPOINT:** Point the telescope at the astronomical source
- 2) **PHOT_DAQC:** Set the Photometer Data Acquisition configuration
- 3) **PCAL:** Internally calibrate the Photometer *if necessary*
- 4) Perform seven-point jiggle map
 - **JIGGLE:** Move the BSM to i^{th} jiggle position (initially $i=1$)
 - **CHOP:** Perform a series of chop cycles on the source (as in POF1)
 - Increment jiggle position number
 - Repeat these steps in 4) for all seven jiggle positions
- 5) **PCAL:** Internally calibrate the Photometer *if necessary*
- 6) Repeat steps 4-5 as many times as the jiggle sequence is to be repeated
- 7) **TNOD:** Nod the telescope and wait to settle
- 8) **PCAL:** Internally calibrate the Photometer *if necessary*
- 9) Repeat steps 4-8 as many times as necessary
- 10) **PHOT_SDHC_RESET:** Reset the Photometer Data and Hardware Configuration

- It is assumed that the number of chop cycles will be the same at each jiggle position.

- The OBS has to keep track of the jiggle position number, the jiggle cycle sequence number, the chop cycle number (at each jiggle position) and the number of nod cycles (at each jiggle cycle sequence).
- It will probably not be necessary for the Photometer internal calibrator to be flashed for each jiggle position because [AD-1] states that the Observatory Function for PCAL (see POF8 below) will be executed at an interval of an hour or more. The above sequence allows the option of operating PCAL more flexibly if desired.

5.3 POF3: n-Point Jiggle Map

It is assumed that the sequence of steps in this POF is the same as for POF2.

- 1) **TPOINT:** Point the telescope at the astronomical source
- 2) **PHOT_DAQC:** Set the Photometer Data Acquisition configuration
- 3) **PCAL:** Internally calibrate the Photometer *if necessary*
- 4) Perform n-point jiggle map
 - **JIGGLE:** Move the BSM to i^{th} jiggle position (initially $i=1$)
 - **CHOP:** Perform a series of chop cycles on the source (as in POF1)
 - Increment jiggle position number
 - Repeat these steps in 4) for all n jiggle positions
- 5) **PCAL:** Internally calibrate the Photometer if necessary
- 6) Repeat steps 4-5 as many times as the jiggle sequence is to be repeated
- 7) **TNOD:** Nod the telescope and wait to settle
- 8) **PCAL:** Internally calibrate the Photometer if necessary
- 9) Repeat steps 4-8 as many times as necessary
- 10) **PHOT_SDHC_RESET:** Reset the Photometer Data and Hardware Configuration

- We assume that the number of chop cycles will be the same at each jiggle position.
- The OBS has to keep track of the jiggle position number, the jiggle cycle sequence number, the chop cycle number (at each jiggle position) and the number of nod cycles (at each jiggle cycle sequence).
- It will probably not be necessary for the Photometer internal calibrator to be flashed for each jiggle position because [AD-1] states that the Observatory Function for PCAL (see POF8 below) will be executed at an interval of an hour or more. The above sequence allows the option of operating PCAL more flexibly if desired.

5.4 POF4: Raster Map

A raster map is simply a rectangular grid of several n-Point Jiggle Maps (POF3) interleaved with Photometer internal calibrator flashes. The scenario set out below assumes that each raster point in the map may be visited more than once by simply repeating **TRASTER**, the telescope raster BB as specified in [AD-3]. **The BSM is used to chop in the Y direction, which may not necessarily be perpendicular to the lines in the raster map.**

- 1) **PHOT_DAQC:** Set the Photometer Data Acquisition configuration
- 2) **TRASTER:** Perform a raster map with the telescope
- 3) For each raster point in the map perform the following steps
 - a) **DPU: WAIT:** Wait for the telescope to reach raster point
 - b) **PCAL:** Internally calibrate the Photometer *if necessary*
 - c) **JIGGLE:** Move the BSM to i^{th} jiggle position (initially $i=1$)
 - d) **CHOP:** Perform a series of chop cycles on the source (as in POF1)
 - e) Increment jiggle position number
 - f) Repeat steps c) to d) for all n jiggle positions
 - g) Repeat steps c) to f) as many times as the jiggle sequence is to be repeated at each raster point
 - h) **TNOD:** Nod the telescope and wait to settle
 - i) **PCAL:** Internally calibrate the Photometer *if necessary*
 - j) Repeat steps c) to g) at the nod position as necessary
- 4) Repeat steps 2) and 3) *if necessary*
- 5) **PCAL:** Internally calibrate the Photometer *if necessary*
- 6) **PHOT_SDHC_RESET:** Reset the Photometer Data and Hardware Configuration

- For each raster point the OBS has to keep track of the jiggle position number, the jiggle cycle sequence number, the chop cycle number (at each jiggle position) and the number of nod cycles (at each jiggle cycle sequence).

5.5 POF5: Scan Map Without Chopping

A scan map without chopping is a continuous map of a region of the sky over a number of lines on the sky interleaved with Photometer internal calibrator flashes. No spacecraft Nodding is performed. In the following scenario it is assumed that scan map may be repeated a number of times.

- 1) **PHOT_DAQC**: Set the Photometer Data Acquisition configuration
 - 2) **TSCAN**: Perform line scans on the sky using the telescope
 - 3) **PCAL**: Internally calibrate the Photometer *if necessary*
 - 4) **PSCAN**: Ask the DCU to collect science data while the telescope scans along a line on the sky
 - 5) Increment line scan number after each line scan
 - 6) **DPU: WAIT**: Wait for TBS time until the telescope is on the next line
 - 7) Repeat steps 4-6 for all lines
 - 8) **PCAL**: Internally calibrate the Photometer *if necessary*
 - 9) Repeat steps 2-8 for as many times as necessary for the line scan map.
 - 10) **PHOT_SDHC_RESET**: Reset the Photometer Data and Hardware Configuration
- The OBS has to keep track of the line scan count.
 - The BSM may need to be commanded to the nominal "rest" position even for this POF because there needs to be active control over its position in case it starts to drift.
 - It is assumed that the Photometer internal calibrator could be flashed at the start of the observation and then after the telescope has visited all the lines of the line scan at least once. [AD-1] states that POF8 will be executed at an interval of an hour or more.

5.6 POF6: Scan Map With Chopping

A scan map with chopping (for high 1/f noise) is a continuous map of a region of the sky over a number of lines on the sky interleaved with Photometer internal calibrator flashes. This POF is similar to POF1. **The BSM is used to chop in the Y direction, which may not necessarily be in a direction perpendicular to the lines in the scan map.**

- 1) **PHOT_DAQC**: Set the Photometer Data Acquisition configuration
 - 2) **TSCAN**: Perform line scans on the sky using the telescope
 - 3) **PCAL**: Internally calibrate the Photometer *if necessary*
 - 4) **CHOP**: Perform a series of chop cycles on the source for the duration of scan along line 1
 - 5) Increment line scan number
 - 6) **DPU: WAIT**: Wait for TBS time until the telescope is on the next line
 - 7) Repeat steps 4-6 for all lines
 - 8) **PCAL**: Internally calibrate the Photometer *if necessary*
 - 9) Repeat steps 2-8 for as many times as necessary for the line scan map.
 - 10) **PHOT_SDHC_RESET**: Reset the Photometer Data and Hardware Configuration
- The OBS has to keep track of the line scan count and the chop cycle count.
 - It is assumed that the Photometer internal calibrator could be flashed at the start of the observation and then after the telescope has visited all the lines of the line scan at least once. [AD-1] states that POF8 will be executed at an interval of an hour or more.

5.7 POF7: Photometer Peak-Up

TBW

5.8 POF8: Photometer Calibrate

A Photometer calibration takes place with the power to the BSM switched on but with the BSM not operating (i.e. the BSM is not chopping or jiggling) so that the only modulation of the detectors is as a consequence of the

Photometer Calibrator (PCAL). It is assumed that the instrument will already be in PHOT_STBY mode with the Photometer detector arrays switched on.

- 1) **PHOT_DAQC:** Set the Photometer Data Acquisition configuration
- 2) **PCAL_ON:** Switch on PCAL subsystem
- 3) **DPU: WAIT:** Wait some TBS time
- 4) Reset counter for PCAL sequence
- 5) **PCAL:** Perform PCAL excitation sequence
- 6) **DPU: WAIT:** Wait some TBS time
- 7) Increment counter for PCAL sequence
- 8) Repeat steps 5-7 as necessary
- 9) **PCAL_OFF:** Switch off PCAL subsystem
- 10) **DPU: WAIT:** Wait TBS time before resuming operations
- 11) **PHOT_SDHC_RESET:** Reset the Photometer Data and Hardware Configuration

6. SPECTROMETER OPERATIONS

6.1 SOF1: Spectrum of Point Source (Continuous Scan)

It is assumed that the instrument will be in SPEC_STBY mode initially with the Spectrometer BDAs, SMEC and SCAL switched on.

1. **TPOINT:** Point the telescope at the astronomical source
2. **DPU: WAIT:** Wait for some TBS time to allow the SMEC to stabilise.
3. **SPEC_DAQC:** Set the Spectrometer Data Acquisition configuration (see Section 7.7)
4. **SPEC_PCAL:** Internally calibrate the Spectrometer using the PCAL source *as necessary*
5. Initialise FTS scan counter
6. **SPEC_SCAN:** Perform an FTS scan
7. Increment FTS scan counter
8. Repeat steps 6-7 as required
9. **SPEC_PCAL:** Internally calibrate the Spectrometer using the PCAL source *as necessary*
10. **SPEC_HDC_RESET:** Reset the Spectrometer Data and Hardware Configuration

6.2 SOF2: Fully Sampled Spectral Map (Continuous Scan)

It is assumed that the instrument will be in SPEC_STBY mode initially with the Spectrometer BDAs and SCAL switched on.

1. **TPOINT:** Point the telescope at the astronomical source
2. **DPU: WAIT:** Wait for some TBS time to allow the SMEC to stabilise.
3. **SPEC_DAQC:** Set the Spectrometer Data Acquisition configuration (see Section 7.7)
4. **SPEC_PCAL:** Internally calibrate the Spectrometer using the PCAL source *as necessary*
5. Make a fully sampled spectral map
 - a) Initialise the jiggle position counter
 - b) **JIGGLE:** Move the BSM to i^{th} jiggle position (Initially $i=1$)
 - c) Initialise FTS scan counter
 - d) **SPEC_SCAN:** Perform an FTS scan
 - e) Increment FTS scan counter
 - f) Repeat steps d) and e) as many times as required
 - g) Repeat steps b) to f) for the n jiggle positions
6. Repeat all the steps in 5) for as many jiggle cycles as necessary
7. **SPEC_PCAL:** Internally calibrate the Spectrometer using the PCAL source *as necessary*
8. **SPEC_HDC_RESET:** Reset the Spectrometer Data and Hardware Configuration

6.3 SOF3: Spectrum of Point Source (Step-and-Integrate)

This Observatory Function is similar to SOF1, except that here the FTS mirror is stepped to a given position and the BSM used to perform a number of chop cycles between two positions on the sky. This process is repeated for all FTS mirror positions to build up a complete scan. The use of SCAL is not necessary for this Observatory Function.

- 1) **TPOINT:** Point the telescope at the astronomical source
- 2) **SPEC_DAQC:** Set the Spectrometer Data Acquisition configuration (see Section 7.7)
- 3) **SPEC_PCAL:** Internally calibrate the Spectrometer using the PCAL source *as necessary*
- 4) Perform a spectral scan in step-and-integrate mode:
 - a) Initialise FTS scan counter
 - b) **SPEC_STEP:** Step the FTS mirror to required position
 - c) **CHOP:** Perform a series of chop cycles from given FTS mirror position
 - d) Repeat steps b) and c) until end of FTS scan is reached
 - e) Increment FTS scan counter
 - f) Repeat steps b) to e) for the required number of FTS scans
- 5) **SPEC_PCAL:** Internally calibrate the Spectrometer using the PCAL source *as necessary*
- 6) **SPEC_HDC_RESET:** Reset the Spectrometer Data and Hardware Configuration

6.4 SOF4: Fully Sampled Spectral Map (Step-and-Integrate)

This Observatory Function is essentially SOF3 performed at each of the jiggle positions of an n-point jiggle map.

- 1) **TPOINT:** Point the telescope at the astronomical source
- 2) **SPEC_DAQC:** Set the Spectrometer Data Acquisition configuration (see Section 7.7)
- 3) **SPEC_PCAL:** Internally calibrate the Spectrometer using the PCAL source *as necessary*
- 4) Perform a fully sampled spectral map in step-and-integrate mode:
 - a) Initialise jiggle position counter
 - b) **JIGGLE:** Move the BSM to the i^{th} jiggle position (initially $i=1$)
 - c) Perform a spectral scan in step-and-integrate mode:
 - I) Initialise FTS scan counter
 - II) **SPEC_STEP:** Step the FTS mirror to required position
 - III) **CHOP:** Perform a series of chop cycles from given FTS mirror position
 - IV) Repeat above steps II) and III) until end of FTS scan is reached
 - V) Increment FTS scan counter
 - VI) Repeat steps II) to V) for required number of FTS scans at each jiggle position
 - VII) Repeat all steps in b) and c) for all n jiggle positions
- 5) Repeat all of the steps in 4) for the required number of jiggle cycles
- 6) **SPEC_PCAL:** Internally calibrate the Spectrometer using the PCAL source *as necessary*
- 7) **SPEC_HDC_RESET:** Reset the Spectrometer Data and Hardware Configuration

7. BUILDING BLOCKS

7.1 PHOT_STBY_START: Switch to PHOT_STBY mode

7.1.1 Interface

TBW

7.1.2 Implementation

As already described in Section 3, for all Photometer operations the instrument is expected to be in the PHOT_STBY mode. A possible implementation for switching from the REDY mode to PHOT_STBY mode is as follows:

PHOT_STBY_START: Switch to Photometer Standby Mode		
Command	Description	
DCU: SET_PHOTO_JFET_PWR	Switch on power to the Photometer JFETs	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>ON</i>	<i>12 bit word. Bits set for the JFETs to be switched on</i>	<i>All bits are set, i.e. 'FFF'</i>
Command	Description	
DCU: SET_PHOTO_BIAS_MODE	Stop the bias generator mode	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>MODE</i>	<i>Bias generator mode</i>	<i>Stop</i>
Command	Description	
DCU: SET_PHOTO_BIAS_FREQ	Set the bias generator frequency divider	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>PHOTO_DIVIDER</i>	<i>Frequency divider (Value: 64 to 511)</i>	
Command	Description	
DCU: SET_PHOTO_BIAS_AMPL	Set the sine output amplitude attenuation. This command is repeated for each of the Photometer BDAs and for the Temperature Control (T/C) bolometers	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>CHANNEL ID</i>	<i>Channel to be set 0: P250 BDA 1: P350 BDA 2: P500 BDA 3: T/C bolometers</i>	
<i>ATT</i>	<i>Sine amplitude attenuation (Value: 0 to 255)</i>	
Command	Description	
DCU: SET_PHOTO_DEMOD_PH	Set the demodulation phase for the Photometer BDAs and the T/C bolometers	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>CHANNEL ID</i>	<i>Channel to be set 0: P250 BDA 1: P350 BDA 2: P500 BDA 3: T/C bolometers</i>	
<i>PHASE</i>	<i>Phase: (Value: 0 to 255?)</i>	
Command	Description	
DCU: SET_PHOTO_JFET_VSS	Set the source biasing voltages for the Photometer BDAs. This command is repeated six times for P250, four times for P350 and twice for P500	

<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
CHANNEL ID	Channel to be set 0 to 5: P250 BDA 6 to 9: P350 BDA 10 to 11: P500 BDA	
VSS	Voltage (Value: 0 to 255)	
Command	Description	
MCU: BSM_ON	Switches on the BSM	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
TBD		

- Where does the DCU command SET_PHOTO_HEATER_PWR go in this sequence? What is its full parameter list (apart from the current)?
- Is there a DCU command SET_HEATER_CURRENT in this sequence? (Christophe Cara's DRCU presentation for the SPIRE DPU OBS meeting 31/07-01/08 2001, page 5).

7.2 SPEC_STBY_START: Switch to SPEC_STBY mode

7.2.1 Interface

TBW

7.2.2 Implementation

For all Spectrometer operations the instrument is expected to be in the SPEC_STBY mode. A possible scenario for switching from the instrument REDY mode to the SPEC_STBY mode is as follows.

SPEC_STBY_START: Switch to FTS Standby Mode		
Command	Description	
DCU: SET_SPECTRO_JFET_PWR	Switch on power to the Spectrometer JFETs	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
ON	3 bit word. Bits set for the JFETs to be switched on	All bits are set, i.e. 111
Command	Description	
DCU: SET_SPECTRO_BIAS_MODE	Set the Spectrometer bias generator mode	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
MODE	Bias generator mode	Stop
Command	Description	
DCU: SET_SPECTRO_BIAS_FREQ	Set the Spectrometer bias generator frequency divider	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
SPECTRO_DIVIDER	Frequency divider (Value: 64 to 511)	
Command	Description	
DCU SET_SPECTRO_BIAS_AMPL	Set the sine output amplitude attenuation. This command is executed in turn for the SW array, MW array and the T/C bolometers	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
CHANNEL ID	Channel to be set 0: SW FTS BDA 1: LW FTS BDA 2: T/C bolometers	
ATT	Sine amplitude attenuation (Value: 0 to 255)	
Command	Description	

SET_SPECTRO_DEMOD_PH	Set the demodulation phase for the Spectrometer BDAs and the T/C bolometers	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
CHANNEL ID	Channel to be set 0: SW FTS BDA 1: LW FTS BDA 2: T/C bolometers	
PHASE	Phase: (Value: 0 to 255?)	
Command	Description	
DCU: SET_SPECTRO_JFET_VSS	Set the source biasing voltages for the Spectrometer BDAs. This command is executed twice for the SW FTS array and once for the LW FTS array	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
CHANNEL ID	Channel to be set 0 to 1: SW FTS array 2: LW FTS array	
Command	Description	
MCU: BSM_ON	Switches on the BSM	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
Command	Description	
MCU: SMEC_ON	Switch on the SMEC	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
TBD		
SCU Command	Description	
SCU: SCAL_ON	Switch on the SCAL system (A and B)	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
TBD		

- Where does the DCU command SET_SPECTRO_HEATER_PWR go in this sequence? What is its full parameter list (apart from the current)?
- Is there a corresponding DCU command SET_HEATER_CURRENT for the Spectrometer in this sequence, as implied for the Photometer?

7.3 PHOT_DAQC: Set Photometer Data Acquisition and Configuration

7.3.1 Interface

TBW

7.3.2 Implementation

Building Block: PHOT_DAQC (Photometer DAQ Configuration)		
Command	Description	
DCU: SET_PHOTO_OFFSET	Get DCU to automatically compute offset table for BDAs (to set the dynamic range for each bolometer). The assumption is that this single commands sets the the table for ALL the bolometers.	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
MODE	Offset setting and acquisition mode	Automatic
Command	Description	
DCU: SET_PHOTO_OFFSET	Set the offset acquisition mode to "acquisition test"	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
MODE	Offset setting and acquisition mode	Acquisition test
Command	Description	

DCU: SET_PHOTO_DATA_MODE	Set the frame type for data acquisition	
Parameter	Description	Default value
MODE	Frame type setting	Offset table
Command	Description	
DCU: SET_PHOTO_FRAME_MODE	Send data frame to the DPU	
Parameter	Description	Default value
DIV	Sampling frequency divider (derived from the Photometer bias frequency)	Derived from bias frequency
FRAME	Number of frames to be transferred to the DPU	1
Command	Description	
DCU: SET_PHOTO_OFFSET	Set the offset acquisition mode to "acquisition"	
Parameter	Description	Default value
MODE	Offset setting and acquisition mode	Acquisition
Command	Description	
DCU: SET_PHOTO_DATA_MODE	Set the frame type for data acquisition.	
Parameter	Description	Default value
MODE	Frame type setting	Photometer Full Array (T2)
Command	Description	
DCU: SET_PHOTO_FRAME_MODE	Set the frame type for data acquisition.	
Parameter	Description	Default value
DIV	Sampling frequency divider (derived from the Photometer bias frequency)	Derived from bias frequency
FRAME	Number of frames to be transferred to the DPU	Continuous

- It is assumed here that the above sequence of acquisition and configuration commands can be executed before the DPU explicitly requests BDA data from the DCU. Until that happens there are no BDA data being generated.

7.4 PCAL: Photometer Calibration with PCAL source

This BB includes all commands to the SCU for switching on the PCAL source, performing the Photometer calibration and then switching off the PCAL source. It is intended to monitor system gain or responsivity drifts.

7.4.1 Interface

Building Block	Description	
PCAL	Perform calibration measurement for the Photometer with PCAL.	
Parameters	Description	Default Value
N_{cycles}	Number of calibration cycles to be executed	
Mode	Type of waveform for calibration cycle	
Level	Initial level of PCAL before start of calibration cycles	
Amplitude	Amplitude of PCAL waveform	
N_{SCU}	Number of SCU frames	
P_{SCU}	Time interval between SCU frames	
N_{BDA}	Number of BDA frames	

P_{BDA}	<i>Time interval between BDA frames</i>	
T_{BDA}	<i>Time delay for collecting BDA frames</i>	

- It is expected that the detector data samples will be labelled with the sample number by the DCU.
- How do we select parameters to be sampled from SCU? Can they also be labelled with the sample number within the frame?
- The OBS will have to keep track of the PCAL excitation number.

7.4.2 Implementation

TBW

7.5 CHOP: Chop the BSM while taking BDA Data

7.5.1 Interface

Building Block	Description	
CHOP	Chop the BSM while taking BDA data	
Parameters	Description	Default Value
Y_0	<i>Initial BSM chop position (the "on source" position)</i>	
Y_1	<i>Final BSM chop position (the "off source" position)</i>	
N_{chops}	<i>Number of BSM chop cycles to be performed between y_0 and y_1</i>	
P_{chop}	<i>Period of BSM chop half-cycle, i.e. dwell time at y_0 (or y_1)</i>	
$N_{chopframes}$	<i>Number of BSM chop position frames per chop half-cycle</i>	
$N_{BDAframes}$	<i>Number of BDA frames per chop half-cycle</i>	
$P_{BDAframes}$	<i>Time period between the sampling of successive BDA frames</i>	
T_{BDA}	<i>Time delay between the issuing of the start chopping command and the sampling of BDA frames</i>	

7.5.2 Implementation

TBW

7.6 PSCAN: Take Photometer data while the telescope is scanning

7.6.1 Interface

Building Block	Description	
PSCAN	Take Photometer BDA data while scanning the telescope	
Parameters	Description	Default Value
$N_{BDAframes}$	<i>Number of BDA frames</i>	
$P_{BDAframes}$	<i>Time period between the sampling of successive BDA frames</i>	
T_{BDA}	<i>Time delay between the issuing of PSCAN command and the sampling of BDA frames</i>	

7.6.2 Implementation

TBW

7.7 MCU: BSM_OFF: Switch off the BSM

7.7.1 Interface

Building Block	Description	
MCU: BSM_OFF	Switch off the BSM	
Parameters	Description	Default Value
TBD		

7.7.2 Implementation

TBW

7.8 JIGGLE: Move the BSM to a given Jiggle Position

This is a very simple BB. Its function is to move the BSM to a jiggle position before other building blocks are executed (e.g. CHOP, SPEC_SCAN, etc). The jiggle position could be for any n-point jiggle table (n=7, 16, 25, 32 or 64).

7.8.1 Interface

Building Block	Description	
JIGGLE	Move the BSM to a given jiggle position	
Parameters	Description	Default Value
Y	Y position of the BSM (Chop axis)	TBD
Z	Z position of the BSM (Jiggle axis)	TBD
$T_{Duration}$	Duration of the JIGGLE command - it is the time taken for the BSM to reach the given jiggle position and stabilise	TBD

7.8.2 Implementation

TBW

7.9 SPEC_DAQC: Set Spectrometer Data Acquisition and Configuration

7.9.1 Interface

TBW

7.9.2 Implementation

Building Block: SPEC_DAQC (Set Spectrometer DAQ Configuration)	
Command	Description
DCU: SET_SPECTRO_OFFSET	Get DCU to automatically compute offset table for BDAs (to set the dynamic range for each bolometer). The assumption is that this single command sets the table for ALL the bolometers.

<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>MODE</i>	<i>Offset setting and acquisition mode</i>	<i>automatic</i>
Command	Description	
DCU: SET_SPECTRO_OFFSET	Set the offset acquisition mode to "acquisition test"	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>MODE</i>	<i>Offset setting and acquisition mode</i>	<i>acquisition test</i>
Command	Description	
DCU: SET_SPECTRO_DATA_MODE	Set the frame type for data acquisition	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>MODE</i>	<i>Frame type setting</i>	<i>Offset table</i>
Command	Description	
DCU: SET_SPECTRO_FRAME_MODE	Send data frame to the DPU	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>DIV</i>	<i>Sampling frequency divider (derived from the Spectrometer bias frequency)</i>	<i>Derived from bias frequency</i>
<i>FRAME</i>	<i>Number of frames to be transferred to the DPU</i>	<i>1</i>
Command	Description	
DCU: SET_SPECTRO_OFFSET	Set the offset acquisition mode to "acquisition"	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>MODE</i>	<i>Offset setting and acquisition mode</i>	<i>acquisition</i>
Command	Description	
DCU: SET_SPECTRO_DATA_MODE	Set the frame type for data acquisition.	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>MODE</i>	<i>Frame type setting</i>	<i>Spectrometer Full Array (T2)</i>
Command	Description	
DCU: SET_SPECTRO_FRAME_MODE	Set the frame type for data acquisition.	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>DIV</i>	<i>Sampling frequency divider (derived from the Spectrometer bias frequency)</i>	<i>Derived from bias frequency</i>
<i>FRAME</i>	<i>Number of frames to be transferred to the DPU</i>	<i>Continuous</i>
Command	Description	
DCU: SET_SMEC_MODE	Set the mode of operation for the Spectrometer	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>MODE</i>	<i>Mode: Open loop Closed loop</i>	<i>Closed loop</i>
Command	Description	
DCU: SET_SMEC_POSITION	Set the SMEC position from home	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>SMEC_POS</i>	<i>Distance from home position for start of FTS scan</i>	<i>?</i>
Command	Description	
DCU: SET_SCAN_SPEED	Set the scan speed for the Spectrometer	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>SCAN_SPEED</i>	<i>Speed of scan</i>	
Command	Description	
DCU: SET_SCAN_LENGTH	Set the scan length for the Spectrometer	
<i>Parameter</i>	<i>Description</i>	<i>Default value</i>
<i>SCAN_LENGTH</i>	<i>Length of scan</i>	

- It is assumed here that the above sequence of acquisition and configuration commands can be executed before the DPU explicitly requests BDA data from the DCU. Until that happens there are no BDA data being generated.
- How is the home position found?
- This BB may need to be modified for the step-and-integrate Observatory Functions SOF3 and SOF4.

7.10 SPEC_SCAN: Scan the FTS while taking detector data

7.10.1 Interface

Building Block	Description	
SPEC_SCAN	Scan the FTS while taking data	
Parameters	Description	Default Value
N	Number of FTS scans to be performed	
$N_{SMECframes}$	Number of SMEC position frames per scan	
$N_{BDAframes}$	Number of BDA frames per scan	
$P_{BDAframes}$	Time period between the sampling of successive BDA frames	
T_{BDA}	Time delay between the issuing of the start scanning command and the sampling of BDAs	

7.10.2 Implementation

TBW

7.11 SPEC_STEP: Step the FTS mirror

7.11.1 Interface

Building Block	Description	
SPEC_STEP	Step the FTS mirror to required position	
Parameters	Description	Default Value
N	Number of steps the FTS mirror is to be moved	TBD
Δx	Step size in SMEC units	TBD
T_{SMEC}	Time delay between the issuing of the stepping command and its execution by the SMEC	

7.11.2 Implementation

TBW

7.12 SPEC_PCAL: PCAL for FTS

7.12.1 Interface

This BB is similar to the one used for internally calibrating the Photometer. The intention is to also use the PCAL source for monitoring the FTS responsivity or gain drifts.

NOTE: At present there is no calibration Observatory Function for the FTS in [AD-1].

Building Block	Description	
SPEC_PCAL	Perform PCAL type calibration measurement for the FTS using the PCAL source	
Parameters	Description	Default Value
N_{cycles}	Number of calibration cycles to be executed	
Mode	Type of waveform for calibration cycle	
Level	Initial level of PCAL before start of calibration cycles	
Amplitude	Amplitude of PCAL waveform	
N_{SCU}	Number of SCU frames	
P_{SCU}	Time interval between SCU frames	
N_{BDA}	Number of BDA frames	
P_{BDA}	Time interval between BDA frames	
T_{BDA}	Time delay for collecting BDA frames	

7.12.2 Implementation

TBW

7.13 SCU: SCAL_OFF: Switch off SCAL

7.13.1 Interface

Building Block	Description	
SCU: SCAL_OFF	Switch off SCAL system (A and B)	
Parameters	Description	Default Value
TBD		

- How do we select parameters to be sampled from SCU? Can they also be labelled with the sample number within the frame?

7.13.2 Implementation

TBW

7.14 PHOT_HDC_RESET: Reset Photometer Hardware and Data Configuration

Resets the hardware and data acquisition configuration at the end of an observation with the Photometer.

7.14.1 Interface

TBW

7.14.2 Implementation

TBW

7.15 SPEC_HDC_RESET: Reset Spectrometer Hardware and Data Configuration

Resets the hardware and data acquisition configuration at the end of an observation with the Spectrometer.

7.15.1 Interface

TBW

7.15.2 Implementation

TBW