

SMEI Instrument Commanding Protocol

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1. Introduction

The purpose of this document is to provide an overview of the commanding strategy and available commands for the SMEI data handling unit (DHU). Detailed command formats are given in the 'SMEI Instrument Commanding Specification (SMEI/BU/SPE/002).

This document does not cover mechanisms for transmission of SMEI telemetry to the spacecraft.

2. Commanding Overview

The SMEI instrument has a number of discrete modes of operation. In each mode, only a subset of the available commands are permitted. This provides a measure of protection from software and commanding errors by requiring a multiple command sequence to be sent.

<i>Mode Name</i>	<i>MNEMONIC</i>	<i>Description</i>
COLD START	CS	Used during the boot sequence before applying software patches to the system software.
SAFE	SAFE	Used during emergencies. Entering this mode attempts to close the shutters and reduce SMEI power requirements to a minimum.
CONFIGURE / STANDBY	CONF	Used to select observing and instrument configurations.
OBSERVING	OBS	Data acquisition mode. Camera images are only taken in this mode.
PATCHING	PATCH	Non-volatile storage update mode. Permits the use of commands to modify data in the E ² PROM.

Table 1. Primary Instrument Modes

Commands to the SMEI DHU are supplied over a redundant MILSPEC-1553 bus. All the command blocks are structured with the same two word header, containing the command number, a sequence number, and the command checksum (CRC). The command blocks are all thirty two words in length, and spare words are filled with zeros. This document does not consider the 1553 command words.

SMEI has three sub-addresses for different types of commands from the spacecraft. Sub-address 4 is used for standard commands. These are routine commands to change the instrument configuration, start observations and so forth.

Sub-address 5 is used during spacecraft emergencies to shutdown SMEI rapidly.

Sub-address 6 is used for supplying SMEI with time and attitude information.

3. Command Summary

The table here summarises the available standard commands (set via S/A 4), and shows which modes each command is available in. A brief description of each command is also given. The DHU ignores commands not permitted in the current operating mode.

<i>COMMAND</i>	<i>AVAILABLE MODES</i>					<i>Description</i>
	<i>CS</i>	<i>SAFE</i>	<i>CONF</i>	<i>OBS</i>	<i>PATCH</i>	
SM_ENBL_SAFE	Y		Y	Y	Y	Enable safe mode
SM_GOTO_SAFE	Y		Y	Y	Y	Enter safe mode
SM_ENBL_PTCH	Y		Y			Enable patch mode
SM_GOTO_PTCH	Y		Y			Enter patch mode
SM_GOTO_CONF		Y		Y	Y	Enter configuration mode
SM_GOTO_OBS			Y			Enter observing mode
SM_DHU_COLD	Y					Continue boot sequence

COMMAND	AVAILABLE MODES					Description
	CS	SAFE	CONF	OBS	PATCH	
SM_SYS_CONF	Y		Y			System configuration control
SM_PATCH_UPL					Y	Upload patch data
SM_PATCH_CMT					Y	Write patch data to E ² PROM
SM_PATCH_DEA					Y	Deactivate a code patch
SM_PATCH_ACT					Y	Activate a code patch
SM_THERM_CTRL			Y			Set-up camera thermal control
SM_1_PWR_ON			Y			Switch on camera power relay
SM_1_ICE_OFF			Y			Switch off de-ice heater
SM_1_ICE_ON			Y			Switch on de-ice heater
SM_1_HOP_EN			Y			Enable HOP activation command
SM_1_HOP_TEST			Y			Run a HOP continuity test
SM_1_HOP_ACT			Y			Active the HOP
SM_1_CONF			Y			Load a predefined configuration
SM_1_DYN_CONF			Y			Load a dynamic configuration
SM_1_MOTOR			Y			Change the shutter position
SM_2_PWR_ON			Y			Switch on camera power relay
SM_2_ICE_OFF			Y			Switch off de-ice heater
SM_2_ICE_ON			Y			Switch on de-ice heater
SM_2_HOP_EN			Y			Enable HOP activation command
SM_2_HOP_TEST			Y			Run a HOP continuity test
SM_2_HOP_ACT			Y			Active the HOP
SM_2_CONF			Y			Load a predefined configuration
SM_2_DYN_CONF			Y			Load a dynamic configuration
SM_2_MOTOR			Y			Change the shutter position
SM_3_PWR_ON			Y			Switch on camera power relay
SM_3_ICE_OFF			Y			Switch off de-ice heater
SM_3_ICE_ON			Y			Switch on de-ice heater
SM_3_HOP_EN			Y			Enable HOP activation command
SM_3_HOP_TEST			Y			Run a HOP continuity test
SM_3_HOP_ACT			Y			Active the HOP
SM_3_CONF			Y			Load a predefined configuration
SM_3_DYN_CONF			Y			Load a dynamic configuration
SM_3_MOTOR			Y			Change the shutter position

Table 2. Standard Command Summary

In addition to the standard commands, SMEI recognises a spacecraft emergency command (set via S/A 5), and attempts to make safe the SMEI instrument, and to reduce power consumption to a minimum. This command does not require an enable.

COMMAND	AVAILABLE MODES					Description
	CS	SAFE	CONF	OBS	PATCH	
SM_EMERG_SAFE	Y	Y	Y	Y	Y	Emergency safe mode

Table 3. Emergency Safe Mode

The final 'command' recognised by SMEI contains time and attitude data sent via S/A 6.

COMMAND	AVAILABLE MODES					Description
	CS	SAFE	CONF	OBS	PATCH	
SM_SC_ATT	Y	Y	Y	Y	Y	Provide time and attitude data

Table 4. Time and Attitude Data

4. Detailed Command Descriptions

This section provides details of the parameters taken by each command. A number of the commands are per camera. To reduce the duplication in this section, we replace '1', '2' and '3' with the generic identifier 'x'.

4.1 SM_ENBL_SAFE

This command is used to enable the SM_GOTO_SAFE command. It acts as protection from accidentally shutting down the instrument.

4.2 SM_GOTO_SAFE

This command puts SMEI into safe mode, in preparation for being switched off by the spacecraft. It is only performed if the preceding command is SM_ENBL_SAFE, and they are issued within 60 seconds.

4.3 SM_ENBL_PTCH

This command is used to enable the SM_GOTO_PTCH command. It acts as protection from accidentally entering the E²PROM update mode.

4.4 SM_GOTO_PTCH

This command puts SMEI into patch mode. It is only performed if the preceding command is SM_ENBL_PTCH, and they are issued within 60 seconds.

4.5 SM_GOTO_CONF

This command puts SMEI into configuration mode. This mode is used to change observing parameters.

4.6 SM_GOTO_OBS

This command puts SMEI into observation mode. The camera configurations set in configuration mode are used to configure the CCD electronics, and images acquisition is started.

4.7 SM_DHU_COLD

This command finishes the SMEI boot process and enters configuration mode. The boot process pauses in cold start mode before the system software checks the uploaded software image area of the has any patches applied to it from the -E²PROM. This allows recovery from a corrupted E²PROM image by directly entering patch mode and either disabling or re-uploading a fresh software image.-

4.8 SM_ENBL_SCNF

This command is used to enable the SM_SYS_CONF command. It acts as protection from accidentally changing the global configuration register.

4.9 SM_SYS_CONF

This command provides access to the SMEI instrument global configuration register. This command is used to enable data test modes for interface tests, and tweak internal behaviour for problem diagnosis. The command contains a logical-and mask, and a logical-xor mask. Appropriate use permits individual bits of the SMEI global configuration register to be set, cleared or toggled. It is only performed if the preceding command is SM_ENBL_SCNF, and they are issued within 60 seconds.

4.10 SM_PATCH_UPL

This command supplies 29 words of binary patch data to SMEI. The 29 words are written into an 5 kiloword buffer at the commanded offset. Issuing this command repeatedly permits a complete patch to be uploaded before it is committed to the E²PROM using the SM_PATCH_CMT command.

4.11 SM_PATCH_CMT

This command copies the commanded portion of the patch buffer to the given location in the E²PROM. It is used after a patch has been uploaded by SM_PATCH_UPL to commit the change to the non-volatile store. The SMEI DHU can take longer than 200ms to commit a large patch. This command therefore requires a delay of 5 seconds to be inserted after a commit command before another command is transmitted.

4.12 SM_PATCH_DEA

This command deactivates an uploaded software patch. Software ~~images~~~~patches~~ are committed to a special region in the E²PROM which is reserved for this purpose. This patch sets a flag to ignore a particular patch in the region the checksums used to verify the presence and validity of an uploaded software image to an invalid pattern. This prevents the uploaded software image from being used.

4.13 SM_PATCH_ACT

This command activates an uploaded software patch by writing the commanded software image CRC value to the E²PROM. Software patches are ~~committed to a special region in the E²PROM which is reserved for this purpose~~~~are only loaded if the CRC value is correct.~~ This CRC is calculated using the 16-bit SDLC CRC algorithm.

4.14 SM_THERM_CTRL

This command sets the control temperatures for the three camera cold fingers. It also sets the maximum number of heaters that are permitted to be active at any given point in time. This allows active control of the cold finger temperature to prevent thermal cycling of the cold finger to CCD bonding material.

4.15 SM_x_PWR_ON

This command switches on the power relay for a camera. This enables power to the secondary switching facilities in the DHU, and does not switch on the cameras directly. There is no corresponding off command to avoid a single point failure.

4.16 SM_x_ICE_OFF

This command switches off a de-icing heater override. Note that the active temperature control settings configured using SM_THERM_CTRL have precedence over this command.

4.17 SM_x_ICE_ON

This command enables a de-icing heater for the specified amount of time. The target temperature for the cold finger is also specified, and if the temperature is below that specified, the heater is switched on. Note that this command overrides the global thermal control specified in SM_THERM_CTRL.

4.18 SM_x_HOP_EN

This command enables the SM_x_HOP_ACT command. This serves as protection against accidental activation of the HOP. Note that the camera relay must also be in the ON position for the HOP to be fired.

4.19 SM_x_HOP_TEST

This command is used to test the continuity of the HOP firing circuitry. It switches on the HOP briefly, and allows the instrument power monitor to register the increase in current while the HOP is powered. This command requires that the camera power relay is in the ON position. It does not require SM_x_HOP_EN to have been sent, as a single erroneous transmission of this command will not cause the hop to fire.

4.20 SM_x_HOP_ACT

This command activates the HOP for the specified duration. It is only performed if the SM_x_HOP_EN command was the previous command, and that both are issued within 60 seconds. Note that the camera power relay must be in the ON position for power to be supplied to the HOP.

4.21 SM_x_CONF

This command selects a predefined observation configuration for the camera. It copies the relevant table from the E²PROM.

<u>N</u>	<u>Camera Mode Description</u>	<u>CCD Binning</u>	<u>Rice Comp</u>	<u>ROI Filter</u>	<u>Flat-Field</u>	<u>Shutter Position</u>	<u>FF LED</u>
<u>0</u>	<u>Off</u>	<u>=</u>	<u>=</u>	<u>=</u>	<u>=</u>	<u>Flat Field</u>	<u>Off</u>
<u>1</u>	<u>Standby</u>	<u>=</u>	<u>=</u>	<u>=</u>	<u>=</u>	<u>Flat Field</u>	<u>Off</u>
<u>2</u>	<u>Eng (Default)</u>	<u>1 x 1</u>	<u>On</u>	<u>On</u>	<u>Off</u>	<u>Open</u>	<u>Off</u>
<u>3</u>	<u>Hi-Res (Default)</u>	<u>2 x 2</u>	<u>On</u>	<u>On</u>	<u>On</u>	<u>Open</u>	<u>Off</u>
<u>4</u>	<u>Normal (Default)</u>	<u>4 x 4</u>	<u>On</u>	<u>On</u>	<u>On</u>	<u>Open</u>	<u>Off</u>
<u>5</u>	<u>Normal (Low FF Cal)</u>	<u>4 x 4</u>	<u>On</u>	<u>Off</u>	<u>Off</u>	<u>Open</u>	<u>On</u>
<u>6</u>	<u>Normal (Med FF Cal)</u>	<u>4 x 4</u>	<u>On</u>	<u>Off</u>	<u>Off</u>	<u>Closed</u>	<u>On</u>
<u>7</u>	<u>Normal (High FF Cal)</u>	<u>4 x 4</u>	<u>On</u>	<u>Off</u>	<u>Off</u>	<u>Flat Field</u>	<u>On</u>
<u>8</u>	<u>Eng (Low FF Cal)</u>	<u>1 x 1</u>	<u>On</u>	<u>Off</u>	<u>Off</u>	<u>Open</u>	<u>On</u>
<u>9</u>	<u>Eng (Med FF Cal)</u>	<u>1 x 1</u>	<u>On</u>	<u>Off</u>	<u>Off</u>	<u>Closed</u>	<u>On</u>
<u>10</u>	<u>Eng (High FF Cal)</u>	<u>1 x 1</u>	<u>On</u>	<u>Off</u>	<u>Off</u>	<u>Flat Field</u>	<u>On</u>
<u>11</u>	<u>Eng (Low FF Cal)</u>	<u>1 x 1</u>	<u>On</u>	<u>On</u>	<u>Off</u>	<u>Open</u>	<u>On</u>
<u>12</u>	<u>Eng (Med FF Cal)</u>	<u>1 x 1</u>	<u>On</u>	<u>On</u>	<u>Off</u>	<u>Closed</u>	<u>On</u>
<u>13</u>	<u>Eng (High FF Cal)</u>	<u>1 x 1</u>	<u>On</u>	<u>On</u>	<u>Off</u>	<u>Flat Field</u>	<u>On</u>
<u>14</u>	<u>Hi-Res (No ROI)</u>	<u>2 x 2</u>	<u>On</u>	<u>Off</u>	<u>Off</u>	<u>Open</u>	<u>Off</u>
<u>15</u>	<u>Normal (No ROI)</u>	<u>4 x 4</u>	<u>On</u>	<u>Off</u>	<u>Off</u>	<u>Open</u>	<u>Off</u>

Table 5. Predefined Camera Configurations

Note: 'Off' mode switches off the camera electronics.
'Standby' mode leaves the electronics on but inhibits camera readout.

Mapping of shutter positions against motor coil phases (parameter N in the 'SM X MOTOR N,T' command) is given in table 6.

<u>Shutter Position</u>	<u>Motor Phase</u>		<u>Shutter Monitor</u>
	<u>DHU A</u>	<u>DHU B</u>	
<u>Open</u>	<u>1</u>	<u>3</u>	<u>Open = 1</u>
<u>Closed</u>	<u>2</u>	<u>2</u>	<u>Open = 0</u>
<u>Flat Field</u>	<u>0</u>	<u>0</u>	<u>Open = 0</u>

Table 6. Shutter Position To Motor Phase Relationship

Note: Different motor phases are required for 'Open' position for the two DHUs in order get valid feedback from the shutter position monitor.

Other camera configurations can be set using the 'SM X DYN CONF' command where the thirty words of configuration data D_{00} to D_{29} must be supplied.

4.22 SM_x_DYN_CONF

This command sets the observation configuration for the camera to the uploaded data supplied. This allows test or infrequently used configurations to be configured 'on the fly', without requiring changes to the E²PROM.

4.23 SM_x_MOTOR

This command can be used to manually test the filter wheel stepper motor. The supplied parameters indicate which of the four coils to energise, and the duration. Note that the camera power relay must be in the ON position for power to be switched.

4.24 SM_EMERG_SAFE

This command is issued during emergency conditions. On receipt, SMEI immediately switches off the three cameras, and attempts to sequentially close the shutters, starting with camera 3. for the three cameras. Note that SMEI does not protect this command. It's format is defined in Section C of the Interface Control Document.

4.25 SM_SC_ATT

This command provides the time and attitude solution data to SMEI. The format is defined in Section C of the Interface Control Document.

5. References

SMEI Instrument Command Specification	SMEI/BU/SPE/002
SMEI Instrument Telemetry Specification	SMEI/BU/SPE/004
Coriolis Interface Control Document	CDRL NO. 004