MODULUS – Ptolemy

Ptolemy Mode Description: CASE oven pyrolysis

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CHANGE RECORD

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13 November 2013	Document created	1.0
31 July 2014	TC added to modify oven and transfer pipe power	1.1

TABLE OF CONTENTS

1. Introduction

This document describes the command sequence and operation of Ptolemy Module CASE oven pyrolysis. This module heats the oven containing absorbent material to release trapped comet gas and analyse it for bulk composition as the gas is released.

1.1 Applicable Documents

Ref	Title	Document Number	Issue	Date
AD1	Ptolemy Telecommand and Telemetry Definitions	RO-LPT-RAL-TN-3403	5.1	26 Feb 02
AD2	Ptolemy Operations plan	RO-LPT-OU-PL-3101	4.0	25 Nov 10
AD3	Ptolemy mode description Module E - Channel B (C and N isotopes)	RO-LPT-OU-PL-3134	2.2	05 Nov 13
AD4	Ptolemy Flight Operations Plan for the First Science Sequence	RO-LPT-OU-PL-3147	1.2	06 Nov 13
AD5	Ptolemy Initialisation Description	RO-LPT-OU-PL-3112	1.0	13 Jul 04
AD6	CASE oven power parameter change			

1.2 List of acronyms

AD Applicable Document
CASE Comet Atmosphere Sample Experiment
CSS Chemistry Set Simulator
FM Flight Model
HTO High Temperature Oven
GRM Ground Reference Model
QM Qualification Model
TC Telecommand

2. CASE oven pyrolysis

The HTO#1 (High Temperature Oven) contains an adsorbent material which passively traps volatiles at the low temperatures where it is located on the Lander balcony. The CASE oven pyrolysis module heats the oven to +200°C to release the volatiles. Background measurements of the pressure and gas composition in the mass spectrometer are measured both before and after oven heating. The pressure in the manifolds and mass spectra are acquired during oven heating as the trapped volatiles are released. At the end of the experiment Ptolemy is in a state ready to begin module E (AD3) for carbon and nitrogen isotopic analysis of the released gas with valves V11 and V13 and heaters ENC1 and ENC2 operating. Usually the CASE oven pyrolysis will not be followed by module E in order to preserve resources, in which case Ptolemy can be commanded into Safe mode to switch off the operating components.

The adsorbent material continuously traps volatiles, including volatiles from spacecraft outgassing, until it becomes saturated. These need to be removed before commencing experiments where the cometary volatiles want to be trapped over a known time period. Executing the CASE oven pyrolysis module without the mass spectrometer enabled will remove the trapped volatiles whilst preserving the limited nano-tip lifetime. The amount of volatiles released will be measured by the pressure readings within the manifolds.

2.1 Sequence outline

1. Monitor current on voltage rails for 3 seconds.
2. Heat ENC1 at 80% power and ENC2 at 20% power to maintain temperature. Heat sample inlet pipe at 20% power.
3. Evacuate manifold1 through manifold 2 and Valve-V7.
4. Close Valves V2, V4, V7 and V13. Measure the pressure in the manifolds, pG4 and pG5.
5. Acquire background mass spectra: Switch on the mass spectrometer and perform an RF calibration. Open valves V2, V4 and V13. Acquire 3 mass spectra of WGA7.
6. Reduce power by switching off ENC1&2 before oven heating.
7. Begin heating the oven to +200°C at 70% power. Acquire a mass spectrum every 20 seconds. After the initial 20 seconds reduce the power of the oven to 40%. Total heating time 2 minutes.
8. Switch off Oven and Pipe heaters. Close V2, V4 and V13. Measure pressure in the manifolds, pG4 and pG5. Switch on ENC1 and ENC2.
9. Evacuate gas from manifold 2 and prepare for isotopic measurement of gas in manifold1. Open V7, V11 and V13. Acquire 3 mass spectra of the background gas. Switch off the mass spectrometer and close V7. Open valve V4 and allow gas to expand into manifold2. Close V4, Ptolemy now in a state ready to execute module E (C and N isotopes).
10. Monitor current on voltage rails for 3 seconds.

The detailed Ptolemy sequence is listed in section 4.

2.2 Resources

Start State – All Ptolemy subsystems off
End State – Valves V11 and V13 open. Heaters ENC1 and ENC2 operating.

Subsystems operated:

Valves	V2, V4, V7, V11 and V13
Heaters	ENC1, ENC2, PIPE
Reactors	Roven
Mass spec.	RF calibration, WGA7

Data Volume:

Aux Science packets	3
Spectrum packets	60
Number of spectra	12

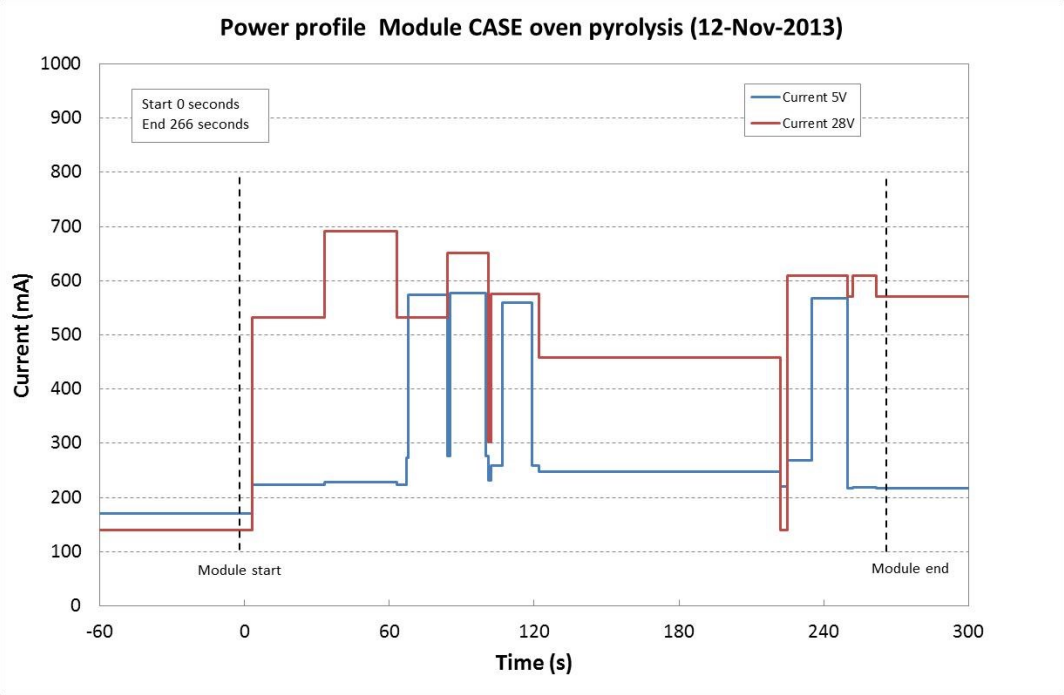
Resources:

Helium used	none
Hydrogen used	none
Oxygen used	none
Reference gas	none
Nano-tip use	1.08 s (90 ms/spectrum)

Power profile Nominal:	5.2V Supply Rail		28V supply rail	
	Current (mA)	Power (W)	Current (mA)	Power (W)
Average	311	1.62	535	14.97
Maximum	559	2.91	704	19.7

Duration 266 s
Total energy 4412 J

Calculated power profile



2.3 Ptolemy Models

A summary of the use of the CASE oven pyrolysis module with the various Ptolemy models is given below.

Model	Use	Power Profile (c.f. FM)	Timing (c.f. FM)	Sensors
FM	Limited	-	-	-
QM	Vacuum	Different	Same	Same
CSS	Any time	Different	Same	Same
GRM	Any time	Different	Same	Same

2.3.1 Flight Model (FM)

The CASE oven pyrolysis module uses the mass spectrometer nano-tips so its use should be limited, however it can be used at any time if the mass spectrometer voltages are not enabled e.g. durung oven conditioning.

2.3.2 Qualification Model (QM)

The CASE oven pyrolysis module uses the mass spectrometer high voltage supplies. It should only be used when the QM is under vacuum. The QM does not have an operating transfer pipe so the power profiles of the QM will be different from the FM.

2.3.3 Chemistry Set Simulator (CSS)

The CASE oven pyrolysis module can be used at any time on the CSS.

2.3.4 Ground Reference Model (GRM)

The CASE oven pyrolysis module can be used at any time on the GRM. There are no high voltage supplies on the GRM.

3. Operation of the Case Oven Pyrolysis module

3.1 Load Ptolemy Memory

In order to operate the CASE oven pyrolysis module, the commands have to be loaded onto Ptolemy EEPROM using the Ptolemy Load Memory TC (AD1). The TCs to upload the module only need to be transmitted once for each Ptolemy instrument, unless a check memory TC indicates that the Ptolemy EEPROM has become corrupted.

Total number of Load memory TCs 10
Number of words 218
Sequence control C7D0 to C7D9
Memory address page 5 offset 7D00 to 7EB2

Load memory CASE oven pyrolysis TC1 of 10

```
1F3C C7D0 0039 1006 0200 9701 0005 7D00
0016 28CE 28D4 28D6 3000 0128 CE28 D428
D630 0001 28CE 28D4 28D6 3000 0114 7103
8C00 C814 7302 12C9 FF14 7503 8C00 1773
```

Load memory CASE oven pyrolysis TC2 of 10

```
1F3C C7D1 0039 1006 0200 9701 0005 7D2C
0016 3228 C028 C228 C428 CE28 9628 9830
000A 28C0 28C2 28C4 28CE 2896 2898 3000
0A28 C028 C228 C428 CE28 9628 9830 431D
```

Load memory CASE oven pyrolysis TC3 of 10

```
1F3C C7D2 0039 1006 0200 9701 0005 7D58
0016 000A 000D 0003 0007 0019 28C0 28C2
28CE 2896 2898 3000 0A28 C028 C228 CE28
9628 9830 000A 28C0 28C2 28CE 2896 E5F5
```

Load memory CASE oven pyrolysis TC4 of 10

```
1F3C C7D3 0039 1006 0200 9701 0005 7D84
0016 2898 3000 0A00 0200 0600 0C00 1830
0001 2896 2898 3000 0128 9628 9830 0001
2896 2898 3000 0145 0330 0001 8230 D243
```

Load memory CASE oven pyrolysis TC5 of 10

```
1F3C C7D4 0039 1006 0200 9701 0005 7DB0
0016 0001 0003 0007 0019 3000 0112 0705
0003 0130 0001 1470 1472 3000 010C 6F07
9133 E130 0005 1207 0500 0101 3000 EB2B
```

Load memory CASE oven pyrolysis TC6 of 10

```
1F3C C7D5 0039 1006 0200 9701 0005 7DDC
0016 030C 6F07 9133 9630 0005 28BE 2896
2898 28CE 1207 0500 0101 3000 0330 0005
28BE 2896 2898 28CE 1207 0500 0101 11EF
```

Load memory CASE oven pyrolysis TC7 of 10

```
1F3C C7D6 0039 1006 0200 9701 0005 7E08
0016 3000 0330 0005 28BE 2896 2898 28CE
1207 0500 0101 3000 0330 0005 28BE 2896
2898 28CE 1207 0500 0101 3000 0330 1B8A
```

Load memory CASE oven pyrolysis TC8 of 10

```
1F3C C7D7 0039 1006 0200 9701 0005 7E34
0016 0005 28BE 2896 2898 28CE 1207 0500
0101 3000 0314 740C 6E00 0200 0600 1830
0001 28BE 2896 2898 28CE 3000 0128 46E1
```

Load memory CASE oven pyrolysis TC9 of 10

```
1F3C C7D8 0039 1006 0200 9701 0005 7E60
0016 BE28 9628 9828 CE30 0001 28BE 2896
2898 28CE 1471 038C 00C8 1473 0212 C9FF
000D 0015 0019 3000 0A12 0705 0003 A16D
```

Load memory CASE oven pyrolysis TC10 of 10

```
1F3C C7D9 0035 1006 0200 9701 0005 7E8C
0014 0144 000C 3000 0200 0730 000A 0006
3000 0128 D428 D630 0001 28D4 28D6 3000
0128 D428 D630 0001 FFFF D0DA
```

3.2 Execution of the CASE oven pyrolysis module

The sequence to execute the CASE oven pyrolysis module in a standalone mode is as follows:

1. Start with Ptolemy switched on and having transmitted the Ptolemy Initialisation TCs.
2. Check Memory CASE oven pyrolysis module
3. Transmit TC to set Ptolemy into Standby mode
4. Transmit TC to enable the relevant Ptolemy subsystems
5. Transmit TC to define module start address
6. Transmit TC to start the CASE oven pyrolysis module
7. Once the CASE oven pyrolysis module has been completed then transmit TC to set Ptolemy into Safe mode

TC: Check Memory Module U

1F3C F160 0019 1006 0900 9703 0005 7D00
0064 0005 7DC8 0064 0005 7E90 0012 8607

The results of the Memory check TC are returned as a Check memory report within a Housekeeping packet.

Memory Address		Number of Words	Expected Checksum
Page	Offset		
0005	7D00	0064	FCBD
0005	7DC8	0064	FB90
0005	7E90	0012	CAC1

TC: Parameter update – define CASE oven pyrolysis module start address

1F3C F180 000D 10C3 0100 1FFE 0002 0005
7D00 C310

Updates parameter 0x200E with two words to define the start address as EEPROM page 5 0x7D00

TC: Start Heating Module (0x7xxx)

1F3C F140 0005 10C1 0800 1520

The TCs listed below were used to execute the CASE oven pyrolysis module on the CSS on 12-Nov-2013 having initialised Ptolemy with Initialisation(3).seq (AD4)

Check memory	1F3C F160 0019 1006 0900 9703 0005 7D00 0064 0005 7DC8 0064 0005 7E90 0012 8607
Start Standby	1F3C C000 000B 10C1 0000 0009 0000 0000 CE64
Hazard enable	1F3C C000 000B 10C2 0100 FFFF FBFF 0070 3239
Update parameter	1F3C F180 000D 10C3 0100 1FFE 0002 0005 7D00 C310
Start module	1F3C F140 0005 10C1 0800 1520
Select Safe mode	1F3C F004 0005 10C1 FF00 C48F

4. CASE oven parameter change

In the first PDCS operation of the CASE mode it was noted that the oven only reached a temperature of +200°C. The Lander Change Request board accepted a change to implement a TC to increase the Oven power. Details of the change are described in AD6

New TC:

1F3C C7DA 0023 1006 0200 9703 0005 7D2C 0001 3C28 0005 7DCE 0002 913D FF30 0005 7DE0 0002 913D FF30 3FEC

The checksum results for the modified CASE sequence are:

Memory Address		Number of Words	Original Checksum	Modified Checksum
Page	Offset			
0005	7D00	0064	FCBD	F2BD
0005	7DC8	0064	FB90	8C90
0005	7E90	0012	CAC1	CAC1

The estimated energy usage of the new sequence is 5183 J

5. Script CASE oven pyrolysis

Script file name: CASE oven pyrolysis (12-Nov-2013)

98 Commands

Time (s)	Command	Comments
3	Loop, , Begin, 3, , Aux Data, AD590, , , , Aux Data, i5V, , , , Aux Data, i28V, , , , Time Delay, , , , 1, Loop, , End, , ,	Monitor current on voltage rails for 3 seconds.
33	Heater (pwm), ENC1, Begin, 100, 0, 200 Heater (pwm), ENC2, Begin, 60, 201, 255 Heater (pwm), PIPE, Begin, 100, 0, 50 Loop, , Begin, 3, , Aux Data, tENC1, , , , Aux Data, tENC2, , , , Aux Data, tPIPE, , , , Aux Data, AD590, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Time Delay, , , , 10, Loop, , End, , ,	Heat ENC1 at 80% power and ENC2 at 20% power to maintain temperature. Heat sample inlet pipe at 20% power.
63	Valve, V7, Open, , , Valve, V2, Open, , , Valve, V4, Open, , , Valve, V13, Open, , , Loop, , Begin, 3, , Aux Data, tENC1, , , , Aux Data, tENC2, , , , Aux Data, AD590, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Time Delay, , , , 10, Loop, , End, , ,	Evacuate manifold1 through manifold 2 and Valve-V7
	Valve, V2, Close, , , Valve, V4, Close, , , Valve, V7, Close, , , Valve, V13, Close, , , Time Delay, , , , 1, Loop, , Begin, 3, , Aux Data, pG4, , , , Aux Data, pG5, , , , Time Delay, , , , 1,	Close Valves V2, V4, V7 and V13. Measure the pressure in the manifolds, pG4 and pG5.

67	Loop, , End, , ,	
101	Set MS, IT 3, On, , , Time Delay, , , , 1, Calibrations, RF Cal., , , , Time Delay, , , , 1, Valve, V2, Open, , , Valve, V4, Open, , , Valve, V13, Open, , , Time Delay, , , , 1, MS Acquire, IT 5, , 7, 3, 1 Time Delay, , , , 1,	Acquire background mass spectra: Switch on the mass spectrometer and perform an RF calibration. Open valves V2, V4 and V13. Acquire 3 mass spectra of WGA7.
102	Heater (pwm), ENC1, End, , , Heater (pwm), ENC2, End, , , Time Delay, , , , 1,	Reduce power by switching off ENC1&2 before oven heating.
222	Reactor, ROven, Begin, 200, 51, 225 Time Delay, , , , 5, MS Acquire, IT 5, , 7, 1, 1 Time Delay, , , , 3, Reactor, ROven, Begin, 200, 51, 150 Loop, , Begin, 5, , Time Delay, , , , 5, Aux Data, tOven, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Aux Data, AD590, , , , MS Acquire, IT 5, , 7, 1, 1 Time Delay, , , , 3, Loop, , End, , ,	Begin heating the oven to +200°C at 70% power. Acquire a mass spectrum every 20 seconds. After the initial 20 seconds reduce the power of the oven to 40%. Total heating time 2 minutes.
225	Heater (pwm), PIPE, End, , , Reactor, ROven, End, , , Valve, V2, Close, , , Valve, V4, Close, , , Valve, V13, Close, , , Loop, , Begin, 3, , Time Delay, , , , 1, Aux Data, tOven, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Aux Data, AD590, , , , Loop, , End, , , Heater (pwm), ENC1, Begin, 100, 0, 200 Heater (pwm), ENC2, Begin, 60, 201, 255	Switch off Oven and Pipe heaters. Close V2, V4 and V13. Measure pressure in the manifolds, pG4 and pG5. Switch on ENC1 and ENC2.
	Valve, V7, Open, , , Valve, V11, Open, , , Valve, V13, Open, , , Time Delay, , , , 10, MS Acquire, IT 5, , 7, 3, 1	Evacuate gas from manifold 2 and prepare for isotopic measurement of gas in manifold1. Open V7, V11 and V13. Acquire 3 mass spectra of the background gas. Switch off the mass spectrometer and

263	Set MS, , Off, , , Valve, V7, Close, , , Time Delay, , , , 2, Valve, V4, Open, , , Time Delay, , , , 10, Valve, V4, Close, , , Time Delay, , , , 1,	close V7. Open valve V4 and allow gas to expand into manifold2. Close V4, Ptolemy now in a state ready to execute module E (C and N isotopes).
266	Loop, , Begin, 3, , Aux Data, i5V, , , , Aux Data, i28V, , , , Time Delay, , , , 1, Loop, , End, , ,	Monitor current on voltage rails for 3 seconds.