MODULUS – Ptolemy

Ptolemy Mode Description: Module C100 – Sample pyrolysis +100ºC

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1. Introduction

This document describes the command sequence and operation of Ptolemy Sample pyrolysis +100ºC Module. The module heats a sample contained in a medium or high temperature oven to +100ºC and it is expected that large amounts of water will be released. The volatiles released are admitted into manifold1. Subsequent modules will analyse the water for oxygen and hydrogen isotopic composition and then remove excess water before analysis for bulk composition and carbon and nitrogen isotopic measurements.

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 Flight Operations Plan for the First Science Sequence	RO-LPT-OU-PL-3147	1.0	24 Aug 13
AD4	Ptolemy Initialisation Description	RO-LPT-OU-PL-3112	1.0	13 Jul 04

2. Sample Pyrolysis +100ºC Module

This module performs the sequence of commands in the special case where the sample is heated to +100ºC and large amounts of water are released. The volatiles are released into manifold1 in preparation for injection onto GC channel C.

2.1 Sequence outline

1. Measure the currents on the 5.2V and 28V voltage rails.
2. Switch on reactor R2 at full power, target temperature+100˚C to remove any water. Switch on both manifold heaters, ENC1 at 80% power (PWM 0-200) target temperature +100˚C and ENC2 at 20% power (PWM 201-255), target temperature +60˚C.
3. Wait 60 seconds, monitor the temperature and pressure in both manifolds. Monitor temperature of R2.
4. Open V3, water from R2 expands into manifold 1.
5. Wait 60 seconds, monitor the temperature and pressure in both manifolds. Monitor temperature of R2.
6. Switch off manifold heaters to ensure maximum current on 28V rail <900mA. Open valves V4 and V7 to evacuate water from R2 and manifold 1 via manifold 2.
7. Wait 60 seconds, monitor the temperature and pressure in both manifolds. Monitor temperature of R2.
8. Switch off R2 and close V3, R2 is now prepared to adsorb water later. Open V2 and V16, any residual gas is evacuated through manifold 2. Switch on ENC1 at full power target temperature +100˚C and the transfer pipe heater at 20% power (PWM 0-50), target temperature +100˚C.
9. Wait 60 seconds, monitor the temperature and pressure in both manifolds. Monitor temperature of R2.
10. Sample heating. Close V4 and V7 so evolved gases will enter manifold 1. Reduce power on ENC1 to 10% (PWM 226-255). Begin heating the sample at 70% power (PWM 51-225). Monitor pressures in manifolds 1 and 2. After 30% 20 seconds reduce power to 30% (PWM 51-125) and increase power of ENC1 to 50% (PWM 126-255). Confolds for atinue monitoring pressure in both manifolds for a further 2 minutes.
11. End of sample heating. Switch off oven and transfer pipe heaters. Increase power on ENC1 to 100% (PWM 0-255) and switch on ENC2 at 50% power (PWM 0-127).
12. Measure temperatures of both manifolds, transfer pipe heater and sample oven. Measure pressure within both manifolds. Measure the currents on the 5.2V and 28V voltage rails.

The detailed Ptolemy sequence is listed in section 4.

At the end of the sequence Ptolemy returns to standby mode and Valve 16 is open and both manifold heaters are operating. Ptolemy will remain in this state until commanded to start the next module or commanded into Safe mode.

2.2 Resources

Start State – All Ptolemy subsystems off
End State – V16 open, ENC1 100% power, ENC2 50% power

Subsystems operated:
Valves: V2, V3, V4, V7, V16
Heaters: PIPE, ENC1, ENC2
Reactors R3, ROven

Data Volume:

Aux Science packets	10
Spectrum packets	0
Number of spectra	0

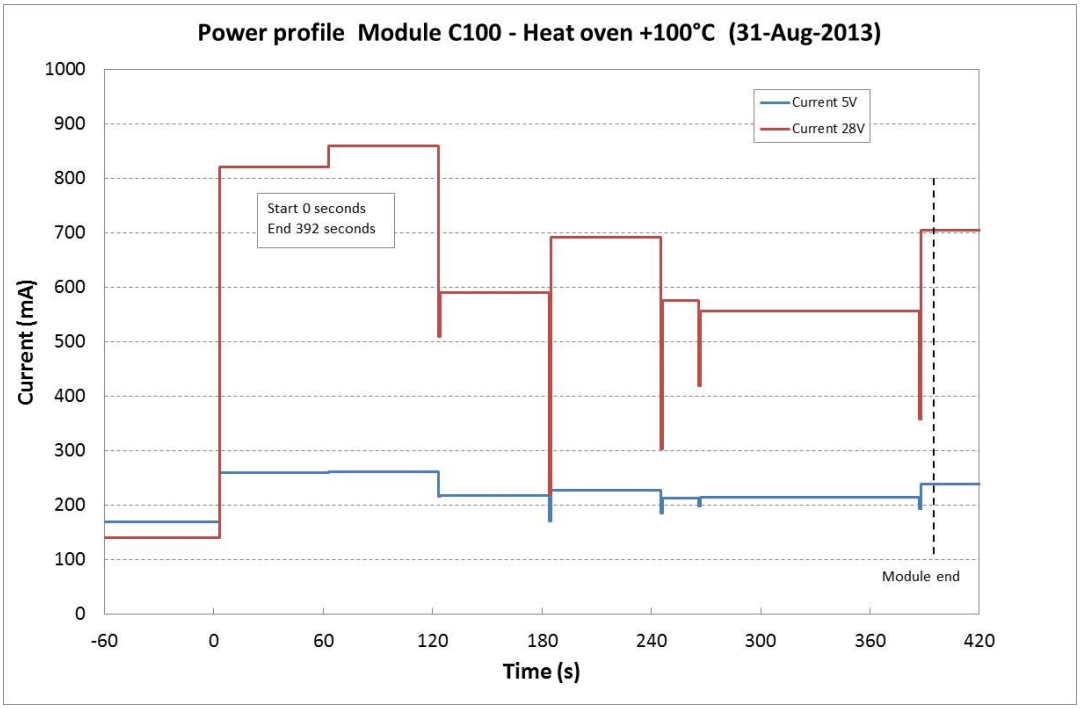
Resources:

Helium used	none
Hydrogen used	none
Oxygen used	none
Reference gas	none
Nano-tip use	none

Power profile Nominal:	5.2V Supply Rail		28V supply rail	
	Current (mA)	Power (W)	Current (mA)	Power (W)
Average	231	1.20	666	18.65
Maximum	260	1.35	820	22.96

Duration 392 s
Total energy 7782 J

Calculated power profile



2.3 Ptolemy Models

A summary of the use of Module C100 – Sample pyrolysis +100°C with the various Ptolemy models is given below.

Model	Use	Power Profile (c.f. FM)	Timing (c.f. FM)	Sensors
FM	Any time	-	-	-
QM	Any time	Same, except no transfer pipe heater	Same	Same
CSS	Any time	Different	Same	Pressure sensors and heater different
GRM	Any time	Different	Same	Pressure sensors and heater different

2.3.1 Flight Model (FM)

Module C100 – Sample pyrolysis +100°C does not use any limited resources and as such can be operated as many times as allowed by the power and data budget.

2.3.2 Qualification Model (QM)

Module C100 – Sample pyrolysis +100°C can be used on the Ptolemy QM whilst it is in air or in Vacuum. There is a difference with the power profile as the transfer pipe isn't connected on the QM.

2.3.3 Chemistry Set Simulator (CSS)

Module C100 – Sample pyrolysis +100°C can be used on the CSS at any time. The timings should be the same as for the FM. As thermal properties of the heater simulators are different from the FM, the power profile will be different from the FM. The CSS does not simulate gas flow in the manifolds, so the pressure sensors will not give the same results as the FM.

2.3.4 Ground Reference Model (GRM)

Module C100 – Sample pyrolysis +100°C can be used on the GRM at any time. The timings should be the same as for the FM. As thermal properties of the heater simulators are different from the FM, the power profile will be different from the FM. The GRM does not simulate gas flow, so the pressure sensors will not give the same results as the FM

3. Operation of the Module C100 – Sample pyrolysis +100°C

3.1 Load Ptolemy Memory

In order to operate the Sample pyrolysis +100ºC 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 19
Number of words 409
Sequence control C740 to C752
Memory address page 5 offset 7400 to 7730

Load memory Module C100 – Sample pyrolysis +100°C TC1 of 19

```
1F3C C740 0039 1006 0200 9701 0005 7400
0016 28D4 28D6 3000 0128 D428 D630 0001
28D4 28D6 3000 010C 5303 8C00 FF14 7103
8C00 C814 7302 12C9 FF28 A228 C028 3C06
```

Load memory Module C100 – Sample pyrolysis +100°C TC2 of 19

```
1F3C C741 0039 1006 0200 9701 0005 742C
0016 C228 CE28 9628 9830 000A 28A2 28C0
28C2 28CE 2896 2898 3000 0A28 A228 C028
C228 CE28 9628 9830 000A 28A2 28C0 1DD7
```

Load memory Module C100 – Sample pyrolysis +100°C TC3 of 19

```
1F3C C742 0039 1006 0200 9701 0005 7458
0016 28C2 28CE 2896 2898 3000 0A28 A228
C028 C228 CE28 9628 9830 000A 28A2 28C0
28C2 28CE 2896 2898 3000 0A00 0528 78E5
```

Load memory Module C100 – Sample pyrolysis +100°C TC4 of 19

```
1F3C C743 0039 1006 0200 9701 0005 7484
0016 A228 C028 C228 CE28 9628 9830 000A
28A2 28C0 28C2 28CE 2896 2898 3000 0A28
A228 C028 C228 CE28 9628 9830 000A 589B
```

Load memory Module C100 – Sample pyrolysis +100°C TC5 of 19

```
1F3C C744 0039 1006 0200 9701 0005 74B0
0016 28A2 28C0 28C2 28CE 2896 2898 3000
0A28 A228 C028 C228 CE28 9628 9830 000A
28A2 28C0 28C2 28CE 2896 2898 3000 97AB
```

Load memory Module C100 – Sample pyrolysis +100°C TC6 of 19

```
1F3C C745 0039 1006 0200 9701 0005 74DC
0016 0A14 7014 7230 0001 0007 000D 28A2
28C0 28C2 28CE 2896 2898 3000 0A28 A228
C028 C228 CE28 9628 9830 000A 28A2 CB43
```

Load memory Module C100 – Sample pyrolysis +100°C TC7 of 19

```
1F3C C746 0039 1006 0200 9701 0005 7508
0016 28C0 28C2 28CE 2896 2898 3000 0A28
A228 C028 C228 CE28 9628 9830 000A 28A2
28C0 28C2 28CE 2896 2898 3000 0A28 B51E
```

Load memory Module C100 – Sample pyrolysis +100°C TC8 of 19

```
1F3C C747 0039 1006 0200 9701 0005 7534
0016 A228 C028 C228 CE28 9628 9830 000A
0C52 0004 3000 0100 1F00 0314 7103 8C00
FF14 7503 8C00 3228 A228 C028 C228 3171
```

Load memory Module C100 – Sample pyrolysis +100°C TC9 of 19

```
1F3C C748 0039 1006 0200 9701 0005 7560
0016 C428 CE28 9628 9830 000A 28A2 28C0
28C2 28C4 28CE 2896 2898 3000 0A28 A228
C028 C228 C428 CE28 9628 9830 000A 3E87
```

Load memory Module C100 – Sample pyrolysis +100°C TC10 of 19

```
1F3C C749 0039 1006 0200 9701 0005 758C
0016 28A2 28C0 28C2 28C4 28CE 2896 2898
3000 0A28 A228 C028 C228 C428 CE28 9628
9830 000A 28A2 28C0 28C2 28C4 28CE 8753
```

Load memory Module C100 – Sample pyrolysis +100°C TC11 of 19

```
1F3C C74A 0039 1006 0200 9701 0005 75B8
0016 2896 2898 3000 0A00 0C00 0614 7103
8CE2 FF30 0001 0C6F 038C 33E1 28BE 2896
2898 28CE 3000 0228 BE28 9628 9828 D3B8
```

Load memory Module C100 – Sample pyrolysis +100°C TC12 of 19

```
1F3C C74B 0039 1006 0200 9701 0005 75E4
0016 CE30 0002 28BE 2896 2898 28CE 3000
0228 BE28 9628 9828 CE30 0002 28BE 2896
2898 28CE 3000 0228 BE28 9628 9828 C140
```

Load memory Module C100 – Sample pyrolysis +100°C TC13 of 19

```
1F3C C74C 0039 1006 0200 9701 0005 7610
0016 CE30 0002 28BE 2896 2898 28CE 3000
0228 BE28 9628 9828 CE30 0002 28BE 2896
2898 28CE 3000 0228 BE28 9628 9828 0074
```

Load memory Module C100 – Sample pyrolysis +100°C TC14 of 19

```
1F3C C74D 0039 1006 0200 9701 0005 763C
0016 CE30 0002 0C6F 038C 337D 3000 0114
7103 8C7E FF28 BE28 9628 9828 CE30 000A
28BE 2896 2898 28CE 3000 0A28 BE28 5B9A
```

Load memory Module C100 – Sample pyrolysis +100°C TC15 of 19

```
1F3C C74E 0039 1006 0200 9701 0005 7668
0016 9628 9828 CE30 000A 28BE 2896 2898
28CE 3000 0A28 BE28 9628 9828 CE30 000A
28BE 2896 2898 28CE 3000 0A28 BE28 E07B
```

Load memory Module C100 – Sample pyrolysis +100°C TC16 of 19

```
1F3C C74F 0039 1006 0200 9701 0005 7694
0016 9628 9828 CE30 000A 28BE 2896 2898
28CE 3000 0A28 BE28 9628 9828 CE30 000A
28BE 2896 2898 28CE 3000 0A28 BE28 EE3C
```

Load memory Module C100 – Sample pyrolysis +100°C TC17 of 19

```
1F3C C750 0039 1006 0200 9701 0005 76C0
0016 9628 9828 CE30 000A 28BE 2896 2898
28CE 3000 0A14 740C 6E00 0230 0001 1471
038C 00FF 1473 0212 0080 3000 0128 5B8F
```

Load memory Module C100 – Sample pyrolysis +100°C TC18 of 19

```
1F3C C751 0039 1006 0200 9701 0005 76EC
0016 A228 C028 C228 BE28 C428 CE28 9628
9828 D428 D630 0001 28A2 28C0 28C2 28BE
28C4 28CE 2896 2898 28D4 28D6 3000 6615
```

Load memory Module C100 – Sample pyrolysis +100°C TC19 of 19

```
1F3C C752 0027 1006 0200 9701 0005 7718
000D 0128 A228 C028 C228 BE28 C428 CE28
9628 9828 D428 D630 0001 FFFF 9BE3
```

3.2 Execution of Module C100 – Sample pyrolysis +100°C

The sequence to execute Module C100 – Sample pyrolysis +100°C in a Standalone mode is as follows:

1. Start with Ptolemy switched on and having transmitted the Ptolemy Initialisation TCs
2. Check Memory Module C100
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 Begin Sample pyrolysis +100°C module
7. Once the Sample pyrolysis +100°C module has been completed then transmit TC to set Ptolemy into Safe mode

TC: Check Memory Module C100

```
1F3C F102 0025 1006 0900 9705 0005 7400
0064 0005 74C8 0064 0005 7590 0064 0005
7658 0064 0005 7720 0009 E2AB
```

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	7400	0064	B884
0005	74C8	0064	9683
0005	7590	0064	AD3D
0005	7658	0064	DFD3
0005	7720	0009	47CE

TC: Parameter update – define Module C100 start address

```
1F3C F122 000D 10C3 0100 1FFE 0002 0005
7400 FD57
```

Updates parameter 0x1FFE with two words to define the start address as EEPROM page 5 0x7400

TC: Start Module C100 – Sample pyrolysis +100°C

```
1F3C F142 0005 10C1 0800 75C3
```

The TCs listed below were used to execute Module A on the CSS on 05-Sep-2013 having initialised Ptolemy with Initialisation(3).seq (AD4)

Check memory	1F3C F102 0025 1006 0900 9705 0005 7400 0064 0005 74C8 0064 0005 7590 0064 0005 7658 0064 0005 7720 0009 E2AB
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 F122 000D 10C3 0100 1FFE 0002 0005 7400 FD57
Start Module C100	1F3C F142 0005 10C1 0800 75C3
Select Safe mode	1F3C F004 0005 10C1 FF00 C48F

4. Script Module C100 – Sample pyrolysis +100°C

Script file name: Module C100 - Pyrolysis 100 deg C (31-Aug-2013)

100 Commands

Time (s)	Command	Comments
3	Loop, , Begin, 3, , Aux Data, i5V, , , , Aux Data, i28V, , , , Time Delay, , , , 1, Loop, , End, , ,	Duration 3 seconds Measure currents on 5.2V and 28V voltage rails.
3	Reactor, R2, Begin, 100, 0, 255 Heater (pwm), ENC1, Begin, 100, 0, 200 Heater (pwm), ENC2, Begin, 60, 201, 255	Switch on reactor R2 at full power, target temperature+100°C to remove any water. Switch on both manifold heaters, ENC1 at 80% power (PWM 0-200) target temperature +100°C and ENC2 at 20% power (PWM 201-255), target temperature +60°C.
63	Loop, , Begin, 6, , Aux Data, tR2, , , , Aux Data, tENC1, , , , Aux Data, tENC2, , , , Aux Data, AD590, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Time Delay, , , , 10, Loop, , End, , ,	Wait 60 seconds, monitor the temperature and pressure in both manifolds. Monitor temperature of R2
63	Valve, V3, Open, , ,	Open V3, water from R2 expands into manifold 1.
123	Loop, , Begin, 6, , Aux Data, tR2, , , , Aux Data, tENC1, , , , Aux Data, tENC2, , , , Aux Data, AD590, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Time Delay, , , , 10, Loop, , End, , ,	Wait 60 seconds, monitor the temperature and pressure in both manifolds. Monitor temperature of R2.
124	Heater (pwm), ENC1, End, , , Heater (pwm), ENC2, End, , , Time Delay, , , , 1, Valve, V4, Open, , , Valve, V7, Open, , ,	Switch off manifold heaters to ensure maximum current on 28V rail <900mA. Open valves V4 and V7 to evacuate water from R2 and manifold 1 via manifold 2.
	Loop, , Begin, 6, , Aux Data, tR2, , , , Aux Data, tENC1, , , , Aux Data, tENC2, , , ,	Wait 60 seconds, monitor the temperature and pressure in both manifolds. Monitor temperature of R2.

184	Aux Data, AD590, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Time Delay, , , , 10, Loop, , End, , ,	
185	Reactor, R2, End, , , Valve, V3, Close, , , Time Delay, , , , 1, Valve, V16, Open, , , Valve, V2, Open, , , Heater (pwm), ENC1, Begin, 100, 0, 255 Heater (pwm), PIPE, Begin, 100, 0, 50	Switch off R2 and close V3, R2 is now prepared to adsorb water later. Open V2 and V16, any residual gas is evacuated through manifold 2. Switch on ENC1 at full power target temperature +100°C and the transfer pipe heater at 20% power (PWM 0-50), target temperature +100°C.
245	Loop, , Begin, 6, , Aux Data, tR2, , , , Aux Data, tENC1, , , , Aux Data, tENC2, , , , Aux Data, tPIPE, , , , Aux Data, AD590, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Time Delay, , , , 10, Loop, , End, , ,	Wait 60 seconds, monitor the temperature and pressure in both manifolds. Monitor temperature of R2.
387	Valve, V7, Close, , , Valve, V4, Close, , , Heater (pwm), ENC1, Begin, 100, 226, 255 Time Delay, , , , 1, Reactor, ROven, Begin, 100, 51, 225 Loop, , Begin, 10, , Aux Data, tOven, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Aux Data, AD590, , , , Time Delay, , , , 2, Loop, , End, , , Reactor, ROven, Begin, 100, 51, 125 Time Delay, , , , 1, Heater (pwm), ENC1, Begin, 100, 126, 255 Loop, , Begin, 12, , Aux Data, tOven, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Aux Data, AD590, , , , Time Delay, , , , 10, Loop, , End, , ,	Sample heating. Duration 142 seconds. Close V4 and V7 so evolved gases will enter manifold 1. Reduce power on ENC1 to 10% (PWM 226-255). Begin heating the sample at 70% power (PWM 51-225). Monitor pressures in manifolds 1 and 2. After 30% 20 seconds reduce power to 30% (PWM 51-125) and increase power of ENC1 to 50% (PWM 126-255). Continue sample heating and monitoring pressure in both manifolds for a further 2 minutes.
	Heater (pwm), PIPE, End, , , Reactor, ROven, End, , ,	End of sample heating. Switch off oven and transfer pipe heaters.

389	Valve, V2, Close, , , Time Delay, , , , 1, Heater (pwm), ENC1, Begin, 100, 0, 255 Heater (pwm), ENC2, Begin, 60, 0, 128 Time Delay, , , , 1,	Close V2. Increase power on ENC1 to 100% (PWM 0-255) and switch on ENC2 at 50% power (PWM 0-127).
392	Loop, , Begin, 3, , Aux Data, tR2, , , , Aux Data, tENC1, , , , Aux Data, tENC2, , , , Aux Data, tOven, , , , Aux Data, tPIPE, , , , Aux Data, AD590, , , , Aux Data, pG4, , , , Aux Data, pG5, , , , Aux Data, i5V, , , , Aux Data, i28V, , , , Time Delay, , , , 1, Loop, , End, , ,	Measure temperatures of both manifolds, transfer pipe heater and sample oven. Measure pressure within both manifolds. Measure the currents on the 5.2V and 28V voltage rails.