COPS Instrument Modes

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List of Abbreviations

COPS	Comet Pressure Sensor
DPU	Digital Processing Unit
FM	Flight Model
HK	Housekeeping
ROSINA	Rosetta Orbiter Spectrometer for Ion and Neutral Analysis
S/C	Space Craft
TBD	To Be Defined
TBC	To Be Confirmed

1 Scope

The Comet Pressure Sensor will measure the ambient total pressure as well as the comet ram pressure. These two quantities can be used to derive the speed and the Mach number of the cometary gas. COPS will also serve as a pressure monitor for safety purposes. It will distribute the total pressure to all Rosetta instruments.
This document contains the COPS instrument modes and measurement sequences.

1.1 Reference documents

N°	Institution	Document Title	Reference	Issue
[1]	UoB	EID-B: ROSETTA-Rosina Experiment Interface Document	RO-EST-RS3013/EID B	Issue 1, Rev. 0 15-01-1999
[1]	UoB	Rosina Users Manual	RO-ROS-MAN-1007 prepared by Kathrin Altwegg	Draft 2, Rev. 0 19-09-2000

1.2 Introduction

The Comet Pressure Sensor (COPS) consists of two gauges. The first gauge called “nude gauge” measures the total pressure (more exactly the density) of the comet gas. The second called the “ram gauge” measures the ram pressure (equivalent to the comet gas flux). The nude gauge uses filaments to emit electrons and to ionize the gas, the ram gauge uses microtip arrays.

2 COPS Modes and measurement sequences

COPS Instrument Parameters Settings

Channel	NUDe gauge	
	RAM gauge	
	BOTh	
Task	NONe	
	AMBient	
	OFfSet	
	OPTimization	
Emission	EMIssion{ Fil, Mic, I_F, I_M }	
Data acquisition	ALGorithm{A}	

3 Explanations of the COPS Parameters

To measure the pressure, COPS can work with the both gauges (nude and ram gauges) or just one.

3.1 Channel

The NUDe gauge mode is used for monitoring purposes. In case there is not enough power available the RAM gauge mode (which uses less power) can also be used for monitoring, however the result is somewhat less precise. The mode BOTh is the science mode of COPS. From this mode only the gas dynamics can be derived.

3.2 Task

AMBient means that the instrument measures the cometary (asteroidal) ambient pressure.
OFfSet is the measurement of the offsets of one or both gauges.
OPTimization means that the instrument performs a routine to find automatically the best configuration (emission range and electrometer range) to have the best pressure precision.
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EMIssion means that the COPS set up the voltages to have the specified emission.
The parameters that set the emission current and the active emitter(s) are:
- Fil (1bit): 0 for left filament or 1 for right filament active.
- Mic (8 bits): Microtip group status
  - Bit 1: Mic 1 status (0 = disable, 1=enable)
  - Bit 2: Mic 2 status (0 = disable, 1=enable)
  - Bit 3: Mic 3 status (0 = disable, 1=enable)
  - Bit 4: Mic 4 status (0 = disable, 1=enable)
  - Bit 5: Mic 5 status (0 = disable, 1=enable)
  - Bit 6: Mic 6 status (0 = disable, 1=enable)
  - Bit 7: Mic 7 status (0 = disable, 1=enable)
  - Bit 8: Mic 8 status (0 = disable, 1=enable)

The current levels (parameters I_I and I_M) set the filament and the microtip(s) emission.
- I_I (0-3): emission filament to 0, 5, 15, 100µA

I_M (0-3):: emission microtip(s) to 0, 5, 15, 100µA

3.3 Data acquisition

Algorithm indicates which method used the DPU to calculate the ambient pressure (TBD).

4 Example of COPS Modes

The numbering of the Mode used the following last digits (combination of channel and task):
0: General for COPS Instrument / DPU action modes
1: NUD, OFS
2: NUD, AMB
3: NUD, OPT

4: RAM, OFS
5: RAM, AMB
6: RAM, OPT
7: BOT, OFS
8: BOT, AMB
9: BOT, OPT

The numbering should be arranged as follows:
0 to 49: Basic modes for switch on/off
49 to 99: Basic offset modes
100 to 299: Basic optimization modes
300 to 399: Basic emission modes
400 to 499: Standard survey modes
500 to 599: Basic conditioning modes
600 to 999: Custom modes

M57:
Mode (BOT, OFS, EMI(0,0,0,0)
In this mode the instrument would check the offsets level of both gauges.

M106:
Mode (RAM, OPT , EMI{0,15,0,0})
In this mode the instrument would be optimized, the emission and ion range of the Ram gauge (all microtips on) would automatically be set for the best pressure precision.

M339:
Mode (BOT, AMB, EMI {1,3,3,3})
In this mode the instrument would step up the filament 1 emission to 100μA and the microtips 1 and 2 emission also to 100μA.

M402:
Mode (NUD, AMB, EMI {0,0,1,0}
In this mode, the nude gauge measures the ambient pressure with an emission of 5 μA

5 Power Consumption

The power consumption of COPS is composed of two main components, namely of the standby power (low voltage converters and main controller), and of the filament. The power used by the microtips can be neglected. The following table shows the two contributions:

	Power (W)
Standby mode (LVPS, MC)	4.5
Filament	2

- Not run in parallel to analyzer part, filament or cover motor

The power used in each mode can therefore be calculated. A normal measurement mode with microtips needs 4.5 W; with the filament 6.5 W.

6 Example of COPS measurement sequences

Standard monitoring sequence

Step no	Mode	Description	Time
10	M0	COPS on	0.5min
20	M1	Nude gauge 12 V on	1 min
30	M51	Offset measurement 5min	
40	M333	filament emission to 100µA (2h)	120min
50	go to 30		

Standard science mode

Step no	Mode	Description	Time
10	M0	COPS on	0.5min
20	M7	Ram and nude gauge 12 V on	1 min
30	M57	Offset measurement	5min
40	M107	Optimization	10 min
50	M329	filament emission to 15µA (2h)	120min
60	go to 30		

7 Tabels necessary to run COPS autonomously

To calculated the pressure, the DPU use the following formula:

For the nude gauge:

$$\mathrm{p(mbar)_{NG}} = \frac{(\mathrm{Ion\_current_{fil}(A)} - \mathrm{Ion\_offset_{fil}(A)})}{(\mathrm{Immission\_current_{fil}(A)} - \mathrm{Immission\_offset_{fil}(A)}) \cdot \mathrm{S_{NG}}}$$

For the ram gauge:

$$p(\text{mbar})_{RG} = \frac{(\text{Ion\_current}_{mic}(A) - \text{Ion\_offset}_{mic}(A))}{(\text{Immission\_current}_{mic}(A) - \text{Immission\_offset}_{mic}(A)) \cdot S_{RG}}$$

The Ion offset value is measured in background mode.
S is the calibration factor, it is about 30 for the nude gauge and 5 for the ram gauge.
This factor depends of the temperature and the ambient gas.

Flux formula for the Ram gauge:

$$\text{phi\_out} = 0.25 * \sqrt{\frac{8 \cdot kB \cdot T\_RG}{\pi \cdot \text{mass}}} * \frac{p\_RG}{T\_RG * kB}$$

phi_out = gas flux [$1/m^2*s$]
kB = Boltzmann-constant = $1.38e^{-23}$ [J/K]
T_RG = ram gauge temp. [K]
mass = 18 amu = $2.9889e^{-26}$ [Kg] (H_2o is the default mass)
p_RG = ram pressure [Pa] = 100*[$p(\text{mbar})_{RG}$]

7.1 Calibration factor Table

*Formula or table (TBD)

S_RG Value	S_NG Value	Temperature [°C]	Gas	Emission	Remark
4.5	29	0			
5	30	20	N_2	10 uA	Default S_RG and S_NG Values
5.1	31	40			
5.6	34	…	N_2		
…	…		H_2O		
			CO_2	10 uA	
			…	100 uA	
			…	…	

Note:
The default gas is N_2 (first pressure measurement).
The S_RG/NG Gas table element will be optimized after a measurement of the DFMS or RTOF (TBD).

7.2 Table of General settings

In this table are the parameter values in function of the mode.

Table Legend:
- x : means that the value is defined by the last mode
- Y: means that it is possible to have an update of this value (Optimization modes)

	Mode	Nude gauge			Ram gauge			Emitter(s)	Remark
-	-	Filament current limit	Filament Anode Grid V	Filament Regulation value / Range	Microtips current limit	microtips Anode Grid V	Microtips Regulation value / Range	Microtips-Arrays / Filament	-
Switch on/off	M0	-	-	-	-	-	-	-	COPS on, 28V
	M1	0	0	0	-	-	-	-	Nude gauge on, +/-12V filament
	M4	-	-	-	0	0	0	-	Ram gauge on, +/-12V microtips
	M7	0	0	0	0	0	0	-	Nude & Ram gauge on, +/-12V
Offset	M51	0	180V	0	-	-	-	F: x	Filament offset
	M54	-	-	-	0	180V	0	M: x	Microtips offset
	M57	0	180V	0	0	180V	0	F & M: x	Fil. & Microtips offset
	…								
Optimization	M101	x	x	Y	-	-	-	F : x	Filament optimization
	M104	-	-	-	x	x	Y	M: x	Microtips optimization
	M107	X	X	Y	x	x	Y	F & M: x	Fil. & Microtips optimization
Measureme	M312	0.85A	180V	5uA /LR	-	-	-	F: 1 (left)	Mode(NUD,AMB, EMI{1,0,2,0})
	M322	0.9A	180V	15uA /LR	-	-	-	F: 1 (left)	Mode(NUD, AMB, EMI{1,0,2,0})

	M332	1A	180V	100uA /HR	-	-	-	F: 1	Mode(NUD, AMB, EMI{1,0,3,0})
	…								
	M316	-	-	-	0.15A	180V	5uA /LR	M: 1	Mode(RAM, AMB, EMI{0,1,0,1})
	M326	-	-	-	0.2A	180V	15uA /LR	M: 1	Mode(RAM, AMB, EMI{0,1,0,2})
	M336	-	-	-	0.25A	180V	100uA /HR	M: 1	Mode(RAM, AMB, EMI{0,1,0,3})
	M319	0.8A	180V	5uA /LR	0.15A	180V	5uA /LR	F: 1 M: 1	Mode(BOT, AMB, EMI{1,1,1,1})
	M329	0.9A	180V	15uA /LR	0.2A	180V	15uA /LR	F: 1 M: 1	Mode(BOT, AMB, EMI{1,1,2,2})
	M339	1A	180V	100uA /HR	0.25A	180V	100uA /HR	F: 1 M: 1	Mode(BOT, AMB, EMI{1,1,3,3})
	…								
	M399	1A	180V	100uA /HR	0.2A	180V	15uA /LR	F: 1 M: 1	Mode(BOT, AMB, EMI{1,1,3,1})
	…								
	M339	1A	180V	100uA /HR	0.25A	180V	100uA /HR	F: 1 M: 1 & 2	Mode(RAM, AMB, EMI{1,3,3,3})
	M519	TBC	180V	1A /HR	TBC	180V	1A TBD /HR	F: 1 M: 1	Mode(BOT,COND{1,3}), slowly stepped upwards
	…								