HERSCHEL - SPIRE

SMECm FM - Performance test report

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1 Scope of the document

This document is the SMECm FM performance test report.
The tests were carried out at LAM between the 29th June and the 10th July 2006.

2 Documents

2.1 Applicable Documents

	Title	Author	Reference	Date

2.2 Reference Documents

	Title	Author	Reference	Date

3 Test configuration

The mechanism is supposed to be in normal conditions, in flight or, if on the ground, horizontal (Y along or opposite to gravity)

3.1 SMECm FM

The mechanism was in its deliverable configuration except that:

- the accelerometers used for the cryogenic vibrations were still mounted
- the harnesses linked to the preamplifier board and the actuator (J29 and J30) were not shielded

The mechanism position was upwards i.e. +Y opposite to gravity.
The mechanism is not perfectly horizontal so that its natural rest position is at about X=10 mm. This ensures that it is completely out of all the mechanical stops if high transient temperature rates are desired.

3.2 MCU

The MCU model used was the ½ QM2.
This model had been upgraded to the delivered QM2 level as far as the MAC, SMEC and BSM boards are concerned. The BSM board was not used during the tests.
The backplane board had not been upgraded.
Only one set of boards is mounted in this model.

3.3 Cables

The four SMECm connectors were plugged to four cryostat internal cables.
The four cryostat internal cables were plugged to four feedthroughs.
The four feedthroughs were plugged to four cryostat external cables.
According to the channel to be tested, 2 of the four cryostat external cables were plugged to the MCU harness.

3.4 Test set-up

The SMECm is mounted inside the LASCO vacuum chamber.
The cold source is a SUMITOMO cryogenerator, the screens are cooled via another cryogenerator and a third cryogenerator is used for secondary pumping.

The cryogenerators generates high levels of vibrations inside the chamber, not compatible with a nominal operation of the SMECm.
Thus, when necessary, all the cryogenerators were shut off to achieve a quiet environment for performance tests of the SMECm.
During a shut off of the cryogenerators, the base plate temperature of the SMECm rises from about 6K to 20K in about 15 mn, while the pressure rises from a few 10^{-7} mbar to a few 10^{-5} mbar.
When the cryogenerators are shut off, the autonomy of the installation is about 15 to 20 minutes after which all the cryogenerators must be switched on again to get back to a proper level of vacuum and temperature.

4 Parameters intrinsic to SMECm FM

This chapter is dedicated to the parameters which are not dependent on the MCU model, on the SMECm temperature (except when noted) or on the SMECm position.

4.1 SMEC travel

The travel is counted from the X=0 mechanical stop.
The mechanical travel at 300K is 39.89 mm
The mechanical travel at 4K is 39.73 mm
To prevent a control problem when the control loop is closed, the scientific travel is limited to 0.1mm less than the mechanical travel at both ends:

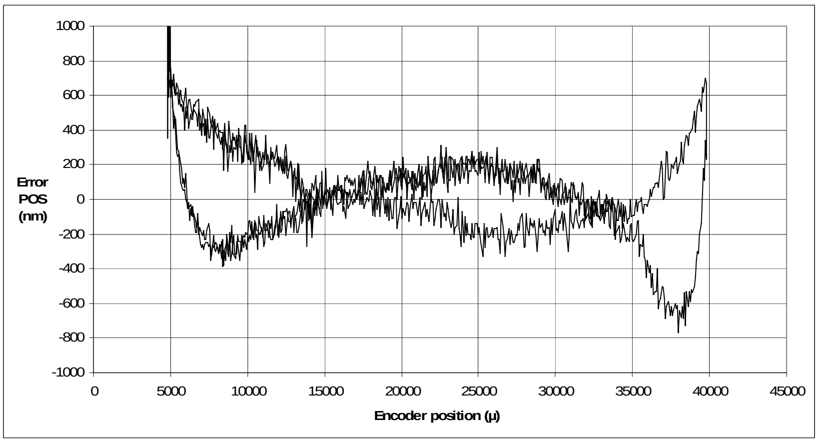
The scientific travel (in closed loop) is 0.1 to 39.6 mm at 4K.

4.2 PID control parameters

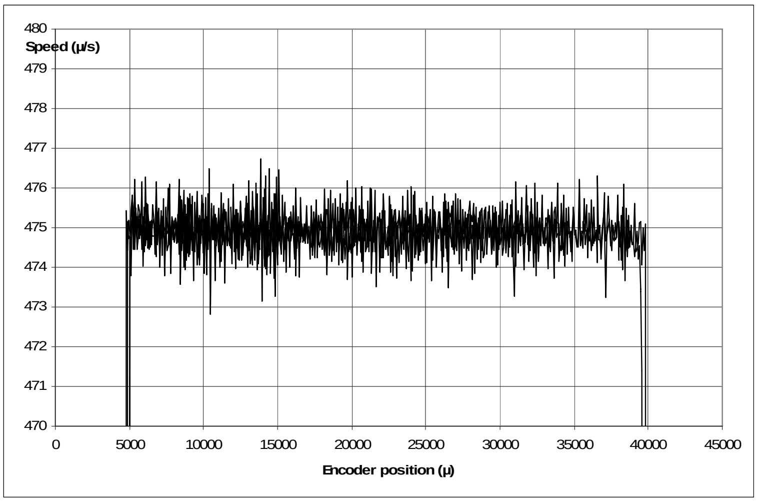
The PID control parameters are the same as for the SMECm CQM.

Parameter	Hex value	Decimal value	Command
Integral limit	0x7D0	2000	904E07D0
Slew rate limiter	0x12C	300	9051012C
Kd	0x2BC	700	904B02BC
Kp	0x7D0	2000	904A07D0
Ki	0x3E8	1000	904D03E8

The PID control parameters are the same at 300K and at cryogenic temperature.
They are not dependent on the SMECm position.

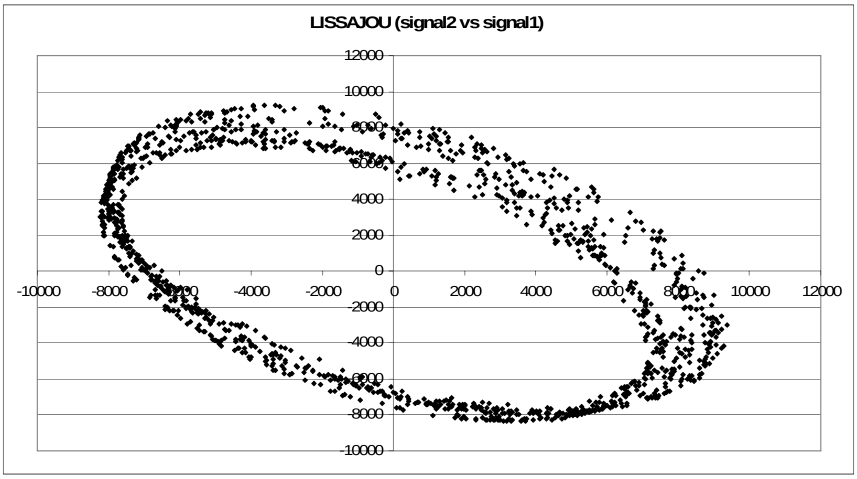


The short term position error is within the 100 nm specification.



The speed is within the 10µ/s specification.

Note : the commanded speed was 500µ/s and the real speed is 475µ/s. This is due to the fact that the elementary task duration in the control software has been elongated from 20 to 21µ/s and the speed computation inside the software has not been updated. This is a systematic error of 5%.



This Lissajou curve shows that there has been no loss of encoder count.

4.3 Signals amplitude behaviour along the travel

The overall shape of the signal amplitudes is intrinsic to the SMECm FM.
The amplitude absolute values are dependent on the LED level chosen, on the MCU model and on the SMECm temperature.
At 300K, there is a variation of about 6% of the amplitude along the travel.

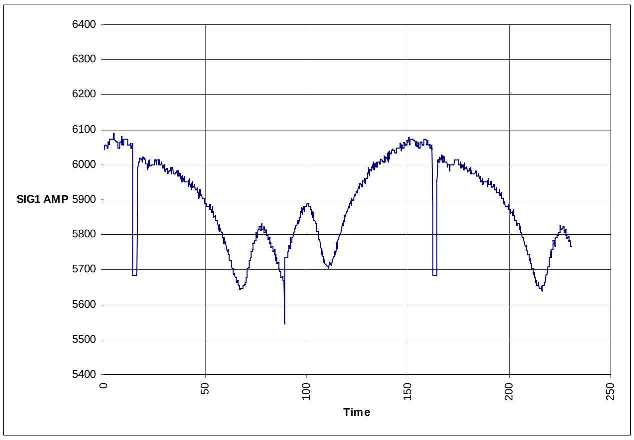


Figure 1: Signal 1 amplitude at 300K

At cryogenic temperature, the variation is about 70% of the amplitude along the travel.

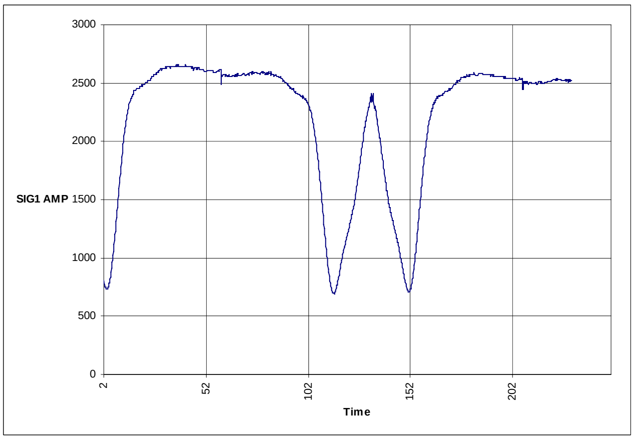


Figure 2: Signal amplitude at 9K

This variation along the travel is due to the rule. It might be a scratch on the rule or a slight misalignment that put the secondary engravings in the field of view of the encoder head.
The difference between 300K and cryo temperature is due to a lateral relative displacement of the rule w.r.t. the encoder head.
The software copes with it and it has no significant impact on the control performances.

4.4 Latch

The latch has been actuated around 100 times, about 1/3 at 300K and 2/3 at cryogenic temperature. There has been no operating failure.
The magnetoresistive sensors have the same equivalent resistance at 300K and at 4K, on the prime and redundant one.

- When latched, the magnetoresistive sensors indicate 320 Ohms.
- When unlatched, the magnetoresistive sensors indicate 560 Ohms

5 Parameters dependent on the models and/or gravity/position

This chapter is dedicated to the parameters which are dependent on the MCU model and/or on the SMECm temperature and/or on the SMECm position.

5.1 LED levels

At 300K, le LED level is always number 7.
At 4K, there are 6 LED levels available.

The LED real levels are MCU model dependent and SMECm temperature dependent. They will have to be updated with the MCU FM and at the 4K SMECm temperature.

LED level	Coef w.r.t. Level 1	Signal 1 OFFSET	Signal 2 OFFSET	Note
1	1	28000	29000	
2	1.4	32000	31000	
3	2	44000	37000	USED
4				Saturated
5				Saturated
6				Saturated
7				Saturated

Table 1: LED level impact on encoder prime signals at 9 to 20K

The LED level 3 used with the prime encoder gives a minimum amplitude of 700 and maximum of 2600 on both signals (offsets substracted).

LED level	Coef w.r.t. Level 1	Signal 1 OFFSET	Signal 2 OFFSET	Note
1	1	11000	25000	
2	1.25	18000	27000	
3	2	20000	30000	
4	3	24000	35000	USED
5	5	31000	42000	
6	7	41000	50000	
7				

Table 2: LED level impact on encoder redundant signals at 9 to 20K

The LED level 4 used with the redundant encoder gives a minimum amplitude of 1000 and maximum of 4000 on both signals (offsets substracted).

5.2 Motor current versus DAC and ADC (with MCU ½ QM2)

Here is the correspondence between DAC, ADC and mA values.

This table is MCU model dependent. It will have to be updated with the MCU FM.

DAC Hex	DAC Dec	Measure mA	ADC Hex	ADC Dec	ADC noise Dec	ADC noise mA
0x0	1	-95.5	0xE6	230	301	0.9
0x1000	4096	-83.5				
0x2000	8192	-71.6				
0x3000	12288	-59.7	0x303D	12349	459	1.3
0x4000	16384	-47.8				
0x5000	20480	-35.9				
0x6000	24576	-23.9	0x5FDE	24542	458	1.3
0x7C00	31744	-3.1	0x7C14	31764	404	1.2
0x8000	32768	-0.1	0x7FCC	32716	10	0.0
0x9000	36864	11.8	0x8FB9	36793	431	1.3
0xA000	40960	23.7	0x9F8E	40846	429	1.3
0xB000	45056	35.7	0xAF49	44873	426	1.2
0xC000	49152	47.6	0xBF7A	49018	418	1.2
0xD000	53248	59.5	0xCF5B	53083	410	1.2
0xE000	57344	71.4	0xDF53	57171	410	1.2
0xF000	61440	83.3	0xEF11	61201	406	1.2
0xFFFF	65535	95.2	0xFEE4	65252	331	1.0

When SMECm is at 300K, the current given by the MCU ½ QM2 is limited to -37.7mA and +33.7mA. This limitation is due to the fact that the actuator coil resistance is 580 Ohms at 300K, too high for the MCU to output the full range of current.

When SMECm is at 4K, the full range given in the table is available.

5.3 Motor current versus position

The position is the one given by the encoder, in closed loop.

The curve below is only indicative as the current level for a given position depends on the SMECm orientation w.r.t. gravity.

The law current/position is position and gravity dependent when the current is given in mA plus MCU dependent when the current is given in ADU.

The calibration will have to be done for the ground tests in SPIRE and then in flight.

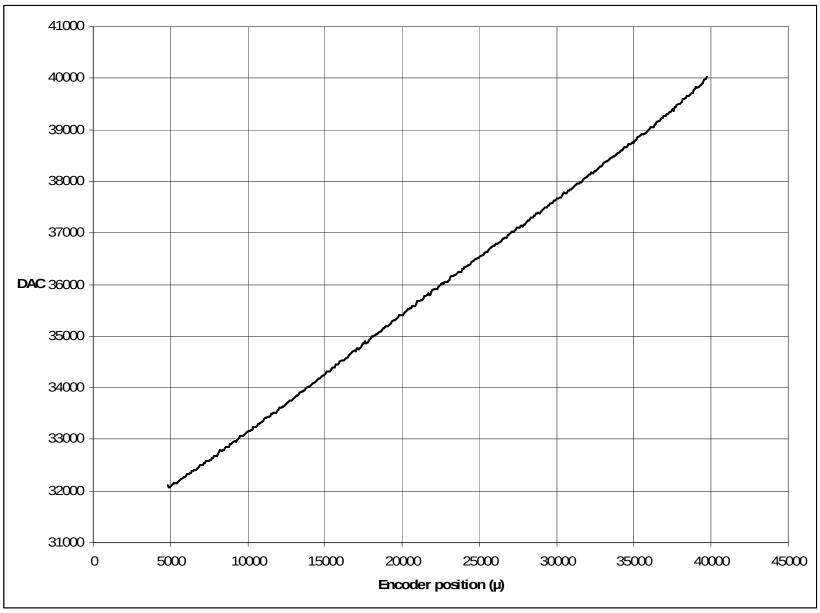


Figure 3: DAC versus encoder position

The curve shows that the current varies quite linearly with the positon. This is a characterisitc of the mechanism and is not model (SMECm or MCU) dependent.
The slope value is gravity and position dependent.

5.4 LVDT DC output versus position

Typical characteristics of the LVDT inside the SMECm FM

The LVDT output is MCU model dependent and SMECm temperature dependent (to a lesser degree). The figures will have to be recalibrated when the SMECm is integrated in SPIRE, at 4K with the MCU FM.

The position is the one given by the encoder, in closed loop.

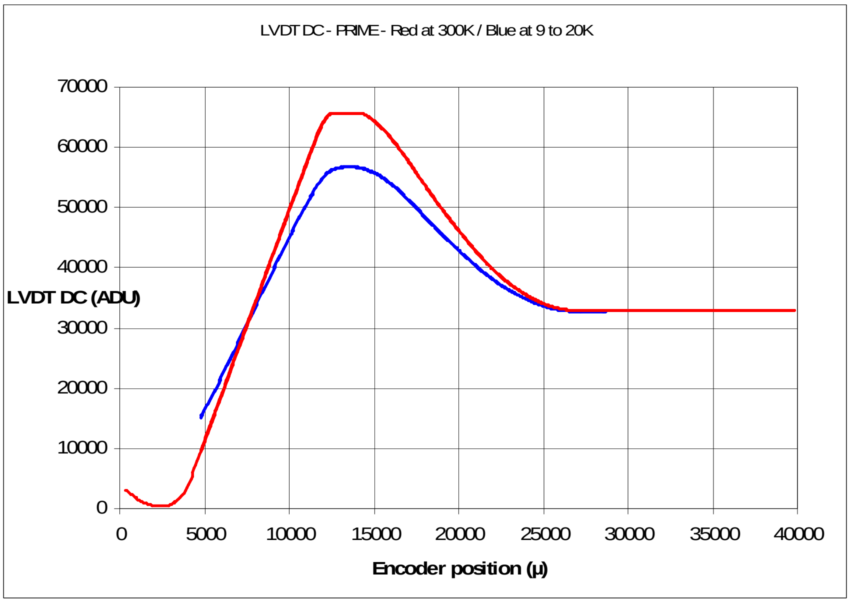


Figure 4: LVDT DC versus Encoder position

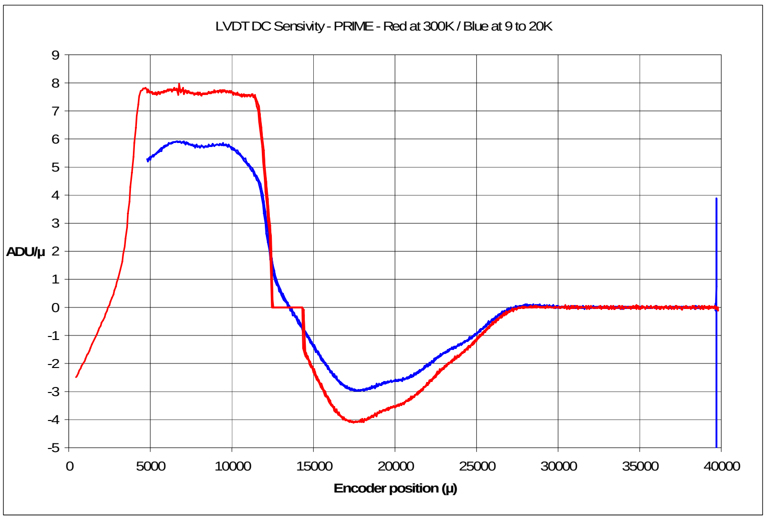


Figure 5: LVDT Sensitivity (ADU / µ) versus Encoder position

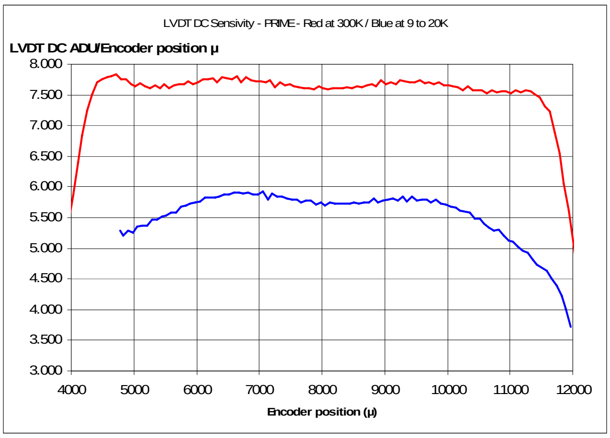


Figure 6: Zoom on the linear part

EncPOS	LVDT DC		EncPOS	LVDT DC
300K	300K		9 to 20K	9 to 20K
µ	ADU		µ	ADU
0	3619			
341	3116			
1033	1613			
2032	476			
3030	724			
4029	3871			
5027	11376		4981	16210
6025	19024		5981	21752
7024	26763		6979	27606
8022	34396		7978	33401
9020	42021		8976	39134
10018	49704		9974	44904
11017	57268		10973	50341
12015	64173		11971	54932
13014	65535		12970	56660
14012	65535		13968	56732
15010	64370		14966	55860
16009	61538		15965	54069
17007	57788		16963	51509
18006	53732		17961	48587
19004	49825		19037	45506
20002	46200		20035	42834
21001	42802		21033	40293
21999	39813		22032	38033
22998	37389		23030	36210
23996	35483		24029	34753
24994	34056		25027	33625
25993	33205		26025	32956
26991	32868		27024	32729
27990	32818		28022	32752
28988	32831		29021	32816