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Rosetta/SREM TM data

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Contents

List of Reference Documents

[RO-ESC-IF-5003]	Rosetta/MARS EXPRESS Data Delivery Interface Document
[RO-MMT-IF-2011]	Rosetta/MARS EXPRESS Generic TM/TC Interface Control Document
[RO-ESC-PL-5000]	Rosetta Flight Operations Plan
[RO-SE-SURD]	SREM Rosetta Software Requirements Document
[RO-DSS-RS-1033]	SREM Experiment OBCP URD

Acronyms and Abbreviations

APID	Application Process ID
DDS	Data Disposition System
ESOC	European Space Operations Center
SREM	Standard Radiation Environment Monitor
SCET	Spacecraft Event Time

1 Introduction

The data from the SREM aboard Rosetta is disseminated via the Data Disposition System (DDS). The TM formats for Rosetta are described in the documents [RO-ESC-IF-5003,RO-MMT-IF-2011]. The relevant information for SREM is summarized below.

2 DDS TM format

The experiment packets on-board the spacecraft are split into separate fixed length blocks and formatted into transfer frames for download to the ground and transfer to ESOC. These separate frames are then reconstituted back into complete experiment packets by the RMCS/MEMCS at ESOC and the complete experiment packets are delivered to the PIs. The experiment packets are timestamped with the Spacecraft Event Time (SCET). The SCET is the calibrated time of generation of the first bit in the associated packet. The contents of each reconstituted packet of experiment data is unprocessed, and a header is attached to the beginning of each packet (the DDS Packet Header) described below. For security reasons, each experiment packet is sent three times to ground.

2.1 DDS Packet Header

The DDS Packet Header for Telemetry Packets is an 18-octet header attached to the beginning of each packet. It includes the SCET time stamp, ground station received from, etc. This information is necessary to identify the source of the data packet. A bit and byte packed fixed format is used which is shown in table 1.

Table 1: DDS Packet Header items [RO-ESC-IF-5003]

Octet	Field	Type	Description
0 - 7	SCET	64 bit time	Time correlated OBT
8 - 11	Packet length	32 bit integer	Number of octets within the data packet excluding the DDS Packet Header
12 - 13	Ground Station ID	16 bit integer	00: ESA Villafranca2 15: ESA Kourou 16: NDIULite 17: ESA New Norcia 22: NASA Goldstone 23: NASA Canberra 24: NASA Madrid 7F: ESA/ESOC Test Station 82: NDIU classic
14 - 15	Virtual Channel ID	16 bit integer	0=VC0, 1=VC1
16	SLE Service		Identifies SLE service channel and the type of data
17	Time quality		0: good 1: inaccurate 2: bad

2.1.1 Spacecraft Event Time (SCET)

The time format used is the Sun MJT, as standard on Sun Solaris UNIX platforms. The format is two 32-bit integers. The first contains the number of seconds since 00:00, 1st January 1970 and

the second integer contains the number of microseconds.

2.2 Data Records

Following the DDS Packet Header is the Telemetry Packet Data. The overall structure of the Telemetry Packet complies with the ESA Packet Telemetry Standard [RO-ESC-IF-5003]. The Rosetta telemetry packets are specialized as defined in the Rosetta/MEX Generic TM/TC ICD [RO-MMT-IF-2011].

The telemetry source packets are of variable length and conform to the structure shown in figure 1.

SOURCE PACKET HEADER (48 bits)							PACKET DATA FIELD (VARIABLE)	
PACKET ID				PACKET SEQUENCE CONTROL		PACKET LENGTH	DATA FIELD HEADER	SOURCE DATA
Version Number	Type	Data Field Header Flag	Application Process ID	Segment-ation Flags	Source Sequence Count			
3	1	1	11	2	14			
16				16		16	80	Variable

Figure 1: Telemetry source packet fields [RO-MMT-IF-2011]

2.2.1 Source Packet Header

The fields of the Source Packet Header as shown in figure 1 are described in table 2.

Table 2: Source Packet Header Fields [RO-MMT-IF-2011]

Packet ID	
Version Number	The Version Number is set to 000_{BIN} for all telemetry issued on-board.
Type	For telemetry source packets, the type is set to zero.
Data Field Header Flag	This indicates the presence or absence of a Data Field Header and must be set to 1.
Application Process ID (APID)	The Application Process ID uniquely identifies the on board source of the packet. For SREM the APID is set to 148.
Packet Sequence Control	
Segmentation Flags	These two bits are set to 11_{BIN} indicating "no segmentation".
Source Sequence Count	Used to represent the actual Sequence Count. A separate source sequence count is maintained for each Application Process ID and is incremented by 1 whenever the source (APID) releases a packet. Therefore the counter corresponds to the order of release of packets by the source and enables the ground to detect missing packets. Ideally, this counter should never re-initialize, however under no circumstances shall it "short-cycle" (i.e. have a discontinuity other than to a value zero). The counter wraps around from 214-1 to zero, and starts at zero at power on of the unit or on start of the application generating the packet.

2.2.2 Data Field Header

The data field header is preceded by the source packet header and followed by source data and error control in the telemetry packet (refer to figure 1). All data field headers have the same basic structure, as shown in figure 2. The SCET of the Data Field Header is in units of 2^{-16} seconds.

SCET Time	PUS Version	Checksum Flag	Spare	Packet Type	Packet Subtype	Pad
48 bits	3 bits	1 bit	4 bits	8 bits	8 bits	8 bits
Mandatory	mandatory	mandatory	mandatory	mandatory	mandatory	mandatory

Figure 2: Data field header fields [RO-MMT-IF-2011]

2.2.3 Source data

The packet source data constitutes the data element of the telemetry reports to the ground. For SREM aboard Rosetta there are two different types of Source data, SREM Accumulation Data and SREM Total Dose Data.

According to [RO-ESC-PL-5000] there are five TC procedures defined for SREM, SE-FCP-001 to SE-FCP-005 to control the operation of the instrument (see table 3).

Table 3: TC procedures for SREM aboard Rosetta [RO-ESC-PL-5000]

SE-FCP-001	SREM Switch ON
SE-FCP-002	SREM Switch OFF
SE-FCP-003	SREM Accumulation via OBCP
SE-FCP-004	SREM Hibernation Data Read via OBCP
SE-FCP-005	SREM Memory Dump via OBCP

In normal operation SREM will be put into the 'SREM Accumulation via OBCP' operation mode with procedure SE-FCP-003 . SE-FCP-003 takes four parameters (see table 4).

Table 4: Parameters of TC procedure SE-FCP-003 [RO-ESC-PL-5000]

VSK01480	File ID	SREM accumulation file ID
VSK01481	Integration Time	Duration of accumulation interval in seconds
VSK01482	TD Frequency	Number of accumulations which are executed before an 'SREM Total Dose' is read out.
VSK01483	Stop_now	Is set to YES to stop SREM Accumulation via OBCP.

The operation of SREM in 'SREM Accumulation via OBCP'-mode is shown in flowchart figure 3 [RO-SE-SURD]. At the beginning of each accumulation the SCET (6 byte) is stored for later synchronization of the accumulation times. Then the data is accumulated. At the end of the accumulation period the HK data (14 byte) and the accumulation file (84 byte) are read out (SREM Accumulation Data). After 'TD Frequency' cycles the Total Dose (16 byte) is read out (SREM Total Dose Data).

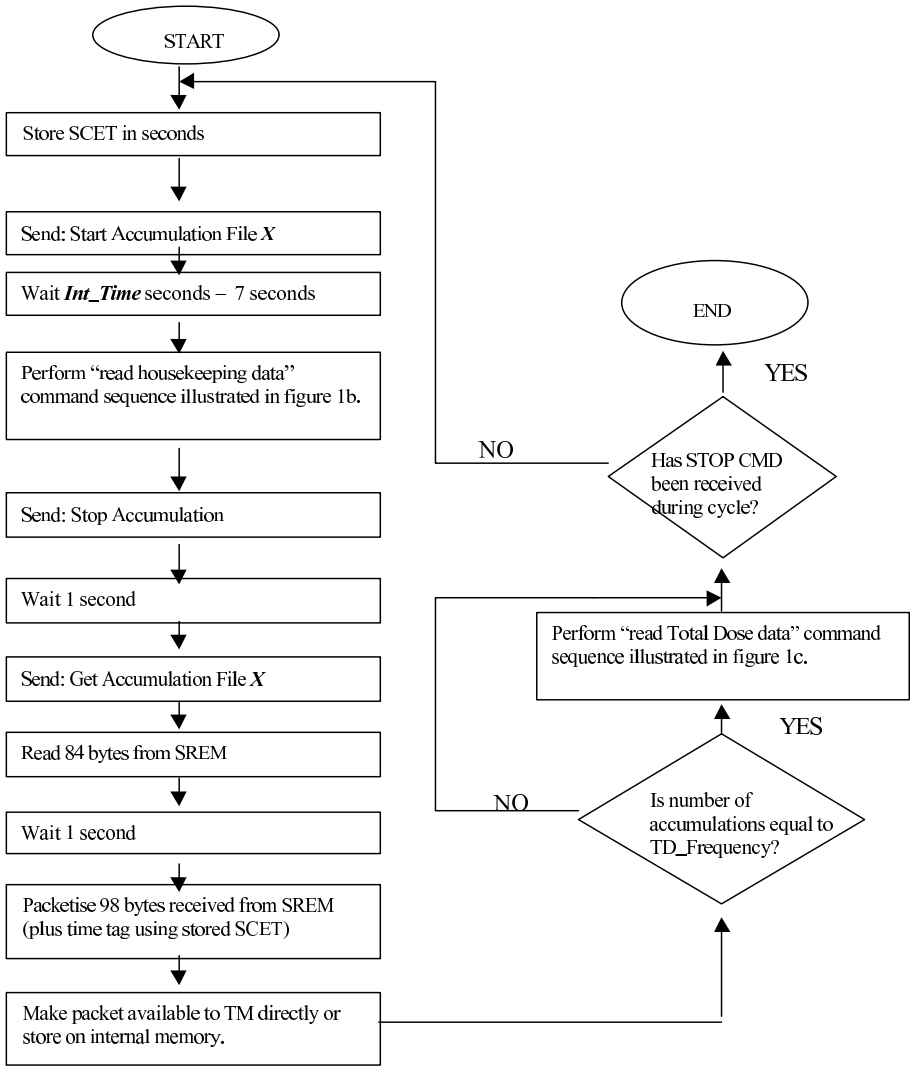


Figure 3: Flow Chart of the SREM Accumulation command sequence SE-FCP-003 [RO-SE-SURD]

The SREM Accumulation Data and SREM Total Dose Data consist of following items (table 5). For the SCET of the Accumulation Data, which is in units of seconds, only the two last words are relevant.

Table 5: SREM Data items [RO-SE-SURD]

Accumulation Data		Total Dose Data	
item	bytes	item	bytes
SCET	8	Internal RadFET value	2
HK status word	2	Internal RadFET temperature	2
D1/D2 temperature	2	V_cal_ref_1_raw	2
D3 temperature	2	V_cal_ref_2_raw	2
Analog ground (-6V)	2	V_cal_ref_3_raw	2
6V voltage	2	V_cal_ref_4_raw	2
5V voltage	2	C_cal_ref_1_raw	2
High voltage	2	C_cal_ref_2_raw	2
Accumulation file ID	2		
ACC status word	2		
Start time (SREM time)	4		
Stopt time (SREM time)	4		
Counter TC1	4		
Counter S12	4		
Counter S13	4		
Counter S14	4		
Counter S15	4		
Counter TC2	4		
Counter S25	4		
Counter C1	4		
Counter C2	4		
Counter C3	4		
Counter C4	4		
Counter TC3	4		
Counter S32	4		
Counter S33	4		
Counter S34	4		
Counter PL1	4		
Counter PL2	4		
Counter PL3	4		
Total	106		16

3 Time synchronization

The SREM experiment packets contain five different time stamps (see table 6).

t1 is generated on reception of the packet on ground. It is UT corresponding to t2 (t1=t2). t2 is the SCET the packet is generated on the spacecraft. t3 is the SCET at stop of the data accumulation (t3≈t5). t4 and t5 are SREM times and correspond to the start and stop time of the accumulation.

Through relation t1=t2 the conversion between SCET and UT is defined. Through relation t3=t5 the conversion between SREM time and SCET is defined. These two rules finally allow to convert SREM time to UT.

Table 6: Time information contained in SREM experiment packets

t1	SCET (UT)	DDS Packet Header, time of data packet generation
t2	SCET	Data Field Header, time of data packet generation
t3	SCET	SREM Accumulation Data, stop of accumulation
t4	Start accumulation SREM time	SREM Accumulation Data
t5	Stop accumulation SREM time	SREM Accumulation Data

4 Test data

According to the described SREM/Rosetta data formats a data decoding software was developed and tested with test data. Two sets of SREM test data are available. The first data set contains data taken from December 1 to 5, 2003. The second data set contains data taken on February 2, 2004. For the first data set the applied TC sequence is not known. The second data set was gathered during a visit to ESOC together with Armelle Hubault.

4.1 December 2003 test data

4.1.1 APID, Type, and subtype

APID, Type, and Subtype (in Source Packet Header) of all experiment packets have the nominal values of 148/3/25.

4.1.2 SREM status words

HK status word
Except for two cases, all HK status words have the same value of 0010010010000000_{bin}. The set bits indicate accumulation on, Command valid, and high voltage on. The two exceptions have the value 0010010010100000_{bin}. The extra bit indicates a watchdog elapsed.

ACC status word
Except for one case, all ACC status words have the same value of 0000010010000000_{bin}. The set bits indicate Command valid and high voltage on. The exception has the value 0000010010100000_{bin}. The extra bit indicates a watchdog elapsed.

4.1.3 SE-FCP-003 parameters

See table 4 for definitions.

Accumulation file ID
In all cases 129. This corresponds to the default setting of parameter VSK01480 of TC procedure SE-FCP-003 which is 882_{hex}=0001000100000001_{bin} (=group 1, file 1) [RO-DSS-RS-1033].

Integration time
Except for one case all accumulation times were within 120 ± 1 *sec*. The accumulation time is given by t5-t4 (see table 6). In one case the stop time was earlier than the start time.

TD Frequency
Except for one case the TD frequency was 5 (one Total Dose reading after five consecutive Accumulation Files).

4.1.4 HK temperatures and voltages

Temperatures and voltages are raw values, which have to be converted into physical units. Since the corresponding conversion tables are actually not on-hand this has to be done later. However, the raw values are of reasonable order of magnitude.

4.1.5 Times

See table 6 for definitions.

t1, SCET (UT)
t1 in the first packet is 2003-12-01T19:01:29.916132, and t1 in the last packet is 2003-12-05T12:00:32.381104.

These are exactly the times which are also delivered by DDS upon a query of the catalog.

SREM was obviously not continuously operated or read out. In figure 4 t1 is plotted versus the hours of t1 relative to the first experiment packet. For each Accumulation file and Total Dose reading three experiment packets were received (according to specifications). The time between generation of packets 1 and 2 and 2 and 3 was fairly constant and approximately 32 seconds. This is the expected value because the packet generation is issued by default with a *Period_Ratio* of $1/32\ Hz$ [RO-DSS-RS-1033]. The time between generation of the last packet of an Accumulation File and the first packet of the next Accumulation File was around 160 seconds. The time between generation of the last packet of an Accumulation File and the first packet of a Total Dose reading was around 75 seconds. The time between the generation of the last packet of a Total Dose reading and the first packet of the following Accumulation Files was 156 seconds.

Thus the first packets were generated in time steps of (starting after a Total Dose reading) 220 (=32+32+156), 4x224 (224=32+32+160), 140 (=32+32+75) seconds.

This is generally in agreement with the [RO-DSS-RS-1033] because of the wait times introduced between start of succeeding accumulations. However, the times found in the test data are smaller that the nominal values of 258, 5x258, and 120 seconds.

Except for a period on December 4, one hour of data reception was followed by an hour without reception of any data packets, suggesting that SREM was periodically switched on and off.

t2, SCET

According to the specifications, times t1 and t2 are equivalent and there must be a linear relationship between them. In the upper panel of figure 5 t1 is plotted versus t2 together with the best linear fit. The lower panel shows the relative difference between measured and fitted values. The differences are relatively small. Per 1 *sec* real time (t1) t2 increased on average by a value of 0.9993. Thus the units of t2 are in very good approximation 1 *sec*.

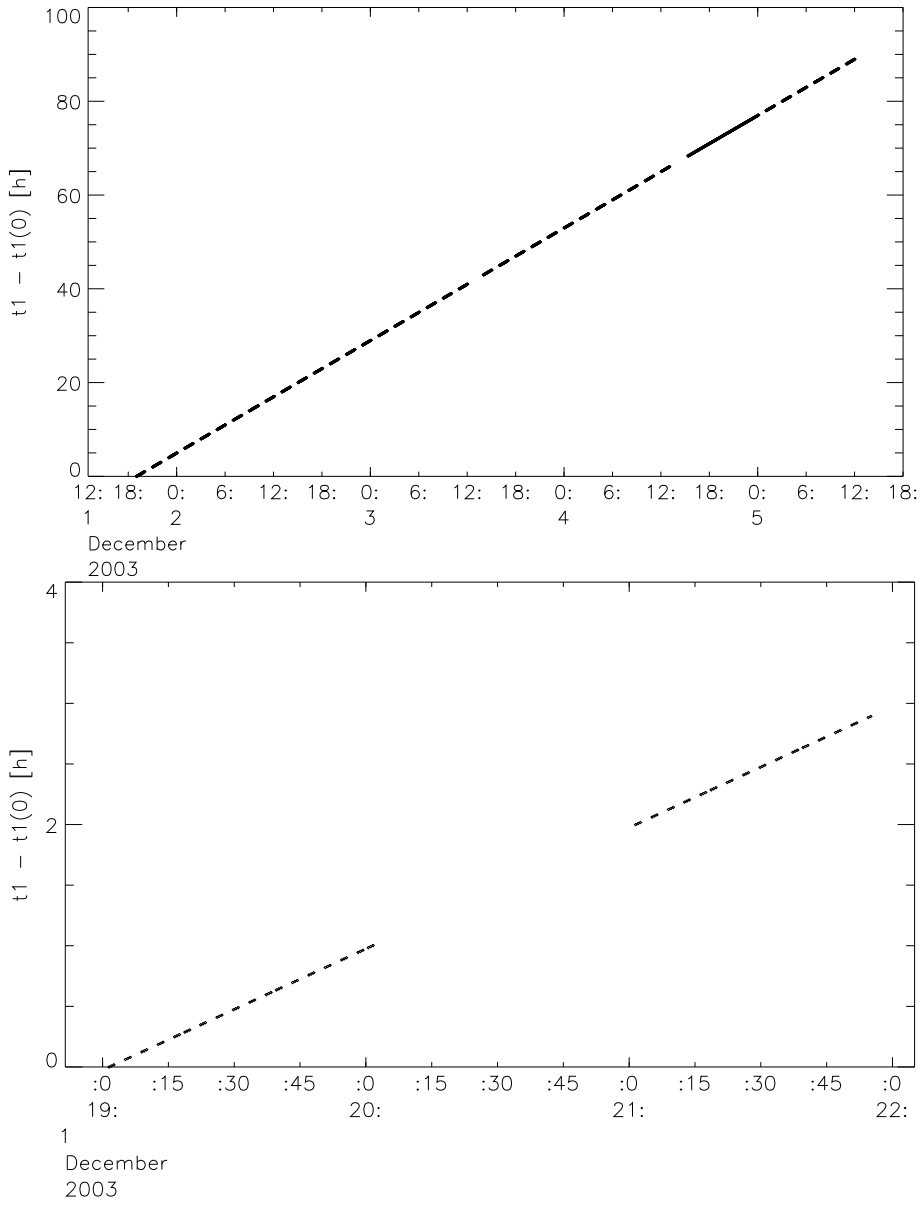


Figure 4: t1 versus the hours of t1 relative to the first experiment packet. The lower panel shows a close up view of the first few hours of measurements.

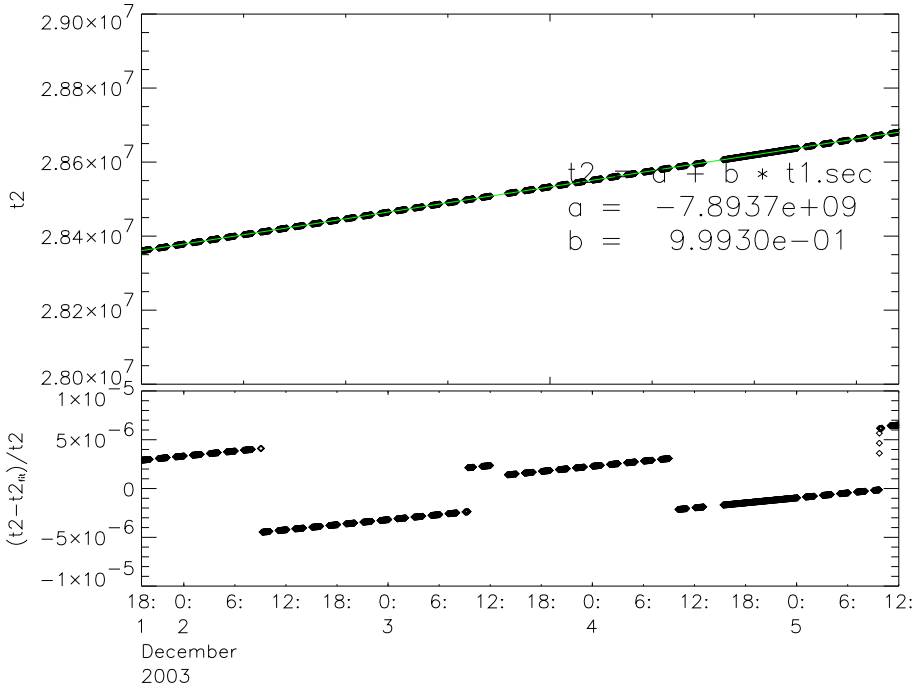


Figure 5: Linear relationship between t1 and t2.

t3, SCET

t3 is the SCET time an accumulation is stoped and t2 is the SCET time, the corresponding transfer frame is generated. Thus t3 must be smaller than the corresponding t2. According to [RO-DSS-RS-1033] the time difference should be around 4 to 5 seconds. As shown in figure 6, where t3-t2 is plotted versus t1, this is mainly the case.

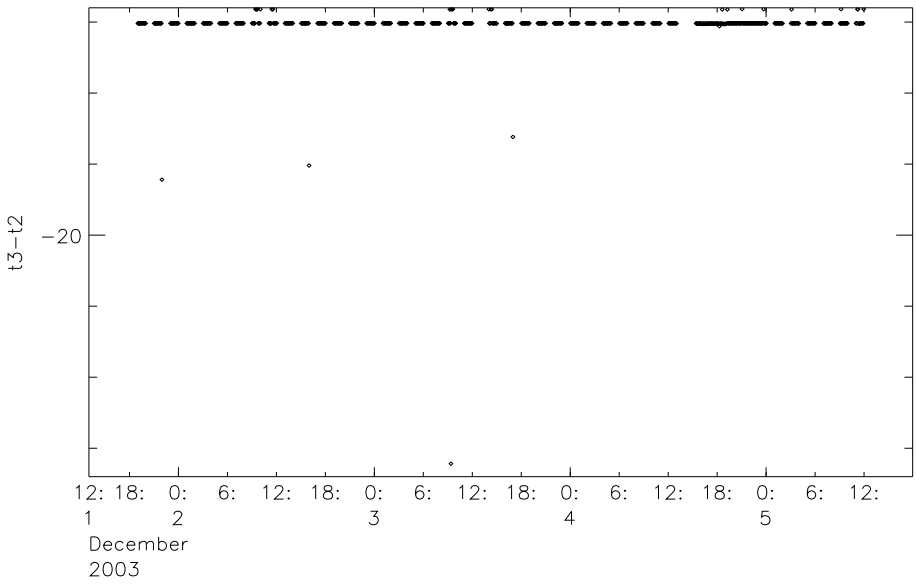


Figure 6: t3-t2 versus t1. The difference between t3 and t2 is in most case between 4 and 5 seconds, which agrees with the time needed to read out the accumulation file from the SREM memory (KSER8111.D040 in [RO-DSS-RS-1033]).

t4 and t5, SREM time

t4 and t5 are SREM times. The units are 100 *msec*. The difference between t4 and t5 is the accumulation time $t_{acc} = t5 - t4$). t_{acc} is plotted in figure 7 as function of t1. t_{acc} was 120 s throughout the entire period under investigation.

t4 and t5 are 4 byte long and can therefore have a maximum value which corresponds to more than 13 y. The timers are reset after overflow or when the instrument is switched off. As shown in figure 8 the timer t4 (and also t5 which is not shown here) was frequently reset during the investigated period, suggesting that the instrument was switched off and on many times.

SREM was not continuously operated. Whereas the accumulation times are 120 seconds, the time steps between two consecutive starts of accumulation is larger. This however is in agreement with the [RO-DSS-RS-1033] because of the wait times introduced between start of succeeding accumulations.

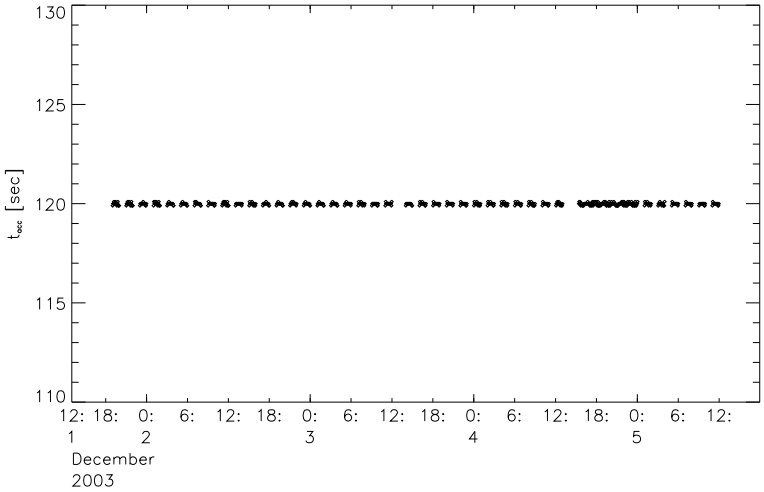


Figure 7: Accumulation time t_{acc} versus t1

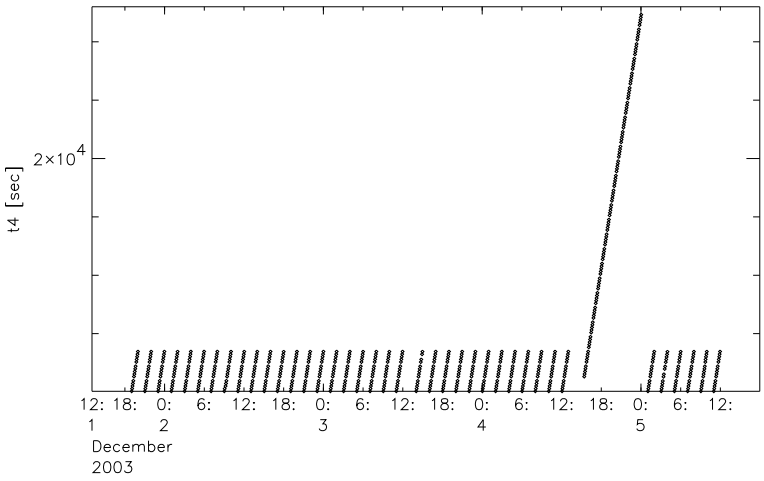


Figure 8: SREM start accumulation time t4 versus t1.

4.1.6 Counting rates

In figure 9 the average counting rates are shown. The values agree well with previously measured rates of the background generated by cosmics.

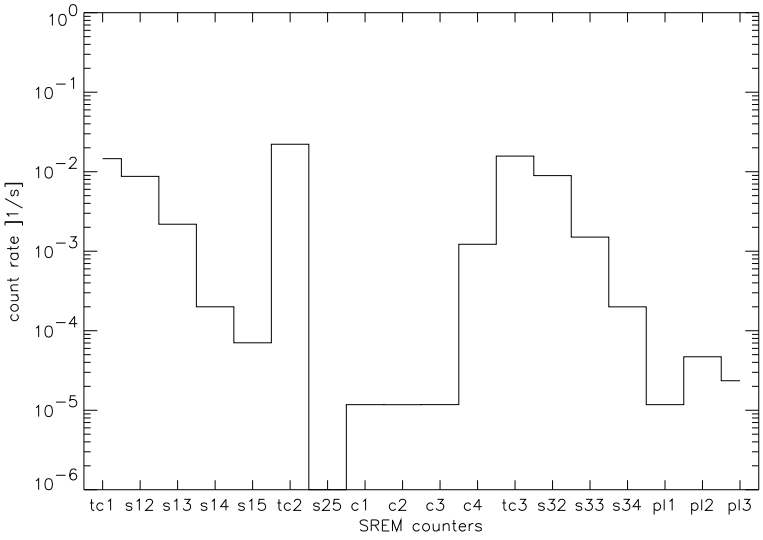


Figure 9: Count rates in the 18 SREM counters.

4.2 February 2004 test data

On February 2, 2004 Armelle Hubault and Paul Bühler carried out a short test with the SREM spare model at ESOC.

SREM was switched on and put with command sequence SE-FCP-03 into accumulation mode with an Integration Time of $t_{acc} = 60\ s$, a TD Frequency value of 3 and with the File ID set to 1. After roughly 15 minutes SREM was stopped and restarted with $t_{acc} = 90\ s$, TD Frequency of 2, and File ID set to 2. In total 10 Accumulation Files and 4 Total Dose readings were recorded.

The Total Dose readings seem to contain reasonable values. However, all Accumulation Files are empty.

4.2.1 APID, Type, and subtype

APID, Type, and Subtype (in Source Packet Header) of all experiment packets have the nominal values of 148/3/25.

4.2.2 SREM status words

HK status word
HK status words are either 0000000010000000_{bin} or 0000010010000000_{bin}. In both cases the set bits indicate that the high voltage was on. In the second case the Command valid bit is set. Both cases however indicate, that accumulation was off.

ACC status word
All ACC status words are completely empty!

4.2.3 SE-FCP-003 parameters

See table 4 for definitions.

Accumulation file ID
In all cases 1152. This is not a valid File ID value!

Integration time
All start and stop accumulation times are 0. No accumulation time can be computed.

TD Frequency
There are two cycles with a TD frequency of 3 and two cycles with a TD frequency of 2. This corresponds with the issued TCs.

4.2.4 Times

See table 6 for definitions.

t1, SCET (UT)

t1 in the first packet is 2004-02-02T14:06:55.6768, and t1 in the last packet is 2004-02-02T14:47:55.7351. These are also the times which are delivered by DDS upon a query of the catalog. Figure 10 shows t1 versus the hours of t1 relative to the first experiment packet. In total 10 Accumulation files and 4 Total Dose readings were received (each of them 3 times).

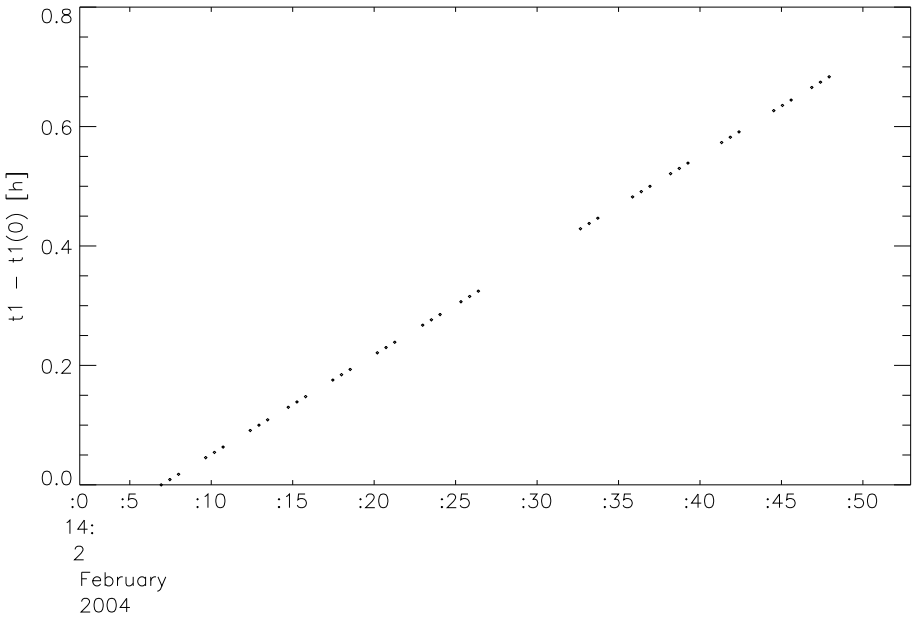


Figure 10: t1 versus the hours of t1 relative to the first experiment packet.

t2, SCET

According to the specifications times t1 and t2 are equivalent and there must be a linear relationship between them. In the upper panel of figure 11 t1 is plotted versus t2 together with the best linear fit. The lower panel shows the relative difference between measured and fitted values. The differences are relatively small. Per 1 *sec* real time (t1) t2 increased on average by a value of 0.9985. Thus the units of t2 are in very good approximation 1 *sec*.

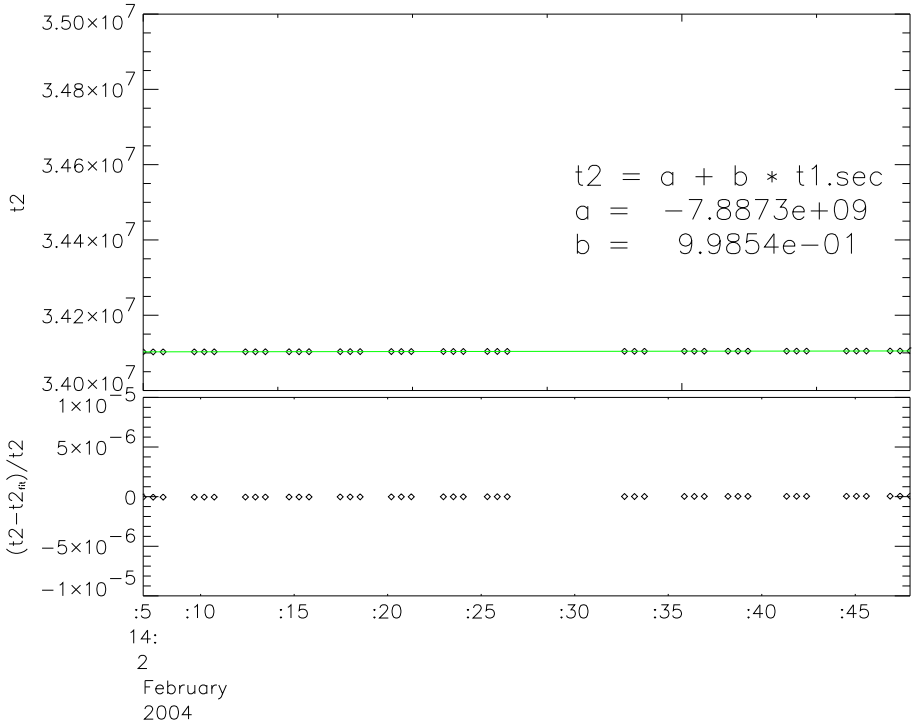


Figure 11: Linear relationship between t1 and t2.

t3, SCET

t3 is the SCET time an accumulation is started and t2 is the SCET time, the corresponding transfer frame is generated. Thus t3 must be smaller than the corresponding t2. According to [RO-DSS-RS-1033] the time difference should be around 4 to 5 seconds. As shown in figure 6, where t3-t2 is plotted versus t1, this is mainly the case.

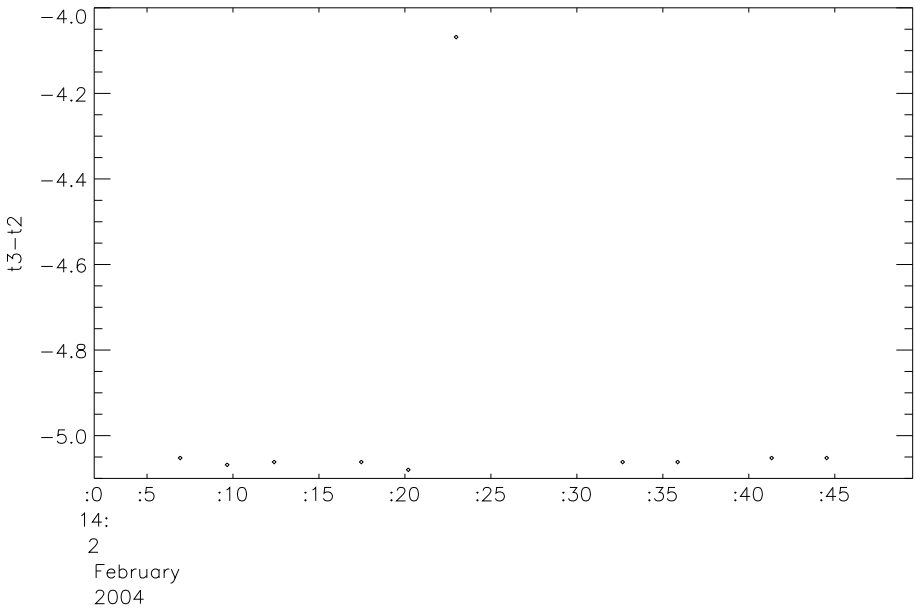


Figure 12: t3-t2 versus t1. t3 is (not as expected) larger than t2, suggesting t2 and t3 to be different types of SCET.

t4 and t5, SREM time

All t4 and t5 values are 0.0!

4.2.5 Counting rates

All SREM counters are 0.0!

4.3 Conclusions and Questions - and Answers

Generally the format of the data delivered by DDS seems to correspond with the expected format. However, in the data sets from December 2003 and February 2004 three major problems were found:

1. In both cases (data sets) SREM was not continuously operated. SREM should start an accumulation as soon as the previous accumulation is stopped and not only when the transfer packets are generated. How can this be achieved with the actual command sequences? Does anything need to be changed?

   Answer 1:
   In the OBCP procedures [RO-DSS-RS-1033] wait times are introduced between successive steps, which explain the time gaps betwen successive starts of accumulation. However, the time gaps found in the test data are not exactly the values specified in [RO-DSS-RS-1033]. Which wait time are actually implemented?

2. SCET t2 and t3 do not seem to be of the same type. This makes it impossible to synchronize the start accumulation times with real time! Why do t2 and t3 not correspond? Which SCET time (t3) is actually saved at the start of an accumulation?

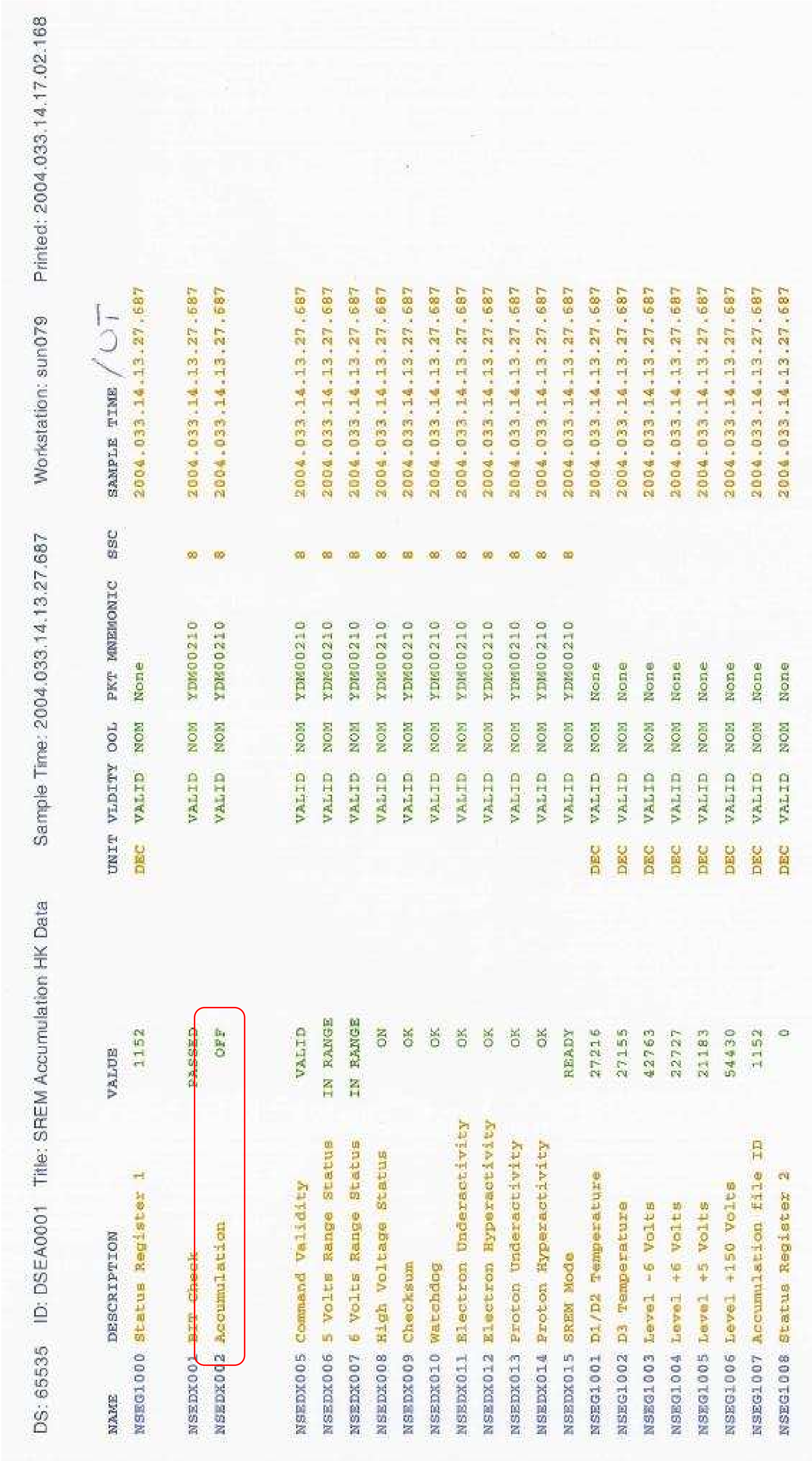
   Answer 1:
   The last word of t2 contains subsecond information. To obtain the relevant seconds only use the first two words. For t3 only use the last two words. The meaning/content of the first word is not clear. In this case the units of both SCET are seconds. t3 is then smaller than t2, as required. The difference is around 4 seconds, which is the time needed to read out the accumulation file from the SREM memory.

3. In the data set from February 2004, obviously no accumulation data was acquired. This is reflected in the status words, where the Accumulation ON bit is not set and was also displayed on screen at ESOC where Accumulation OFF was indicated (see figure 13). Is this a problem of the used command sequence SE-FCP-003? Did we make a mistake when we issued the commands?

   Answer 1:
   The parameter VSK01480 (File ID) of TC sequence SE-FCP-003 (SREM Accumulation via OBCP) has the following format [RO-DSS-RS-1033]:

   $000010aaabbbbbbb_{bin}$ where aaa=Accumulation Group (0 (000_{bin}) .. 7 (111_{bin})) and bbbbbbb=Accumu
   File ID (0 (000_{bin}) .. 127 (1111111_{bin})).

   The default value is 881_{hex} = 0000100010000001 (Accumulation Group=1 and Accumulation File ID = 1, which is File 129=1·128+1). 129 is the value found in the December 2003 data set!



DS: 65535 ID: DSEA0001 Title: SREM Accumulation HK Data Sample Time: 2004.033.14.13.27.687 Workstation: sun079 Printed: 2004.033.14.17.02.168

NAME	DESCRIPTION	VALUE	UNIT	VLDITY	OOL	PKT MNEMONIC	SSC	SAMPLE TIME
NSEG1000	Status Register 1	1152	DEC	VALID	NOM	None		2004.033.14.13.27.687
NSEDX001	BIT Check	PASSED		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX002	Accumulation	OFF		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX005	Command Validity	VALID		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX006	5 Volts Range Status	IN RANGE		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX007	6 Volts Range Status	IN RANGE		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX008	High Voltage Status	ON		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX009	Checksum	OK		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX010	Watchdog	OK		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX011	Electron Underactivity	OK		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX012	Electron Hyperactivity	OK		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX013	Proton Underactivity	OK		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX014	Proton Hyperactivity	OK		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEDX015	SREM Mode	READY		VALID	NOM	YDM00210	8	2004.033.14.13.27.687
NSEG1001	D1/D2 Temperature	27216	DEC	VALID	NOM	None		2004.033.14.13.27.687
NSEG1002	D3 Temperature	27155	DEC	VALID	NOM	None		2004.033.14.13.27.687
NSEG1003	Level -6 Volts	42763	DEC	VALID	NOM	None		2004.033.14.13.27.687
NSEG1004	Level +6 Volts	22727	DEC	VALID	NOM	None		2004.033.14.13.27.687
NSEG1005	Level +5 Volts	21183	DEC	VALID	NOM	None		2004.033.14.13.27.687
NSEG1006	Level +150 Volts	54430	DEC	VALID	NOM	None		2004.033.14.13.27.687
NSEG1007	Accumulation file ID	1152	DEC	VALID	NOM	None		2004.033.14.13.27.687
NSEG1008	Status Register 2	0	DEC	VALID	NOM	None		2004.033.14.13.27.687

Figure 13: Status display during SREM test from February 2, 2004 at ESOC.