R O S E T T A

FLIGHT REPORTS
of RPC–MAG

RO–IGEP–TR–0015

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Anomaly Report & Analysis

of the

MAG-OB Failure in June 2005

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Contents

1 Introduction

This Analysis Report is related to the Anomaly Report ROS–SC–91 :

Anomaly Report Tracking System

Project	Rosetta Spacecraft Anomalies			Project ID	ROS_SC
SC	MAG sensor not working	State	Open	ID	ROS_SC-91

Originator	Armelle Hubault	Criticality	Low		
Created	2005-06-21 15:07	Urgency	Low	Event Type	Unexpected_Event/Behaviou r
		Reproducibility	Unknown	Type	Local
Occurrence Date	2005-06-17	Classification	Space Segment | Payload | RPC		

Description	
Description	During RPC activities on DOY 2005.167, MAG team reported a problem with one of MAG sensors. Analysis shows that the sensor did not work between DOY 167 and DOY 170 (16 to 19 June); it failed since the switch on at 167:08:35 until the switch off at 170:23:00. A power cycle was subsequently requested on DOY 172 and this solved the problem. The switch on temperature on DOY 172 was -129 C -- the same as on DOY 167.
Item Configuration	
Environment	
Recommendation	
Affected Requirement	

Processing	
Root Cause	Unknown
Preventive Action	No
Resolution	

Related Files
No files are attached to this Report

Actions
No actions assigned to this AR

Related Reports
No Reports related to this Report

Figure 1: Anomaly Report: AR-ROS-91

2 Event description

Studies about cometary orbits revealed the unique chance to meet the tail of the just recently discovered comet P/CATALINA. Our Swedish colleagues from the RPC–LAP team computed, that ROSETTA would pass CATALINA's plasma tail at a distance of just 10 Million kilometers in the time period June 17. - 19., 2005. Therefore, it was decided to switch on RPC on July 16. and perform measurements until June 19.
On the first view everything looked nominal. According to our HK data all necessary voltages had the right values (refer to the plots in Appendix B) and the RPC-MAG IB sensor transmitted reasonable data in the usual manner (refer to Figure 2). The OB sensor, however, sent a faulty signal (refer to Figure 3):

- the B_x component was permanently saturated.
- the B_y component showed erratic variations of a few thousand Nanotesla.
- the B_z component was permanently saturated.

This behavior did not change over the whole operation period until the switch off on June 19. The OB data looked erroneous in the science packets (sampled by 3 individual 20 bit ADCs) and the housekeeping packets (sampled by a different 16 bit ADC) as well (refer to Appendix C). The temperature of the IB and OB sensor (thermistors inside the magnetic field sensors) was, however, measured in the right way (refer to Figure 17).

As only the OB sensor failed and the other parts of the instrument were working nominally, we could be quite sure that there was at no time any danger for the other RPC-Instruments or the spacecraft. Therefore, RPC stayed powered on until the evening of June 19 (ROSETTA was out of pass anyway) and was switched off via MTL at 2005-06-19T23:15.

The next switch on was executed manually at 2005-06-21T08:02. Now everything was nominal as usual. The complete instrument, both sensors, worked fine as all the time before.

RPC was finally switched off manually at 2005-06-21T16:29.

Remark:
The increased noise level of the IB sensor is caused by the variations of the OB–Y sensor with an amplitude of some thousand Nanotesla. Both sensors are only 15 cm apart. Therefore, the huge OB–Y variations have a magnetically influence to the IB sensor in the order of some Nanotesla.

2.1 Diagnosis

There were detailed discussions inside the MAG team about the erroneous behavior. The first guess was that there might occur problems due to the low sensor temperature. Studying our instrument development description, however, revealed, that the sensors have been operated (several power on/off cycles) down to at least -160° C during the development phase (refer to the test description in the RFW sheet, Appendix G). Therefore, a temperature effect was discarded as error source. An in depth analysis, excluding the nominal working instrument parts step by step, should help to locate the origin of the error:

- RPC was powered on nominally in terms of stable voltages.
- All necessary voltages (+5V, -5V, U_{ref}=2.5V) were present as expected [1] (proofed by HK data, refer to Appendix B).
- Data were transmitted in HK and Science frames.
- The Thermistors inside the OB and IB sensors worked properly.
- The IB sensor worked nominally.
- OB science and OB HK values showed the same signature.
- The overall RPC current was nominal (refer to the Figures in Appendix D)
- Readings are constant but not zero. Therefore, a loose contact in the connectors or harness can be screened out.
- The failure must be originated somewhere in the OB part of the instrument rather than in any commonly used section.

Due to this facts the only possible error source seems to be:

- Excitation of OB missing or faulty.

With this assumption the error source can be encircled a bit more:

- Oscillator failure.
  $\rightsquigarrow$ Not possible, as RPC-MAG is operating with only one master oscillator working on f_0= 4.19443 MHz.
  All frequencies needed for the whole instrument are derived from this oscillator. As the s/w runs properly, the FPGAs must work properly as well (the FPGAs need the master clock!): f_0 signal is obviously present.

[1] However, there can not be made any statement about transient switch on events, as the HK sampling rate is only 1 frame per 32 s. For such an analysis we would need an oscilloscope access to the RPC unit....

- The master clock f_0 is divided by 84 to generate an input frequency of f_1= 50 kHz for the FGM drive electronics (refer to circuit diagram in Appendix E). Furthermore this frequency is divided by 2 times 2 to provide the needed f_2=25 kHz and f_3= 12.5 kHz. Thus, up to this point the failure probability is extremely low.
- The most likely failure source is the complex behavior of the resonant circuit consisting of L_1 , C_s and the sensor excitation coil (refer to the right side of Figure 16) during the power on phase.

Rationale:

The described resonant circuit has to oscillate exactly on his resonance frequency of 12.5 KHz. This can only be guaranteed, if during the RPCMAG activation phase enough power is provided via the s/c or RPC PIU power supply. It is absolutely necessary that the supply voltage rises "immediately" with a steep flank. If the flank is to flat, respective the slew rate is to slow, the resonant circuit is not able to draw the high initial current needed to fall into the right oscillation state (the resonant circuit is not excited with a simple sinusoidal signal but with steep needle pulses to minimize power consumption. Therefore, sufficient power has to be provided to generate even the first needle pulse in the right height). It might happen that the circuit will not start oscillating which will of course cause a failure behavior.

This behavior is a known fact from the development time of the instrument and has also been reproduced recently with a RPCMAG prototype unit at IGEP TU-BS using a "soft" power supply. The failure did, however, not occur if the supply voltages were switched on and connected instantaneously using a relais.

The observed failure never happened during s/c ground tests or in flight (until now) with the original s/c power units. Maybe the instrument was switched on in an inconvenient moment, when there were spikes on the main power lines or the s/c power consumption was to high for a very short time. Therefore, we had a look to the total drawn current by RPC (refer to Appendix D). These figures, however, do not show any abnormal behavior. But the time resolution (1 Minute) and also the current resolution is not high enough to reveal transient start-up events.

3 Conclusion

The observed failure in June, 2005 did not leave any damage behind. All RPC is again working nominal.

The failure source can not be located definitely, but with the utmost probability, a catenation of unfortunate circumstances lead through a faulty oscillation of the resonant circuit in the sensor excitation drive. This is an absolutely uncritical error which can be corrected by a repeated Power off/on cycle.

The best modus operandi for RPCMAG would of course be to switch the instrument on, ensure that it works nominally, and leave it in the powered state to minimize the power on cycles.

A Plots of the IB and OB Sensors - Science Data

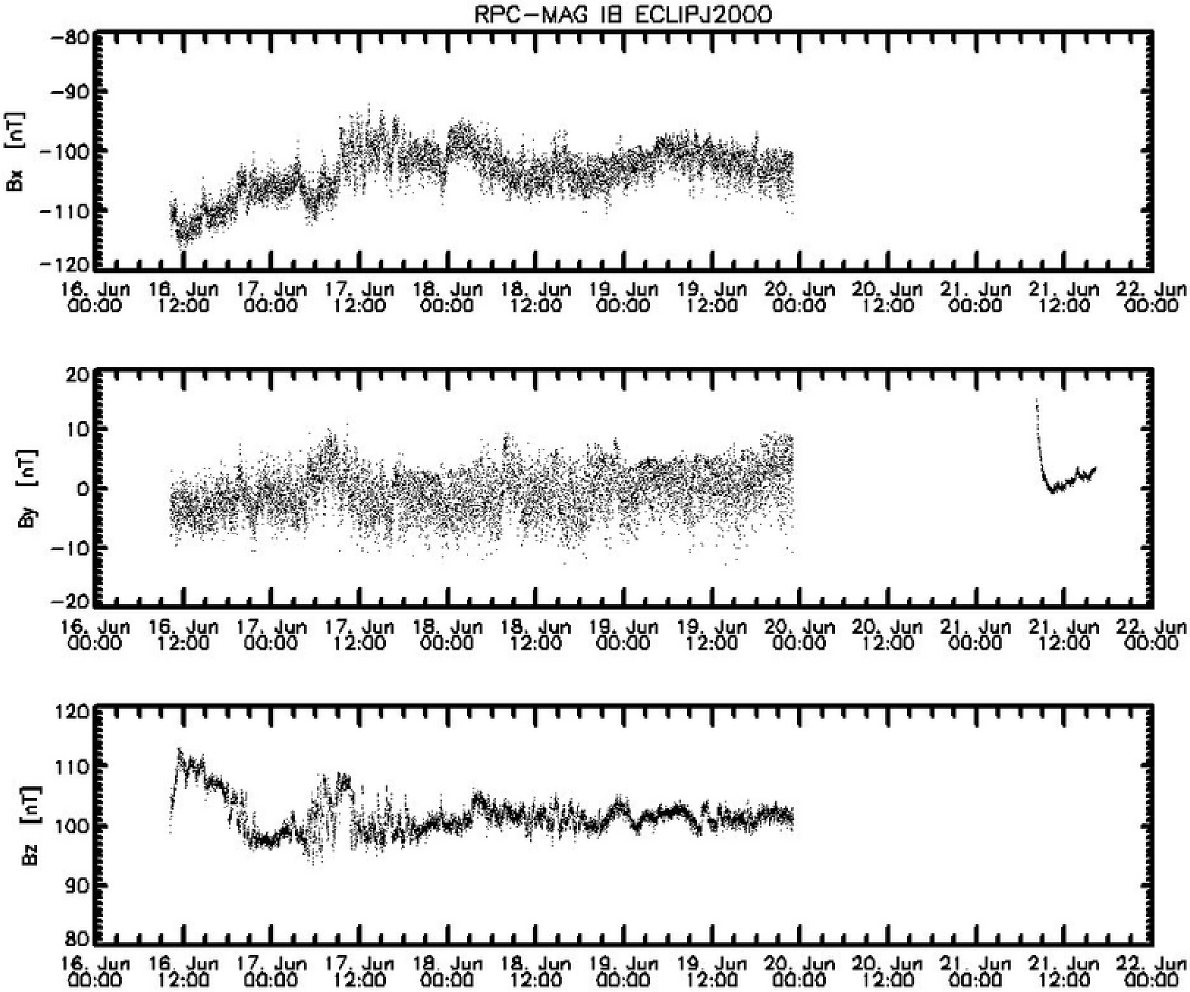

Figure 2: RPCMAG: Magnetic field measured with the IB Sensor

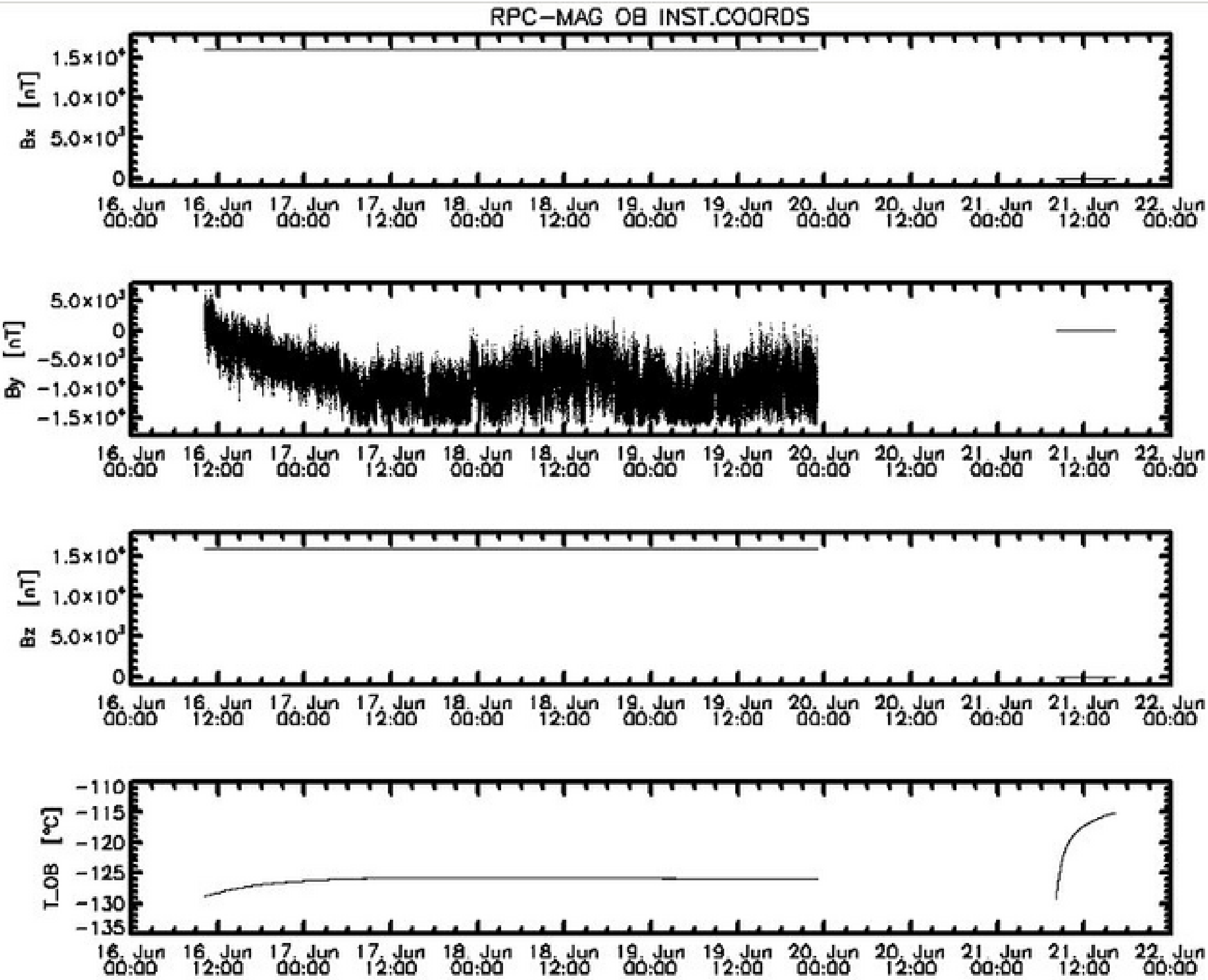

Figure 3: RPCMAG: Magnetic field measured with the OB Sensor

B Plots of the Housekeeping Data

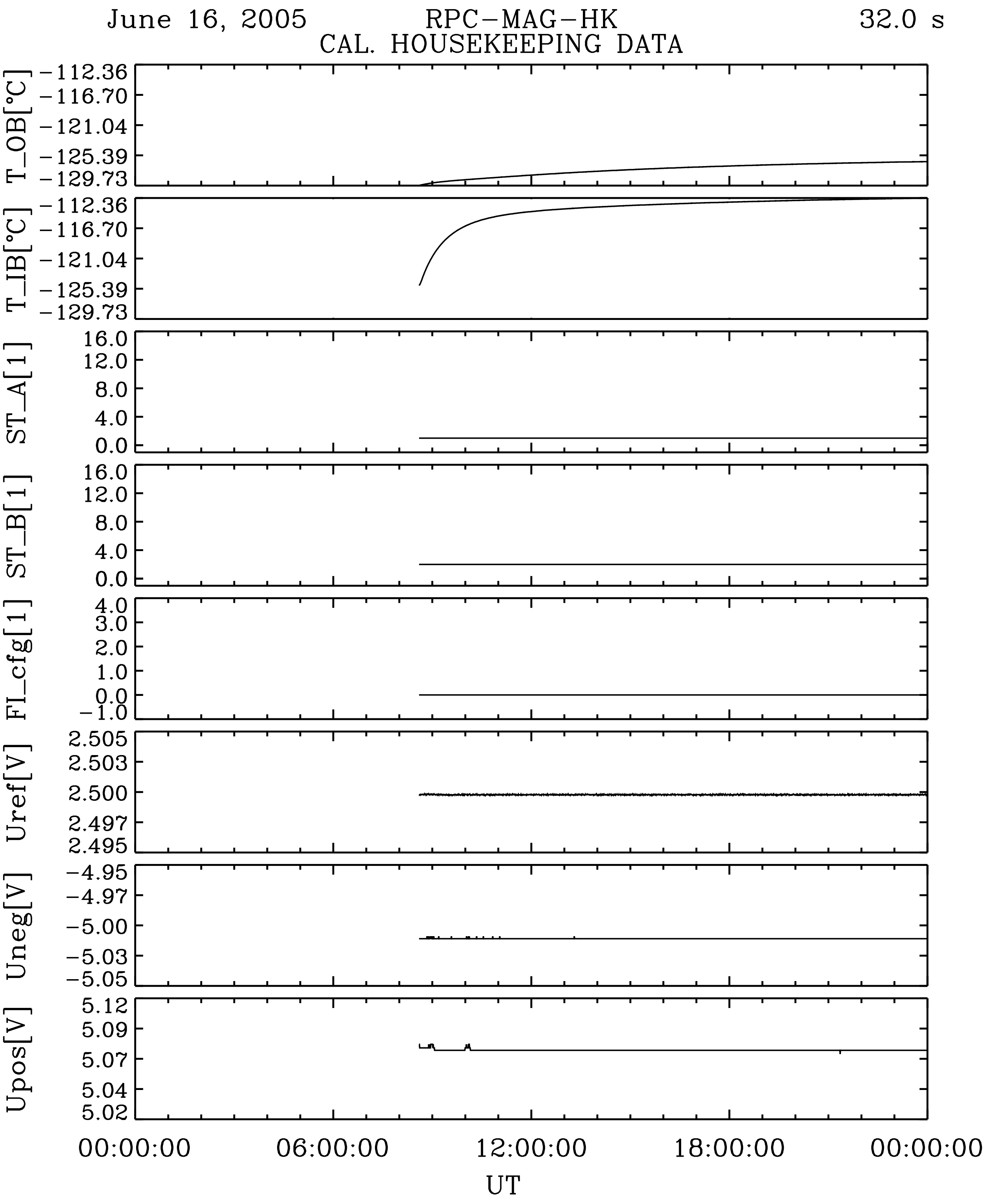

Figure 4: Housekeeping Data: 2005–06-16

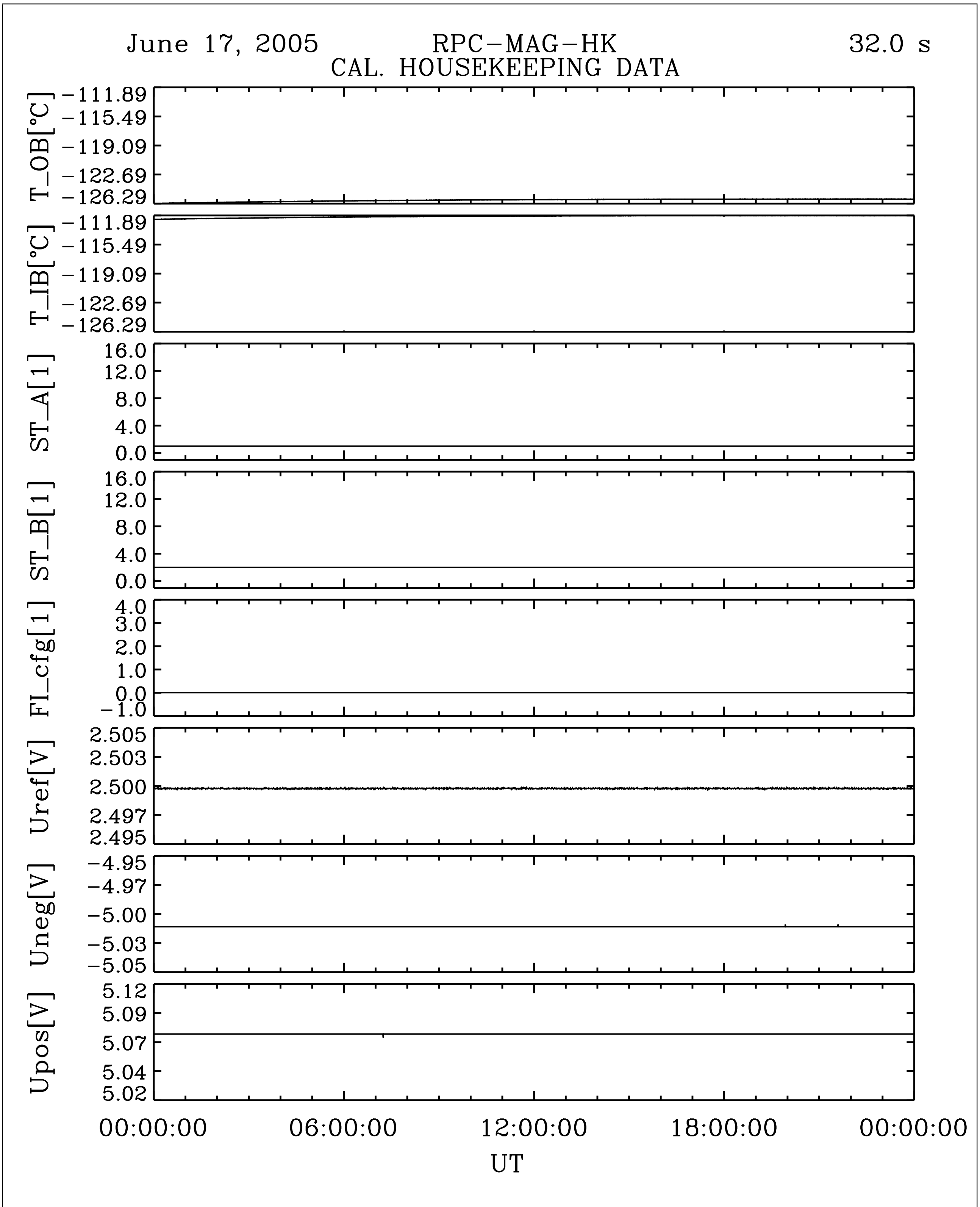

Figure 5: Housekeeping Data: 2005–06–17

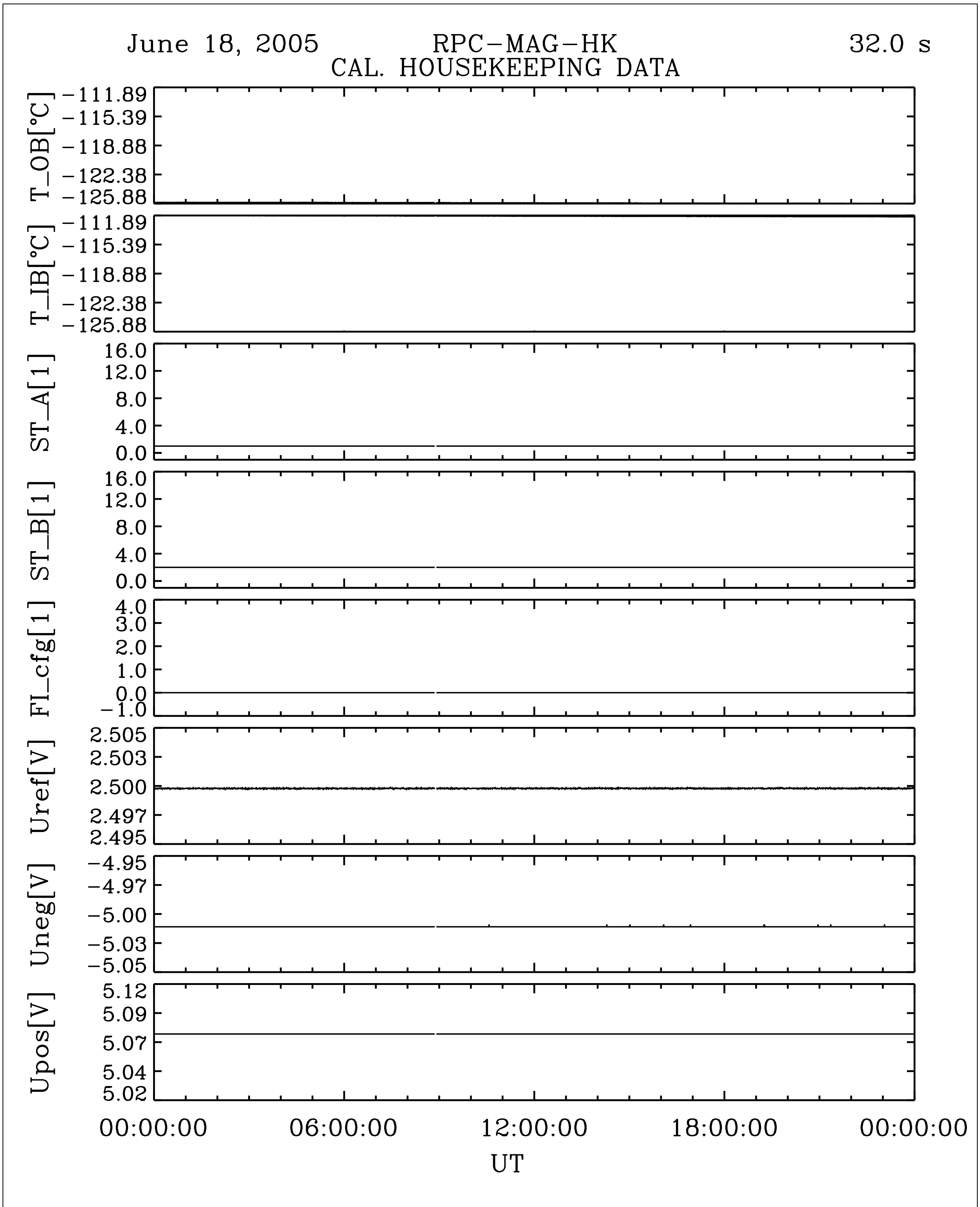

Figure 6: Housekeeping Data: 2005–06-18

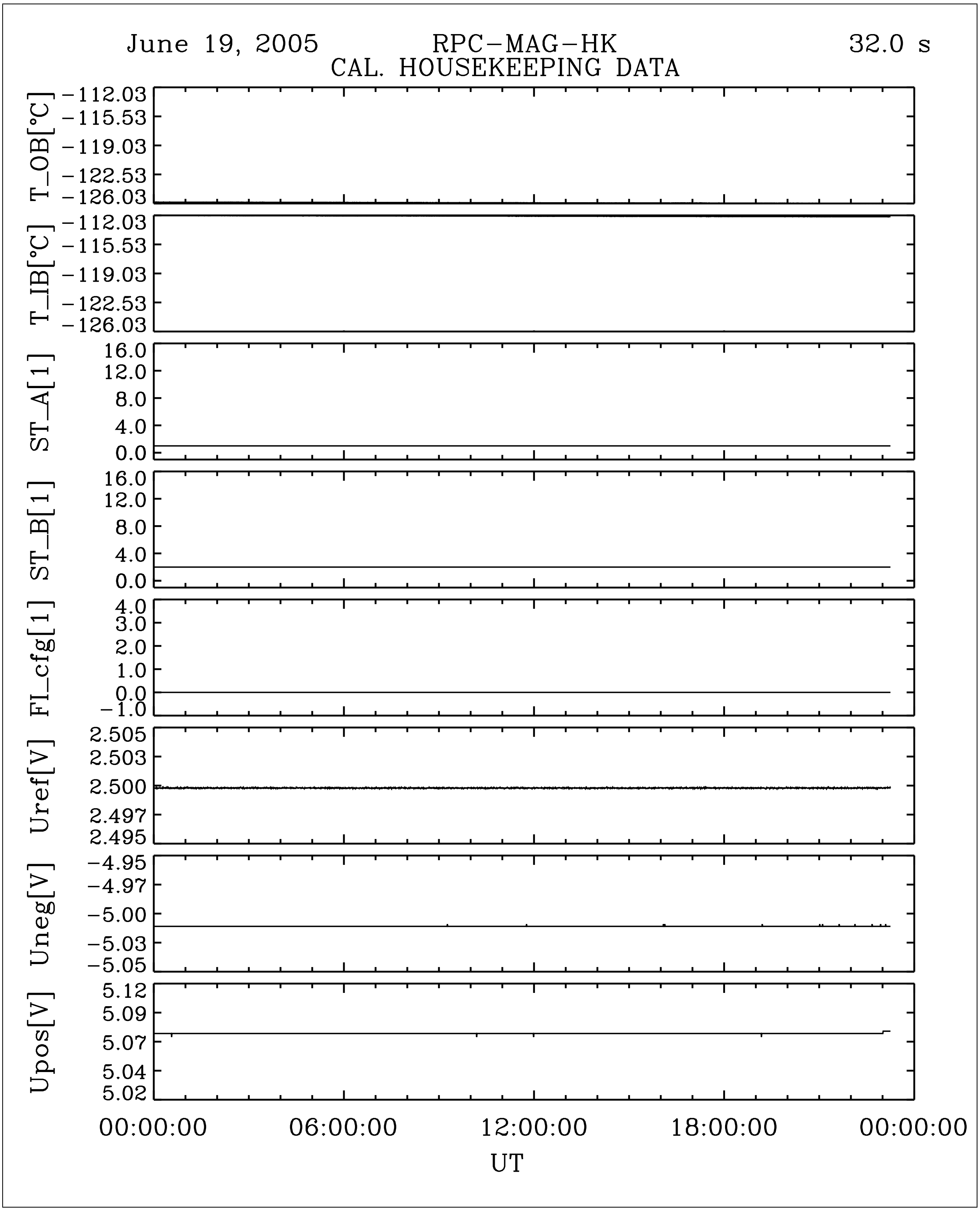

Figure 7: Housekeeping Data: 2005–06–19

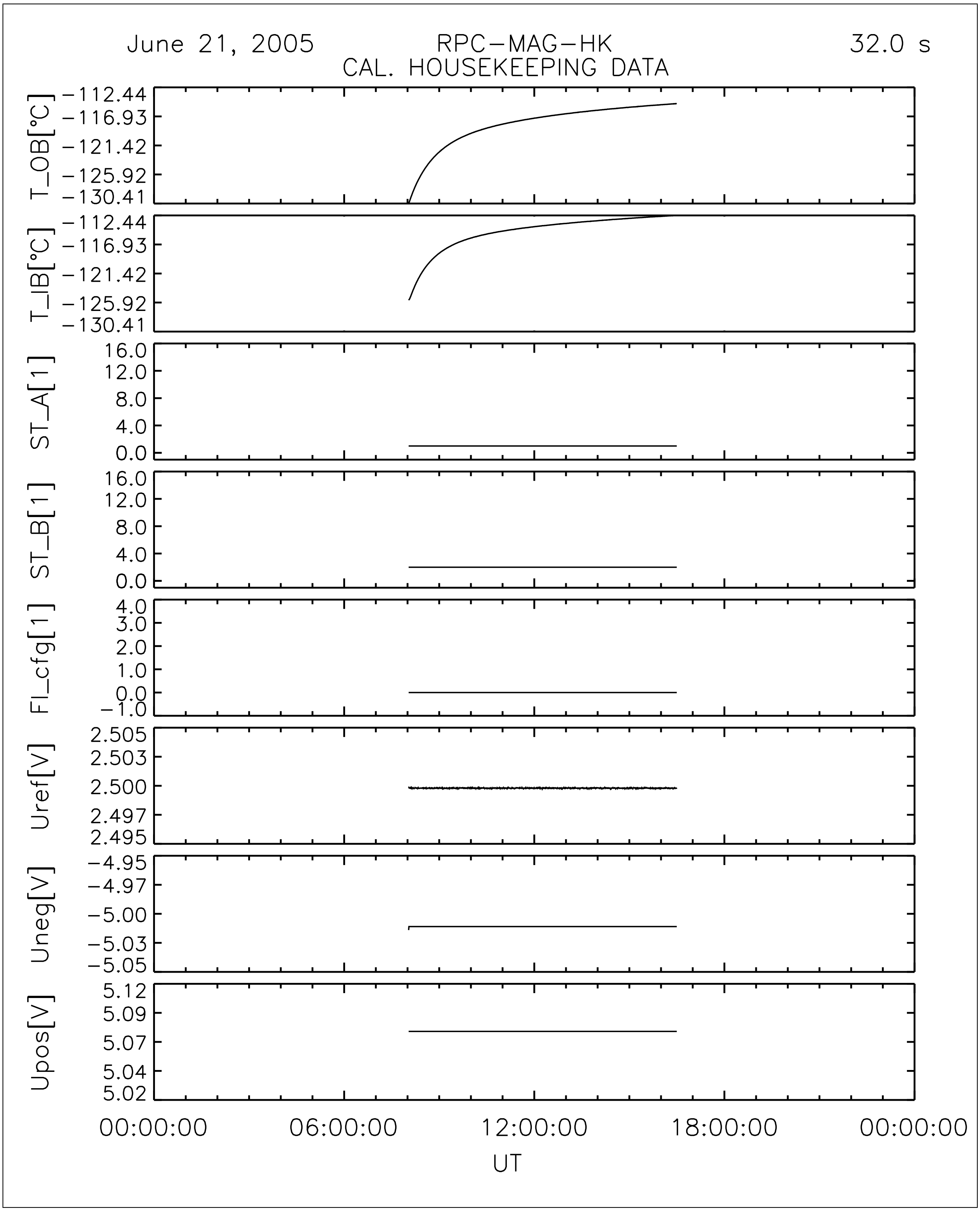

Figure 8: Housekeeping Data: 2005–06-21

C Magnetic Field (OB–Sensor) inside the HK Data

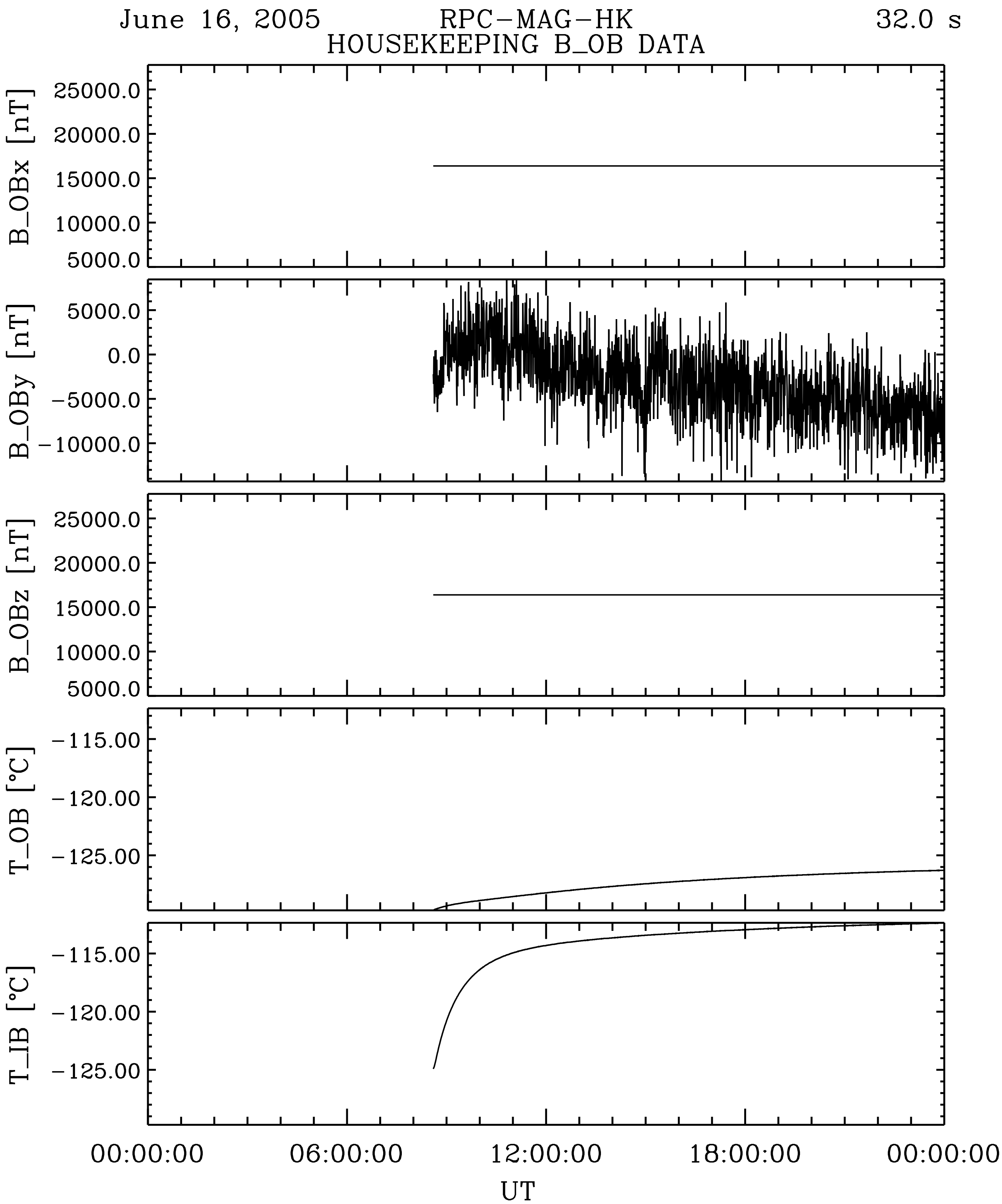

Figure 9: Magnetic Field (OB) in Housekeeping Data: 2005-06-16

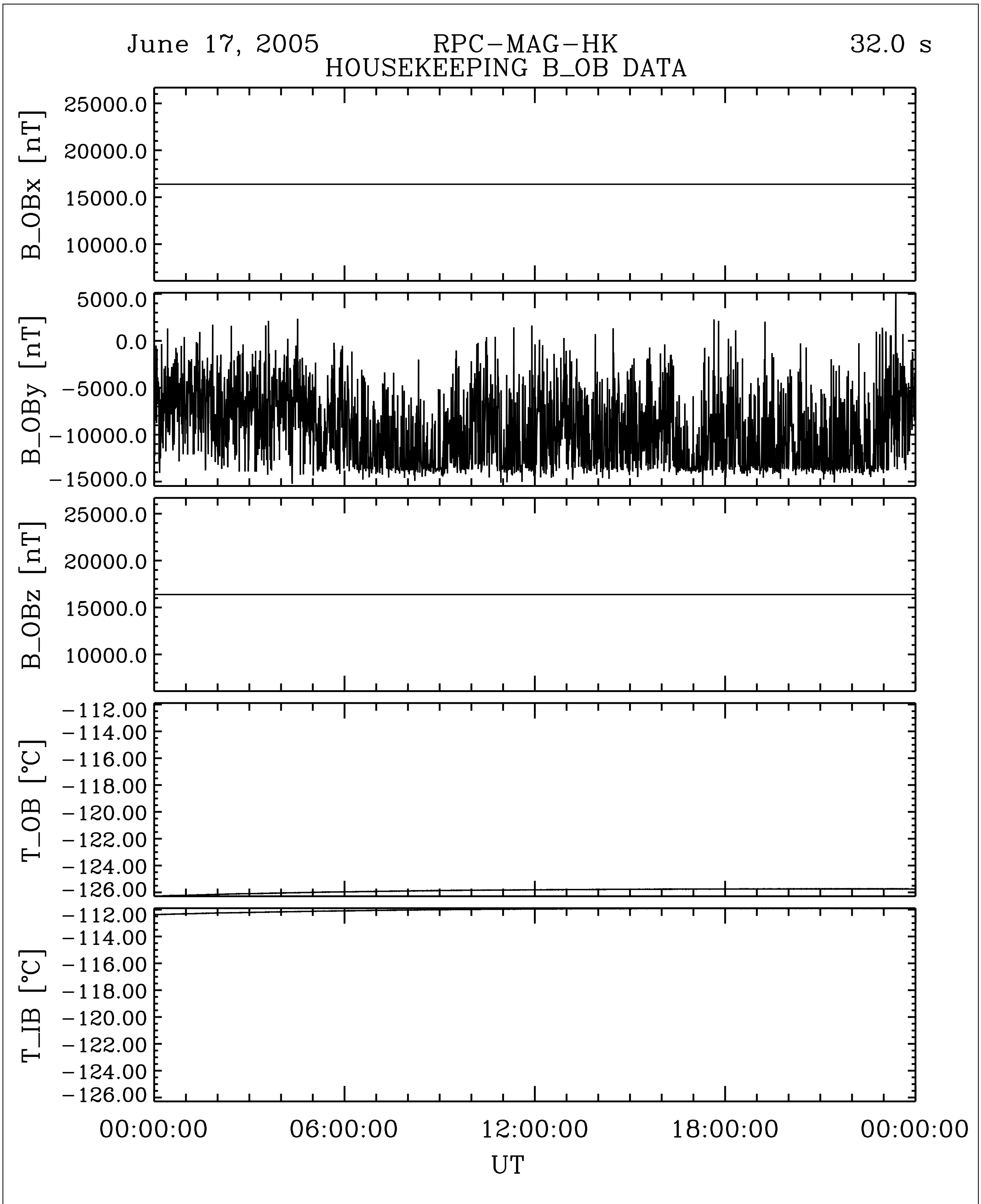

Figure 10: Magnetic Field (OB) in Housekeeping Data: 2005-06-17

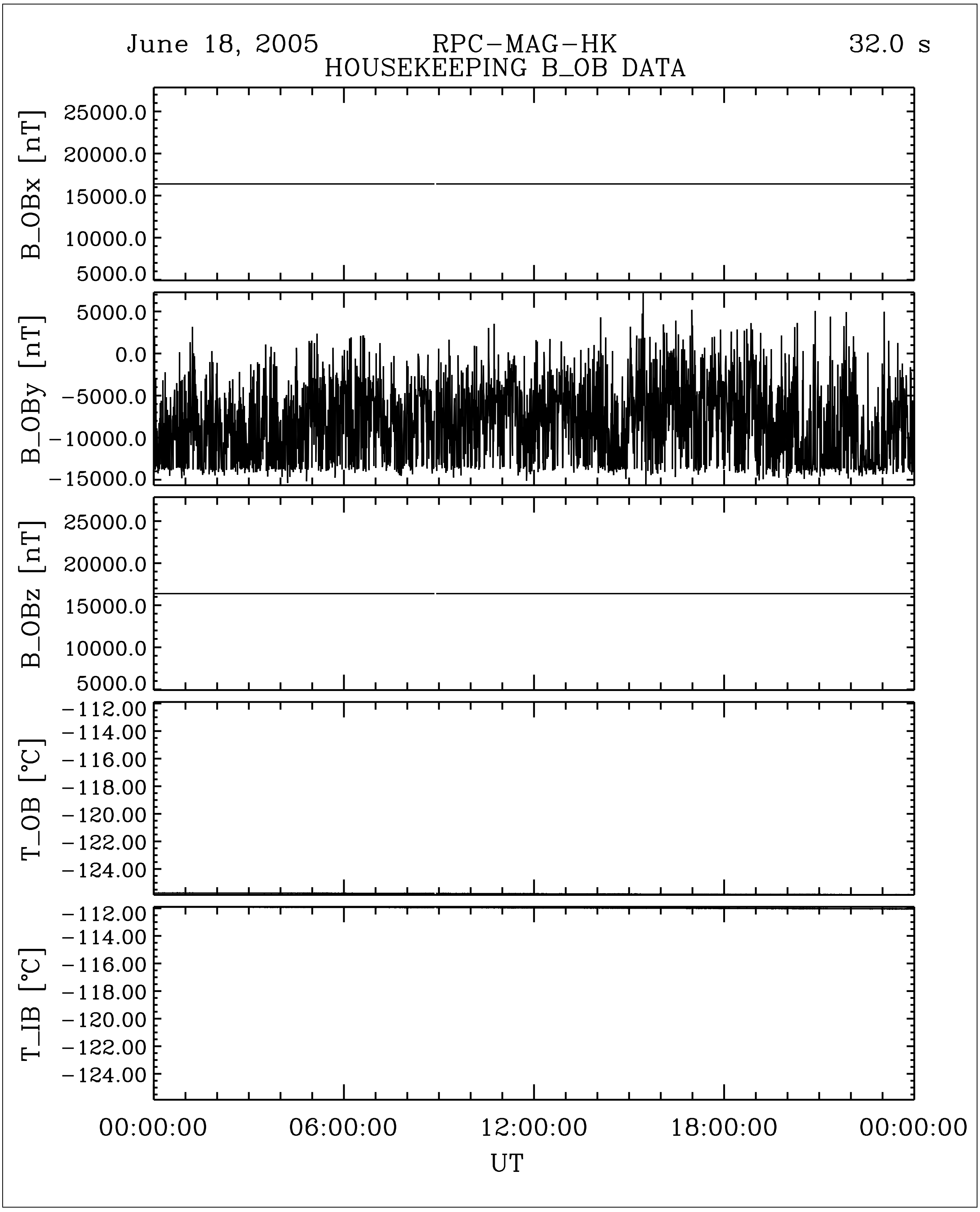

Figure 11: Magnetic Field (OB) in Housekeeping Data: 2005-06-18

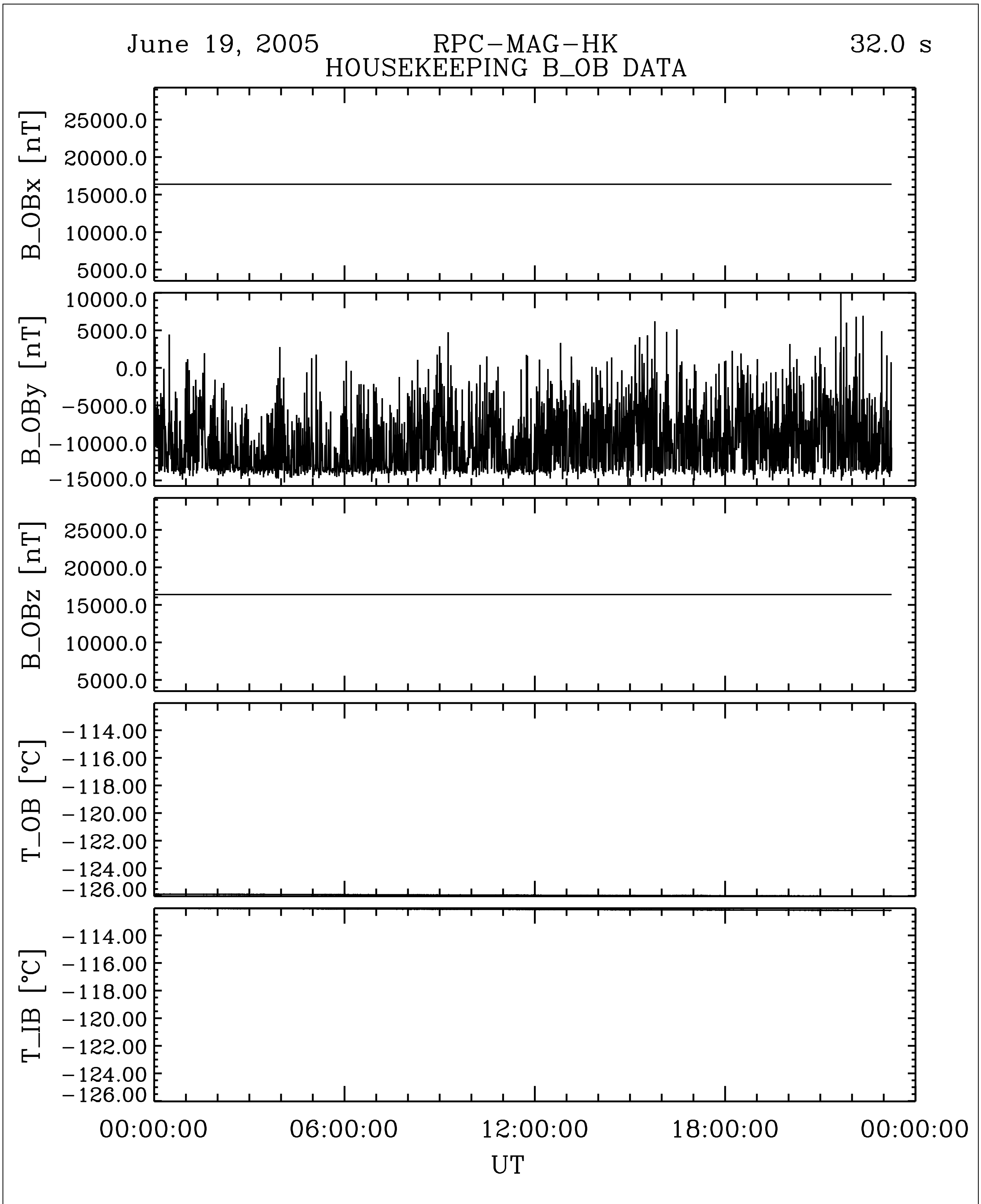

Figure 12: Magnetic Field (OB) in Housekeeping Data: 2005-06-19

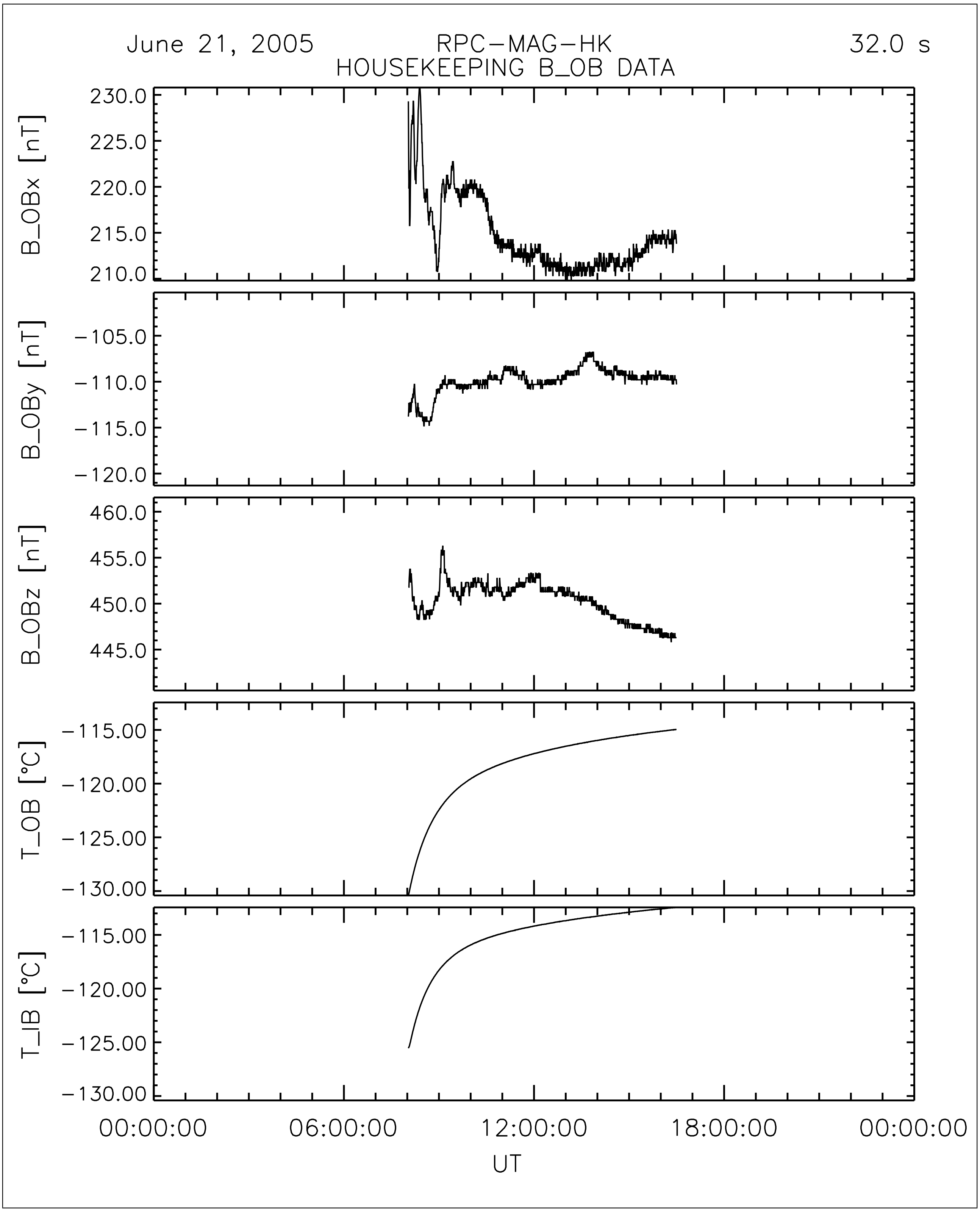

Figure 13: Magnetic Field (OB) in Housekeeping Data: 2005-06-21

D PLOTS of the Total RPC Current

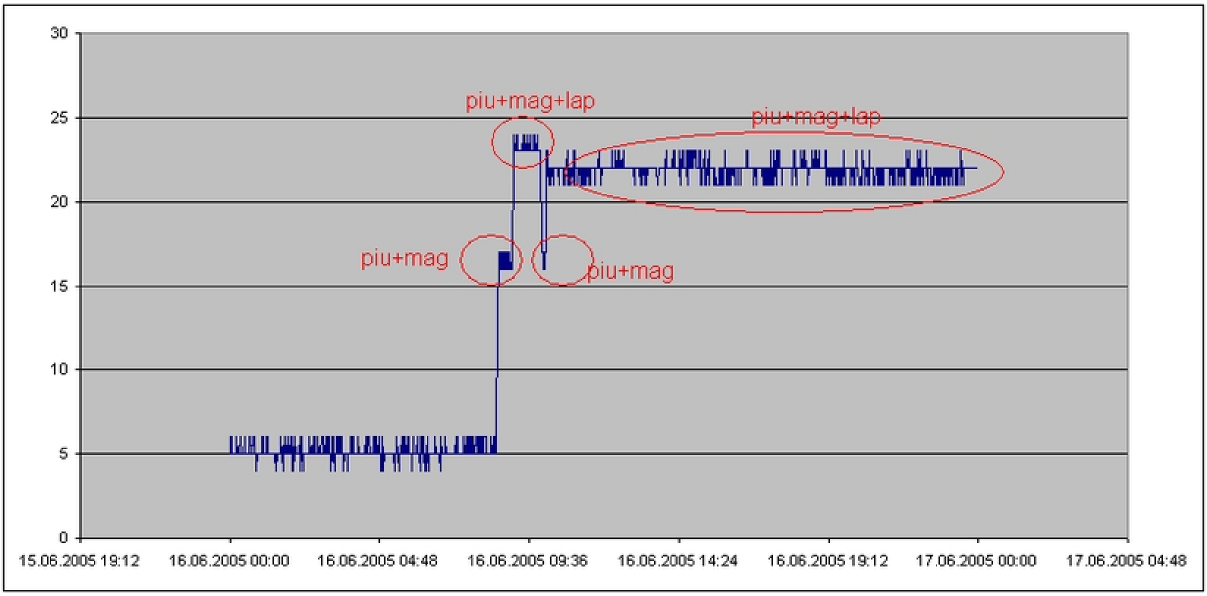

Figure 14: RPC: Total Current (in relative units): 2005-06-16

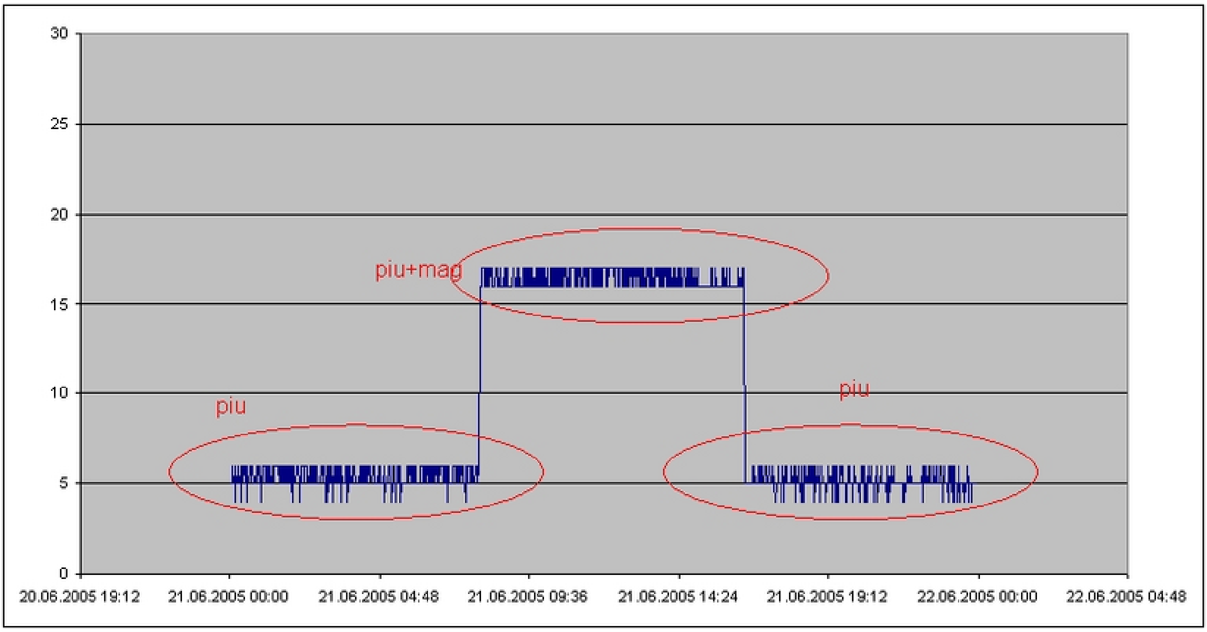

Figure 15: RPC: Total Current (in relative units): 2005-06-21

E The RPCMAG FGM Driver Electronics

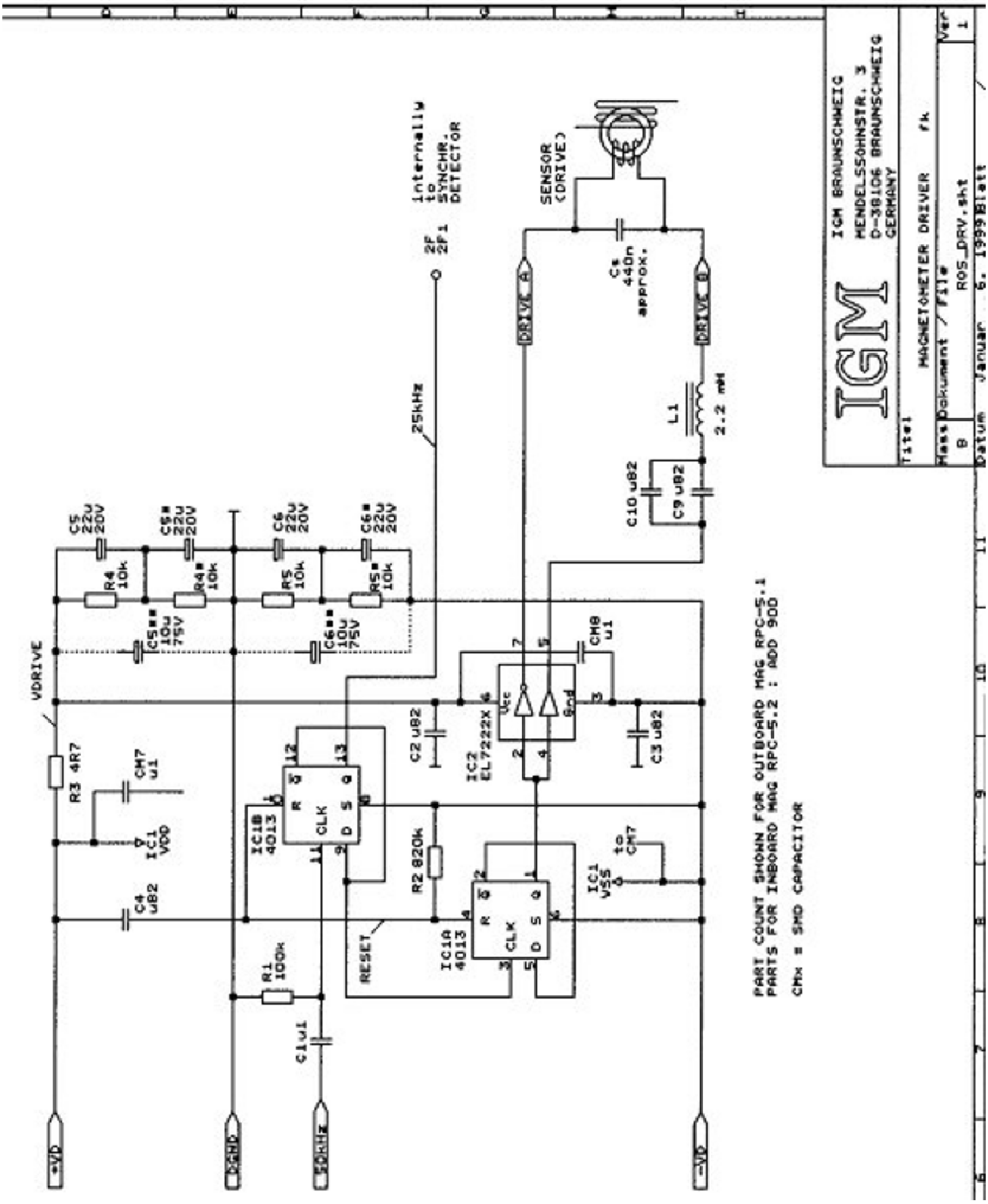

Figure 16: RPCMAG Driver Electronics

F The Sensor Temperatures and s/c Attitude during the Period June,16.-21.

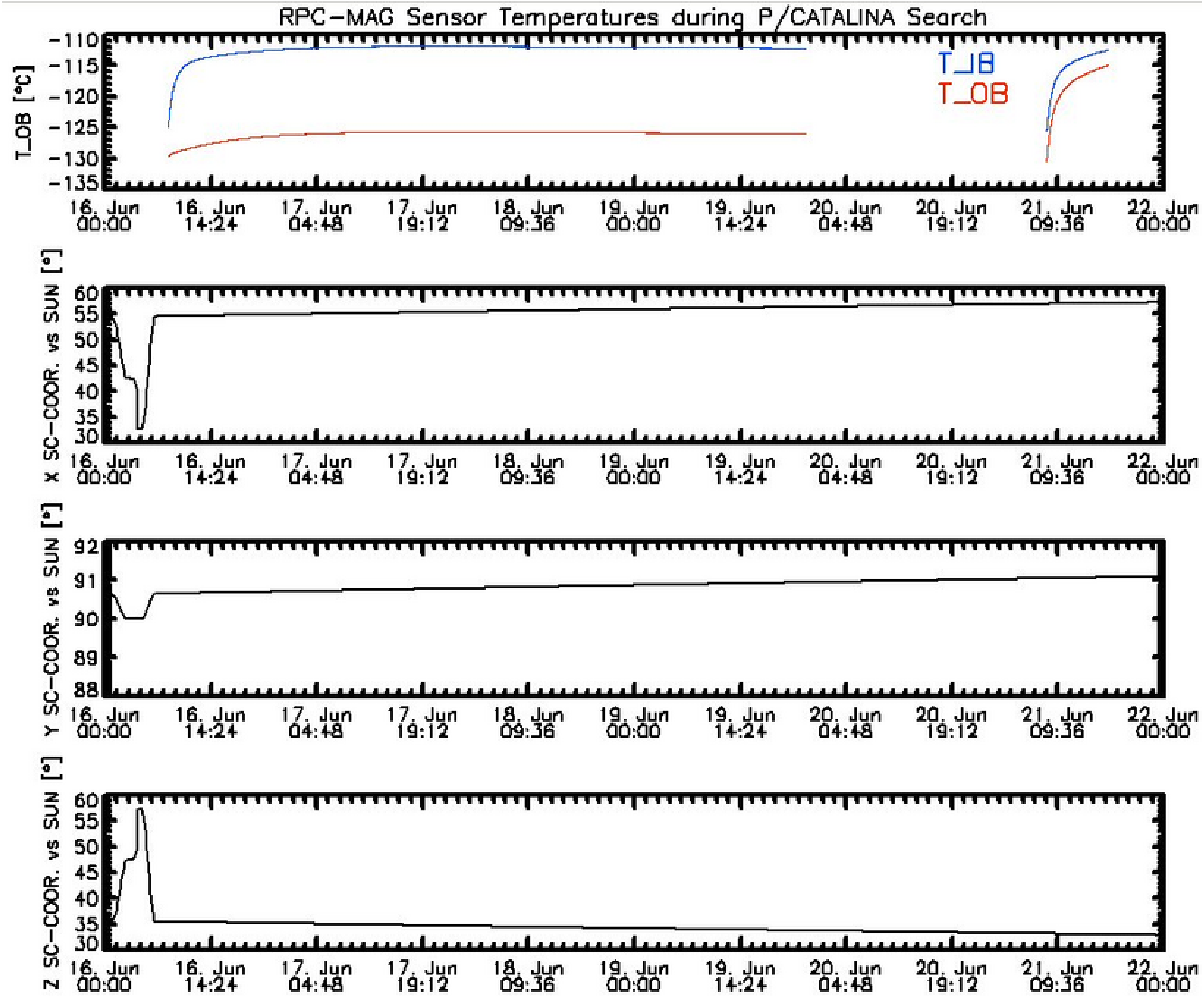

Figure 17: RPCMAG: Sensor Temperatures

G RFW for Thermal Tests

REQUEST FOR WAIVER *Rosetta Plasma Consortium*	*[0] RFW number*:	**RO-RPC-RW-**	**......**
	Issue/Rev: 01/00	*Date*:	03 /01 /2001

Equipment:	( ) 1: IES	( ) 2: ICA	( ) 3: LAP	( ) 4: MIP	(x) 5: MAG	( ) 6: PIU	( ) 7: EGSE	( ) 8: *other*
Unit:		*Model*:	( ) BB	( ) STM	(x) EQM	(x) FM	(x) FS	

Related NCR (if any):

[1] Title of Request:
Modified Thermal Vacuum Test Procedure for RPC-MAG Sensors 5.1,5.2 Qualification and Acceptance Test

[2] Affected End Items:
RPC-MAG Sensors –5.1,-5.2

[3] Requirements / Interface Documents affected:
EID –A sect.4.4.10

[4] Description of Deviation:
1. For the negative boom sensors temperature range it is impossible to run in magnetic controlled environment and down to –160C in any vacuum chamber. We only run this test in air in a Mumetal chamber for the negative T-range.
2. We were unable to perform 8 cycles (Qualification) and 4 cycles (Acceptance) from room temperature to – 160C.We only could run 2 ½ cycles because of facility-, liquid Nitrogen- and duration limitations.

[5] Other items or requirements (potentially) affected:

none

[6] Need for RFW / Rationale for Acceptance:
To control the proper operation of the MAG sensors during TV test this test has to be run under controlled magnetic environment .Because also the very small sensors(36g) contain only mechanical parts besides the Pt thermistor no vacuum is required. To test the maximum mechanical stresses caused by negative temperatures we have thrown the sensors into liquid nitrogen as a maximum thermal shock test!(- no failure). For qualification and Acceptance test we then performed two and a half cycles between room temperature and down to – 192C (requested was – 160Conly for Qual)respectively down to –160C for 6! Sensors (FM,FS,FSS) with about 4 hours at minimum temperatures. We also performed several switch-ON/Off sequences. All tests went fine, no failure. The total number of cycles was limited because of liquid nitrogen available (400liter liquid nitrogen were consumed for these 2 1/2 cycles within 3.5 days.) and the only available chamber in Europe booking schedule.

[7] Originator:	*Name*:	*Signature*:	*Date*:
MAG TM	Guenter Musmann.	[signature]	30/01/2001
[8] Approvals / Rejection:	*Name*:	*Signature*:	*Date*:
PI, TM:			
RPC:CM	G.Musmann	[signature]	30.1.2001
ESA RPO:			

Attachments:

Distribution:

Figure 18: Request for Waiver: Thermal Tests