Cluster EFW Anomaly Report

Problem with Probe 1 on SC3

Anders Eriksson, Per-Arne Lindqvist, Lennart Åhlén, Mats André

EFW-IRFU-AR-004
Version 1.1

27 September 2002

Document control

Version	Date	Comments
0.1	2002-09-13	Draft
0.2	2002-09-15	Comment why P1 on both SC1 and SC3 added
1.0	2002-09-15	Changes after comments from Mats. Released.
1.1	2002-09-27	Typographical correction to Table 1

Contents

1 Introduction

EFW probe 1 (P1) on Cluster SC3 stopped working properly at 2002-07-29 09:06:59 UT. Subsequent resets and power cycling of EFW has not remedied the situation. The failure shows characteristics very similar to the failure of P1 on SC1 2001-12-28, as can be seen when comparing the diagrams in this report with those in EFW-IRFU-AR-003. We will frequently refer to this earlier report.

2 Observations during the failure

Figure 1 shows EFW, WHISPER and STAFF SA data from the time of the failure. At the time, all probes on SC1 were in electric field mode with a bias current set at -35 digital units, corresponding to -137 nA. At 09:06:59, the probe-to-spacecraft potential of P1 (black line in top panel) suddenly falls from around -23 V to -68.57 V, which is the saturation value of the A-to-D converters. Compared to Figure 1 of EFW-IRFU-AR-003, there is not as much increase in narrowband WHISPER contamination, but otherwise the two failures show the same characteristics.

In Figure 2, we see a blowup of the 20 seconds around the failure time. Most characteristics are consistent with Figure 2 of EFW-IRFU-AR-003. The probe potentials (top panel) can be seen to change from about -27 V before the failure to -32 V after an initial overshoot. As P1 now is at maximum negative bias current, it emits more photoelectrons than before, so the spacecraft potential must adjust itself accordingly, which explains the change. The central panel shows the two spinning E-field components E12 and E34. After some initial excursions, E34 reassumes its sinusoidal pattern. E12 of courses changes drastically, with the new value of around 0.4 V/m essentially

being the difference of the P1 and P2 probe potentials, $68 - 32$ V$= 36$ V, divided by the 88 m probe separation. The increased level of variation simply is the variation of the spacecraft potential that can be seen in the top panel divided by the 88 m, which we should expect to see as V1 is stuck at -68 V while V2 varies with the satellite potential.

The similarity to the failure of P1 on SC1 is retained in the one-second plots in Figure 3. The individual probe potentials are sampled at a rate of 5 per second, while E12 and E34 are sampled 25 times per second. All data are low-pass filtered at 10 Hz, so there is a time constant of about 0.1 s associated with the filters. E12 reaches its peak value in about this time, while V1 immediately goes down to -68 V (sample not shown), without signs of any time constant. This can be the case because the V1 data are undersampled (filtered at 10 Hz, sampled at 5 per second).

In addition to these science data, the EFW digital subcom telemetry (DSC, time resolution 32 s) carries some additional information. As in the case of SC1, there is no change in the set bias value on P1; nor is there any change of the value of the bias current measured onboard. The total current to WEC, plotted in Figure 4 for all the day, does not show any clear signature at the time of the failure either.

Overview of WEC data

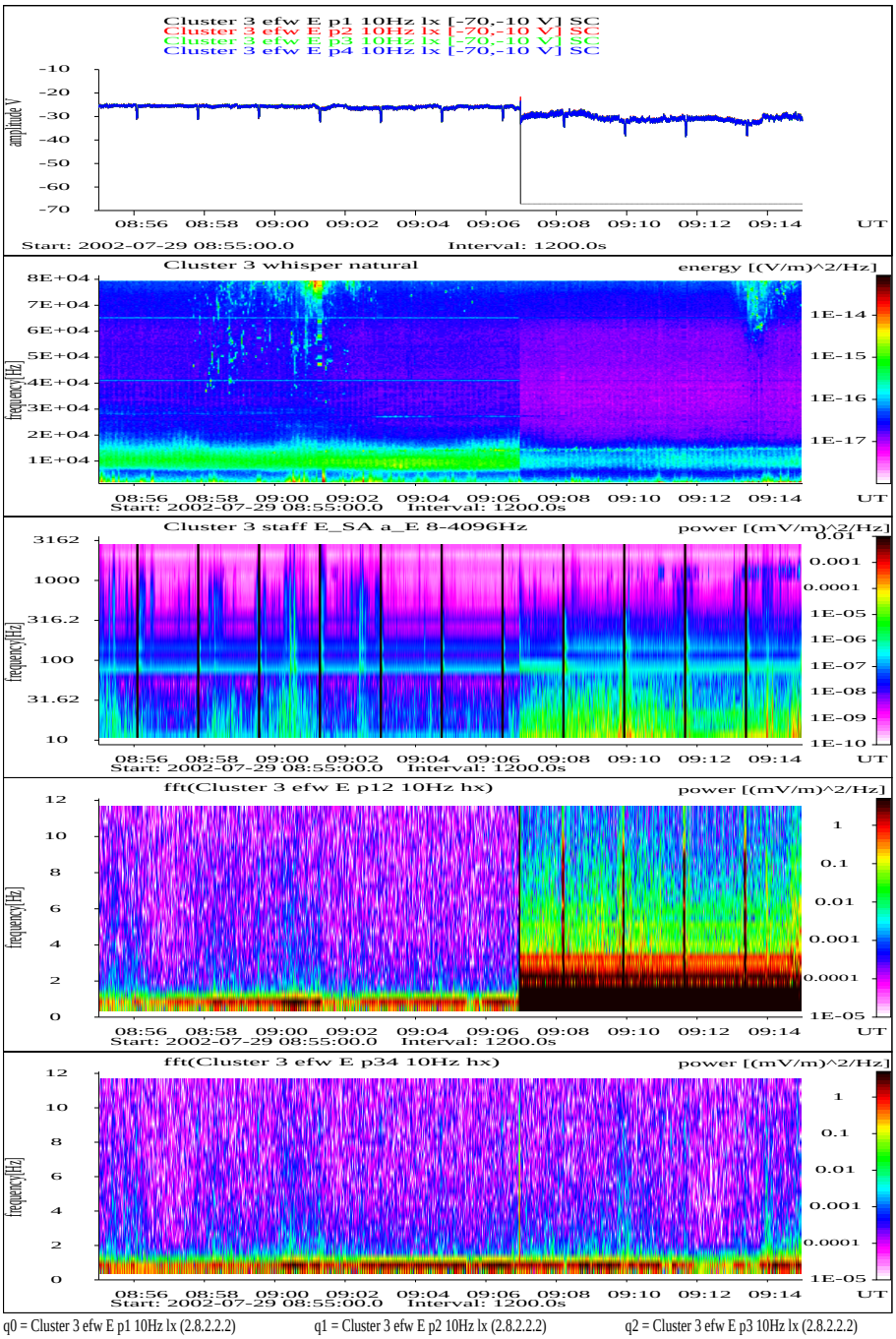


Figure 1: WEC data from SC3 at the time of the P1 failure. From top to bottom: (1) EFW individual probe potentials, in order black-rgb for P1-P4. (2) WHISPER natural mode spectra. (3) STAFF SA electric spectra. (4, 5) Spectra of EFW E12 and E34, respectively.

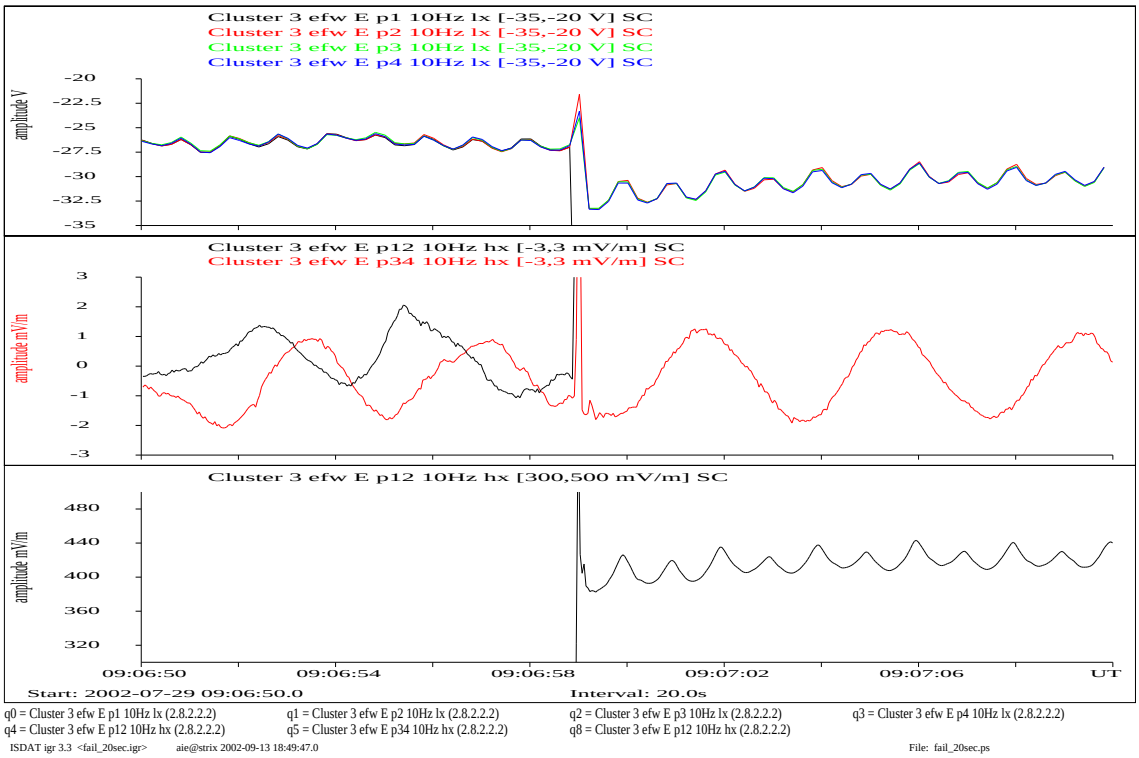
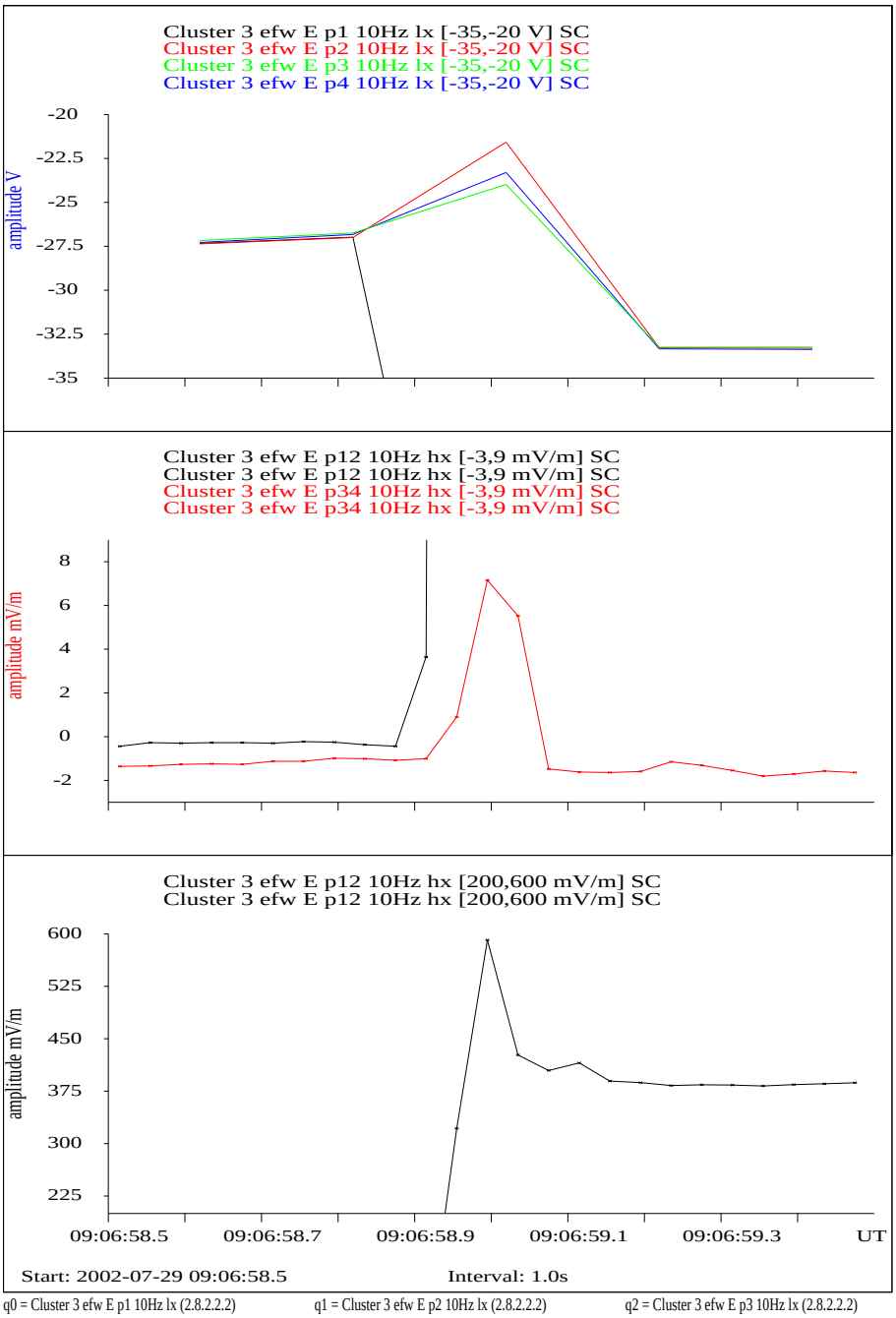


Figure 2: SC3 EFW data at the time of P1 failure. From top to bottom: (1) individual probe potentials, in order black-rgb for P1-P4. (2) E12 and E34. (3) E34 (shifted plot).

Details of EFW data



q0 = Cluster 3 efw E p1 10Hz lx (2.8.2.2.2)
q1 = Cluster 3 efw E p2 10Hz lx (2.8.2.2.2)
q2 = Cluster 3 efw E p3 10Hz lx (2.8.2.2.2)
q3 = Cluster 3 efw E p4 10Hz lx (2.8.2.2.2)
q4 = Cluster 3 efw E p12 10Hz hx (2.8.2.2.2)
q5 = Cluster 3 efw E p12 10Hz hx (2.8.2.2.2)
q6 = Cluster 3 efw E p34 10Hz hx (2.8.2.2.2)
q7 = Cluster 3 efw E p34 10Hz hx (2.8.2.2.2)
q8 = Cluster 3 efw E p12 10Hz hx (2.8.2.2.2)
q9 = Cluster 3 efw E p12 10Hz hx (2.8.2.2.2)

ISDAT igr 3.3 aie@strix 2002-09-13 16:50:17.0 File: fail_1sec.ps

Figure 3: SC3 detailed EFW data at the time of P1 failure. Format as in Figure 2.

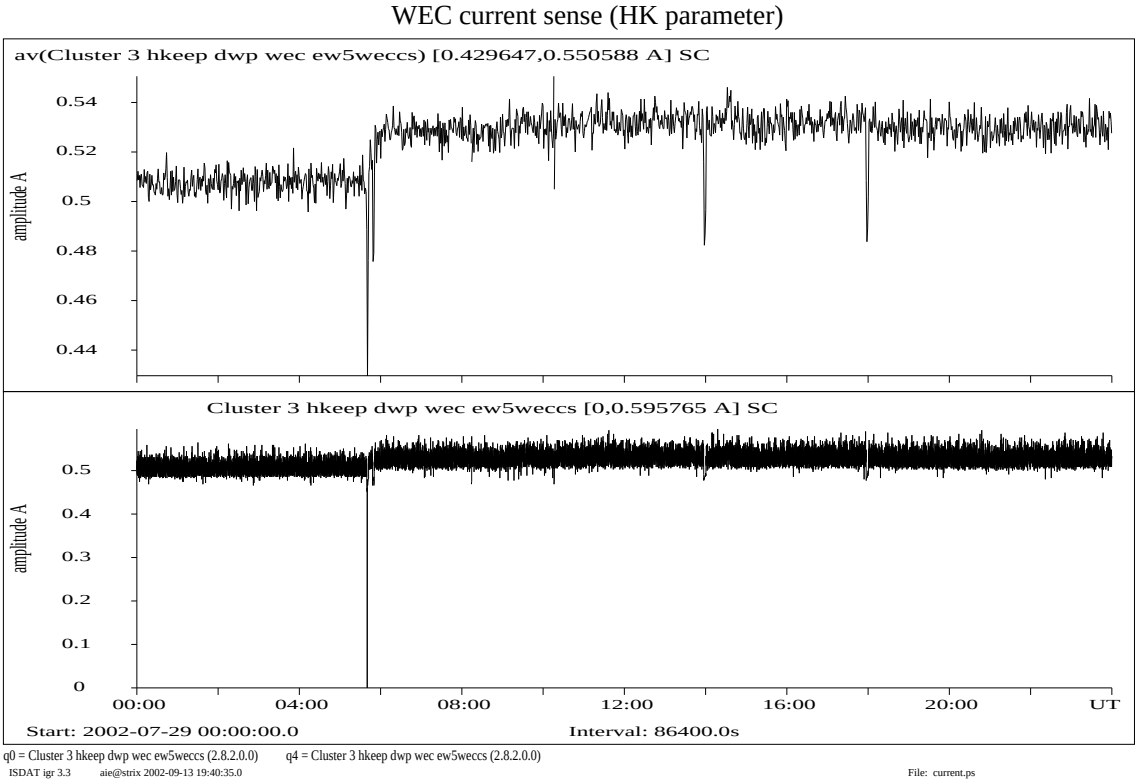


Figure 4: SC3 WEC current for the day of the P1 failure. Top panel is one minute averages, bottom is full HK time resolution (5.1 s).

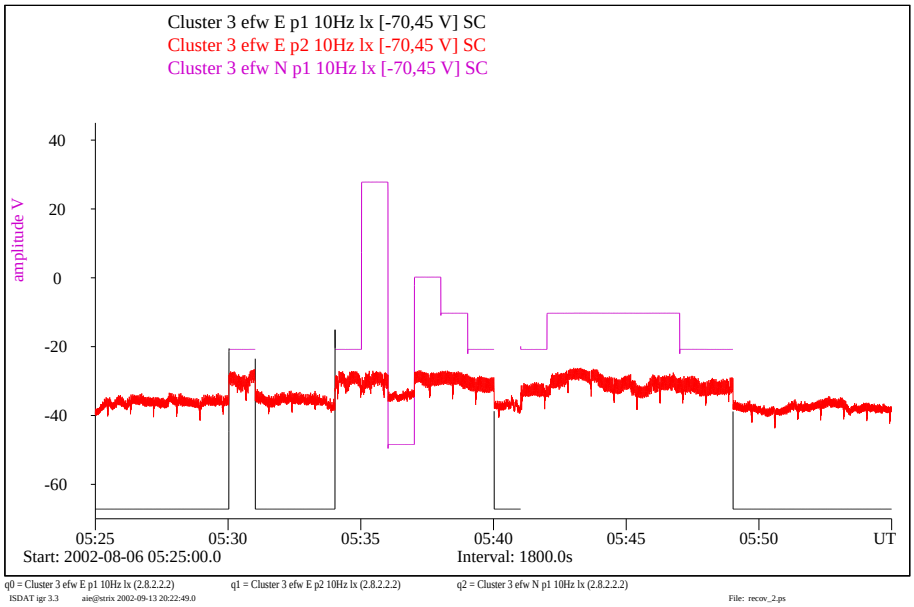


Figure 5: SC3 EFW P1 and P2 data during the recovery attempt and diagnostic test. Red is P2; black/magenta is P1 when in E-field/density mode.

3 Diagnostic experiments

A recovery attempt and diagnostic experiments, similar to those carried out on SC1 in January (see EFW-IRFU-AR-003) was performed on 2002-08-06 05:30 - 06:44 UT. This is summarized in Table 1, with further details in Appendix A (operations report from Per-Arne Linqvist). As in the case of SC1, the recovery attempt was not succesful, while the diagnostic experiment showed the same general characteristics.

An overview of the probe data from the test is seen in Figure 5. Red is probe 2, which stayed in current bias mode (E-field) during the test. Black is P1 when in E-field mode, magenta is P1 when in bias voltage (density) mode. The voltage bias test data are summarized in Table 2. A slight response of the probe potential to the puck voltage change at 05:43 can be seen in the detailed plot in Figure 6.

UT	Commanding	P1 bias	Comment
05:30:00	SWECJ015, X'19', X'01'	-10.8 V	Set probe 1 to density mode
05:31:00	SWECJ015, X'19', X'00'	-133 nA	Set probe 1 to E-field mode
05:32:00	SWECJ015, X'01', X'00'	0 nA	Set probe 1 bias to 0 nA
05:33:00	SWECJ015, X'01', X'DD'	-133 nA	Set probe 1 bias to -140 nA
05:34:00	SWECJ015, X'19', X'01'	-10.8 V	Set probe 1 to density mode
05:35:00	SWECJ015, X'01', X'7F'	+39.1 V	Set probe 1 bias to +40 V
05:36:00	SWECJ015, X'01', X'81'	-39.1 V	Set probe 1 bias to -40 V
05:37:00	SWECJ015, X'01', X'23'	+10.7 V	Set probe 1 bias to +10 V
05:38:00	SWECJ015, X'01', X'00'	0.0 V	Set probe 1 bias to 0 V
05:39:00	SWECJ015, X'01', X'DD'	-10.8 V	Set probe 1 bias to -10 V
05:40:00	SWECJ015, X'19', X'00'	-133 nA	Set probe 1 to E-field mode
05:41:00	SWECJ015, X'19', X'01'	-10.8 V	Set probe 1 to density mode
05:42:00	SWECJ015, X'01', X'00'	0.0 V	Set probe 1 bias to 0 V
05:43:00	SWECJ015, X'09', X'7F'		Set probe 1 puck to +1.25 V
05:44:00	SWECJ015, X'11', X'14'		Set probe 1 guard to +6 V
05:45:00	SWECJ015, X'09', X'80'		Set probe 1 puck to -1.25 V
05:46:00	SWECJ015, X'11', X'EC'		Set probe 1 guard to -6 V
05:47:00	SWECJ015, X'01', X'DD'		Set probe 1 bias to -10 V
05:48:00	SWECJ015, X'09', X'66'		Set probe 1 bias to -10 V
05:49:00	SWECJ015, X'19', X'00'	-133 nA	Set probe 1 to E-field mode
05:55:00	WEC switch off		
05:58:00	WEC switch on		
06:15:00	Switch on each WEC instrument and set up EFW		
06:44:06	WEC macro restarted, tests completed		

Table 1: Summary of WEC/EFW commanding during the recovery attempt and diagnostic experiment. Further details are available in Appendix A. The comment may say "140 nA" at the same time as the bias column says "-133 nA": the comment uses the nominal value of 4 nA or 0.3 V per bias step, while the bias column uses the actually measured values during ground tests.

Bias [V]	Measured value [V]
-39	-48
-11	-21
0	-10
+11	0
+39	+28

Table 2: Response of P1 to bias settings when in bias voltage mode.

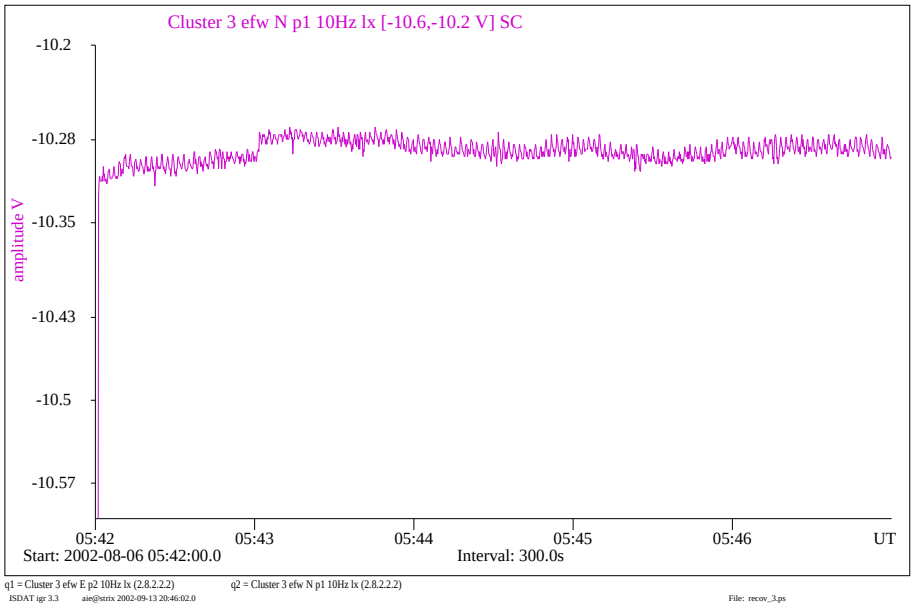


Figure 6: Detail of the SC3 EFW P1 data during the diagnostic test. The probe is in bias voltage mode. There is a small effect of the puck voltage setting to +1.25 V at 05:43, and an even smaller of its setting to -1.25 V at 05:45.

4 Failure identification and possible remedy

The data above can be summarized as follows:

- When in E-field mode (current bias), the voltage returned from the probe shows maximum negative value.
- When in E-field mode, the probe really is at maximum negative bias, as the s/c potential is seen to adjust itself accordingly at the time of the failure.
- When in Langmuir mode, the probe returns a voltage 9 – 12 V lower than the bias set (see Table 2).

As in the case of P1 on SC1, the result points to a failure of the 12 V power to the preamplifier in the puck. Such a failure would have immediate impact on the feedback to the bias circuitry, so that the probe gets stuck at maximum negative bias as is observed, and also give the observed difference between set and measured potential when in Langmuir mode. The small cross-talk observed when changing the puck potential is also consistent with this interpretation.

A power failure on the 12 V line could occur for a variety of reasons, from component breakdown to micrometeoroid impact on the wire boom. Most of the possible failure scenarios give no hope of recovery, with the exception of the possibility of a lose connection. If this is the explanation, then the problem may possibly be cured by deploying the boom a little more, say a few decimeters. The vibrations in the boom when running the motor could possibly rectify the situation. If the location of the bad connection should be one of the slip-springs/brushes mounted at both ends of the cable spool, a further deployment would in this case be very likely to fix the problem.

The fact that it is the same probe (P1) that has failed on SC1 and SC3 is hard to interpret: the probability for this to happen is 25

We therefore propose to do a deployment of the boom according to the following scenario.

Deploy the boom by one click, corresponding to 10 cm. This should take about 10 seconds. The procedures used for deployment during commissioning can be used with some modifications. For one thing, we want to deploy only one boom in a pair. Also, the values of some parameters to stop deployment in case of command link loss, etc, should be modified. Basically, the following should be done:

a) Set the onboard monitor of boom length to stop deployment after 30 cm. b) Set a time-tagged command to stop the deployment 20 seconds after deployment start (corresponding to 20 cm boom length). c) Use EFW commands to deploy the boom 1 click (corresponding to 10 cm boom length, or 10 seconds deployment time).

This gives three levels of safety in stopping the boom deployment. As mentioned above, the estimated remaining cable available in the boom unit is at least 2.5 meters, so a deployment of 10 cm is well within this length. As a fourth safety level, if the boom should reach end-of-wire, there is a switch which will stop deployment.

During deployment the status of the probe will be monitored by EFW. A total deployment time of 10 seconds, however, gives no time for reaction in real-time to whatever might happen. After the deployment, a few diagnostic measurements will easily

tell if the operation was successful, i.e., if the probe is again capable of measuring the electric field. If not, it should be considered to try the operation once again, deploying another 10 cm. This should be discussed with all involved parties at the time. Whether to continue with even more trials of course also remains to be discussed.

For practical reasons, it may be desirable to have EFW instrument representatives present at ESOC during the operation. This is mainly for ease of communication and discussion of what should be done if the operation is not successful. The near-realtime monitoring and post-deployment analysis of data can be done at an EFW home institution, e.g., in Stockholm or Uppsala. If this analysis should be done at ESOC, it is necessary to have access to the PISA LAN and IP numbers in the same ways as during the commissioning phase at the end of 2000.

Appendix A
Operations report 2002-08-06

From: "Per-Arne Lindqvist, KTH Stockholm" <lindqvist@plasma.kth.se>
To: <wec-ops@acse.shef.ac.uk>; <ma@irfu.se>; <silvano.manganelli@esa.int>;
    <juergen.volpp@esa.int>; <Philippe.Escoubet@esa.int>
Subject: Special ops on SC3 EFW probe 1 2002-08-06
Date: den 6 augusti 2002 09:34

Dear All,

At 2002-07-29 09:06:59 UT, SC3 EFW probe 1 went into negative saturation at around -68 V (similar to what happened to SC1 probe 1 at 2001-12-28 03:02:57).

Tests of SC3 probe 1 were made today 2002-08-06 to determine the state of the probe and possibly correct the problem. Unfortunately the tests showed exactly the same behaviour as on SC1 probe 1, which means that also here we suspect a failure in the supply of the +12 V voltage to the preamplifier in the probe. The EFW instrument on SC3 has now been left in a state identical to the instrument on SC1, with probe 1 in density mode with a voltage bias of 0 V, and with the EFW telemetry modified accordingly.

The timeline was as follows (UT on 2002-08-06).

1. Switch probe to density mode and back to E-field mode:

```
05:30 SWECJ015, X'19', X'01'     ! Set probe 1 to density mode
05:31 SWECJ015, X'19', X'00'     ! Set probe 1 to E-field mode
```

2. Switch bias current to zero and back to -140 nA:

```
05:32 SWECJ015, X'01', X'00'     ! Set probe 1 bias to 0 nA
05:33 SWECJ015, X'01', X'DD'     ! Set probe 1 bias to -140 nA
```

3. Switch probe to density mode and play with voltage:

```
05:34 SWECJ015, X'19', X'01'     ! Set probe 1 to density mode
05:35 SWECJ015, X'01', X'7F'     ! Set probe 1 bias to +40 V
05:36 SWECJ015, X'01', X'81'     ! Set probe 1 bias to -40 V
05:37 SWECJ015, X'01', X'23'     ! Set probe 1 bias to +10 V
05:38 SWECJ015, X'01', X'00'     ! Set probe 1 bias to 0 V
05:39 SWECJ015, X'01', X'DD'     ! Set probe 1 bias to -10 V
05:40 SWECJ015, X'19', X'00'     ! Set probe 1 to E-field mode
```

4. Additional tests to determine crosstalk with puck and guard voltages::

```
05:41 SWECJ015, X’19’, X’01’    ! Set probe 1 to density mode
05:42 SWECJ015, X’01’, X’00’    ! Set probe 1 bias to 0 V
05:43 SWECJ015, X’09’, X’7f’    ! Set probe 1 puck to +1.25 V
05:44 SWECJ015, X’11’, X’14’    ! Set probe 1 guard to +6 V
05:45 SWECJ015, X’09’, X’80’    ! Set probe 1 puck to -1.25 V
05:46 SWECJ015, X’11’, X’EC’    ! Set probe 1 guard to -6 V
05:47 SWECJ015, X’01’, X’DD’    ! Set probe 1 bias to -10 V
05:48 SWECJ015, X’09’, X’66’    ! Set probe 1 puck to -1 V
05:49 SWECJ015, X’19’, X’00’    ! Set probe 1 to E-field mode

5. Switch WEC off and on again, plus WEC reconfiguration to NM52

05:55 FCP_WEC_M002 ! Switch off each WEC instrument, and WEC LCL
05:58 FCP_WEC_M001 ! Switch on the WEC LCL
06:15 FCP_WEC_M902 ! Switch on each WEC instrument and set up EFW
                     (default parameters)

06:30    SWECJ275,X’1A’,X’AD’,X’13’,X’50’,X’0E’,X’4F’,X’CB’,X’10’,X’50’,X’100’;
06:30:18 SWECJ019,X’01’;
06:30:24 SWECJ013,X’0F’;
06:30:25 SWECJ004,X’17’;

6. Setup EFW on SC3 to run in same way as SC1:

06:39:54 SWECJ134                ! Stop WEC mode
06:40    SWECJ353                ! Reset EFW
06:41    SWECJ305,X’00’,X’DD’,X’DD’,X’DD’,
                  X’00’,X’66’,X’66’,X’66’,
                  X’00’,X’EC’,X’EC’,X’EC’   ! Setup bias etc
06:42    SWECJ355                ! Load spin fit patch special for probe 3+4
06:43    SWECJ015,X’19’,X’01’;   ! Set probe 1 to density mode
06:43:10 SWECJ015,X’46’,X’08’;   ! Modify LX to V3,V4,V1,V2
06:43:20 SWECJ015,X’47’,X’04’;
06:43:30 SWECJ015,X’47’,X’00’;
06:43:40 SWECJ015,X’46’,X’00’;   ! Modify HX to V2LV34L
06:43:50 SWECJ015,X’47’,X’94’;
06:44    SWECJ013,X’0F’;         ! Restart correlator
06:44:06 SWECJ004,X’17’;         ! Restart WEC macro.

--------------------

In addition, the following commands were uplinked for execution on SC3
to cancel the effects of EFW resets in the MSP schedule:

2002-08-06T11:39:18Z  SWECJ015,X’19’,X’01’  ! Set probe 1 to density mode
2002-08-06T11:39:24Z  SWECJ015,X’01’,X’00’  ! Set probe 1 bias to 0 V

2002-08-07T17:21:18Z  SWECJ015,X’19’,X’01’  ! Set probe 1 to density mode
2002-08-07T17:21:24Z  SWECJ015,X’01’,X’00’  ! Set probe 1 bias to 0 V
```

```
2002-08-08T21:45:18Z  SWECJ015,X’19’,X’01’  ! Set probe 1 to density mode
2002-08-08T21:45:24Z  SWECJ015,X’01’,X’00’  ! Set probe 1 bias to 0 V

2002-08-10T02:15:18Z  SWECJ015,X’19’,X’01’  ! Set probe 1 to density mode
2002-08-10T02:15:24Z  SWECJ015,X’01’,X’00’  ! Set probe 1 bias to 0 V
```

and the following commands were uplinked for execution on SC3 to setup WBD to use the Ey antenna:

```
2002-08-06T12:14:20Z  SWECJ251 X’00’, X’D7’, X’8863’
2002-08-06T12:14:21Z  SWECJ251 X’01’, X’D7’, X’8823’
2002-08-06T12:14:22Z  SWECJ251 X’00’, X’98’, X’8843’

2002-08-07T19:49:20Z  SWECJ251 X’00’, X’D7’, X’8863’
2002-08-07T19:49:21Z  SWECJ251 X’01’, X’D7’, X’8823’
2002-08-07T19:49:22Z  SWECJ251 X’00’, X’98’, X’8843’
```

An additional note on the CDDS: It worked perfectly for data retrieval up until 06:00 UT. After this time, the files REQUEST.DDS were no longer picked up by the system. At 06:35, the system started working as expected again.

Many thanks to Silvano and others at ESOC for help with this operation.

Best regards,
Per-Arne