This analysis includes a total of four test sequences during commissioning phase (from OD 26, OD 27(2x) and OD 32) for setting up the PACS photometry mode, starting out of SAFE mode. This PHOT orbit prologue has three options to fill the stabilisation time for the PACS CSs: (i) just waiting without recording data (ii) recording of VRL noise data in high gain mode (iii) recording bolometer sky signals for a subarray in full 40 Hz resolution (also in high gain). All 3 options are included in the analysis, including a verbal description of the commanding procedures, the confirmation of certain setting in HK entries and an analysis of the diagnostic data during mechanism configuration.

No events were produced. The evaporator temperature at the end of this PHOT orbit prologue was in all 4 cases $283 \pm 1$ mK, despite the very different test histories and despite the very different thermal environments. This orbit prologue also includes the SPU bit-rounding scheme (2-bit rounding in high gain mode and no bit rounding in low gain mode) for the first time which is correctly implemented for in-orbit operations. The CRDCCP counter (NCR4497) was correctly incrementing in the 3 relevant cases where science data were produced. Key aspects of this setup-procedure are compared to the same test sequences during TVTB (two executions), FM-IST (three executions) and FM-ILT at MPE on 11/April/2007. Anomalies: (1) The executions of the "VRL" option (OD 26 and OD 27) left the instrument in a wrong configuration and subsequent measurements on these days only have VRL signals and no bolometer signals. The bug is meanwhile corrected, but the PacsEng_PHOT_orbit_prologue was not used since then in the "VRL" option. It should also be noted that the shortest allowed wait time for the CS stabilisation has to be bigger than 200 s (only "VRL" and "40Hz" options) which is not obvious from the input-mask when creating an AOR. (2) The autonomy function 15 which watches the VSS currents is supposed to be enabled at the end of this test, but it remained disabled in all cases (commented out in the CUS-script). The reason has to be followed up and a simple CUS-modification might fix this point. (3) The pipeline frame generation for the science data ("VRL" and "40Hz" options) is not working reliably for several uncomplete SPU buffers, produced by very fast starting and stopping of the SPU in different modes (0/2 bit-rounding, low/high gain, compression mode: nominal & lossless compression, detector selection tables). In future updates for PacsEng_PHOT_orbit_prologue these unnecessary start/stop commands should be eliminated.
Contents

1 Overview 2
2 Content & Commanding History 3
  2.1 Commanding history per OD 3
  2.2 Detailed commanding: general instrument configuration 3
  2.3 Detailed commanding: "VRL" option 6
  2.4 Detailed commanding: "40Hz" option 6
3 Data packet analysis 7
  3.1 "PacsEng\_PHOT\_orbit_prologue" during OD 26 ... OD 32 7
  3.2 "PHOT\_setup\_OBS" during FM-tests on ground 7
4 Validation of commands 8
5 Temperatures during the setup 14
6 Issues identified during FM-IST/TVTB 17

1 Overview

Author : T. Müller, MPE
Test ID : 517 (nominal) & 703 (redundant) & 528 (nominal AOT)
PACS Setup of Photometry
CUS : PHOT\_setup\_OBS
FM-CoP : 1342178014: Calibration\_CPFFT\_3-CPFFT\_IST414\_nStdPHOT\_setup\_nominal\_na_0001
       1342178059: Calibration\_CPSP\_PHOT\_2-CPSP\_PHOT\_IST517\_nStdPHOT\_setup\_nominal\_na_0001
       1342178068: Calibration\_CP\_PHot\_Setup\_1-CP\_Ph\_Setup\_Trial\_orbitpro\_na_0001
       1342178508: Calibration\_CP\_Phot\_Setup\_1-CP\_Phot\_Setup\_na\_nStd\_orbitpro\_na_0001
FM-TVTB : FIST\_SPT\_Setup\_Phot\_517\_20081204.tm
           FIST\_AOT\_Setup\_Phot\_528\_20081204.tm
FM-IST : FIST\_SPT\_Phot\_517\_20080827.tm (nominal)
          FIST\_SPT\_Phot\_703\_redundant\_20080828.tm (redundant)
          FIST\_SPT\_Phot\_517\_nominal\_20080828.tm (nominal)
          (FIST\_SPT\_Phot\_517\_nominal\_20080828\_02.tm (nominal))
FM-ILT : FILT\_IST\_20070411\_517\_Phot\_Setup\_48.tm
Documents : RD-1: HP-2-ASED-TP-0205, Issue 1
             RD-2: PACS-ME-TP-021
2 Content & Commanding History

This test contains a sequence of commands to perform the PACS configuration for photometry mode, starting out of SAFE mode, partially executed after the cooler recycling.

"PacsEng_PHOT_orbit_prologue" requires the input of two bias tables: one in case there is a science block executed during the CS stabilisation ("VRL" and "40Hz" options) and another one which is put in place at the end of the setup for subsequent measurements. The procedure also allows to specify settings for both Pacs CSs (current default values are 48.0 Ω for CS1 and 58.0 Ω for CS2) in combination with a stabilisation time. The filter position (default is position A) and the bolometer mode (direct or DDCS) is also selectable (default is direct mode).

The analysis here uses the recorded in-orbit data for the CUS observing mode "PacsEng_PHOT_orbit_prologue" with default bias tables, default CS settings (but different stabilisation times) and direct mode in combination with 3 options:

- **justWait**: calling the procedure "PHOT_setup"
- **VRL**: calling the procedure "Phot_lowFreq_Vrl_filler" which performs a low frequency noise measurement on VRL in high gain (after execution of "PHOT_setup").
- **40 Hz**: calling the procedure "Phot_SPU40Hz_filler" which allows to observe the sky with a few pixels (via detector selection table "PACSDetSel_20090429") at full 40 Hz resolution in high gain (after execution of "PHOT_setup").

The second and third options are introduced to obtain science data in specific bolometer configurations (sky or VRL) while the CSs are stabilizing. These options were not available during previous tests. There, the CUS observing mode "PHOT_setup_OBS" was always used, which called the building block "PHOT_setup" with the default bias "calUfile" "BOLObias_ilt_standard_low", the default filter position "POS A" (green band) and the resistance values 48.0 and 58.0 Ω for the PACS calibration sources CS1 and CS2.

2.1 Commanding history per OD

Commanding history on OD 26:

- OBSID 1342178011 PacsEng_BOLO_cooler 1005001 Cooler recycling
- OBSID 1342178012 PacsEng_Phot_thermal 1005002 Thermal behaviour test PHOT
- OBSID 1342178013 PacsEng_ENTER_SAFE_Mode 1005003 SAFE mode
- OBSID 1342178014 PacsEng_PHOT_orbit_prologue 1005004 nStdPHOTsetup_nominal (BOLObias_ilt_standard_low, 48.0, 58.0, 2100, direct mode, VRL, BOLObias_ilt_standard_high)

Commanding history on OD 27:

- OBSID 1342178058 PacsEng_BOLO_cooler 1005038 Cooler recycling
- OBSID 1342178059 PacsEng_PHOT_orbit_prologue 1005039 nStdPHOTsetup_nominal (BOLObias_ilt_standard_low, 48.0, 58.0, 2100, direct mode, VRL, BOLObias_ilt_standard_high)
- OBSID 1342178067 PacsEng_orbit_epilogue 1005047 CPPhotSetup_na_nStd_orbitpro (BOLObias_ilt_standard_low, 48.0, 58.0, 600, direct mode, 40 Hz, BOLObias_ilt_standard_high)

Commanding history on OD 31/32:

- OBSID 1342178507 PacsEng_BOLO_cooler 1005347 Cooler recycling (OD 31)
- OBSID 1342178508 PacsEng_PHOT_orbit_prologue 1005364 nStdPHOTsetup_nominal (OD 32) (BOLObias_ilt_standard_low, 48.0, 58.0, 2100, direct mode, justWait, BOLObias_ilt_standard_high)

2.2 Detailed commanding: general instrument configuration

The CUS observing mode "PacsEng_PHOT_orbit_prologue" executes in all cases the procedure "PHOT_setup" which contains the following commanding sections:

- the procedure "PHOT_dpu_dmc_setup(\"BOTH Array\",4)"
- Configure the photometry HK for both channels:
  ```
  Pacs_DPU_SET_HK_LIST(\"PHOT\",\"BOTH Array\")
  ```
- place the chopper current "chop_ia" information into one of the configurable HK entries:
  Pacs_DMC_WRT_DIAGHK_CONF_TAB(wrdLen,params,check_sum);

- write bolometer receiver options:
  Pacs_DMC_WRT_BOL_REC_OPT(params,check_sum);

- write blue and red DEC receiver options:
  Pacs_DMC_WRT_B_DEC_REC_OPT(params,check_sum);
  Pacs_DMC_WRT_R_DEC_REC_OPT(params,check_sum);

- write the timing FPGA parameters (with values from a lookup table "FPGA_params",
  "Plast","phase_inc"):
  Pacs_DMC_WRT_TIMING_FPGA_PAR(parlist,check_sum);

- Apply the new parameters:
  Pacs_DMC_SET_TIMING_FPGA_PAR();

- Change the sync signal:
  Pacs_DMC_SYNCHRONIZE_ON_DET(sync_srce);

- Upload WRT_TIMING_FPGA_PAR with 0,0,26,0\times977602A,0x22* (during FM-ILT
  & FM-IST) and WRT_TIMING_FPGA_PAR with 0,1,0,26,0\times977602A,0x22* (during
  FM-TVTB), write to register and activate:
  Pacs_DMC_WRT_TIMING_FPGA_PAR(parlist,check_sum);

- Apply the new parameters:
  Pacs_DMC_SET_TIMING_FPGA_PAR();

- Start forwarding data from BOL to SPU (bit 2 is clear):
  Pacs_DMC_WRT_BOL_REC_OPT(params,check_sum);

- Validate science data photometry
  *
  : the "phase_shift_reg" was changed to '1' starting with the TVTB test to avoid CRDCCP
  counter problems (NCR4497) and therefore to avoid chopper synchronisation problems.

- configure filterwheel:
  (i) write and start diagnostic HK with 5 ms interval (DMC_FW_PHOT_CTRL-211;
    DMC_FWGRAT_HALLA-256; DMC_FWGRAT_HALLB-257; DMC_FWPH_CUR_POS-260;
    DMC_FPU_TSEN_ST-404; DMC_FWPH_TEMP-406; DMC_FW_GR_VMOTA-556;
    DMC_FW_GR_IMOTA-560; DMC_FWPH_POS_A-563; DMC_FW_GR_VMOTB-564;
    DMC_FW_GR_IMOTB-567; DMC_FWPH_POS_B-569);
  (ii) configuration of filter wheel parameters CONF_phot_fltw();
  (iii) PHOT_fltw_move(phot_fltw_id);
  (iv) Stop diagnostic HK values:
    Pacs_DMC_STOP_DIAG_HK();

- configure chopper:
  (i) write and start diagnostic HK with 5 ms interval (DMC_CHOP_CTRL_ST-209;
    DMC_CHOP_CUR_POS-244; DMC_CHOP_SETPOINT-245; DMC_CHOP_TARGET-246;
    DMC_CHOP_PID_ERR-247; DMC_CHOP_PID_ACC-248; DMC_CHOP_MAX_DIT-249;
    DMC_CHOP.Output-258; DMC_CHOPPER_TEMP-407; DMC_CHOP_VA-557;
    DMC_CHOP_IA-561; DMC_CHOP_VB-565);
  (ii) configuration of chopper parameters CONF_chopper("CONFChopper","nom_sky");
  (iii) Switch-on chopper controller CHOP_on_off("ON");
  (iv) Move chopper to default position:
    Pacs_DMC_MOVE_CHOP_ABS(chop_def_pos); (v) Stop diagnostic HK values:
    Pacs_DMC_STOP_DIAG_HK();

- configure PACS Calibration sources:
  (i) configuration of PACS calibration sources CONF_cs("Both");
  (ii) Switch-on and temperature settings:
    CS_on_off("CS1","ON"); CS_temp("CS1",temp_CS1);
CS.on_off("CS2","ON"); CS.temp("CS2",temp_CS2);

- the procedure "PHOT_switch_on_groups()"
  - disable autonomy functions:
    (i) disable AF 12 (to check for the protection biases)
    Pacs_DPU.SET_FUNCT("EVENT_BOL_BIAS","DISABLE");
    (ii) disable AF 15 (to check for the VSS currents of groups and BUs)
    Pacs_DPU.SET_FUNCT("EVENT_BOL_IRO","DISABLE");
    (iii) disable AF 17 (to check for group power)
    Pacs_DPU.SET_FUNCT("EVENT_BOL_V_PWR","DISABLE");
  - consecutive switch-on of all groups:
    Pacs_DMC.SEND_COMMAND_BOLC(operand);
    0xa000001; 0xa000003; 0xa000007; 0xa00000f; 0xa00001f; 0xa00003f;
  - enable autonomy function 17 "generate_event_pwr" to check the HK entries:
    PC_PWR.ANA_P.#, PC_PWR.ANA_N.# and PC_PWR_DIG.#, with # = [1,2,3,4,5,6,7]:
    Pacs_DPU.SET_FUNCT("EVENT_BOL_V_PWR","ENABLE");

- the procedure "PHOT_set_bias_volt(calUfile,1/2/3/4/5/6)" for perform the following steps for each group:
  - switch-on biases 22 (VDD-PROT-CL), 21 (VDD-PROT-BU), 23 (GND-BU)
  - set the right biases in the following sequence:
    "VINJ", "VH", "VL", "VRL", "VCH";

- the procedure "PHOT_seq_setup()"
  - Pacs_BOLC.SET_CLOCK_MUX("STOP");
  - Pacs_BOLC.FINE_TIME_SETTING(0x14);
  - Pacs_BOLC.FINE_TIME_SETTING(0x111b4);
  - Pacs_BOLC.FINE_TIME_SETTING(0x24874);
  - Pacs_BOLC.FINE_TIME_SETTING(0x34ce4);
  - Pacs_BOLC.FINE_TIME_SETTING(0x44fe6);
  - Pacs_BOLC.FINE_TIME_SETTING(0x58c2c);
  - Pacs_BOLC.FINE_TIME_SETTING(0x69124);
  - Pacs_BOLC.FINE_TIME_SETTING(0x79334);
  - Pacs_BOLC.FINE_TIME_SETTING(0x89b14);
  - Pacs_BOLC.FINE_TIME_SETTING(0x9a100);
  - Pacs_BOLC.SET_CLOCK_MUX("Sequencer");

- the procedure "PHOT_change_data_mode("Bolo_HK")" to enable bolometer data and HK data
- the procedure "gotoDirect" to switch to direct mode
- the procedure "PHOT_set_gain("LOW")" to go to low gain
- the procedure "PHOT_spu_setup(0,0,0,0,false)" to configure the SPU with default compression/reduction mode and without raw channels, but the data flow will not be started here

- the autonomy-function 12 to check for the protection biases
  "Pacs_DPU.SET_FUNCT("EVENT_BOL_BIAS","ENABLE")"

- the autonomy-function 14 to check for TEMP_EV < 0.3K
  "Pacs_DPU.SET_FUNCT("EVENT_BOL_T_FPU","ENABLE")"

"PacsEng_PHOT_orbit_prologue" with the option "justWait" only executes the procedure "PHOT_setup" and then stops the observations by resetting the BBID & OBSID.
2.3 Detailed commanding: "VRL" option
Executed after the steps described in Sect. 2.2. The option "VRL" triggers the execution of procedure "Phot_lowFreq_Vrl_filler" which contains the following additional commanding sections (just after PHOT_setup and before the resetting the BBID and OBSID):

- Bias setting of the detectors for high gain in direct mode
- Sequence mode: blocking on CKRL for the mode non-hache on VRL
- 2 min stabilisation time
- Set VRL to 0.45 V
- Noise measurement during measureTime
- End bias setting of the detectors (back to direct mode, low gain and to the standard bias table for low gain)
- Stop SPU for science data downlink

2.4 Detailed commanding: "40Hz" option
Executed after the steps described in Sect. 2.2. The option "40 Hz" triggers the execution of the procedure "Phot_SPU40Hz_filler" which contains the following additional commanding sections (just after PHOT_setup and before the resetting the BBID and OBSID):

- Bias setting of the detectors for high gain in direct mode
- Set the PACS chopper at the position 664
- Stop SPU and load a new Detector selection table ("PACSDetSel_20090429")
- Special SPU setup to downlink 40Hz science data of some pixels
- 2 min stabilisation time
- Noise measurement during measureTime
- End bias setting of the detectors (back to direct mode, low gain and to the standard bias table for low gain)
- Stop science data downlink
- Stop SPU for science data downlink and load default DetSel Table ("PACSDetSel_20081203")
3 Data packet analysis

3.1 "PacsEng_PHOT_orbit_prologue” during OD 26 ... OD 32

<table>
<thead>
<tr>
<th>Packet Type</th>
<th>OD 26</th>
<th>OD 27</th>
<th>OD 27</th>
<th>OD 32</th>
</tr>
</thead>
<tbody>
<tr>
<td>VRL option</td>
<td>1342178014</td>
<td>1342178059</td>
<td>1342178068</td>
<td>1342178508</td>
</tr>
<tr>
<td>2282 sec</td>
<td>2282 sec</td>
<td>807 sec</td>
<td>2272</td>
<td></td>
</tr>
<tr>
<td>justWait option</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIAGNOSTIC_HK</td>
<td>2100 sec</td>
<td>2100 sec</td>
<td>600 sec</td>
<td>2100 sec</td>
</tr>
<tr>
<td>ESSENTIAL_HK</td>
<td>216</td>
<td>216</td>
<td>216</td>
<td>216</td>
</tr>
<tr>
<td>PHOT_HK</td>
<td>226</td>
<td>226</td>
<td>80</td>
<td>225</td>
</tr>
<tr>
<td>TC_ACP_OK</td>
<td>1130</td>
<td>1130</td>
<td>399</td>
<td>1125</td>
</tr>
<tr>
<td>PHOT_SC_BLUE</td>
<td>337</td>
<td>337</td>
<td>385</td>
<td>207</td>
</tr>
<tr>
<td>PHOT_SC_RED</td>
<td>14843</td>
<td>14835</td>
<td>6055</td>
<td>0</td>
</tr>
<tr>
<td>Packet Type</td>
<td>3884</td>
<td>3876</td>
<td>1569</td>
<td>0</td>
</tr>
</tbody>
</table>

The packet analysis looks very clean (except the number of TC_ACP_OK which is not correctly reflecting the number of CUS commands):

- there are no event packets
- the science packets are only produced in the "VRL” and "40 Hz” options, as commanded
- the diagnostic HK packets are consistent
- no OBCPs are running

3.2 ”PHOT_setup_OBS” during FM-tests on ground

<table>
<thead>
<tr>
<th>Packet Type</th>
<th>FM_ILT (MPE) (nominal)</th>
<th>FM_JST (ESTEC) (nominal)</th>
<th>FM-TVTB (AOT prep)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO_PRIME_HK</td>
<td>2070411</td>
<td>20080827 (nominal)</td>
<td>20081204 (AOT prep)</td>
</tr>
<tr>
<td>ESSENTIAL_HK</td>
<td>30</td>
<td>238</td>
<td>120</td>
</tr>
<tr>
<td>PHOT_HK</td>
<td>142</td>
<td>1128</td>
<td>558</td>
</tr>
<tr>
<td>TC_ACP_OK</td>
<td>211</td>
<td>212</td>
<td>212</td>
</tr>
<tr>
<td>DIAGNOSTIC_HK</td>
<td>217</td>
<td>216</td>
<td>216</td>
</tr>
</tbody>
</table>

All 5 photometer configuration procedures during FM-IST and FM-TV TB worked perfectly without producing any event. The number of commands changed from FM-ILT to the FM-IST/TVTB phase due to the manual configuration of one HK entry (to monitor the chopper current).
4 Validation of commands

1. PHOT_HK produced, both channels have data:
   DM_BLUE_ENC_PAC start from fixed value, increments by 320 (can change by ±2)
   DM_RED_ENC_PAC start from fixed value, increments by 80 (can change by ±1)
The reason of the jitter in these packets is due to the sampling jitter for individual HK-packets.
The counters start running after the writing of the bolometer receiver options "Pacs_DMC_WRT_BOL_REC_OPT".

2. FPGA:
The commanded FPGA parameter "phase_inc" is different from the value given in the DEC/MEC UM (Issue 4.8, 11 Nov 2008): The value "Plast" in the Cal-file "FPGA_params" is "158850052", corresponding to "0x977DC04", while the value "0x0977602A" is listed in the DEC/MEC UM. The difference is caused by an optimisation procedure for the "phase_inc" parameter which was performed during FM-ILT at MPE based on the true BOLC synchronisation signal.

3. Manual configuration of the chopper current: The raw value of the chopper current is available in all HK-packets in the HK-entry "DM_CUSTOM.Ent.1". The translation into a current is possible via the calibration curves.

4. DIAGNOSTIC_HK produced:

<table>
<thead>
<tr>
<th>ID</th>
<th>FW</th>
<th>Name</th>
<th>CHOP</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID_1</td>
<td>211</td>
<td>DMC_FW_PHOT_CTRL</td>
<td>209</td>
<td>DMC_CHOP_CTRL_ST</td>
</tr>
<tr>
<td>ID_2</td>
<td>256</td>
<td>DMC_FWGRAT_HALLA</td>
<td>244</td>
<td>DMC_CHOP_CUR_POS</td>
</tr>
<tr>
<td>ID_3</td>
<td>257</td>
<td>DMC_FWGRAT_HALLB</td>
<td>245</td>
<td>DMC_CHOP_SETPOINT</td>
</tr>
<tr>
<td>ID_4</td>
<td>260</td>
<td>DMC_FWPH_CUR_POS</td>
<td>246</td>
<td>DMC_CHOP_TARGET</td>
</tr>
<tr>
<td>ID_5</td>
<td>404</td>
<td>DMC_FPUT_T_SENS_ST</td>
<td>247</td>
<td>DMC_CHOP_PID_ERR</td>
</tr>
<tr>
<td>ID_6</td>
<td>406</td>
<td>DMC_FW_PHOT_TEMP</td>
<td>248</td>
<td>DMC_CHOP_PID_ACC</td>
</tr>
<tr>
<td>ID_7</td>
<td>556</td>
<td>DMC_FW_GR_VMOTA</td>
<td>249</td>
<td>DMC_CHOP_MAX_DIT</td>
</tr>
<tr>
<td>ID_8</td>
<td>560</td>
<td>DMC_FW_GR_IMOTA</td>
<td>258</td>
<td>DMC_CHOP_OUTPUT</td>
</tr>
<tr>
<td>ID_9</td>
<td>563</td>
<td>DMC_FWPHOT_POS_A</td>
<td>407</td>
<td>DMC_CHOPPERTEMP</td>
</tr>
<tr>
<td>ID_10</td>
<td>564</td>
<td>DMC_FW_GR_VMOTB</td>
<td>557</td>
<td>DMC_CHOP_VA</td>
</tr>
<tr>
<td>ID_11</td>
<td>567</td>
<td>DMC_FW_GR_IMOTB</td>
<td>561</td>
<td>DMC_CHOP_JA</td>
</tr>
<tr>
<td>ID_12</td>
<td>569</td>
<td>DMC_FWPHOT_POS_B</td>
<td>565</td>
<td>DMC_CHOP_VB</td>
</tr>
<tr>
<td>ID_13</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>ID_14</td>
<td>452</td>
<td>—</td>
<td>452</td>
<td>—</td>
</tr>
<tr>
<td>ID_15</td>
<td>512</td>
<td>—</td>
<td>512</td>
<td>—</td>
</tr>
<tr>
<td>ID_16</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

5. Filter position set to A (DM_FWPH_CUR_POS)

6. Chopper controlled at 0 (DM_CHOP_CUR_POS):
   Within the "PHOT_setup" CUS module, the chopper is configured with its standard controller parameters. After about 3 seconds the chopper controller is switched on and after a 10 seconds stabilization time the chopper controller is enabled and a move command to position zero is executed. During that phase diagnostic data of the key chopper HK parameters is taken at a frequency of 200 Hz. The chopper target and the chopper positions are shown in Fig. 1. Acceptable chopper position oscillations are seen when the chopper controller is switched on. The lack of reproducibility between the different activations may well be due to the different temperatures at their execution time (also seen during previous ground tests). In the frame of this report, no anomalous noise on the chopper position read-back is observed.

7. PACS calibration sources are heating up to 48 and 58Ω (DM_CS1_RES_VAL and DM_CS2_RES_VAL going up; DM_CS1_TARGET and DM_CS2_TARGET are correctly set)

8. Status of autonomy functions: DP_AF_STATUS
   (i) disable AF 12 (to check for the protection biases): was already disabled before (bit 12 of the DP_AF_STATUS stays at "0")
   (ii) disable AF 15 (to check for the VSS currents of groups and BUs): was already disabled before (bit 15 of the DP_AF_STATUS stays at "0")
   (iii) disable AF 17 (to check for group power): was already disabled before (bit 17 of the DP_AF_STATUS stays at "0")

9. Switch-on of groups:
   BOL_PWR_ANA_P_1/2/3/4/5/6/7 goes to +9 V
Figure 1: The chopper readback and target positions during the photometry initialisation phase. As long as the controller is not enabled the target value is -1, at the time of the enabling, the last position read-back is copied into the target position. The target goes to zero as soon as the command “move chopper to zero” is executed. See also information under topic Nr. 6.

BOL_PWR_ANA_N.1/2/3/4/5/6/7 goes to -9 V
BOL_PWR_DIG.1/2/3/4/5/6/7 goes to +5 V

10. Status of autonomy functions: DP_AF_STATUS
   enable autonomy function 17 "generate_event_pwr" to check the HK entries: PC_PWR_ANA_P.#, PC_PWR_ANA_N.# and PC_PWR_DIG.#., with # = [1,2,3,4,5,6,7];
   bit 17 of the DP_AF_STATUS goes to “1” (ENABLED)

11. application of biases: the correct biases to all groups have been applied, as specified in calUfile "BOLObias_preILT_standard_low"

12. configuration of the sequencer: → no corresponding HK entry

13. bolometer configuration:
   - the procedure "PHOT_change_data_mode("Bolo_HK")" to enable bolometer data and HK data: ok.
   - the procedure "goDirect" to switch to direct mode and "PHOT_set_gain("LOW")" to go to low gain → BOL_STATUS at "0005" (for direct mode in low gain)
   - the procedure "PHOT_spsetup(0,0,0,0,false)" to configure the SPU with default compression/reduction mode and without raw channels, but the data flow will not be started here: ok.
- Option "justWait": the bolometer status stays at "0005" for direct mode in low gain (SPU remains stopped)

- Option "VRL": the bolometer status goes from "0005" to "0004" for direct mode in high gain (SPU started for a certain time and then stopped again); in the end back to direct mode in low gain "0005"

- Option "40Hz": the bolometer status goes from "0005" to "0004" for direct mode in high gain (SPU started for a certain time and then stopped again); in the end back to direct mode in low gain "0005"

<table>
<thead>
<tr>
<th>BOL_STATUS</th>
<th>OD 26</th>
<th>OD 27</th>
<th>OD 27</th>
<th>OD 32</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1342178014</td>
<td>1342178059</td>
<td>1342178068</td>
<td>1342178508</td>
</tr>
<tr>
<td>pre-condition</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>after bolometer configuration</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>during CSstabilisation</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>end of measurement</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bias HKs</th>
<th>OD 26</th>
<th>OD 27</th>
<th>OD 27</th>
<th>OD 32</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1342178014</td>
<td>1342178059</td>
<td>1342178068</td>
<td>1342178508</td>
</tr>
<tr>
<td>VRL option</td>
<td>VRL option</td>
<td>40 Hz option</td>
<td>justWait option</td>
<td></td>
</tr>
<tr>
<td>BOL_CKRLH</td>
<td>2.0 V</td>
<td>2.0 V</td>
<td>0.0 V</td>
<td>-</td>
</tr>
<tr>
<td>BOL_CKRLL</td>
<td>2.0 V</td>
<td>2.0 V</td>
<td>0.0 V</td>
<td>-</td>
</tr>
<tr>
<td>BOL_VDECXH</td>
<td>0.0 V</td>
<td>0.0 V</td>
<td>2.0 V</td>
<td>-</td>
</tr>
<tr>
<td>BOL_VDECXL</td>
<td>0.0 V</td>
<td>0.0 V</td>
<td>2.0 V</td>
<td>-</td>
</tr>
<tr>
<td>SPL_REAL</td>
<td>2-bit</td>
<td>2-bit</td>
<td>2-bit</td>
<td>-</td>
</tr>
<tr>
<td>SPS_REAL</td>
<td>2-bit</td>
<td>2-bit</td>
<td>2-bit</td>
<td>-</td>
</tr>
</tbody>
</table>

End of test

| BOL_CKRLH | 0.0 V | 0.0 V | 0.0 V | 0.0 V |
| BOL_CKRLL | 0.0 V | 0.0 V | 0.0 V | 0.0 V |
| BOL_VDECXH | 2.0 V | 2.0 V | 2.0 V | 2.0 V |
| BOL_VDECXL | 2.0 V | 2.0 V | 2.0 V | 2.0 V |
| SPL_REAL | 0-bit | 0-bit | 0-bit | 0-bit |
| SPS_REAL | 0-bit | 0-bit | 0-bit | 0-bit |

The sequence mode, the gain and the SPU was in all cases correctly set:
(1) after the bolometer configuration (direct mode, low gain, no bit rounding),
(2) for the science data block if executed (direct mode, VRL/bolometer signal, high gain 2-bit rounding) and
(3) in the end of the orbit prologue (direct mode, low gain no bit rounding).

The science blocks in the "VRL" option is supposed to be executed with BOL_CKRLH/BOL_CKRLL at 2.0 V and BOL_VDECXH/BOL_VDECXL at 0.0 V. This was the case on both occasions.
The science blocks in the "40 Hz" option is supposed to be executed with BOL_CKRLH/BOL_CKRLL at 0.0 V and BOL_VDECXH/BOL_VDECXL at 2.0 V. This was the case during OD27.
At the end of this test the configuration should be back to direct mode on the bolometers, corresponding to BOL_CKRLH/BOL_CKRLL at 0.0 V and BOL_VDECXH/BOL_VDECXL at 2.0 V. This was the case in the last 2 executions, but not in the first two executions.
The following measurements are executed with wrong settings (VRL mode instead of direct bolometer signal):
- OD 26: data rate test (OBSID: 1342178021), saturation test (OBSID: 1342178022)
- OD 27: photometer calibration recipes (OBSID: 1342178060), chopped FOV-scan in photometry (OBSID: 1342178061)
14. starting and stopping of the SPU:

- Option "justWait" with 2100 s wait time:

<table>
<thead>
<tr>
<th>time[ms]</th>
<th>command</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>164000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>164000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
</tbody>
</table>

- Option "VRL" with 2100 s integration time:

<table>
<thead>
<tr>
<th>time[ms]</th>
<th>command</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>164000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>164000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>184000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>185000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>193000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>194000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>202000</td>
<td>Pacs_SPUS_START_REDUCT_COMPR</td>
<td>→ SPUS started</td>
</tr>
<tr>
<td>203000</td>
<td>Pacs_SPUL_START_REDUCT_COMPR</td>
<td>→ SPUL started</td>
</tr>
<tr>
<td>205000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ SPUS stopped after 3 sec</td>
</tr>
<tr>
<td>205000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ SPUL stopped after 2 sec</td>
</tr>
<tr>
<td>211000</td>
<td>Pacs_SPUS_START_REDUCT_COMPR</td>
<td>→ SPUS started</td>
</tr>
<tr>
<td>211000</td>
<td>Pacs_SPUL_START_REDUCT_COMPR</td>
<td>→ SPUL started</td>
</tr>
<tr>
<td>2326000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ SPUS stopped after 2115 sec</td>
</tr>
<tr>
<td>2327000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ SPUL stopped after 2116 sec</td>
</tr>
<tr>
<td>2335000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>2335000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>2341000</td>
<td>Pacs_SPUS_START_REDUCT_COMPR</td>
<td>→ SPUS started</td>
</tr>
<tr>
<td>2341000</td>
<td>Pacs_SPUL_START_REDUCT_COMPR</td>
<td>→ SPUL started</td>
</tr>
<tr>
<td>2342000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ SPUS stopped after 1 sec</td>
</tr>
<tr>
<td>2342000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ SPUL stopped after 1 sec</td>
</tr>
</tbody>
</table>

- Option "40Hz" with 600 s wait time:
<table>
<thead>
<tr>
<th>time[ms]</th>
<th>command</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>164000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>164000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>184000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>185000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>193000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>194000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>202000</td>
<td>Pacs_SPUS_START_REDUCT_COMPR</td>
<td>→ SPUS started</td>
</tr>
<tr>
<td>203000</td>
<td>Pacs_SPUL_START_REDUCT_COMPR</td>
<td>→ SPUL started</td>
</tr>
<tr>
<td>205000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ SPUS stopped after 3 sec</td>
</tr>
<tr>
<td>205000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ SPUL stopped after 2 sec</td>
</tr>
<tr>
<td>211000</td>
<td>Pacs_SPUS_START_REDUCT_COMPR</td>
<td>→ SPUS started</td>
</tr>
<tr>
<td>211000</td>
<td>Pacs_SPUL_START_REDUCT_COMPR</td>
<td>→ SPUL started</td>
</tr>
<tr>
<td>212000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ SPUS stopped after 1 sec</td>
</tr>
<tr>
<td>213000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ SPUL stopped after 2 sec</td>
</tr>
<tr>
<td>225000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>225000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>230000</td>
<td>Pacs_SPUS_START_REDUCT_COMPR</td>
<td>→ SPUS started</td>
</tr>
<tr>
<td>230000</td>
<td>Pacs_SPUL_START_REDUCT_COMPR</td>
<td>→ SPUL started</td>
</tr>
<tr>
<td>766000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ SPUS stopped after 536 sec</td>
</tr>
<tr>
<td>767000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ SPUL stopped after 537 sec</td>
</tr>
<tr>
<td>775000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>776000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ no action</td>
</tr>
<tr>
<td>784000</td>
<td>Pacs_SPUS_START_REDUCT_COMPR</td>
<td>→ SPUS started</td>
</tr>
<tr>
<td>785000</td>
<td>Pacs_SPUL_START_REDUCT_COMPR</td>
<td>→ SPUL started</td>
</tr>
<tr>
<td>787000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ SPUS stopped after 3 sec</td>
</tr>
<tr>
<td>787000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ SPUL stopped after 2 sec</td>
</tr>
<tr>
<td>793000</td>
<td>Pacs_SPUS_START_REDUCT_COMPR</td>
<td>→ SPUS started</td>
</tr>
<tr>
<td>793000</td>
<td>Pacs_SPUL_START_REDUCT_COMPR</td>
<td>→ SPUL started</td>
</tr>
<tr>
<td>794000</td>
<td>Pacs_SPUS_STOP_REDUCT_COMPR</td>
<td>→ SPUS stopped after 1 sec</td>
</tr>
<tr>
<td>794000</td>
<td>Pacs_SPUL_STOP_REDUCT_COMPR</td>
<td>→ SPUL stopped after 1 sec</td>
</tr>
</tbody>
</table>

The very short SPU running times of 1-3 sec are causing trouble in the frame generation. PacsEng_PHOT_orbit_prologue" should be cleaned up for the options "VRL" and "40Hz" to avoid unnecessary activities on the SPU side!
15. final autonomy functions at the end of the orbit prologue:

- the autonomy-function 12 to check for the protection biases (VDDPROT.CL⋆ and VD-DPROT.BU⋆):
  bit 12 of the DP_AF_STATUS at "1" (ENABLED)

- the autonomy-function 13 to check for temperatures of all boards within the warm electronic BOLC-unit (TEMP_BOLC⋆, TEMP_PSU⋆):
  bit 13 of the DP_AF_STATUS at "1" (ENABLED)

- the autonomy-function 14 to check for 300 mK temperature sensors (TEMP_EV, TEMP_FPU1, TEMP_FPU2 < 0.32/0.40 K):
  bit 14 of the DP_AF_STATUS at "1" (ENABLED)

- the autonomy-function 15 to check for the bolometer VSS currents (I_VSS⋆, I_VSS_BU⋆):
  bit 14 of the DP_AF_STATUS should be at "1", but it is currently not set (DISABLED) → anomaly which has to be followed up

- the autonomy-function 16 to check for the heater currents of the evaporator switch and the sorption pump switch to stay below 1.5 mA (HEAT_SP_SWT, HEAT_EV_SWT):
  bit 16 of the DP_AF_STATUS at "1" (ENABLED)

- the autonomy-function 17 to check for the voltages on the power lines (BC_PWR_ANA⋆, BC_PWR_DIG⋆):
  bit 17 of the DP_AF_STATUS at "1" (ENABLED)

- the autonomy-function 18 to check for sorption pump heater current, but only during recycling (HEATER_SP):
  bit 18 of the DP_AF_STATUS at "0" (DISABLED)

- the autonomy-function 19 to check for the heater current absorption within the PhFPU (HEATER_FPU):
  bit 19 of the DP_AF_STATUS at "1" (ENABLED)

- the autonomy-function 20 (not relevant for bolometer operations)

- the autonomy-function 21 to check for the heater current of the sorption pump during nominal operations (HEATER_SP):
  bit 21 of the DP_AF_STATUS at "1" (ENABLED)

**Summary**: All relevant AFs for the nominal photometry mode are set in the end of the orbit prologue, except AF15 to check the VSS currents (commented out in the CUS-script Building Block "PHOT_setup"). Dedicated tests are needed (on FS and in-flight in a test observation at the end of an OD) to verify the correct functioning of this AF15 before putting it in place again as part of the PacsEng_PHOT_orbit_prologue.
5 Temperatures during the setup

The temperature behaviour on the bolometer 300 mK level is shown in Fig. 2. In all 4 cases the evaporator temperature is close to 283 mK at the end of the orbit prologue, while the FPU1 and FPU2 sensors show about 6 mK less. During the orbit prologue the temperature patterns are very different, depending on the commanding history and the time since the last recycling.

Figure 2: The bolometer 300 mK level temperature behaviour during the photometry setup-procedure in the 4 executions. Top left: execution about 2:10 hours after recycling. Top right: immediately after recycling. Bottom left: 5:30 hours after recycling. Bottom right: 4:05 hours after recycling.
Figure 3: The bolometer 2K level temperature behaviour during the photometry setup-procedure in the 4 executions. For the commanding history see Sect. 2.1 and Fig. 2.
Figure 4: The FPU temperature behaviour during the photometry setup-procedure in the 4 executions. The differences in absolute temperatures are related to the different environmental temperatures. Left figures: the Pacs CS were still close to final temperatures from previous tests. Right figures: the ballistic heating phases for the Pacs CSs are nicely visible.
6 Issues identified during FM-IST/TVTB

The following points have been identified during FM-IST/TVTB:

- the current default gain is "low gain", but in the AOT prologue there is a switch between low and high gain based on the input flux for the subsequent observations. This should be verified in orbit for fluxes close to the "gain switch flux".
  → gain-switch has been tested on the FS-setup and was meanwhile also used in-orbit (Pacs sneak-preview).

- the SPU configuration has to be changed for low and high gain observations: no bit rounding within the SPU for low gain and two-bit rounding in high gain mode (one-bit rounding in high gain PACS/SPIRE parallel mode) to stay within the 130 kbit/s bandwidth. This has to be verified in orbit with the true data, noise, glitches structures and on the final telescope temperature/emissivity background.
  → the bit-rounding concept is in place and has been used correctly in-orbit.

- The SPU is currently averaging 4 readouts, starting with the very first readout as soon as a sequence becomes active (DMC sequence flag equal 1). It is foreseen to shift the start of the SPU averaging by 1 (values 0...3 are allowed), i.e. ignoring the first readout after the sequences is activated. But this software option has not been tested yet.
  → the option has been tested on the FS-setup, but still has to be verified for in-orbit data (but OBCP executions are needed, not part of this analysis).

- averaging of a sub-set of readouts and deleting the rest (e.g., average of first 5, then skipping the next 3 for PACS/SPIRE parallel in blue channel).
  → this "decimation concept" is available with the latest SPU OBSW, but the ground-software is not in place yet. Successful tests have only been done on the FS-setup.

- since the TVTB test the FPGA configuration is done with a "phase_shift_reg" of '1' to avoid CRDCCP counter problems (NCR4497) and therefore to avoid chopper synchronisation problems. It has to be verified if this "curing" of the chopper synchronisation problem works also in orbit.
  → There was no CRDCCP counter problem seen (only checked for orbit-prologues with "VRL" option where the frame generation worked fine). The CRDCCP counter is correctly increasing with 40 per second.

![OBSID 1342178014](image1)

![OBSID 1342178059](image2)

Figure 5: The CRDCCP counter increase per second during two orbit prologues (execution with "VRL"-option with nominal science data with 4-readout averages). This test is referring to NCR4497.

17