

**Test 2.3.1 — Angular Calibration of the PACS Chopper: Offset and specific torque measurements Objectives**

The major part of the chopper angular calibration is done on module level by the manufacturer Carl Zeiss. During PACS ground level tests, the offset of the mechanical zero point (no drive current) from the optical zero point (normal to the interface plate surface, determining the mounting orientation of the chopper in the FPU) of the chopper has to be determined at the begin of every test campaign. The same has to be done during the performance verification phase in orbit. The reason is that after mounting the chopper device in the FPU and due to different orientations of the axis during ILT, IMT, IST, some hysteresis in the flex pivots torque in combination with gravitational forces (during ground tests) may cause a slightly different mechanical zero position. We will determine the offset for the specific test configuration for both fieldplates (nominal and redundant ones) and correct the DECMEC read-out for this. Thus, the mechanical zero point position is defined by a zero read-back of the position sensor for this specific test configuration. This offset has to be taken into account in the conversion of the angular calibration from the original Zeiss relation to the DECMEC relation.

A second part of this test is the measurement of the specific torque, also for ground (only ILT) and in-orbit tests. This is the most essential characteristics of the chopper motor and is needed for the control loop simulations and adjustments of some control loop parameters. The specific torque will be determined by static open loop operation of the chopper.

For this test, we will operate the chopper in nominal mode (fieldplate 1). Furthermore, we will determine the offset and the specific torque also in degraded mode, using three different coil configurations. Measurements with fieldplate 2 (redundant mode) are not foreseen.

**Priority**

A (on ground)

**When performed / frequency**

CQM-ILT  
PFM-ILT  
EQM-IST  
PFM-IST  
In Flight

**Inputs, prerequisites**

- chopper angular calibration curve by Zeiss;
- fieldplate output amplification factor by Zeiss and CSL with sensitive calibration devices and different methods;

**Interconnections****A. Fulfilled By****B. Fulfilling**

input to 2.3.2 Chopper PID optimization;

**OGSE Setup, astr. sources, OBSW Compr./Red.**

not needed;

**Test Implementation Procedure (TIP)**

To summarize, during ILT and IMT test we measure the DECMEC read-out with drive current and control electronics disabled to determine the mechanical zero point for the specific test configuration (mounting and orientation). Under open loop configuration (control electronics disabled), we measure the angular deflections. The results of this measurement are used to determine the specific torque. During performance verification in orbit we will repeat these two test procedures.

During the routine phase, we will repeat the test in a longer interval (1 year (TBC)) to check that there is no fatigue of mechanical elements or change in the magnetization of the permanent magnets of the chopper motor.

Step #	Test Implementation Procedure	OGSE Setup	Products Online Analysis	Pass/Fail & Remarks
	PFM ILT TIP for req. 2.3.1.spec — Angular Calibration of the PACS Chopper: Offset and specific torque measurements			
	<div>Default Setup for this PTD</div>			
0.01	Switch on PACS (if not already done).			
0.02	Setup spectroscopy mode (if not already done). Default parameters of spectroscopy mode.		Check nominal spec. HK	
0.03	Set diagnostic HK for chopper measures at readout frequency. synchronize on blue spectrometer readout 209 DMC_CHOP_CTRL_ST - Chopper Control Status 244 DMC_CHOP_CUR_POS - Chopper: Actual position from readout by HK 245 DMC_CHOP_SETPOIN - Chopper: Position servo setpoint 246 DMC_CHOP_TARGET - Chopper: Final position for move 247 DMC_CHOP_PID_ERR - Chopper: Current error between position and setpoint 248 DMC_CHOP_PID_ACC - Chopper: Integral accumulator of servo PID algorithm 249 DMC_CHOP_MAX_DIT - Chopper: Maximum Dither Value 258 DMC_CHOP_OUTPUT - Current set in chopper output 407 DMC_CHOPPER_TEMP - Chopper temperature sensor resistor value 557 DMC_CHOP_VA - Chopper amplifier voltage side A 561 DMC_CHOP_IA - Chopper amplifier current side A 565 DMC_CHOP_VB - Chopper amplifier voltage side B			
	<div>Step 1: Measurement of the Chopper Offset</div>			

1.01	<p>Determination of DECMEC read-out offset for mechanical zero point</p> <p><u>The following procedure is recommended:</u></p> <ul style="list-style-type: none"> <li>• switch fieldplates on (should be on when DECMEC is on);</li> <li>• set chopper read-out offset = 0;</li> <li>• disable chopper control;</li> <li>• switch off drive current;</li> <li>• measure chopper read-out value;</li> <li>• set chopper read-out offset = <math>-1 \times</math> measured read-out;</li> <li>• convert read-out offset value to offset voltage on Zeiss calibration curve to make this point the new origin of the calibration curve;</li> <li>• offset value is written with DMC_WRT_CHOP_CONF_PAR to word9;</li> </ul>			
	Step 2: Measurement of the specific torque			

2.01	Static open loop tests of chopper for determination of specific torque after offset correction  The following procedure is recommended <ul style="list-style-type: none"> <li>• switch fieldplates on (should be on when DECMEC is on);</li> <li>• select coil configuration (nominal mode: 3 coils, degraded mode: coils 1+2, 2, 2+3)</li> <li>• disable chopper control;</li> <li>• command chopper in open loop mode, i.e. by direct commanding of the drive current;</li> <li>• cover a reasonable range of the permitted angle range; for maximum currents of different coil configurations check available EICDs;</li> <li>• when changing the drive current the chopper mirror shows a damped oscillation around the final plateau position; measure longer than this swinging-in period (determined by the damping constant) to get a proper angle measurement;</li> <li>• note that the specific torque changes for different coil configurations, i.e. for degraded modes with coils 1+2, 2 only and 2+3 this measurement must be repeated; then also higher maximum currents are needed;</li> </ul>			
	<b>Step 3: End of Test</b>			
3.01	Set PACS in default starting mode. stop diagnostic housekeeping set PACS back to its default starting mode			

**Estimated time needed**

For the chopper offset we estimate a few minutes. For the open loop operation in order to determine the specific torque we estimate 30 minutes per chopper coil configuration.

**Success criteria, required accuracy**

No success criteria for this test procedure.

**Test Analysis Procedure (TAP)**

Step #	Test Analysis Procedure (Offline)	Online Analysis Input	Output, Products	Requirements on IA
	CQM ILT TAP for req. 2.3.1 Angular Calibration of the PACS Chopper: Offset and specific torque measurements			
	<b>Step 1: Measurement of the Chopper Offset</b>			
1.01	The negative value of the DECMEC read-out DMC_CHOP_CUR_POS under no drive conditions is used as the offset value;	housekeeping		
	<b>Step 2: Measurement of the specific torque</b>			
	Note that the spring constant c is documented in the EICD of the relevant model: PACS-MA-TN-??? (TBC)			
2.01	Plot $\Phi$ /DMC_CHOP_CUR_POS) versus commanded drive current I (DMC_CHOP_OUTPUT); check for linear parts of the curve calculate specific torque: $S=c \times \frac{\Phi(ROU)}{I_{drive}}$	housekeeping	average value or table of specific torque dependent on angle for each coil configuration	

**Output, products**

**Coding Strategy**

**Version number**

*Revision : 1.1*