SPIRE Bolometer Phase Calibration Product

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1.1 Reference Documents

1.2 Introduction

This technical note describes the Bolometer Phase calibration product. This calibration product contains the optimum phase settings determined from Phase-Up measurements for both “nominal” and “bright” bolometer operating modes. This calibration product is currently only used for Spectrometer processing and so this note does not deal with the Photometer phases.

The standard Spectrometer “bright” mode uses the bolometers with a dephased high bias setting and so has different optimum phases than the nominal mode.

1.3 Spectrometer Bright Mode Bias and Phase settings

Table 1 shows the detector bias and phase settings for the Spectrometer nominal mode and the two bright modes that have been used through the mission. The “old setting” (nominal bias, dephased) was used early in the mission for some tests (last observation was on OD451). The final bright mode adopted for the release of the AOT was the “High Bias Mode”.

	SSW Bias (mV)	SSW Phase (deg)	SLW Bias (mV)	SLW Phase (deg)
Nominal Mode	35.969	186.353	31.132	190.588
Old setting (nominal bias, dephased)	31.127	118.588	31.132	117.176
High Bias Mode	176.385	103.059	176.417	108.706

Table 1: *Bias and Phase settings for the different modes.*

1.4 Phase-Up measurements

Phase-Up measurements are used to determine the optimum phase setting for a certain bias voltage and frequency. This is a relatively simple exercise whereby the phase is changed over a large range and the voltage measured. A cosine function is fitted for each bolometer and the median central value is taken as the phase setting for that array.

Measurements were made at various times during PV phase to determine the optimum phases for each array at different bias voltages and different bias frequencies. The optimum phases were calculated by Bruce Swinyard and the results versus frequency and bias are given in the Appendix. These were the numbers used to derive the phases actually set in the final AOT (shown in Table 1).

During the rest of the mission, Phase-Up observations have been carried out at regular intervals. In summer 2010, Yilmaz Gul investigated these observations to determine the trend in optimum phase through the mission (presented to the SDAG on 26 August 2010). He fitted a cosine function to the JFET voltages. An example fit for one detector from SLW is shown in Figure 1 and results for nominal mode in Figures 2 and 3.

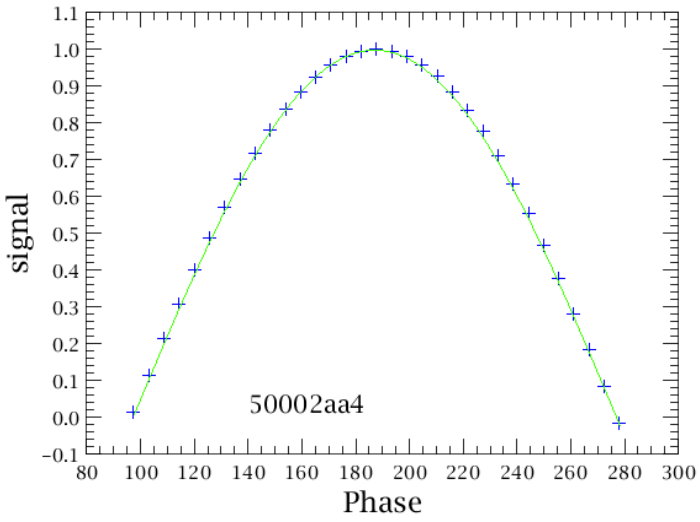

Figure 1: *Example fit to a Phase-Up using a cosine function.*

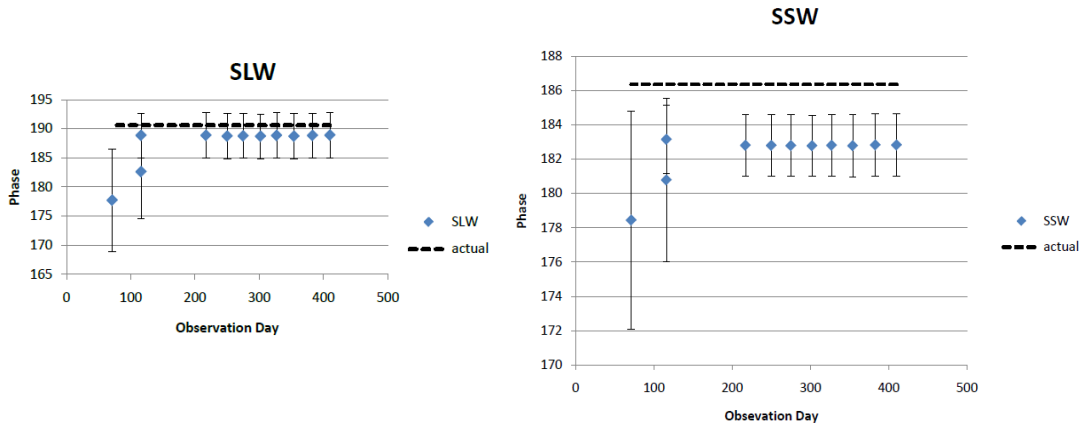

Figure 2*: Best phase determined for nominal mode from observations throughout the mission (up to OD 410). The dashed line shows the actual phases used (Table 1). The error bars show the spread over detectors in the array.*

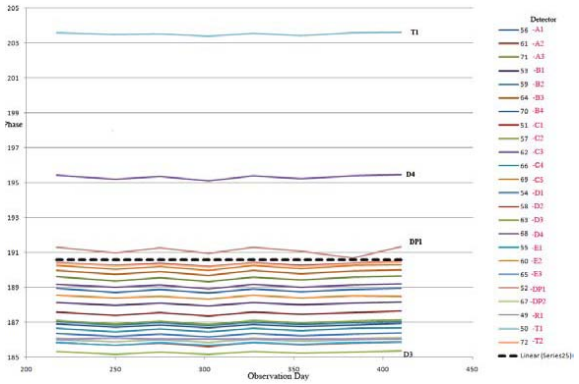

Figure 3: *Spread in best phase for different detectors in SLW. This spread was translated into the error bars shown in Figure 2.*

A high bias mode phase-up was observed on OD495 (0x50006C08). A nominal mode phase-up was also done on this day (0x50006C07). Both were pointed at dark sky. The data were processed by Yilmaz Gul in September 2010 in the same way as described above. The results are shown in Table 2

as the average over all detectors, and also individually for the centre detectors. The full results for all detectors individually are given in the Appendix.

	SSW Phase (all dets)	SSWD4 Phase	SLW Phase (all dets)	SLWC3 Phase
0x50006C07 (Nominal mode)	182.80 ± 1.82	182.05	188.88 ± 3.91	185.34
0x50006C08 (Bright mode)	172.47 ± 0.83	172.60	176.29 ± 6.25	174.24

Table 2: *Measured best phase from OD495 (in degrees). The error for all detectors is a measure of the detector to detector scatter.*

1.5 Modelling the phase & determining the fixed phase offset

In order to predict the phase for any bias setting (as required for carrying out the multi-level noise test for instance), Bruce Swinyard carried out some modelling of the phases. He ran the "EIDP" spreadsheets provided by JPL with the delivery of the flight model detectors. These are:

PFM_PLW_EIDP_V6A.XLS
PFM_PMW_EIDP10.XLS
PFM_PSW_EIDP9.XLS
PFM_SLW_EIDP14.XLS
PFM_SSW_EIDP10.XLS

These spreadsheets allow one to calculate the bolometer resistance for each bolometer for a given bias setting and optical loading for all bolometers. The optical loading from the telescope was estimated using loadcurves taken against the dark sky (probably on OD50 but it doesn't make much difference). The spreadsheets were modified to directly calculate the phase at a number of bias voltages using the following formula,

$$\phi_{set} = 180\text{-ATAN}(-2\pi F^{*}C^{*}R_{tot})-\phi_{fixed}(F) \qquad (1)$$

where ϕ_{set} is the optimum phase at bias frequency F. Initial guesses were used for the capacitance, C, and the fixed phase, $\phi_{fixed}(F)$, was set to zero. For each bias setting, the mean bolometer resistance was taken over all channels (including darks and thermistors) and a fixed mean value used for the load resistor to calculate R_{tot},

$$R_{tot} = R_L R_{bol}/(R_L + R_{bol})$$

Using the measured values, trial values for C and $\phi_{fixed}(F)$ were used in order to minimise the errors between the prediction and the measured phases.

The "result" from this exercise is the average capacitance for each array and the value of the fixed part of the phase equation that is only dependent on frequency and not on the bolometer resistance. Table 3 gives these values for all five arrays.

		70 Hz	130 Hz	190 Hz	80 Hz	160 Hz	240 Hz
Array	C (pF)	ϕ_{fixed}	ϕ_{fixed}	ϕ_{fixed}	ϕ_{fixed}	ϕ_{fixed}	ϕ_{fixed}
PLW	65	23.26	8.89	1.86			
PMW	30	22.13	6.5	-0.85			
PSW	43	22.64	7.83	0.12			
SLW	60				24.47	13.6	9.09
SSW	70				23.29	11.44	7.23

Table 3: *Calibration values for phase correction*

1.6 Final calibration product

Figure 2 shows that the optimum phase is very stable through the mission. Therefore, the phase-up results for the two observations from OD495 should be representative for the whole mission. These two observations were used to fill the calibration product. Detectors without a fit were set to NaN in the calibration product. The offset phases from Table 3 for 160 Hz were also included as metadata in the calibration product.

1.7 Appendix: Peak Phases

Peak phase settings from PV phase (median over all detectors)

1a PSW

Bias Setting (0-P mV)	70 Hz	130 Hz	190 Hz
15.0368235	163	182	192
30.0736471	160.75	178	189
50.1227451	158.35		185.6
127.813		173.45	

1b PMW

Bias Setting (0-P mV)	70 Hz	130 Hz	190 Hz
15.13235294	163.25	182.5	193
31.27352941	160.75	179	189
50.44117647	159		185.8
128.625		173.75	

1c PLW

Bias Setting (0-P mV)	70 Hz	130 Hz	190 Hz
15.195176	166.4	187	199
31.403365	161.85	180.4	193.45
50.650588	159.35		187.8
129.159		173.8	

1d SLW

Bias Setting (0-P mV)	80 Hz	160 Hz	240 Hz
15.2202902	169.6	190.8	206
29.74874902	167.1	188.6	202
100.315549	159.9	178.2	
125.2214784	158.9	176.4	

1e SSW

Bias Setting (0-P mV)	80 Hz	160 Hz	240 Hz
15.2202902	168	188.8	201.5
29.74874902	165	184.8	197
100.315549	159	175.2	
125.22148	158.1	174.3	

Peak phases determined from the nominal and bright mode Phase-Up observations on OD495.

Detector	Nominal best phase	High Bias best phase
SSWA1	181.674955496	171.971047592
SSWA2	182.759191016	172.928788968
SSWA3	182.488132136	172.983000744
SSWA4	183.210955816	172.820365416
SSWB1	181.331614248	172.603518312
SSWB2	181.476178984	172.820365416
SSWB3	182.307426216	172.458953576
SSWB4	184.999944424	172.711941864
SSWB5	186.138391720	172.639659496
SSWC1	181.747237864	172.115612328
SSWC2	181.150908328	172.531235944
SSWC3	181.07862596	172.730012456
SSWC4	183.409732328	172.838436008
SSWC5	183.355520552	172.386671208
SSWC6	182.235143848	173.741965608
SSWD1	181.674955496	172.151753512
SSWD2	180.825637672	173.037212520
SSWD3	180.789496488	168.212364456
SSWD4	182.054437928	172.603518312
SSWD5		
SSWD6	182.144790888	172.711941864
SSWD7	182.741120424	172.621588904
SSWE1	181.837590824	172.368600616
SSWE2	181.313543656	172.115612328
SSWE3	181.765308456	172.458953576
SSWE4	182.090579112	172.892647784
SSWE5	183.825355944	172.115612328
SSWE6	181.277402472	172.549306536
SSWF1	181.07862596	172.693871272
SSWF2	184.620461992	172.440882984
SSWF3	184.024132456	172.350530024
SSWF4		
SSWF5	188.234580392	172.296318248
SSWG1	187.855097960	171.934906408
SSWG2	183.409732328	172.22403588
SSWG3	183.174814632	173.21791844
SSWG4	183.951850088	173.199847848
SLWA1	186.915427176	174.500930472
SLWA2	187.620180264	171.067517992
SLWA3	189.626015976	174.75391876
SLWB1	188.162298024	174.247942184
SLWB2	187.041921320	174.374436328
SLWB3	189.987427816	174.320224552
SLWB4	188.957404072	174.627424616
SLWC1	185.849262248	174.537071656
SLWC2	187.114203688	174.374436328
SLWC3	189.174251176	171.356647464
SLWC4	186.68050948	174.266012776
SLWC5	190.29462788	174.627424616

SLWD1	186.373309416	174.519001064
SLWD2	190.439192616	173.814247976
SLWD3	185.343285672	174.247942184
SLWD4	195.444746600	174.356365736
SLWE1	185.867332840	174.139518632
SLWE2	188.559851048	174.266012776
SLWE3	186.04803876	174.735848168