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Title **Diplexer Calibration Results CoP**

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Distribution

Document Change Record

Issue	Date	Changed Section	Description of Change
Draft 01	10 Sep 2009	All	New document

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1 DOCUMENTS

1.1 Applicable Documents

1.2 Reference Documents

RD-1 "Diplexer Coarse and Fine calibration", HIFI TB/TV TRR Presentation, 25 June 2008

RD-2 "Diplexer Scan Survey", HIFI TB/TV TRR Presentation,

RD-3 "Diplexer Calibration: LO subband dependence and IF passband shape", SRON-G/HIFI/TN/2008-24, Draft 0.2, 2 October 2008

RD-4 "Effect of Diplexer Misalignment on Sideband Gain", JPL/HIFI/TN/2009-002, Draft, 5 March 2009

RD-5 Diplexer Test Results TB/TV and SOVT-2, SRON-G/HIFI/TR/2009-x, Draft 01, 8 April 2009

2 INTRODUCTION

This document summarizes the diplexer calibration results obtained during CoP. The reader is referred to earlier documents (RD-1 to -5) for detailed information on the procedure and testmodes. Here we restrict ourselves to discussion of the results, interpretation and discussing the application for routine operations.

3 OBJECTIVES

The diplexer calibration objectives can be summarized as follows:

- Determine diplexer settings for best LO coupling in coarse calibration test (depends on LO-FP alignment, spacecraft orientation/gravity)
- Generate LUT for all frequencies in diplexer bands and update CUS with these config files
- Determine best Vd2 settings that provide optimum LO level for heterodyne diplexer fine calibration test
- Using diplexer calibration results, identify impure LO frequencies
- Develop physical model of diplexer behaviour on the basis of diplexer scan survey results

Further details can be found in RD-1 and RD-2.

4 DIPLEXER COARSE CALIBRATION RESULTS COP

During CoP one change was made relative to earlier diplexer coarse scans. To calibrate timing delays between mixer current sampling and diplexer actuator current commanding each scan was taken both in forward as well as reverse mode. In this way a small residual calibration error in earlier measurements can be taken out by either determining the delay or simultaneously fitting forward and reverse scans in the model.

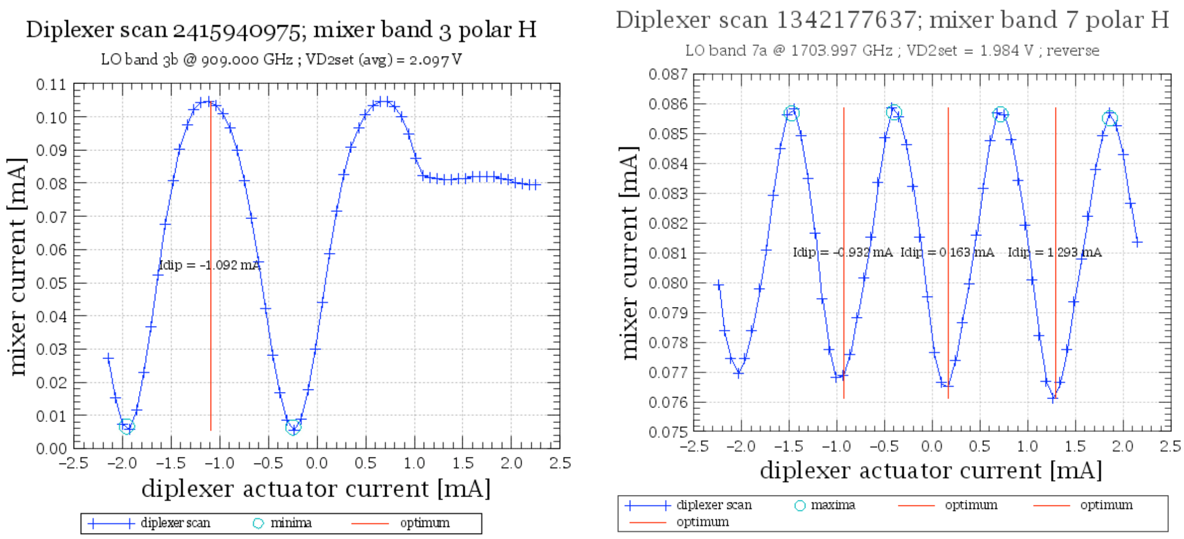

Fig. 1 - Examples of diplexer coarse scans for band 3 and 7b in CoP

The tests were executed without any problems. All data was properly collected and data analysis went smooth without reported problems. Examples of typical IA analysis results are shown in Fig.1.

We obtain data of good quality of both polarizations for all four diplexer bands 3, 4, 6 and 7. All 8 individual diplexer mechanisms are healthy and behave as expected (full constructive and destructive interference can be obtained and mechanisms can be tuned across the expected ranges).

From the data the pseudo-vector scans could be properly constructed providing early estimates of best settings for the LO given target currents for the mixers. An example is given in Fig. 2.

Pseudo-vector scans, constructed from the measured mixer current maxima observed during a diplexer scan and their corresponding drain voltages, reveal good qualitative continuity of coupled LO power to the mixers now sampled at 29 different frequencies in band 3, 21 different frequencies in band 4, 22 different frequencies in band 6, and finally 25 different frequencies in band 7. There is no evidence for presence of ice or other significant changes in LO-mixer coupling. Actual vector scans will provide the full quantitative picture and detailed confirmation.

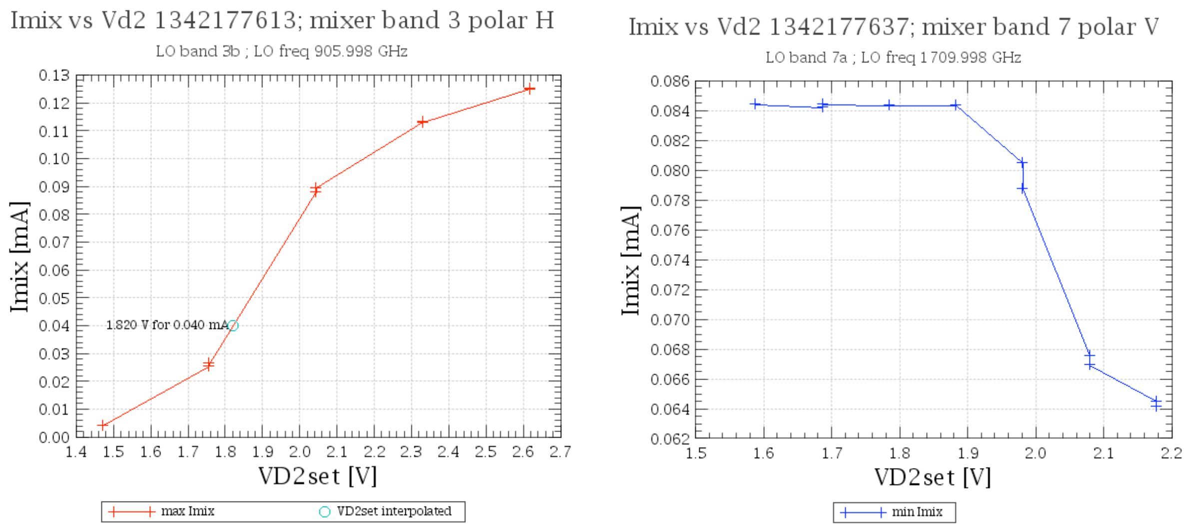

Fig. 2 – Dependence of Imix at optimum diplexer settings and Vd2.

5 DIPLEXER LOOKUP TABLES

A physical model fit clearly reveals zero-gravity effects. The pathlength differences for all 4 mechanisms acting on H(orizontal) polarization have systematically dropped by 36-52 micron, whereas the OPD's for the V(ertical) polarization have systematically increased by 32-58 micron. For two H-mechanisms the location of the physical mechanical endstops has moved in actuator current space by 0.5 mA towards the upper limit of the supply. Solid evidence that we are actually in space.

The sign and magnitude of the zero-gravity effect is in good agreement with the predicted imbalance of the mechanisms (offset between center of mass and pivot axis and absence of acting forces as applicable during ILT, TBTV, SOVT)

The fitted rest positions of the movable rooftop mirrors in space now fully agree again (within the error of measurement) with the warm alignment measurements (in a horizontal configuration with gravity vector // pivot axis) prior to integration into the HIFI Focal Plane Unit back in 2005/2006.

Now the rest positions as well as endstops in zero-gravity are known in actuator current space, the final LUT for application in space have been optimized. The periodic sawtooth actuator current table is positioned in such a way in actuator currents space that the following conditions are satisfied:

1. There is 0.2 mA current margin to either stay sufficiently far away from the limits of the actuator current source (+/- 2,24 mA) or from a physical endstop, whatever is applicable.
2. The average actuator current across the band corresponds to a pathlength difference which is as close as possible to the nominal pathlength difference at the centre IF frequency, i.e. 20.833 mm for HEB bands (IF centre frequency of 3.6 GHz) resp. 12.5 mm for SIS bands (IF centre frequency of 6 GHz). This condition will imply minimum side band ratio contribution from the diplexer

The exact situation for the final LUT's are discussed in the following sections.

6 LUT BAND 3

In blue the H polarization is indicated, red corresponds to V polarization. Black dashed lines indicate the current source limits – 0.2 mA margin, a colored dashed line indicates the physical endstop – 0.2 mA margin. Open circles indicate the (redundant) measured diplexer optima collected at a given frequency both in the forward and reverse scan. Solid circles indicate the reduced optima, shifted by periodicity of the diplexer in the actuator current domain to align them in the same current interval. The average current of the solid traces (the LUT) corresponds to a best match to the nominal path difference.

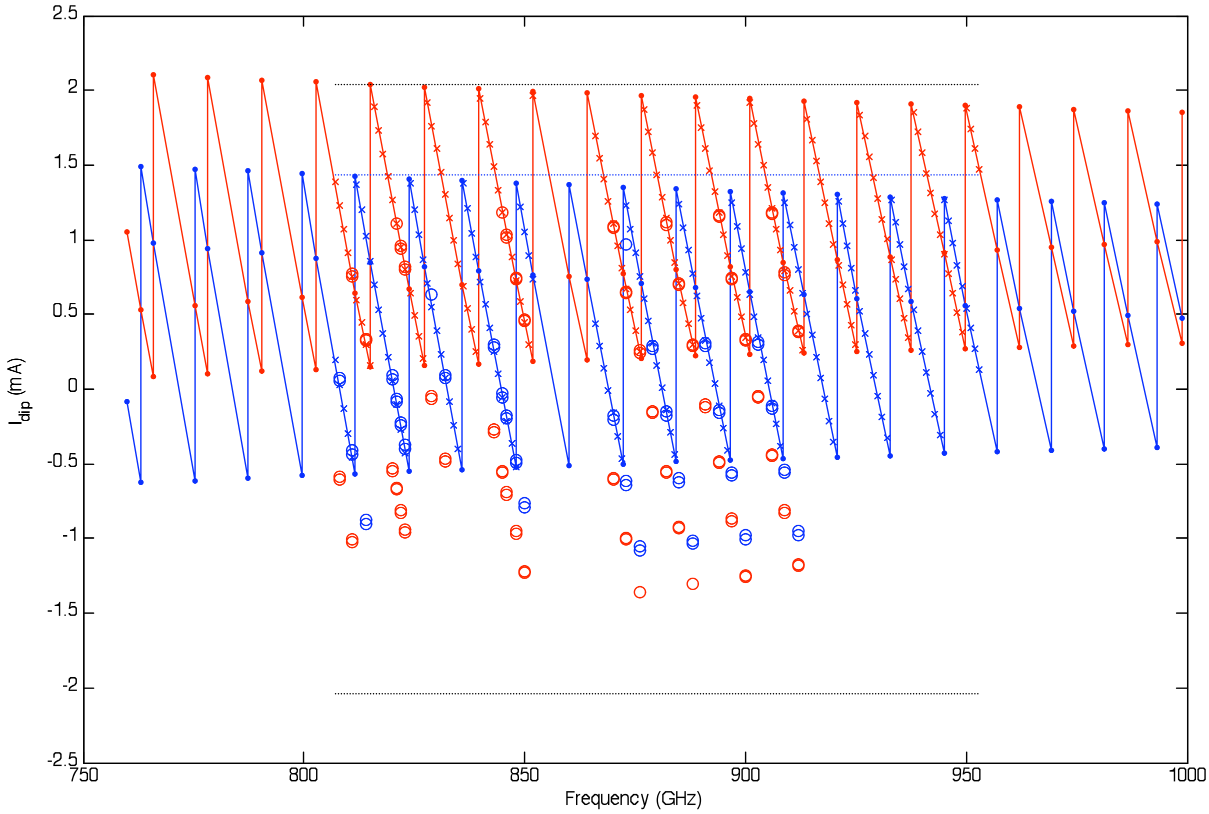

Fig 3.- LUT in band 3 together with clipping limits and measured data.

7 LUT BAND 4

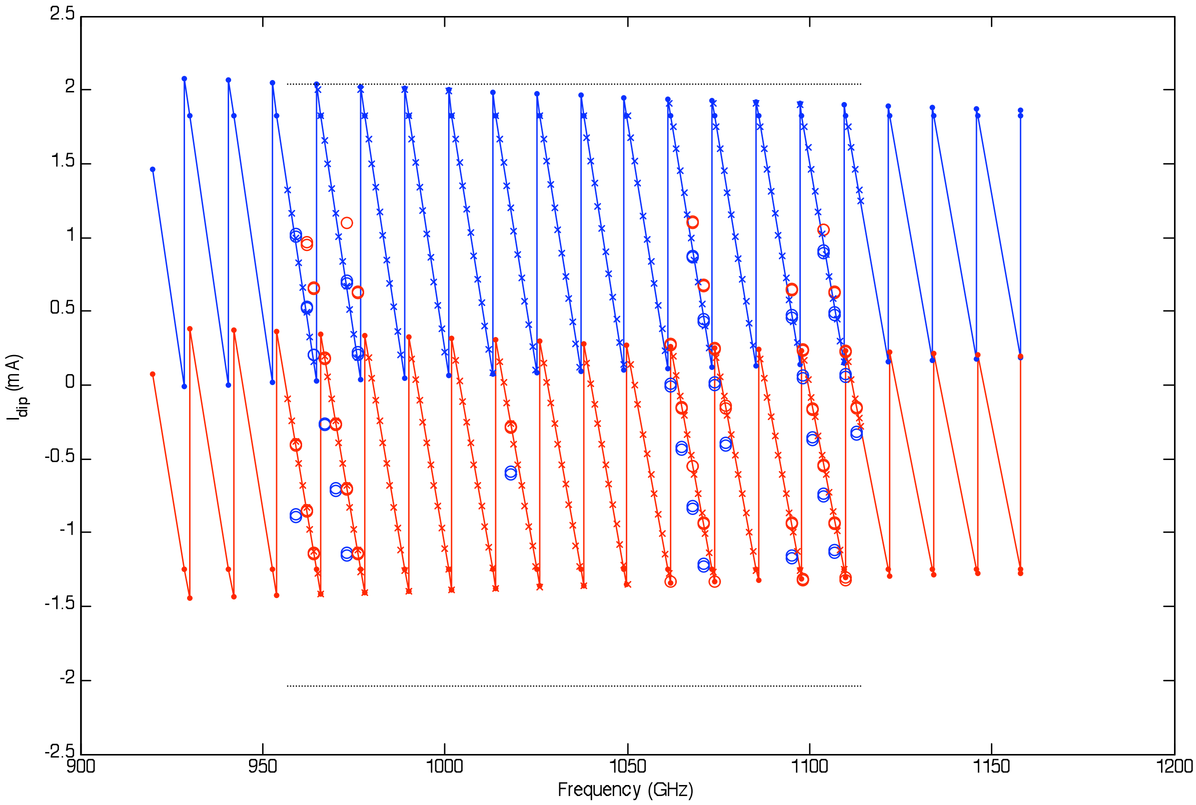

Fig 4.- LUT in band 4 together with clipping limits and measured data.

8 LUT BAND 6

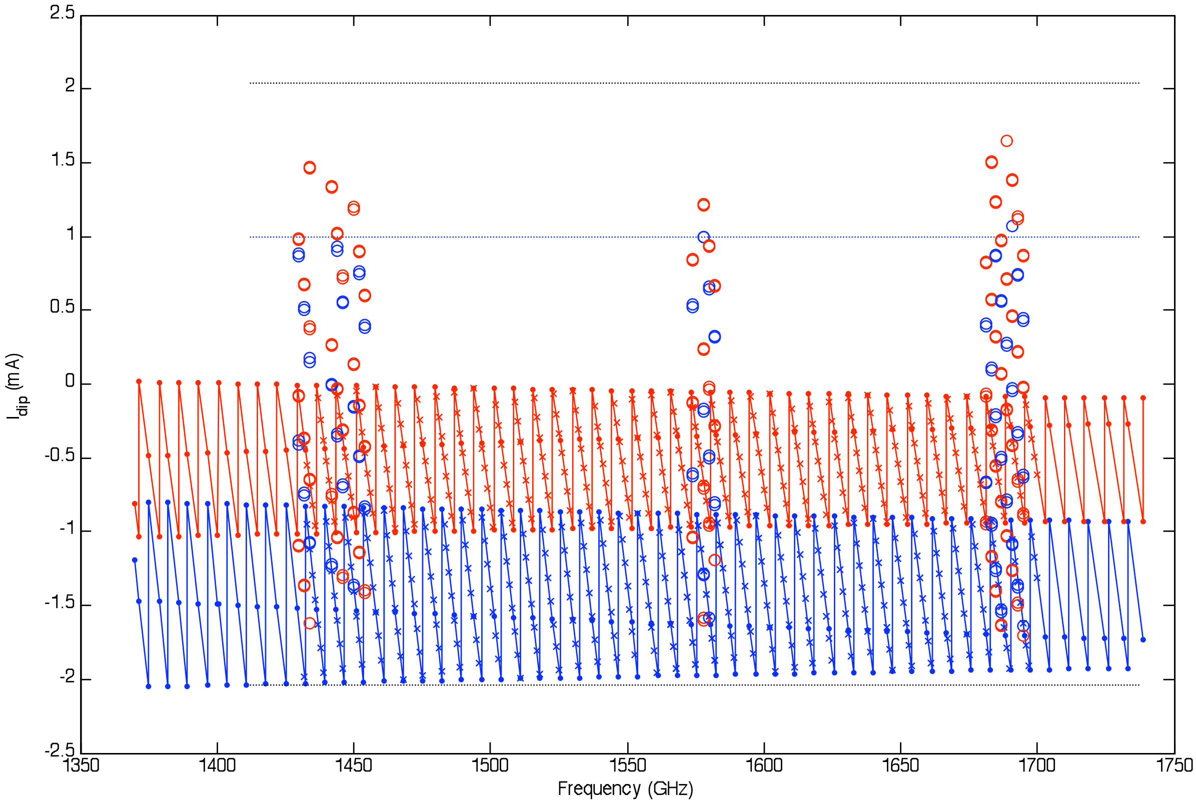

Fig 5.- LUT in band 6 together with clipping limits and measured data.

9 LUT BAND 7

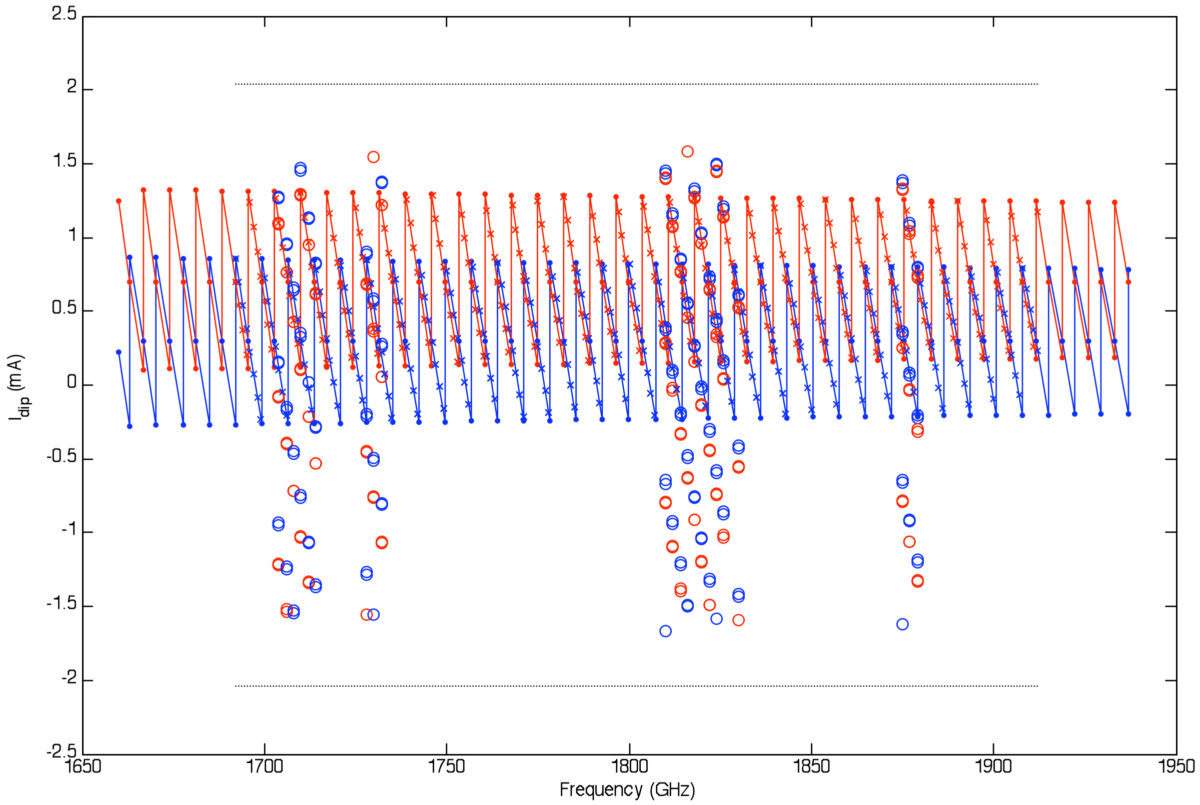

Fig 6.- LUT in band 7 together with clipping limits and measured data.

10 APPLICATION FOR ROUTINE OPERATIONS

Optimized Lookup Tables for diplexer tuning have been generated and have been implemented in CUS and end-to-end consistency has been confirmed.

Diplexer calibration should initially be part of the regression test program to confirm stability over long time scales.

Since a physical model of diplexer mechanisms exists and the diplexer adds to the sideband calibration budget the following approach regarding future calibration is recommended:

- Correct SBR measurement data taken during ILT for diplexer contribution on the basis of actuator current to obtain an “intrinsic SBR” without diplexer contribution.
- Implement a pipeline routine that can correct spectra for IF slope contribution from diplexer passband on the basis of the applicable diplexer actuator current and physical model
- Finally apply intrinsic SBR in further reduction and calibration of spectra

Key to this is to always correct for the diplexer contribution to the SBR (or passband) on the basis of actuator current. This approach would ensure a transparent method to whatever LUT is in place and and allows reprocessing of data in a decoupled fashion when a physical model update is required due e.g. thermal drift or changes in orbit.

11 SUMMARY AND CONCLUSIONS

- Diplexer calibration was executed without reported problems
- Behaviour is as expected and fully consistent with zero-gravity operation. Diplexer mechanisms are healthy.
- Optimized LUTs are generated for all bands, checked for overall consistency and implemented in uplink