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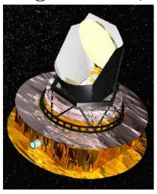

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Contents

1 Scope

This report describes a measure of performances of compressor obtained by using data from RAA tests of the DM model.

1.1 Limits of Applicability

This document refers to the DM models of REBA, REBA Application Software, TMH/TQL.

2 Applicable / Reference Documents

2.1 Applicable Documents

References

[AD-1] *Planck-LFI Communications, ICD*,
M. Miccolis,
PL-LFI-PST-ID?013, Version 3.0, January 2004

[AD-2] *Telemetry Handling System ? User Requirements Document*
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PL-LFI-OAT-UR-004, Version 2.0, September 2004

[AD-3] *Planck LFI ? Characterisation of the Compression Rate for the New Baseline for the Scientific Data Streams Coding*
M. Maris
PL-LFI-OAT-TN?029, Version 1.0, March 2004

[AD-4] *Planck-LFI: Characterisation of the On board Processing Parameters*
M. Maris
PL-LFI-OAT-TN?030, Version 0.0, March 2004

[AD-5] *Planck-LFI: Test Report on the TMH/QM by Using A Known Signal Tests Data*
M. Maris, M. Fraillis, M. Guerrini
PL-LFI-OAT-RP-017, Version 1.0, 20 March 2004

2.2 Reference Documents

References

[RD-1] *Planck LFI ? Test Plan for the TMH Software*
M. Maris, X. Dupac. M. Fraillis
PL-LFI-OAT-PL?000, Version 1.0, November 2005

[RD-1] *Reconfiguration for LFI on-board data processing and scientific telemetry*
M. Miccolis, A. Mennella, M. Bersanelli, M. Maris
PL-LFI-PST-TN-037, Issue 1.0, March 2003

[RD-2] M.Maris,
PL-LFI-OAT-RP-012, October 2005

[RD-3] M.Maris,
PL-LFI-OAT-RP-013, October 2005

[RD-4] *Planck-LFI: the DTOI generation tool and IDL handling library.*
M.Guerrini, M.Maris
report in preparation, 2006

2.3 Acronyms List

ADU	Analog / Digital Unit
FM	Flight Model
FP	Floating Point
PType	Processing Type
QM	Qualification Model
TMH	Telemetry Handler
TMU	Telemetry Unscrambler
TQL	Telemetry Quick-Look
OBT	On Board Time
TOI	Time Ordered Information
TOD	Time Ordered Data

3 Introduction

During the RAA campaign and the TMH test campaign compressor have been tested both with noise and signals of known shape.

This report is an analysis of performances of the compressor as a function of entropy for PType 5 data.

This is a follow-up of what already discussed in a more limited manner in [AD-5].

4 Definitions

We recall here classical definitions useful to understand the following discussion.

DATA_LENGTH The length of data contained in a scientific packet, after removal of headers, usually expressed in bytes.

UNCOMPRESSED_SAMPLES The number of uncompressed samples in a packet.

Compression Rate per Packet (C_{r}) The compression rate obtained (measured) in a packet. Defined as

$$C_{\mathrm{r}} = \frac{2 \cdot \mathrm{UNCOMPRESSED\_SAMPLES}}{\mathrm{DATA\_LENGTH}}, \tag{1}$$

where the divisor 2 is number of bytes needed to represent a sample.

Measured Entropy per Packet (H_{pck}) The entropy for the raw (not demixed or reconverted to floating point) uncompressed data into a packet. It is measured in bits.

Expected Compression Rate per Packet The expected C_{r} for packet for a given H_{pck}, for samples represented by 16-bits integers

$$C_{\mathrm{r}}^{\mathrm{Th}} = \frac{16}{H_{\mathrm{pck}}}, \tag{2}$$

Compressor Efficiency (C_{eff}) The efficiency of the compressor with respect to the expected C_{r}

$$C_{\mathrm{eff}} = \frac{C_{\mathrm{r}}}{C_{\mathrm{r}}^{\mathrm{Th}}} \,. \tag{3}$$

Expected Processing Error (Q_{err}) The processing error expected after demixing and reconstructing data, following [AD-1] is (see [AD-4])

$$Q_{\mathrm{err}} = \frac{1}{\sqrt{12}} \frac{1}{\mathrm{SECOND\_QUANT}} \sqrt{\frac{\mathrm{GMF_1}^2 + \mathrm{GMF_2}^2}{(\mathrm{GMF_2} - \mathrm{GMF_1})^2}} \,. \tag{4}$$

5 Procedure

Following [AD-5] for each data set, starting from the content of the relative `tmu` directory we generated the DTOI for the data in the test [RD-4]. A DTOI contains TOI for a given test, but in a DTOI only decompressed data (without any other transformation) in included. In addition DTOIs includes (among others) the relevant packet-by-packet statistics for this analysis: DATA_LENGTH, UNCOMPRESSED_SAMPLES, $C_{\rm r}$ and $H_{\rm pck}$.

From these data $C_{\rm r}^{\rm Th}$ and $C_{\rm eff}$ for each packet has been assessed.

Correlation have been attempted between $C_{\rm r}$, $C_{\rm r}^{\rm Th}$, $C_{\rm eff}$ and packet statistics as for the processing pars and the related expected processing error.

Data Set	Kind of Signal	Source	ps file
TUN_0032	Thermal Noise	RAA Campaing	TUN_0032_compression_rate.ps
TUN_0033	Thermal Noise	RAA Campaing	TUN_0033_compression_rate.ps
TUN_0034	Thermal Noise	RAA Campaing	TUN_0034_compression_rate.ps
XXX_9028	Square Wave	TMH Test Campaing	XXX_9028_compression_rate.ps
XXX_9029	Triangular Wave	TMH Test Campaing	XXX_9029_compression_rate.ps

Table 1: List of data sets considered for the analysis. In the last column the postcript files authomatically generated by the analysis program and allegated to this report.

6 Results

Tab. 1 reports the data sets considered. Those sets have been already analysed in [RD-2], [RD-3], [AD-5]. Here we will focus on the main results.

Here we analysed data coming from a single FH but aggregating all the data generated by all of the four radiometer of the FH of choice.

The analysis program generated automatically plots which are not included in this Issue of the report but are added as allegate files, paged as follow:

1. page with test identification number,
2. the second a resume of the results,
3. $C_{\rm r}$ as a function of processing pars,
4. optional page for the legend of symbols (different symbols are used to disentangle data coming from the same feed-horn but different detectors),
5. $C_{\rm r}$ as a function of $Q_{\rm err}$,
6. DATA_LENGTH as a function of $Q_{\rm err}$,
7. $C_{\rm r}$ as a function of $H_{\rm pck}$,
8. $C_{\rm eff}$ as a function of $H_{\rm pck}$,
9. histogram of $C_{\rm eff}$.
10. page with test identification number.

Usually detectors are coded as follow $+$ for DTC = 0, RAD = 0, $\Box$ for DTC = 0, RAD = 1, $*$ for DTC = 1, RAD = 0 and ∇ for DTC = 1, RAD = 1.

6.1 $C_{\rm r}$ as function of processing pars

For tests with deterministic signals, it is not possible to drawn any strong correlation between $C_{\rm r}$ and the processing pars.

This is expected since with the mixing scheme it is not possible to characterise the $C_{\rm r}$ as a function of a single REBA parameter in the case of a strongly deterministic signal like those.

In the case of noise instead it is very easy to see a clear dependence on SECOND_QUANT very well represented by a linear increase of $C_{\rm r}$ as a function of SECOND_QUANT in log-log space.

Dependences on other parameters are hard to asses since the lack of data.

6.2 $C_{\rm r}$ as a function of $Q_{\rm err}$

The plot is interesting sing $Q_{\rm err}$ sinthetizes the information on most of the REBA parameters.

For deterministic signals $C_{\rm r}$ is roughly a function of $Q_{\rm err}$ and saturates when $Q_{\rm err} > 1$ adu. The reason is likely the fact that no more than 2048 samples may be compressed into a packet by REBA.

In particular it is evident as in XXX_9029, data from Detector 0, Radiometer 0 (crosses) has a minor population of packets with very low compression rates.

For noise instead the $C_{\rm r}$ scales very well with $Q_{\rm err}$ in log - log space. As expected, increasing the allowed $Q_{\rm err}$ data are better compressed.

6.3 $C_{\rm r}$ as a function of $H_{\rm pck}$

Figures for this test reports, in addition to data, the averaged $C_{\rm r}$ (red horizontal line) as the $C_{\rm r}^{\rm Th}$ (black full line) and the result of a linear fit of $C_{\rm r}$ v.z. $H_{\rm pck}$ in log-log space (dotted black line)

The spotted shape of many of these plots is due to the fact that the main source of variation of entropy is the change of REBA parameters performed over a discrete time interval.

Both for noise and deterministic signals the $C_{\rm r}$ is well characterised as a function of entropy. A linear trend in the log ? log space is evident. Especially, for deterministic signals some outsiders are spread around.

It is evident as always the $C_{\rm r}$ is less than $C_{\rm r}^{\rm Th}$. The difference growing for increasing entropy. This both for deterministic signals as for noise.

For deterministic signals, up to $C_{\rm r} \approx 10$ is obtained. However, this result is for $H_{\rm pck} \approx 1$ which is surely not the case of true data.

With noise, up to $C_{\rm r} \approx 6$ is obtained.

In conclusion the Compressor seems able to reach the required averaged compression rate.

6.4 $C_{\rm eff}$ as a function of $H_{\rm pck}$

It is important to asses not only the maximum $C_{\rm r}$ attainable but the efficiency of compression software measured by the $C_{\rm eff}$ statistic. This fix the overall quality of the software, since for a given signal statistic (rms) a low $C_{\rm eff}$ will force to increase the strength of the requantization step. This in order to further reduce the signal entropy to asses the required averaged $C_{\rm r}$ and to limit the possible $C_{\rm r}$ variation in case of instability of the signal occurs.

In the figures a red horizontal line overimposed to data gives the the Averaged $C_{\rm eff}$, dashed horizontal lines the $\pm 1\sigma$?range of $C_{\rm eff}$. A dashed line gives an attempt of fit with a polynomial (degree 1 or 2) in linear ? linear space the evident decreasing trend of $C_{\rm eff}$ as a function of $H_{\rm pck}$.

It is evident as, both for square waves and triangular waves, that the $C_{\rm eff}$ is alway less than 1 and, in average, $C_{\rm eff} \approx 0.8?0.9$ decreasing for increasing entropy.

For noise, the $C_{\rm eff}$ in the range of entropies relevant for compressing to a factor 2 - 3 16-bits signals (5-8 bits) the $C_{\rm eff}$ is always less - equal 80%. Extrapolating to, as an example $H_{\rm pck} \approx 8$ bits it is possible to see that $C_{\rm eff}$ will be about 0.6.

The histogram of $C_{\rm eff}$ for the various tests provides another view of the same problem.

However, a more exhaustive set of tests would be required in order to properly calibrate $C_{\rm eff}$ as a function of REBA pars. It can not be excluded that REBA parameters where not completely optimised for the input statistics.

7 Conclusions

This report outlines methods to asses the performances of the onboard compressor for Planck/LFI.

In the report these methods are applied to data acquired in the RAA test DM campaign and TMH test DM campaign.

Main conclusions are

1. $C_{\rm r}$ at the required level of 2 - 3 is feasible,
2. It is possible to correlate very well $C_{\rm r}$ and $Q_{\rm err}$.
3. The compressor efficiency is in most cases below 90%.
4. The compressor efficiency however is not stable, being a decreasing function of $H_{\rm pck}$.