ATLAS Level-1 Calorimeter Trigger Pre-Processor MCM
Final Design Review Summary

The Final Design Review (FDR) for the ATLAS level-1 calorimeter trigger Pre-Processor MCM took place by means of a video/audio conference on Thursday 12th April 2001. The Review Panel consisted of:

Christian Bohm (University of Stockholm) - *via* audio link

Eric Eisenhandler (Queen Mary, University of London)

Philippe Farthouat (CERN, representing ATLAS Technical Co-ordination) - *via* video link

Viraj Perera (Rutherford Appleton Laboratory)

Uli Schaefer (University of Mainz) – *via* e-mail

Tony Gillman (Rutherford Appleton Laboratory) - Hardware Co-ordinator

Representing the Heidelberg group were:

Paul Hanke

Ullrich Pfeiffer

et al

The documentation available to the Panel in advance of the review was the following:

"Specification of the Pre-Processor Multi-Chip Module (PPrMCM) for the ATLAS Level-1 Calorimeter Trigger" – Draft Version 0.1, 26 March 2001

http://wwwasic.kip.uni-heidelberg.de/atlas/DATA/docs/pprmcm0.1.pdf

Based upon this documentation, the reviewers had submitted detailed lists of questions and comments to the designers several days before the review.

Agenda:

The review started at 08:00 GMT with a point-by-point evaluation of the reviewers' written comments. Where these concerned issues of clarification, style or typographical accuracy it was agreed that in all cases the appropriate changes would automatically be implemented, but in several areas there was need for further discussion.

The review concluded with reference back to the MCM Preliminary Design Review (http://hepwww.rl.ac.uk/Atlas-L1/Modules/Components.html), held on 24th January 2000 at RAL, to ensure that all ten recommendations listed in the PDR summary (11th February 2000) had been followed.

The review closed at 12:00 GMT.

Recommendations:

The following specific recommendations were made:

1. The LVDS low-speed serialiser dies selected for the pre-production devices are rated for operating speeds below 40 MHz. As the LHC clock speed is actually 40.08 MHz, these devices may need to be upgraded to the high-speed variants, which are rated for operating speeds above 40 MHz, for use in the production MCMs.
2. The maximum tolerable clock jitter for the LVDS serialiser devices is quoted as 150 psec, which is believed to be tighter than the TTCrx chips are guaranteed to deliver. This must be checked, and an appropriate low-jitter phase-locked loop must be added to the PPM design if necessary to stabilise this clock.

3. National Semiconductor recommends multiple decoupling for the LVDS serialisers (1/10/100 nF), but there is limited area available on the MCM substrate for this function. Only a single 10 nF capacitor can be provided per serialiser, so for stable link operation it is important for the extra capacitors to be added at PPM board-level.
4. The proposed procedure for replacing defective FADC dies by mounting new dies above old dies is regarded as acceptable, as it is believed to be an industry-standard technique, but careful attention must be paid to issues such as grounding, etc.
5. The MTBF calculations for the MCM are highly sensitive to individual die failure rates. The nominal figures quoted would lead to ~8% MCM failures per annum, which would imply a PPM failure about every three days. This is an unacceptably high failure rate, and a careful analysis of the pre-production MCM mortalities will be essential to identify the weakest components.
6. A further improvement to the overall MCM reliability might be achieved by burn-in of the individual dies before assembly on the substrates. Again, a thorough failure analysis of the first 64 pre-production MCMs will indicate whether reliability would improve sufficiently to justify the extra complication and cost.
7. The essential reason for choosing 12-bit (rather than 10-bit) FADC devices is to achieve a significant improvement to the ENOB figure. This should be clearly explained.
8. In close conjunction with the assembly company, a thorough Test Plan for the initial devices is still evolving, but several issues still need to be clearly defined; e.g. the envelopes of parameter tolerances, the financial liability for failures and associated re-working.
9. The choice of an appropriate material for die-attachment is very important. For example, do the FADC dies require the use of silver-loaded adhesive? All details of this nature must be precisely specified to the assembly company to avoid expensive and time-consuming errors.
10. The proposal to use 25 μm diameter aluminium bond wires should be checked to ensure that the recommended industry-standard current limits will not be exceeded.
11. The number of ground and power pins provided on the package should be as large as possible.
12. Moisture ingress into the MCMs must obviously be prevented. Although the substrate lid will not have a fully-hermetic seal, the internal cavity will be filled with silicone gel. As a further precaution, the assembled MCMs should be stored in a dry nitrogen cabinet, and complete PPMs should be stored in dry nitrogen bags.

Conclusions

The reviewers appreciated the very thorough documentation provided for this device by the Heidelberg group. It is clear that a considerable amount of work has been carried out since the time of the Preliminary Design Review over a year ago, and the design now appears very sound. The PPrMCM is considered to be a well-engineered device, with a long history of successful development stages. The recommendations from the Preliminary Design Review have been adopted in almost all cases.

Although details of the test programme are still evolving, the reviewers were pleased to note that the group is working in close partnership with an appropriate commercial assembly company. They regard this to be of crucial importance, as close monitoring of the assembly procedures for the initial devices will be essential. Failure rates will remain unknown until the first pre-production devices are sampled.

Finally, some concern was expressed at the level of experienced effort in the Heidelberg group which is currently available to the project, in light of the imminent departure of the principal designer.

The reviewers conclude that, subject to confirmation that the above points have been satisfactorily addressed, the design is approved for pre-production manufacture.