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MONSOON

Report on the Torrent DHE Requirements Compliance Testing.

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Revision History

Version	Date Issued	Sections Affected	Remarks
0.1	08/30/2011 Moore	All	Draft
1.0	09/03/2011 Moore	All	Added discussion section. Release of draft.

Executive Summary.

This report summarizes the results obtained during the process of testing the Torrent Image Acquisition System for compliance to the design requirements. The requirements have been derived from functional and performance specifications that were developed during the system definition stage and contained in the document TRNT-AD-11-0001 rev 5.0.

The performance of the Torrent system is defined by the sum of the design of all of the components (i.e. hardware + software + mechanical + firmware = performance). In this way the performance of the Torrent systems that are deployed to the observatories will be guaranteed by the design of the system, not by individual calibration or 'tweaking' of electronics that has been the norm of the situation before MONSOON developments.

The design verification testing exercise is therefore an essential part of the development stage to indicate when the system is ready for deployment. We expect that the adjudicators will be able to make an informed appraisal of the state of readiness of Torrent by reading this report.

The 'Good' news:

The Torrent system is generically stable and consistent. This means that for any given Torrent hardware and software system or between different Torrent hardware components, the performance is repeatable and stable. This is fundamental to imparting confidence that the Torrent systems are logical and predictable.

The Torrent systems are rugged. At various times during compliance testing the testers managed to confuse pin numbers, plug and unplug live hardware, and suffered hand slips and upsets that resulted in extraordinary conditions such as short circuits and over voltage or over current events. During all of these accidental events the recovery of the Torrent system was instantaneous when the condition was removed.

With a few exceptions, the generic qualities testing, the hardware capabilities testing, and the specific hardware capabilities testing (sections 4, 5, & 6) specifications were met. Table 1 shows the results:

Table 1 – 'Raw Score Card' for Torrent Design Verification

Test purpose	Doc section	# of tests	Passed	Not Tested	Failed
Generic qualities	4	6	5	0	1
Functionality	5	26	18	3	5
Performance	6	25	19	1	5
Demonstration	7	19	9	2	8

The reason for the single test failure in the generic qualities testing (section 4) and two of the failures in the hardware capabilities testing (section 5) is because the firmware and/or software functionality to support the specification has not yet been implemented. These areas of functionality are enhanced features of Torrent (e.g. local image memory, Ethernet communications support, and NIR detector capabilities) and do not prevent the Torrent controller from performing the basic role of image acquisition.

The remaining three failures to meet specifications for the functional tests (section 5) were the result of minor excursions from the specifications (e.g. the timing resolution of the sequencer is 37ns and not the 25ns specified, the physical size is somewhat larger than originally conceived, etc.). These excursions do not impart any real impediment to the deployment of Torrent at the observatories.

Three of the five test failures in section 6 (performance testing) are concerned with lower voltage or lower current capability than the specification and have little impact on normal detector performance. One of these shortcomings can be rectified by the change of a resistor value (test 6.3.2.2) while the remaining two (6.2.8 & 6.3.2.1) can be discounted since the performance is adequate for normal detector operations.

A review of the results obtained by the demonstration testing (section 7) reveal three failures due to lack of firmware and/or software functionality to support the specification i.e. functionality that has not yet been implemented (7.5.2, 7.5.3, and 7.5.4) and one failure due to an easily rectifiable software bug (7.5.1). Of the five remaining failures, two tests, 7.1.3 and 7.1.5, have specifications that are overly restrictive on time allowances for diagnostic and restorative procedures. These two tests should be considered passed – indeed, the capability to change out and recover from a faulty detector controller within ten minutes must be a first for Torrent in terms of agility and capability. In addition, test 7.4.2 which also failed to pass the specification should, after further analysis of the results which are discussed further on in this document, should be considered a pass. Table 2 shows the corrected 'Score Card' results for the Torrent Design Validation.

Table 2 - 'Corrected Score Card' for Torrent Design Validation

Test purpose	Doc section	# of tests	Passed	Not Tested	No prejudice	Failed
Generic qualities	4	6	5	0	1	0
Functionality	5	26	18	3	5	0
Performance	6	25	19	1	3	2
Demonstration	7	19	8	2	7	2

The 'Bad' news:
There is no bad news. This heading is just to make the evaluation of the designed performance more balanced.

The 'Ugly' news:
There are two results that need to be addressed before Torrent deployment. Test 6.1.5 which measured the electronic noise performance is over twice the required specification and the tests 7.3.1 and 7.3.2 measure the video channel bias level stability.

The electronic noise values measured in test 6.1.5 is substantiated by a corresponding test in the demonstration testing (section 7 tests 7.2.1). The requirement for noise has a direct affect on the quality of science data that is acquired by these controllers and as such this area need further attention.

The bias stability requirement is so tight as to be within the noise envelope of the current Torrent performance. The performance in this respect should be re-evaluated once the noise has been brought down to the specification.

In Summary:
The Torrent design has passed the majority of the functional and performance benchmarks set for it. There are some performance details (e.g. servo tuning) and 'bugs' (as always) in the implementation that need to be addressed before Torrent can be deployed. These minor engineering changes do not inhibit the schedule for the production of Torrent hardware since no unscheduled modifications need to be made to the design to rectify these problems. The following document section discusses the relevant test results that either failed or partially succeeded and identifies remedial action that should be applied.

Discussion of results:

1. Discussion of test 5.1.1.
The difference between the specification of 25ns and the result of 37ns is essentially one of design. All clocks in the Torrent DHE hardware are synchronous to control noise the controller spectrum and its impact on the detector signal. The choice of 37ns for a sequencer clock period was made to accommodate the requirement for the Systran communication clock generator to function at 106.26MHz.

This test also highlighted a firmware code bug on the sequencer instruction set which requires a delay value to be at least 2.

Recommended action:
1a. This bug should be rectified in the pre-deployment firmware release.

2. Discussion of test 5.2.2.
This feature should be made available as an upgrade to the basic Torrent system at a later date. It is a significant feature that should not be abandoned. A future upgrades can be achieved with a change of firmware and software only. No hardware modifications need to be made.

Recommended action:
None.

3. Discussion of test 5.2.3.
This feature should be made available as an upgrade to the basic Torrent system at a later date. It is a feature that should be investigated coincident with the Ethernet communications feature (5.2.2) to allow a very fast quick look capability. A future upgrades can be achieved with a change of firmware and software only. No hardware modifications need to be made.

Recommended action:
None.

4. Discussion of test 5.3.2.
The shutter status signals are propagated to the sequencer firmware module in the correct manner, however, the firmware code that uses these signals to control the integration timer has not been implemented. In addition, The firmware that measures the open and close time of the shutter based on the shutter status signals does not work.

Recommended action:
4a. The shutter timer bug should be rectified and the integration timer control code implemented in the pre-deployment firmware release.

5. Discussion of test 5.3.3.
The firmware that controls the operation of the pre-flash switch operation from the sequencer event register does not allow the pre-flash signal to be cancelled. This is a simple firmware code bug.

Recommended action:
5a. This bug should be rectified in the pre-deployment firmware release.

6. Discussion of test 5.3.4 and 6.3.2.3.
The servo control loop for the control of the detector heater shares a common design with the other servo control loops in the Torrent system. These other loops control the primary power supply voltages to the AFE boards. These servo loops also exhibit occasional temporal instability.

Recommended action:
6a. The servo instability should be investigated and the problem rectified in the pre-deployment firmware release.

7. Discussion of test 5.3.5.
The TSM-UTIL board provides for a hardware limit set point restrict the amount of current that can be sourced to the detector heater. The circuit works but the actual thresholds are some 20% higher than expected. This is not a significant issue since the set point values are sufficiently spaced to make this error negligible in an actual implementation.

Recommended action:
7a. Note on the drawing that formula used to calculate the set point value and add a warning that the set point values are approximate only.

8. Discussion of test 5.3.7.
The telemetry for the +/- 10v AFE supplies is not supported in firmware. The –5v reference telemetry from the AFE board is incorrectly displayed.

Recommended action:
8a. The correct values should be set in the attribute descriptor for the –5v telemetry values.
8b. The firmware code to add the +/-10v telemetry channels should be implemented in the pre-deployment firmware release.
8c. The Borg attributes associated with these telemetry values should be implemented.

9. Discussion of test 5.3.10.
Currently the PAN communications status signal (that detects the Systran communication link health) is functional but not connected to any function.

Recommended action:
9a. Firmware code to effect a communication reset should be implemented in the pre-deployment firmware release

10. Discussion of test 5.5.1.
We are still awaiting detailed results from the thermal testing currently being carried out in the Tucson labs. Preliminary information is sufficiently encouraging to predict that the required thermal performance will be either met or in the least, sufficient for release of the design to production.

There is one detail that needs to be further investigated. The high voltage bias voltage generators fail to become operational when the Torrent controller is powered up and the temperature is below 5^{o} Celsius.

Recommended action:
10a. Investigate the low temperature failure mode to determine the cause and implement a fix to this problem.
10b. Continue to characterize the thermal performance of the Torrent DHE to satisfy the design verification test criteria.

11. Discussion of test 5.5.2 and 5.5.3.
We are still awaiting detailed results from the thermal testing currently being carried out in the Tucson labs.

Recommended action:
11a. Continue to characterize the thermal performance of the Torrent DHE to satisfy the design verification test criteria.

12. Discussion of test 6.1.5 and 7.2.1.
The requirement for the noise figure is based upon achieving 'detector limited performance' for the Torrent design. Currently, with the nominal gain of the acquisition channel set to achieve approximately 0.5e- / ADU conversion, the noise figure of the design is high by a factor of approx. 2.3. Characterization of the noise was carried out during testing to determine the major source of the noise. This testing confirms that the noise is additive throughout the analog signal chain i.e. there is not one single noise source but every gain stage is adding an above normal amount of noise. Table 3 shows the noise figures for the different analog signal processing stages at a measured gain of 2.58μv / ADU input referred (i.e. approx. 0.5e-/ADU).

Table 3 - Torrent DHE Noise contributions

Noise Signal	ADC Buffer	Integrator	Buffer	Pre-amplifier
ADU	1.96	3.3	4.5	7.1
Mv	5.07	8.5	11.5	18.32

This suggests that the selection of the amplifier types and the component values selected for bandwidth control of these amplifiers can be adjusted to improve the noise performance.

Recommended action:
12a. An analysis and some experimentation should be performed on the AFE analog signal processing chain to improve the noise performance of the design.

13. Discussion of test 6.1.9 and 7.4.2.
To test the Torrent performance for video channel cross talk we used a simulated video signal injected into channel 1 while clamping video channel 2 to ground through a 2K Ohm shunt resistor. The simulated video signal was generated using the clock[12] output with divider network of 75K / 200 Ohms and programming a step in amplitude during readout that corresponded to row 2048. This produced the expected horizontal shift in pixel values at half the detector row dimension on one channel. The simulated amplitude on video channel 1 was approx. 23,733 ADU and the corresponding step feature measured on channel 2 was approx. 33 ADU which is reflected in the test report values.

However, during demonstration testing and after Mark remarked that previous testing had shown a much lower value, I re-evaluated the cross talk based on the method Mark had used. This method relies on measuring the cross talk due to a bright cosmetic feature present on the detector; in this case, several saturated columns (i.e. > 262K ADU) in the right hand side of the detector used for evaluation. The results of the first test 7.4.2 were based on cosmetic features with much less amplitude (of order 10% dynamic range). Analysis on the images with 100% dynamic range excursions for the cosmetic produced a value of less than 60 ADU (maximum value of 0.02% cross talk) due to any effects of cross talk; a value that is only a factor of two from the specified requirement, and a value which is the worst

case since the test aggressor, the cosmetic defect, drives video channel 1 into saturation and we cannot know the true amplitude of the aggressor signal.

Our recommendation is that the effects of cross talk be measured again using another (or the first) Torrent system installed on either a test bench with an optical source or on sky i.e. discount the evaluation of test 6.1.9 based on the analysis of the effects on a real detector and retest using another detector and Torrent system to characterize the effects. Our motives for this recommendation are that the level of 0.14% cross talk as measured by the synthetic test there is a major limitation that severely impacts the science productivity of Torrent, but at a level of 0.02% the impact is normally masked by the background noise signal so, if the cross talk was truly in the 0.1% range as measured using the synthetic signal, then this should have also produced a result in the demonstration test that more closely resembled this value and not one that is seven times less.

Recommended action:
13a. Discount the actual results of test 6.1.9 and retest with another detector in a test setup with an optical spot generator or equivalent stimulus.

14. Discussion of test 6.2.7.
The clock rail cross talk test shows local cross talk between adjacent channels but good isolation between non-adjacent channels. This effect is sufficiently severe (measured at approx. 100mv effect for full dynamic range on the aggressor channel) to be worrisome in some situations.

Recommended action:
14a. An analysis and some experimentation should be performed on the AFE clock circuits to improve the cross talk performance of the design.

15. Discussion of test 6.2.8.
This test measures the worst case effect and places the clock generator circuitry under the most stress; a condition that will not likely occur in a deployed situation. The achieved test result is not detrimental to production plans.

Recommended action:
None.

16. Discussion of test 6.3.2.1.
This test measures the worst case situation and places the bias generator circuitry under the most stress; a condition that will not likely occur in a deployed situation. The achieved test result is within the specification of the amplifier used to drive the bias signal and the lack of current is not detrimental to production plans.

Recommended action:
None.

17. Discussion of test 6.3.2.2.
The actual dynamic range of the high voltage biases is currently limited by the AFE component selection associated with the high voltage regulators.

Recommended action:
17a. Adjust the AFE component values associated with the +/- HV supply regulation to achieve a 30v dynamic range on the high voltage biases.

18. Discussion of test 7.3.1 and 7.3.2.
The requirement of these tests puts the measured quantity inside the noise signal of the images used for analysis. This makes exacting an accurate measurement difficult to achieve.

Recommended action:
18a. Retest the bias stability when the noise of the system has been reduced to specification.

19. Discussion of test 7.3.3.
We are still awaiting detailed results from the thermal testing currently being carried out in the Tucson labs.

Recommended action:
19a. Continue to characterize the thermal performance of the Torrent DHE to satisfy the design verification test criteria.

20. Discussion of test 7.5.2.
This feature should be made available as an upgrade to the Torrent system at a later date. It is a hard requirement that must be implemented. This upgrade can be achieved with a change of software only. No hardware modifications need to be made.

Recommended action:
None.

21. Discussion of test 7.5.4.
This feature should be made available as an upgrade to the basic Torrent system at a later date. It is a significant feature that should not be abandoned. A future upgrades can be achieved with a change of firmware and software only. No hardware modifications need to be made.

Recommended action:
None.