Electrical Characterisation and Quality Assurance of ATLAS TileCal LVPS Bricks Using a Single-Board Test Bench

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ATLAS HL-LHC

The High-Luminosity Large Hadron Collider (HL-LHC)[2] will significantly increase the luminosity of the Large Hadron Collider, placing greater demands on detector electronics, data acquisition systems, and power distribution networks. To ensure reliable operation under these conditions, the ATLAS Tile Calorimeter (TileCal) shown in Figure 1, is undergoing a comprehensive Phase-II upgrade.

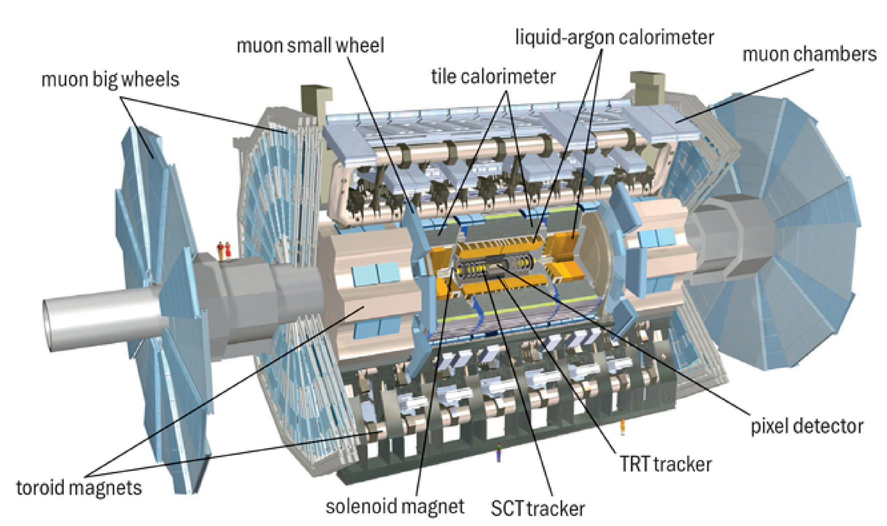


Figure 1. ATLAS detector with TileCal labeled "tile calorimeter"

A key component of the upgraded detector architecture is the Low Voltage Power Supply (LVPS) system, which provides stable power to the front-end electronics. Reliable LVPS operation is essential for maintaining detector performance and minimizing operational downtime. As part of the production quality assurance programme, an upgraded single-brick test bench has been developed to perform early electrical validation of LVPS converter boards also known as "Brick or LVPS Brick" before burn-in testing and detector integration.

TILECAL PHASE II UPGRADE

The ATLAS Tile Calorimeter[1] is the central hadronic calorimeter of the detector and is responsible for measuring hadronic particle energies, jet reconstruction, missing transverse energy, and muon identification.

To meet the requirements of HL-LHC operation, TileCal is being upgraded with:

- New front-end electronics
- Improved radiation tolerance
- Upgraded LVPS infrastructure
- Enhanced system reliability

The upgraded electronics architecture shown in Figure 2 requires highly reliable power supplies capable of stable long-term operation. Consequently, comprehensive quality assurance testing is required throughout production to ensure that all LVPS components satisfy operational specifications.

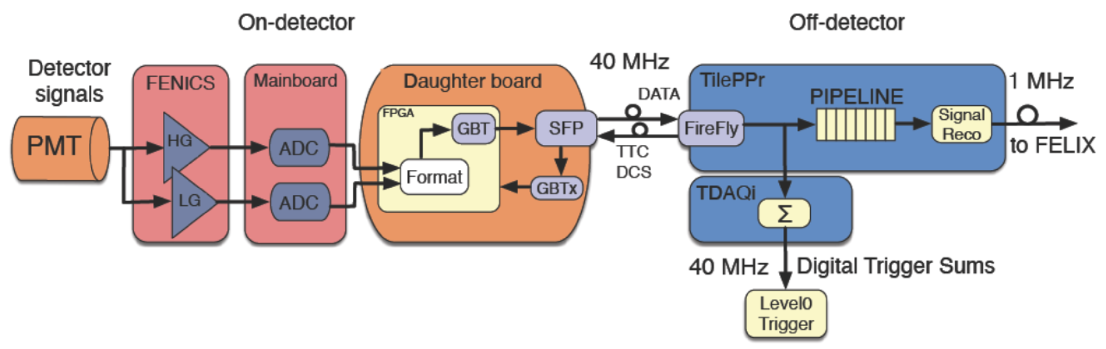


Figure 2. TileCal Phase-II upgrade architecture.

LVPS BRICK OVERVIEW

The LVPS brick shown in Figure 3, converts high-voltage DC input power into low-voltage outputs required by TileCal front-end electronics. Each converter board must satisfy strict electrical and operational requirements before deployment.

Parameters	Typical Value
Input Voltage	∼200 V DC
Output Voltage	∼10 V
Load Current	∼2.3 A
Output Power	Up to 70 W
Efficiency	> 60 %

The performance of these bricks directly impacts the reliability and stability of the upgraded TileCal electronics system.

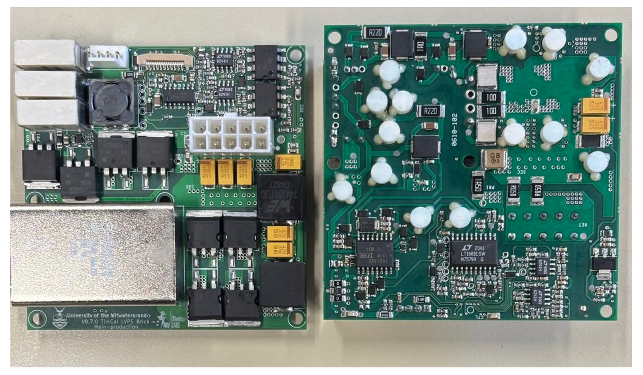


Figure 3. LVPS brick top (left) and bottom (right) side.

UPGRADED SINGLE-BRICK TEST BENCH

An upgraded single-brick test bench has been developed to perform controlled electrical characterisation of individual LVPS converter boards prior to burn-in testing.

On the test bench, the LVPS brick undergoes 11 test that evaluate:

- Output voltage regulation
- Load current stability
- Input current behaviour
- Operational compliance

The system enables early identification of faulty or non-compliant units before they progress to later stages of production and integration i.e a good brick it should pass all 11 testss.

EXPERIMENTAL PROCEDURE

LVPS converter bricks undergo a multi-stage quality assurance process before integration into the ATLAS TileCal Phase-II upgrade as shown in Figue 4:

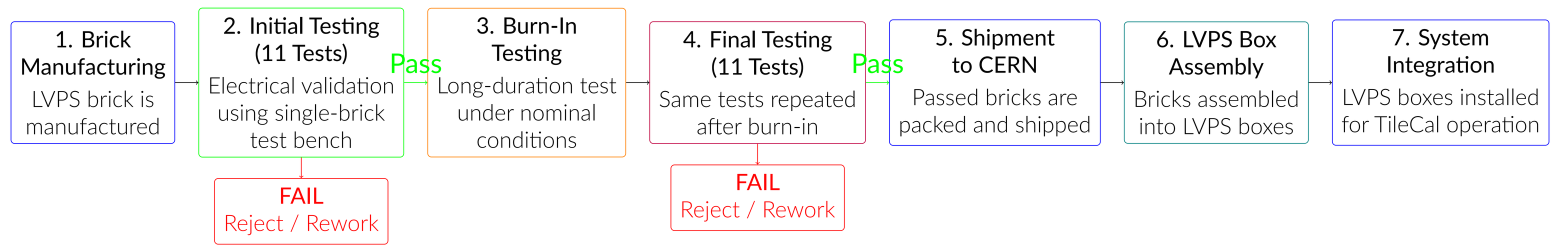
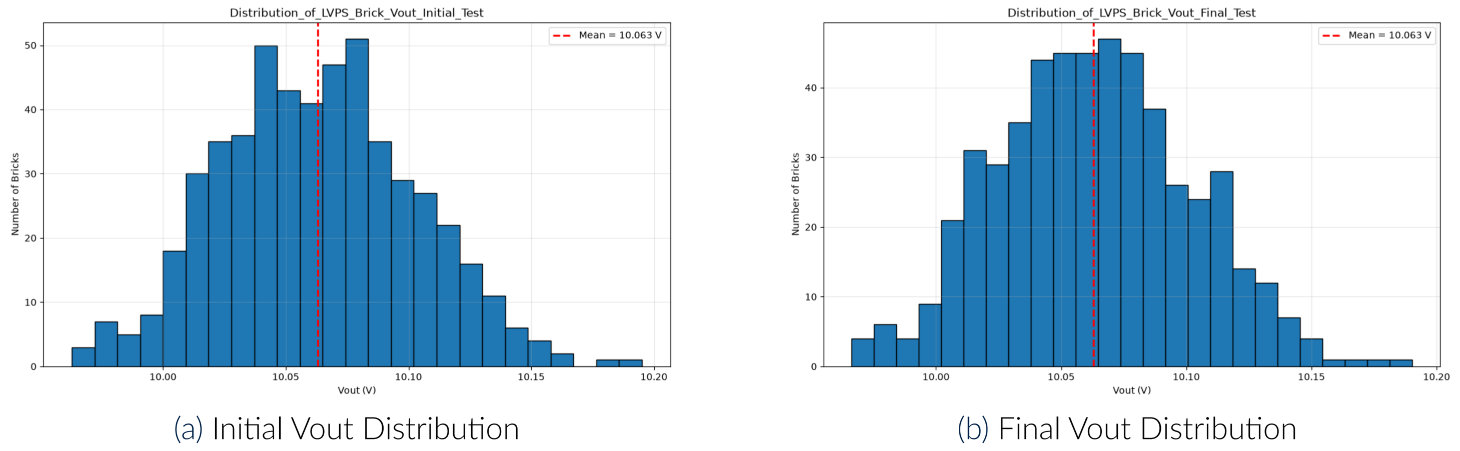


Figure 4. TileCal LVPS brick production and testing workflow. Each brick undergoes initial testing using eleven electrical tests, followed by burn-in testing if all tests are passed. After burn-in, the same eleven tests are repeated as final testing before shipment to CERN for LVPS box assembly.

RESULTS AND DISCUSSION

The output voltage (Vout) distributions from the initial and final testing stages were analysed to evaluate the consistency of the LVPS brick production process shown in Figure 5. Both histograms exhibit an approximately Gaussian distribution centred close to the nominal output voltage of 10 V, indicating stable and reproducible electrical performance across the production batch. Most bricks are concentrated within a narrow voltage range, while only a few outliers appear at the distribution tails, suggesting minimal production variation.



(a) Initial Vout Distribution (b) Final Vout Distribution

Figure 5. Vout Distribution Histogram

The final testing results show a mean output voltage of 10.063 V, demonstrating that the burn-in process did not significantly affect the output voltage characteristics. The close agreement between the initial and final test distributions confirms that the LVPS bricks maintained stable performance throughout the quality assurance process. Overall, the narrow distributions and small number of outliers demonstrate good manufacturing consistency, effective burn-in screening, and reliable voltage regulation, confirming that the tested LVPS bricks satisfy the performance requirements for the ATLAS Tile Calorimeter Phase-II upgrade.

CONCLUSION

The quality assurance analysis demonstrated that the LVPS bricks exhibited stable and consistent electrical performance throughout the production process. The output voltage distributions obtained during the initial and final testing stages showed approximately Gaussian behaviour centred close to the nominal 10 V output, indicating good manufacturing consistency and reliable voltage regulation. The close agreement between the two distributions confirms that the burn-in procedure did not introduce significant performance degradation and effectively screened the bricks before final acceptance. Furthermore, the small spread in the measured output voltages and the low occurrence of outliers demonstrate the repeatability of the manufacturing and testing processes. Overall, the results validate the effectiveness of the implemented quality assurance framework in identifying compliant LVPS bricks and ensuring reliable performance for integration into the ATLAS Tile Calorimeter Phase-II upgrade. These findings provide confidence that the tested bricks meet the required performance standards for long-term operation in the High-Luminosity Large Hadron Collider environment.

REFERENCES

[1] Technical Design Report for the Phase-II Upgrade of the ATLAS Tile Calorimeter. Technical report, CERN, Geneva, 2017.

[2] Apollinari G., Béjar Alonso I., Brüning O., Fessia P., Lamont M., Rossi L., and Tavian L. *High-Luminosity Large Hadron Collider (HL-LHC).* CERN Yellow Reports: Monographs. CERN, Geneva, 2017.