The ATLAS Tile Calorimeter

The Tile-Calorimeter (TileCal) is a sampling calorimeter which forms the central region of the Hadronic calorimeter of the ATLAS experiment. It performs several critical functions within ATLAS such as the measurement and reconstruction of hadrons, jets, hadronic decays of $\tau$-leptons, and missing transverse energy. It also participates in muon identification and provides inputs to the Level 1 calorimeter trigger system. TileCal is composed of 256 wedge-shaped modules which are arranged azimuthally around the beam axis. A module consists of alternating steel (absorber) tiles and plastic scintillating tiles (active medium) with a Super Drawer (SD) housing the Front-End (FE) electronics and the Photomultiplier tubes located on its outer radius.

Burn-in Motivation

Access to the Bricks is limited to approximately once per year. Therefore, any Bricks which fail will result in a portion of a module being offline for a commensurate time emphasizing the importance of the Brick reliability. To maximize this we are required to minimize their failure rate. The failure rate of electronics can be represented by a “Bathtub” curve (Fig.3). Observe the undesirable failure rate within the infant mortality region. Burn-in testing serves to address this by performing accelerated ageing of the Bricks. The accelerated ageing causes Bricks that would fail during their early lifetime to fail immediately thereby effectively screening out the infant mortality failures.

Low-Voltage Power Supply

Function: Provides low voltage power to the front-end electronics of the SDs. A Low-Voltage Power Supply (LVPS), of which there is one per TileCal module, steps down 200VDC, received from off-detector high-voltage supplies, to the 10VDC required by the front-end electronics. The LVPS’s location can be seen in in Fig.1 where they are housed within shielding (blue boxes) at the outer radius of the Tilecal modules. An LVPS consists of an Embedded Local Monitoring Board (ELMB), a Fuse board, a water-cooled heatsink, and eight transformer-coupled buck converters (Bricks). The Bricks make use of an isolated primary (see Fig.2) and secondary side. These secondary side contains an LCBuck, which are arranged azimuthally around the beam axis. A module consists of alternating steel (absorber) tiles and plastic scintillating tiles (active medium) with a Super Drawer (SD) housing the Front-End (FE) electronics and the Photomultiplier tubes located on its outer radius.

Burn-in Procedure

The purpose of the Burn-in procedure is to accelerate aging of the Bricks. This is achieved by operating the Brick within a sub-optimal environment (increased temperature and load) thereby stimulating similar failure mechanisms which appear during normal operation. The Bricks operating temperature is increased by reducing the cooling capacity of the heatsinks (Cooling plates) to which they are attached.

Burn-in operating parameters

The Burn-in parameters are higher than nominal to ensure accelerated aging but have to remain below the limits imposed by the Bricks protection circuitry.

- Run-time: 8 hours
- Operating Temperature of Bricks: 60°C
- Load: 5 A

Burn-in test Station

As depicted in Fig.6, the Burn-in station hardware is composed of a Personal Computer (PC), a 200 VDC High-Voltage (HV) power supply, various custom Printed Circuit Boards (PCBs) designs, electronic components, connectors, wiring, Cooling Plates (CP), a water-chiller, and a mechanical chassis known as the test-bed. The PCBs are subdivided into four types, the Main Board (MB), the Brick Interface Board (BIB), the Load Interface Board (LIB) and the Dummy Load Board (DLB). The Burn-in station comprises a MB (x1) responsible for communicating to the BIBs (x8) and LIBs (x2) through an application-specific control and monitoring program developed in LabVIEW. The BIBs interface between the Main board and the eight Bricks undergoing burn-in. They digitize performance metric analog signals (such as output voltage) received from the Bricks. The BIBs are also used to switch the Bricks on/off and act as a switch for the 200 VDC input to a Brick.

Fig.6 Block diagram illustrating the burn-in station. Adapted from diagram by S. Mongelli.

Preliminary Burn-in results

The Burn-in station is in a mature stage. To date preliminary testing of the hardware and software has commenced with favourable results being observed. As can be seen in Fig. 7 (left) the burn-in temperature parameter is being met with the hot spot being measured resulting from the primary-side MOSFETs. It is worth noting that the thermistor (with associated temperature $T_2$ utilized for the on-Brick measurements is located adjacent to these MOSFETs and is utilized in the Bricks Over Temperature Protection (OTP) circuitry. The $T_2$ temperature monitored during the burn-in procedure is illustrated in Fig.7 (middle). The burn-in temperature is stable with a mean value of 60.69°C and standard deviation of $\sigma$ = 0.18°C.