Control System for ATLAS TileCal HVRemote boards

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Motivation

The electronic system in charge of the control and distribution of high-voltage (HV) to the 9852 PMTs of the TileCal detector at the ATLAS experiment is currently being upgraded. Its core comprises two cards [1]: the HVOpto and the HVMicro. There are problems in the current setup, such as:
• The system is inside the detector, thus working under high doses of radiation.
• The servicing and replacement of faulty cards is possible only when LHC stops at least for a few months.
To alleviate these constraints, in the upgrade it is proposed to move the TileCal's HVOpto electronic control system to the USA15 room (far from radiation), with the goal of increasing the expected lifetime of the system and providing for immediate maintenance and replacement [2][3].
However, the power supplies of the HVRemote board will now be linked through a bunch of 100 m long cables, which degrades stability and noise levels.
The large number of long cables and their installation/integration is the weakest point of the HVRemote solution. There is an alternative solution [4] developed by the ANL team that keeps the HV electronics in the detector.
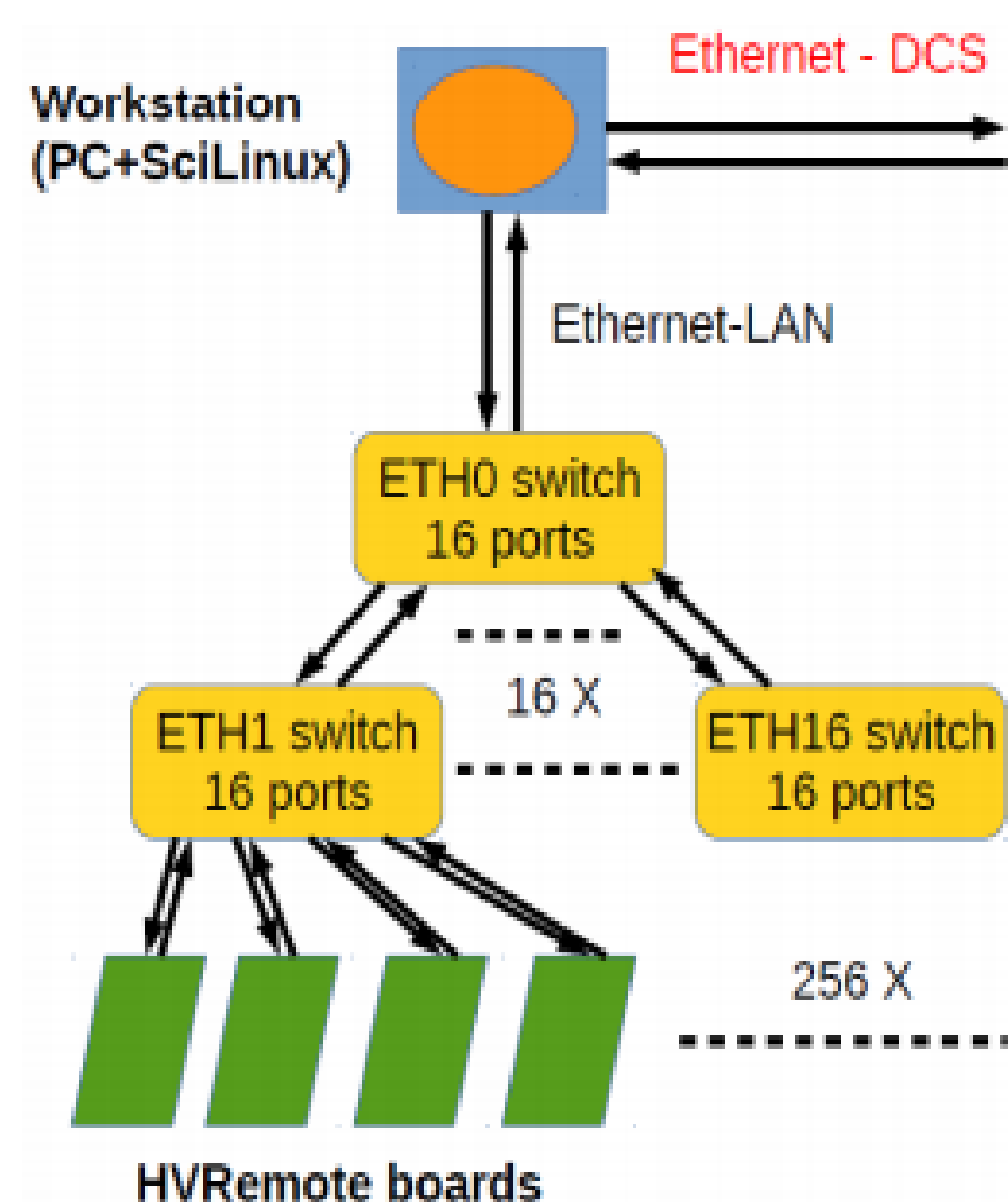

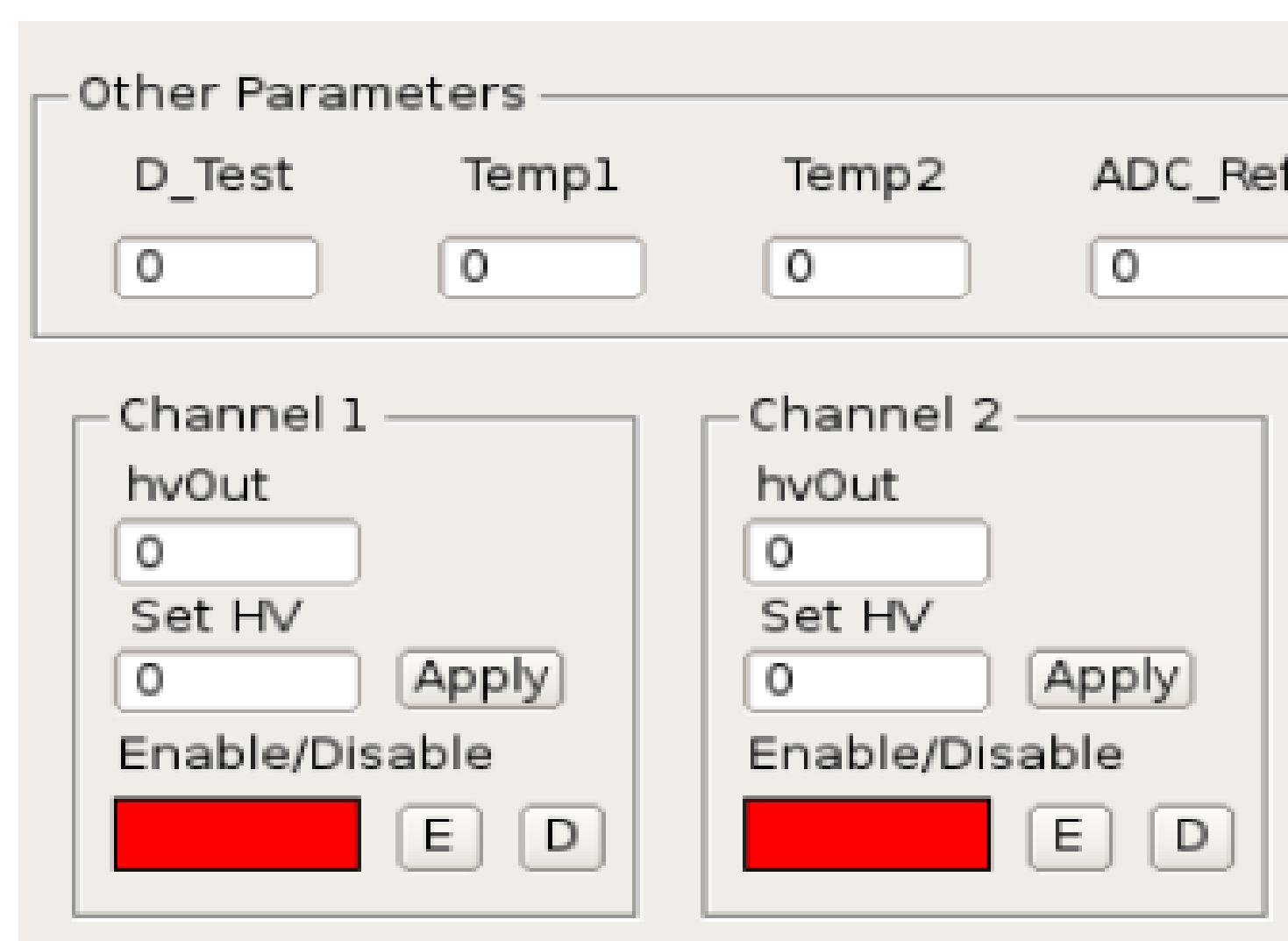Figure 1 – Architecture of HVRemote Control Tree

Figure 2 – Partial view of the WinCC DCS interface developed for the HVRemote card

The HVRemote Control Path and Hardware

The architecture of the upgraded system is shown in Figure 1. The control master is a PC/workstation configured as a node of the DCS of ATLAS. The DCS commands and the data read from the HVRemote boards flow through a tree of Ethernet links, connecting the PC and 256 boards, each of these managing 48 PMT channels. The control software comprises DCS (high-level commands), C++ and Python programs, running in the PC, which use the DCS API (Figure 2), and C programs running in the Tibbo EM1206 modules. These modules (one for each HVRemote board), are used to read commands from the Ethernet channel, convert them into raw digital signals and send them to HVRemote's digital control circuits through a SPI link. The reverse data flow (from the HVRemote to the upstream DCS computers) is also managed by the system.

Evaluation of the Tibbo EM1206 module

To probe the interfacing solution, it was used a Tibbo EM1206-EV evaluation board. Tibbo supplies an integrated development system, which includes C libraries for sockets programming and SSH communications. Tibbo supplies a standalone tool, the *IO Ninja*, which allows testing Ethernet communications between the board and the PC.
A raw Ethernet client using sockets was developed in C and deployed in the module. It succeeded in communicating with an Ethernet master in the PC, programmed in Python, and with the *IO Ninja* working as an Ethernet/sockets master.
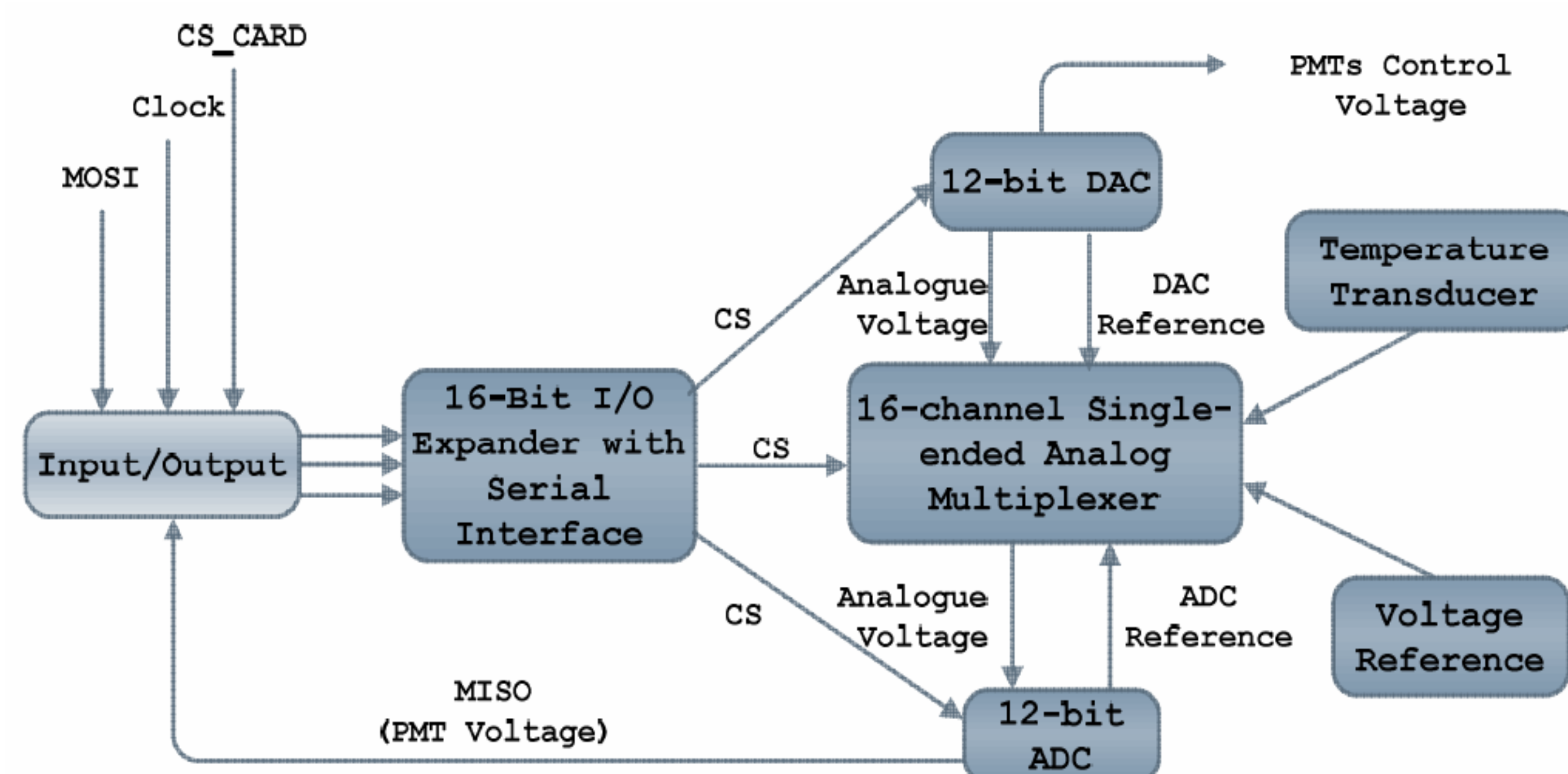

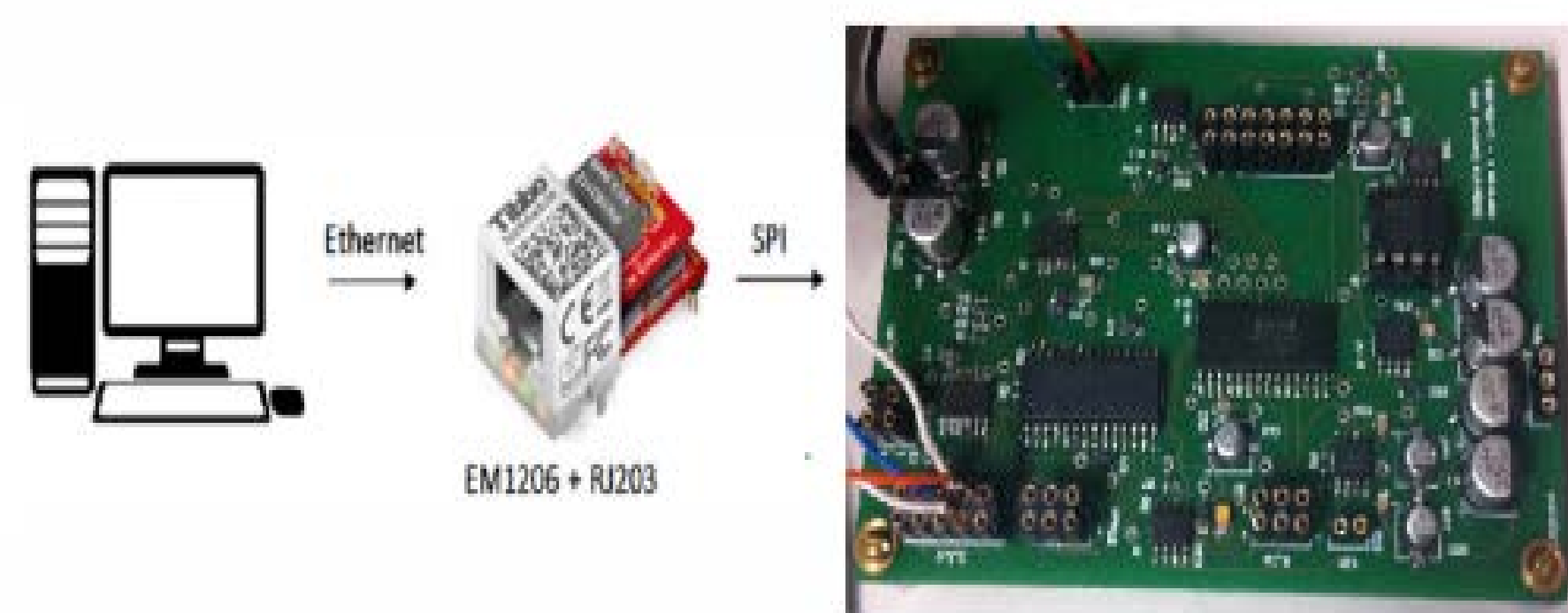Figure 3 – Block Diagram of the HVRemote-Ctrl Card.

Figure 4 – Protocols in the HVRemote System. HVRemote-Ctrl board at right.
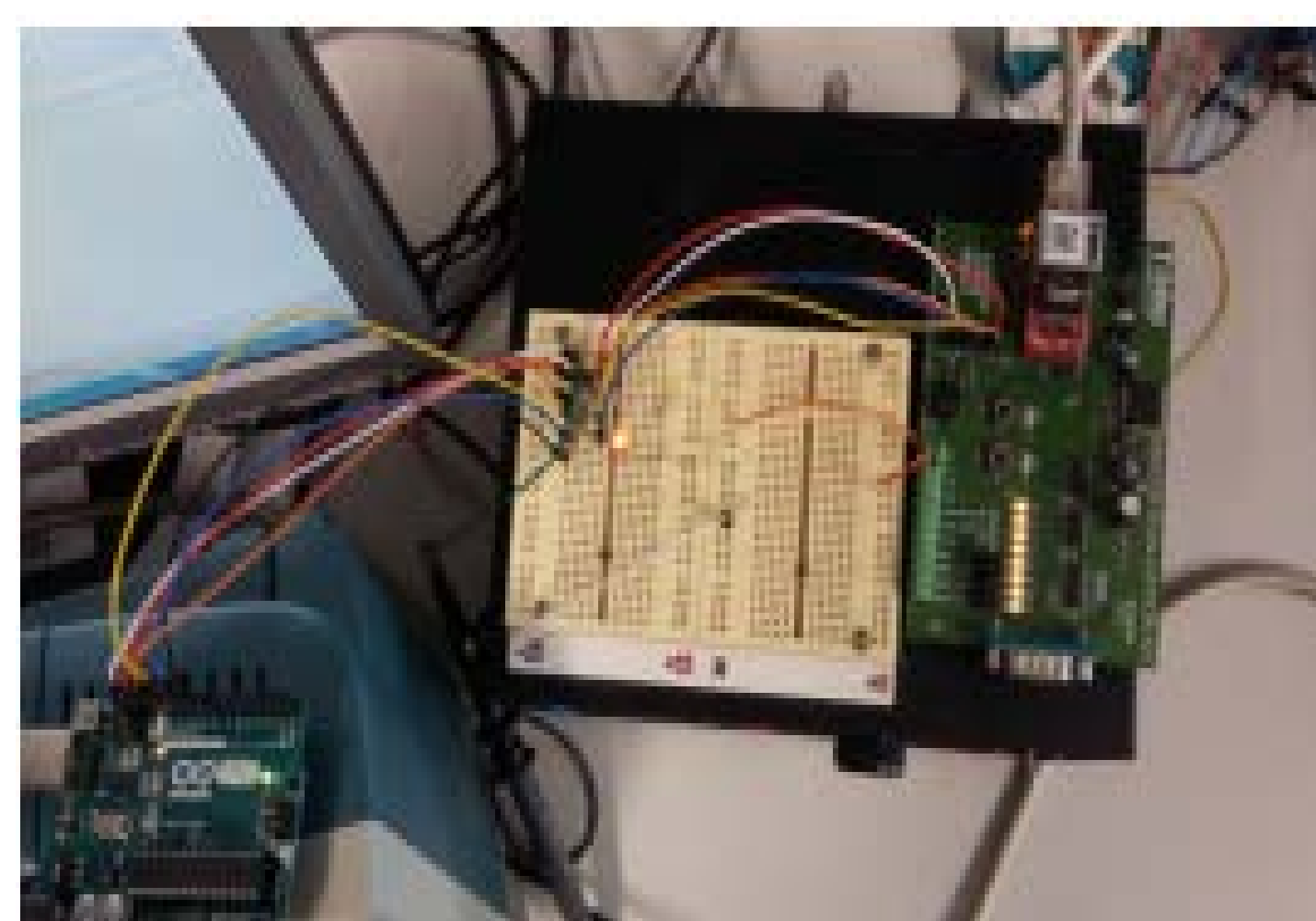

Figure 5 – Tests of Tibbo-Arduino communication through the SPI interface

The HVRemote-Ctrl Testing Card

To evaluate the supervising and control electronics of the HVRemote, it was built a test card, the HVRemote-Ctrl (Figures 3 and 4), which has the same control components of the HVRemote, but lacks the front-end electronics of the PMTs. This provides means to test the digital control hardware and the Tibbo module, and to assess the transfer speeds. A DC/DC converter is used to couple the 3.3 V signals from Tibbo to 5 V in CMOS hardware. The test card has a 16-bit port expander with SPI, a 12-bit DAC, a 16-bit analog multiplexer, an instrumentation amplifier, a 12-bit ADC, a temperature sensor and a voltage reference. These are the same components (albeit in less quantity) and architecture used in the HVRemote full card.

Conclusions

The development of the HVRemote continues, guided by knowledge gained from the test and validation of the HVRemote-Ctrl card. The following tasks have been completed:
• Development of the HVRemote-Ctrl card to evaluate the digital control and supervising system. The test of the second prototype is undergoing.
• Development, in Python, of a panel to manage the HVRemote-Ctrl card.
• Evaluation of the Tibbo EM1206 module as a suitable Ethernet controller for the HVRemote board.
• Evaluation of the Tibbo EM1206 module as SPI master, using Arduinos configured as SPI slaves (Figure 5).
The speeds measured in both Ethernet and SPI communications with the Tibbo module are suitable to monitor in real time all 256 HVRemote boards and 9852 PMTs in the TileCal.
In the next weeks the prototype of a full HVRemote card will be assembled.

References

[1] – R. Chadelas et al., "High voltage distributor system for the Tile hadron calorimeter of the ATLAS detector", ATLAS-TILECAL-2000-003, 2000, https://cds.cern.ch/record/436230
[2] – F. Vazeille, "Performance of a remote High Voltage power supply for the Phase II upgrade of the ATLAS Tile Calorimeter", JINST 11 C02050, 2016
[3] – A. Gomes, "The new front-end electronics for the ATLAS Tile Calorimeter Phase 2 Upgrade", JINST 11 C02015, 2016
[4] – G. Drake, "The New Front-End Electronics for the ATLAS Tile Calorimeter Phase 2 Upgrade", ATLAS note ATLTILECAL-PROC-2015-023, https://cds.cern.ch/record/2114792