Tango Integration of the SKA-Low Power and Signal Distribution System

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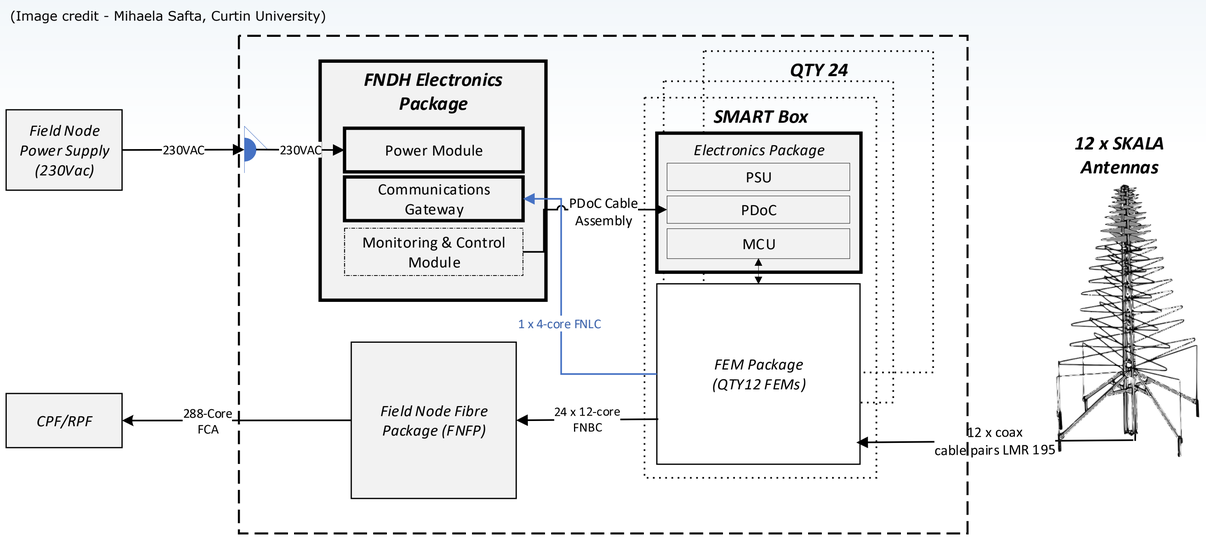
SKA-Low

The SKA-Low radio telescope is being built in the desert of Western Australia. It will have over 130,000 antennas grouped into 512 Field Stations, distributed in three spiral arms radiating from a central core. The SKA-Low's unique design employs wire-type antennas and advanced back-end technology for efficiency at low frequencies. It operates as a mathematical telescope, processing data, applying time-delays to align the phases of signals received from a certain direction, to form virtual beams that "point" the telescope in different directions without moving parts.

Each Field Station of the SKA-Low telescope consists of a 256 antenna-element array to capture and amplify the signal from the sky. The Power and Signal Distribution subsystem (PaSD), designed by Curtin Institute of Radio Astronomy (CIRA), is responsible for control and monitoring of the electronic components of the RF signal chain for the antennas, and collecting the RF signals for transmission to the Central Processing Facility.

PaSD Architecture

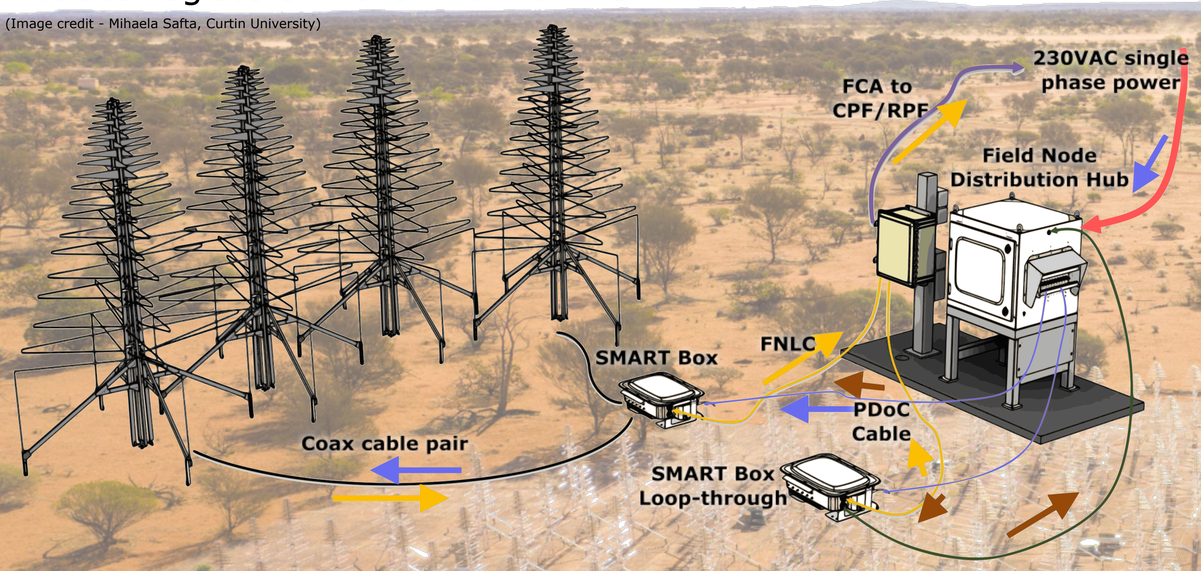
(Image credit - Mihaela Safta, Curtin University)



The PaSD system comprises Small Modular Aggregation and RFoF Trunk (SMART) boxes to which up to 12 antennas can be connected each, and one Field Node Distribution Hub (FNDH) per station which distributes power to all the SMART boxes and provides an ethernet-serial communications gateway. Micro-controllers inside the SMART boxes and FNDH protect the equipment from damage by automatically turning off ports in response to current and temperature readings, thus separating the equipment protection concerns from any external control system.

All communication to the SMART boxes is funnelled through the FNDH on a multi-drop serial bus using the Modbus ASCII protocol. Various PaSD parameters can be monitored or controlled via Modbus registers in the FNDH and SMART boxes.

(Image credit - Mihaela Safta, Curtin University)



Monitor, Control & Calibration

The Monitor, Control and Calibration System (MCCS) is responsible for the monitoring and control of all the local hardware on the SKA-Low Field Stations. The MCCS is a reasonably complex product which includes the software to control and calibrate the Data Acquisition system and the PaSD is a sub-system that must integrate into the MCCS architecture.

Software Design

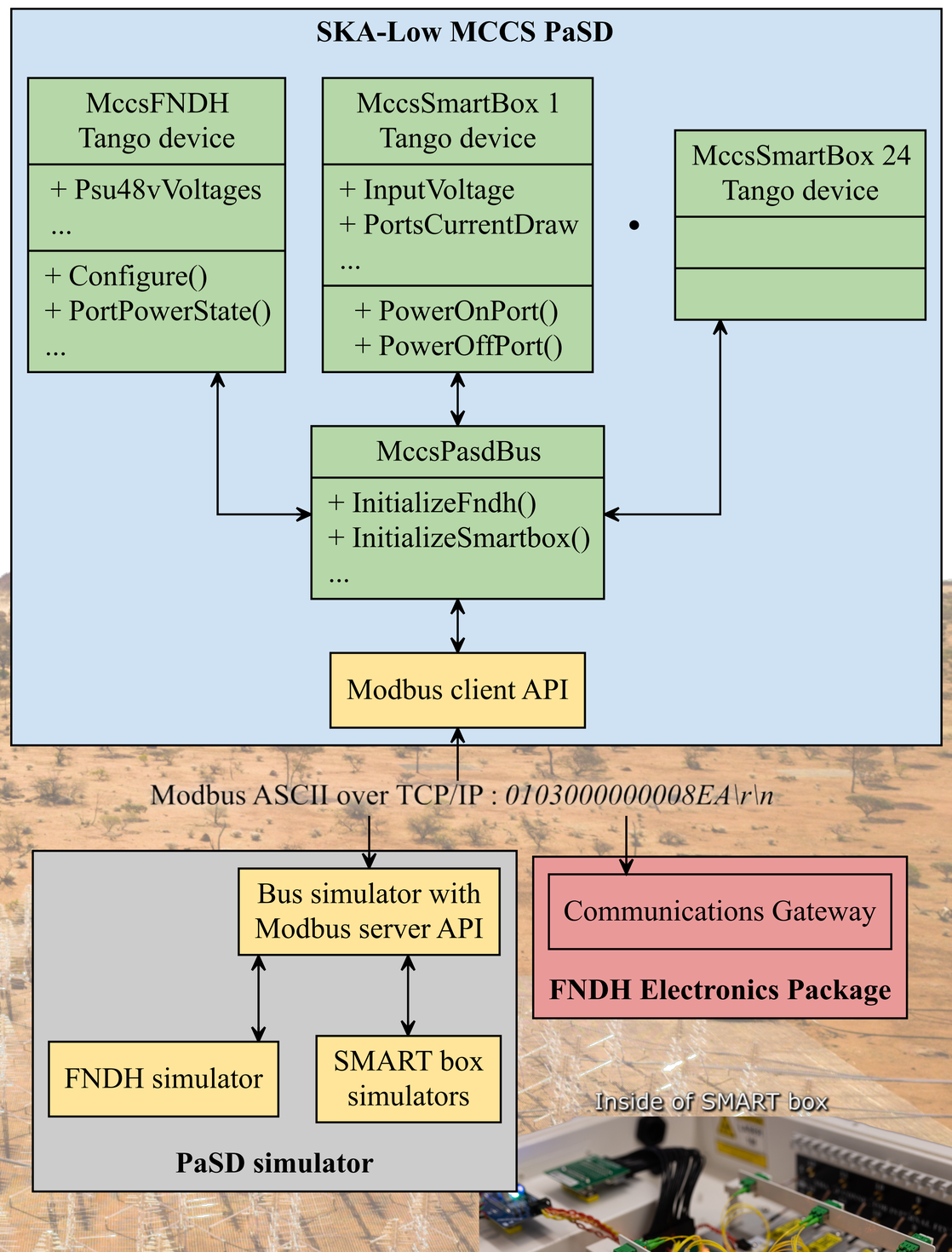
The shared serial bus means that each SMART box must be polled in turn. Therefore all communication is sent through a single Tango device client, named the MccsPasdBus. A separate Tango device corresponding to each physical device then proxies through MccsPasdBus to expose its attributes and commands.

The low level transport code in the MccsPasdBus device is implemented with the PyModbus library. PyModbus has a lightweight implementation with minimal dependencies and supports the ability to add customizations. It exposes an API for all of the standard Modbus commands, including the ones needed for this application, namely: read holding registers, write single register and write multiple registers.

The Tango device code has been separated from the low-level Modbus communication through the creation of a PaSD Modbus API. This comprises two parts: a client side which has public methods used by MccsPasdBus to read and write attributes and execute commands, and a server side which provides a Modbus interface to a simulator used for testing purposes.

Simulation and Testing

There are functional, integration and unit tests for all the components of the PaSD software implemented with pytest. The tests are run as part of the CI/CD pipelines on SKAO's Gitlab. Since the infrastructure lacks access to the PaSD hardware, tests are run against a pure Python PasdBusSimulator, which simulates a Field Station. The simulator can replicate various system states, including alarm and fault conditions.



Inside of SMART box