A Python GUI for the

SKA AAVS1 Racks Management

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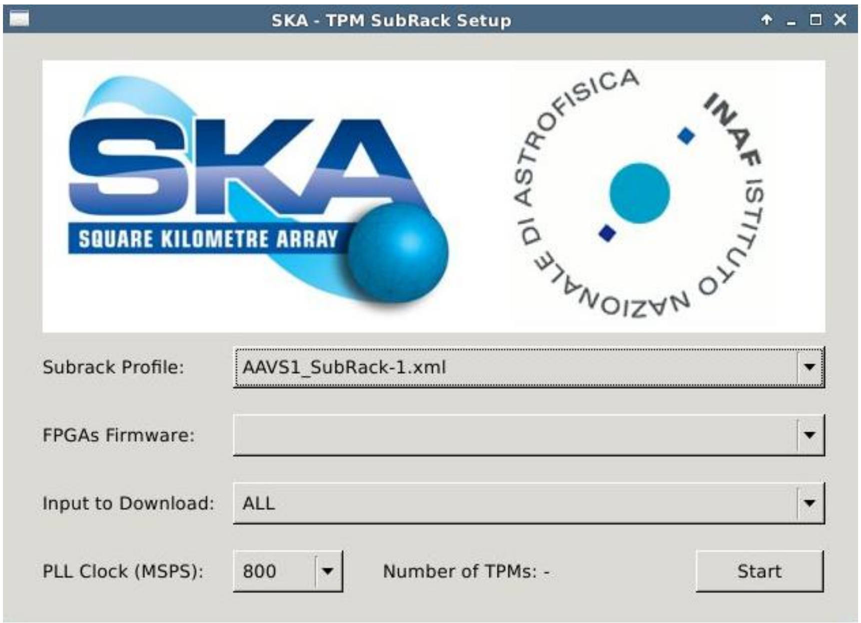

SKA - TPM SubRack Setup

Subrack Profile: AAVS1_SubRack-1.xml

FPGAs Firmware:

Input to Download: ALL

PLL Clock (MSPS): 800

Number of TPMs: -

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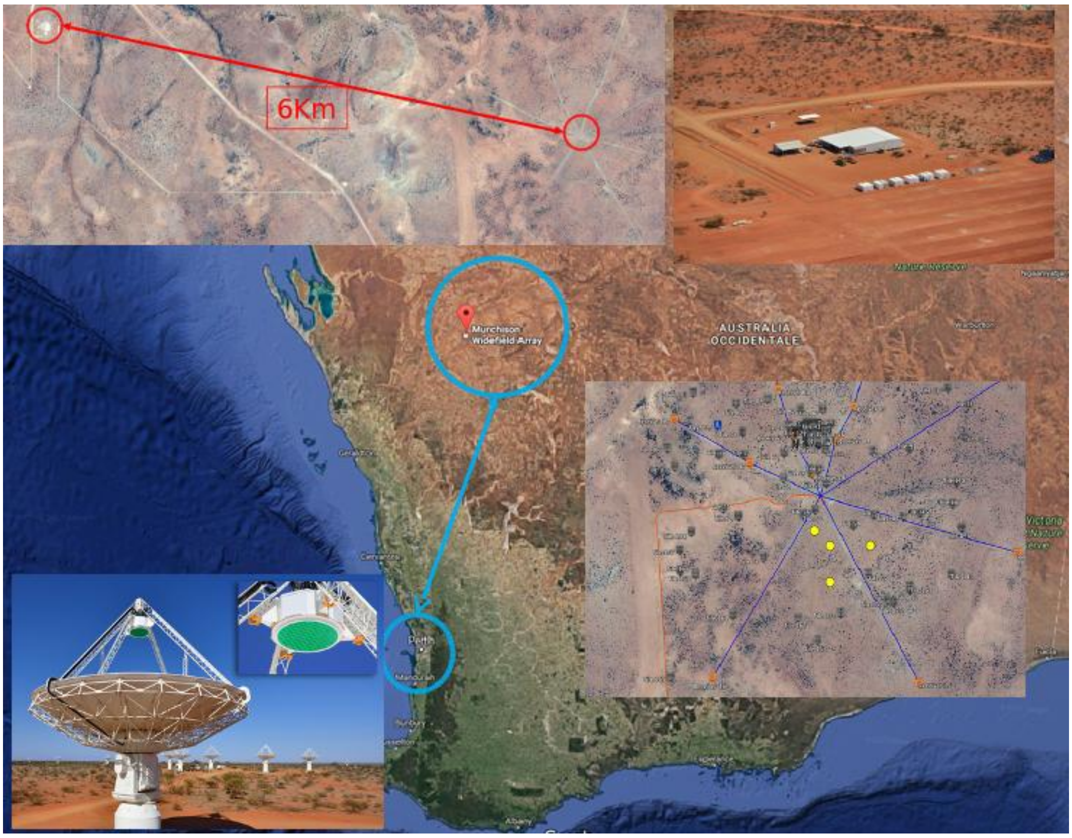
Introduction

AAVS1 (Aperture Array Verification System 1) is the first SKA Low Frequency Aperture Array (LFAA) test bench installed in the Western Australia in the MRO site (Murchison Radio Observatory). It is placed within the MWA field, at 6 Km from the ASKAP control room.



The Murchison Radio Observatory site in the Western Australia. The four yellow dots are the AAVS1 stations within the MWA core.

A group of us has done the AAVS1 deployment in 2017: Jader Monari, Federico Perini, Marco Schiaffino, Simone Rusticelli, Marco Poloni and Andrea Mattana (myself).

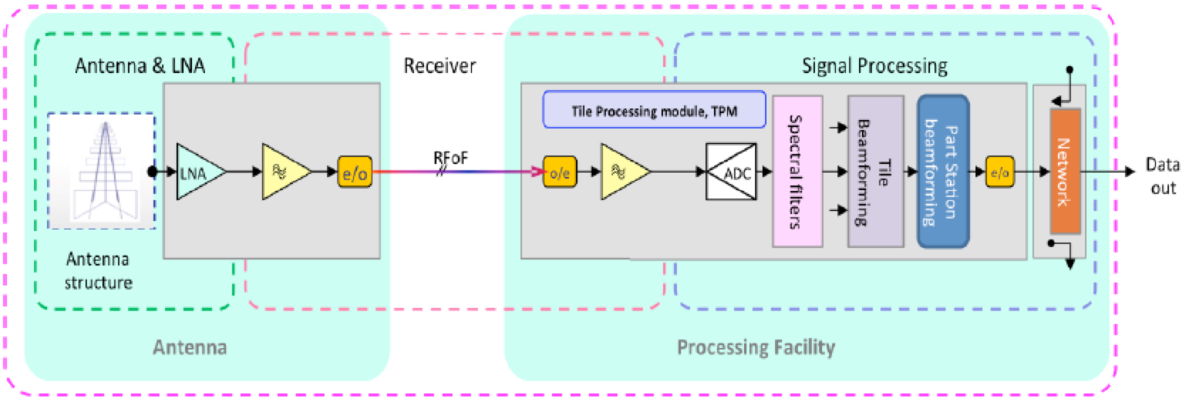
AAVS1 is a product of the Aperture Array Design and Construction and Consortium (AADCC) for SKA-LFAA where INAF has the biggest role leading the WP of Antenna Receivers and pushing effort in the WP of the Signal Processing providing the iTPM (Italian Tile Processing Module).

The iTPM board was the only usable and tested backend ready at the time of AAVS1 deploy.

iTPM is just one of more candidates boards for the SKA LFAA Backend, in this document I will use the word TPM or iTPM meaning exactly the same thing.

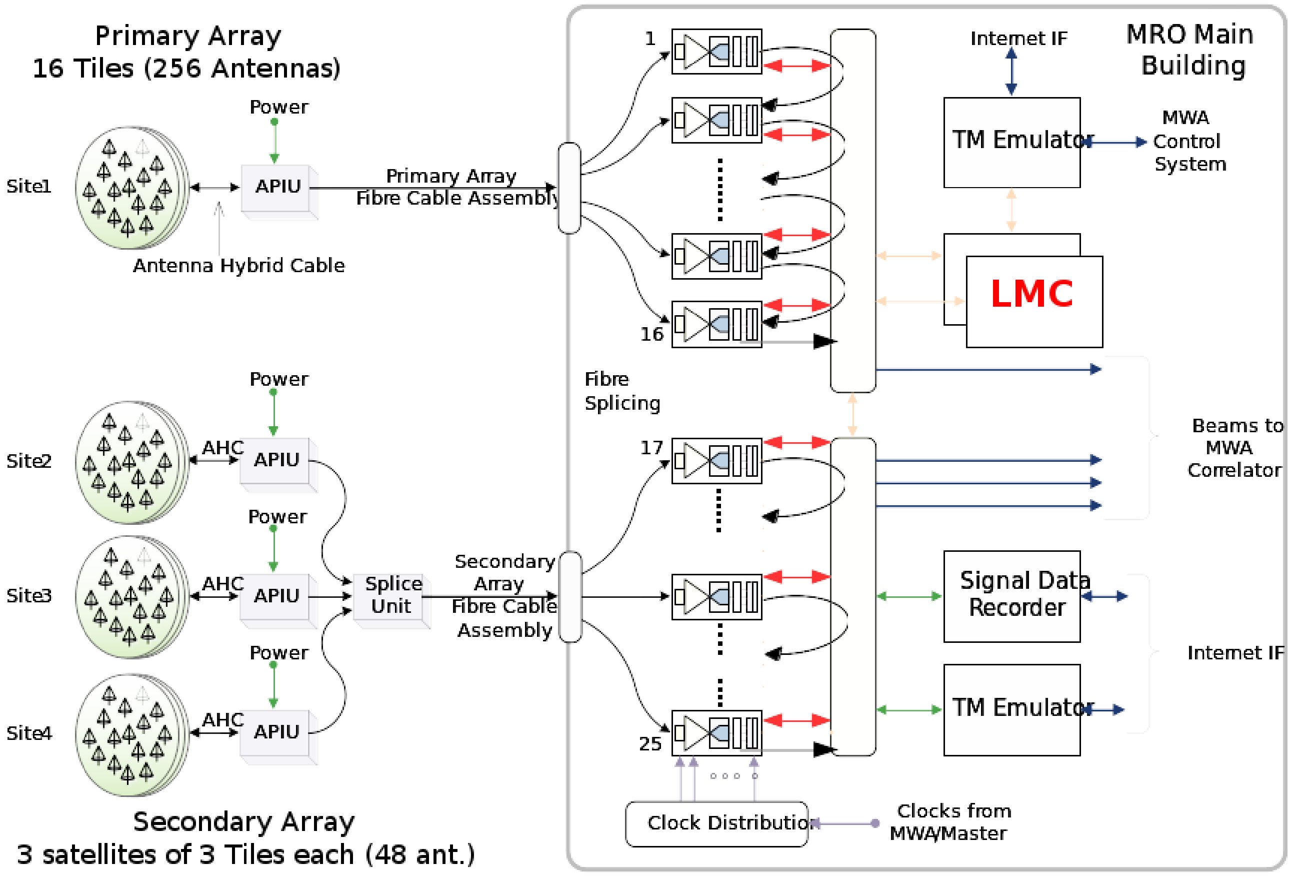
TPM does the signal acquisition and data pre-processing of a station slice of 16 antennas, called *Tile*.

The following picture shows the data acquisition diagram, the big grey group on the right are most of the TPM tasks.



In the processing facility there is a powerful workstation called LMC (Local Monitor and Control) that is responsible for the management of all the TPMs and computes the phase and amplitude coefficients for the antennas calibration with which the TPM can compute a coherent Beam of the Tile.

Each TPM passes the Beam of the Tile to the next TPM that add its contribute (see next picture). The last TPM in the chain output the beam of Station to the Central Signal Processor (CSP).



AAVS1 consists in one big station of 256 dual polarization log periodic antennas (main core), and three smaller satellites of 48 antennas. Since one TPM handles signals of 16 antennas, the AAVS1 Racks host 25 TPMs (and two spare boards).

The AAVS1 Main Station, 256 SKALA2 antennas

In the second mid of 2016, the production of the 25 iTPMs started and we feel the need to manage sets of TPM boards even during lab tests. Since the LMC software was not yet available, we developed our own management software.

The purpose of this document is to describe the AAVS1 Rack Management software.

This software has not been proposed to the community to be the legacy software being GUI based, but some primitives' routines, such the Pre-ADU management, have been provided to the SKA LMC developers to be included in the legacy software.

Software Description

System Requirements

The Rack Management Software is written in Python Language. It is mainly based on the QT4 libraries (required) providing an easy widget implementation.

The software is platform independent being Python a runtime interpreter. We have used it both on Microsoft Windows 7 computers and Linux Ubuntu 14.04 machine.

The software is compatible with Python 2.7, and requires the following libraries: Standard Python Libraries:

os, sys, struct, math, datetime, time, subprocess

Additional required Libraries:

PyQt4, xml, numpy, matplotlib, netifaces, glob.

The additional libraries can be installed through the package installer Python PIP (setuptools):

Software Structure

The Software wants to manage at least one SubRack at time, and talk to at least one TPM of a SubRack. The functions have been split in several files according to the following scalable scheme.

There is a main widget called *SKA-TPM* that instantiates a SubRack object (fig 3.1). A SubRack object is a set of TPM instances. The SubRack creation requires an XML file descriptor containing few information such how many TPMs are contained in the SubRack.

Each TPM is an object the TPM Class (fig 3.2). The file descriptor contains the TPM IP address, the TCP Port for the communication, the socket timeout for read/write operation, the position of the TPM inside the SubRack and the ADU and Pre-ADU board serial numbers.

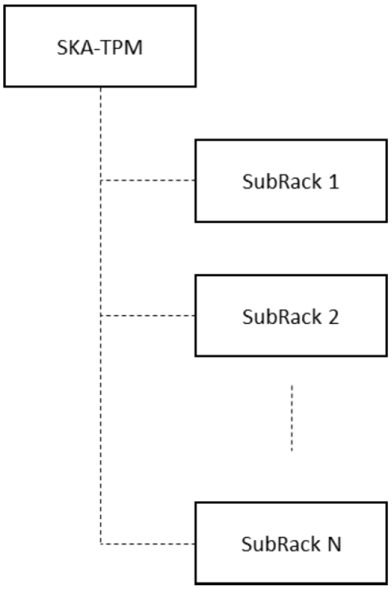


Fig 3.1

For each TPM object, you can instantiate a PRE-ADU object of the class PRE-ADU (fig 3.3), with which you can access to the configuration of the 16 dual pol receivers.

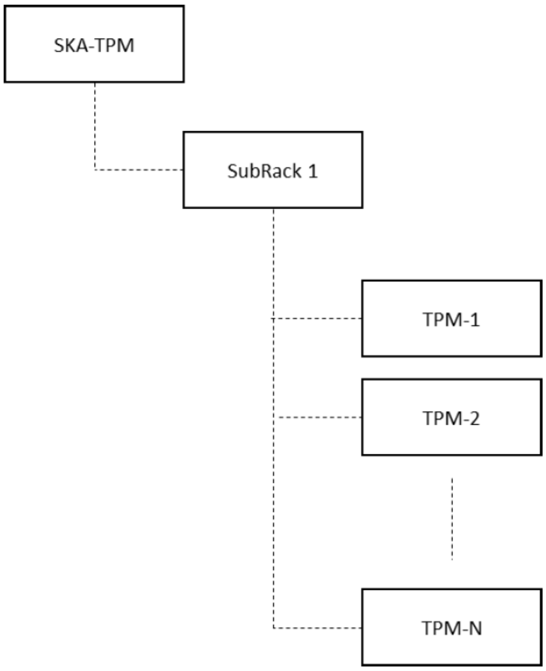


Fig 3.2

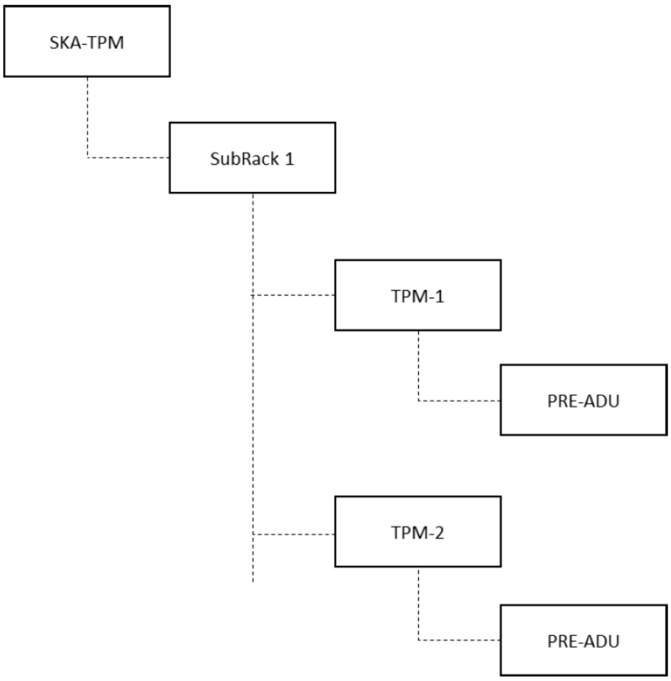


Fig 3.3

The GUI is a state machine always idle. When a button is pressed the connected function runs until the execution of the routine end, and the software goes idle again. There are some no blocking threads running in parallel that can be enabled and disabled by the user.

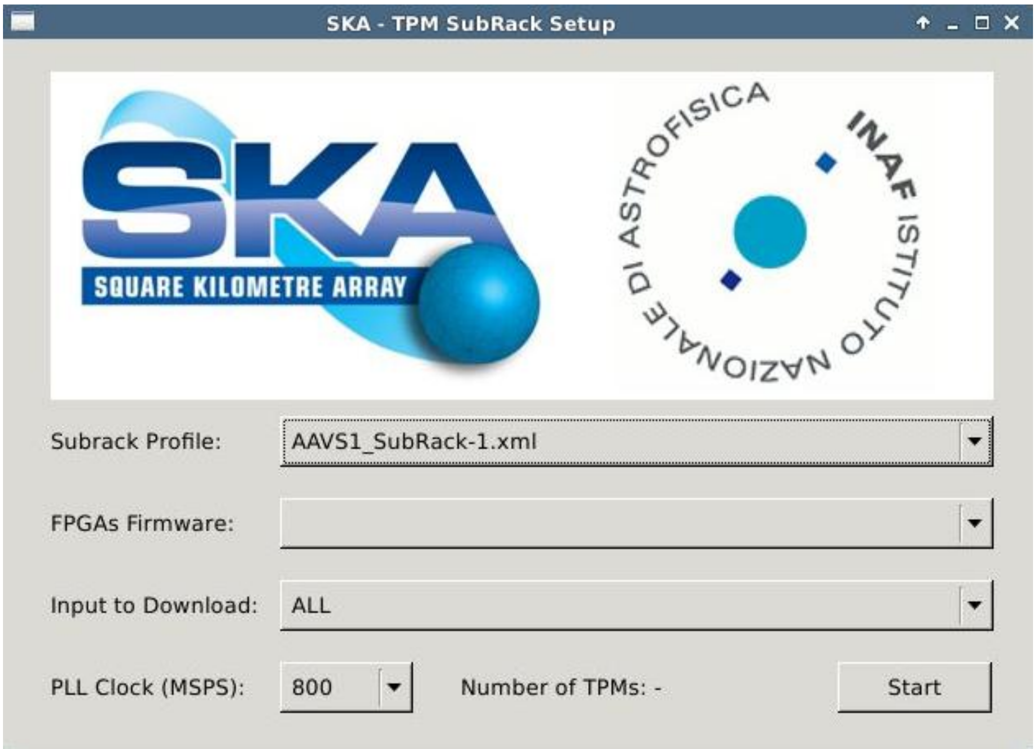
User Manual

Main Application

The main widget allows to select one of the AAVS1 SubRacks.

You can start the application with the command:

```
mattana@aavs-lmc:~/SKA-AAVS1/tools/pyska$ python ska_tpm.py
```



SKA - TPM SubRack Setup

Subrack Profile: AAVS1_SubRack-1.xml

FPGAs Firmware:

Input to Download: ALL

PLL Clock (MSPS): 800

Number of TPMs: -

This application was intended to be also used to download FPGA Firmware and to configure TPMs, but this function has been intentionally disabled to avoid accident on changing operating modes to different TPMs while they were operative.

SubRack Profile comboBox shows a list of SubRack profile. You can select one of them to connect to a SubRack. You can connect to multiple SubRacks once at time.

There is an xml file descriptor for each SubRack containing information of what is available on that.

Here an example:

```
<?xml version="1.0" encoding="ISO-8859-15"?>

<project name='SKA-LAB'> <!-- First entry -->
       <iTPM id='0'>
        <subrack_position>0</subrack_position>
             <serial>5041602005</serial>
             <ipaddr>10.0.10.1</ipaddr>
             <macaddr>d8-80-39-92-6b-b0</macaddr>
             <udpport>10000</udpport>
        <udptimeout>1</udptimeout>
             <preadu_l>06/041-048</preadu_l>
             <preadu_r>07/049-056</preadu_r>
       </iTPM>
       <iTPM id='1'>
        <subrack_position>1</subrack_position>
             <serial>5041602027</serial>
             <ipaddr>10.0.10.2</ipaddr>
             <macaddr>d8:80:39:92:5a:90</macaddr>
             <udpport>10000</udpport>
        <udptimeout>1</udptimeout>
             <preadu_l>08/057-064</preadu_l>
             <preadu_r>09/065-072</preadu_r>
       </iTPM>
       <iTPM id='2'>
        <subrack_position>2</subrack_position>
             <serial>5041602010</serial>
             <ipaddr>10.0.10.3</ipaddr>
             <macaddr>d8-80-39-92-57-a8</macaddr>
             <udpport>10000</udpport>
        <udptimeout>1</udptimeout>
             <preadu_l>10/073-080</preadu_l>
             <preadu_r>11/081-088</preadu_r>
       </iTPM>
       <iTPM id='3'>
        <subrack_position>3</subrack_position>
             <serial>5041602002</serial>
             <ipaddr>10.0.10.4</ipaddr>
             <macaddr>d8:80:39:92:31:2e</macaddr>
             <udpport>10000</udpport>
        <udptimeout>1</udptimeout>
             <preadu_l>12/089-096</preadu_l>
             <preadu_r>13/097-104</preadu_r>
       </iTPM>
</project>
```

As you can see above the SubRack file descriptor contains:

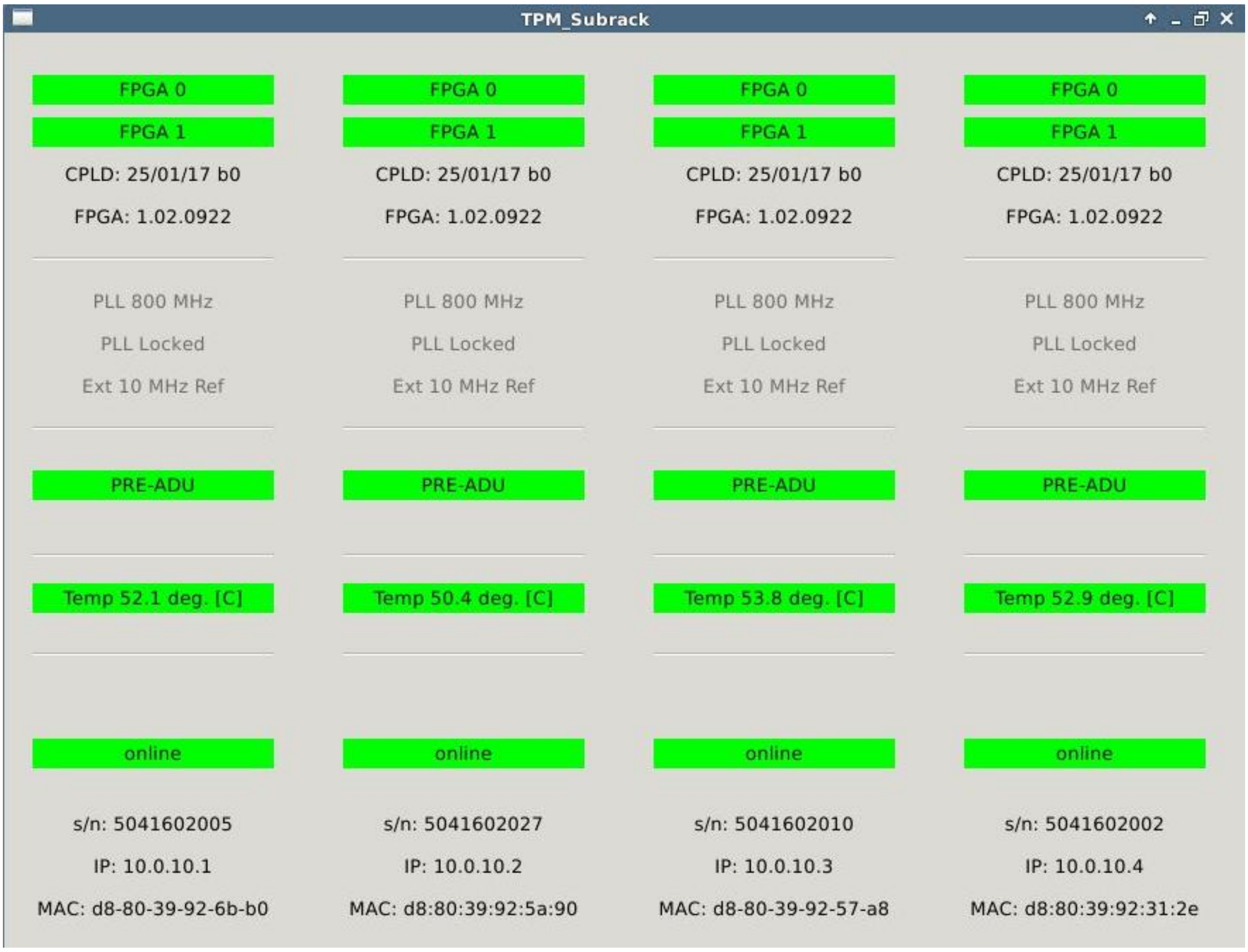
1. A project name strings, might be useful to know where the SubRacks is connected (i.e. SKA-AVS1)
2. Within the Project Level there are the TPMs having this meta data:
    a. The position within the SubRack
    b. The TPM-ADU Serial Number
    c. The IP address for TPM management, including UDP port and connection timeout
    d. The MAC address (useful also to crosscheck if a board has been replaced)
    e. Pre-ADUs serial numbers (left and right boards)

You can connect to TPMs of a SubRack by selecting one profile and clicking to the button “Start”.

TPM Configuration

The creation of this window depends on the content of the SubRack profile file.

The TPM version 1.2 is designed to be 6U x 21hp size, which means that a SubRack (19 inches standard rack form) can hosts four TPMs. Since the file descriptor is just a logical association between a SubRack and TPMs in principle you can have also more than four TPMS.



FPGA 0	FPGA 0	FPGA 0	FPGA 0
FPGA 1	FPGA 1	FPGA 1	FPGA 1
CPLD: 25/01/17 b0	CPLD: 25/01/17 b0	CPLD: 25/01/17 b0	CPLD: 25/01/17 b0
FPGA: 1.02.0922	FPGA: 1.02.0922	FPGA: 1.02.0922	FPGA: 1.02.0922
PLL 800 MHz	PLL 800 MHz	PLL 800 MHz	PLL 800 MHz
PLL Locked	PLL Locked	PLL Locked	PLL Locked
Ext 10 MHz Ref	Ext 10 MHz Ref	Ext 10 MHz Ref	Ext 10 MHz Ref
PRE-ADU	PRE-ADU	PRE-ADU	PRE-ADU
Temp 52.1 deg. [C]	Temp 50.4 deg. [C]	Temp 53.8 deg. [C]	Temp 52.9 deg. [C]
online	online	online	online
s/n: 5041602005	s/n: 5041602027	s/n: 5041602010	s/n: 5041602002
IP: 10.0.10.1	IP: 10.0.10.2	IP: 10.0.10.3	IP: 10.0.10.4
MAC: d8-80-39-92-6b-b0	MAC: d8:80:39:92:5a:90	MAC: d8-80-39-92-57-a8	MAC: d8:80:39:92:31:2e

The above window is the widget generated for the previous file descriptor example.

When created it opens a connection to all the TPMs. Each column of the widget represents a TPM.

There is a main thread reading in polling every 10 seconds the status of each TPM. the result is reported on the text labels, and, when makes sense, the text label changes the background color as conditional formatting.

From the top of the window there are:

- The status of the two FPGAs. Green means programmed, Red not programmed;
- CPLD firmware version;

- FPGA firmware version, left empty if FPGAs are not programmed;
- ADC Sample Rate as PLL configuration;
- PLL lock status (Locked/Unlocked);
- PLL Reference source (External 10 MHz signal/Internal 10 MHz VCXO);
- PRE-ADUs status, Green means powered on, Red means powered off;
- TPM board temperature (Celsius degrees) measured from a sensor placed in the center of the ADU board (between the two FPGAs and the ADCs). If the values is below 60 °C, background color is green, if between 60 and 65 is yellow colored (soft limit), Red for higher temperatures;
- Connection status (online/offline). When offline is not possible to access to all the previous information and they look disabled (grey and some transparency);
- TPM Serial Number, IP address, MAC address as written in the SubRack profile XML file. If MAC address does not match with the UDP Packet content the MAC text label background color changes to yellow to inform that that board is changed and the database needs to be updated.

This last feature is important for the actual status of the project where the serial numbers are not hardcoded in the CPLD firmware.

You can access to the PRE-ADUs configuration by clicking over the PRE-ADU text label. If powered on a new window will be opened.

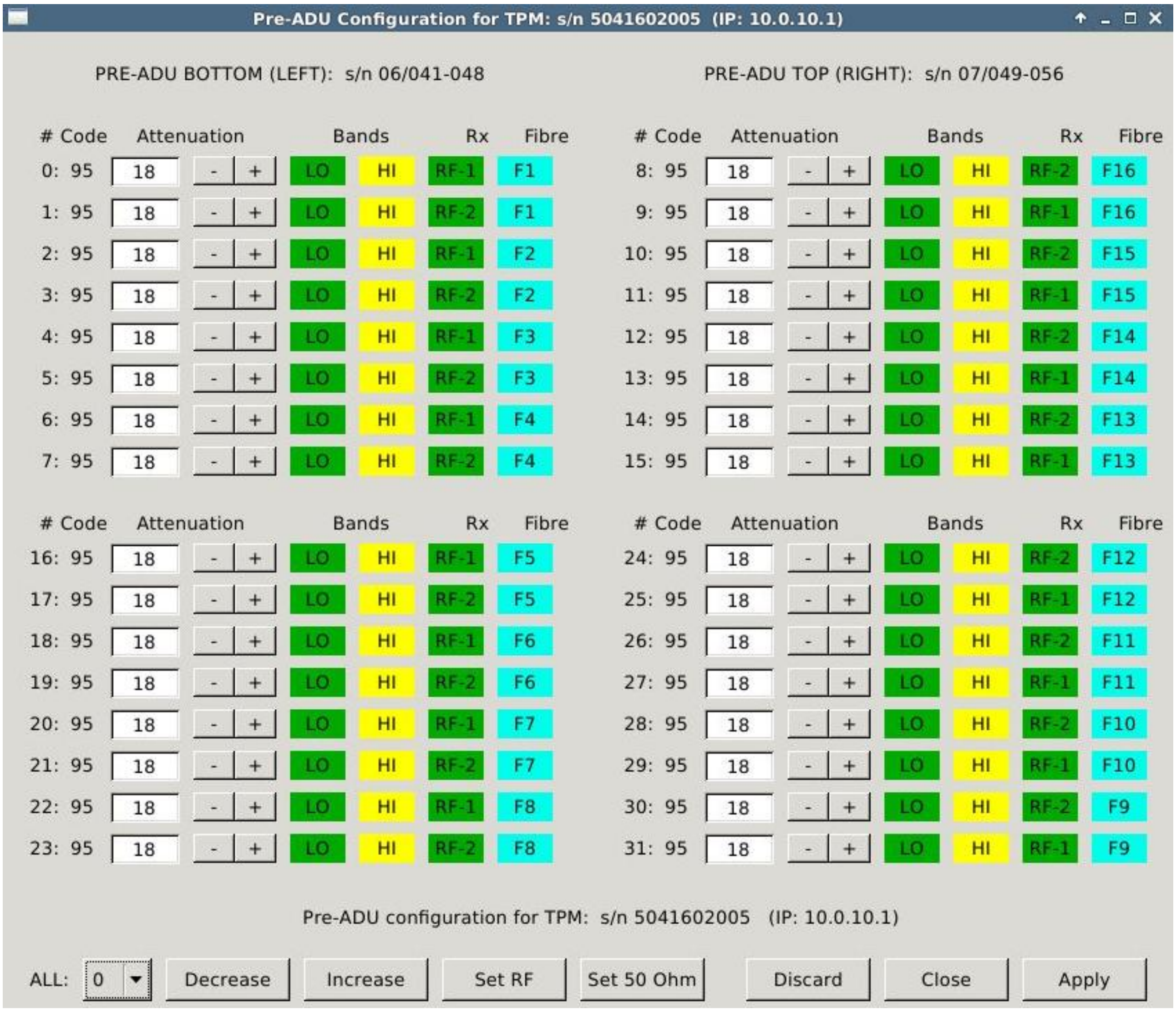
Receivers Configuration

The TPM is equipped with two PRE-ADU boards. There are two SPI links connecting the TPM CPLD and the PRE-ADU registers to set the configuration. Programmable DC-DC converters onboard of TPM-ADU provide the supply of the PRE-ADU boards.

Each PRE-ADU has eight optical receivers. The optical modules use the WDM technologies (wavelength multiplexing) to transmit more than one optical signal on the same fiber. These modules manage two wavelengths, 1270 nm and 1330 nm, and they are used to transmit the two polarization of one antenna.

Therefore, each PRE-ADU manage 16 input channels coming from 8 antennas. One TPM is able to acquire 32 input signals of 16 antennas. “Tile” is the name of a group of 16 antennas.

Depending of the prospective you can call PRE-ADU Left and Right (looking to a TPM in a SubRack) or PRE-ADU Top and Bottom (referring to the PCB surface of the TPM-ADU where Top is the side with the ADCs and FPGAs).



Pre-ADU Configuration for TPM: s/n 5041602005 (IP: 10.0.10.1)

PRE-ADU BOTTOM (LEFT): s/n 06/041-048

# Code	Attenuation		Bands		Rx	Fibre
0: 95	18	- +	LO	HI	RF-1	F1
1: 95	18	- +	LO	HI	RF-2	F1
2: 95	18	- +	LO	HI	RF-1	F2
3: 95	18	- +	LO	HI	RF-2	F2
4: 95	18	- +	LO	HI	RF-1	F3
5: 95	18	- +	LO	HI	RF-2	F3
6: 95	18	- +	LO	HI	RF-1	F4
7: 95	18	- +	LO	HI	RF-2	F4

# Code	Attenuation		Bands		Rx	Fibre
16: 95	18	- +	LO	HI	RF-1	F5
17: 95	18	- +	LO	HI	RF-2	F5
18: 95	18	- +	LO	HI	RF-1	F6
19: 95	18	- +	LO	HI	RF-2	F6
20: 95	18	- +	LO	HI	RF-1	F7
21: 95	18	- +	LO	HI	RF-2	F7
22: 95	18	- +	LO	HI	RF-1	F8
23: 95	18	- +	LO	HI	RF-2	F8

PRE-ADU TOP (RIGHT): s/n 07/049-056

# Code	Attenuation		Bands		Rx	Fibre
8: 95	18	- +	LO	HI	RF-2	F16
9: 95	18	- +	LO	HI	RF-1	F16
10: 95	18	- +	LO	HI	RF-2	F15
11: 95	18	- +	LO	HI	RF-1	F15
12: 95	18	- +	LO	HI	RF-2	F14
13: 95	18	- +	LO	HI	RF-1	F14
14: 95	18	- +	LO	HI	RF-2	F13
15: 95	18	- +	LO	HI	RF-1	F13

# Code	Attenuation		Bands		Rx	Fibre
24: 95	18	- +	LO	HI	RF-2	F12
25: 95	18	- +	LO	HI	RF-1	F12
26: 95	18	- +	LO	HI	RF-2	F11
27: 95	18	- +	LO	HI	RF-1	F11
28: 95	18	- +	LO	HI	RF-2	F10
29: 95	18	- +	LO	HI	RF-1	F10
30: 95	18	- +	LO	HI	RF-2	F9
31: 95	18	- +	LO	HI	RF-1	F9

Pre-ADU configuration for TPM: s/n 5041602005 (IP: 10.0.10.1)

ALL: 0

The PRE-ADU window is a collection of 32 receivers object, therefore, 32 instance of the class Receivers. A Receiver class provides function to:

- set the value of the digital step attenuator of the receiver;
- select the band of the filter;
- terminate the signal to a 50 Ohms.

The window is dived per PRE-ADU (lef and right) and group of eight signal since there are 2 connectors (driving 8 signal each) linking a PRE-ADU board to a TPM-ADU board.

Each line is a receiver. From left to Right there are:

- The corresponding TPM-ADU number (it starts from 0 to 31);
- The Hexadecimal code to be sent to the receiver register to set the configuration;
- The digital step attenuator dB value in the range between 0 and 31 (1 dB step);
- Two push buttons to decrease (-) and increase (+) by one dB the attenuation value;
- Two active colored text labels, LO for the 375 MHz Low pass filter, HI for the 375-650 MHz pass band filter. You can set a filter by pushing a text label like for a button. The Green backgrounded is the selected filter, yellow the not used. You can select only one filter at time, the selection affect all the board so whatever you select, all the 32 receivers change the configuration;
- RF Channel. It is a text label reporting the number of the corresponding RF path (that means the wavelength of the optical signal). It is an active label. If green colored the RF input signal is enabled, you can disable the signal by clicking to this label (like a button) to terminate the signal to a 50 Ohm resistance;
- The last label shows the number of the corresponding optical input as seen from the TPM front panel.

While each line is setting a different configuration to receivers, there are buttons to the bottom of the window that applies a changed to all the receivers.

Whenever a change is done, the corresponding SPI hexadecimal code font becomes bold style telling that there is a change between what is shown in the window and the configuration of the board.

You can discard all changes or you can apply all changes to the board by using the buttons.

When a change is applied, the TPM receives the new configuration, writes it to the two SPI lanes.

The software reads again the configuration as crosscheck. If everything went ok, the new hexadecimal SPI code is shown with the regular font style.