

# Test Setup and Software for HIC Testing

This document describes the setting up of the test system for the testing of single HICs in the HIC production sites. The current version of the document is aimed at the pre-production phase, in particular the description of the software will evolve in the coming weeks.

## 1. Components

The following section describes the main component of the test system.

## 1.1 Crate

The crate is a 6U crate to house the power boards and up to 3 MOSAIC boards. The crate can be rack mounted or sitting on the desk top. The fan unit can be mounted either on top or on the bottom of the crate (in that case turn around the fan unit to have the air blowing into the crate).

The MOSAIC boards are to be inserted in the left section with the back plane, which provides power to the MOSAIC. The right part without back plane is for the power boards. Connected to the back plane you find three cables, which are to supply power to the MOSAIC. The pin assignment is: RED +5V, BLACK GND, BLUE -12V. The -12V are not necessary for standard operation, **but needed for tests of the DCNTRL line**. The +5V can be provided with a benchtop power supply. Consider a current of 2.5 A per MOSAIC on the +5 V channel and 200 mA per MOSAIC on the -12 V channel. If the crate is equipped with more than one MOSAIC, check the voltage at the backplane during operation; **if the voltage drop is to high (>100 mV) add sense lines to the +5V channel**.

In some crates, there are no card rails in the positions for the power board. However, in the MOSAIC section there are rails also in positions where not needed. You can carefully remove them and place them in the right part of the crate for the power board

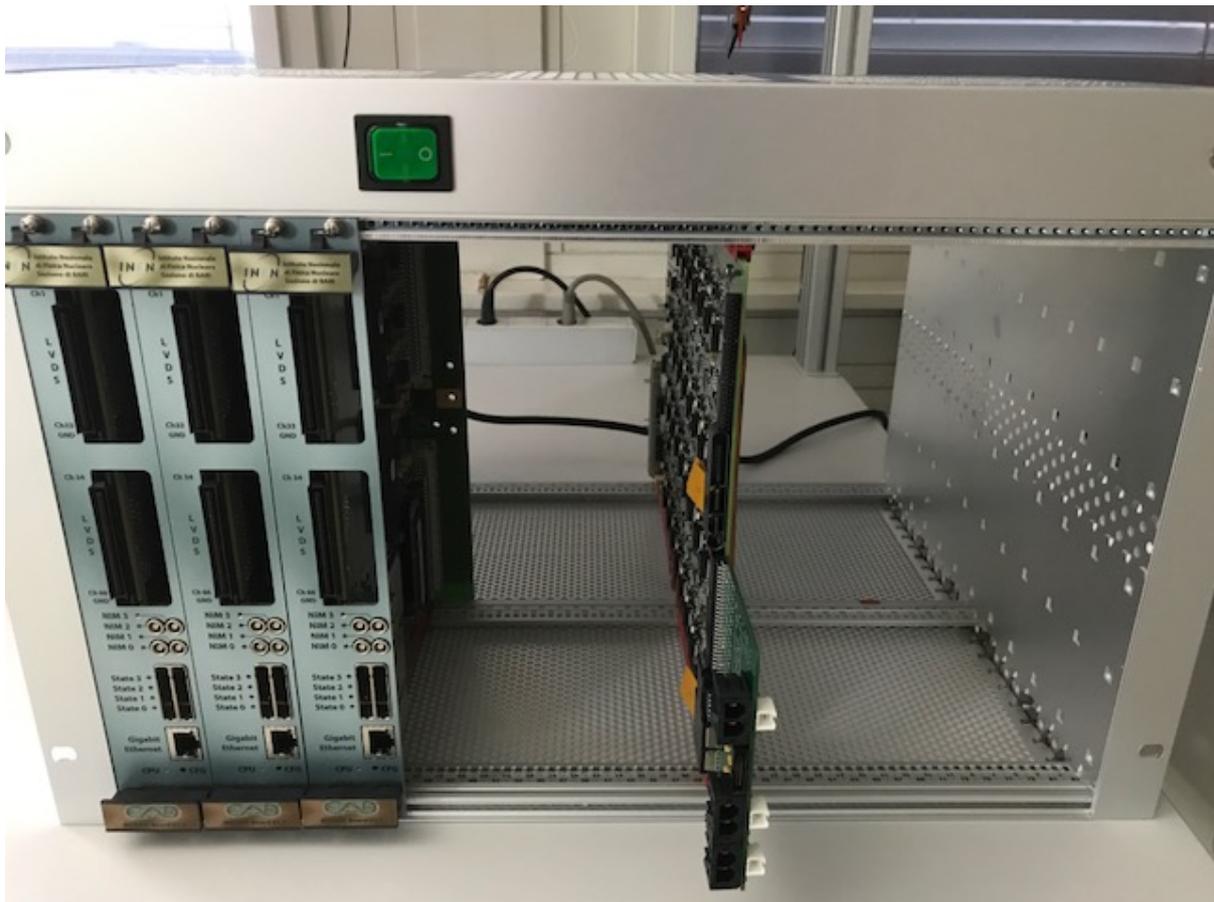


Figure 1: Crate with 3 MOSAIC boards (left) and 1 power board

## 1.2 Power Board

Connect the power board following the instructions in the power board manual.

[https://twiki.cern.ch/twiki/pub/ALICE/Documentation/2017\\_07\\_14 ITS\\_power\\_system\\_V1\\_1\\_32-channel\\_operation\\_manual.pdf](https://twiki.cern.ch/twiki/pub/ALICE/Documentation/2017_07_14 ITS_power_system_V1_1_32-channel_operation_manual.pdf)

The power is to be provided through the breakout board, therefore please follow the instructions in section 7.1.1 in the power board manual.

The power board is controlled through the MOSAIC. A connection therefore has to be made between the mezzanine of the MOSAIC board to the connector on the power board, as described in the power board manual. Figure 2 shows a stack of MOSAIC card with the control connection to the power board in the central MOSAIC. Note that the mezzanine has to be mounted in the slot close to the LEMO connectors.

**For reliable communication between MOSAIC and power board the GND of the power board supply needs to be connected to the GND of the MOSAIC power supply.**

For the connection to the module please see below.



Figure 2: Stack of 3 MOSAIC cards. The additional card in the central MOSAIC is the mezzanine, which is connected to the power board via twisted pair cable.

### 1.3 Test Box

For Qualification and Endurance test the modules are placed in dedicated test boxes, which provide ventilation and protection from ambient light. All connections to the test boxes are made on the rear side, the modules are loaded from the front side: after sliding the HICs with their support plate into the foreseen rails, both the blue Firefly cables and the power cable can be connected. Figure 3 shows both the front view and the rear view of the single HIC box. In February 2018 the drawer with the HIC adaptor has been exchanged in the single HIC box, in order to allow a measurement of the amplitude of the DCTRL signals. Figure 4 shows the back plane of the new box with the pinout of the signals used for the DCTRL measurement. A guide for the substitution of the drawer is available on the testing Twiki.

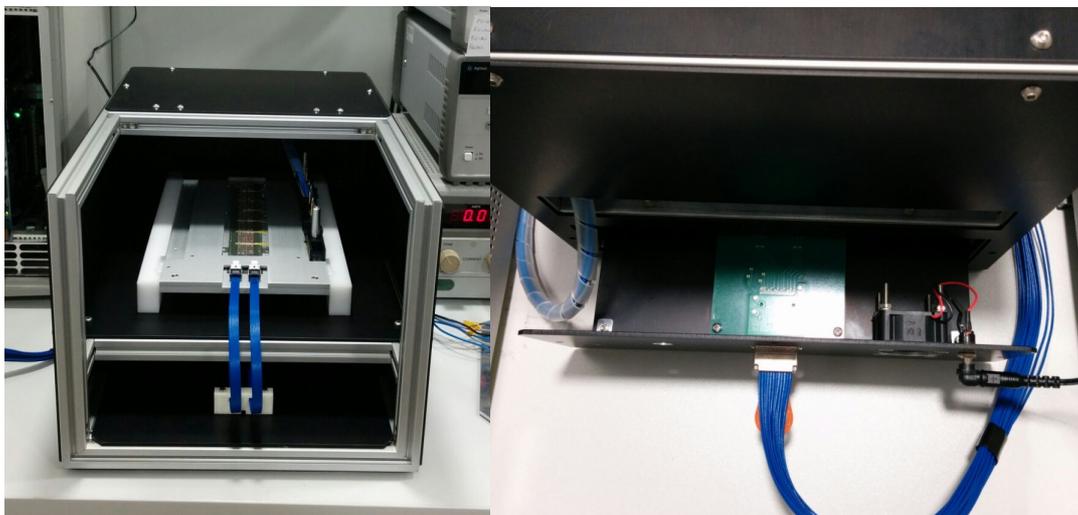


Figure 3: HIC test Box front view (left) and rear view (right). The cabling for the power connection is still missing in this setup. All internal cabling is installed in the delivered boxes, externally the EyeSpeed cable and the power cable have to be connected to the rear side of the boxes, as well as the power supply for the ventilation.



#### Active OB adapter



Figure 4: Rear view of the module box with the new adaptor for the DCTRL measurement (left) and pinout (right)

In case of the endurance test box, the HICs are divided onto two trays, as shown in Figure 5. On the rear side, you find two identical sets of connections for the two trays (Figure 6). The power connection is divided onto two different connectors, one for the first HIC, the other for the remaining four. Note that the top tray has to be connected to the MOSAIC and power board which are indexed with \_0



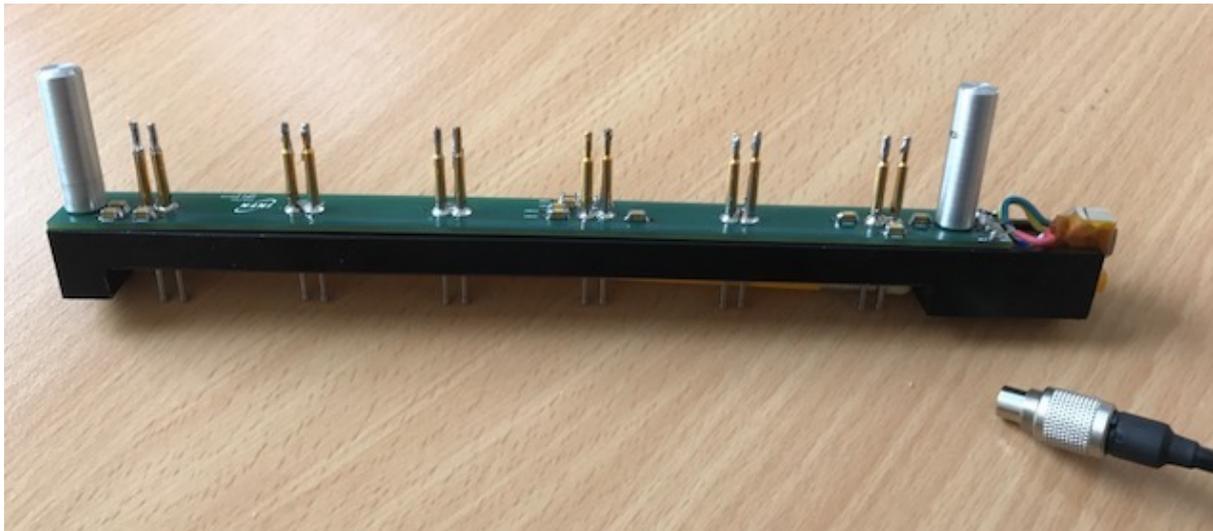
Figure 5: Front view of the endurance test box



Figure 6: Rear view of the endurance test box

### 1.3 Power Adaptors

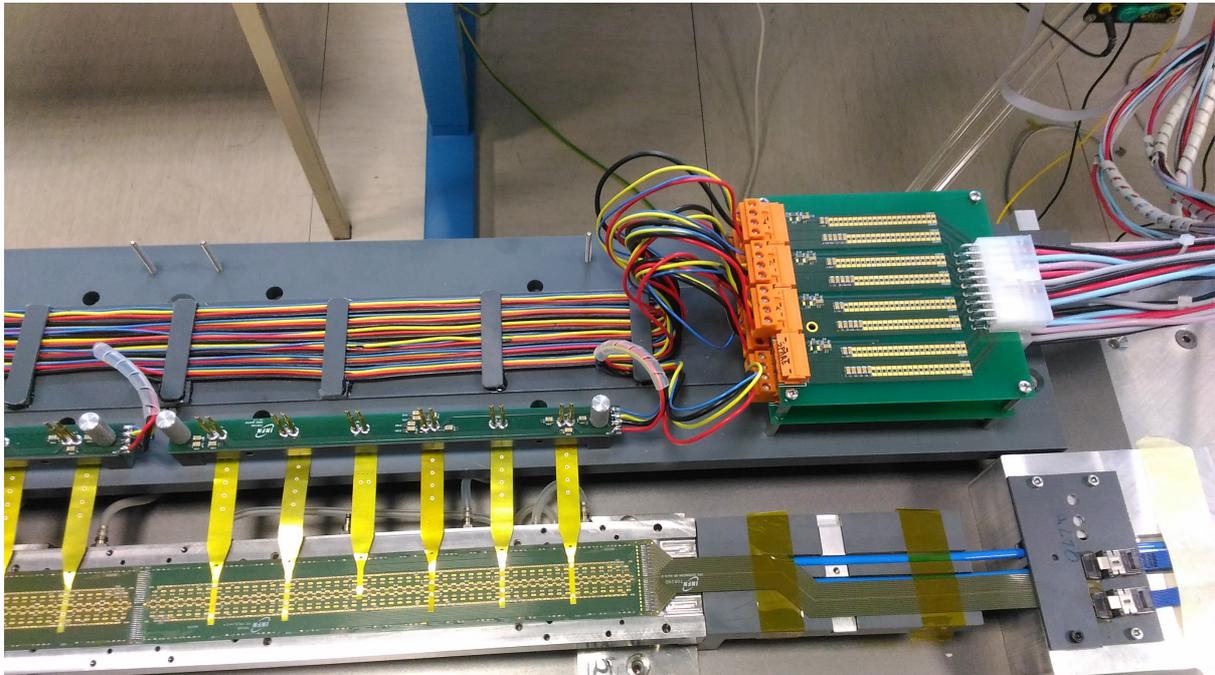
In all tests, except the full stave test, power is provided through spring-loaded power adaptors (Figure 2), which are connected reversibly to the cross-cables of the HICs. When screw tightening the power adaptors to the ground plate, **please make sure to avoid any lateral movements in order to not damage the cross-cables and their connection to the FPC.** Figure 11 shows the voltages connected to the different pins of the power adaptors.



*Figure 7: Power adaptor with cable. In the test system the cable is installed inside the box and is connected to the power adaptor after the HIC with the support plate has been inserted into the test box.*

## 1.4 Half-Stave Powering Bar

In case of the half-stave the power adaptors are mounted on a support bar between the two possible half-stave positions (left and right). The power is distributed to the power adaptors through a wire model of the power bus, which is in turn connected to two simple filter-boards. Each filter board contains connections for four HICs. All components are shown in Figure 8.



*Figure 8: End section of the half-stave test setup. At the top the wire-model of the power bus is connected to the filter boards with the orange connectors. Each connector carries the voltages for one HIC. The cables on the right connect to the power board BOB.*

## 2. Connecting the Setup

### 2.1 Wiring the Single-HIC Box

The 7-pin power connector of the module box has to be connected with a cable to the breakout board of the power board.

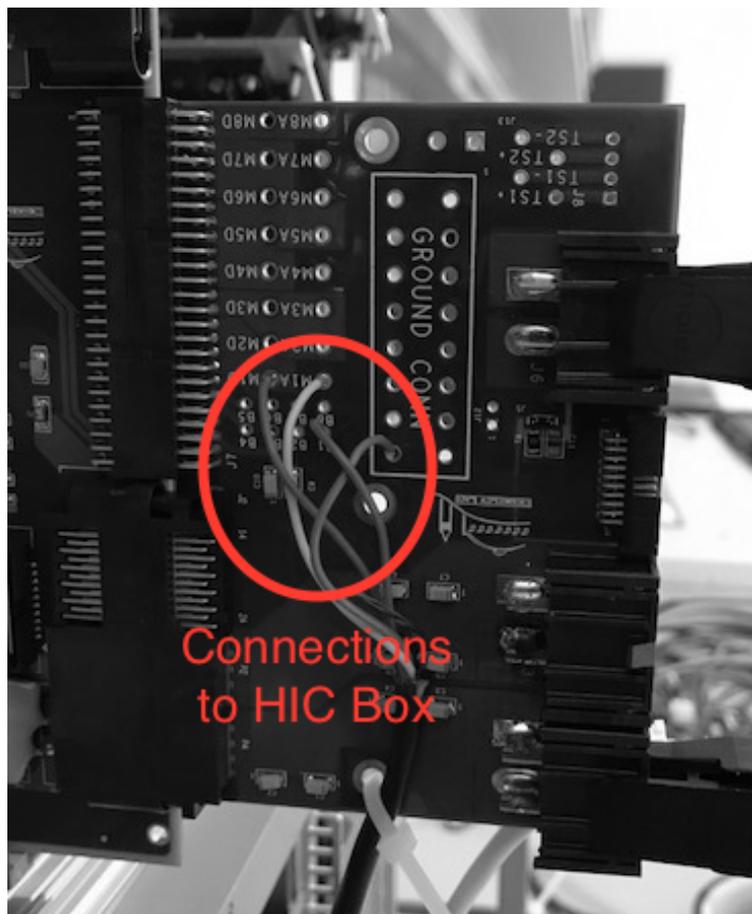


Figure 9: Breakout board of the power board. The wires soldered in the circle at the centre connect to the power adaptor through the 7-pin connector at the rear of the HIC test box

To make the correct connections you need to follow the following procedure:

- 1) Prepare a cable using the connector parts delivered with the module box: To do this crimp a 4 x 1.5 mm<sup>2</sup> (AWG 16) cable or 4 single 1.5 mm<sup>2</sup> wires to the connector. Note that only four of the seven pins are used according to the following scheme (colours refer to the internal wiring of the box and can be ignored here). **The cable should be only as long as needed to connect the box to the power board!**

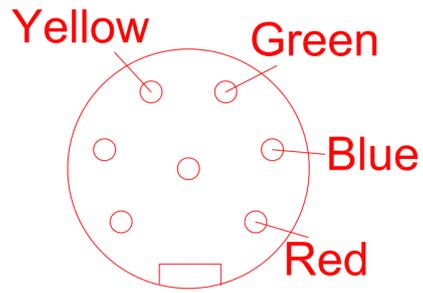


Figure 10: Used pins of the power connector of the HIC test box. *Colours refer to internal wiring and can be ignored here.*

- 2) Connect a power adaptor to the cable inside the module box
- 3) By means of a multimeter find out which lines of the cable prepared under 1) are connected to which pin of the power adaptor and solder them to the breakout board according to the scheme given in Figure 11 and Table 1.

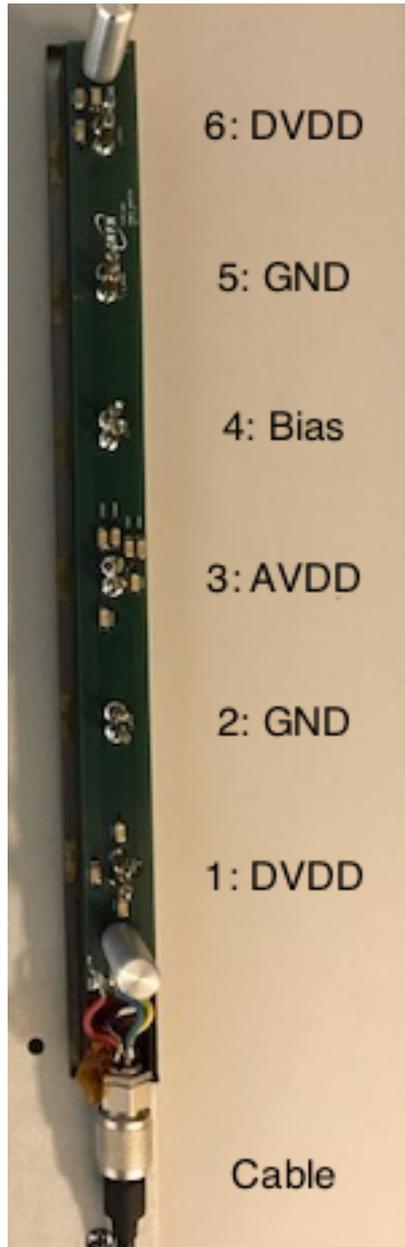


Figure 11: Power adaptor with voltage connected to each pin pair. The connector is at the bottom.

PIN pair on adaptor	Voltage	Connection on breakout board
1	DVDD	M1D
2	GND	GROUND
3	AVDD	M1A
4	Bias	B1
5	GND	GROUND
6	DVDD	M1D

Table 1: Connectivity table between power adaptor and breakout board. The first column is the pin pair on the power adaptor (counting starting from the connector), the second the potential and the last column the corresponding pad on the breakout board.

## 2.2 Wiring the Endurance Test Box

In case of the endurance test box you will receive two sets of power cables with the connectors on the box side attached. The other ends of the cables have to be soldered to the breakout boards of the power board foreseen for the endurance test. The procedure has to be done twice, once for the top 5 modules, once for the bottom 5 modules. Each group of five modules has an identical set of connections on the back of the box; for the power cables each of these groups has to be connected to one breakout board. There is no strict rule, which half has to be connected to which breakout board, **however the corresponding power unit has to be connected to the same MOSAIC that is used for the control of the same 5 modules.**

The pinout of the wires is the following:

- The wires are bundled in groups of 5, each bundle carrying a label HIC1 ... HIC5. The HIC numbers correspond to the channel numbers on the breakout board, e.g. the analogue power of HIC3 has to be connected to M3A on the breakout board.
- The colour scheme is the following:
  - Red: DVDD, to be connected to MXD on the breakout board (X = 1..5)
  - Violet: AVDD, to be connected to MXA on the breakout board
  - Blue: back bias, to be connected to BX on the breakout board
  - Black and Grey: GND, to be connected to any ground pad on the breakout board
- If you cut the wires to length, please make sure to use the same length for all wires, such that the voltage drop is comparable for all HICs.

The connection of the other cables has to be done in the following way:

- Green LVDS cable: the cable has to be connected to the connector on the back side of the endurance test box and to the lower LVDS connector on the MOSAIC board (the same slot where the power board mezzanine is located)
- The Eye speed cable is used to connect the data lines between the box and the MOSAIC board. On the eye speed connectors located at the rear side of the endurance test box you have to use the lower slot.

### **MOSAIC numbering:**

The numbering of the MOSAIC boards in the config file (e.g. for IP address and power board half) is such that the one connected to the top half of the box has the index 0, the one connected to the bottom half the index 1. Violating this rule would still result in a working setup but would mix up the association of test result and HIC ID.

## 2.3 Connecting the half-stave test setup

For the half-stave test setup the power has to be connected through the filter boards to the power board (cf. Figure 8). The different channels on the filter boards are identical, however you have to make sure that the first module on the half-stave is connected to the channels indexed 1 on the power board breakout board, the second to the channels indexed 2 and so on. This means that you are free in connecting the orange connectors to the filter board as long as you connect the cables to the power board BOB accordingly. All 7 (4) bundles have to be soldered to one power board BOB, using the following pinout:

- The wires are bundled in groups of 5, each bundle carrying a label HIC1 ... HIC7. The HIC numbers correspond to the channel numbers on the breakout board, e.g. the analogue power of HIC3 has to be connected to M3A on the breakout board.
- The colour scheme is the following:
  - Red: DVDD, to be connected to MXD on the breakout board ( $X = 1..5$ )
  - Violet: AVDD, to be connected to MXA on the breakout board
  - Blue: back bias, to be connected to BX on the breakout board
  - Black and Grey: GND, to be connected to any ground pad on the breakout board
- If you cut the wires to length, please make sure to use the same length for all wires, such that the voltage drop is comparable for all HICs.

The connection of the Eyespeed cables to the half-stave adapter (Firefly <-> Eyespeed adaptor) has to be done such that the top one connects to the MOSAIC indexed 1 in the config file, the bottom one to the one indexed 0.

Note: in the near future the adaptor between firefly and eyespeed cables will be exchanged with an adaptor that allows a direct measurement of the DCTRL signal amplitude, similar to the one used for the HIC tests. Instructions on the installation of this adaptor will follow as soon as it is available.

## 2.4 Connecting the Dctrl measurement

### Preparations:

To prepare the DCTRL measurement you need to

- Provide the -12V to the crate (i.e. connect all three cables: red +5V, black GND, blue -12V)
- Update the MOSAIC to the latest firmware
- Prepare a power cable to provide +3.3V to the new HIC/HS adaptor; connectors for the power cable are provided together with the new drawer
- The 4<sup>th</sup> LEMO (NIM 3 on the front panel, number 4 on the PCB inside the MOSAIC) has to be configured as an output; for this you need to add a solder bridge as described in the MOSAIC manual (p 5/1-5, fig. 3)

### Connections:

In order to perform the measurement of the DCTRL amplitude you have to connect the oscilloscope to the PC via USB. Furthermore, you have to do the following connections:

Signal HIC	Signal Half-Stage	Oscilloscope Input
MOSAIC NIM 3	MOSAIC NIM 3	Ext. Trigger In
HIC-Adaptor J10	HS-Adaptor J6	Channel 1
HIC-Adaptor J11	HS-Adaptor J7	Channel 2
HIC-Adaptor J15	HS-Adaptor J8	Channel 3
HIC-Adaptor J16	HS-Adaptor J9	Channel 4

Please note that all connections need to be terminated at the oscilloscope with an external 50 Ohm resistor.

Figure 12 shows the connections of the LEMO cables on the oscilloscope and the MOSAIC side.

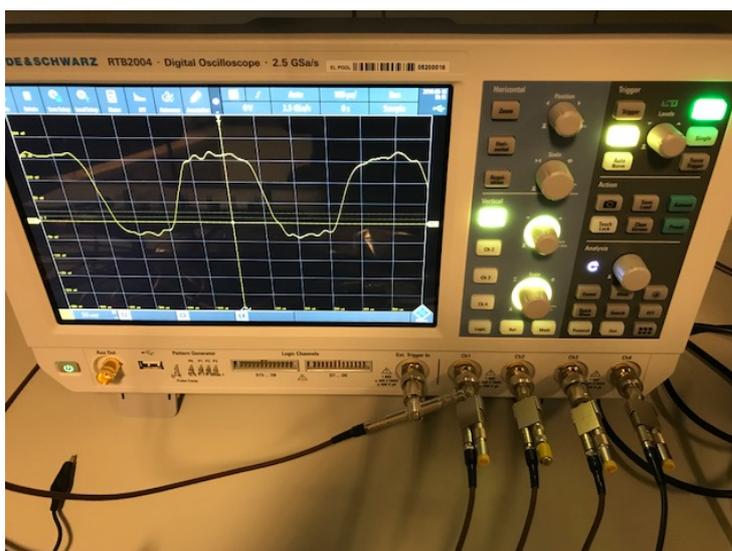


Figure 12: Oscilloscope and MOSAIC connections for DCTRL measurement

### **USB Mode:**

The used oscilloscope has three different USB modes. In order to be detected by the software the mode has to be set to VCP. To do so, go to the menu on the right side of the screen, chose setup -> Interface -> USB -> Parameter and then select USB VCP. If successful, a lsusb command from the command line should show the oscilloscope with the vendorId:productId combination 0aad:013c. For different (not working) USB modes the second ID is different.

### **Access to the USB port:**

Depending on your system / account settings, you might not be allowed to access the serial port through the USB port. This will manifest itself with the error message: IO Exception (13): Permission denied, file serial/src/impl/[unix.cc](#), line 142

In that case you need to update the udev-rules of your PC. To do so you create the rules file with the command `sudoedit /etc/udev/rules.d/50-usb.rules`. In this file you add the line `SUBSYSTEM=="tty", ATTRS{idVendor}=="0aad", ATTRS{idProduct}=="013c", MODE="0666"` and save. After that you either reboot your PC or execute the two commands `udevadm control --reload` and `udevadm trigger`

## 3 Power Board Calibration

Before the power board can be connected to a HIC it needs to be calibrated to correctly take into account board-to-board fluctuations and the properties of the setup.

**Please perform these steps very carefully, as they are prerequisite for the correct voltages on the HICs!**

The calibration required from the user consists in two steps: measuring of the cable resistances and an automatic procedure in the test GUI to calibrate the output voltages and the offset of the current measurement.

### 3.1 Connectivity Check

Before using the power board it is recommended to do a first test if everything is connected correctly. For this the powerboard GUI can be used, which is in the same software repository as the test GUI, but in the subfolder /MosaicSrc/powerboard/GUI. To compile it, execute the same two steps as for the main GUI (qmake-qt5 -makefile; make). Then start it with ./pbGUI. In this GUI you can switch on/off channels and set voltages and check whether they appear on the adaptor pins where you would expect them (cf. Figure 11).

### 3.2 Measurement of cable resistance:

In order to correct for the voltage drop in the cables, their resistance has to be measured.

- Measure the resistance from the contact points on the breakout board to the pins of the power adaptor
- Since the resistance to be measured is small **this has to be done as a 4-point measurement**. (A 0.1 Ohm contribution of the measuring tips and their contact would translate into a ~100 mV error of the voltage on the HIC !)
- Measure separately the resistances of AVDD, DVDD and GND
- In case of the endurance test the measurement has to be done for one HIC only, since all cable lengths inside and outside the box are equal
- The calibration for the half-stave setup is not implemented yet, but the measurement will be from the breakout board to the filter board (exact point to be defined)

### 3.3 Calibration of the output voltage and current measurement

The calibration of the output voltage and the offset of the current measurement is done automatically by the GUI. For this purpose the GUI has a calibration window, where after entering the resistances the automatic calibration procedure can be started. This procedure needs to be executed once for each new setup (or after a setup change).

- **The calibration procedure needs to be executed without load, i.e. with no module attached!**
- After calibration, please check that you have two calibration files (top/bottom) inside the GUI directory, with non-trivial entries for all HICs (1 for the qualification test, 2 x 5 for the endurance test)

### 3.4 Top and Bottom power unit

Each power board has two separate power units with one breakout board each. These are identical except for the internal line resistances. Therefore, even if any of the two can be used, the GUI needs to know which one is used (or which one is used for which half of the setup in case of the endurance test). Differently to previous versions of the GUI, the information of top/bottom has to be set in the config file. For this, a parameter PBBOTTOM has been introduced. The default value is 0, i.e. if the parameter is not given in the config file, the GUI assumes that the top power unit is used; if this is not the case the parameter has to be set to 1. Top and bottom denote the top and bottom halves in “standard” orientation of the crate and the power board, which is with the component side of the power board to the left.

If more than one power unit is used, the parameter PBBOTTOM has to be indexed. The index corresponds to the board index of the connected MOSAIC.

Example:

If the top half of the endurance test box is powered by the bottom power unit the config file needs to have the following two lines

```
PBBOTTOM_0 1
```

```
PBBOTTOM_1 0
```

(Note that MOSAIC\_0 is the one connected to the top half of the box)

### 3.5 Voltage regulation by the GUI

Once the measured resistances have been entered into the GUI and the calibration executed (instructions to follow), the GUI will regulate the voltage such that the voltage on the cross-cables under all conditions is as close to 1.8V as possible. If no calibration is present, the user has the option to continue without. In this case the software will use design parameters for the voltage characteristics and 0 for all offsets and resistances.

## Performing a HIC Test

Once the preparations described in the previous sections are done, the system can be connected to test a HIC:

1. Connect the input power of the MOSAIC board
2. Connect the input power of the power board
3. Connect the mezzanine of the MOSAIC to the corresponding connector of the power board (cf. power board documentation). Make sure the jumpers on the power board are set as described in the documentation of the power board.
4. **Before proceeding make sure MOSAIC and power board are switched off**
5. Connect the MOSAIC and the HIC box with the EyeSpeed cable
6. Connect the power cable that was soldered to the breakout board to the HIC box
7. Screw the power adaptor onto the support plate of the HIC  
**Make sure to not make any lateral movements with the adaptor when the pins are in contact with the cross cables. This would move the cross cables and risk to damage them**
8. Slide the support plate with HIC and power adaptor into the HIC box, *carefully* connect the firefly cables and the power cable
9. Power on the MOSAIC and the power board
10. Start the test (see next section)

## Test Software

The standard way to perform tests on HICs and staves is the GUI distributed with the new-alpide-software. To install the GUI, pull the latest version of the new-alpide-software and follow the instructions in Doc/UserManual.pdf

### **Configuration files to be prepared:**

Before starting a new test with the GUI you need to make sure that the configuration file meets the below requirements.

1. The configuration file always need to placed inside the new-alpide-software/GUI directory.
2. Depending of the test that you are going to perform the configuration file should have a specific name.
  - OB HIC Qualification Test - Config.cfg
  - IB HIC Qualification Test - Configib.cfg
  - OB HIC Endurance Test - Config.cfg
  - OB HIC Reception Test - Config.cfg
  - OB HIC Fast Power Test - ConfigPower.cfg
  - OB HS Qualification Test - Config\_HS.cfg
  - IB HIC DCTRL Test - Configib.cfg
  - ML HS Qualification Test - Config\_HS.cfg
  - IB Stave Qualification Test - Configib.cfg
3. Configuration file parameters

#### **DEVICE**

- OB HIC Qualification Test -DEVICE OBHIC\_PB
- IB HIC Qualification Test - DEVICE IBHIC\_PB
- OB HIC Endurance Test - DEVICE ENDURANCETEST\_PB
- OB HIC Reception Test - DEVICE OBHIC\_PB
- OB HIC Fast Power Test - DEVICE OBHIC\_PB
- OB HS Qualification Test -DEVICE HALFSTAVE\_PB
- IB HIC DCTRL Test - DEVICE IBHIC\_PB
- ML HS Qualification Test - DEVICE HALFSTAVE\_PB
- IB Stave Qualification Test - DEVICE IBHIC\_PB

#### **NMODULES**

- OL HS Qualification Test - NMODULES 7
- ML HS Qualification Test - NMODULES 4

#### **ENHIC\_#**

The below values are the default ones, which means that you can leave them commented inside the configuration file.

- OL HS Qualification Test:
  - ENHIC\_0 1
  - ENHIC\_1 1
  - ENHIC\_2 1
  - ENHIC\_3 1
  - ENHIC\_4 1
  - ENHIC\_5 1

ENHIC\_6 1

- ML HS Qualification Test

ENHIC\_0 1

ENHIC\_1 1

ENHIC\_2 1

ENHIC\_3 1

In case you want to disable a HIC use ENHIC\_# 0

### **ENSIDEA8 1**

### **ENSIDEBO 1**

- In the case of an OL HS Qualification Test or ML HS Qualification Test you want to disable one of the half of the HS you should use ENSIDEA8 0 or ENSIDEBO 0.

### **The operating system has to be CentOS CERN 7.**

1. To perform a test, start the GUI and chose “New Test” from the start menu
2. In the following dialog box enter your name and a HIC ID and chose “OB Qualification Test” from the drop down menu  
(the entries of operator and HIC ID will later be compared to the entries existing in the database. Currently this is not yet the case; however the HIC ID is part of the result filenames, so you should use the real name here)
3. When choosing “OB Qualification test” the GUI instantiates an OB HIC and builds a test program. In the module display you will see an OB HIC with (hopefully) 14 green chips. The colour is the result of a first test on which chip responds on the control interface. If a chip is red, it did not respond and will be excluded from all further tests.
4. Press “start test” to start the test program.
5. The GUI will now perform all tests one after the other and write the results to output files. After a test has been finished a colour code (green – orange – red) will tell the result of the quality cuts of each test.

### **Fallback Solution**

In case of problems with the GUI the HICs can of course still be tested with the standalone programs of the new-alpide-software. However, note that in this case you should use the power board GUI prepared by Giuseppe de Robertis to control the power board. This can be found in the new-alpide-software/MosaicSrc/powerboard/GUI/pbGUI