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Operator's guide to electrical tests

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This document is an operator's guide to performing the electrical tests required in the Quality Assurance procedures in the ATLAS/SCT detector module production.

Introduction

The scope of this document is to describe the set-up and its operation as it is in Uppsala. For further details of the software package SCTDAQ please refer to the documentation available on the web:

http://atlas.web.cern.ch/Atlas/GROUPS/INNER_DETECTOR/SCT/testdaq/testdaq.html.

For more details on the tests performed please consult the Electrical Tests Specification on:

http://hepwww.rl.ac.uk/atlas-sct/documents/Electrical_Tests.htm.

Contents

1. The set-up – generalities

The test set-up for ATLAS/SCT detector modules is situated in room 82121 in the Ångström laboratory. The set-up consists of two PCs, two cold boxes, one Huber cooling/heating system and associated read-out electronics.

The ATLAS-DCS PC is used for several purposes. For example: Interaction to the SCT production database, control of the Huber cooling/heating system, monitoring of the cold box environment, to perform I/V measurements and monitoring of the ambient temperature and humidity. The database interaction is done via a web-interface, and the other services are implemented as LabView applications. The ATLAS-DAQ PC runs ROOT with the software package SCTDAQ. This system controls the read-out electronics necessary to collect data from the detector modules under test. This software package also does the analysis of the data and produces plots and summary files for the operator and for the SCT production database.

The two cold-boxes are used for different purposes and the layout and control of them are therefore different. The smaller box is aimed for hybrid reception test and for hybrid/detector module debugging. It is water-cooled and the flow is regulated via the tap below the panel, next to door to the clean room. The nitrogen flow is regulated at the panel in the north-west corner of the room. The jigs for the small cold-box allow either reception tests of either three hybrids in parallel or debugging of one hybrid or detector module. The large cold-box is cooled or heated by the LabView controlled Huber cooler/heater system. By loading different configuration files with the HuberControl.vi on the ATLAS-DCS PC, the operator can choose a number of different temperature profiles. Similarly as for the small cold-box, the nitrogen flow is controlled via the panel in the north-west corner of the room. The large cold-box can host up to six detector modules in their production frames at once. It is aimed for electrical tests of completed detector modules, temperature cycling, long term tests and the final electrical characterisation of detector modules.

2. Performed measurements

The electrical tests of hybrids and detector modules consist of many sub-tests as described in the Electrical Tests Specification. These sub-tests are grouped together to two sets of measurements performed at several occasions during the module production. One small (and comparatively fast) series of measurements is called the ConfirmationSequence; it checks the integrity and functionality of the hybrid or module. This sequence is run between every major step in the production. The larger set of tests, the CharacterisationSequence, is normally run at the end to give a complete characterisation of the detector module performance. For diagnostic purposes, it is also possible to run this sequence at any intermediate step. In addition to these two sets of measurements, there is the variant Module Long Term Test (ModuleLTT). This is a continuous measurement run during the whole duration of the Long Term Test.

The measurements at the different steps in the production are labelled according to the following:

TABLE 1. Defined test labels

Label	Type*	Comment
HybridReception	Conf	At reception of hybrids from Japan.
PostBonding	Conf	After hybrid-to-baseboard assembly and electrical bonding.
PostTC	Conf	After Thermal Cycling (-25° C to 40° C ten times).
ModLTT	Conf	Data taken during the Module Long Term Test.
PreShipment	Conf	Measurement done before shipment to Bergen or Oslo.
FinalChar	Char	Final Characterisation before shipment to Oxford.

* Conf = ConfirmationSequence
Char = CharacterisationSequence

These are the standard labels on the measurements performed in Uppsala. If for some reason one of these measurements has to be redone, use the standard label followed by a _retest1, retest2 etc. where 1 is the running number of the re-tests. For instance: PostBonding_retest2, for the second re-measurement after the bonding. If necessary it is possible to define other measurement labels, even though this is not recommended since it might cause confusion.

The detector I/V measurement can be done at the PostBonding, PostTC, PreShipment and FinalChar measurements. Initially it will be performed at all these occasions, but will probably be reduced further in to the production.

3. Execution of tests

This gives a step by step instruction of how to perform the required electrical tests on hybrids and detector modules. It describes each step in detail and could be used as a cookbook for testing modules.

3.1 MOUNTING OF HYBRID OR DETECTOR MODULE

To measure a hybrid:

1. Bring the hybrid jig into the clean room.
2. Place the hybrid on the jig, snap on the electrical connector and fasten it with the four clamps.
3. Repeat this procedure for up to three hybrids on the jig.
4. Screw the hybrid jig on the cooling plate in the small test-box.
5. Connect the 50-way cable between the patch cards and the support card.
6. Connect the power cable and the signal cable between the support card and the DAQ crate.

To measure a detector module:

1. Fasten the detector module (in its frame) on to the cooling block in the big test-box.
2. Connect the 50-way cable between the patch card and the support card.
3. Repeat this procedure for up to six modules in the box.
4. Connect the power and signal cables between the support card and the DAQ crate.

3.2 CONTROLLING TEMPERATURE AND HUMIDITY

For the small test-box:

1. The cooling is provided by a cold water flow through the bottom, the sides and the lid of the box. This is turned on and regulated via a tap below the panel next to the door to the clean room.
2. The humidity is controlled by a nitrogen flow. This is regulated from a panel in the north-west corner of the room.
3. Run C:\AtlasProduction\vi\ColdBoxMon.vi on the ATLAS-DCS PC to monitor the temperature and the humidity in the box.
4. Temperature and humidity log files are found in the folder C:\AtlasProduction\vi\logfiles\.
5. Wait for the temperature and humidity to stabilise

For the big test-box:

1. The humidity is controlled by a nitrogen flow. This is regulated from a panel in the north-west corner of the room.
2. The temperature is controlled by the Huber heating/cooling system.
3. Switch on the Huber and the additional heating block in the sound proof cabinet below the box.
4. Start the C:\AtlasProduction\vi\HuberControl.vi on the ATLAS DCS computer.
5. Load the relevant temperature profile for the test to be performed.
6. Start the C:\AtlasProduction\vi\ColdBoxMon.vi to monitor the test environment.
7. Temperature and humidity log files are found in the folder C:\AtlasProduction\vi\logfiles\.
8. Wait for the temperature and humidity to stabilise.

3.3 APPLYING THE HIGH-VOLTAGE

The high voltage is supplied by a Stanford 310 HV supply controlled by a LabView interface. Custom-made supplies will eventually replace this set-up as soon as they are available. At this point, the user instructions only cover the Stanford set-up.

To apply detector bias for electrical measurements:

1. Connect the HV cables for electrical tests according to the posted scheme.
2. Set the switch to bias module 0, module 1 or both in parallel.
3. Start the C:\AtlasProduction\vi\IVMeasurement.vi on the ATLAS DCS computer.
4. Push the button ‘Set Voltage’.

5. Configure target voltage, step size and delay time and set the voltage.
6. To ramp down the voltage, configure zero volts and set the voltage.

3.4 CONFIGURING SCTDAQ

The read-out channels in SCTDAQ are configured via two different types of configuration files. These files reside in the directory D:\sctvar\config and are called st_system_config.dat and <SerialNumber>.det. The first file describes which module that is connected to what read-out channel. The second file gives the configuration of that specific module, which should normally be identical for all modules during production.

An example of the st_system_config.dat:

```
/*
ST Configuration file: example 22.08.2002
=====================================
*/
       DETECTOR LV    HV    SLOG     RSLOG    OPTO_TX           ROPTO_TX  OPTO_RX            MuSTARD         Module
       id pr ac cr ch id ch id ch pg id ch pg typ id ch iset typ id ch  id c0 c1 th0 th1  id s0 s1 d0 d1  Filename
-----------------------------------------------------------------------------------------------------------------
Module   0  1  1  0  0  0  0  0  0  0  0  1  0  -1 -1  1  0    -1  -1  1  -1  0  1 100 100  0  0  1  8 8  20220380200001
Module   1  1  1  0  1  0  1  0  2  0  0  3  0  -1 -1  1  0    -1  -1  1  -1  0  1 100 100  0  2  3  8 8  20220380200002
Module   2  1  1  0  2  0  2  0  4  0  0  5  0  -1 -1  1  0    -1  -1  1  -1  0  1 100 100  0  4  5  8 8  20220380200003
Module   3  1  1  0  3  0  3  0  6  0  0  7  0  -1 -1  1  0    -1  -1  1  -1  0  1 100 100  0  6  7  8 8  20220380200004
Module   4  1  1  0  4  0  4  0  8  0  0  9  0  -1 -1  1  0    -1  -1  1  -1  0  1 100 100  0  8  9  8 8  20220380200005
#Module  5  1  1  0  5  0  5  0 10  0  0 11  0  -1 -1  1  0    -1  -1  1  -1  0  1 100 100  0 10 11  8 8  20220380200006
/*END*/
```

Comments on the entries in the file that are regularly changed by the operator

- The set-up supports up to six modules numbered 0-5 in the DETECTOR/ id column.
- LV/ch gives low voltage channel for that module and is numbered 0-5.
- HV/ch gives low voltage channel for that module and is numbered 0-5. This only applies to a system where the HV is integrated in the SCTDAQ. At present see Section 3.3.
- SLOG/ch gives the channel for clock and commands sent to the module. Should be an even number between 0 and 8. DAQ channel n corresponds to SLOG channel 2*n.
- RSLOG/ch gives the channel for redundant clock and commands sent to the module. Must be n+1 for a module with SLOG channel n.
- MuSTARD/s1 and /s2 are the channels for receiving the data from the module. For every module s1 and s2 must be identical to SLOG/ch and RSLOG/ch.
- Module Filename is the serial number of the module connected to that DAQ channel.

Comments on the entries in the file that are normally not changed by the operator:

- DETECTOR/pr and /ac should be 1 meaning that the module is present and active.
- LV/cr gives low-voltage crate number and should always be 0.

- HV/id gives high-voltage module number and should always be 0.
- SLOG and RSLOG /id and /pg are SLOG-module and page number and should be 0.
- The 11 columns tagged OPTO are for optical readout and can be ignored.
- MuSTARD/id is the MuSTARD-module number and should be 0.
- MuSTARD/d0 and d1 are delays to compensate for different length of the DAQ cables. As long as the cables are the same can be left untouched. Technically speaking, it is a delay that determines the timing with respect to the clock-phase in latching the data read back from the module.

The entry Module Filename defines the name the module connected to that particular read out channel. The specific parameters of the module are given in the file <SerialNumber>.det, where <SerialNumber> is the file name given in st_system_config.dat. This file should be identical for all modules and can be generated by copying the file C:\sctdaq\config\default.det to the directory D:\sctvar\config and renaming it to <SerialNumber>.det. An example of a correct detector module configuration file is given in Section 7.

3.5 PERFORMING THE MEASUREMENT

1. Make sure that the configuration files correspond to the modules connected to the set-up, as described in Section 3.4.
2. Start SCTDAQ via the icon on the desktop.
3. Give your initials as they are registered in the SCTDB.
4. Check that the hybrid power has come on. If it has not, try “LV recovery” from the main menu (can be repeated if it does not work first time, but only up to ten times).
5. Check the hybrid temperature and currents via DCSQuery or DCS->Log.
6. If you have installed new cables, run the “Set Stream Delay” scan. This produces two integer values per hybrid/module (one per link), given as “optimum” in the printout. These values are loaded after the test, but may also be recorded for future use by changing the d0 and d1 values in the st_system_config.dat file.
7. To perform an I/V measurement of the module, switch the LV power off with the LVOff button. Disconnect the cables between the DAQ crate and the support card and connect the 25-pin HV cable directly on the support card. Perform the I/V measurement according to Section 4.
8. If an I/V measurement has been done, re-connect the cables between the support card and the crate. Load the temperature profile corresponding to the measurements to be done and wait for the temperature and humidity to stabilise.
9. The measurements relevant to the QA procedure are found in a menu that appears if the button ABCD Tests is pushed.
10. Start the appropriate test sequence. For a characterisation or confirmation test use a scope to do the hard-reset test. The other tests run without intervention of the operator.
11. Keep an eye on the test while it is running, for program crashes.
12. After the test sequence is completed run the script Archive and Publish via the menu button. This will make back-up copies of the relevant files and create a web page with the results.

NB: Make sure that the C:\sctvar\results\<SerialNumber>_<Date>.txt file is clear from old entries from for instance crashed measurements. If necessary, open and edit the file since all measurements present in this file will be archived and published.

13. When finished, shut down SCTDAQ via the “Exit” menu button. Confirm in the Rint window: type y (usually it gives you an error the first time: click on Exit again and type y again, and the system will shut down). Do not stop root using “.q” as this does not turn off the LV or HV power.
14. When SCTDAQ has exited, check that the LV and HV power lights are all off. If they are not, restart SCTDAQ and immediately “Exit”. This should turn the power off cleanly.

4. Detector I/V measurement

The detector I/V measurement is done with the Stanford/Keithley HV set-up, controlled by a LabView interface run on the ATLAS-DCS computer. The procedure is as follows:

1. Mount the detector module in the Huber cooled test box.
2. Connect the Stanford/Keithley I/V set-up I/V measurements according to the posted scheme. Make sure that the DAQ system is not connected to the module.
3. Start the C:\AtlasProduction\vi\HuberControl.vi on the ATLAS DCS computer to control the environment temperature. Load the temperature profile IVMeasurement.txt.
4. Start the C:\AtlasProduction\vi\ColdBoxMon.vi to monitor the test environment. Temperature and humidity log files are found in the folder C:\AtlasProduction\vi\logfiles\.
5. Start the C:\AtlasProduction\vi\IVMeasurement.vi on the ATLAS DCS computer.
6. Wait until the temperature and humidity has stabilised.
7. Configure the scan 0 to 500 volts in steps of 10 V, 10 seconds rest time at each steps via the LabView interface.
8. Store the data in the on the ATLAS directory (with <Label> given according to the Table 1) as /SQ/<SerialNumber>/IV/<Date>_<Label>_IV.txt.
9. To convert the data to SCTDAQ/SCTDB compatible format, start SCTDAQ and run the macro ProcessIV.cpp. This has to be run in the SCTDAQ environment to have access to the relevant variables.
10. Submit the results to the SCT database (initially local storage).
11. Verify that leakage current corresponds to the sum of the four detector currents, as registered in the SCT database.

5. File management

After each measurement sequence, the relevant files form the sctvar\config, sctvar\data, sctvar\ps and sctvar\results directories will be copied to a back-up repository. For transparency within the Production Cluster and the SCT Collaboration, web pages presenting the results are generated automatically. This is partially taking the role envisaged for the SCTDB, and this procedure might be eliminated when the SCTDB is fully operational. A Perl script, executed from the SCTDAQ interface does the file management and the generation of web pages.

For the Site Qualification modules the data will be backed up in the file structure presented below. Data from the production modules will be stored in a similar structure only with the directory name SQ changed to Production.

W:\SQ\<SerialNumber>\BaseBoard\

W:\SQ\<SerialNumber>\BaseBoard\<BaseBoardSerialNumber>\

Directory containing data from Metrology of the sensor baseboard assembly.

W:\SQ\<SerialNumber>\Electrical\

W:\SQ\<SerialNumber>\Electrical\<Label>\

Directories containing results and postscript from the electrical measurements of the hybrid or module. <Label> is the measurement label as defined in Table 1.

W:\SQ\<SerialNumber>\Electrical\<Label>\data\

Directory containing raw data from the electrical measurements of the hybrid or module. <Label> is the measurement label as defined in Table 1.

W:\SQ\<SerialNumber>\IV\

Directory containing raw data from the I/V measurements.

W:\SQ\<SerialNumber>\Metrology\

Directory containing data from Metrology of the completed module.

W:\SQ\<SerialNumber>\TC\

Directory containing temperature and humidity profiles from the Thermal Cycling of the module.

The file W:\SQ\<SerialNumber>\Components.txt is used for the bookkeeping of components of the module and of the test performed on the module. A similar data structure is defined for the web publication defined in the ATLAS Uppsala web directory.

The results and postscript files for each test and module is stored in:

http://www4.tsl.uu.se/~Atlas/Electrical/<SerialNumber>/<Label>/

The Perl script produces one summary file for each module:

http://www4.tsl.uu.se/~Atlas/Electrical/<SerialNumber>/<SerialNumber>.html

And one file presenting the results from that particular test http://www4.tsl.uu.se/~Atlas/Electrical/<SerialNumber>/<Label>/<SerialNumber>.html

6. Database interaction

The SCTDB in not yet ready with the implementation of the data from the electrical tests of hybrids and detector modules, hence the interface to the database is not yet defined. The procedures to interact with the database will be defined as soon as the implementation is finished.

7. Example of detector module configuration

Here follows an example of the 'standard' configuration of a detector module. This file can be copied and renamed from C:\sctdaq\config\default.det.

```
#
# Default Configuration file for ABCD3T module
#
# P.W.Phillips 18.01.2002
#
# Here is a brief explanation of the variables that have to be set:
#
# First row
#  Required for all modules
#   Link0   enable MUSTARD channel 0 (associated to first hybrid)
#   Link1   enable MUSTARD channel 1 (associated to second hybrid)
#   Oddity  How is the top address line of the chips bonded?
#            -1 - follows SELECT line
#             0 - bonded low => hybrid is even
#             1 - unbonded   => hybrid is odd
#   Chipset 3 = ABCD (not actually used yet)
#   DTM     "Enable Data Taking Mode" - set 1 here!!
#  Extras required for Liverpool Forward Support Card
#   (see http://hep.ph.liv.ac.uk/~ashley/support.html)
#   SCmode  Support Card readout mode (0-3)
#   bpm_dr  DORIC bpm drive current (0-4)
#   vdac0   threshold for data receiver 0 (0-1023)
#   vdac1   threshold for data receiver 1 (0-1023)
#
# Second row
#  Required for all modules
#   Select use primary or redundant clock and control
#   Vdet    detector bias voltage
#   Idet    detector bias current trip limit (remember to allow for charging currents)
#   Vcc
#   Icc     current warning limit (no effect)
#   Vdd
#   Idd     current warning limit (no effect)
#   Vi1     - redundant -
#   iVi1    - redundant -
```

```
#   vled0   (Vvcsel0)
#   Iled0   (Ivcsel0) current warning limit (no effect)
#   vled0   (Vvcsel0)
#   Iled0   (Ivcsel0) current warning limit (no effect)
#   Vpin
#   Ramp    HV ramp rate [1(fast) - 4(slow)] (assumes SCTHV)
#
# One row per chip, preceeded by "Chip n" tag
#  Comp.    Compression mode (0-3)
#  Act.     Is chip active? (must be active to participate in scans)
#  Cal_m    Calibration Mode - select strobed cal line (0-3)
#  T_range  TrimDAC range (0-3)
#  Mask_r   Mask bit - readout contents of mask register (0/1)
#  Edge     Edge Detect bit (0/1)
#  Acc.     Accumulate bit (0/1)
#  Del.     Strobe Delay      (0-63)
#  Vth      Threshold Voltage (0-637.5 mV)
#  Vcal     Calibration level (0-159.375 mV)
#  FEShp.   FE Shaper Current (0-37.2 microA)
#  FEBias   FE Bias Current   (0-285.2 microA)
#  Role     Role of chip:
#             0 - missing
#             1 - dead    (bypass this chip)
#             2 - end
#             3 - master
#             4 - slave
#             5 - lonely  (master + end)
#
#
Module : Link0  Link1  Oddity Chipset DTM SCmode bpm_dr vdac0 vdac1
           1      1      -1      4     1    0      3     512   512
 Select  Vdet  Idet  Vcc  Icc  Vdd  Idd  Vi1  iVi1 Vled0 Iled0 Vled1 Iled1 Vpin Ramp
    0    200.  100.  3.5 1000. 4.0  600.  0.  10.    6.   10.    6.   10.   6.   2

Chip 0 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   38   500. 15. 30.0   220.0    3
Chip 1 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   38   500. 15. 30.0   220.0    4
Chip 2 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   38   500. 15. 30.0   220.0    4
Chip 3 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   38   500. 15. 30.0   220.0    4
Chip 4 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   38   500. 15. 30.0   220.0    4
Chip 5 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   38   500. 15. 30.0   220.0    2
Chip 6 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   40   500. 15. 30.0   220.0    3
Chip 7 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   40   500. 15. 30.0   220.0    4
Chip 8 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   40   500. 15. 30.0   220.0    4
Chip 9 : Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
           1     1    0     0      0     0    0   40   500. 15. 30.0   220.0    4
```

```
Chip 10: Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
          1     1    0     0      0     0    0   40   500. 15. 30.0   220.0     4
Chip 11: Comp. Act. Cal_m Trim_r Mask_r Edge Acc. Del. Vth Vcal FEShp. FEBias Role
          1     1    0     0      0     0    0   40   500. 15. 30.0   220.0     2
#
# optional extensions
#
# list of masked channels, preceeded by tag "Mask"
#
# 1536* TrimDAC settings (integers), preceeded by tag "Trim"
#
```