Electrical testing of Endcap modules at Glasgow

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(Note this is only a first version of the document. It is not finished. Some details are to be added and some will change, especially those regarding cold multi-module testing and the long term testing of modules.)

The main reference for SCT module electrical tests is *"Electrical Tests of SCT hybrids and Modules"* by Peter Phillips and Lars Eklund, available at hepwww.rl.ac.uk/atlas-sct/documents/Electrical_test.html or by following the links from the SCT home page. This document must be read before attempting electrical characterisation of an Endcap module.

The module will be electrical measured several times while at Glasgow. This document should be used for all such tests.

Outline of tests required

Electrical Conformation is a short test to confirm the functionality of an Endcap module and is preformed after reception of the module, prior to wirebonding. After wirebonding and thermal cycling the module is placed in the multi-module testing jig where a conformation test is preformed followed by a long term electrical and detector IV test that utilises the conformation test. The Characterisation sequence performs a full electrical characterisation and is only performed at the end of the long term testing of the module.

Module mounting

Module mounting is only performed in the wirebonding clean room. Care must be taken when handling a module including the maintenance of cleanliness and anti-static precautions. Module mounting is performed on the dissipative mat on the desk in front of the N_2 storage cabinets. The operator must be connected to earth via an anti-static wrist strap.
Valencia test boxes are used for all module electrical tests. The test boxes are fitted with PT1000 temperature sensor, a Honeywell humidity sensor and the AERO patch card. Only used these boxes for electrical tests.

Take an empty module test box from the cabinet in the clean room. Remove the lib taking care to keep all screws to one side. Remove the large nut from the cooling point and the small plastic nut from the far end mounting point.
Take the module in its transport box and its kaptons cables out of the N_2 storage cabinet. Place the module flat on the work surface. Remove the three screws that hold the transport box together. Lift the module by the edges of the transport frame, gripping near each end of the frame. Holding the module horizontal over the test box align the hybrid mounting hole over the mounting pin, taking care that the far-end module-mounting hole is over the far-end mounting pin. Carefully lower the module down onto the mounting points, making sure that the hybrid fits correctly onto the

cooling point. Take the large nut and secure the module. Replace the small plastic nut on the far end mounting point. At this stage check the electrical resistance between the module and the test box is less than 0.5Ohms.
Connect the kaptons to the module, connecting the power tape first. Connect the kaptons to the patch card.
Replace the test box lid. The module is ready for electrical testing.
Take the module and corresponding traveller document out of the bonding room to the electrical test area.
Only ever carry one module at a time.

Module set-up

The module test box must be connected to the electrical readout hardware and to suitable cooling.
Never turn on the module without cooling.
The air-conditioning should always be on – check that this is the case.

Single module testing

For the initial electrical conformation test and any debugging the single module electrical readout stand is required.

Hardware required:

- PC Cobbler
- VME crate with full DAQ minus CLOAC module
- Betta-tech chiller (xxx)
- N_2 Gas line, cold box and DCS, if cold operation is required.

(Hardware situated next to environmental chamber.)

1. Connect the module to the chiller via the quick release valve connections on the module text box. Turn the chiller on and set the temperature to 15^{o}C.
2. Making sure that the VME crate is powered down connect signal and power cables to the module patch card.
3. Turn on the PC and then the VME crate.
4. Run T&M explorer from the desktop icon. You will be prompted to run Resman – do so. Resman must be run whenever the VME crate's power is cycled.
5. Click on the st_system_config desktop icon to open it and edit to include the module to be tested. Use the barcode scanner to scan in the module serial number from the traveller document.
   If this is the first confirmation test a module.det file must be created. Open example.det file (icon on desktop) and save under the correct module name, again using the barcode scanner to enter the module name.
6. Confirm there is no .trim, .mask or .rcdat files in the config directory for the module under test.
7. Run SCTDAQ from the desktop icon.

Multi-module testing

For the long-term electrical conformation test and the final full characterisation the multi-module electrical readout stand is required.

Hardware required:

- PC DORRIS
- VME crate with full DAQ
- Betta-tech chiller (xxx)
- Freezer
- N_2 gas line
- Multi-module test box rig
- DCS

These tests will normally be performed with 6 modules at once.

1. Place each module test box in to the multi-module test rig taking care to make sure that you know the order of the modules, the first being the module on the far right. Place the test rig into the freezer.
2. Check freezer and module nitrogen flow meters are closed. Confirm the chiller is switched off.
3. Connect the test box coolant inlet and outlet pipes, via quick release valve connectors, and the N_2 gas pipes to the test rig back panel. It is not possible to connect the coolant lines to the N_2 gas line.
4. Confirm the connection of the test rig back panel coolant and N_2 lines to the patch panel in the freezer.
5. Connect the DCS cables from each test box to the freezers DCS patch panel.
6. Making sure that the VME crate is powered down connect signal and power cables to each module patch card.
7. Turn on DCS power supplies if off. Run DCS on the DCS PC.
8. Switch in the coolant circuits of the freezer and the module test boxes.
9. Turn on the chiller and set the temperature to 15^{o}C.
10. Close and lock freezer.
11. Monitor DCS to confirm that all test boxes and environment temperature and humidity sensors are present.
12. Set freezer flow to 20 l/min and module flow to 0.5 l/min.
13. Purge system until the freezer dew point falls below -20^{o}C. This takes approximately 1 hour.
14. Turn on modules:
    - Turn on the PC and then the VME crate. Check that the power lights are on for each LV-3 card. If these do not come on cycle the crate power.
    - Run T&M explorer from the desktop icon. You will be prompted to run resman – do so. Resman must be run whenever the VME crate's power is cycled.
    - Click on the st_system_config desktop icon to open it and edit to include the modules to be tested. Use the barcode scanner to scan in the serial numbers from the traveller documents. Make sure that the module serial numbers are entered in the correct order.
    - Copy the correct module.det files from Cobbler. As the modules will have been tested before there is no need to edit the module.det files.

- What to do about .mask, .trim and .rcdat files? – need to find out
- Run SCTDAQ from the desktop icon.
- Run SCTDAQ and turn on the module(s) LV and HV (this is described in the "Running a conformation, characterisation or long-term test on modules" section point 1 to 5). If the modules temperature is allowed to go below 0^oC without being powered it is difficult to turn on and will probably need to be warmed up again.

15. Confirm all test box dew points are below -20^oC.
16. Confirm freezer and module chiller circuits are open.
17. Set chiller temperature to -10^oC.
18. When the module thermistor, as read by SCTDAQ, has reached 10^oC testing may begin.
19. During all tests monitor dew point of module text boxes and freezer.

Running a conformation, characterisation or long-term test on modules

These instructions should be followed once the module(s) have been installed in the test system and are cooled and powered.

1. Start SCTDAQ by clicking on the desktop icon. Root will run first then ST.cpp. Type your initials (as they appear in the database) at the prompt, and "01" when asked to verify them. (or "00" if you typed them incorrectly.
2. SCTDAQ will now start. Two more windows will appear, to make three in total:
   - Rint: a text message and command window. You use this for answering questions (as done above for your initials).
   - Burst Display window: a graphical display of the hit-pattern obtained from the module(s) under test. The window title contains the current run number.
   - Root interface menu: a menu system to allow push bottom operation of the SCTDAQ system. This is the main interface to the test system
3. Check that the hybrid power (one SCT LV light for each hybrid just above the connector) has come on. If the light has not come on hit "LV recovery" on the root interface menu. This tried to recover power ten times and can take a few minutes to complete. If the light does not come one refer to the problem shooting section at the end of this document.
4. Bias up the detector by clicking on HV ramp up. (more here)
5. Check the hybrid temperature and currents, found on the right hand side of the burst display window, and note in the logbook.
   The values should be: Vcc = 3.5V
   Vdd = 4.0V
   Icc ≈ 950mA
   Idd ≈ 500mA
   Idet ≈ 0.5-1μA
   T1 ≈ 24-30^oC for room temperature tests or
   T1 ≈ 10±5^oC for cold tests

If the currents or temperatures are anomalous there is a problem, refer to the problem shooting section at the end of this document

6. To bring up the production test menu click on “ABCD tests” on the main root interface menu
7. If you have installed new cables you should run the “Set Strobe Delay” scan by click If you have installed new cables, you should run the “Set Stream Delay” scan by clicking on the ABCD test menu button. This corrects for small differences in cable lengths. It produces two integer values per hybrid (one per link), given as “optimum” in the printout. These values are loaded after the test, but can also be recorded for future use (if the cables will not be changed again immediately!) by changing the d0 and d1 values in the st_system_config.det file.
8. Before starting the sequence of tests, **make a note** of what the run number and “first scan” of the sequence will be: the run number is given in the title of the Burst Display window. The first scan is 1 if you just started SCTDAQ and did not run the stream delay scan. If you ran the stream delay scan, the first scan of the characterisation sequence will be 2. (If you have run other tests the scan number will be one higher than the last scan so far).
9. Now start the appropriate test from the ABCD tests menu. For a characterisation test, clicking on “Characterisation Sequence” for a conformation test click on “Conformation Sequence”. In the case of the Characterisation Sequence the first test is the “hard reset” test which requires user interaction. For the long-term test, use the “Module LTT (????)” menu button – you will not get a hard reset test at the start in this case.
10. Hard reset test: this is an interactive test that requires you use the scope. Use the scope in the testing room. This is normally set up with a LEMO cable: this needs to be plugged into the appropriate “monitor” socket of the Mustard card in the VME crate. The hard reset test software advises you which socket to use (MA, MB or MC). Note that the signals out of these sockets are multiplexed four ways. The multiplex setting can be read off the two yellow LEDs on the Mustard front panel marked “M” and “L” (most and least significant bits). You have to change the multiplex setting yourself during the test using the button on the Mustard. Follow the instructions and check that the signals appear and disappear on all relevant channels as instructed. The answer to all the questions should be “01” (*i.e.* 1=OK). Make sure to check, however! You should be asked six times per module under test.
11. The other tests in the sequence run on without intervention. The typical length of a characterisation sequence is about 60 minutes per module. However this can vary (upwards!) quite a lot if there are noisy channels on the module, so be patient. For a six module test, a characterisation can therefore take most of the day. The cold long-term test currently takes 24h and can conveniently be run overnight.
12. Keep an eye on the test while it is running. It may stop with an error, or root may crash. If that happens, you need to start again, by stopping SCTDAQ and restarting ideally (if root crashes be aware that the LV and HV channels are often left on). It is particularly important to keep a watch on the long-term test.
13. When the test sequence has completed the module(s) must be brought to room temperature if operated in the cold, otherwise you may shut down SCTDAQ (see 14).

- Maintain N_2 flow during warm up.
- Turn off the module HV (click on HV ramp down on the Root interface menu). Confirm the HV light(s) have gone out.
- Keep the module LV supplies on to ensure the module is warmed than its surroundings at all times.
- Turn the chiller temperature to 0^oC.
- Leave the module(s) powered until the DCS environment temperature reads 0^oC.
- Confirm that the module temperature is higher than 15^oC.
- Turn the chiller temperature to 15^oC.
- Wait until the DCS environment temperature reads 15^oC and the module temperature reads between 25 and 35^oC.

14. Shut down SCTDAQ by using the "Exit" button on the main SCTDAQ menu. You are asked to 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 module LV or HV power. Occasionally root crashes, or has to be stopped with ctl-c. In this case, restart it and exit it properly to get the LV/HV turned off cleanly.
15. 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.
16. If operating cold turn the chiller temperature to 25^oC and wait until the DCS environment temperature reads at least 18^oC before opening the freezer.
17. Unplug the module patch cards from the power and signal cables and disconnect the DCS cables.
18. Switch off the cooling and N_2 gas flow. Disconnect the module from the cooling circuit and the N_2 circuit. If the multi-module test was performed remove the module test rig from the freezer and each module test box from the test-rig.
19. Return the module(s), one at a time, to the N_2 flow cabinets in the bonding clean room.
20. Only when the LV/HV lights are all off and the module is disconnected should you turn off the VME crate.

(Do I need to run the IV scan again at some point – will refer to QA document to find out)

Processing and analysis of test results

To be added

Uploading data to the database

To be added

Problem shooting

To b added

1. LV does not come on at power up
2. Incorrect currents or temperatures