Operating Manual for Electrical Tests in Birmingham

Version 0.4
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Currently we have three electrical test systems in Birmingham, although only two are fully operational. All three PC systems live in the hybrid/module testing room **PB8G**. There are three controlling PCs, **epat2**, **epat6** and **epat7**. The epat2 system is connected to a VME crate next to it, and is equipped to test at least four modules or hybrids at a time. The epat6 system is connected through the wall to the VME crate in the small room **PB8A**. The epat7 system is connected to the VME crate next to it, but is not yet fully operational.

The intention is to run epat2 as the "room/warm temperature" test system, epat6 as the "cold" test system, and epat7 as a "special purpose/diagnostic" system. The epat2 system is thus connected to a series of cooling blocks and/or module cooling plates, while the epat6 system is connected to devices in the adjacent freezer, and epat6 is connected to a single cooling block. The three systems run consistent versions of the electrical test software (root and sctdaq). Epat2 and epat6 will be equipped to run up to six hybrids (or four modules) at once. They do *not* share their main (C: and D:) filesystems, although all test systems have access to the N: disk, which is a large (backed up) RAID disk on the particle physics Linux system (as /home/atlas/f1bdata/).

Each hybrid is installed into the electrical test system on its production jig. For warm and room temperature tests the jig is attached to a cooling block; for cold runs the jig is placed in the freezer.

Cooling block configuration (epat2/epat7 systems)

Cooling blocks are installed on the table next to the rack, and may be used individually or in chains: note that the cooling blocks *only* have in and out cooling water connections. The in and out connections are interchangeable.

The cooling device for testing devices on the epat2 system is the **chiller** placed just outside the door of the test room. The chiller cooling water temperature may be set by the rotary dial on the chiller front panel. Do not run the chiller below about 8C set temperature to avoid condensation problems. If at any time condensation is observed on cooling blocks or hybrid jigs, switch off immediately and raise the chiller temperature. The actual coolant water temperature is somewhat warmer than the "set temperature" on the chiller – thus setting the dial to 8 will actually mean unheated cooling blocks will sit at around 16C.

Chilling for the epat7 system is provided by the "**gurgley tom**" home-made chiller. Only use the "gurgley tom" if the main chiller is not available (either because it is already in use, or is being maintained/repaired). The gurgley tom does not have a settable temperature, and so may only be used for room temperature tests (*i.e.* not the long-term test). Since it blows humid air out of the top, it is best not to run it for extended periods. It also must be topped up with water periodically: check the side beaker.

The normal cooling block configuration for the epat2 system is that the several blocks are connected in a chain to the chiller. There may also be module cooling plates in the chain.

In any case where the configuration (chaining) of the cooling blocks is changed, you should run the cooling first without hybrid(s) or module(s) installed to check that there are no water leaks.

Hybrid installation to cooling blocks

Hybrid production jigs are attached to the cooling blocks by up to six allen-keyed screws. The use of three screws at the corners of the hybrids is recommended, more if you wish. Hybrid jigs must have the upper cover in place before testing commences.

When installing hybrids, **do not** attach the support cards to the jigs – but leave this until the VME crate is switched on and the LV/HV power is off. **Do** check that the hex screws holding the small "patch" card on the hybrid jig are fastened properly, so fixing the patch card – otherwise plugging/unplugging the support card can move the hybrid.

The hybrid jig-support card connection is robust enough to allow the support cards to sit unsupported when connected. Two cables run from each support card to the VME crate – one is connected to the appropriate SCTLV channel, the other to the "patch panel card" connectors. If the cables to the VME crate are not already attached to the support card, attach them to the support card but **do not** at this stage plug the support card into the hybrid jig connector.

Hybrid installation in freezer

Cold tests of hybrids in the freezer need to be run at a freezer set temperature of approximately –6.0 to obtain 0C on the hybrid. Be careful that N2 is always flowing at a sufficient rate through the freezer when it is cold to avoid condensation/icing. Also avoid opening more than necessary.

Safest is to install hybrids at a warm freezer temperature (15C or above), connect to the N2 supply in the freezer, and then to cool down with N2 flowing. Similarly, warm up to close to room temperature with N2 flowing before removing hybrids. In emergencies it is possible to remove the hybrid cold but they must be transferred **immediately** to a N2 enclosure with a fast-flowing N2 supply.

Running a characterisation or long-term test on hybrids

1. Make sure no support cards are connected to devices.

2. Make sure VME crate is on, but no LV or HV is on. Check PC is **not** running root/sctdaq

3. Install hybrids as described above.

4. Connect hybrid patch cards to the support cards.

5. Turn on cooling. For room temperature tests the chiller temperature should be set at 16C. For the hybrid long-term test it should be set at 30C. For room temperature tests the gurgley tom may be used. For cold tests, this step involves cooling down the freezer.

6. Check d:\sctvar\config\st_system_config.dat defines the correct hybrids or modules.

7. In normal testing, you do not need a .det file: so in this case check that no .det file exists in the same (config) directory. If you are running a characterisation test, check that .trim and .mask files do not exist. If you are running a long-term (warm or cold) test, the .trim file – and .mask file if needed – should be present, so that the long-duration tests can be run trimmed.

8. *(Only needed for epat6/7)* Run resman (the VME-interface Resource Manager, available on the desktop) if the VME crate has been powered off recently. You need to click on "Close" when resman has run.

9. Start sctdaq: Type your initials at the prompt, and "01" when asked to verify (or 00 if you typed them incorrectly!). Click "Close" after the Resource Manager has run, if it does.

10. Sctdaq will now start. Two more windows appear, to make three in total:

    - Rint, a text message/command window. You mainly use this for answering questions (you already typed your initials in this window).
    - Burst Display window (showing event hit-pattern histograms). The window title also contains the current run number. Note it!
    - "Root interface to Win32" menu. The standard tests are all run using the menu system. This first menu is referred to as the "main menu".

11. Check that the hybrid power (one SCTLV light for each hybrid, just above the connector) 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).

12. Check the hybrid temperature and currents. These can be seen on the right-hand side of the "Burst Display" window.

    The main items to check are vcc and vdd, which should be 3.5 and 4 V respectively; icc and idd, which should be around 950 and 500 mA, respectively, and t1 and t2 which should be 24-30C for a room temperature test (35-37C for a warm long-term test, -3 to +3 for a cold test). Don't worry if icc is slightly above 1A. If the temperature or currents (or voltages) are anomalous, you have a problem.

    (Note that all temperature monitoring is now done through the SCTLV(3). This may change when the third test system is functional)

13. The menu you will need for the production tests is brought up by clicking on "ABCD tests" about half-way down the startup menu. This menu is referred to below as the "ABCD tests menu".

14. 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 system config file.

15. 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 did run 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).

16. Now start the appropriate test from the ABCD tests menu. For a characterisation test, clicking on "Characterisation Sequence". In this case the first test is the "hard reset" test: this requires you to do some work, so don't leave! For the warm long-term test, use the "Hybrid Warm LTT" menu button – you will not get a hard reset test at the start in this case.

17. Hard reset test: this is an interactive test that requires you use the scope. Use the low quality 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 hybrid under test.

18. After the hard reset tests, switch off the scope.

19. The other tests in the sequence run on without intervention. For hybrids the typical length of a characterisation sequence from here on is about 60 minutes per hybrid. This can vary (upwards!) quite a lot if there are noisy channels on the hybrid, so be patient. For a six hybrid test, a characterisation can therefore take most of the day. The warm long-term test currently takes 90h, although this should be reduced with experience. The cold hybrid test is approximately 12h and can conveniently be run overnight.

20. 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 channels are often left on). It is particularly important to keep a watch on the long-term test.

The characterisation sequence is nicely documented in Peter and Lars’ document “Electrical Tests of SCT Hybrids and Modules”. Read it, if you need to keep occupied while waiting for the tests to run.

21. When the test sequence has completed, you may 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 hybrid LV 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.

22. When sctdaq has exited, check that the LV power lights are all off. If they are not, restart sctdaq and immediately “Exit”. This should turn the power off cleanly.

23. Now unplug the hybrid patch cards from the support cards.

24. Only when the power is off on the SCTLVs (and SCTHVs in the event you are actually testing a module) and the hybrids are disconnected from the crate may you switch off the VME. If you are doing more tests soon, you can just leave the VME on.

25. Now switch off the cooling.

Processing and analysis of test results

Now you may analyse the results of the test sequence. There are some perl scripts installed on the test systems, in directory c: \PerlScripts, to help with this.

1. Get a command prompt by Start->Programs->Command Prompt.

2. In the command prompt window, type “cd perlscripts”.

3. Work out which “named test sequence” you have been running. The name of the test sequence follows according to a convention defined in the UK-B community:

    - for the first test of a hybrid after ASIC attach this is “Hybrid_Initial”
    - for the hybrid long term test it is “Hybrid_Longterm”
    - for the hybrid cold test this is “Hybrid_Cold”
    - for the first test after the pitch adaptor is bonded it is “Hybrid_Completion”.
    - Subsequent retests after any of these tests are denoted as Hybrid_Initial_Retest1, Hybrid_Initial_Retest2, etc.

Do not use a test sequence name that has already been used for that hybrid (if you do this by mistake, you will be alerted and will not overwrite the previous results. Check for previously used sequence names by looking for directories n:\atlas\sct\sctvar_archive\<hybrid>\<test>, where <hybrid> is the hybrid serial number as given in the rightmost column of the st_system_config file, and <test> is a test sequence name, as above. If the <test> directory exists for the test you think you are running, use a _RetestN name, incrementing N by one if such tests have already been done.

4. Now run the command

```
perl StoreTestResults.pl <hybrid> <test> <run> <scan>
```

where you need to replace <hybrid> by the serial number of your hybrid (as indicated in the system config file), <test> by the name of the test sequence, and <run> and <scan> by the run number and start scan number you noted above.

5. Check the \sctvar_archive\<hybrid>\<test> directory after running the script: you should see the directory is created and that files have been copied into it.

6. If StoreTestResults seems to have worked, analyse the results by running the second perl script

```
perl MakeWebIndex.pl <hybrid> <test>
```

This makes an `index.html` file in the \sctvar_archive\<hybrid>\<test> directory. Double-click on this file in NT Explorer to look at it. You will see several tables, one of DCS quantities, one of test results, with links to the postscript files for tests which make them, possibly some tables of defective channels, and an overall result file (or several) for all the tests at the bottom.

7. Check the DCS table that the temperatures were within the specified range: from 24-30C for the room temperature tests, 35-38C for the long-term test, -3 to +3 for cold tests. Check that the other DCS ranges look reasonable too (Vdd goes down to 3.5V in the FullBypassTest, so only worry if the minimum is not 3.5V).

8. Next check that all tests have status "PASS". Also check for defects: a perfect hybrid will have no defects on all tests except the TrimRangeScan test – this often produces a small number (up to about 20) of unimportant defects. Check in the results file (at the bottom of the page) if there are other defects. Look also at the "Comments" column in the web page table: strobe delays should be in a narrow band; gains are usually between 50 and 65 mV/fC; noises from "ThreePointGain" and "ResponseCurve" should be between about 550 and 650 ENC (absolutely not above 750 ENC); "Estimated ENC" from the NO (NoiseOccupancy) test should be in the same range, and the noise occupancies at 1fC should all be zero for hybrids; timewalk values should be at least 5ns and no more than 16 ns. You should also look at all the plots. Note that the long-term test just runs a long sequence of confirmation tests, so there may be no occurrences of the tests which are only done in a characterisation sequence.

Running a module characterisation test

Production modules arrive in the new-style QM "carrier boxes". The modules do not need to be removed from these boxes, but the boxes can instead be bolted directly onto the carrier cooling plates. N_2 should also be flowed into the gas input channel on the carrier box. (If there is no gas input channel, the N2 has to be flowed instead via the cooling plate, which entails removing one face of the carrier box – a much more delicate operation).

The steps as listed above for hybrid tests are then performed. Once sctdaq is running, turn off the hybrid power (main menu, item "LV off") and let the hybrid temperature stabilise (at 15-16C for a room temperature test). Then run an I-V curve test (ABCD tests menu, option 3 if test to be run to 500V). When this is complete, the HV will be left on at 200V. Turn on the LV power (main menu, LV on) and proceed with characterisation test exactly as above for a hybrid.

The module characterisation test results can be analysed exactly as for the hybrid. The I-V test results will appear on the web page.

Running a long-term module test

The exact details of this test procedure are still in development, since no production modules have yet been successfully tested cold in Birmingham.

The module long-term test proceeds as above, except that the module is placed in the freezer for testing, without cooling plate. Make sure there is a decent N2 flow, and that the freezer is kept sealed as much as possible while cold.

When the modules are installed and connected up in the freezer, set the temperature to a low value (not yet determined). Keep an eye on the hybrid thermistor temperatures. When they approach OC (less than 2C) turn on the module HV and start the long-term test. Do not run an I-V curve cold, as you will learn nothing and turning off the LV will cool the module quickly down to –15C or so, from where it can be difficult to switch back on.

The module LTT runs for 24h. Check repeatedly during the test that the N_2 continues to flow (keep an eye on the pressure gauge close to the door of the basement lab area, and change the bottle if the gas will run out *eg* overnight). At the end of the test, maintain the N_2 flow during warm-up. Turn off the module HV before warm-up, but keep the LV on to ensure the module is warmer than its surroundings, just in case any condensation does form. Warm up in steps, checking before each ramp of the chamber that the hybrid thermistor is already warmer than the new target temperature.

When the hybrid temperature reaches 23C the freezer can be turned off, as can the hybrid LV. Wait until the (unpowered) hybrid temperature reaches 18C before opening up and removing the module.