ATLAS ITk Upgrade
Strip Detector Quality Control

Documentation and user manual

LabVIEW code for Sensor QC

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Contents

1 Getting started

Setting up the LabVIEW scripts on your local machine

The LabVIEW files can be downloaded in a zip file or their git repository cloned from `https://github.com/chtklein/itk-strip-sensor-qc`. The directories contain files compiled for different LabVIEW versions starting with LabVIEW 2013.

Some versions of LV might not contain libraries used in the QC scripts. To date the only known issue comes from the DDE communication protocol needed in the implementation of the Alessi probestation. It has to be noted that DDE only works on 32-bit installations of LV as the .ddl file used for communication will not work otherwise. The DDE library has can be found in `./LabVIEW XXXX/InstrControl/additional LV libraries/` and has to be copied to `[LabVIEW version]/vi.lib/Platform/` if it is missing.

Additionally, third-party instrument drivers can be included for instrument control. The ones currently in use can also be found in the aforementioned folder, and the libraries have to be moved to `[LabVIEW version]/instr.lib/`.

Local configuration

In `./QCtests/general_VIs/LocalConfig/QCconfig.txt` several parameters (e.g. institute name, data directories, etc.) are defined which should be changed accordingly for every local setup. The file will be automatically read at the beginning of every measurement script and overrides whatever is in the LV global.

- INSTITUTE – local institute abbreviation as used in the production database
- MANUFACTURERS – list of sensor production manufacturers, i.e. Hamamatsu; this list can be extended if scripts are used for R&D purposes
- DEVICES – list of different device types tested at the institute; batch names should be listed according to database categories (e.g. ATLAS18SS for pre-production short-strip sensors)
- SERIALNUMBERS – location (full path) of database serial numbers lookup file
- DATADIR – full path to directory structure used to save measurement data files
- BAKDIR – full path to directory used to save screenshots and temporary data files for backup in the case of long-term measurements
- USER – list of all users at the local institute which can be chosen from in a drop-down list later; names differing from this list can be entered before the measurement but will have to be re-entered every time unless added to the list
- SMU, LCR, MULTI – lists of locally available instrument, currently unused

Apart from the text file, for instruments corresponding to already implemented instrument classes, adjust the “Instrument addresses” cluster in the global variable

`InstrControl.lvclass:InstrumentSetup.vi`. Multiple instances of the same type of instrument can be added, but need unique identification in the field "Instrument name". Remove any surplus instruments listed in the cluster and save the content by right-clicking the border of the "Instrument addresses" cluster and select "Data Operations → Make Current Value Default".

2 Common VIs

The first VIs presented in this document will be the ones which are shared between most, if not all, measurement scripts.

Entering DUT information

Coming soon . . .

Hardware and Matrix Configuration

This VI is used to make changes to default measurement settings and ad-hoc changes to the instrument addresses if needed.

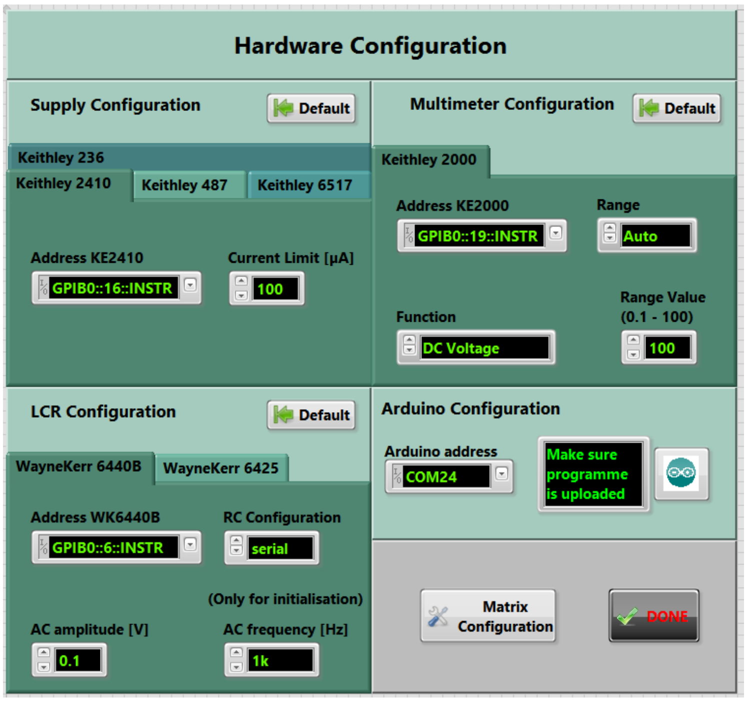


Figure 1: Front panel of the Hardware configuration VI.

The instrument addresses initially displayed are the ones saved in the "Instrument addresses" cluster and should correspond to the local setup. However, if changes to the address are necessary, e.g. if a new instrument is moved between setups, the correct address should be available from the drop-down list, provided the instrument is connected and communications are working properly. The current version of the LV code supports all modes of communication available through NI-VISA, which includes: GPIB, serial, VXI, GPIB-VXI, PXI, TCPIP, USB, and FireWire. Please note that aside from GPIB, serial, and TCPIP (for the Semiprobe probestation), other communication protocols have not been tested yet.

Instrument settings available here are limited to the ones which are most crucial to the measurements. Each available instrument in the local setup (excluding matrices/multiplexers and probestations) should have their own tab here, including multiple versions of the same instrument type. If an Arduino is used, the address can similarly be selected here and the Arduino software accessed by clicking the button with the Arduino logo.

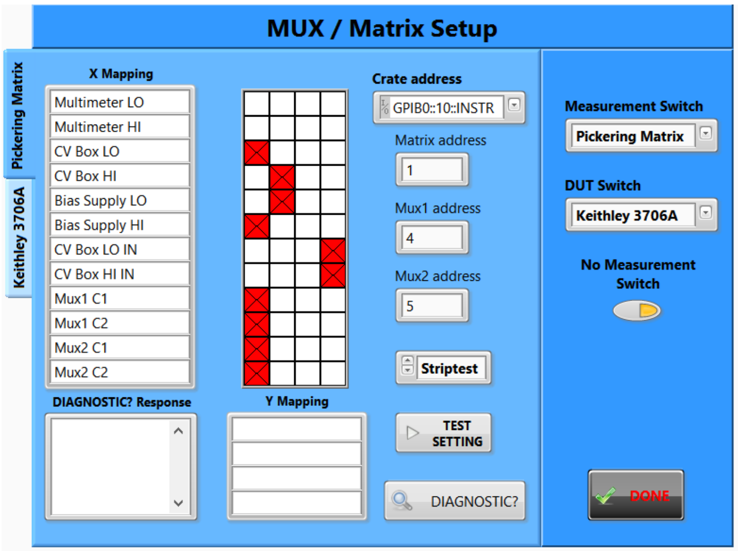


Figure 2: Front panel of the Hardware configuration VI.

By clicking on the "Matrix Configuration" button, one can access the Matrix Configuration VI. Here settings for the matrices and multiplexers can be checked and adjusted as well as tested. Generally, the switching systems can be used to either switch between different measurement settings, e.g. during a striptest or sequential testing, or to switch between DUTs in a multi-sensor setup. On the right-hand side, the switching system to be used for either role can be selected. If there is no matrix used as a measurement switch in the setup the corresponding option should be enabled.

Pickering Matrix and MUX The Pickering matrix has currently been implemented as a measurement switch only. For the Pickering system the internal crate addresses of the matrix and multiplexers can be selected in addition to the VISA address of the crate. With the "Test Setting" button, the mapping for the different types of measurement can be activated and the "DIAGNOSTIC?" button queries the instrument crate with the response displaying the instruments in the crate and their internal addresses.

Keithley 3706A The Keithley switching system in conjunction with two 10× multiplexer cards is currently only being used as a DUT switch. The only adjustments needed for the Keithley are the instrument address and the slots used for the multiplexer cards.

Saving data and log files

Unless tests are being performed automatically in sequence, after the completion of every measurement scan the user is being given the option to save the data file via the "Save" button.

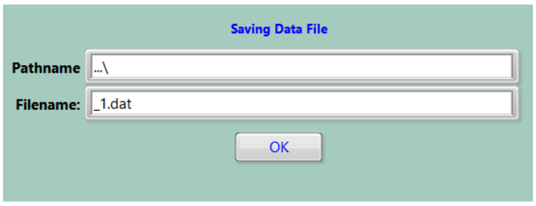
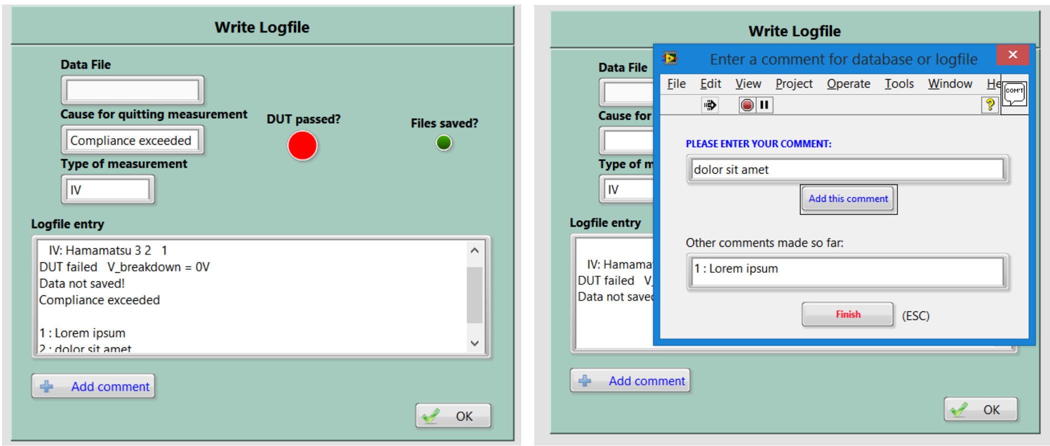


Figure 3: Prompt to confirm saving data file(s).

Upon pressing the the "Save" button, the prompt shown in Fig. 3 requires additional confirmation and shows the file path where the file will be saved as well as the file name. The LV code creates the file structure where data is saved automatically, starting from parent directory given in the local configuration file (see previous section). The path structure is as follows: [parent directory] / [device type] / [batch] / [database serial number] / [measurement type]. The file name is also generated automatically from the database serial number, the measurement type, and the number of scans done for that particular test on the current sensor.



(a) (b)

Figure 4: Front panel of the VI used to add entries to the logfile (left) and adding additional comments to the automatcally generated information.

After saving the data file or quitting without saving, a log file entry is generated. The entry contains automatically generated information, such as the DUT and test information, whether the DUT passed or failed the test, the data file name and its file path (if saved), and generic information as to how the run has ended (e.g. run aborted, compliance exceeded). In addition, further comments can be added to the entry via the respective buttons as shown in Fig. 4.

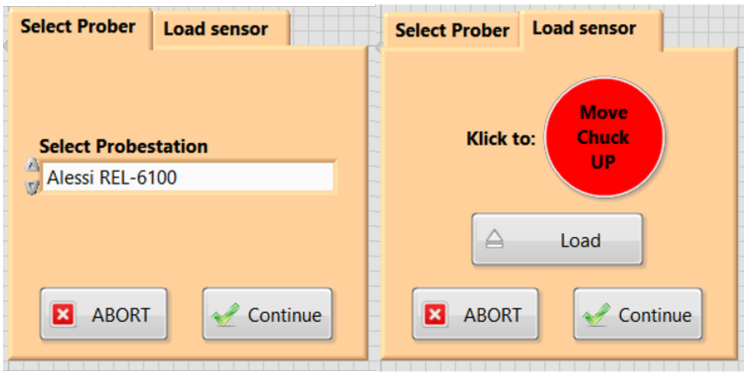
3 IV measurements

4 CV & C_{is} measurements

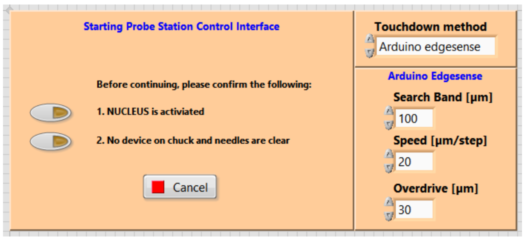
5 Striptests

Prober selection

Upon running the striptest VI, the probe station selection automatically opens, which also includes the selection of some parameters e.g. for the edgesense. Currently there are 2 probe stations implemented, the Alessi REL-6100 and the SemiProbe. The initialisation VIs are shown below in Fig. 5. After the probe station is selected and initialised, the open VI is meant to facilitate loading of sensors by being able to move the chuck to a pre-defined load position and back to the centre, as well as allowing the chuck to be moved between the *Separate* and *Contact* position.



(a)



(b)

Figure 5: (a): VI for the selection of probe station and loading of DUT. (b,c): Initialisation VIs for the Alessi and SemiProbe probe station, respectively.

Loading a probe plan and aligning the sensor

The next step includes the loading of the probeplan, either the alignment of chuck in theta or the rotation of the probeplan coordinates to fit the chuck rotation, and the option to test the loaded coordinates and alignments by jumping to the AC measurement pads.

The user has to select a probe plan used as a map of probe points in the strip test by clicking on the “New” button. Care has to be taken to set the correct number of probe card channels or select the “Single Needle” Mode first, since the coordinates included in the probe plans are *enabled* for movement according to the number of needles used. The coordinates loaded can be checked in the window which opens upon selecting a probe plan.

After confirming the probe plan selection the jig has to be aligned and a reference on the sensor surface has to be chosen. For this purpose move the cross-hair to corresponding top and bottom fiducials and read the coordinates with the respective buttons. In the process of doing this the chuck moves automatically to the last coordinates used for the next field to be readout. After alignment the coordinates of the reference point are readout similarly. Alternatively, if the jig is already aligned and/or the reference point is the same, the respective buttons can be selected to skip these steps. This is especially useful if only a new reference point has to be selected without the sensor being exchanged or if the measurement is restarted with the same sensor.

Completing the alignment procedure leads back to the probe plan initialisation VI. The probe plan can be exercised by jumping between strips corresponding to the loaded probe plan. Simply select the respective region and strip number from the list and press the “Jump” button.

important: Neither is the edgesense activated yet nor is the movement limited to the strips enabled according to the number of probe needles! Therefore keep the platen raised and/or the chuck lowered while exercising the probe plan. Use this function to test the layout of the jig in order to prevent collisions from happening during strip test.

Special features using a probe card

The main reason to use a probe card is the opportunity to measure multiple strips without having to move the chuck to a new position for each new strip. Hence the strip test procedure was edited in order to minimise the time needed for the full strip test. Since hot-switching at 100 V can yield difficulties due to the RC behaviour of the cables and the probe card itself and resulting in current spikes originating from discharge processes while switching the card channels, these effects have to be accounted for with a reasonable settling time.

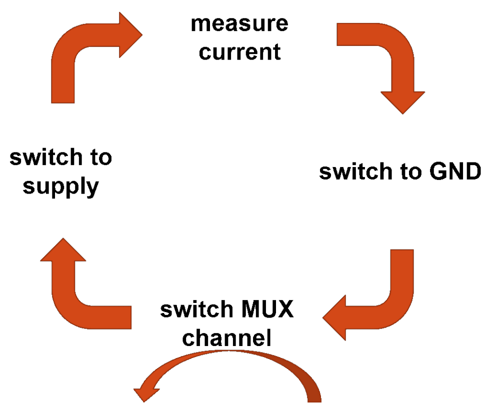


Figure 6: Schematic of pinhole measurements used for the *Rolling Current Readout.*

Due to the two 8x2 multiplexers leading to 4 simultaneously usable probe card channels, a specific readout procedure has been devised in order to minimise the time necessary for the pinhole measurement. According to the scheme displayed in Fig. 6 there are 4 steps in the current measurement used to determine pinholes. Having one MUX output present in each step at any given time during the measurement allows for the necessary delay to be reduced, since the switching processes and the SMU readout itself introduce a "natural" delay, during which the current of channels, which are switched to high voltage/GND, are allowed to settle.

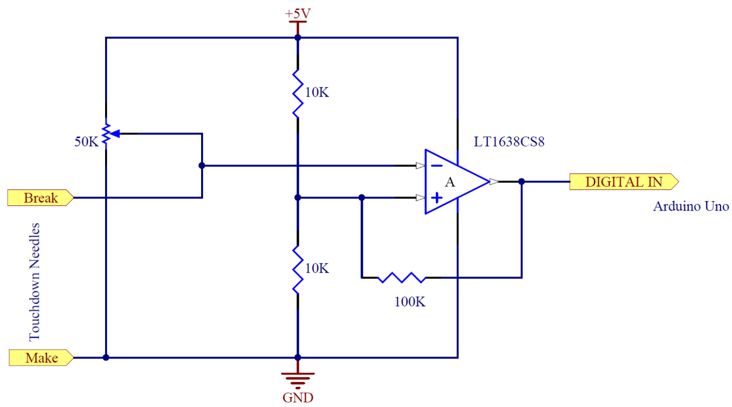


Figure 7: Circuit diagram of the Schmitt trigger used in conjunction with the Arduino for touchdown feedback

The probe card also provides two touchdown needles in addition to the 32 signal channels used for measurement. These needles can be used in a custom-made touchdown feedback using make or break contact configuration, i.e. one needle touches down on the sensor surface in alignment with the measurement needles, whereas the second one loses the contact to the first needle upon touching the surface. The edgesense circuit uses the break contact configuration in conjunction with a *Schmitt trigger* on a digital input pin of the Arduino to provide the necessary touchdown information. The circuit is shown in Fig. 7 The reference voltage is set to 2.5V with the Arduino providing the asymmetric supply +5V/GND for the amplifier. The make needle is pulled to GND potential resulting in the amplifier sourcing +5 V without surface contact and 0 V upon touchdown due to the break needle being at floating potential.

For the edgesense to work, the initial z coordinate – i.e. the chuck height at the previous position – has to be known, as well as the search band, defining the limits around the initial z within which the new z value is searched, the step size, and the overdrive. The general concept of the edgesense is as follows:

1. when moving to a new position, the chuck is lowered to the *Separate* state
2. upon arriving at the target x and y coordinates, the chuck is risen to the lower limit of the search band, i.e. the initial z minus half the search band
3. the output of the Arduino is checked for contact
4. if no contact is established, the chuck is moved up by the step size
5. the last two steps are repeated until either a contact has been established or the upper limit of the search band is reached

6. the chuck is moved up by the overdrive value to ensure a good contact for all needles
7. in the case of no contact until the previous step, the Arduino is checked one last time and if the result is still negative, an error message is shown; if there is a contact, the z coordinate minus the overdrive is saved for moving to the next position

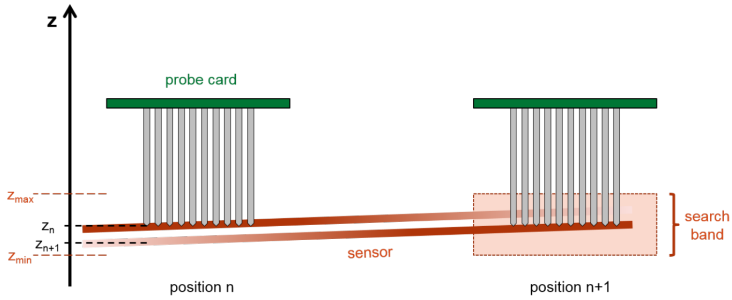


Figure 8: Schematic of the touchdown procedure.

important 1: In the single needle mode the Arduino edgesense cannot be used, however, it can still be used as a temperature and light sensor.

important 2: Please be considerate about the number of probe card needles. The VIs are made with the intention of using a probe card with 32 needles. A probe card with a number of needles other than a multiple of 4 might not work in combination with the rolling current readout. If the number of needles does not work with the sensor specs, the VI will give a warning.

Striptest setup

Similar to all other measurement VIs, firstly, a prompt opens which requires the user to enter the DUT information. The user is selected in the striptest VI itself, where the DUT information are displayed. For the striptest setup itself as shown in Fig. 9, options are to select the regions to be tested and their respective range.

important: When selecting the measurement range, please keep in mind that when using a probe card only multiples of the number of probe card channels are enabled for movement. As such even when selecting a smaller strip range, more/fewer strips can end up being measured due to the restricted movement when using a probe card.

If not all parts of the striptest procedure can be done at the same time, e.g. due to the lack of a switching matrix, the included tests can be selected with the checkboxes in the lower right corner.

The default values for the actual measurement parameters – sensor bias, LCR meter frequency, required fraction of good strips for passing, and the pinhole measurement parameters – are those from the QC document. Like for the other measurements, they are read from a text file when running the VI and can be changed either for a single run during the setup (changes need to be confirmed with the “Configure Measurement” button) or for all future runs by changing the text file.

The hardware used can be selected from the dropdown selection and configured in the *HardwareConfiguration* VI which opens when clicking the “Configure Hardware” button.

The striptest will commence with the “Continue” button and everything will be aborted and the running VIs stopped with the “Quit” button, similar to the other measurements.

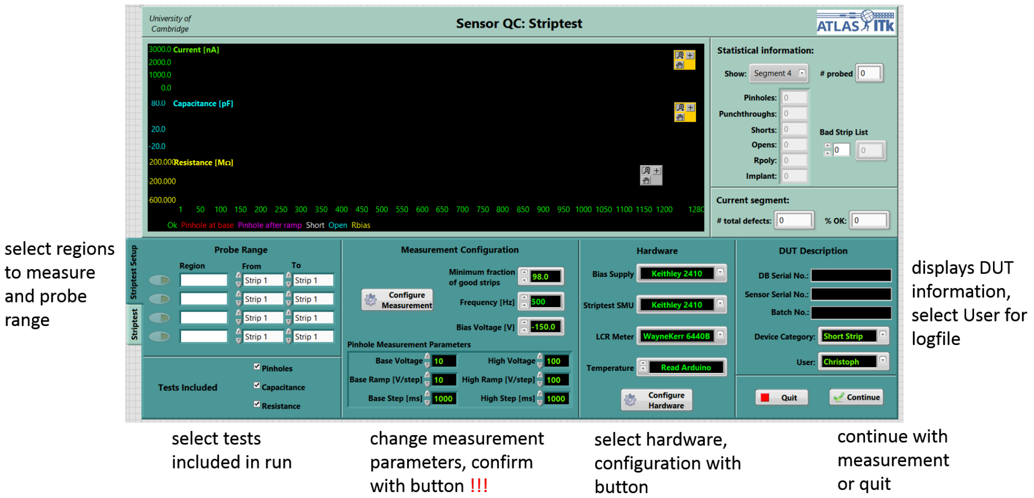


Figure 9: Striptest VI front panel during setup.

Striptest run

Continuing from the striptest setup, the measurement procedure starts.

important: Make sure the hatch of the probe station is closed.

The first step of the strip test is to bias the DUT in steps of 10 V to the value given in the strip test setup. After the subsequent initialisation and trimming of the LCR meter, a reference measurement for the pinhole test is conducted without touching the DUT. If the compliance of the bias supply (not the SMU) is exceeded, the strip test is aborted automatically.

Upon completion of these steps the actual strip test is executed for every strip given in the test setup. The measured current, capacitance, and resistance, as well as the type of strip defect is continually being displayed – automatically for the active region, for the other regions if selected. Additionally, statistical information consisting of the total number of probed strips, the strip defect list of the selected segment. The ratio of good strips and the total number of defects in the segment currently being measured is shown at all times.

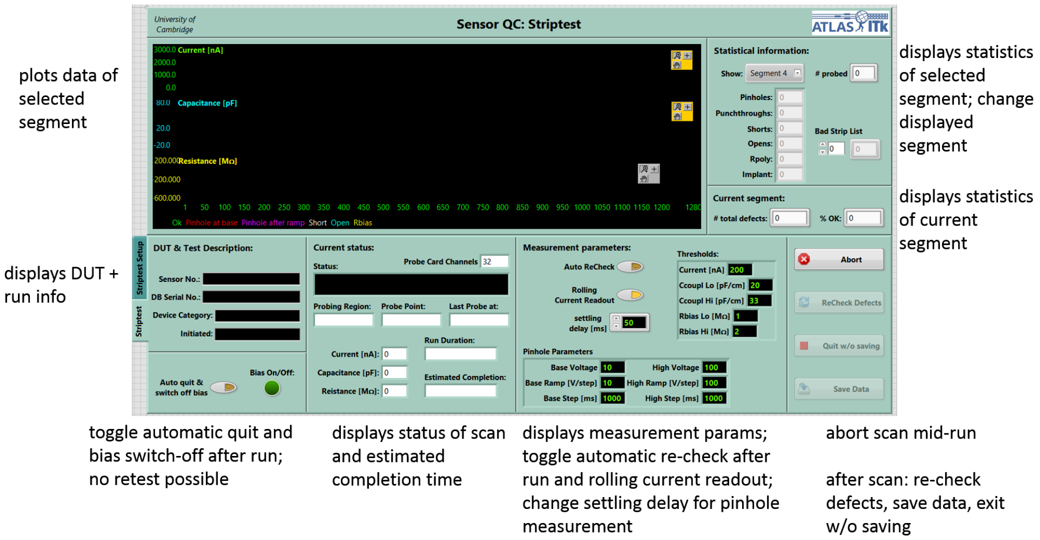


Figure 10: Striptest VI front panel during scan.

important 1: While the capacitance, and resistance thresholds are taken from the technical specifications and enforced depending on the type of sensor, the current threshold can be adjusted if necessary (currently hardcoded in the LV block diagram). The current threshold should be adjusted with regards to the leakage current observable in the pinhole test, but generally pinholes and punchthroughs can be easily identified by the exceedingly high current compared to the baseline.

important 2: The rolling current readout can be enabled/disabled via the respective button. If a probe card is used for the measurement, it is enabled by default. It cannot be enabled in single needle mode.

important 3: If all occurring defects should be re-tested automatically or the bias ramped down after the test (and potentially the automatic re-test), the corresponding buttons can be enabled to toggle this.

After the strip test is finished, the user can choose to retest defect strips (or let them be retested automatically) by pressing the "ReCheck" button. Similarly to the actual strip test, current, capacitance, and resistance of the currently (re-)tested region are shown and subsequently updated for the repeated measurement. The measurement data and the defect list can be either updated automatically or the changes have to be confirmed for each retested strip.

6 Including new instruments

(a) Open LabVIEW project "InstrControl.lvproj". Don?t have any other VIs open or editing of the project may be blocked. The project lists all instrument classes present.

(b) Right-click "My Computer", select "New → Class". Options upon right-clicking may look slightly different depending on the LV version and installed add-ons. Give your class a name. Choose one which allows easy identification of the instrument it is being used for.

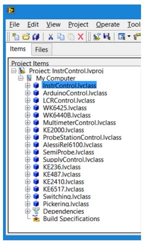
(c) Right-click new class, select "Properties → Inheritance" and change inheritance accordingly.

(d) Right-click new class, select "New → VI for Override". VIs with * must be overwritten; all others can be, if necessary. Usually, only VIs which require procedures specific for each instrument or need to be unique – and not just differ in GPIB commands used – are denoted as "override required".

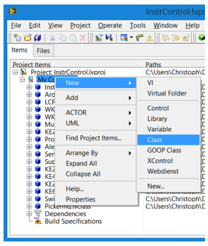
(e) "InstrumentSetup" global: add default properties cluster. Add instrument (name, address, type) in address cluster.

(f) Add instrument with relevant parameters in "HardwareConfiguration.vi". Not all parameters which can be configured are also relevant. Select only those necessary to be configured by the user, all others can be hardcoded in the instrument initialisation VI.

(g) Add instrument in "InstrumentSelection.vi" with correct type + name. The Instrument selection VI is important to create an object with the correct address from the instrument classes and store that newly created object in the corresponding measurement configuration global. E.g. during IV scans the selected supply from the specific instrument daughter classes will be saved as the more generic "Supply" class object from its parent class in the configuration cluster to be referenced during the measurement script.



(a)



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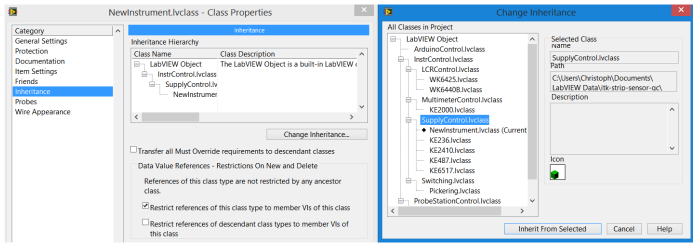
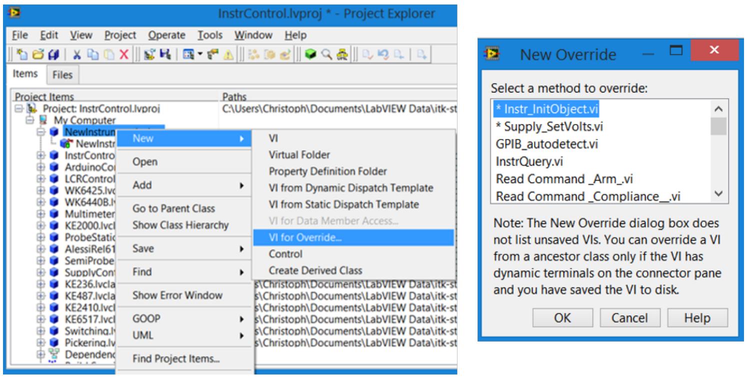
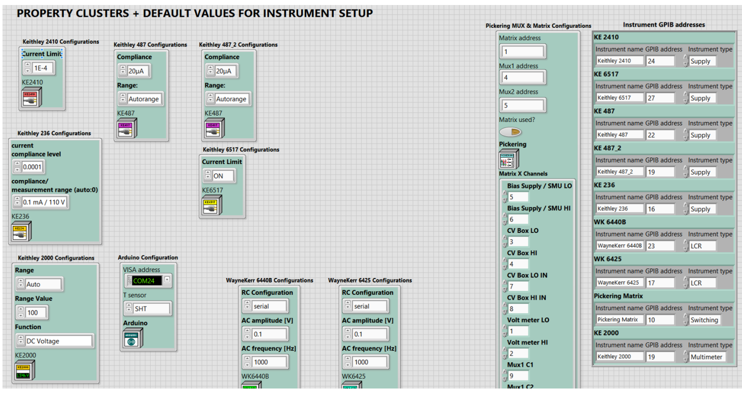


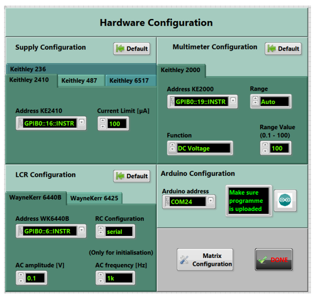
(c)



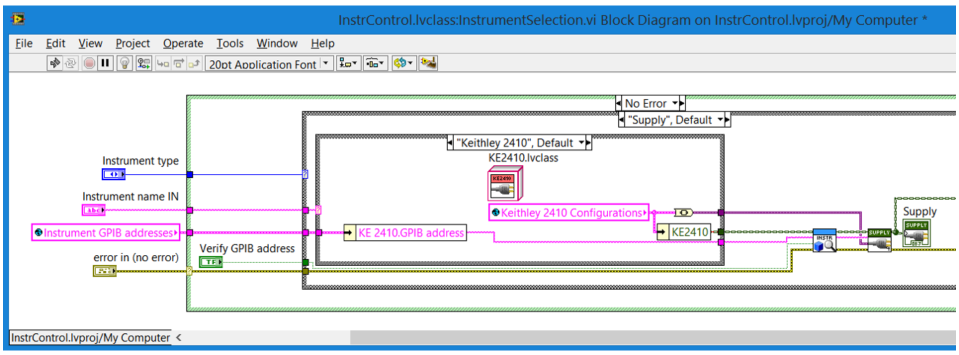
(d)



(e)



(f)



(g)

Figure 11: Steps to include a new instrument in the instrument control class structure.