

MPI TS150 Manual Probe Station

Version of 2024-11-18.

1. Introduction

The MPI TS150 probe station is used for electrical testing of devices produced on wafers or dies. The probe station features four tungsten probes mounted on micro-manipulators, coupled with a binocular microscope for accurate probe positioning/landing on metal contact pads.

Two instruments are available for measurements:

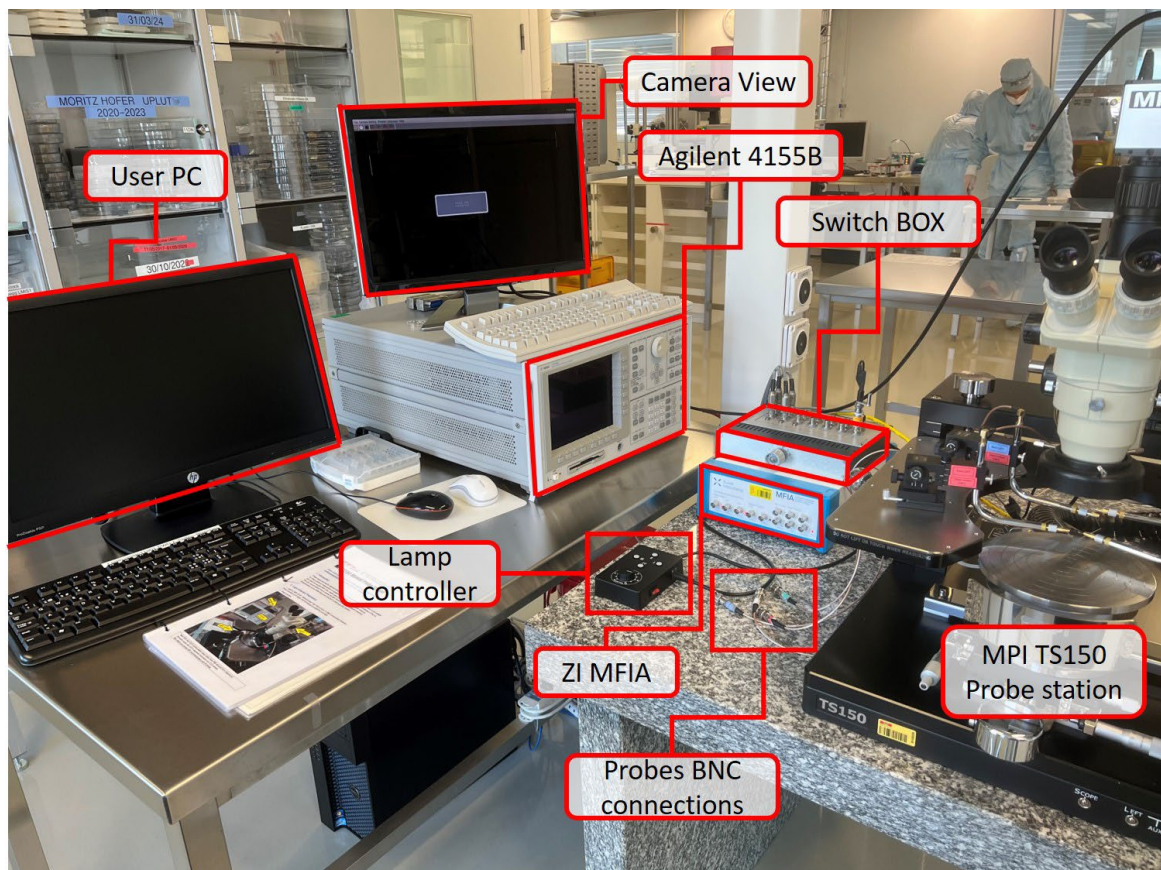
- Agilent 4155B semiconductor parameter analyzer, used for 2- or 4-probes DC measurements
- Zürich Instruments MFIA impedance analyzer, used for 2- or 4-probes AC measurements

Both instruments are controlled through a windows-based PC using their respective software Easy Expert and LabOne.

The probe station is not suitable for sheet resistance measurement of thin conducting layers. The Filmetrics R50-4PP in Zone 4 is used for that purpose. Details are found here:

<https://www.epfl.ch/research/facilities/cmi/equipment/metrology/filmetrics-r50-200-4pp/>

Setup overview:



2. Login & System Preparation

Login on the “Z11 MPI TS150 – probe station” with CAE on zone 11 (BM+1) accounting computer. The proper operation of the X-Y stage and microscope is enabled by your login.

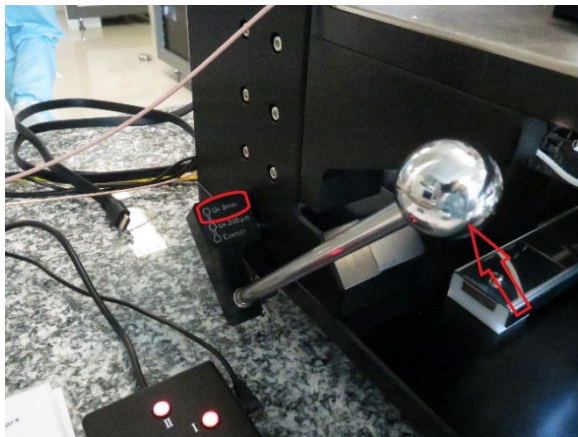
i	Z11 MPI TS150 - probe station	16.03.2023	11:23:49	1d 01:10:55	Available
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Before loading a sample on the chuck:

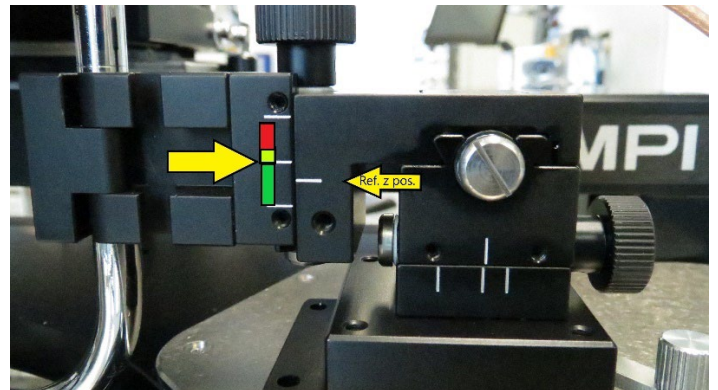
- Turn on the lamp and set intensity to maximum



- Check for the lever position to be set to “Up 3mm” and locked (see below). If not move platform to the upper level.
- Check the z position of all manipulators. Move all probe tips to the safe distance range (see below).

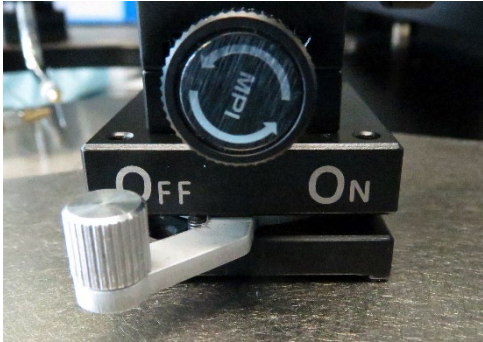


Sample (or Chuck) vertical distance control on the left side shown at 3mm distance. Rotate lever to lock for safe loading operation.

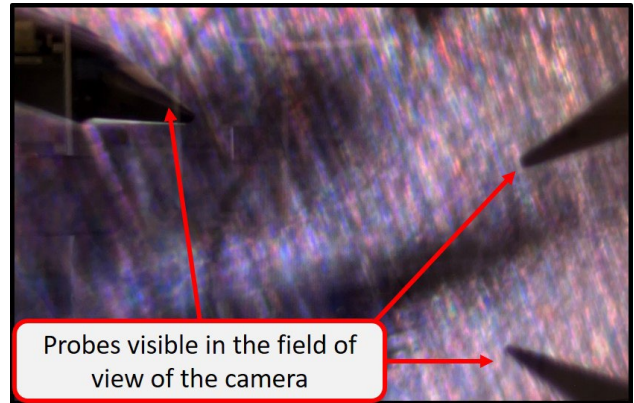


For all micromanipulators, move the tip z-position higher than the middle position marker as shown in this picture (green area is safe).

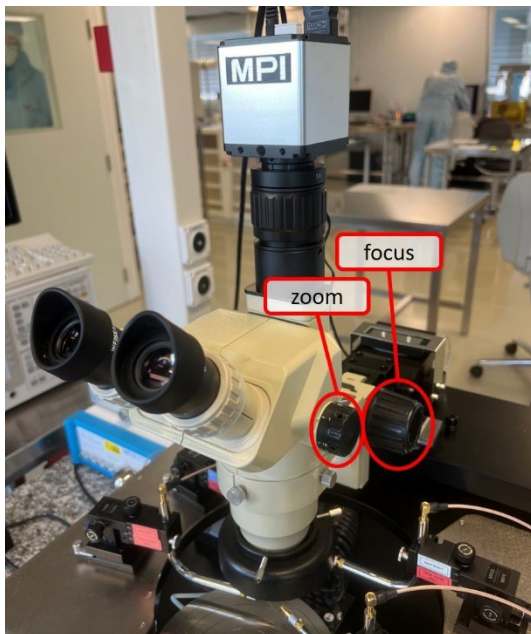
- Unlock the manipulators (2 or 4 depending on your measurement requirements) and move them into the camera field of view. The side “ON”, “OFF” lever is used to toggle the magnetic clamping (see image below).
- Zoom and focus knobs are available on the binocular microscope (on both sides) to optimize the live view settings.
- If required (in cases where all contact pads are not together in the field of view), the binocular position can be unlocked and moved to different positions.



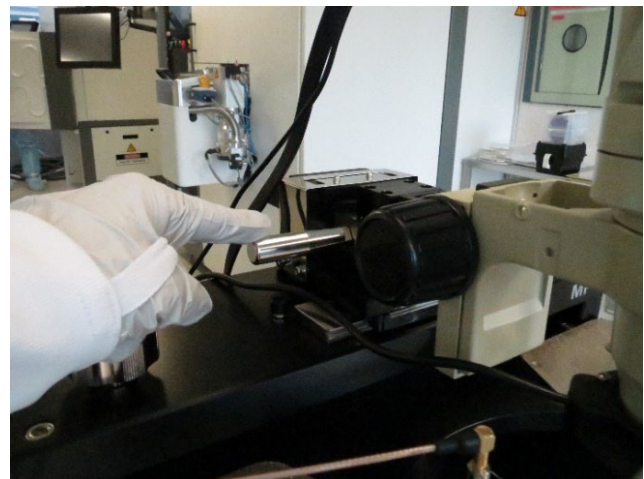
Magnetic clamping unlocked → the micromanipulator can be moved in position.



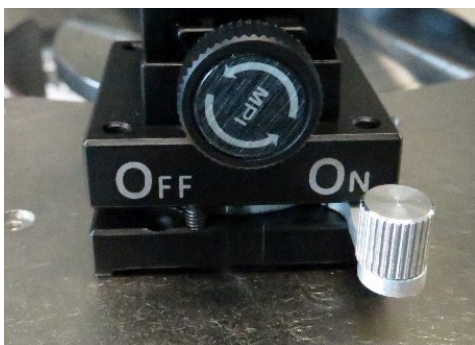
Probes are moved in the camera field of view.



Adjustments of the image zoom and focus are available on the binocular microscope.



Microscope locking/unlocking switch on the MPI prober main frame.

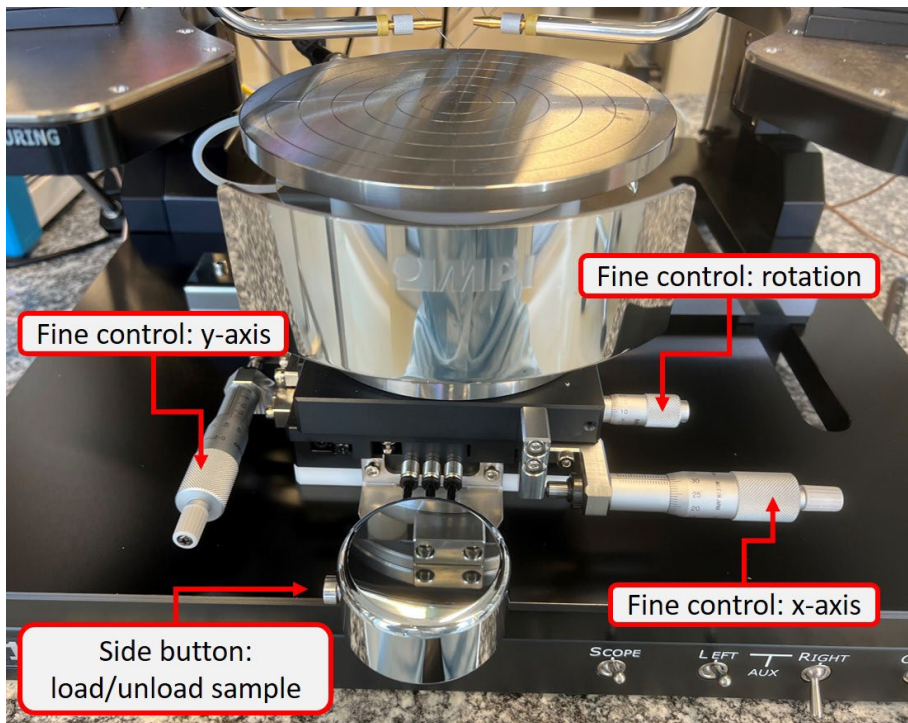


Micromanipulator are in place → Magnetic clamping locked.

3. Loading the sample & contacting the probes, step by step

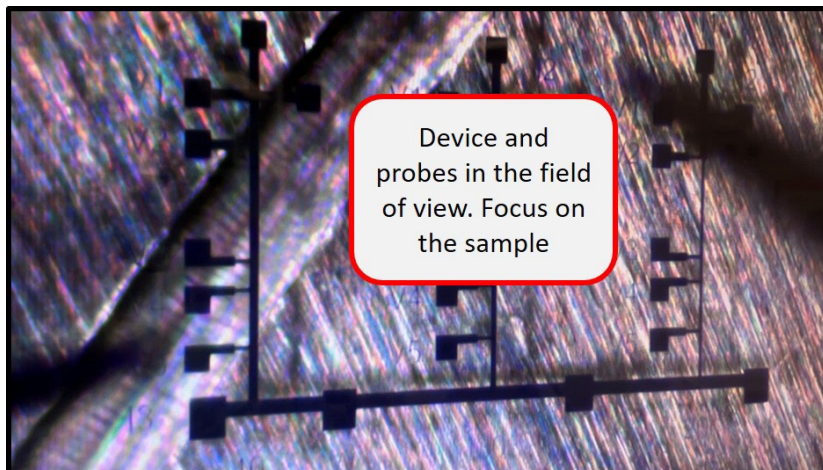
The following sequence will be used to load the sample on the chuck:

- Push on the side button of the metal handler to release the chuck fixation.
- Pull the chuck towards the front and load your sample.
- Activate the vacuum with the “Chuck” switch on the main frame.
- Move the sample in the field of view of the camera.
- Adjust zoom and focus on the sample.
- Use the fine control micrometer knobs for accurate positioning of the device to be tested.



Chuck vacuum ON/OFF switch.

Chuck movement: 1) Side button to move from the sample loading position to under the field of view of the camera, 2) Fine sample positioning with the micrometer knobs.



The device is now visible in the camera field of view, together with the probes. Fine focus is done at the sample level.

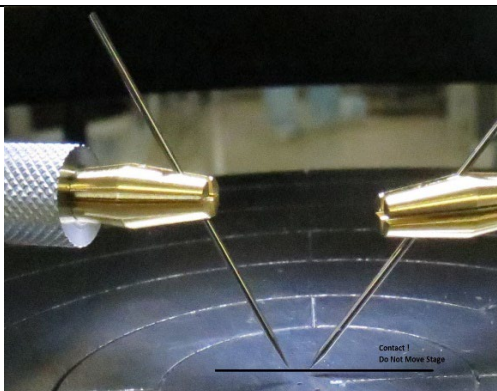
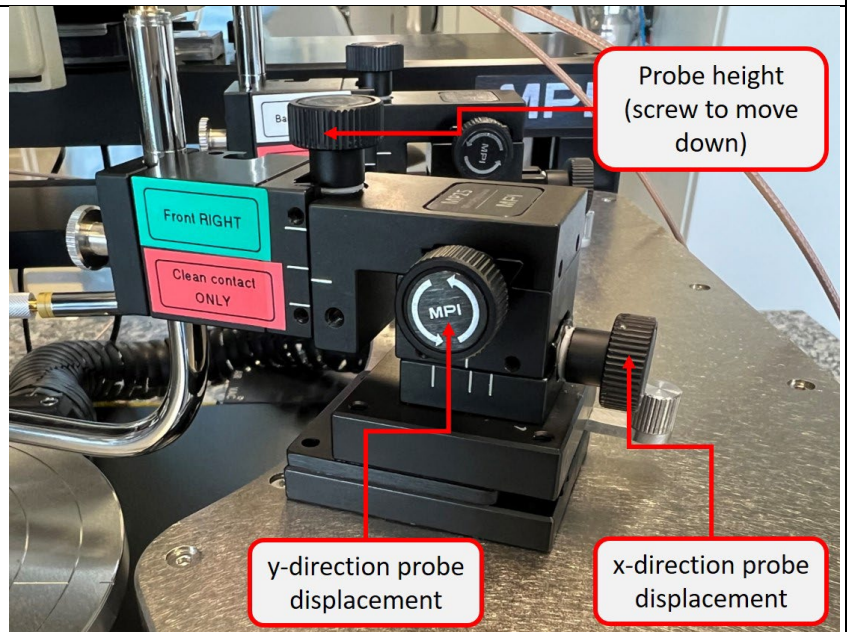
The following sequence will be used to land the probes on the contact pad:

- Take the side metal lever to the “contact” position.
- Move the probes on top of the contact pads using the “X” and “Y” axes movement knobs on the micro-manipulators.
- Slowly move the first probe down (clockwise screwing) with the “Z” axes knob.
- As the probe goes down, it will be more and more in focus and sharp in the camera view. When it lands, it will slide laterally. STOP moving down at that point as too much force can damage the metal pads.



Move down the lever position to “Contact”.
The tips should now be closer to the surface.

Move the probes (or chuck) with the micro-manipulator in the x- and y- directions until the tip is on top of the landing metal pads. Gently move the probe down with the z-direction knob until slight lateral movement of the tip is detected (landing on conducting pad).



Repeat landing operation for each contact.

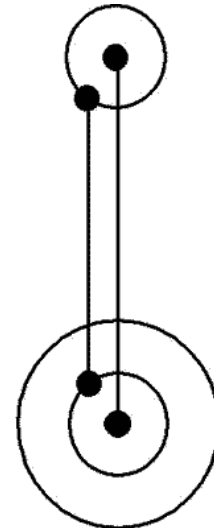
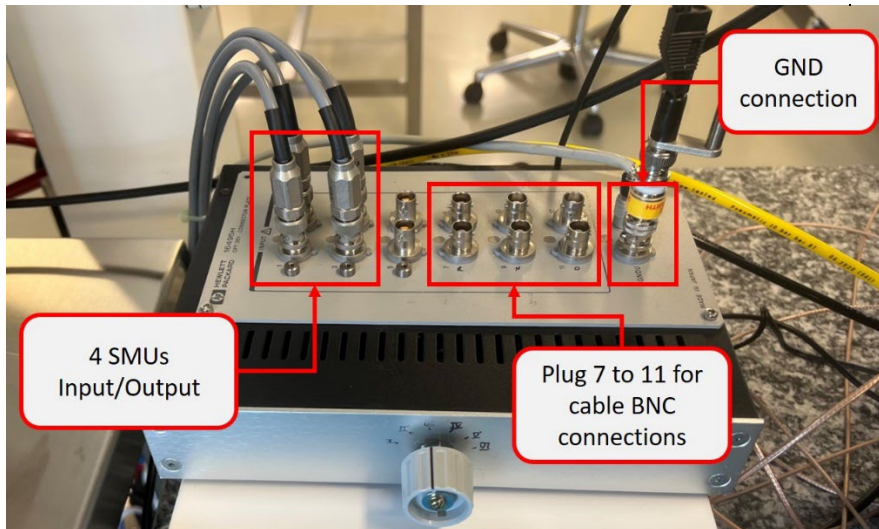
Do not forget to move the platform lever to the middle position before moving the chuck!

Moving the optics is safe.

Use probes only on clean metal pads, that are free of residues!

4. DC measurements: Agilent 4155B probe connection set-up

The Agilent 4155C parameter analyzer provides 4 Source/Measure Units (SMU) for signal input or output. These are labelled SMU1 to SMU4. A switching box with 6 positions is available to manage electrical connections between the probes and the SMUs, which allows rapid switching of predefined software configurations/applications. Probes arm and cable are coaxial (voltage follower outside – measurement central wire) and SMUs are triaxial (ground guard – voltage follower shield – measurement central wire). A connection box provides an easy and flexible transition from Triax (SMU standard) to Coax connectors (probes).



Agilent 4155C Triaxial to BNC coaxial manual connection box.

Switching between different configurations:

- Check the configuration list below to find the available preset measurement configurations. Position III is the default configuration for 2-probe IV and resistance measurements. Position IV is for 4-probe measurements.
- Select the correct configuration with the knob in front of the switching box.



- Connect the cable's BNC connectors of the probes that are used to the switching box, accordingly to the configuration list. Pay attention to the color code (green, blue, red or white) at each end to identify probes or chuck contact.
- DO NOT change the IN/OUT connections of the SMU cables!

Position I: Field effect transistor, with substrate contact on top (probe tip)

<i>FET</i>	BNC7	BNC8	BNC9	BNC10	BNC11
SMU1			Source (Common)		
SMU2	Drain (Var1)				
SMU3		Gate (Var2)			
SMU4					SUB (Pot)

Position II: Field effect transistor, with substrate contact on the chuck (conductive substrate)

<i>FET</i>	BNC7	BNC8	BNC9	BNC10	BNC11
SMU1			Source (Common)		
SMU2	Drain (Var1)				
SMU3		Gate (Var2)			
SMU4				SUB (Pot)	

Position III: Diode VF-ID, 2-points resistance

<i>RES2</i>	BNC7	BNC8	BNC9	BNC10	BNC11
SMU1	High (Var1)				
SMU2					
SMU3			Low (Common)		
SMU4					

Position IV: General 4-points measurement

<i>RES4</i>	BNC7	BNC8	BNC9	BNC10	BNC11
SMU1			I low (Common)		
SMU2	I High (Var1)				
SMU3		V Low			
SMU4					V High

Position V: Bipolar transistor, with substrate contact on the chuck (conductive substrate)

<i>BPT</i>	BNC7	BNC8	BNC9	BNC10	BNC11
SMU1			Emitter (Common)		
SMU2		Base (Var2)			
SMU3	Collector (Var1)				
SMU4				SUB (Pot)	

Position VI: Bipolar transistor, with substrate contact on top (probe tip)

<i>BPT</i>	BNC7	BNC8	BNC9	BNC10	BNC11
SMU1			Emitter (Common)		
SMU2		Base (Var2)			
SMU3	Collector (Var1)				
SMU4					SUB (Pot)

5. DC measurements: EasyEXPERT software


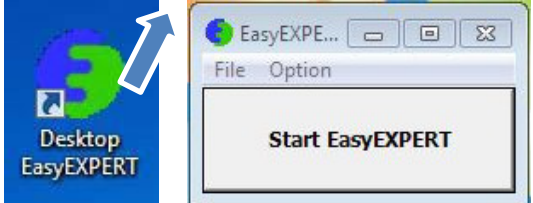
The EasyExpert software is a Windows application to control the Agilent 4155C. Among its benefits are easy set-up and automatic programming and data transfer to the PC hard drive.

Note: The advanced operation manual for EasyEXPERT can be found here:

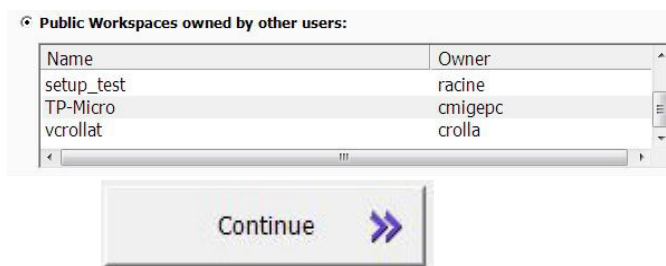
https://www.epfl.ch/research/facilities/cmi/wp-content/uploads/2020/03/EasyExpert_Manual.pdf

Quick guide:

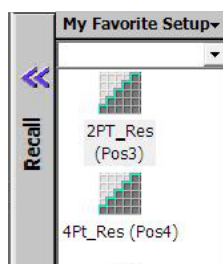
- Make sure the user PC is tuned ON.
- Switch on the Agilent 4155C parameter analyser and start EasyExpert:

	
<p>Switch the Agilent 4155C power on. Auto-calibration and test is started.</p>	<p>After completion of the Agilent auto-calibration, double click on the Desktop EasyEXPERT icon and click on "Start EasyEXPERT".</p>

- Load the "CMi" public workspace and click on "Continue":



- Alternatively, users can create their own workspace to store their own setups/configurations.
- Measurement setups, matching the switching box configurations, are loaded from the "Favorite Setup" list by clicking on "Recall":



- The following table summarizes the different tabs of the measurement setup:

Channel Setup:

The channel setup tab is used to assign the function and driving mode of the 4 SMUs

DO NOT change the assignments unless you want to create your own setup!

Measurement Setup:

The measurement setup tab is used to setup the parameter sweeps for the SMUs which are defined as variables (VAR 1 and/or VAR 2) driving mode.

You should edit the fields according to your experiment needs!

Do not hesitate to use the compliance and noise filtering options. Check the full .pdf manual for more details.

Function Setup:

The function setup tab is used to define new parameters, such as the device resistance in [Ohm], calculated from the voltage/current inputs using user-defined formula.

Display Setup:

The "Display Setup" tab let user defines the parameters for the display of the results on 1) a X-Y Graph, 2) a list, 3) a parameter to be tracked with markers

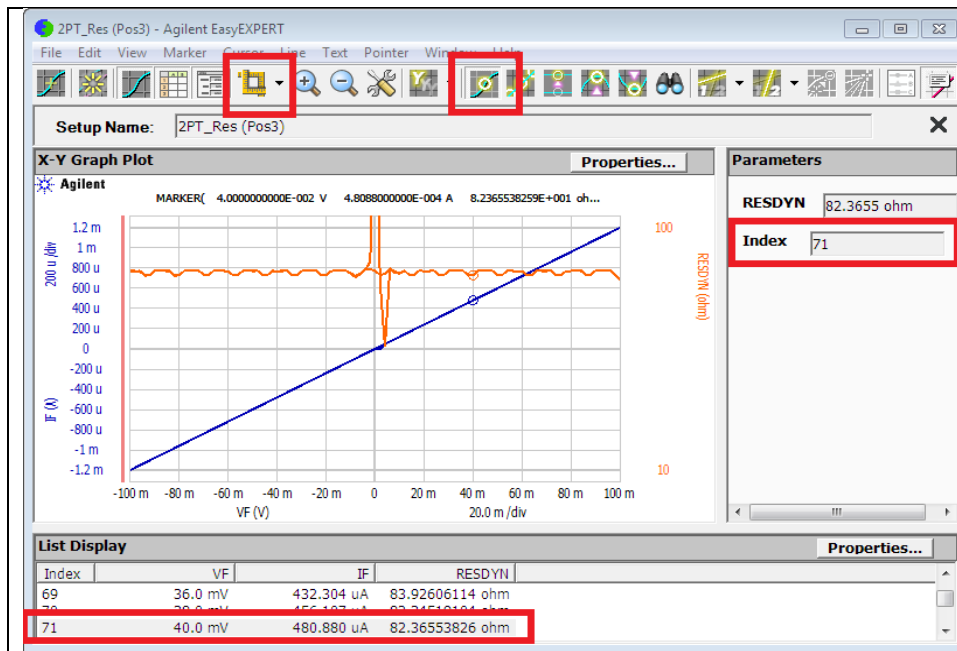
- Once the parameter analyzer is correctly set, the measurements are taken using the green “start” button:



- Alternatively, measurements can be appended to previous ones or streamed continuously using the following buttons:



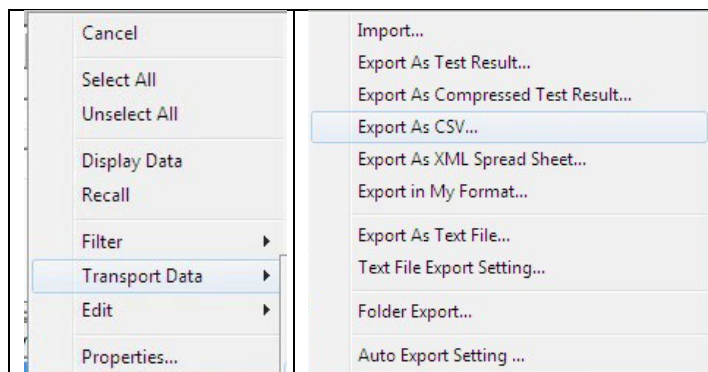
- The measurement window will show up (on top of main window).
- Note: In the main window the “Results” list is updated at each single measurement with a new line. Any measurement can be reloaded to a new measurement window or exported to CSV.



Useful options in the icon palette:

- Auto scaling (first activate X/Ymode)
- Markers to sweep into results simultaneously in plot window, list display and Index (using mouse or pointer)

- Exporting data as .CSV is done from the “Results” list: right-click on the line and go to “Transport Data” → “Export As CSV ...”.



Exported data should be transferred on the CMi transfer server (\\stifiles\cmi-transfert*your_folder*).

Note that the “CMi” workspace will be regularly purged of old measurements (>1 year old).

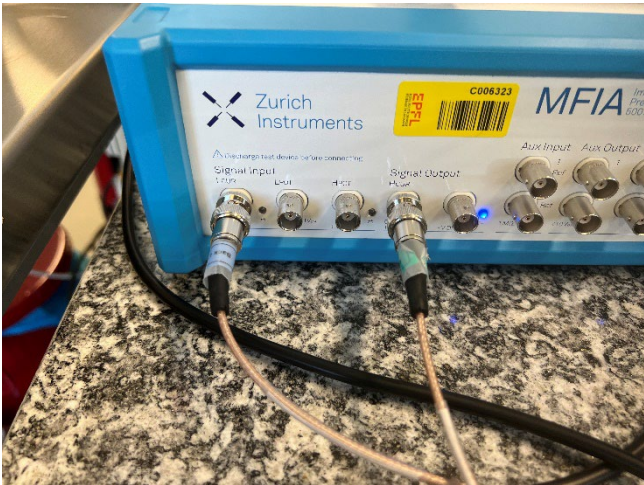

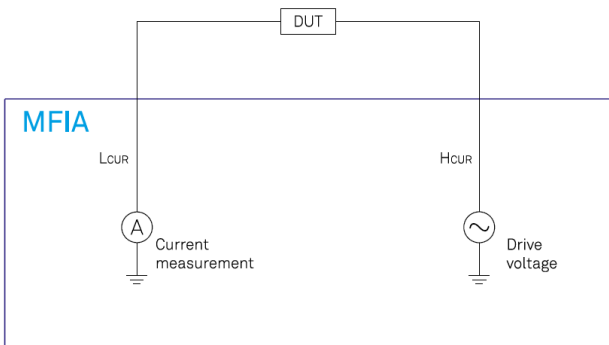
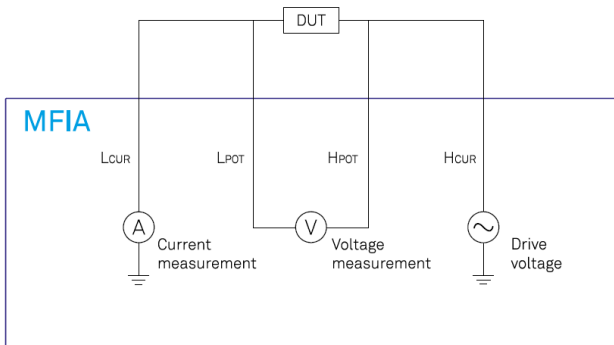
6. AC measurements: ZI MFIA probe connection set-up

Note: The advanced operation manual for the Zürich Instruments MFIA and LabOne software can be found [here](https://www.epfl.ch/research/facilities/cmi/wpcontent/uploads/2023/06/ziMFIA_UserManual.pdf):

https://www.epfl.ch/research/facilities/cmi/wpcontent/uploads/2023/06/ziMFIA_UserManual.pdf

The Zurich Instruments multi-frequency impedance analyzer (MFIA) is a digital impedance analyzer and precision LCR meter that operates in the frequency range from 1 mHz to 5 MHz. The MFIA has a basic accuracy of 0.05% and operates over a measurement range spanning from 1 mΩ to 1 TΩ.

The probe's BNC cables are connected directly to the front panel of the MFIA. Connections for 2-probe and 4-probe measurement setups are shown below, as well as the measurement circuits:

BNC connections for 2-probes impedance measurements	BNC connections for 4-probes impedance measurements
	
	

7. AC measurements: LabOne software

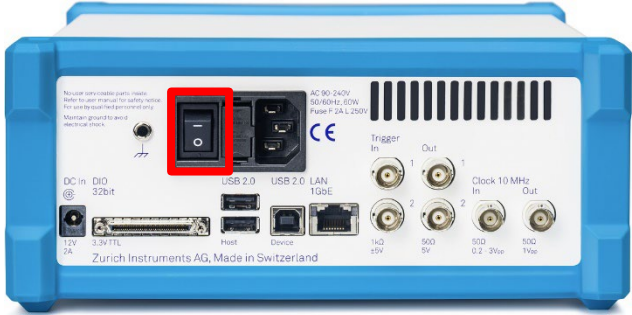

The LabOne software is used to control the MFIA and perform AC measurements on your devices. The following section gives you a description of the basic use of the software.

Advanced users will find more details in the .pdf user manual:

https://www.epfl.ch/research/facilities/cmi/wpcontent/uploads/2023/06/ziMFIA_UserManual.pdf

Quick guide:

- Switch on the ZI MFIA and start the LabOne software:

	 <div style="border: 2px solid red; padding: 5px;"> <p>Found devices (double click to open)</p> <p>MFIA - DEV6758 - 192.168.105.154</p> </div>
<p>Switch the ZI MFIA power on (backpanel). Wait for the status LED to turn blue.</p>	<p>After completion, double click on the “MF Device Finder” icon. A list with the device IP should show up. Double click on the device to start LabOne in a browser window.</p>

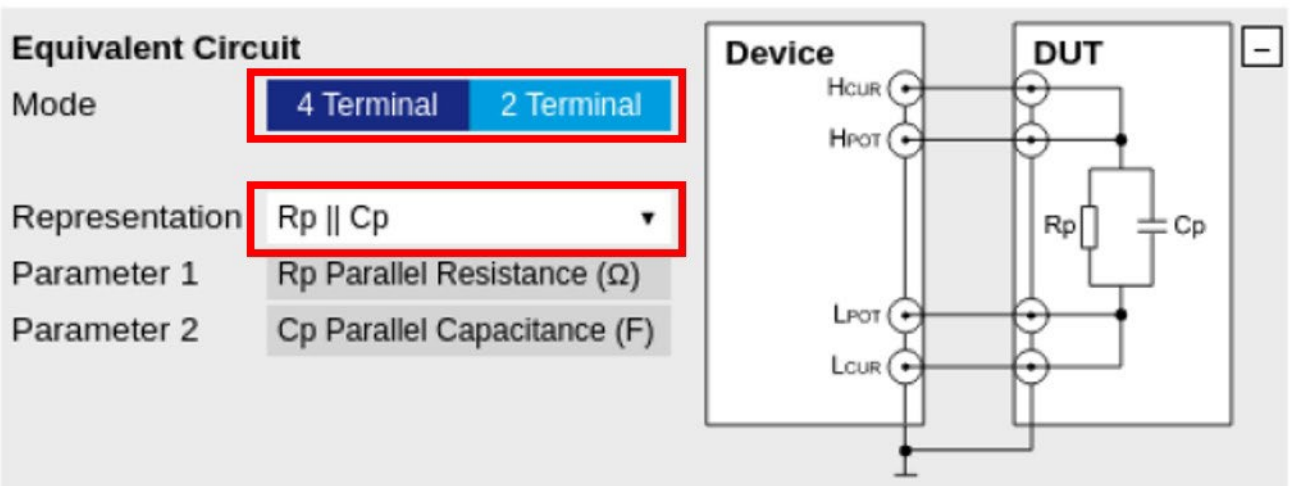
- The impedance analyzer tab is the main control panel for impedance measurements. You can start it by clicking:



- To take measurements, proceed as follows:

The first operations are 1) to set the operating mode (2-probes or 4-probes) matching the probe BNC connections, 2) to set a representation of the DUT to extract the desired parameters. For this, users need to have a good idea about the electrical behavior of their devices.

Both operations are done in the “Equivalent Circuit” window of the impedance analyzer tab (see below).



In the “Measurement Control” tab, select the “Application” mode and choose one of the two standard measurement setups: 1) **LCR Impedance Measurement**, 2) **DC Impedance measurement**. The test signal is set on the right side of the window. The measurements are streamed continuously by clicking on “Enable”.

Measurement Control

Enable ☒

Test Signal (V) 300.0m ☒

Osc Frequency 1.00000000k

Mode

Application **Application** Advanced

Application LCR Impedance Measur ▼

Precision High → medium settling ▼

One-Period Avg ☒ ☐

Range Control

Input Control Auto ▼

Current Range 10.0m







Voltage Range 1.0

Measurement Results

Real(Z)	+1.79256 Ohm
Imag(Z)	-3.14018 kOhm
Abs(Z)	+3.14019 kOhm
Phase(Z)	-89.96729 deg
Frequency	+510.00000 kHz
Parallel Resistance	Suppression
Parallel Capacitance	+99.37900 pF

Real-time measurement results for the device impedance and the extracted LCR values are directly available in the “Measurement Results” tab.

- Note that several parameters (such as DC bias offset) will be available only in the “Advanced” operating mode (see the .pdf guide for more information).
- Besides the “Measurement Results” tab, the MFIA feature a comprehensive tool set to analyze signals both in the time and frequency domains (see below).
- There is not strict distinction between the set of tools and some capabilities are overlapping between the different options. In general, for analyzing **fast signals** of ~60 million samples per second (MSa/s), users should use the **Scope (time and frequency domains)**. For slow signals, < 200 kSa/s, users should use the **Plotter or DAQ (time domain)**, and the **Spectrum or Sweeper (frequency domain)**.

Numeric		Access to all continuously streamed measurement data as numerical values.
Plotter		Displays various continuously streamed measurement data as traces over time (roll mode).
Scope		Displays shots of data samples in time and frequency domain (FFT) representation.
DAQ		Provides complex trigger functionality on all continuously streamed data samples and time domain display.
Spectrum		Provides FFT functionality to all continuously streamed measurement data.
Sweeper		Sweep frequencies, voltages, and other quantities over a defined range and display various response functions including statistical operations.

- Saving data can be done with different methods:

1. Plots can be exported as data to .CSV or as pictures with the following two



buttons:

2. Some of the tools, such as the Sweeper or the Spectrum, are storing measurement data in an "History" list. Data available in the list can be saved directly to .CSV with the button:



8. Logout

- At the end of the measurement session, close the EasyEXPERT or LabOne softwares.
- Move all micro-probe tips about 1mm up (above the medium z marker)
- Move probe platform at higher safety position.
- Slide chuck fully to front.
- Unload the wafer. Move chuck back under the optics.
- Turn off the scope illumination.
- Logout off "MPI TS150 – Manual prober" with CAE on zone 11 (CMi+1) accounting computer.