SoP of I-V Simulator System

Part – 2

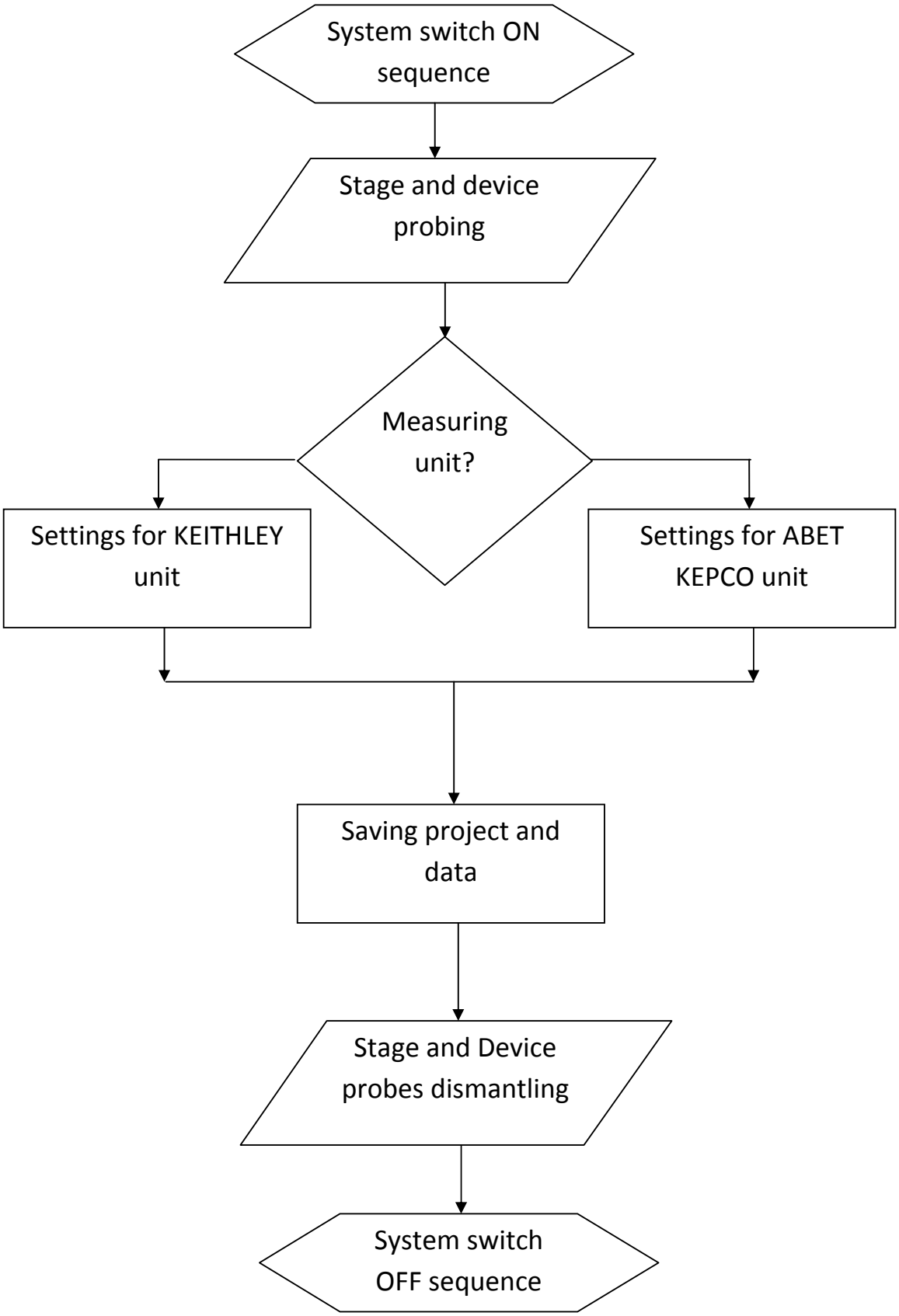
SUN 3000 SOLAR

SIMULATOR

ABET Technologies

Standard operating procedure:

Flowchart of sequence to be followed:



- **<u>System Switch ON sequence to be followed:</u>**

  - ✓ Switch ON system main board power ---> System Spike buster power (Green colour switch) ---> Simulator Power supply switch ---> wait for 10 seconds ---> Check the lamp preset current value is 50 A and then switch ON the lamp power switch.
  - ✓ If lamp preset value has been changed, check with '**System Service and Maintenance procedure'**.
  - ✓ If chiller is required for the experiment, check for proper water level in the chiller and Switch ON chillers main board power supply ---> then switch ON chiller unit ---> set the temperature required and start the system.
  - ✓ Wait for 30-45 minutes to get the lamp saturate in its irradiance.
  - ✓ Switch ON PC system main board switch ---> Switch ON the PC system and monitor.
  - ✓ Insert the USB Simulator Tracer Software key.

- **<u>Stage and Device probing to be followed:</u>**

  - ✓ During the wait time for lamp irradiance to saturate, get the stage and probing ready for the device under characterization.
  - ✓ Switch ON the vacuum pump to get the suction pressure to hold the device in stage. As per requirement depending on the device area switch ON appropriate vacuum holes in the stage.

  - ✓ For *c-Si cell use default stage (Thermo chuck)* ---> Place the cell at the centre of the stage and as per requirement depending on the device area switch ON appropriate vacuum holes in the stage to hold the device ---> set the bus bar probe exactly on the bus bar of the device by using the stage in service method (i.e. stage handle held with notch lock to have some air gap between cell and bus bar probe) use the required number of bus bar probes depending on the number of bus bar in the device ---> use 'Kapton' insulator to

insulate the remaining bus bar probes so that they don't make a short circuit by having contact with the stage ---> after setting the bus bar probe to match with device bus bar, release the notch lock to make the bus bar probe contact with the device bus bar ---> visually inspect if the contact is proper or not (a minimum of 2 pins of which one must be the centre pin of the bus bar probe must make the contact for proper measurement) ---> Connect the probe connectors to the probe station board.

- ✓ If the contacts are not properly made with the bus bar of the device, refer the '**System Service and Maintenance procedure'** for fine adjustments to be made.

- ✓ For *Special type of top contacts using the default stage* ---> Place the cell at the centre of the stage and as per requirement depending on the device area switch ON appropriate vacuum holes in the stage to hold the device ---> use micromanipulator probes for top contact ---> Dismantle the default bus bar probe station ---> fix the micromanipulator stage ---> set the micromanipulator on the stage base plate and magnetise it ---> probe the top contact appropriately (both the micromanipulator probes must contact the top contact area for proper measurement to be made) ---> visually inspect the contact made with microscope if required ---> Connect the probe connectors to the probe station board.

- ✓ For *Special type of cell devices (devices that require back side illumination)* ---> Dismantle the default thermo chuck stage and fix the flip-chuck stage ---> set the device with the slider moved to appropriate level depending on the cell area in the flip-chuck ---> switch ON vacuum holes appropriately for the cell area ---> set the micromanipulators on the stage base plate and magnetise it ---> probe the contacts appropriately (both the micromanipulator probes must contact the contact area for proper measurement to be made) ---> visually inspect the contact made with microscope if

required ---> flip the chuck slowly and set it for measurement ---> Connect the probe connectors to the probe station board.

- **<u>Settings for KEITHLEY unit:</u>**

  - ✓ Open the Simulator Tracer software in PC ---> wait for 30 sec ---> Switch ON the KEITHLEY unit ---> wait for 1 min.
  - ✓ In the Simulators Tracer software, go to **Hardware** tab ---> set device as KEITHLEY 26xx ---> shutter control as KEITHLEY 26xx.
  - ✓ In the Simulators Tracer software go to **Measurement** tab ---> check V_{oc} of the cell device by pressing V_{oc} button ---> check I_{sc} of the cell device by pressing I_{sc} button ---> repeat the same 3-4 times in intervals of 5 sec to see if there is large variation in the measurement (large variation in the measurement means, the four probe contacts are not made proper and this confirms electrical conductivity of the probes with the contacts, for more reference check in '**System Service and Maintenance procedure')**.

  - ✓ For *Illuminated I-V* ---> Set the range of the Voltage to be scanned appropriately after identifying the V_{oc} of the device ---> Set the current range appropriately after identifying in the I_{sc} of the device (I_{sc} greater than 1.5 A cannot be measured with KEITHLEY unit, switch to KEPCO for the measurement) ---> Set the material of the device in the dropdown list ---> set the substrate type as P – type or N – type ---> Select Illuminated I-V for illuminated I-V measurement ---> Click 'Start Trace' ---> Define name of the sample, Active Area of the sample ---> Run the scan ---> After 15 – 20 Seconds the measured I-V plots and database generates in the project.

  - ✓ For *Dark I-V* ---> Set the range of the Voltage to be scanned appropriately in the range required for scanning the device ---> Set the current range appropriately (ideally 1-10 mA for small area devices and 1 A for large area devices ---> Set the material of the

device in the dropdown list ---> set the substrate type as P – type or N – type ---> Select Dark I-V for dark I-V measurement ---> Click 'Start Trace' ---> Define name of the sample, Active Area of the sample ---> Run the scan ---> After 15 – 20 Seconds the measured I-V plots database generates in the project ---> Right click the plot, select 'Logarithmic' to view the Logarithmic of the plot.

- **<u>Settings for KEPCO unit:</u>**

  - ✓ Open the Simulator Tracer software in PC ---> wait for 30 sec ---> Switch ON the KEPCO unit ---> wait for 1 min.
  - ✓ In the Simulators Tracer software, go to **Hardware** tab ---> set device as ABET KEPCO ---> shutter control as ABET KEPCO.
  - ✓ In the Simulators Tracer software go to **Measurement** tab ---> check V_{oc} of the cell device by pressing Start V_{oc} button ---> check I_{sc} of the cell device by pressing End I_{sc} button ---> repeat the same 3-4 times in intervals of 5 sec to see if there is large variation in the measurement (large variation in the measurement means, the four probe contacts are not made proper and this confirms electrical conductivity of the probes with the contacts, for more reference check in '**System Service and Maintenance procedure')**.

  - ✓ For *Illuminated I-V* ---> Set the range of the Voltage to be scanned appropriately in the slider after identifying the V_{oc} and I_{sc} of the device ---> Left side of the slider corresponds to I_{sc} setting and Right side corresponds to the V_{oc} setting ---> Since KEPCO unit measures the device floating I-V, Set the current side slider range approximately to the range of the I_{sc} measured and voltage side slider range approximately a little forward biased than the exact '0' current measured at the V_{oc} (example 0.3-0.8 V in the right side slider range) ---> Set the material of the device in the dropdown list ---> set the substrate type as P – type or N – type ---> Select Illuminated I-V for illuminated I-V measurement ---> Click 'Start

Trace' ---> Define name of the sample, Active Area of the sample ---> Run the scan.

- ✓ For *Dark I-V* ---> Measure the Dark I-V using KEITHLEY unit using the KEITHLEY settings as discussed above, ABET KEPCO is not very sensitive to lower currents ---> ABET KEPCO can measure effectively in the current range of 1 A to 20 A only.

- **<u>Saving Project and Data:</u>**

  - ✓ After completion of all measurements, *save the data to a project file* in the folder directory in the desktop named 'User Files' in the order of Department ---> User ---> Date.
  - ✓ After saving project, to *extract data of each measurement* ---> Right click individual measurement in the data base of the project ---> Select Export data ---> Select 'Standard curve file' ---> Give suitable name to the measurement data ---> Save the data to export the measurement to a '*.stf' file in the project directory ---> The exported stf file format can be accessed through Notepad ---> Repeat the same for all measurements in the project database.

- **<u>Stage and Device probe dismantling to be followed:</u>**

  - ✓ Save the project > in 'Hardware Tab' set Driver as 'No Device' and Shutter control as 'No Device' > close the Tracer software.
  - ✓ After saving the data, to dismantle special probes and shut down the simulator follow dismantling sequence followed by system switch off sequence.
  - ✓ As per requirement depending on the device area in which vacuum holes were put ON in the stage, put all of them to down position (switch OFF position). Switch OFF the vacuum pump to get the suction pressure OFF in the device stage.

- ✓ For *c-Si cell the default stage (Thermo chuck)* ---> Lift the stage handle ---> Put the stage handle notch lock ---> Displace the Bus bar probes to the ends of the stage ---> Check for the vacuum holes switches OFF ---> Remove the 'Kapton' insulators from the stage if used for measurement ---> Remove the Cell / Device ---> Disconnect the probe connectors from the probe station board.

- ✓ For *Special type of top contacts used along with the default stage* ---> Loosen the Micromanipulators to up position ---> Check for the vacuum holes switches OFF ---> Remove Micromanipulator probes by releasing their magnetic base from its stage ---> Place them in their respective box ---> Remove the Cell / Device from the stage ---> Fix the default bus bar probe station to the stage ---> Disconnect the probe connectors from the probe station board.

- ✓ For *Special type of cell devices (devices that required back side illumination)* ---> Loosen the Micromanipulators to up position ---> Check for the vacuum holes switches OFF ---> Remove Micromanipulator probes by releasing their magnetic base from its stage base ---> Place them in their respective box ---> Switch OFF the vacuum holes that were turned ON for holding the cell ---> Remove the Cell / Device from the stage by loosening the hold area clip ---> turn the flip-chuck to its default position ---> Disconnect the probe connectors from the probe station board ---> Dismantle the flip-chuck stage and fix the default thermo chuck stage back to its position.

- **<u>System Switch OFF sequence to be followed:</u>**

- ✓ Remove the USB Simulator Tracer Software key, and place it safely in cover.
- ✓ Switch OFF PC system and monitor ---> Switch OFF PC main board switch.

- ✓ If chiller was used for the measurement, check for proper water level in the chiller and Switch OFF chiller unit ---> then switch OFF main board power supply of the chiller.
- ✓ Switch OFF lamp in the simulator ---> wait for 10-15 minutes to let the lamp cool down ---> then switch OFF the simulator power supply switch.
- ✓ While waiting for the lamp to cool down, switch OFF KEITHLEY and ABET KEPCO units which ever was used for the measurement respectively.
- ✓ After switching OFF the simulator power supply ---> switch OFF spike buster power switch (Green glowing switch) ---> at last switch OFF system main board power supply of the Simulator.

- **<u>Mandatory steps to be followed for cell area less than 156 sq.cm:</u>**

  - ✓ Prepare a Black chart paper of the size of the Thermochuk and leaving open in the middle for the area of the active are to be exposed to the illumination.
  - ✓ Place the Black chart paper in the Thermochuck at the center with the cell to be measured, ensure that the chuck is not exposed to direct beam to avoid reflection. It acts as a mask.
  - ✓ The use of black paper is to avoid the light reflected from the chuck to get to the cell and result in wrong measurements (increase in intensity more than one sun).
  - ✓ Proper care must be taken while using the black chart paper that the pogo pins are not disturbed and prevent them from breaking.
  - ✓ Take training/orientation sessions on the same if you require confidence in using this methodology.

- **<u>Mandatory steps to be followed in chiller usage:</u>**

  - ✓ The chiller unit water circulation is mandatory for using the Thermochuck.

- ✓ Ensure that the chiller is also turned ON when the Lamp is turned ON in the simulator.
- ✓ The temperature is to be maintained at 25° C in during the measurements for proper measurements to take place.
- ✓ Only RO water must be filled in the chiller tank. The tank must be emptied and refilled new every Friday during the cleaning sessions.
- ✓ The Thermochuck should not be disconnected/removed from the tool without Prior permissions from the SO for special purpose usages.

- **<u>Mandatory Policy to be followed for using ABET simulator:</u>**

1. I-V measurement for solar cells having dimensions 2 cm X 2 cm or less will not be allowed on ABET I-V Solar Simulator.
2. The cells of the area in between 2 cm X 2 cm to 10 cm X 10 cm must be used to measure with black chart paper of exposed area of the cell for proper IV measurements and to avoid the reflections from the chuck. (Orientation session for the same will be given soon)
3. The stage is connected to chiller and water must be circulated to maintain the temperature of the stage during the measurements. (Orientation session for the same will be given soon)
4. Every week, during the cleaning session, the chiller water must be drained and new RO water must be replaced by the user who is incharge of cleaning the tool that day. (Orientation session for the same will be given soon)
5. It is mandatory that every week the chiller water must be drained and replaced new. (Orientation session for the same will be given soon)
6. **The stage should not be removed at any time and if required (for special requirements) prior permission must be taken from the SO to drain the circulating chiller water and then remove.**