

High Throughput Array Screening System



OPERATION and ASSEMBLY MANUAL

VERSION 4.0

High Throughput Array Screening System

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NuVant Systems, Inc.

Crown Point, Indiana

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***array*STAT High Throughput Screening Unit Specifications**



The *Array*STAT is an automated 25-channel potentiostat for high-throughput characterization of electrode components. The Arraystat can switch out (i.e. open circuit) any number of electrodes while others are tested either in parallel or sequentially. The operator can evaluate electrodes individually, or in separate rows or columns. The Arraystat can apply complex sequences of test parameters to any number of the array electrodes in parallel or sequentially.

ArraySTAT applications include:

- Fuel cell and battery components
- Electroplating
- Biomedical devices
- Electrochemical sensors
- Electrosynthesis
- Artificial photosynthesis
- Solar Cells
- Corrosion studies
- Flow field development
- Computational modeling validation

ArraySTAT options include:

- Heater module containing up to 15 PID type K temperature controllers integrated into the control program
- Mass flow controller module with up to 8 Alicat mass flow controllers integrated into the control program
- Parallel and serpentine fuel cell flow field configurations
- Humidifiers
- Liquid feed pump

ArraySTAT-HC (high current) Model Specifications

- Channel inputs: 25
- Applied Potential Range:
 - Single channel only: ± 9.5 V
 - 25 channels simultaneously: ± 5 V
- Applied Potential Resolution: 1 mV
- Compliance Voltage: Same as Applied Potential Range
- Current Range
 - Total Current: Up to 20 A on all channels combined
 - Current per channel: $= 20 \text{ A} / \# \text{ of channels on}$ and maximum 2 A.
E.g.: $20 \text{ A} / 18 \text{ channels} = 1.11 \text{ A}$ average per channel and maximum 2 A per channel.
- Measured Current Resolution: 1.5 mA
- Individually addressable electrode switching for low fuel and/or oxidant stoichiometric ratios

ArraySTAT-LC (low current) Model Specifications

- Channel inputs: 25
- Applied Potential Range:
 - Single channel only: ± 10.0 V
 - 25 channels simultaneously: ± 10.0 V
- Applied Potential Resolution: 1mV

- Compliance Voltage: ± 10.0 V all channels
- Current ranges: 2 (± 100 μ A and ± 10.0 mA)
 - Total Current: Up to 250 mA on all channels combined
 - Current per channel: 10.0 mA maximum
- Measured Current Resolution: 500 nA
- Individually addressable electrode switching for low fuel and/or oxidant stoichiometric ratios

ArraySTAT-ULC (low current) Specifications

- Channel inputs: 25
- Applied Potential Ranges: 2 (± 10.0 V and ± 1.0 V)
 - Single channel only: ± 10.0 V
 - 25 channels simultaneously: ± 10.0 V
- Applied Potential Resolution: ± 10.0 V Range = 1mV and ± 1.0 V Range = 0.1mV
- Compliance Voltage: ± 10.0 V all channels
- Current ranges: 3 (± 1 μ A, ± 100 μ A and ± 10.0 mA)
 - Total Current: Up to 250 mA on all channels combined
 - Current per channel: 10.0 mA maximum
- Measured Current Resolution: ± 1 μ A = 30 pA, ± 100 μ A = 3 nA and ± 10.0 mA = 30 μ A
- Individually addressable electrode switching for low fuel and/or oxidant stoichiometric ratios

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Chapter 1. Safety

1.1. Computer Control and System Safety

Precautions should be taken to ensure sustained operation of the PC controlling the ArraySTAT. A failure of the PC or a crash in the software for any reason may leave the load in an 'ON' but uncontrolled state that may damage the ArraySTAT.

1.2. Grounding

For the safety of the equipment and the operator, the ARRAYSTAT must be connected by means of a protective conductor to earth ground. Under no circumstances should the ground be bypassed. It is advisable not to unplug the instrument when not in use. This protection must not be disabled by the use of two-conductor extension cord or adapter, or any other type of connection that does not maintain earth ground continuity.

1.3. ESD Protection

Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. NuVant products are adequately protected against ESD for their intended use. However, it is possible to damage the product by delivering electrostatic discharges when touching, moving the product, or connecting leads. It is advisable to ground and discharge yourself before touching the product. It is also advisable to ground and discharge any leads and the fuel cell before connecting it to the array potentiostat.

1.4. AC Supply Voltage

Before first connecting the power supply to the equipment, make sure that the line voltage is nominally 120 volts. Never operate the equipment from a line voltage or frequency in excess of that specified. *The equipment may be damaged by the application of incorrect line voltage. Voltage and current conditions inside that equipment described in this manual are sufficient to cause injury and possible death. Only qualified technicians should be permitted to remove the cover or attempt repairs.*

1.5. Fuses

Upon blowing a fuse make sure that the replacement fuse, accessible from the exterior of the equipment on the rear panel, is of the correct rating. The rating of the ac line fuse must correspond to the values stated in the specifications. Refer to Section 3.1.2

1.6. Live Conductors

The opening of covers or removal of parts of this equipment could expose live conductors. The equipment must be disconnected from all power and signal sources prior to the onset of any adjustment, replacement, maintenance, or repair. Only qualified personnel must do adjustments, maintenance or repair.

Chapter 2. Hardware installation

2.1. Description of Controls and Connections

This section provides a general description of the controls and indicators of the panels on the Model ArraySTAT potentiostat.

2.1.1. Potentiostat Front and Back Panel

The following are the parts on the front panel of the Model ARRAYSTAT as shown in the diagram below.

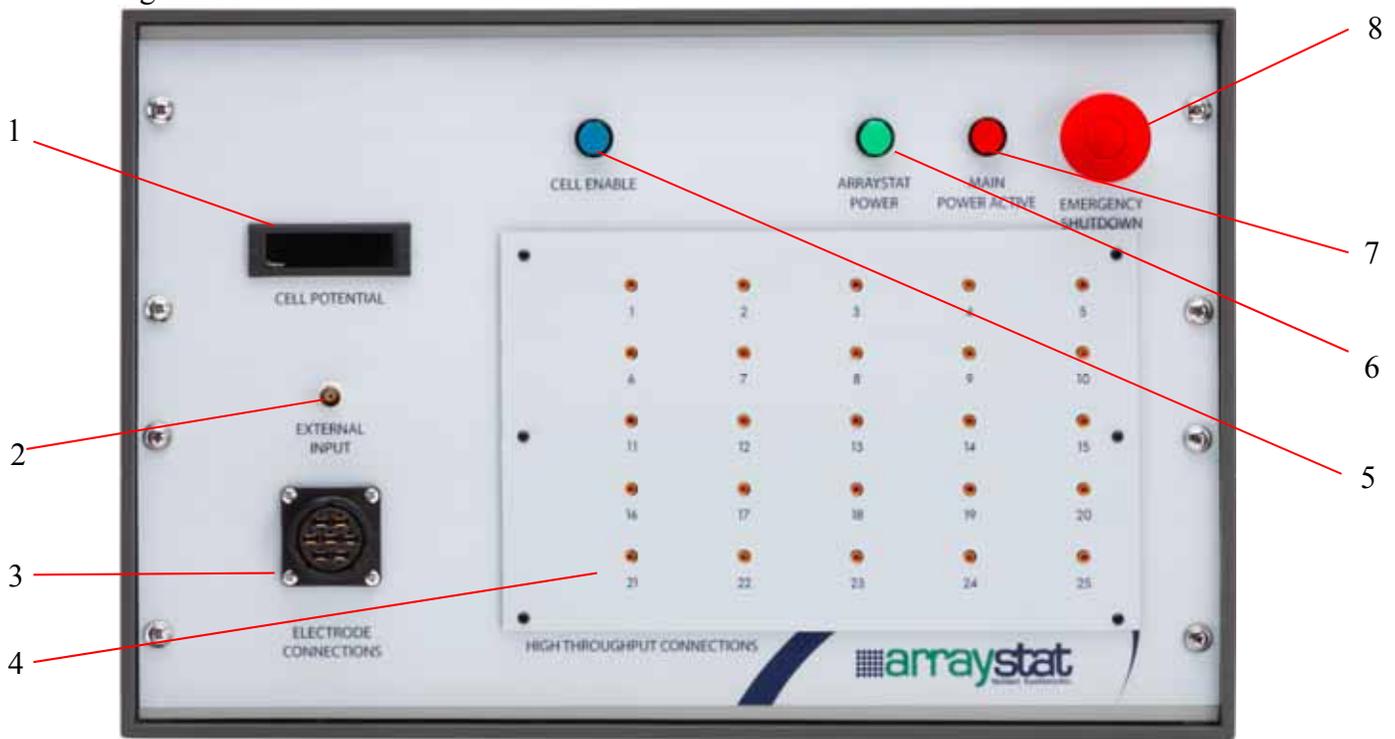


Figure 1 ArraySTAT Front Panel

1. Cell Potential Meter – This meter displays the potential of reference electrode versus chassis ground.

2. External Input – The BCN connector allows the system to be controlled by an external potential control source.

3. Counter, Reference Electrode and Ground Contacts – The counter lead must be connected directly only to the counter electrode plate of the fuel cell. Connecting to any other point on the fuel cell may result in damage to the load. The reference lead may be connected to an internal reference electrode if so desired. If no reference electrode is used it is suggested that this be connected to the counter electrode plate. The ground is present in case the user would like to install a faraday cage, this is suggested when attempting to analyze systems with very small currents (<50µA).

4. Working Electrode Jacks – This along with the counter/reference electrodes are the point of connection of the electronic load to the fuel cell. The unit is equipped with 25 working electrodes, which are connected to the cell by means of standard lead wires that are supplied.

5. Cell Enable Switch – Places the device in series with the potential follower board. This also acts as a safety feature wherein on turning off this switch the cell is isolated from the current flow.

6. Array Power Switch – This switch is used to turn on/off the power of *ArraySTAT* system not including the temperature controllers or heaters.

7. Main Power Light– This light is used to indicate if the main power is on or off.

8. EPO Switch – Emergency Power Off Switch is used to disconnect the power of all units in the *ArraySTAT* including load and temperature controller.

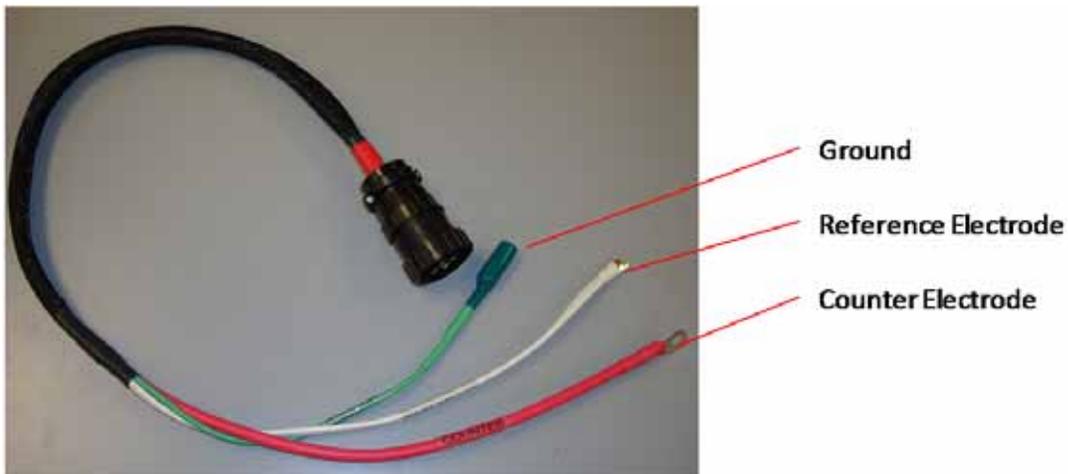


Figure 2 Electrode Cable

The following are the parts on the rear panel of the unit.



Figure 3 Rear Panel of the Instrument

1. DAQ Port – DAQ IN/OUT 1 and DAQ IN/OUT 2 are the ports through which the data acquisition (DAQ) card in the potentiostat is connected by the cables to the computer. These are standard equipment provided by National Instruments.

2. AC Power Input – The *ArraySTAT* is supplied with a power input socket and filter for connection to 120V ac, 50-60 Hz. For normal operation, a **TWENTY (20) AMPERE** normal blow fuse should be in each AC line fuse holder.

2.1.2. Dummy Cells

Dummy cells can be used to test the *ArraySTAT* potentiostat, when its working order is in doubt. This cell should consist of set of resistors with the known value of $1\ \Omega$ for *ArraySTAT*-HC and $10K\ \Omega$ (1^{st} current range), $1K\ \Omega$ (2^{nd} current range) for *ArraySTAT*-LC, these resistors can be placed in parallel with all 25 channels connected to a common counter plane. After connecting all the leads to the dummy cell in the typical fashion run a potential scan (as described in Chapter 3) and determined if the corresponding currents (in each of 25 channels) at the set potentials are the expected values, based on Ohm's Law ($E=IR$). For example, when scanning in the potential range of $-0.5\ \text{V}$ (initial potential) to $+0.5\ \text{V}$ (final potential) with a potential step of $0.1\ \text{V}$ and a time duration of 1 sec, the currents (*ArraySTAT*-HC) should vary between $-0.5\ \text{A}$ and $+0.5\ \text{A}$ as per Ohm's Law. The currents will be respectively different for *ArraySTAT*-LC when using different current ranges and resistors.

If you feel that your system is not functioning properly with the dummy cell, please contact NuVant Systems, Inc. If the dummy cell results appeared normal, and your actual

experiment is not giving the expected results, examine your setup carefully, giving special consideration to cell design, environmental interferences, bad reference electrode, bad connections, or grounding problems.

2.2. Model *ArraySTAT* Fuel Cell Load Precautions and Connection Information

2.2.1. System Connections

The *ArraySTAT*'s data acquisition system has the following electrical characteristics that **MUST** be observed.

1. The assembled high throughput device must be placed on a non-conducting and heat resistant surface so that it is not grounded.
2. Any heater attached to the fuel cell body or end plate must be completely isolated from the heater power source, such as the AC line. Leakage current from the AC line into the fuel cell electrode circuits may result in incorrect and noisy data readings and may cause damage to the *ArraySTAT* and its electronics.
3. Connections for the reactant supply on the Counter side are on the counter electrode and for the array side it is on the end plate. All reactant supply lines, and liquid cooling lines if used, **must** be non-conductive or have a non-conducting section, to provide for electrical isolation from the ground.
4. Care is to be taken in connecting the electrical leads between the pin-jacks on the array block and pin-jacks on the front panel of the *ArraySTAT* so that the numbering corresponds to the appropriate positions on the array, lest a wrong ranking of catalyst performances result.

2.2.2. Input Precautions

The maximum current of the *ArraySTAT*-HC is 20.0 AMPERES when all the channels are active. The current per channel **should not exceed 800 mA** when all channels are active or 2 A per channel when 10 or less channels are active.

The maximum current of the *ArraySTAT*-LC and *ArraySTAT*-ULC is 250 MILIAMPERES when all the channels are active. The current per channel **should not exceed 10 mA** when all channels are active.

Chapter 3. Software installation and operation

This chapter provides an overview of the NuVant ArraySTAT software used to control the ArraySTAT, acquire data traces and provide Graphic User Interface. Included in this section is the initial start-up of the fuel cell test system and software, application of reactant gases, electrical and mechanical connections and precautions, applying AC power to the test system hardware and, finally, starting the control program to test the system, as well as collecting and saving the data.

3.1. Software and Hardware Installation Instructions

The ArraySTAT software, ArrayWare, uses a run time engine and drivers provided by National Instruments. These must be installed before the ArraySTAT card, a NI PCIe - #####, is installed and the ArraySTAT connected and turned on. Please follow the steps below, in order, to ensure correct driver installation and hardware recognition.

NOTE: NuVant's default software is compiled with SSE2 USB device optimization. Intel processors prior to Pentium 4, AMD processors prior to Athlon 64, including all Socket A-based processors and some Celeron processors do not support SSE2. If your target PC processor does not support SSE2 instructions please contact NuVant at 219-644-3231 and ask for a version of code that does not contain SSE2 optimization.

1) Run LVRTE2011std.exe to install the LabVIEW 2011 Standard Run-Time Engine. This file is located on the installation CD at '**DVD drive**':\LVRTE2011 std\LVRTE2011std.exe. Use the default installation parameters. The LabVIEW 2011 Standard Run-Time Engine is also available for download at:

<http://joule.ni.com/nidu/cds/view/p/id/2534/lang/en>

NOTE: The installation files for the Run-Time Engine are automatically extracted to a directory on disk. The installer does not remove the files after installing, if you want to remove these files from disk, be sure to note their location during the unzipping process. Reboot following installation of the LabVIEW 2011 Standard Run-Time Engine.

2) Run the self-extracting executable NIDAQ940f1.exe. This will install NI-DAQmx 9.4 and all necessary driver files. The file is located on the installation CD at '**DVD drive**':\NIDAQ v940f1\NIDAQ940f1.exe. Use the default installation parameters. NI-DAQmx 9.4 is also available for download at:

<http://joule.ni.com/nidu/cds/view/p/id/2604/lang/en>

NOTE: To conserve disk space you can delete your extracted files. It is recommended that you keep the extracted installation files in case you need to add features from the NI-DAQmx distribution in the future.

Reboot following installation of NI-DAQmx 9.4.

3) If the Mass Flow or Temperature Controller option was ordered, complete this step. If no computer automation of Mass Flow or Temperature control is anticipated skip this step. Run the self-extracting executable niser380.exe. This will install NI-Serial 3.8. The file is located on the installation CD at '**DVD drive**':\NISER v380\ niser380.exe.

Use the default installation parameters. NI-Serial 3.8 is also available for download at: <http://joule.ni.com/nidu/cds/view/p/id/2639/lang/en>

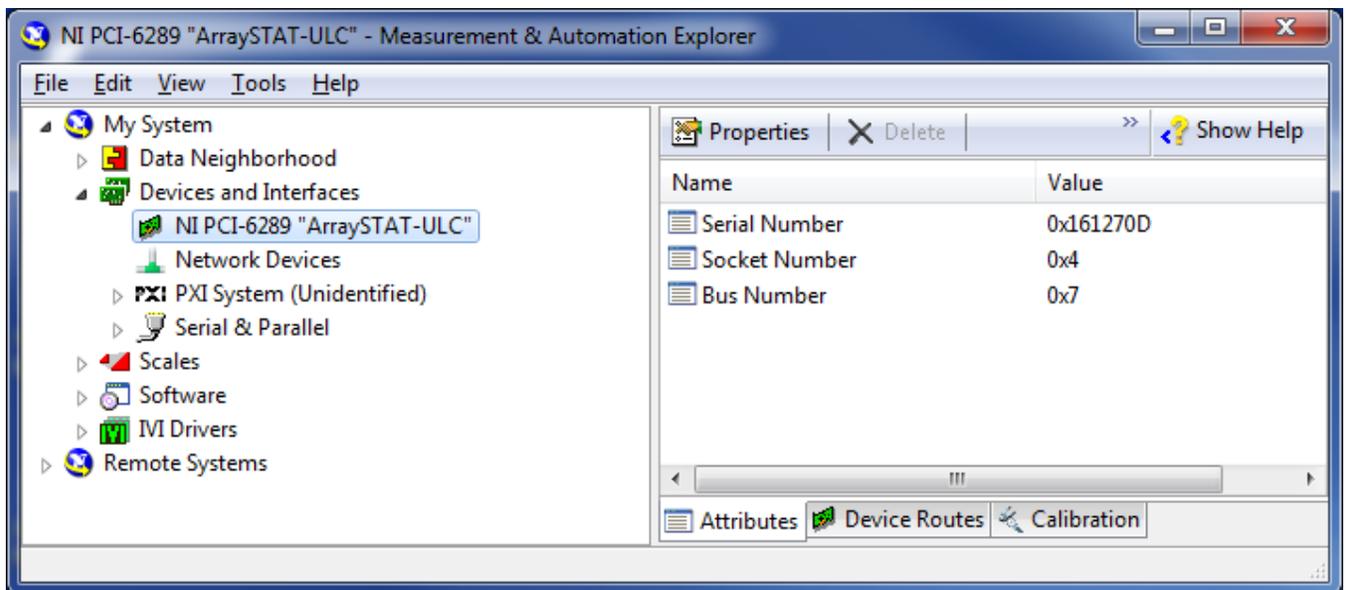
NOTE: To conserve disk space you can delete your extracted files. It is recommended that you keep the extracted installation files in case you need to add features from the NI-Serial 3.8 distribution in the future.

Reboot following installation of NI-Serial 3.8. Further instructions for configuration of serial ports for your equipment is in the ArraySTAT-ULC operation manual.

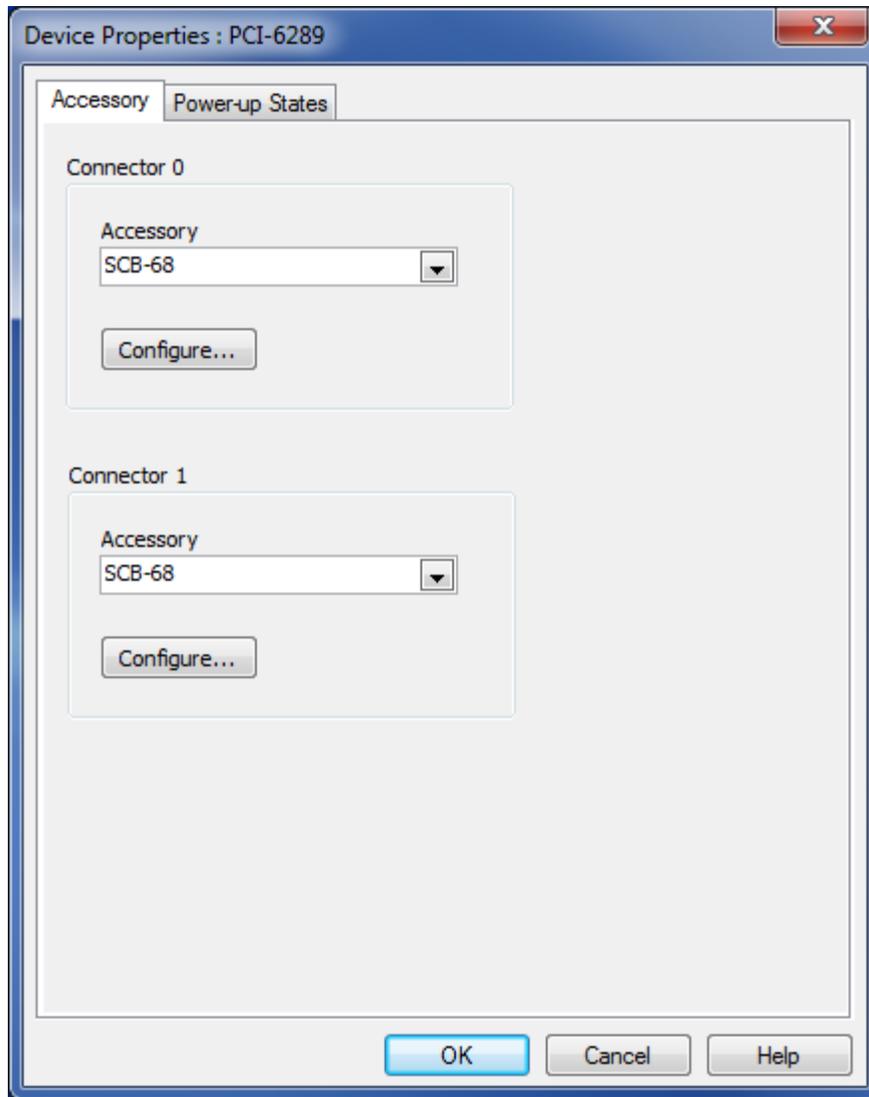
4) Turn off your PC, touch a metal part of the case then disconnect the power cord. Install the NI PCI - 6289 card into a standard PCI slot. Preventing static discharge to the card is important. Plug in the two black cables (cable 0 and cable 1) into the labeled jacks on the card and ArraySTAT-ULC then reconnect the PC power and reboot. Please leave the ArraySTAT-ULC power off while doing this. The card is powered by the PC.

5) The Add New Hardware Wizard will run automatically. Please wait for the Wizard to complete fully--it needs to run twice, once for MAX and another time for Windows. If you are installing multiple NuVant devices, please exit all NuVant programs and plug in your NuVant devices one at a time ensuring the Add Hardware Wizard is completely finished with each device before plugging the next one.

6) Confirm installation of the hardware in the National Instruments Measurement & Automation Explorer (MAX). MAX installs with NI-DAQmx and is under **Program Files\National Instruments\Measurement & Automation**. Click on the expand symbol next to **Devices and Interfaces** and locate the NI PCI-#### card. Below, I've right clicked on the card and re-named my ArraySTAT card from 'dev1' to ArraySTAT-ULC to distinguish it from other devices on my PC. This helps if you wish to run more than one NuVant device with the same type of card.



7) With the NI PCI-#### card selected in MAX click on Properties (above the serial number of the card). Please select the SCB-68 Accessory for BOTH connectors as shown below then click OK.



Click **File-->Save All** then exit MAX.

8) Run the ArrayWare-*** installer. The file is located on the installation CD at '**DVD drive**':\ **ArrayWare-***vx.x.x.xxxx\Ins ArrayWare-xxx vx.x.x.xxxx.exe**. Use the default installation parameters. *NOTE: To recover space you may delete the extracted installation files. However, the program is only 14 MB so you may want to leave it. A re-boot is not required.*

9) Go to **Start-->All Programs-->ArrayWare-ULC vx.x.xx.xxxx-->ArrayWare-ULC** to run the program.

3.2. Starting the Control and Data Acquisition Software:

Note: It is recommended that you disable any screen saver when the control and data acquisition software is running so that it is possible to monitor the system to ensure proper functioning in the initial stages.

3.2.1. Start Screen

1. Go to **Start-->All Programs-->ArrayWare-ULC vx.x.xx.xxx-->ArrayWare-ULC** to run the program.

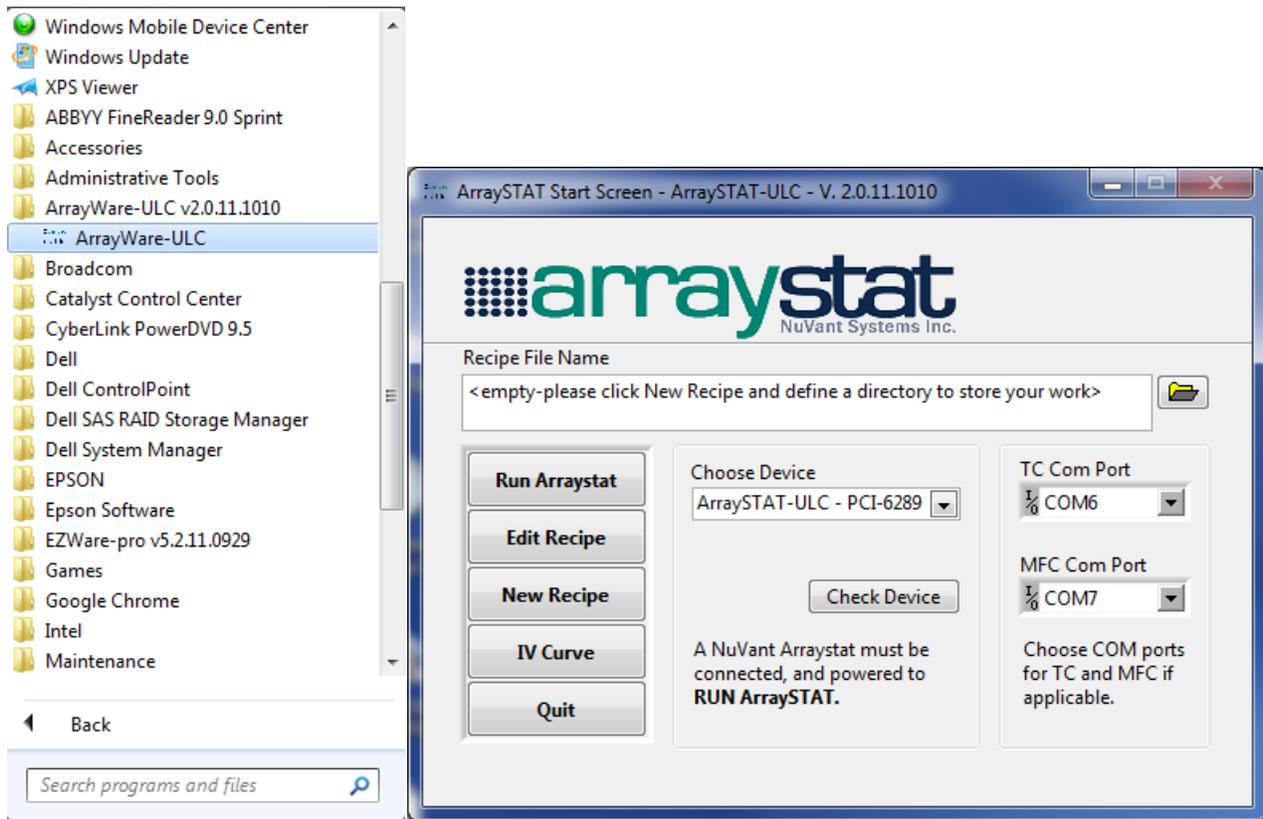
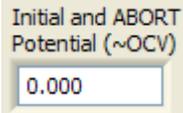


Figure 4, ArrraySTAT Start Screen

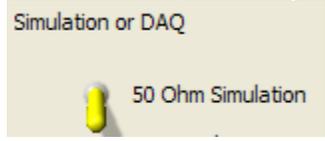
2. Other recipe files may be loaded from the Start Screen by clicking on the folder symbol  next to the **Recipe File Name** entry field.

NOTE: DONE UP TO HERE

3. Enter **Initial and Abort Potential(~OCV)** field , this voltage will be applied to the system while Run *ArraySTAT* window started.

4. If *ArraySTAT* is ready to run, turn the **Simulation or DAQ** switch on DAQ

position: . Users could also run simulations without hooking up computer with *ArraySTAT* system by putting this switch on 50ohm Simulation

position: .

5. To run the recipe, click **RUN *ArraySTAT*** button to open the [Run *ArraySTAT*](#) window, **EDIT RECIPE**, create a **NEW RECIPE** or open **Data Viewer** from this screen.
6. Clicking **EDIT RECIPE** button will open the [Recipe Editor](#) window, where users view and edit recipe file in this window. Or users could click **NEW RECIPE** button to create a new recipe file then click **EDIT RECIPE** button to start editing.
7. Clicking **IV Curve** button will open **IV Curve** window, where users view the history data and graph.
8. Clicking **QUIT** button closes all other running screen and users then exit *ArraySTAT*.

3.2.2. Recipe Editor

Before running it would be expedient to see what you are planning to do and make any changes necessary. Clicking **EDIT RECIPE** button will open the **Recipe Editor Window** as shown in the following figure. This is a simple interface and does not do any process control.

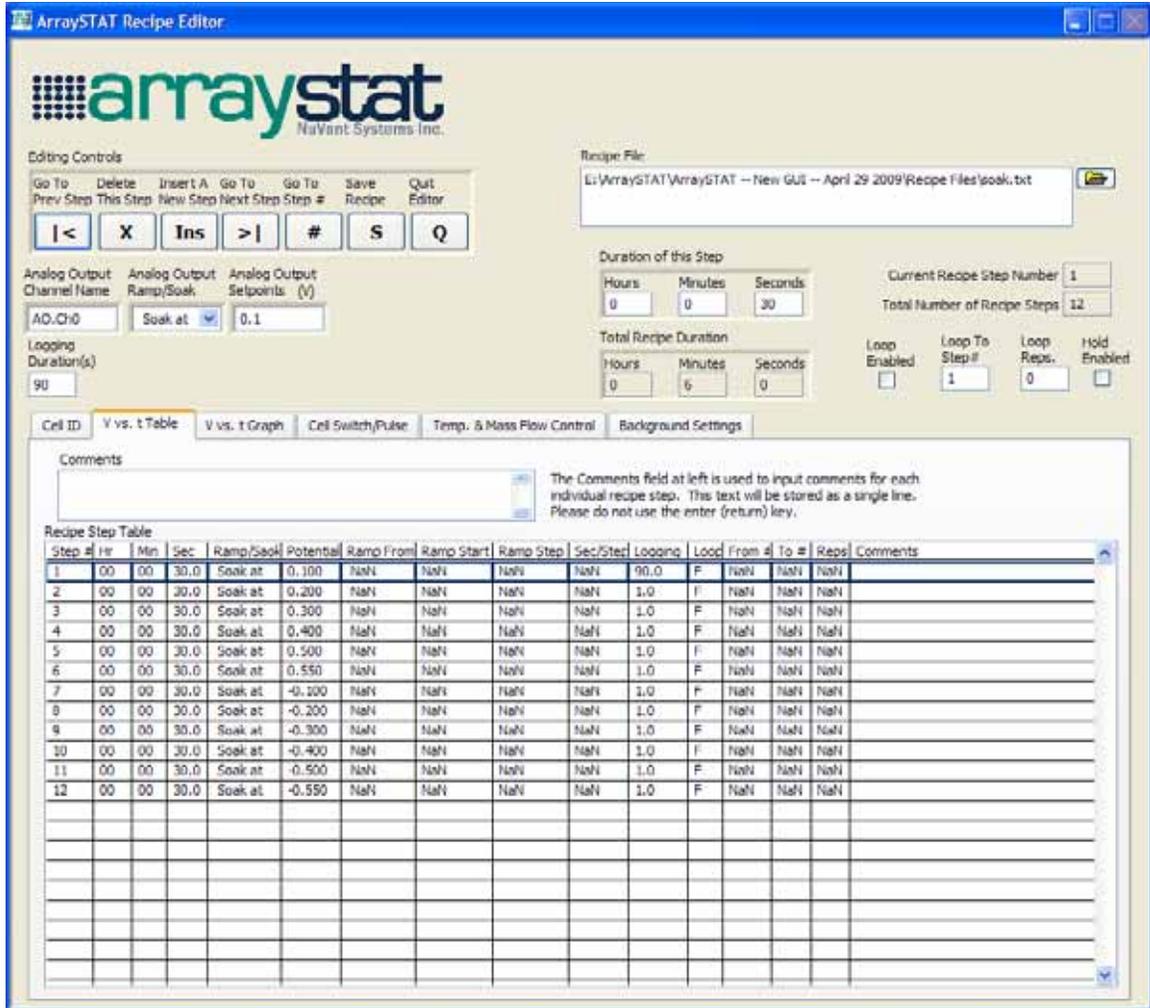
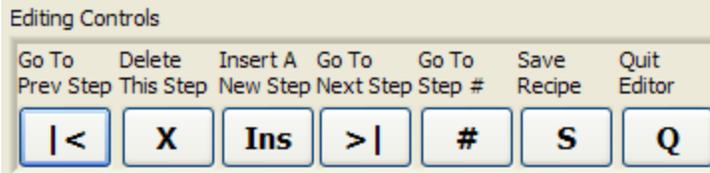
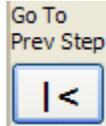


Figure 5 Recipe Editor Window

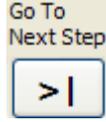
1. Recipe files can be loaded by clicking on the folder symbol  next to the **Recipe File** entry field.
2. The entire recipe is displayed in **Recipe Step Table**. Current step in the recipe is highlighted by blue border. Only this step is edited. Users can enter values of controls above Recipe Step Table to change the selected step.
3. To move between steps, users can use buttons in Editing Controls filed



to choose the step that needs to be edited:



-- Click **Go To Prev Step** button will move the highlight blue border up to the previous step and set it to be current selected step.



-- Click **Go To Next Step** button will move the highlight blue border down to the next step and set it to be current selected step.



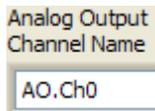
-- Click **Go To Step #** button will pop up a window and ask users to enter desired recipe step to edit, click **RETURN** button to close this window. The highlight blue border will be moved to the desired step.



-- Click **Delete This Step** button will delete the current selected step.



-- Click **Insert A New Step** button will copy the current selected step and insert it at current position.



4. **Analog Output Channel Name** field is the output channel name of *ARRAYSTAT* and doesn't need to change.

5. **Analog Output Ramp/Soak/OCV** controls the potential output type, soak or ramp or OCV:



OR

OR

Soak means holding the potential at the value in **Analog Output Setpoints** field,

, for a time period specified in **Duration of this Step** field

; If **Analog Output Ramp/Soak/OCV** control is set

to **Ramp**, **Ramp From** button is set to **Previous**, the potential will rise (or fall) from last step set point to **Analog Output Setpoint** entered in

field. If **Ramp From** button is set to **Absolute Value**

, the potential will rise (or fall) from **Ramp Start Point** entered

in **Ramp Start Point (V)** field. Users could check the **Reverse Ramp** box to run a reversed ramp of current

step. Three more controls -- **Ramp Step Size**, **Step OK?**, and **Ramp Step Duration (sec)** -- will show up.

User sets **Ramp Step Size** and **Ramp Step Duration**. The minimum value of **Ramp Step Duration** is 0.5s. Both of these parameters are measures of the

discrete staircase comprising the ramp. **Logging Duration(s)** field specifies the data logging duration, the minimum value of logging duration is 0.1 second. In ramp step, the program will record the last data point of each discrete staircase comprising the ramp. **Logging Duration(s)** only applies to soak steps.

6. User can create loops in recipe by checking the **Loop Enabled** button in the last step of the desired loop. **Loop to Step#** is the first step of the desired loop,

Loop To Step#	Loop Reprs.
<input type="text" value="1"/>	<input type="text" value="0"/>

Loop Reprs is the number of repetitions in the loop

7. **Total Recipe Duration** field computes and displays the total running time of entire recipe.
8. ArraySTAT allows users to turn on/off every cell or run different pulse train individually in Cell Switch/Pulse tab.

Total Recipe Duration		
Hours	Minutes	Seconds
<input type="text" value="0"/>	<input type="text" value="4"/>	<input type="text" value="2"/>

The screenshot shows the 'Cell Switch/Pulse' tab in the software. On the left, there is a 'Choose a Cell' list with cells 1 through 24. The 'Pulse Settings' section includes dropdowns for 'Cell Status' (set to On), 'Cell Plot' (set to On), and 'Cell Write' (set to On). Below these are input fields for 'On Time (s)', 'Off Time (s)', 'Number of Cycles', 'Delay (s)', and 'Total Time (s)', all currently set to 0. An 'APPLY' button is located below the input fields. The 'Pulse Setting Table' on the right is a table with 9 columns: Cell Number, Switch Status, Plot Cell, Write Cell, Delay(s), Number of Cycles, On Time(s), Off Time(s), and Total Time(s). The table contains 15 rows of data, with all 'Switch Status', 'Plot Cell', and 'Write Cell' columns set to 'On', and all numerical columns set to 0.0 or 1.

User could choose the cells that he/she wants to turn on/off or apply pulse train to in **Choose a Cell** panel. **Cell Status** control will change the cell to on/off or pulse status. When a cell is set to Pulse status, user need enter the value of **On Time(s)**, **Off Time(s)**, **Number of Cycles** and **Delay(s)** controls which define a pulse train. Delay(s) is the offset time that a pulse train has refers to beginning of current step. **On Time(s)** and **Off Time(s)** are the time the cell is on or off in a single cycle. **Number of Cycles** is the number of cycles of the pulse train. **Total time(s)** is the total running time of the pulse train. **Cell Plot** control will turn on/off the plot of each cell; **Cell Write** control will turn on/off the data recording of each cell.

- Users could control temperatures up to 8 channels at the same time of controlling voltage by specifying the set points of channel temperatures of each step. First of all, users need to specify the **Number of Temperature Controllers** used in the system. **Temp. Set Point** field is the set point temperature of each channel. Users could choose soak or ramp temperature to **Temp. Set Point** by clicking the **Temp. Ramp/Soak** button. Users could click **Apply to Rest Steps** button to apply the temperature settings of the rest of recipe steps. The Check box on the right side of Temp. Set Point is checked, the program will stay in current step until the Temp. Set Point is reached and stabilized.

The screenshot displays the 'Temp. & Mass Flow Control' tab in the software. It is divided into two main sections: 'Temperature Controller Settings' and 'Mass Flow Controller Settings'.

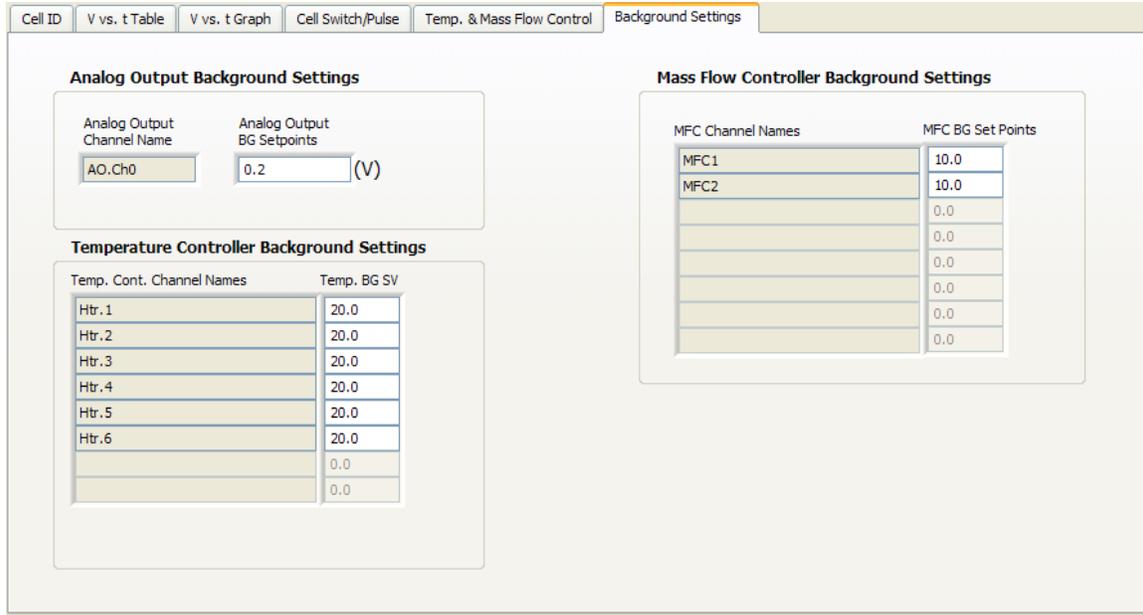
Temperature Controller Settings:

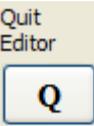
- Number of Temperature Controllers:** 6
- Temp. Cont. Channel Names:** Htr.1, Htr.2, Htr.3, Htr.4, Htr.5, Htr.6
- Temp. Ramp/Soak:** Soak at (selected for all channels), Ramp to (available for Htr.5 and Htr.6)
- Temp. Set Point:** 30.0 for Htr.1-4, 30.0 for Htr.5, 0.0 for Htr.6
- Checkboxes:** Present on the right side of the Set Point column for each channel.
- Apply To Rest Steps:** Button at the bottom.

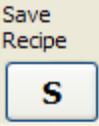
Mass Flow Controller Settings:

- Number of MFCs:** 2
- MFC Channel Names:** MFC1, MFC2
- MFC Ramp/Soak:** Soak at (selected for all channels)
- MFC Set Points:** 50.0 for MFC1, 50.0 for MFC2, 0.0 for subsequent empty rows
- Apply To Rest Steps:** Button at the bottom.

- Users could control gas flows up to 8 channels at the same time of controlling voltage and temperatures by specifying the set points of gas flow rate of each gas flow channel. First of all, users need to specify the **Number of MFCs** used in the system. **MFC. Set Points** field is the set point flow rate of each channel. Users could choose soak or ramp temperature to **MFC. Set Points** by clicking the **MFC Ramp/Soak** button. Users could click **Apply to Rest Steps** button to apply the temperature settings of the rest of recipe steps.
- The Background Settings tab allows users to set the background setting of Analog Output, temperature and mass flow rate when recipe is not running.



12. To leave the editor just click **Quit Editor** button . If you have not saved

your edits you will be asked to do so. You must click **Save Recipe** button  to save the file before any changes will be effective in the Run Screen.

3.2.3. Running ARRAYSTAT

Warning: It is strongly recommended that the “Cell Enable Switch” be set to the OFF state before loading and running a recipe. “Cell Enable Switch” must be set to the ON state before running the recipe.

After editing a recipe for use, load it into the Start Screen. Click the **RUN ArraySTAT** button to open the **Run Screen**.

1. The Run Screen will now appear as shown in the following figure. The **Initial**

and ABORT Potential (OCV) field  on **Feul Cell And ArraySTAT Settings** tab displays the initialization potential. This potential is applied upon starting the **Run Screen**. User may change this potential in this field and press the Enter button on keyboard to make the change take effect.

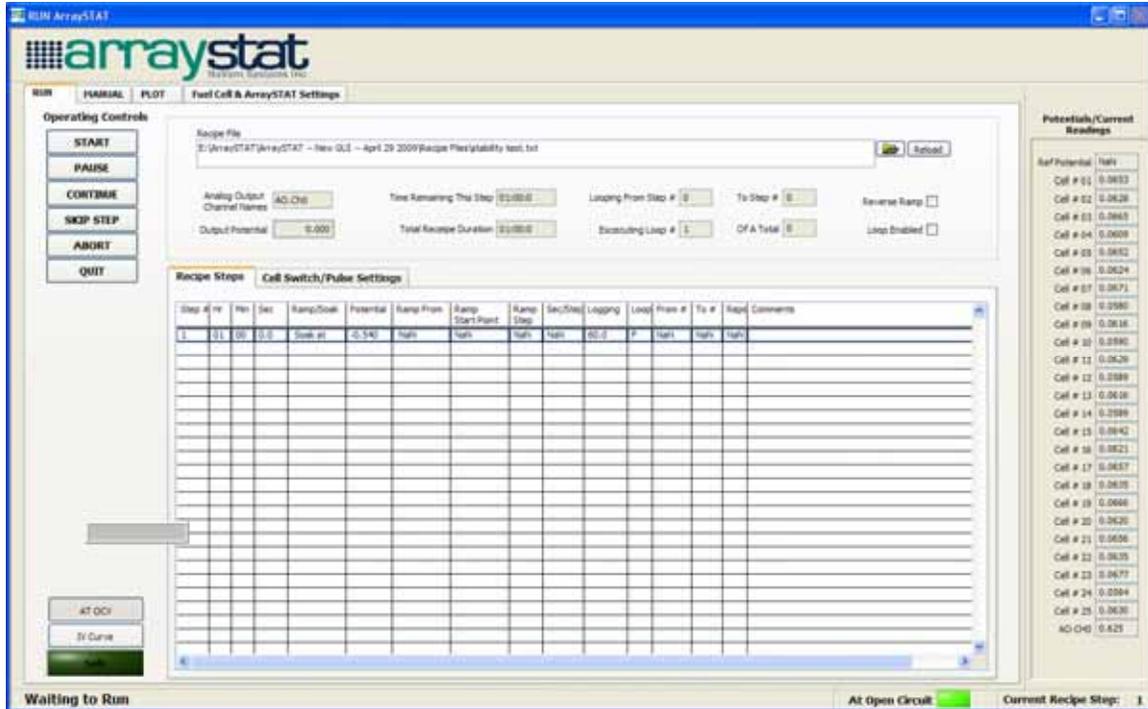
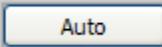
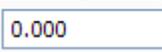


Figure 6 Run ArraySTAT Screen

2. Recipe files can be loaded directly from the Run Screen by clicking on the folder symbol  next to the **Recipe File** entry field.
3. If a recipe file of the same name as that presently loaded in the Run Screen has been edited, it must be **Reload**  for the changes to be loaded.
4. Clicking the **AT OCV/RECIPE DRIVEN** button  will send the potential above it to the *ArraySTAT* system.
5. Clicking **START** button in the **Operating Controls** menu will run the loaded recipe. User will be asked to choose whether he/she wants to log the data to a file or not. If users choose to create a file to save the data, the default file name is concatenated from the present date and time. Users may change the file name and the save path from the default. The file created are *.csv comma separated files. These *.csv files are automatically opened by Excel without the Import Wizard by double clicking on them. Modifications to *.csv files made in Excel must be saved as *.xls Excel files.
6. Clicking **PAUSE** in the **Operating Controls** will pause the execution of the recipe and hold your recipe at its present state and defer writing to your data file until the **CONTINUE** button is pressed.

- Users may then click the **MANUAL** tab to view the recipe override controls.

Pressing **Output Potential Auto/Manual**  button to disengage the ArraySTAT from the recipe voltage set point will allow users to enter a specified potential into the **Manual Potential**  field. If users plan to **CONTINUE** with the recipe, he/she must go back to **Auto** position of the **Output Potential Auto/Manual** control.

- Users could get into manual control mode by clicking the **GO TO OCV** switch then clicking **MANUAL** button to change to screen in Figure 7 Auto/Manual Control, clicking the **AUTO** button to toggle between recipe control and manual control status.

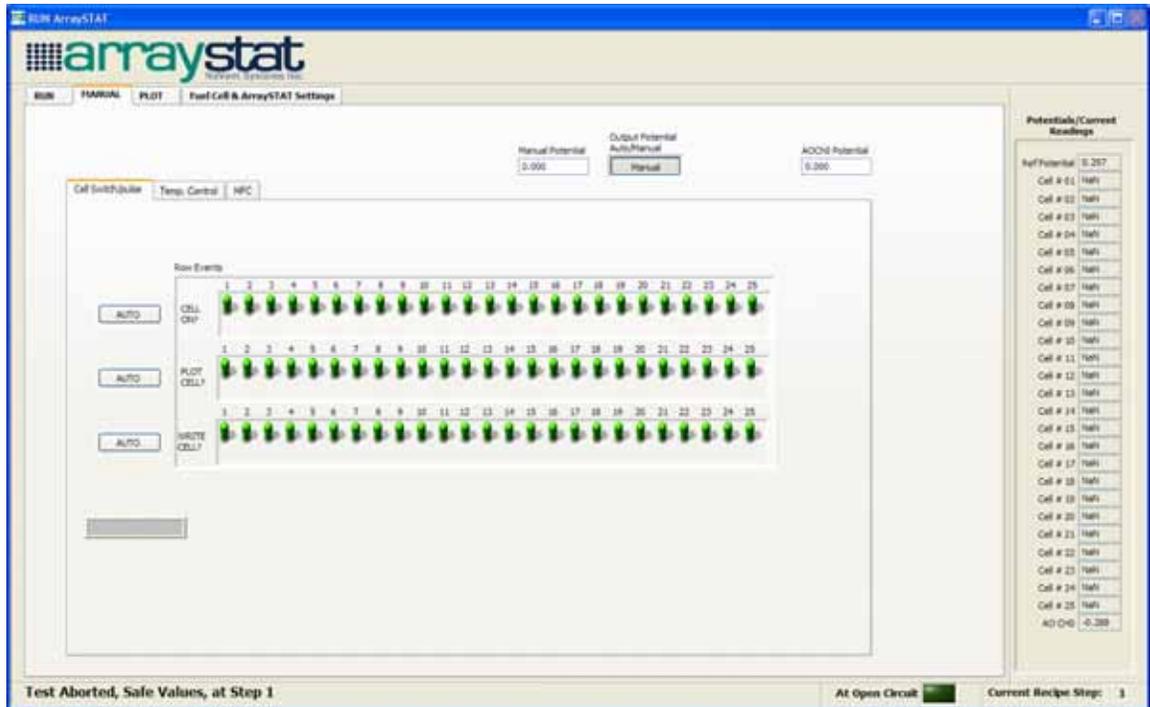


Figure 7 Auto/Manual Control

- As shown in Figure 7 Auto/Manual Control, Cell Switch, Temperature Controller and MFC are also controlled in this panel. In the **Cell Switch** tab, clicking the **AUTO** button to toggle between recipe control and manual control status. Turning on/off the switch in the **CELL ON?** row will turn on/off the corresponding cell. The switch in the **PLOT CELL?** row controls the plot of the corresponding cell. The switch in **WRITE CELL?** determines if the data of the corresponding cell will be logged into a file.

10. Users could view and control temperature in **Temp. Control** tab as shown in

Figure 8 Temperature Control. **Recipe SP** field is the temperature set point set in recipe, **Echoed SP** is the actual set point sent to temperature controllers. If users click **Set Points Auto/Man** button to change from recipe auto control to manual control status, changing the value in the **Manual SP** field will change the actual set point of temperature sent to the controller. **PV** is the present value of channel temperature measured by controller. button is used to control the heater of temperature controller, toggle this button will turn on/off the heaters of all channels. Choosing options from Output Type pull down box will change the control type between PID auto control/manual control/off. When the controller is in Manual mode, users could change the power percentage by changing the value in field. After start the ArraySTAT Run Screen, wait a couple of seconds for the program to establish the communication with temperature controller before start running the recipe. All temperature units are Celsius.

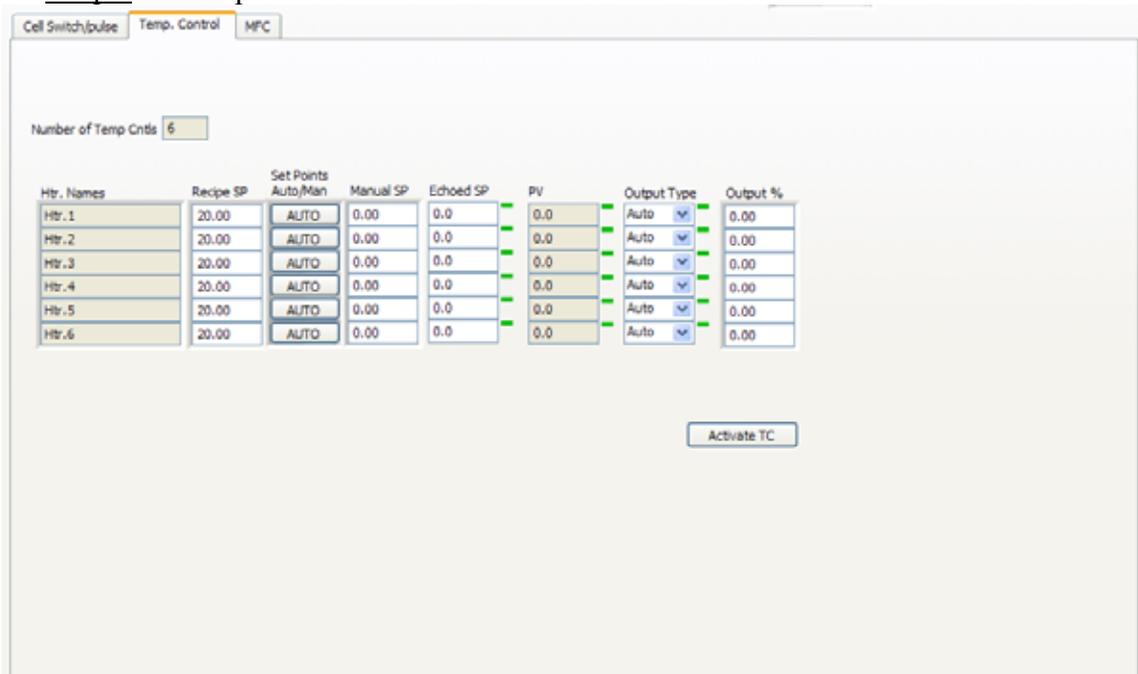


Figure 8 Temperature Control

11. Gas flow rates are controlled and displayed in **MFC** tab as shown in Figure 9 Mass Flow Control. Before control the MFC, users must press

button to activate the MFC control. field is the flow rate set point set

in recipe. If users click button to change from recipe auto control to

manual control status, changing the value in **MFC Setpoints** field will change the actual set point of flow rates sent to the mass flow controllers.

is the flow rate set point echoed from MFCs. is the

measured value of flow rate. are information related to specific MFC.

The MFC ID and full scale flow information should be written in C:\Program Files\ArraySTAT\Data\MFC.ini file as shown in Figure 10 MFC Configuration. MFC coming with *ARRAYSTAT* instrument are usually already configured. Otherwise users need read MFC manual to set up the ID before using it. Users probably need change the com port number according to which port they are using for MFC communication.

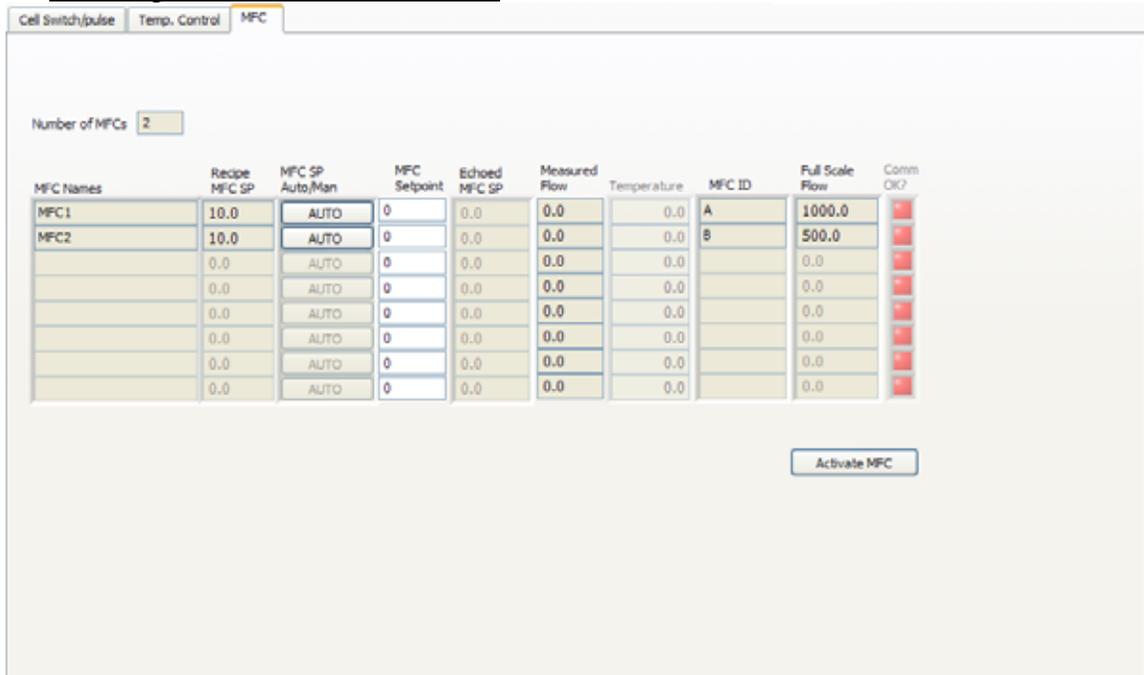


Figure 9 Mass Flow Control

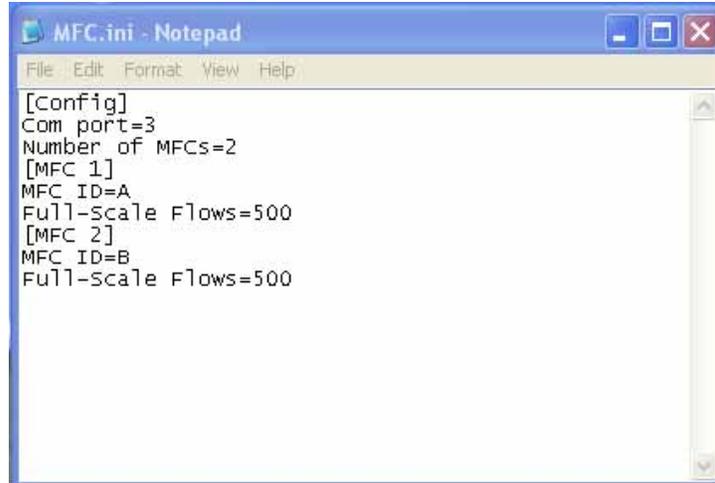


Figure 10 MFC Configuration

- Clicking **SKIP STEP** button in the **Operating Controls** will advance to next step of a running recipe. If no recipe is running or it is aborted, a window as shown in Figure 11 SKIP STEP window will prompt up to ask users to enter the desired step for the program, when the **START** button is pressed, it will jump from the present step to that step and begin execution.

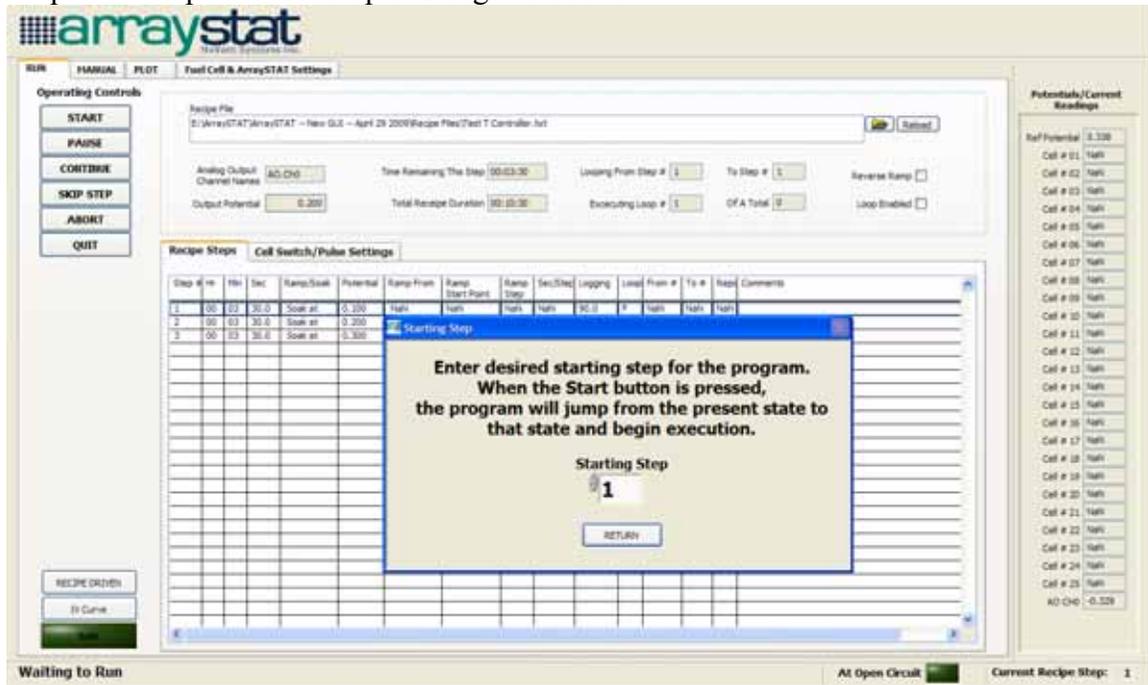


Figure 11 SKIP STEP window

- The **Channel Current Safety Limit** field allows users to enter an upper limit of total current of all channels. If this safety limit is exceeded, the running recipe will be aborted and a unsafe window will prompt up

and potential is hold at last initialized OCV. The upper limit of each channel is 0.540A.

14. The **Cell Voltage Safety Limit** field  allows users to enter an upper limit of cell voltage, If this safety limit is exceeded, the running recipe will be aborted and a window will prompt up and potential is hold at last initialized OCV. The upper limit of field is 1.30V.
15. If users let the recipe run until it is complete he/she will be informed when the file closes.
16. Users could press the **ABORT** button in the **Operating Controls** to quit the running recipe. A window as shown in **Figure 12 Choose an ABORT mode** will prompt up to ask user to choose how he/she wants to leave the system. **Background mode** will output the background settings users set in the recipe file. **HOLD mode** will cause the *ArraySTAT* to remain at its present condition. If users **START** again after **ABORT** with **HOLD** the recipe will resume at the beginning of the step selected.

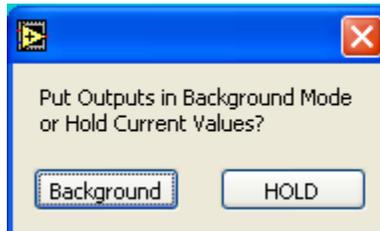


Figure 12 Choose an ABORT mode

17. A Current-time and Potential-time plot as shown in Figure 13 Plot Data**Tab** is presented when the **Plot** tab is clicked.

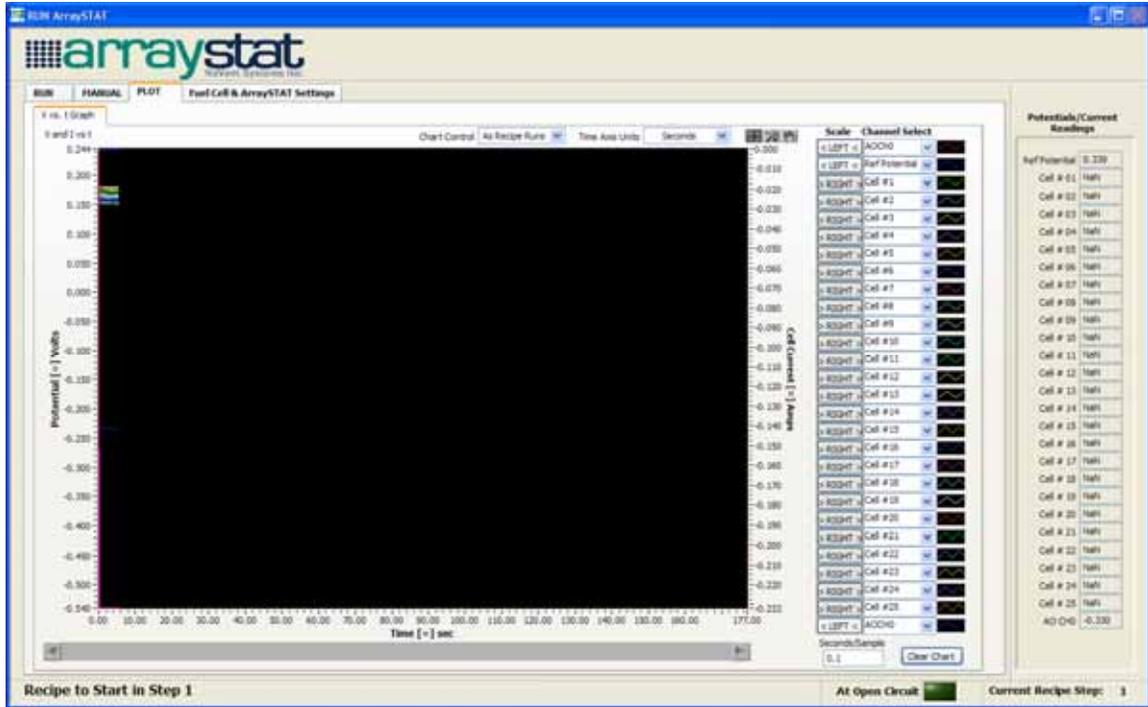
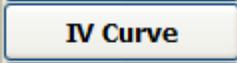


Figure 13 Plot Data

3.2.4. IV Curve

Click the **IV Curve** button  on the RUN tab will open a window shows the IV curve of the running recipe. In **IV Curve** window as shown in Fig 19,

users could view the chart of I vs. V or Vvs. I by flipping the switch . Users could also use **Select Channels** pane to select one or more channels they would like to see. Users could use file browser window to browse through the files on his/her hard drive. Then view the IV curves of previous data file by selecting the file from the file list and selecting the channel users want to see as shown in Fig 20. Users could click UP button to go back to upper directory. Double click a folder to open the selected folder.

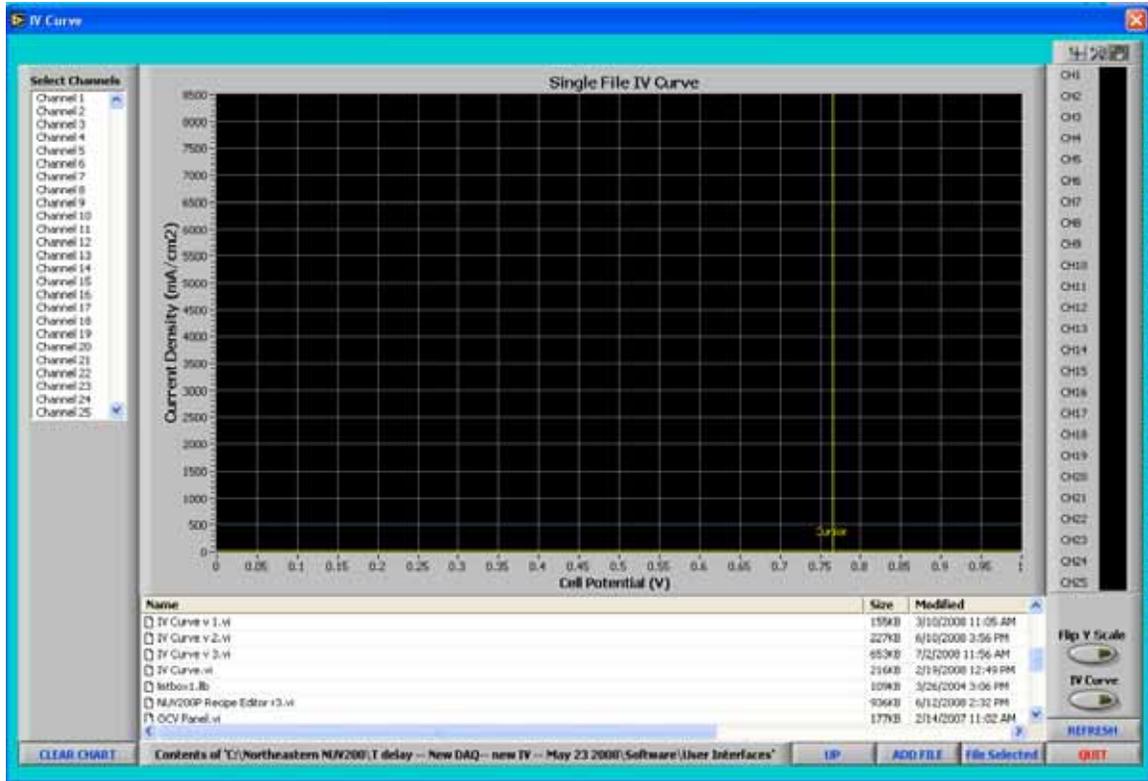


Figure 14 IV Curve

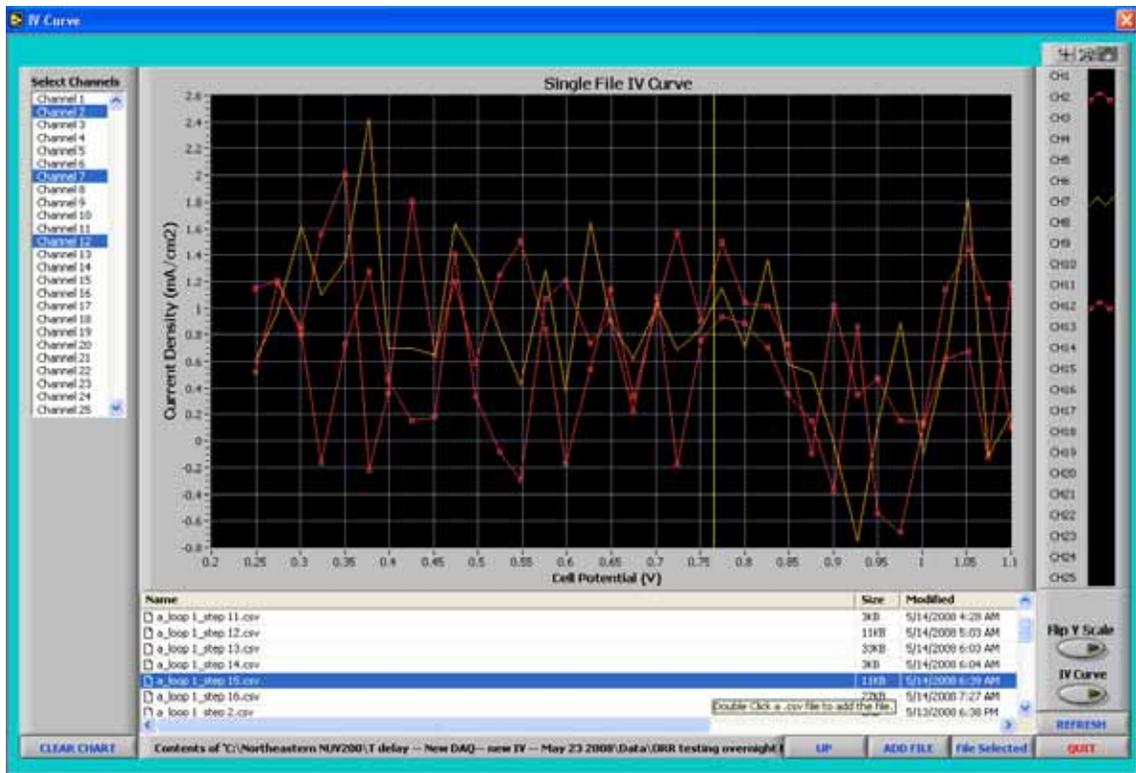


Figure 15 Select Data File

Users could also compare data from different files. First users select the files he/she is interested in, click ADD FILE button to add the selected files to the file list. Then click the FILE SELECTED button to view the file he/she selected. In the FILE SELECTED window, users select the file and the channel he/she wants to compare, click the ADD CHART button to add the curve of those selected channel to the chart. The name and color of each chart will be listed on the right side panel as shown in Fig 21. User could click REMOVE FILE button to remove the selected file from the file list. Click CLEAR CHART button to clear the chart.

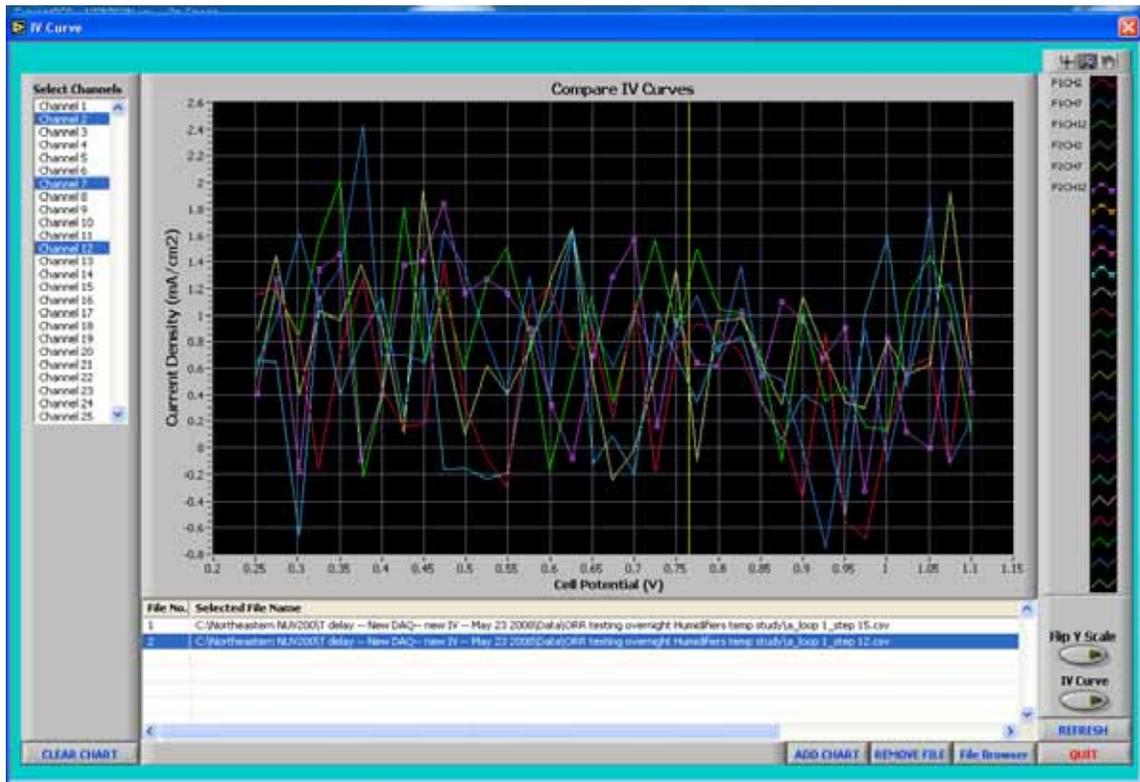


Figure 16 Compare Charts

18. Click **QUIT** button to exit the Run Screen window. Users are not allowed to quit if a recipe is running unless **ABORT** is invoked first.

Chapter 4.

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