



ANDERSON ELECTRIC CONTROLS, INC.

Solar Simulation with AC2000P Power Supplies



Over 40 Years
Est.
1969
of Service



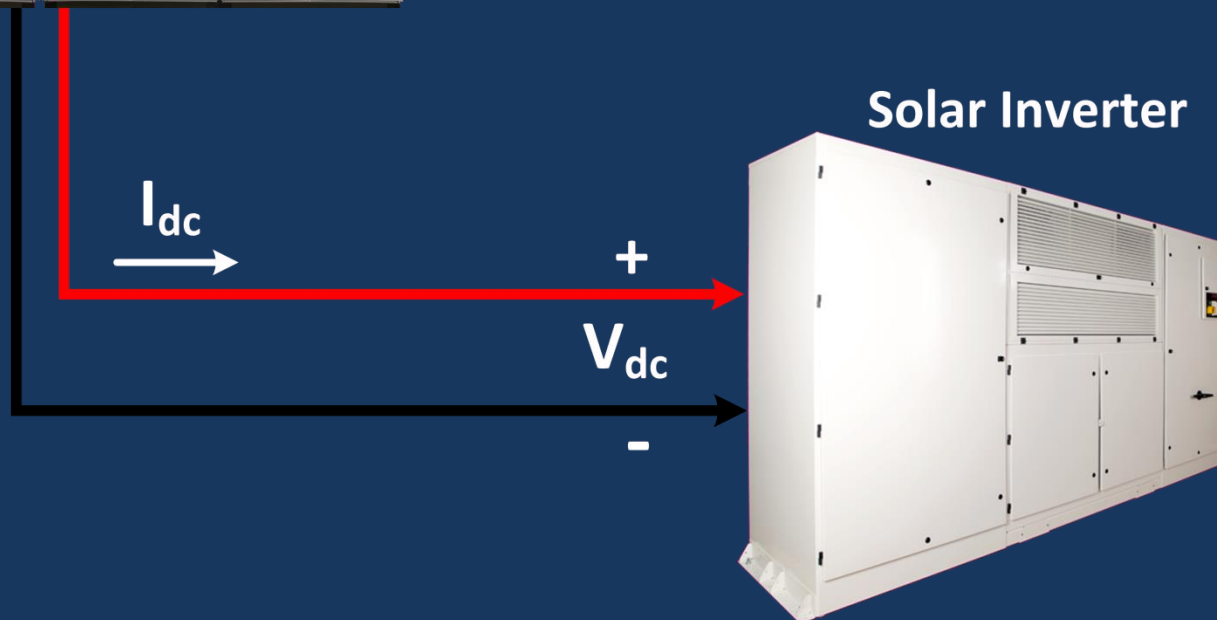
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Standalone Power Supply

AC2000P Power Supply



← Current command

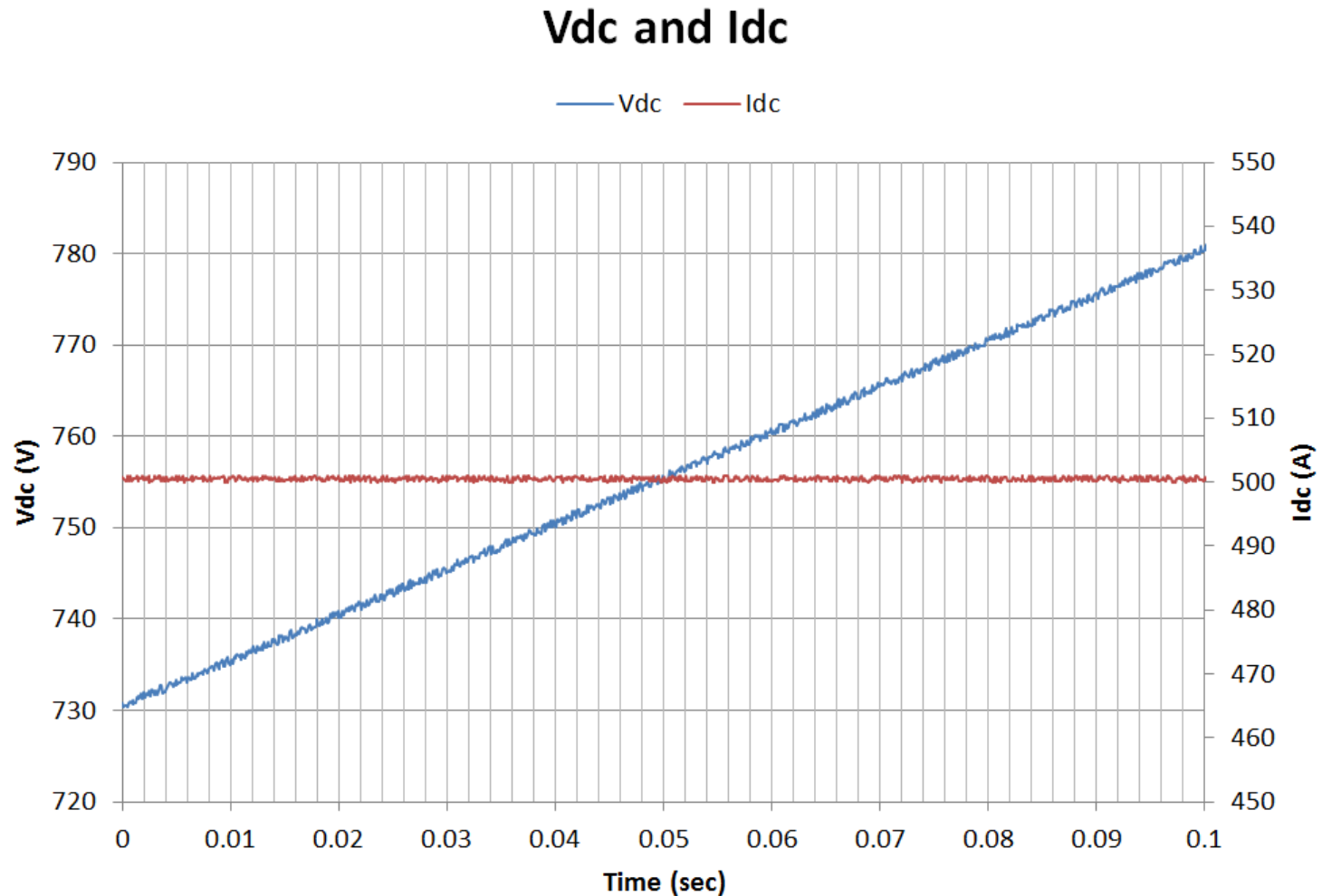


Solar Inverter



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Problem - Static current command

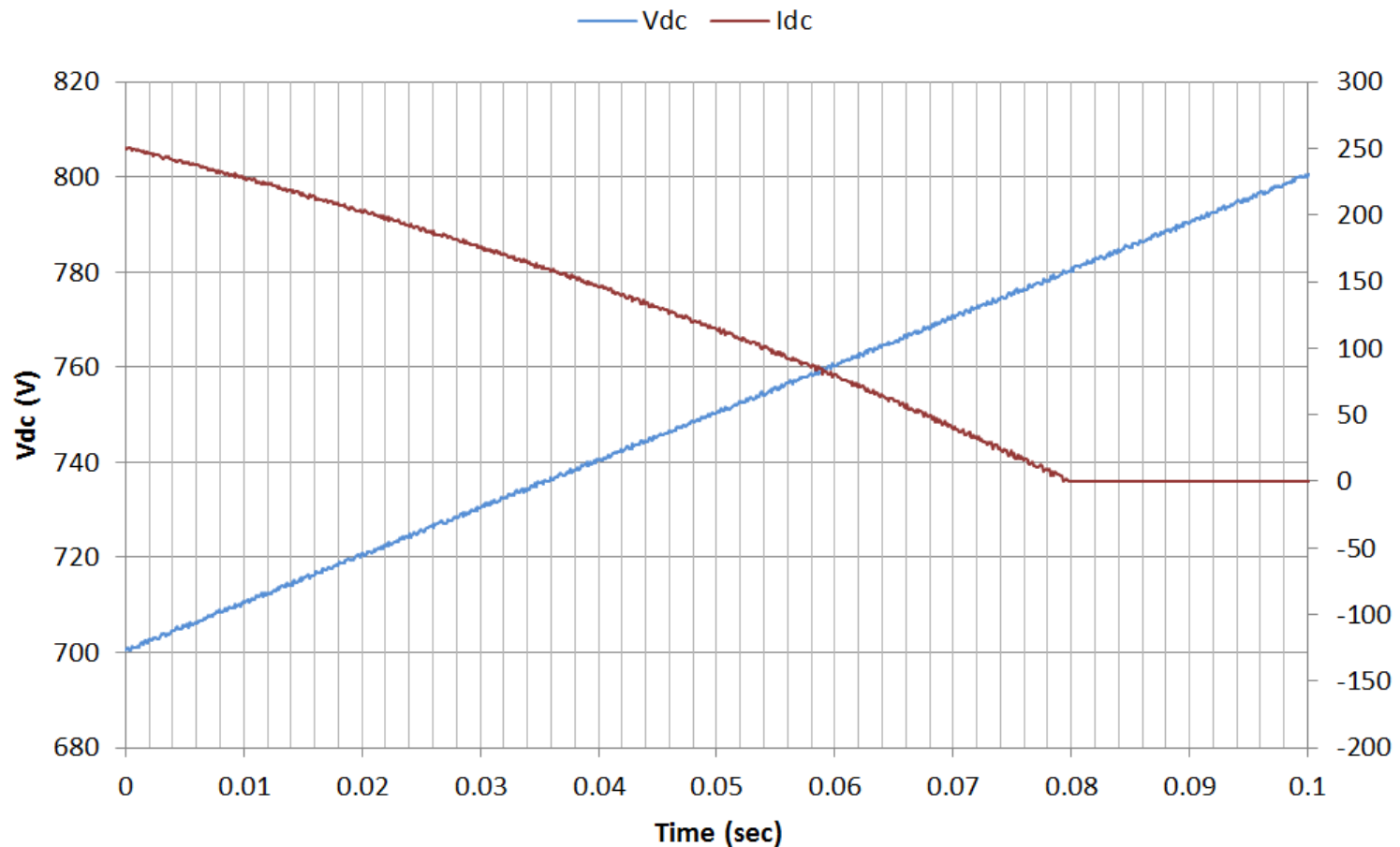




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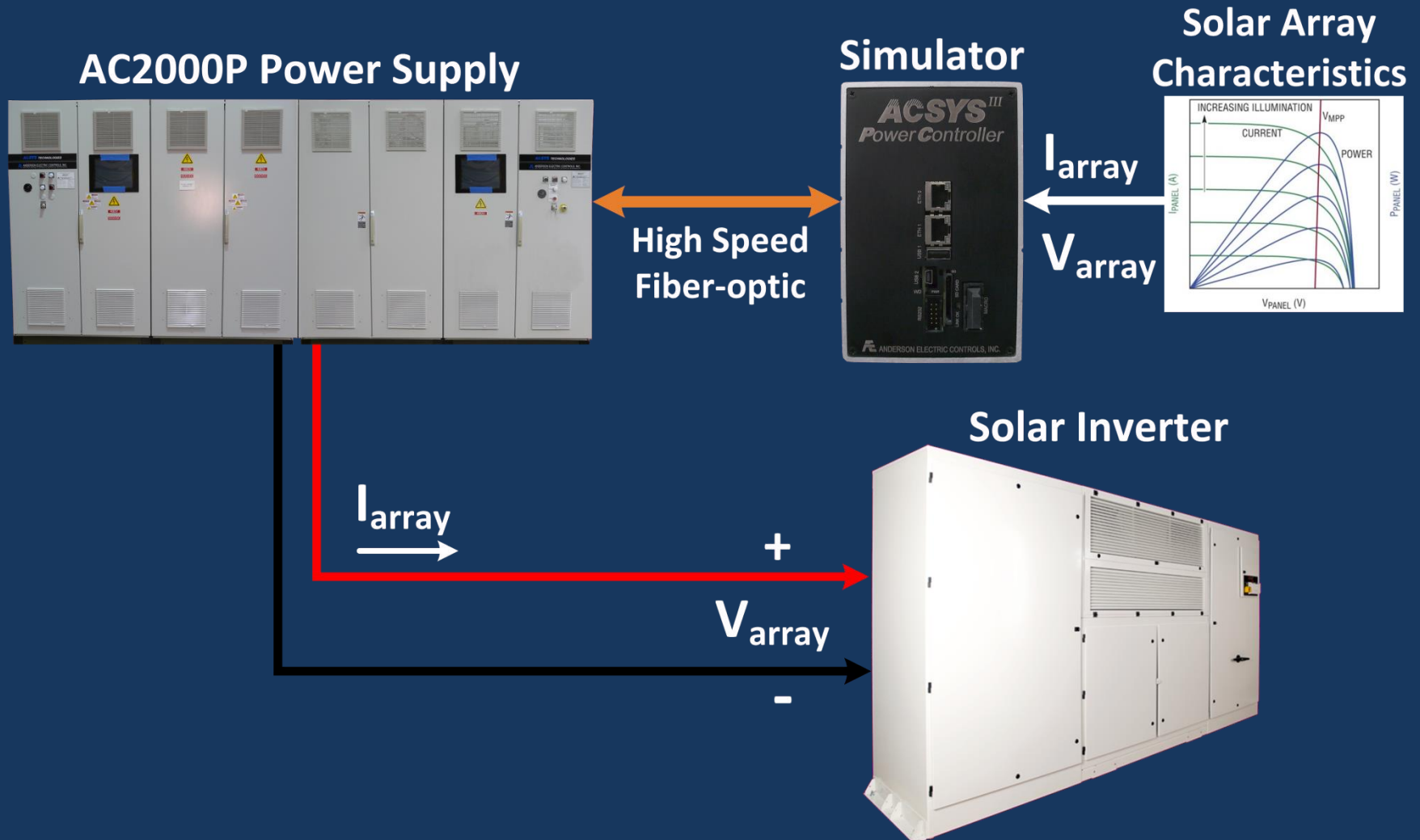
Desired characteristics

Vdc and Idc (Solar Simulation)





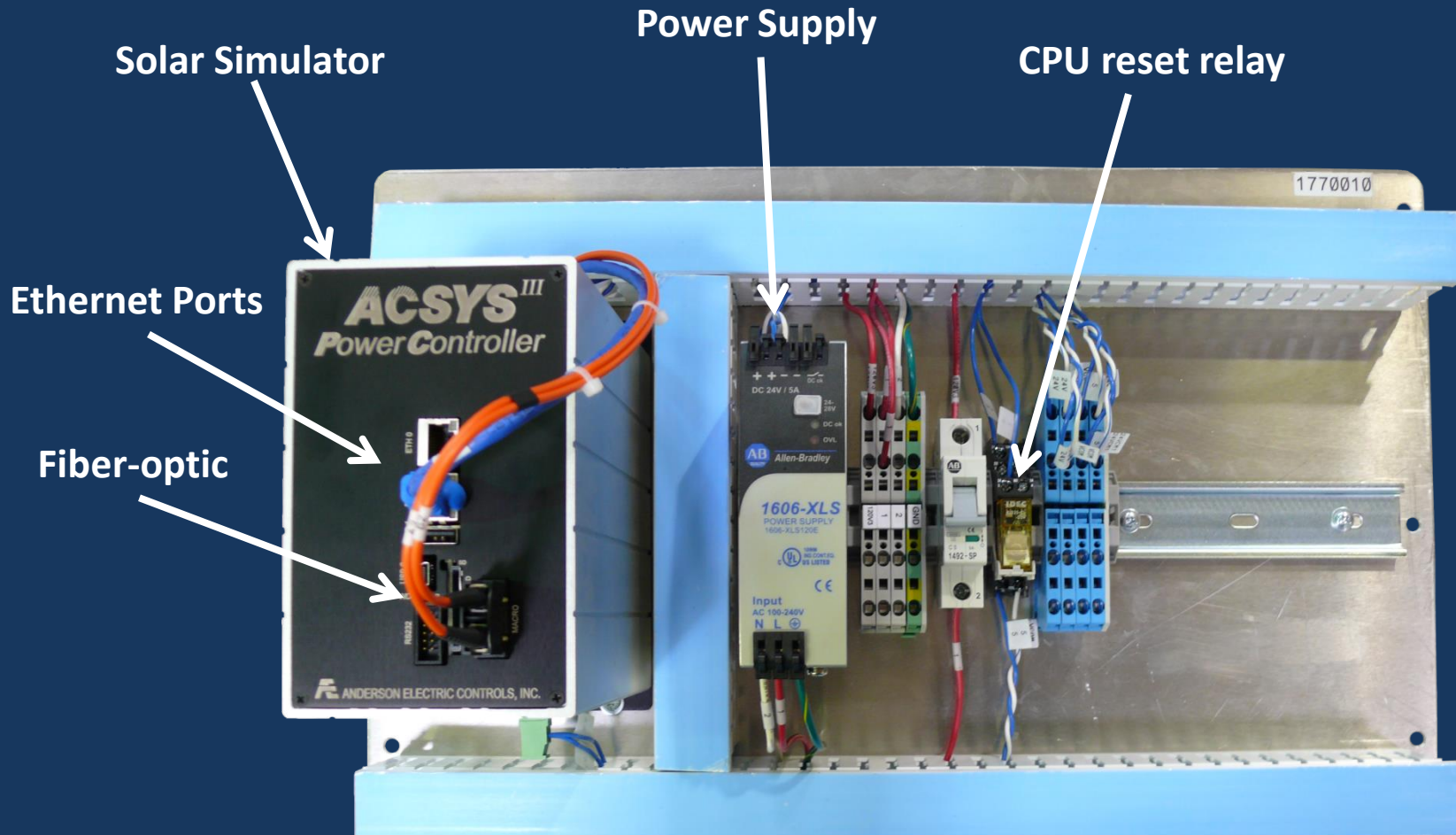
Solar Simulation Concept





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Solar Simulation Hardware





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Solar Simulation Features

- ACSYS Power Controller (APC)
 - High speed fiber-optic ring
 - Gigabit Ethernet ports
 - Algorithms executed at 18 kHz
- Basic simulation mode
 - Array parameters entered manually
- Dynamic simulation mode
 - Parameters set from table-based profiles
 - Profiles can be modified easily using Excel or any other spreadsheet editor
- Adjust parameters and setpoints on the fly
- Over/under voltage protection
- Built-in data acquisition engine
 - All channels are sampled synchronously
 - Programmable gather rate (0.1 Hz to 18 kHz)
 - Up to 16 user-selectable channels (voltage, current, etc)



Our 3rd generation controller:

ACSYS^{III}



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Basic Solar Simulation

- Enter array parameters manually
 - All parameters can be changed on the fly
- Adjustable array parameters
 - Nominal Irradiance
 - Nominal Temperature
 - Open circuit voltage (V_{oc})
 - Open circuit voltage at 200 Watts/m² (V_{oc_200})
 - Short circuit current (I_{sc})
 - Power temperature coefficient (β_p)
 - Voltage temperature coefficient (β_v)
 - Voltage fill factor (FF_v)
 - Current fill factor (FF_i)
- Setpoints
 - Irradiance (Watts/m²)
 - Temperature (deg. C)

The screenshot displays the 'Basic Solar Simulation' window of the Anderson Electric Controls software. The interface is divided into several sections:

- Panel Parameters @ STC:** Includes input fields for V_{oc} (V) set to 500, I_{sc} (A) set to 250, Irr (W/m²) set to 1000, and Temp. (deg C) set to 25.
- Limits:** Includes input fields for V_{min} set to 0 and V_{max} set to 800.
- Other Panel Parameters:** Includes input fields for β_p set to -0.5, β_v set to -0.36, FF_i set to 0.778, FF_v set to 0.778, and $V_{oc@200\text{ W/m}^2}$ set to 500.
- Control:** Features status indicators for 'Connected to Solar Simulator' and 'Solar Simulation Enabled' (both green), and buttons for 'Enable' (checked) and 'Disable' (unchecked). A red indicator shows 'Solar Simulator Faulted', and a 'Reset Faults' button is present.
- Commands:** Includes two vertical sliders: 'Irr. Cmd.' (Watts/m²) ranging from 0 to 2000, and 'Temp. Cmd.' (deg. C) ranging from -100 to 100. Both sliders are currently set to 0.
- Simulator Faults:** A text box at the bottom left displays the message: 'Power Supply #1 not ready. Power Supply #2 not ready.'



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Dynamic Solar Simulation

- Dynamics defined by profiles
- What is a profile?
 - List of commands executed in order
 - Each command is executed at the desired time
 - Stored in CSV format
- Profile features
 - Up to 100,000 steps (rows)
 - Linear interpolation between steps
 - Time resolution down to 250 μ s (4 kHz)
 - Pause / resume at any time
 - Go forward or backward to any step
 - Can be used in conjunction with basic solar simulation (e.g. parameters can be changed manually while a profile is running)
 - Up to 5 profiles can be stored in the APC at any time

The screenshot shows the 'Dynamic Simulation' tab of a software interface. It is divided into several sections:

- Profile Enable/Disable:** Includes a green circle icon and 'Dynamic Simulation Enabled' text. Below are 'Enable Profile 0' (with a green checkmark) and 'Disable Profile 0' (with a red X) buttons. There is a 'Selected Profile (0-4)' dropdown menu set to '0' and a 'Test profile #1' button. An 'Elapsed Time' field shows '0'.
- Other Profile Commands:** Contains 'Pause Profile' and 'Resume Profile' buttons. Below them are 'Interpolate' (with a green checkmark) and 'Step' (with a red square) buttons. A 'Steps to advance/go back' spinner is set to '0'. At the bottom are 'Advance' and 'Go Back' buttons.
- Current Step:** A field showing '0'.
- Profile To Upload (.csv file):** A file path is shown: 'C:\Users\shansen\...olar Simulation\Profiles\solarsim_long.csv'. Below is an 'Upload profile to Solar Simulator' button with a green arrow icon. There are status indicators for 'Uploading', 'Upload Completed', and 'Processing', all with green circles. A table shows 'Step' as '99999' and 'Field' as '0'. To the right, 'Upload to Profile #' is set to '0', 'Bytes Uploaded' is '18833001', and there is an 'Upload Errors' section with a text area.



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Profile Example

Time when
step is
executed



	A	B	C	D	E	F
1	Example Solar Simulation Profile					
2						
3	Step	Time	SolarSim.Irr	SolarSim.Temp	Cmd1	Cmd2
4	0	0.000	1000	25	SET Profile.Period=0.001	SET Profile.Interpolate=1
5	1	5.000	1500	30		
6	2	10.00	1000	35		
7	3	0.001	500	40		
8	4	0.050	1000	35		
9	5	10.00	1500	30		
10	6	5.000	1000	25	GOTO 1	

↑
Step #

↑
Irradiance
Cmd

↑
Temperature
Cmd

↖ ↗
Other
commands



Data Acquisition

- APC can sample system parameters synchronously
 - All channels sampled from deterministic clock for data alignment
 - Up to 16 channels
- Data sample rate is user-programmable
 - 0.1 Hz to 18 kHz
- User-programmable filters
- Save to CSV file for later analysis
- Provides digital oscilloscope functionality
- Available signals:
 - Calculated parameters: V_{mp} , I_{mp} , η_{mppt} , etc.
 - Measured parameters: V_{bus} , I_{bus} , etc.