Fuel Cell Emulation

Overview

Fuel cell emulation is typically used for testing the electrical power components that are use with fuel cells to create fuel cell powered systems. Emulation can solve a number of issues compared to running a fuel cell in the work environment. One of the biggest challenges for companies testing fuel cell power components is having a lab that meets all the proper regulations and safety concerns with a device needing flammable and combustible fuels in the work place.

Testing of your devices and components can easily be tested under a wide range of test parameters in a short amount of time when compared to a live fuel cell. Another advantage is being able to test your product beyond the limits of the fuel cell. Also with emulation you can create profiles as if the fuel cell is not working properly and end of life characteristics. Emulation greatly reduces time and cost of research and development testing, production testing and certification testing.

Fuel cells are devices that convert chemical energy from a fuel source into electricity through a chemical reaction of positively charged hydrogen ions with oxygen or another oxidizing agent. Some fuel cells are connected to reformer so you are not limited to the type of fuel used to convert the energy.
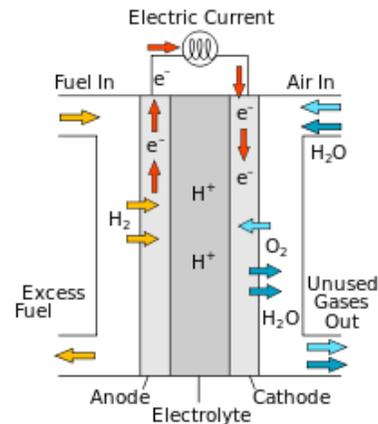

Figure 1: Single cell fuel cell

Intepro Systems simplifies the process of how to create a fuel cell emulator by adding emulation to our PSI 9000 series of fast response DC sources for creating a non-linear voltage output that emulates a fuel cell or fuel cell stack output voltage. So, no matter if you're testing DC/DC convertors or AC inverters our fuel cell emulation reduces your test time and cost. An added benefit to the PSI 9000 is a feature called Auto-Ranging that allows for more voltage and current combinations for achieving maximum power than a traditional power supply that only achieves the wattage rating at the rated maximum voltage and rated maximum current at the same time.
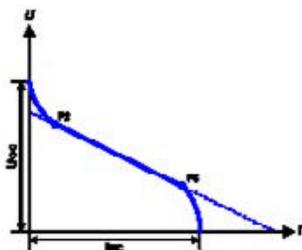

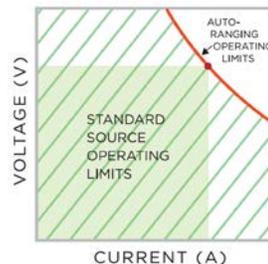*Figure 2: Fuel cell output voltage*
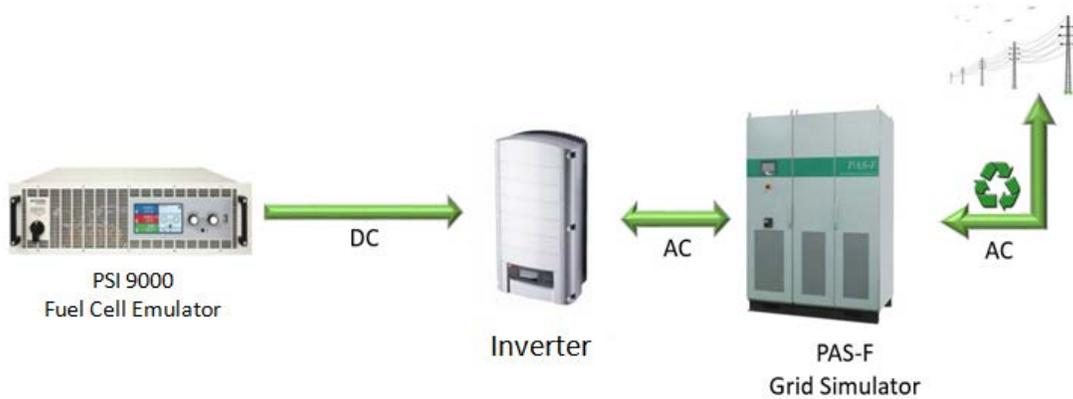

Figure 3: Auto Ranging graph

Figure 4: Test Setup

The FC (fuel cell) table function is used to simulate the characteristics of voltage and current of a fuel cell. This is achieved by setting up the parameters which define points on a typical fuel cell curve, which is then calculated as UI table and passed to the internal function generator.

The user has to adjust values for four support points. The device will request to enter them step by step, indicating the actual point on screen with small graphics. When finished, these points will be used to calculate the curve. Generally, following rules apply when setting up those values:

• UPoint1 > UPoint2 > UPoint3 > UPoint4
• IPoint4 > IPoint3 > IPoint2 > IPoint1
• Values of zero are not accepted

Figure 5: Table Menus

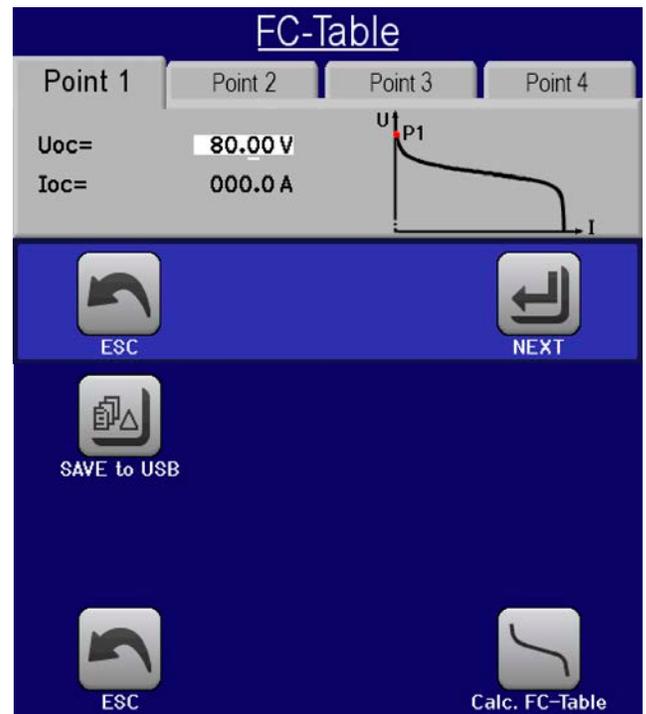The following parameters can be set for the FC table function:

Value	Range	Description
Point 1: Uoc	0 V...U_{Nom}	Open circuit voltage at no load
Point 2+3: U	0 V...U_{Nom}	Voltage and current define the position of these two points in the U-I coordinate system, which represent two supporting points on the curve to be calculated
Point 2+3: I	0 A...I_{Nom}	
Point 4: Isc	0 A...I_{Nom}	DC output current at the MPP

After setting up the four supporting points P1 thru P4, whereas P1 is at position Uoc and 0 A and P4 is at position Isc and 0 V, the device will calculate the function as UI table and load it to the XY generator. Depending on the load current, which can be between 0 A and Isc, the device will set a variable output voltage, whose progress between 0 V and Uoc should result in a curve similar to the one depicted to the left. The slope between P2 and P3 is depending on the values adjusted for P2 and P3 and can be freely modified as long as P3's voltage is lower than the one of P2 and P3's current is higher than the one of P2.

How to configure the FC table

1. In the function generator menu tap on, then and then.
2. Adjust the parameters of the four supporting points, as required for the simulation.
3. Do not forget to adjust the global limits for current and power in the screen which you can access with touch area.
4. After setting the values for the required signal generation, tap on touch area.

After the function has been loaded to the internal XY generator, the simulation is ready to start. *The function can be saved to a USB flash drive as a table, as well as read through any of the digital interfaces. In remote control, the function can't be loaded or controlled.* From the screen where the XY function generator is controlled manually (start/stop), you can go back to the first screen of the FC table function and use the formerly locked touch area to save the table to USB drive. In order to do so, follow the on-screen instructions. The table can be used to analyze the values or to visualize it in Excel or similar tools.

How to work with the FC table function

1. With an appropriate load connected, for example a DC-DC converter, start the function as described in *3.9.4.1*.
2. The output voltage will be set depending on the load current, which is defined by the connected load, and will decrease with increasing current. Without any load, the voltage will rise to the adjusted Uoc value.
3. Stop the function run anytime as described in *3.9.4.1*.
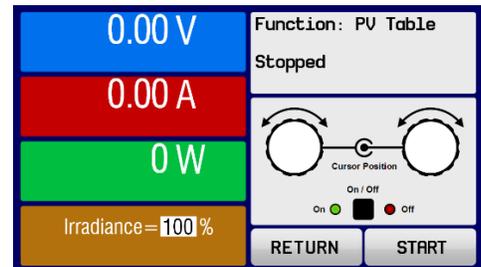
Analog I/O connections available on rear of unit.

Pin	Name	Type*	Description	Default levels	Electrical specifications
1	VSEL	AI	Set voltage value	0...10 V or. 0...5 V correspond to 0..100% of U_{Nom}	Accuracy 0-5 V range: < 0.4% *****
2	CSEL	AI	Set current value	0...10 V or. 0...5 V correspond to 0..100% of I_{Nom}	Accuracy 0-10 V range: < 0.2% ***** Input impedance R_i >40 k...100 k
3	VREF	AO	Reference voltage	10 V or 5 V	Tolerance < 0.2% at I_{max} = +5 mA Short circuit-proof against AGND
4	DGND	POT	Ground for all digital signals		For control and status signals.
5	REMOTE	DI	Switching internal / remote control	Remote = LOW, U_{Low} <1 V Internal = HIGH, U_{High} >4 V Internal = Open	Voltage range = 0...30 V $I_{Max.}$ = -1 mA bei 5 V $U_{LOW\ to\ HIGH\ typ.}$ = 3 V Rec'd sender: Open collector against DGND
6	OT / PF	DO	Overheating or power fail*** alarm	Alarm OT= HIGH, U_{High} > 4 V No Alarm OT= LOW, U_{Low} <1 V	Quasi open collector with pull-up against Vcc** With 5 V on the pin max. flow +1 mA $I_{Max.}$ = -10 mA at U_{CE} = 0,3 V $U_{Max.}$ = 30 V Short circuit-proof against DGND
7	RSEL	AI	Set internal resistance value	0...10 V or. 0...5 V correspond to 0..100% of $R_{Max.}$	Accuracy 0-5 V range: < 0.4% *****
8	PSEL	AI	Set power value	0...10 V or. 0...5 V correspond to 0..100% von P_{Nom}	Accuracy 0-10 V range: < 0.2% ***** Input impedance R_i >40 k...100 k
9	VMON	AO	Actual voltage	0...10 V or. 0...5 V correspond to 0..100% von U_{Nom}	Accuracy < 0.2% at $I_{Max.}$ = +2 mA
10	CMON	AO	Actual current	0...10 V or. 0...5 V correspond to 0..100% von I_{Nom}	Short circuit-proof against AGND
11	AGND	POT	Ground for all analog signals		For -SEL, -MON, VREF Signals
12	R-ACTIVE	DI	R mode on / off	On = LOW, U_{Low} <1 V Off = HIGH, U_{High} >4 V Off = Open	Voltage range = 0...30 V $I_{Max.}$ = -1 mA bei 5 V $U_{LOW\ to\ HIGH\ typ.}$ = 3 V Rec'd sender: Open collector against DGND
13	REM-SB	DI	DC output OFF (DC output ON) (ACK alarms ****)	Off = LOW, U_{Low} <1 V On= HIGH, U_{High} >4 V On = Open	Voltage range = 0...30 V $I_{Max.}$ = +1 mA at 5 V Rec'd sender: Open collector against DGND
14	OVP	DO	Overvoltage alarm	Alarm OVP = HIGH, U_{High} > 4 V No alarm OVP = LOW, U_{Low} <1 V	Quasi open collector with pull-up against Vcc** With 5 V on the pin max. flow +1 mA $I_{Max.}$ = -10 mA at U_{CE} = 0,3 V, $U_{Max.}$ = 30 V Short circuit-proof against DGND
15	CV	DO	Constant voltage regulation active	CV= LOW, U_{Low} <1 V CC/CP/CR = HIGH, U_{High} >4 V	

Intepro Systems PSI 9000 Series with Fuel Cell emulation mode

http://www.inteproate.com/products/dc-sources/psi-auto-ranging-programmable-power-supply/