



Fundamentals of Hydrogen Fuel Cell Technology

SAMPLE



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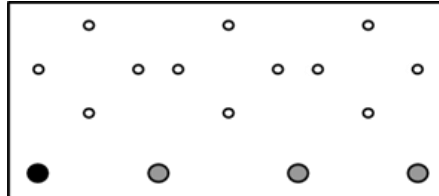
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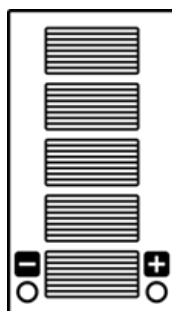
Introduction

Components

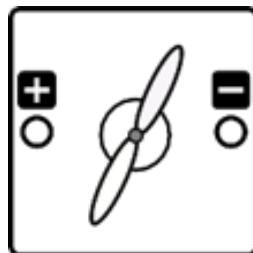
Main Board



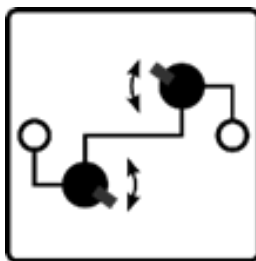
Solar Module 2.5V, 420mA



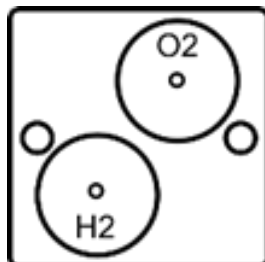
Motor module without gear



Potentiometer module



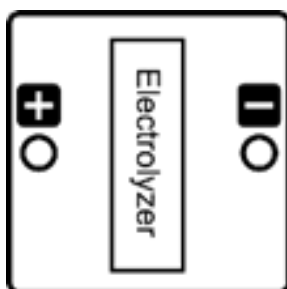
Gas Storage module



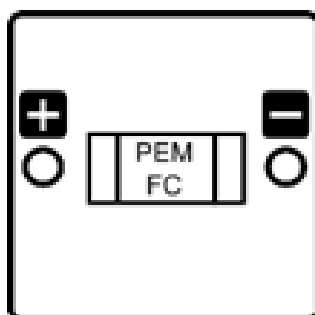
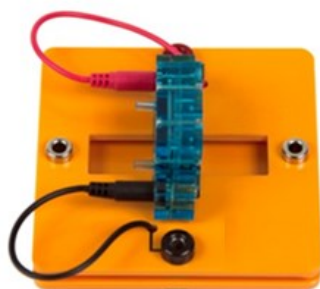
Introduction

Components

Electrolyzer module



PEM fuel cell module



Handling suggestions

Operation of the electrolyzer

Specifications:

Input voltage: 1.8 V ~ 3 V (D.C.)

Input current: -0.7 A

Hydrogen production rate: 7 ml per minute at 1 A

Oxygen production rate: 3,5 ml per minute at 1 A

Important handling guidelines:

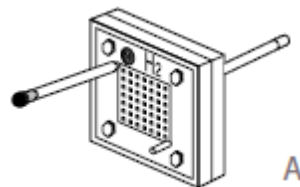
Whenever not in use, the electrolyzer should be stored in an air-tight plastic bag, to keep it from drying out.

Positive and negative pin of the electrolyzer must always be connected to correctly to the voltage source, to avoid damages to the electrolyzer.

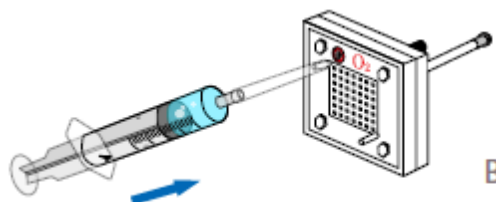
The electrolyzer must only be used with moistened membranes. The distilled water must be filled in on the O₂-side and should be allowed to soak for about 3 minutes. Connecting the dry electrolyzer to the voltage source can lead to irreparable damages.

User instructions:

1. The electrolyzer should be placed on a flat surface. The short piece of tube must be connected to the upper port on the H₂-side (black port) and be sealed with the black pin (see A).



2. The syringe must be filled with distilled water and another short piece of tube should be fitted to it. The other end of the tube must be connected to the upper port on the O₂-side (red port) (see B).

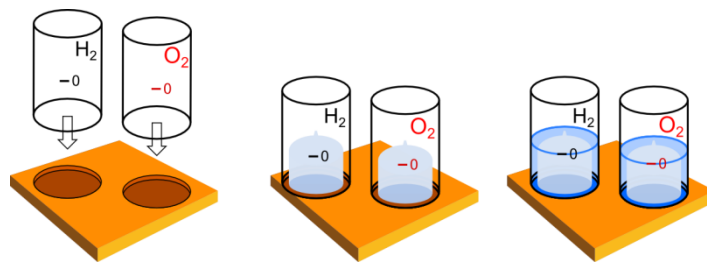


Handling suggestions

Operation of the electrolyzer

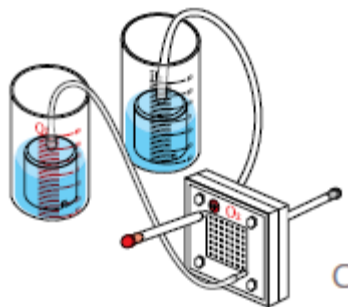
Now, using the syringe, the water should slowly be pumped into the electrolyzer until it leaks out of the lower port. The syringe can now be pulled off the tube, which can be sealed with the red pin. At this point the electrolyzer should sit for 3 minutes.

3. Now, the water barrels should be filled with distilled water up to their respective markings.



4. Each gas storage tank should be pinned onto the ring mount at the bottom of each water barrel, so that the grooves on the bottom of the gas tanks are aligned with the grooves of the ring mounts. Excess water can be removed using the syringe.

5. At this point, the gas storage tanks can be connected to the lower ports of the electrolyzer using the long pieces of tube. The black port of the H₂-side must be connected to the H₂- storage tank and the same goes for the red O₂-side and the O₂ tank (see C).



6. The electrolyzer can now be placed onto the module plate and be connected to it using the respective cables (red for O₂, black for H₂).

7. Now, the unit can be connected to the solar module or an external voltage source to start the electrolytic process.

NOTE: If the hydrogen gas shall later be used for a fuel cell experiment, it is recommended to put a clamp on the tube connecting the H₂-side of the electrolyzer with the H₂ tank. It can be closed after the gas production, so that the hydrogen can be stored in its tank for later experiments.

Handling suggestions

Operation of the PEM Fuel cell



Specifications:

Output power: 270 mW

Output voltage: 0,6 V (DC)

Output current: 0,45 A

Important handling guidelines:

Whenever not in use, the fuel cell should be stored in an air-tight plastic bag, to keep it from drying out.

User instructions:

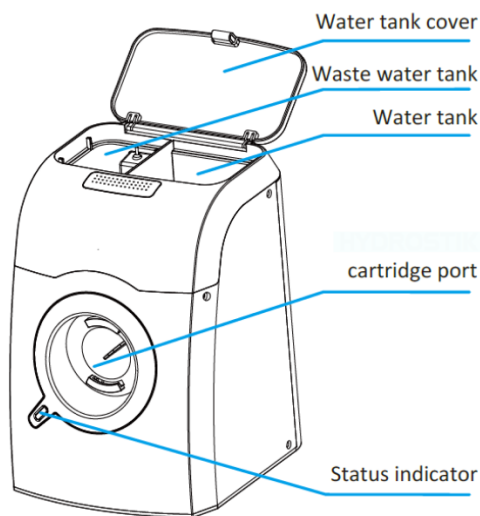
1. To operate the fuel cell, hydrogen gas is needed. This can be obtained from the H₂-Storage or from the H₂ tank from a previous experiment.
2. If the hydrogen is taken from the gas tank, the tube must be clamped to avoid hydrogen gas to leak.
3. The tube of the H₂ tank must be connected to the lower port of the fuel cell. The O₂ supply for this model is ensured by the ambient air.
4. The upper port of the fuel cell must be sealed, using a short piece of tube and a pin.
5. The fuel cell can now be placed onto the module plate and be connected to it using the respective cables (red for O₂, black for H₂).
6. Now, the unit can be connected to an electrical load. (Mind the polarity!).
7. By opening the tube clamp the experiment can be started.

NOTE: For quantitative experiments like taking a characteristic curve, we recommend flushing the fuel cell with hydrogen gas by initiation the gas supply (opening the tube clamp on the tank or opening the valve on the H₂ storage) and removing the pin on the short tube for only 1-2 seconds.

Handling suggestions

Operation of the H2 charger and H2 storage

Designation of the parts:



Specifications H₂-Charger:

- Power: 23 W
- Input voltage: 10 V-19 V (DC)
- Use: De-ionized or distilled water (10-40°C)
- Water consumption: ca. 20 ml/h
- Hydrogen pressure: 0-3 MPa
- Hydrogen production rate: ca. 3 l/h
- Hydrogen purity: 99.99%
- Refill time per cartridge: about 4 h

Handling suggestions

Operation of the H₂ charger and H₂ storage

Specifications H₂-Storage:

- Capacity: 10 l hydrogen
- Storage material: AB5 metal hydride
- Load pressure: 3 MPa
- Working temperature: 0-55°C

Important handling guidelines:

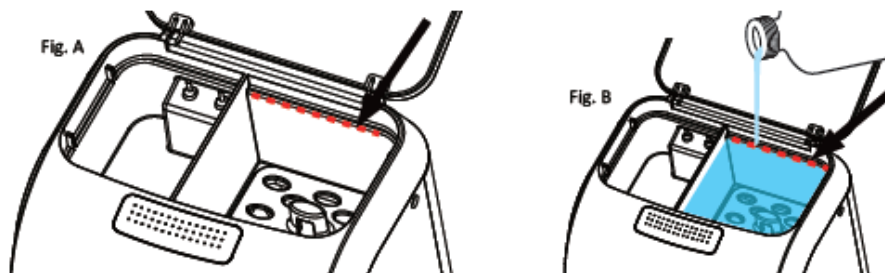
The H₂-Charger must not be disassembled.
Both the H₂-Charger and the H₂-Storage must be kept away from heat or flames.
The H₂-Charger should be operated in an upright position.
Operations should be done in a well-vented room.
All electric connections should be kept away from water.

Status light:

green	red	System status
on		H ₂ -Storage full
1 second on, 1 second off		Filling of H ₂ -Storage is halted
	on	H ₂ -Storage is being filled
	1 second on, 1 second off	Add water or empty the waste water container

Usage instructions:

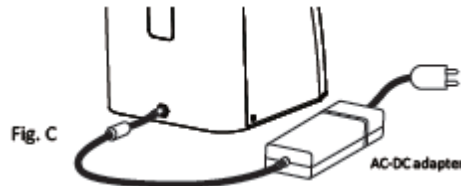
1. Firstly, fill distilled or deionized water up to the mark (see red line and arrow in the figure).



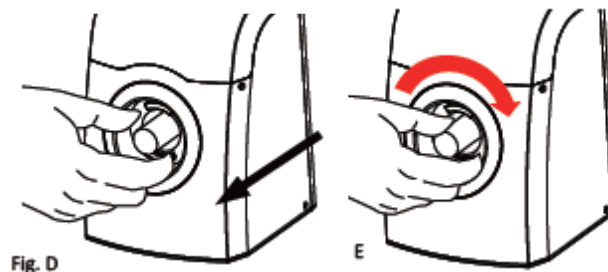
Handling suggestions

Operation of the H₂ charger and H₂ storage

2. Connect the power adaptor to the H₂-Charger. The status light should flash green.



3. Insert the H₂-Storage into the opening on the front side of the H₂-Charger. For this, the stick should be turned clockwise until it locks in place. Don't apply too much force!



4. While the status light is flashing red, the H₂-Storage is being filled. Only when the status light flashes green, the cartridge is completely filled. The stick may now be removed by turning it counter clockwise.

5. Now remove the power adaptor and empty the water tank, in case the H₂-Charger will not be used within the following week. If further cartridges must be filled, revisit this procedure, starting at point 3.

NOTE: Distinct noises (gargling and whistling) are normal during the charging process and are being produced by the self-cleaning of the device.

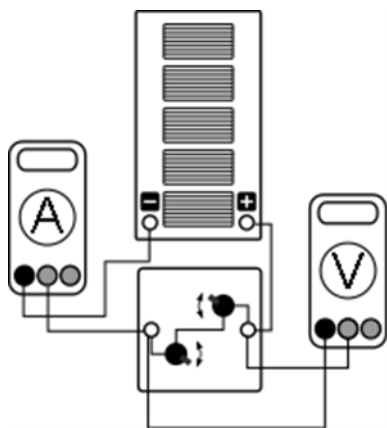
Worksheets

I-V curve of a solar module

Goals

Take the I-V curve of a solar module and interpretist behavior.

Setup



Equipment required

- Solar module
- Lamp
- Cables
- Ammeter
- Voltmeter
- Potentiometer module

Procedure

1. Set up the experiment in accordance with the drawing.
2. Place the lamp in front of the solar module (distance ca. 30 cm) and switch on the lamp.
3. Set sensible values for the voltage and measure the resulting current. For this, first adjust the 1kΩ resistor and then the 100Ω resistor for better control.
4. Enter your measurements into the table.

Measurements

V in V	I in mA	P in mW

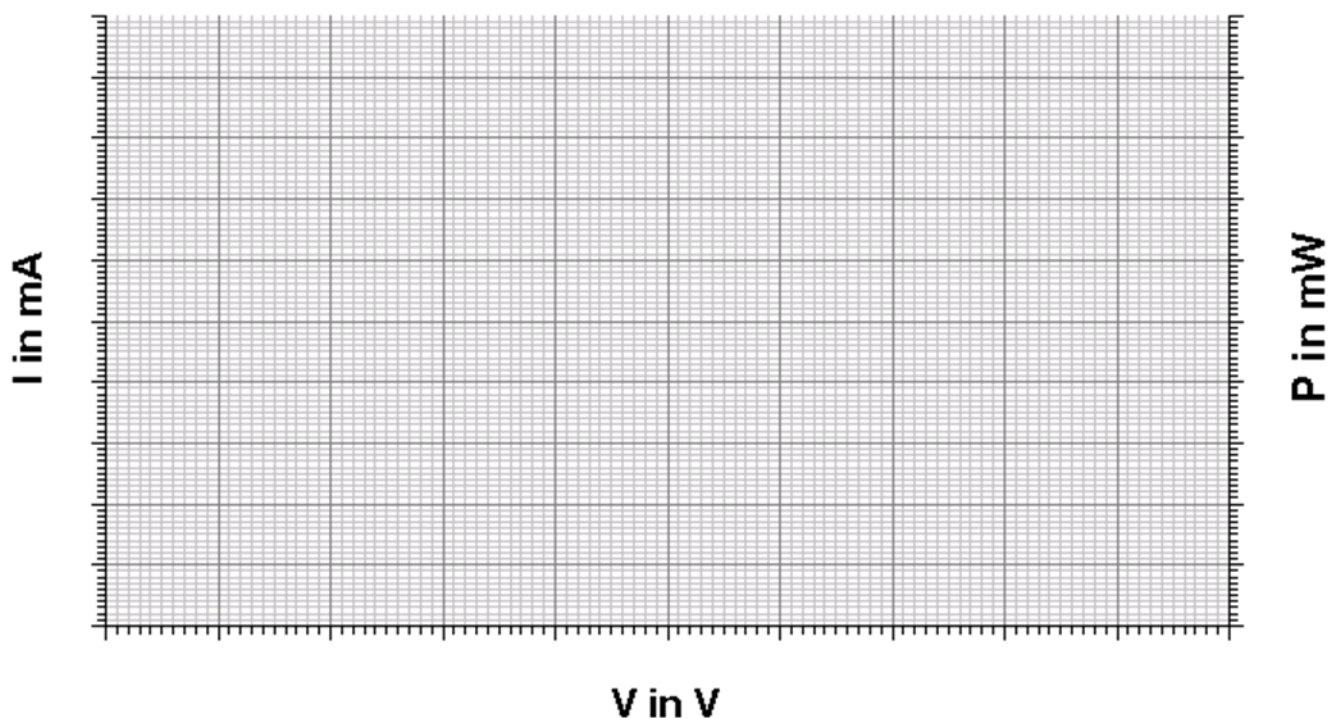
Worksheets

I-V curve of a solar module

Evaluation

1. Calculate the power for every pair of voltage and current values and enter your results into the table.
2. Plot the respective value in the given diagram.
3. Describe the behavior of the current and the power in dependence of the voltage.

Diagrams



Evaluation

The full version of this curriculum is available upon purchase of the kit.

Please see contents for a full list of experiments from the full version.