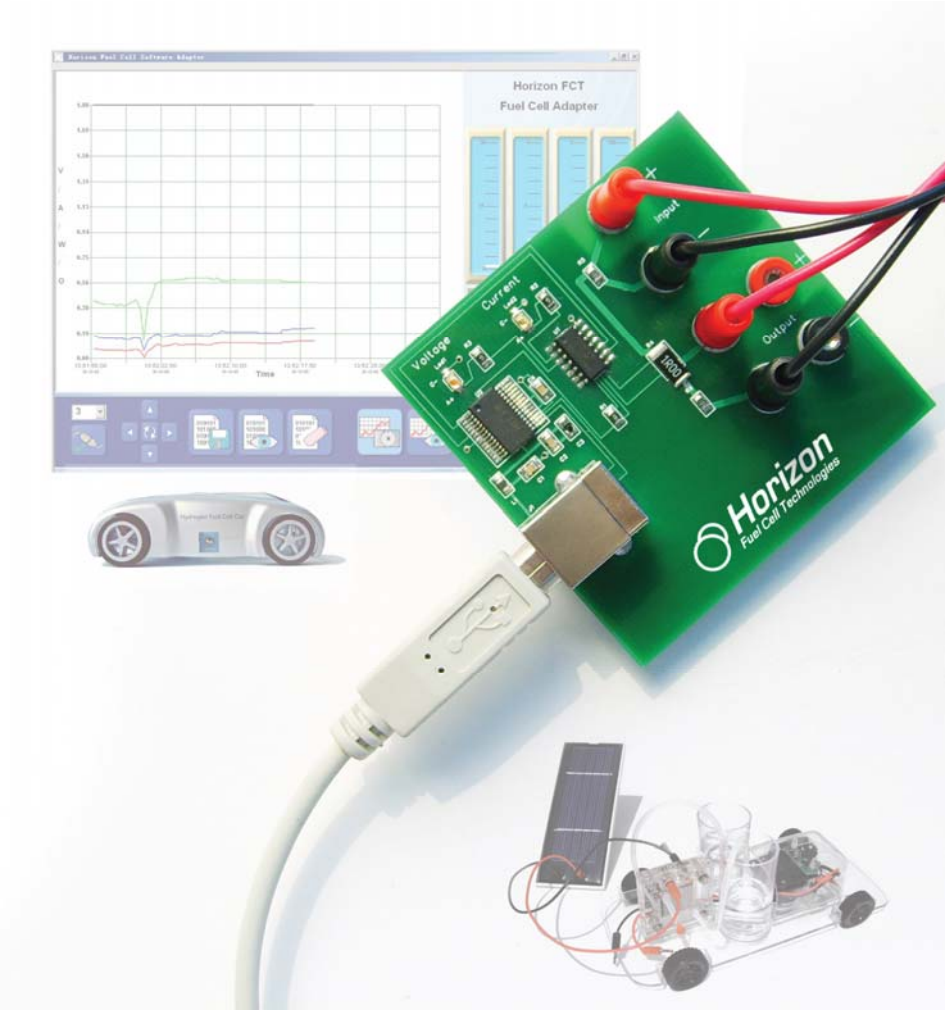
Horizon Fuel Cell Software Adaptor

User Manual

C-7120



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www.fadisel.es - info@fadisel.com

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Horizon Fuel Cell Technologies (Shanghai) Co.Ltd.
4th Floor, Block 18,
No.271 Qiangyang RD.
Shanghai 200333, P.R.China
Phone +86 21 52709082
Fax +86 21 52705064

e-mail info@horizonfuelcell.com

website www.horizonfuelcell.com

1. Introduction

Diminishing resources, more severe environmental impacts and the ever- increasing demand for energy force us to re-evaluate the structure of our energy supply system. Automobile and oil companies increasingly invest in hydrogen technology because it offers solutions to some of these concerns. This fascinating technology combines a sound energy supply with minimal impact on our natural resources.

In order to learn more about how hydrogen fuel cells can power everything from cell phones to cars, the ***Fuel Cell Software Adapter*** allows you to directly peer into the electrical operation of a fuel cell in order to observe how it produces hydrogen from plain water and then uses this hydrogen to create electricity.

The ***Fuel Cell Software Adapter*** takes your regular desktop or laptop PC and turns it into a laboratory instrument where you can "graphically" observe the electrical relationships among voltage, current, resistance and power. Meters are fine for static electrical measurements, but when it comes to seeing what happens in real time – all at once - nothing beats a graphic display!

This is what you have in the ***Fuel Cell Software Adapter*** – a laboratory instrument that is specifically designed to test fuel cells. And the following experiments will teach you more in one minute than you can experience in hours of tedious laboratory measurements with a meter. A picture is worth a 1000 words and nothing is more appropriate for this comparison.

The ***Fuel Cell Software Adaptor*** provides a facility for automatically recording and evaluating the voltage, current and power values of fuel cells. It includes PC software for recording measurements, as well as a Data Acquisition Card for connecting to a computer's USB interface.

Horizon's ***Fuel Cell Software Adaptor*** has been especially developed for fuel cells in the lower power range. The PC software and the Data Acquisition Card are designed for measuring and recording voltage, current, load resistance and power values for fuel cells with a power capacity of up to 5 watts.

The following measurement ranges are possible:

- Voltage measuring range:
  0 volts to 5 volts
- Current measuring range:
  0 amps to 1 amp
- Power measuring range:
  0 watts to 5 watts
- Resistance measuring range:
  0 ohms to 99.999 ohms

For best results, please review each experiment before performing it. This will avoid misunderstandings and provide you with knowledge of what is about to happen.

We wish you many enjoyable hours learning about fuel cell technology and how it can benefit our world with the ***Fuel Cell Software Adaptor.***

2. Intended Use

- Measurements can be carried out and evaluated on fuel cells in the power range up to 5 watts with the ***Fuel Cell Software Adaptor's*** external Data Acquisition Card and the associated software.
- The hardware and software were developed exclusively for educational teaching and demonstration purposes. Any other use is prohibited!

3. General Safety Precautions

In order to avoid any risks, you must follow the following General Safety Precautions when carrying out measurements with the ***Fuel Cell Software Adaptor*** and fuel cells.

- The system may only be set up and operated by a competent person. Students require adult supervision at all times.
- Read the Operating Instructions before setting up the system. Follow them during use and keep them readily available for reference. This also applies to the Operating Instructions for the fuel cells and, if appropriate, any electrolyzer used in the experiments.
- The system is not a toy. Operate the equipment and keep it and the gases produced out of the reach of small children.
- Unless specified otherwise, do not short-circuit or reverse the polarity of the terminals.
- Remove inflammable gases, vapors and fluids from the vicinity of fuel cells and electrolyzers. The catalysts contained in the system can trigger spontaneous combustion.
- Hydrogen and oxygen may escape from fuel cells and electrolyzers. To prevent the gases collecting and forming explosive mixtures only use the system in well ventilated rooms.
- Fuel cells and electrolyzers may only be operated where there is sufficient ventilation at all times. The operator is obliged to prove this by means of appropriate measurements.
- Remove from the vicinity of fuel cells and electrolyzers anything that could ignite the hydrogen such as a naked flame, materials that can become charged with static electricity, substances with a catalytic action, etc.
- Remove from the vicinity of fuel cells and electrolyzers all substances that could spontaneously ignite with increased oxygen concentration.
- Do not smoke in the vicinity of fuel cells and electrolyzers.
- Only use the gas storage tanks Horizon provides to store gas. Never connect other alternatives.
- Horizon will not accept any responsibility for injuries or damage sustained in the event of these Safety Precautions not being followed

4. Related Issues

4.1 Reverse Engineering

You are not entitled to reverse engineer, decompile or disassemble the software product in whole or in part.

4.2 Errors and Omissions

Horizon has made every effort to supply the software and hardware without errors; however, we are not responsible for any unintentional errors or omissions in the design, construction or operation of the product. If you should notice undiscovered errors, please contact us.

Horizon Fuel Cell Technologies
www.horizonfuelcell.com

4.3 System Requirements

The following operating systems are supported - Windows 2000, Windows 98, Windows ME, Windows NT, Windows XP, Windows Vista. MACs with INTEL processors can use Parallels **"Desktop 3.0 for Mac".**

4.4 Minimum Computer Requirements

The minimum requirements are the same as those of the respective operating systems. In addition, the Microsoft .NET Framework run-time environment is required for running the ***Fuel Cell Software Adapter,*** which can be found on the installation CD in German and English.

4.5 Software Installation

You will need administrator rights for software installation under Windows 2000, Windows NT, Windows XP or Windows Vista.

4.6 Supplied Materials

- Data Acquisition Card
- USB Cable
- One 1 ohm, two 10 ohm resistors.
- Capacitor
- CD-ROM with FCA graphics software, USB Driver Software, user manual and PDF installer
- Connection cables

4.7 Other Required Materials Not Supplied

- Windows PC – MACs must have Parallels “Desktop 3.0 for Mac”
- Fuel cell
- Solar panel
- Table fan for wind turbine
- Small DC motor and propeller
- Battery Holder (two AA batteries not included)
- Wind Turbine

5. Hardware Installation

1. Connect one end of the USB cable to the computer and the other end to the Data Acquisition Card.
2. The green and blue LEDs on the Data Acquisition Card should flash to indicate that the connection is made and power from the computer is applied to the circuit board.

6. Software Installation

1. Insert the Horizon ***Fuel Cell Software Adaptor*** CD-ROM into your computer’s disc drive and close the door.
2. On the Desktop, right-click on “Start” then click “Explore”. Find your CD-ROM drive (D, E or higher) then click it to bring up the folder’s contents.
3. Double click on the USB driver software (USB Driver Installer.exe) to install it.
4. Double-click on the **Horizon FC Installer** file and follow the instructions to install it.
5. Next, minimize all applications until the Desktop reappears again. A Horizon FCA icon like that shown here should appear:

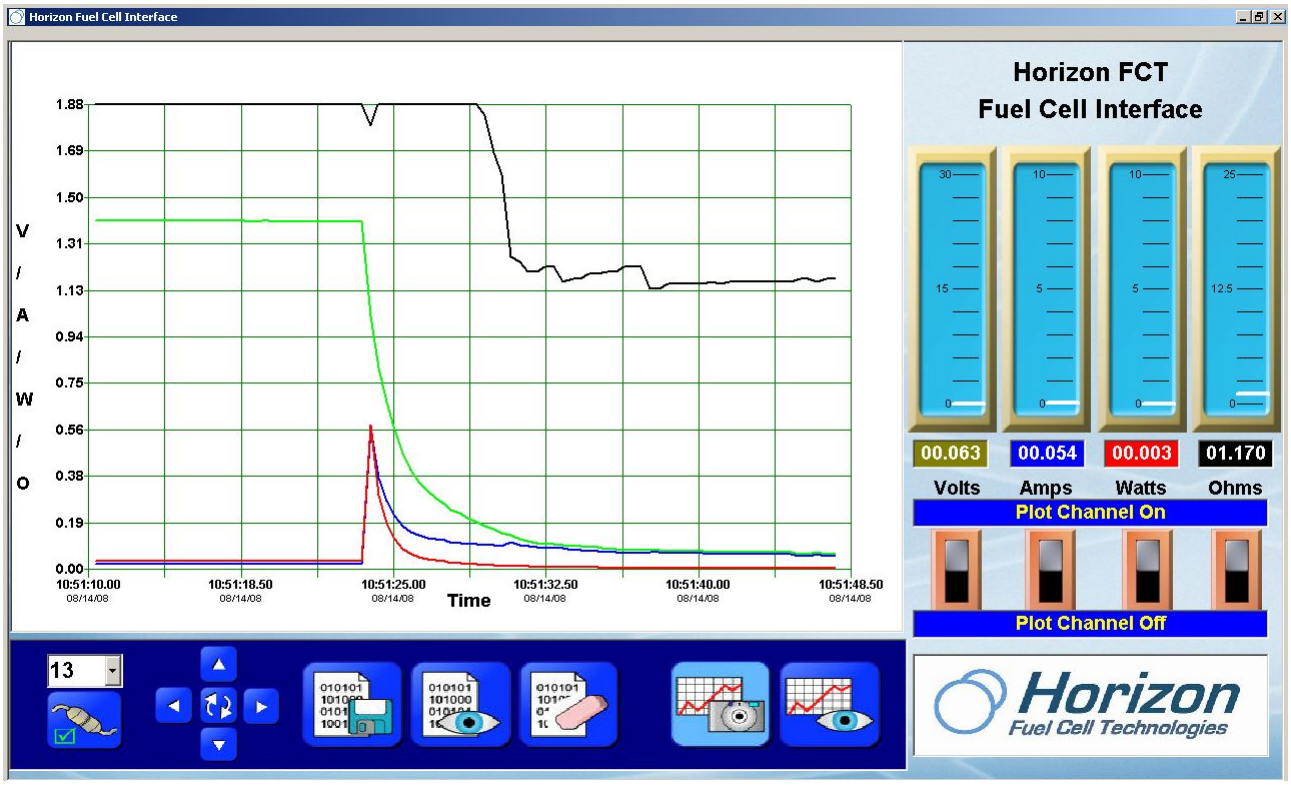
6. Click the Horizon FCA icon. You can choose either English or German.
7. You have successfully installed the hardware and software. Now proceed to **Section 7** on **“Learning to Use the Graphics Software”** to understand what to do next.

7. Learning to Use the Graphic Software

The PC graphic software screen is divided into several regions that control how electrical quantities such as voltage, current, power and resistance readings are displayed.

The large grid area continuously displays four plotted lines in four colors. The colors match the voltage, current, power and resistance values below the vertical meters.

- **Green – Voltage in volts**
- **Blue – Current in amperes**
- **Red – Power in watts**
- **Black – Resistance in ohms**



Before any plots can occur, the graphic software must connect with the attached circuit board that is transmitting data. To do so, first select the correct Comm port number then click on the Connect icon. You can type over the number displayed if it is not correct. To find the correct Comm port go to Control Panel --> System --> Hardware Manager --> Device Manager then click on the Comm port. This is the correct Comm port to type into the number area. Then click the connector icon – the one with the red x.

If correct, the Connect icon will show that the connection is made. If the Comm port is not correct an error message will be displayed, which is usually due to a Comm port already in use.

The plot area can be zoomed in and out of a time range (horizontal axis) or a voltage, current, power or resistance range (vertical axis).

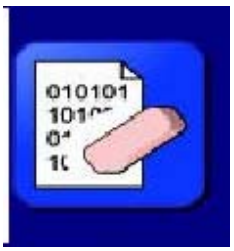
The up and down arrows will zoom the plot in a vertical direction. Up to increase and down to decrease.

The left and right arrows will zoom the plot in a horizontal direction - left for more time and right for less time.

Click the center double-arrow icon to clear the screen and reset the plot. If the plot does not immediately start, click the double-arrow icon again.

To begin data logging, click the data log icon. A file will automatically open to record the data being sent by the circuit board.

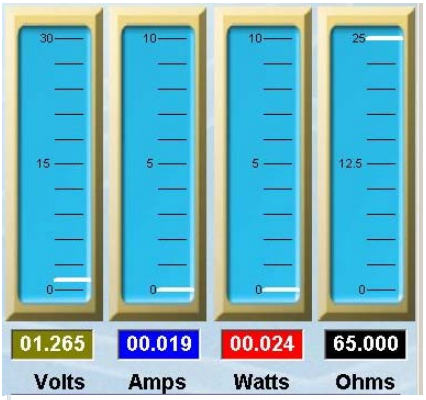
To view the logged data, click on this icon. The logged data will be displayed over the plot area where it can be examined. This same file can be ported to a spread sheet program like Excel for further analysis and plotting. To find the path to the logged data go to **Program Files → Horizon FCA → Data** on your hard disk.



Click this icon to close the data log file and erase all logged data.

Click this icon to capture the plot image on the screen.
These images are automatically saved to a file with a unique name and can be extracted and included in reports or printed out. To find the path to these images go to **Program Files → Horizon FCA → Data** on your hard disk. You will find the captured screen shots as .jpg files, which you can extract and use in reports or print out directly. You can also rename the files, as well.

Click this icon to view the captured images.



The four meters display the voltage, current, power and resistance. Their scales are fixed and unlike the grid plot area, cannot be changed.

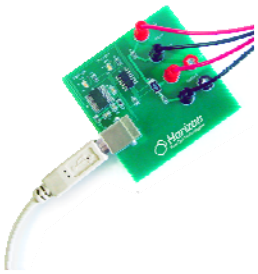
The resistance reading of 99.999 ohms is maximum even if the actual resistance is more.

The other electrical measurements are consistent with their actual values.

To reduce screen clutter in the plot area, the individual switches can be clicked to turn ON or turn OFF the selected plot line.

If your computer is connected to the Internet, clicking on the Horizon icon will take you to their website.

8. Data Acquisition Board



The Data Acquisition Board is the electronic interface between devices such as a fuel cell, solar panel and wind turbine. When connected to a computer via a USB cable, it measures and computes voltage, current, resistance and power then transmits these electrical quantities 3 times a second to the computer. The computer software displays these quantities as both numbers and colored line plots as they are transmitted.

Input and Output Connectors

There are two (2) Input connectors. One is colored red, which indicates positive or plus (+) polarity and the other is colored black to indicate negative (–) polarity. In the following experiments, power sources such as a battery, solar panel, wind turbine or fuel cell will be connected to the Input connectors.

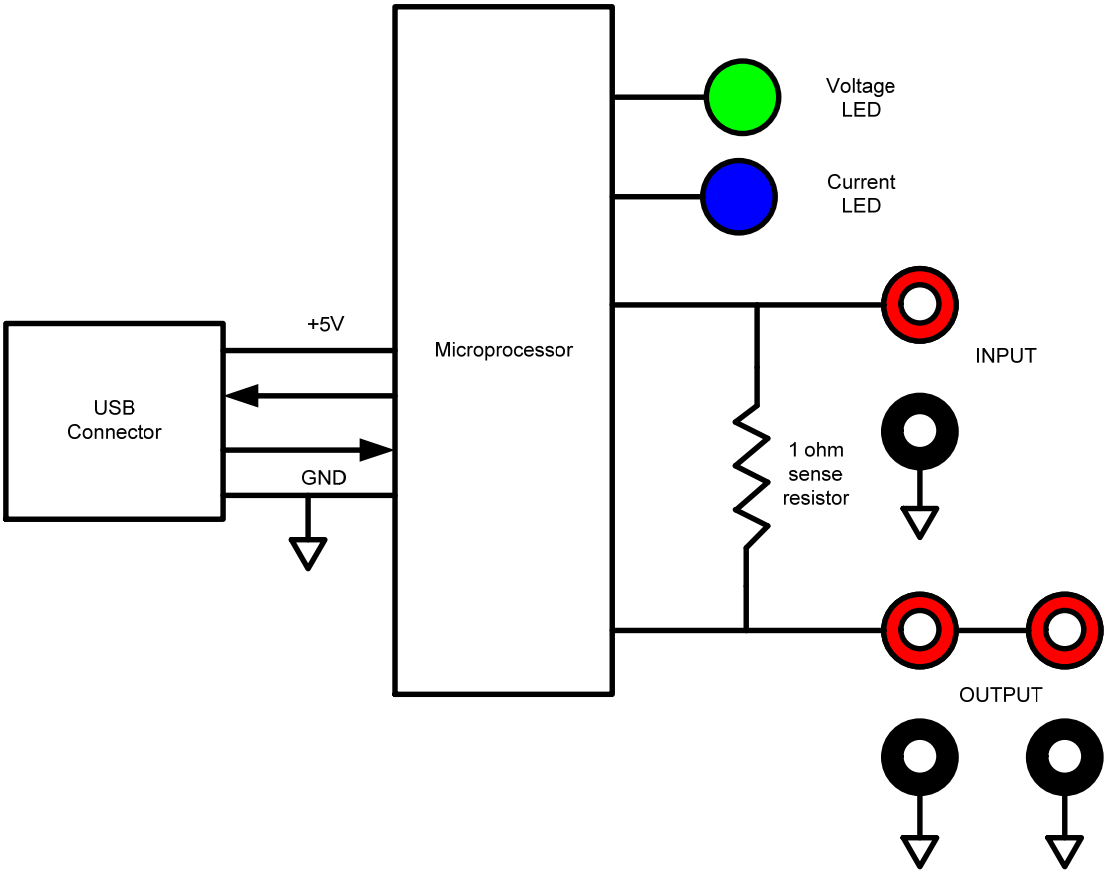
There are four (4) Output connectors, but they are actually two sets of positive and negative connectors arranged in parallel - meaning that the two positive (red) terminals are connected together and the two negative (black) terminals are connected together (but not to each other; i.e., positive to positive and negative to negative). In the following experiments loads such as a resistor, capacitor, motor and fuel cell are used. (a fuel cell can be both a power source as well as a load).

The diagram in the next subject line shows how these connectors are arranged.

1 Ohm Sense Resistor

A 1 ohm sense resistor (labeled R4 on the circuit board) is connected between the Input and Output connectors. Its main purpose is to measure the current flow from the power source on the Input connectors going into the load on the Output connectors. The sense resistor, R4, is also attached to the microprocessor (U1), which does the work of “sensing” current and load resistance.

Since the loads in the following experiments tend to be of small resistance values, generally 10 ohms, or less, the 1 ohm sense resistor must be considered in current and resistance calculations (as will be shown later). An equivalent circuit is shown on the following page:



Flashing LEDs

The two flashing LEDs represent the relative strength of the voltage and current being measured. The green LED indicates voltage and the blue LED indicates current - - the brighter the LEDs, the greater the relative voltage and current being measured (and visa versa). To enhance the understanding between the circuit board and the computer display software, these are the same colors used on the computer display software to display voltage and current.

USB Connector

The USB connector is the cube-like part on the left side of the circuit board. When a USB cable is attached to it and to a computer, power for the circuit board is delivered from the computer and data is transmitted by the circuit board to the computer for display and analysis.

9. Power Sources and Loads

The experiments use the following power sources and loads.

Power Sources

- Battery
- Solar Panel
- Wind Turbine
- Fuel Cell

Loads

- Resistors
- Capacitor
- Motor – Propeller
- Fuel Cell (a fuel cell can be both a power source and a load)

What is a Power Source?

For these experiments a power source is a device that produces both electrical voltage and current (in effect, power). The power sources use chemical energy (battery, solar panel), magnetic energy (wind turbine) or hydrogen (fuel cell) to generate voltage and current.

The equation for power is shown below:

$$P = E*I$$

Where P = Power in watts
E = Voltage in volts
I = Current in amps

What is a Load?

A load is a device that accepts the power coming from a power source and (may) use the power to do work, like spin a motor. Other loads like resistors and capacitors serve to dissipate or store power (respectively). In all cases, loads are used to both consume and regulate the power being produced.

Generally speaking, a load is measured as resistance whose units are in ohms.

In relative terms, a “light” load has a “large” resistance and a “heavy” load has a “small” resistance. This may be counter intuitive, but it is the case, nevertheless. For example, a 100 ohm resistor presents a “lighter” load to a circuit as compared with a 10 ohm resistor.

The equation for computing the association among voltage, current and resistance (load) is as follows:

$$E = I*R$$

Where E = Voltage in volts
I = Current in amps
R = Resistance in ohms

What is a Resistor?

A resistor is an electrical device (usually composed of a passive material like carbon) that limits the flow of current and voltage from a power source. Resistors are important components in any electrical circuit, since other components that are connected to the resistors depend on the limited current and voltage they produce to operate correctly.

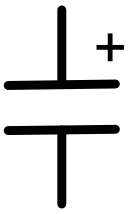
The physical part and electrical symbol for a resistor are shown below:

What is a Capacitor?

A capacitor is a device that stores energy from a power source and then releases the stored energy when it is no longer available. It is somewhat like a rechargeable battery, but quite different in terms of its construction and use in circuits. Depending on the size of the capacitor (its value, in units called Farads), it can store and release energy many times faster as compared with a battery. The experiments will use the capacitor to “filter” or smooth out the voltage “ripples” produced by the wind turbine.

Capacitors come in two basic types – polarized and non-polarized. A polarized capacitor requires that you connect the positive lead to the red terminal on the circuit board and the negative lead to the black terminal. Non-polarized capacitors can have either lead connected to positive or negative. The experiments only use a polarized capacitor.

The physical part and electrical symbol for a polarized capacitor are shown below:

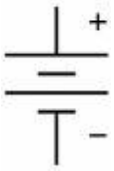


The longer lead of a polarized capacitor is positive (+) while the shorter lead is negative (-). The negative lead is also identified by a series of bar-and-arrow symbols on the part itself. In the experiments that follow, be sure to observe the positive and negative portions of the capacitor.

What is a Battery?

A battery stores chemical energy, which can be converted into electrical energy.

The physical part and electrical symbol for a battery are shown below:



Primary batteries are ready to produce current as soon as they are manufactured. Primary batteries are generally used in flashlights and must be replaced when they go “dead”.

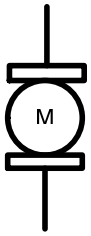
Secondary batteries can be recharged by applying an electrical current, which reverses the chemical reactions that occur during its use. All car batteries are secondary batteries that need constant recharging by the car’s alternator.

The capacity of a battery depends on the discharge conditions, such as the magnitude of the current and the duration of the current. The Battery Capacity (AH, Ampere Hour) is defined as the maximum constant current that a fully charged battery can supply for 20 hours at 68°F (20°C) down to a predetermined terminal voltage. Thus a 1000mAH (milliamp hour) battery will deliver 50mA over a period of 20 hours at room temperature. However, if it is discharged at 100mA, it will run out of charge within 10 hours.

What is a Motor?

There are many types of electrical motors, but the one used in the experiments is a small DC motor that attaches to a propeller. Normally constructed with spinning magnets (rotor) that surround a coil of wires (stator), a motor converts electrical energy into mechanical energy by taking in electrical power and then spinning a shaft using magnetic energy. The shaft can be connected to a "load" such as a propeller to do work; i.e., spinning the propeller to generate wind energy.

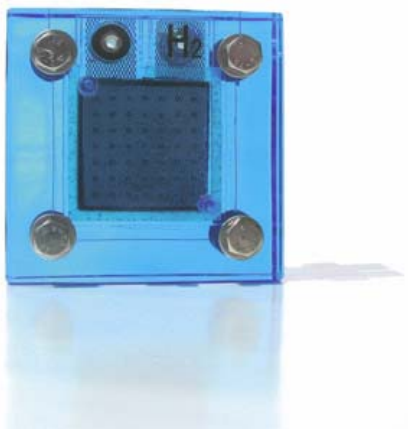
The physical part and electrical symbol for a DC motor are shown below:

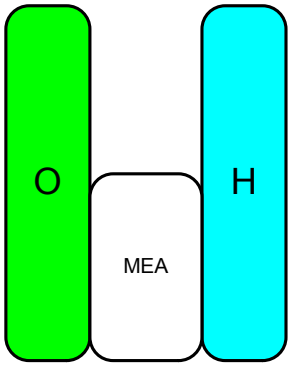


What is Electrolysis?

For our purposes the term electrolysis defines splitting water into its two main components – hydrogen and oxygen. This is what a "reversible" fuel cell does; it splits water (H2O) into hydrogen and oxygen gases in electrolysis mode and then recombines hydrogen and oxygen in fuel cell mode to create electricity, which is why it is called "reversible". It doesn't take much voltage (about 1.5 volts) to split water into hydrogen and oxygen as one of the experiments will demonstrate.

The physical part and symbol for a reversible fuel cell are shown below:



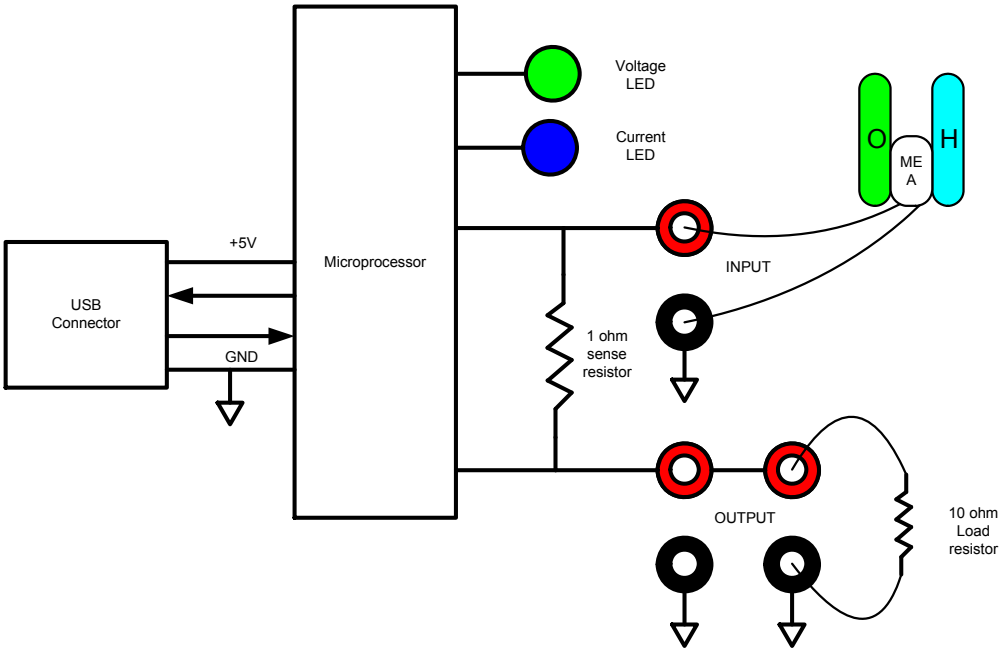


10. Measuring Resistance

When measuring resistance both the external load resistor as well as the 1 ohm sense resistor built into the circuit board must be taken into consideration.

Example 1:

The illustration below shows a 10 ohm load resistor placed across one set of the OUTPUT terminals. The total resistance is really 11 ohms (10 ohm load resistance + 1 ohm sense resistance). While the fuel cell is shown as the power source, a battery, solar panel or wind turbine can also be substituted.



The equivalent circuit is shown below: