Work-Ready Electronics

Synchronizing Curriculum to the Rapidly Changing Workplace

Module: Alternative Energy Sources
Fuel Cells, Solar Power and Ultracapacitors

WORKREADY ELECTRONICS

Alternative Energy Sources

Most of the electrical power we use comes to us through AC power lines. Power supplies in electronic equipment convert the AC input to one or more DC voltages.

Batteries are also a major source of electrical power, and their use in portable electrical and electronic equipment is growing significantly.

Today, there are an increasing number of viable alternative energy sources. While none have the capacity or efficiency to replace our AC generation plants, these sources are beginning to replace and/or supplement batteries in a number of new portable applications. Recent technological developments have made them more efficient and affordable.

This module introduces you to the most common alternative energy sources that you may encounter in electronic work. These include fuel cells, solar power, and ultracapacitors.

Prerequisites for This Module

This module is designed primarily to be used with a DC circuits course but can also serve as a supplement to any other course where the prerequisites given below are met.

Prerequisites for this module are successful completion of the WRE module Portable Power Technology (Batteries) and the following knowledge and skills:

- Basic DC circuit operation
- Ohm's law
- Series and parallel circuits and Kirchhoff's laws
- Capacitor fundamentals for DC circuits

What Technicians Need to Know

- Fuel cell operation
- Fuel cell applications
- Solar cell operation and specifications
- Solar cell applications
- Ultracapacitors operations
- Ultracapacitor applications

Fuel Cells

Energy Source of the Future

Fuel Cells

A fuel cell is an electrochemical power source that generates a DC voltage from a chemical reaction.

A fuel cell is like a battery but requires external sources of hydrogen and oxygen. As long as these chemicals are provided, the fuel cell will produce voltage.

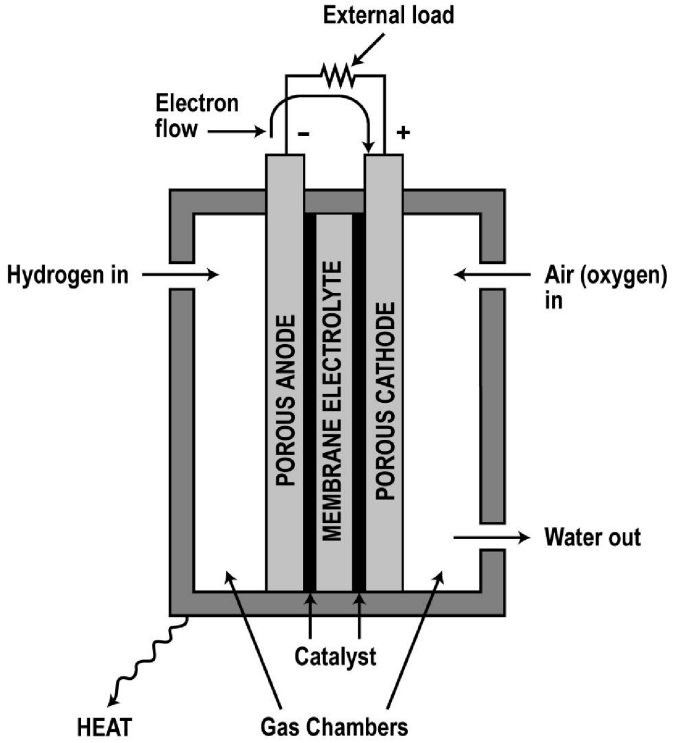
As the hydrogen and oxygen are combined, voltage is produced along with the byproducts pure water (H_2O) and heat.

The output voltage is typically in the 0.3 to 1.2 volt range per fuel cell. Cells are usually stacked to provide a battery with higher output voltage as required for the application.

The current capability is dependent upon the size (surface area) of the electrodes and the quantity of hydrogen and oxygen supplied.

Fuel Cell Basic Structure

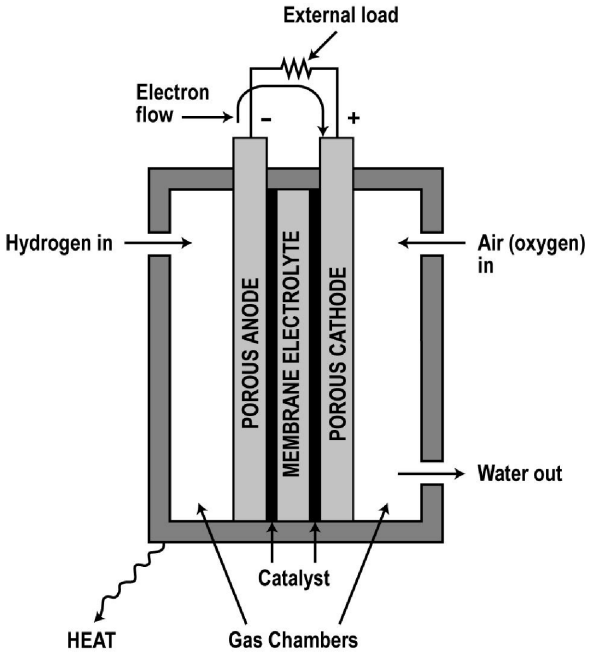
Like a battery, the basic structure of a fuel cell has an anode and a cathode. The electrodes are usually porous so that the gases flow through them. Hydrogen is pumped into the anode while oxygen is supplied to the cathode. The external load is connected between the electrodes. The anode is the negative terminal and the cathode is the positive terminal.



Fuel Cell Operation

The anode and cathode are separated by a thin membrane (electrolyte) in which the chemical reaction takes place. One type of membrane is made of an insulating polymer (a plastic). Each side of the membrane is coated with a catalyst like platinum that makes contact with the electrodes.

As the gases are supplied, the hydrogen is oxidized by the reaction with the electrolyte and electrons are freed for current flow through the load.

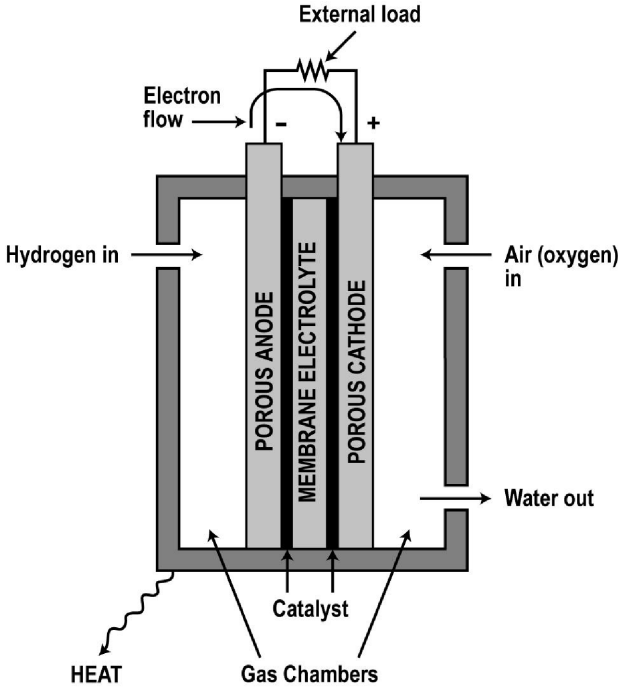


Fuel Cell Operation

The positive hydrogen protons created in the process pass through the membrane to the cathode.

Oxygen is passed over the cathode. The positive hydrogen ions coming through the membrane combine with the oxygen and the electrons from the load to form water and heat.

The process continues until the fuels are depleted or replaced.



A Practical Fuel Cell

Even though fuel cells that work like that described do exist, they require sources of pure hydrogen and oxygen.

Pure hydrogen and oxygen are very expensive to make, transport, and store.

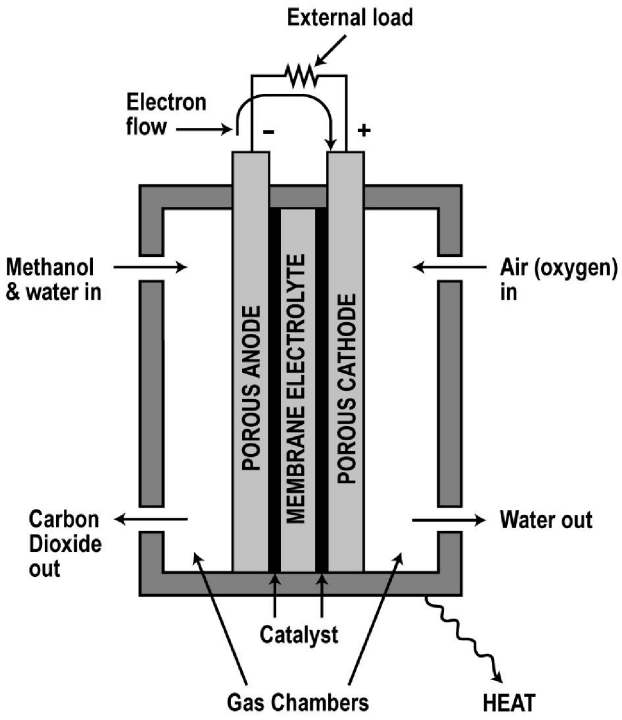
Other more affordable and readily available sources of hydrogen and oxygen can be used to create smaller and less expensive fuel cells.

Direct Methanol Fuel Cell

A typical modern fuel cell for portable power is known as a direct methanol fuel cell (DMFC).

The source of oxygen is from the surrounding air. Air is about 78% nitrogen, 21% oxygen, and 1% other gases.

Openings are provided in the cell to expose the cathode to the air where the oxygen is extracted automatically for reaction with the hydrogen.



Practical Fuel Cell Operation

Hydrogen is obtained from a liquid mixture of methanol and water. Methanol is a very low cost liquid known as wood alcohol that is rich in hydrogen. It is more easily produced than pure hydrogen. Natural gas may also be used.

The process extracts the hydrogen from the methanol and voltage is produced as described earlier.

The byproducts are water, heat, and a small amount of carbon dioxide.

Such fuel cells are stacked in series to produce higher voltages.

Practical fuel cells are available in sizes ranging from about one inch square to refrigerator size.

Fuel Cell Applications

Fuel cells are now used in space craft such as NASA's shuttle and the space station.

They are also used in fixed emergency power sources (uninterruptible power supplies) for hospitals, the military, and for broadcast stations and other systems where power cannot go down. Stationary power systems using fuel cells can be obtained in sizes from a few kilowatts to over 600 kW.

Fuel cells are also available as portable power sources for laptops. They are used in recharging cell phones, PDAs, and other devices and are available now in small packages with replaceable methanol cartridges.

They will also be used in automobiles and all electric vehicles as soon as the costs come down.

Fuel Cell Testing

Fuel cells are tested just like batteries.

Like batteries, the best test results are obtained by measuring the output voltage with a typical load.

The loaded voltage should be above the end point voltage for the specific type of fuel cell being used.

Test your knowledge

Alternative Power Sources
Knowledge Probe 1
Fuel Cells

Click on Course Materials at the top of the page.
Then choose **Knowledge Probe 1**.