

# Solar cells

This case study involves researching about solar cells and study the effect internal resistance has on its efficiency. This ties up with our practical investigation where we investigate the internal resistance of a power supply.

Sunlight can be converted into electrical energy using photovoltaic cells also known as solar cells. Photovoltaic (PV) cells are made of materials called semiconductors such as silicon. When light strikes the cell, a certain portion of it is absorbed within the semiconductor material<sup>1</sup>. The energy absorbed by the semiconductor from the light knocks electrons loose, allowing them to flow freely thus making an electric current. Unlike on Earth, there is no atmosphere in space blocking sun light so there is a good supply of sun light energy if

positioned correctly, but the disadvantage is that the longer they stay exposed to extreme high temperature the more likely for them to get damaged. Temperature also has a major impact on the internal resistance of the solar cell. This could be detrimental to the space program being undertaken. In this case study, I aim to investigate the internal resistance of a power supply and link the results to a power supply in space i.e. a solar cell. By studying the relationship between external load on current and voltage, the internal resistance of a power supply can be determined. Knowledge gained can be used in designing a circuit that meets or exceed requirements that is required for a space exploration .

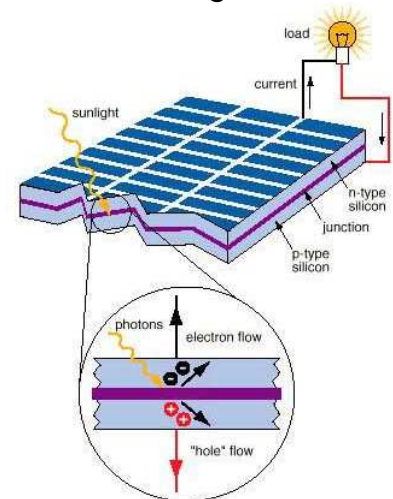


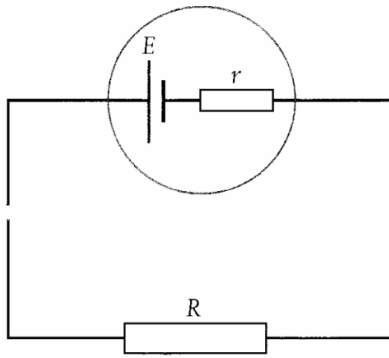
Figure 1

## Internal Resistance

In a power supply there are wires and chemical electrolytes and electrodes that make up a cell which all have electrical resistance. Some energy produced by the power supply is transferred to the resistance. So when the charge travels through the source of e.m. f. It gains energy, but losses some of what it gained due to this resistance. This resistance is known as **Internal Resistance**. The internal resistance is represented as a 'perfect' cell with a resistor connected in series representing the internal resistance, as shown below:

<sup>1</sup> How Stuff Works - <http://science.howstuffworks.com/solar-cell1.htm>. (last Accessed : 08/04/10)

Figure 1 ActewAGL Always - [http://www.actewagl.com.au/education/\\_lib/images/energy/energy07.jpg](http://www.actewagl.com.au/education/_lib/images/energy/energy07.jpg). (last Accessed : 08/04/10)



The circle enclosing  $E$  and  $r$  represents that they are a single component. The current can be worked by connecting the battery to an external resistor.  $R$  and  $r$  are in series with each other, because the current  $I$  flows first through one and then through the other meaning that in total the total resistance is  $R + r$ . From this the formula below is derived:

$$E = I(R+r) \quad \text{or} \quad E = IR + Ir$$

$E$  cannot be measured directly because a voltmeter can only be connected across the whole cell with its internal resistance  $r$ . To do this the terminal p.d.  $V$  is measured given by:

$$V = IR$$

This p.d. will be less than the e.m.f.  $E$  by an amount of  $Ir$  called the **lost volts**. Combining these two together gives:

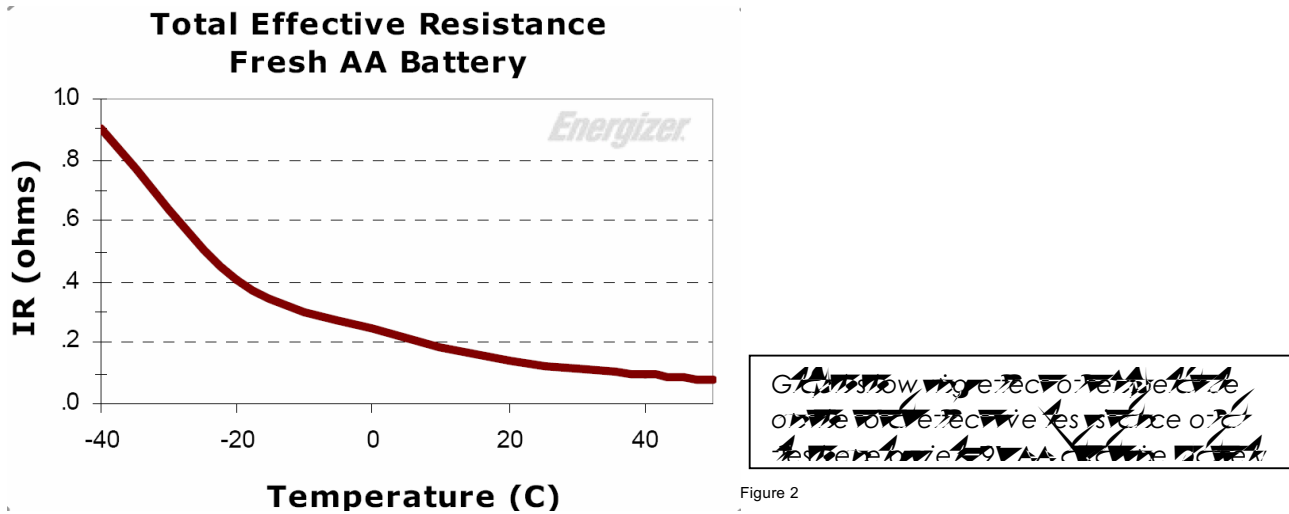
$$V = E - Ir$$

The lost volts tell us the energy transferred to the internal resistance of the supply. If you short circuit a battery with a piece of wire, a big current will flow, and the battery may get warm as energy is transferred within it. This is risky as a large flow of current could cause serious injuries or electrocution. Precautions can be put in place to reduce the risk of this by for example introducing a resistor to the circuit.

In general, internal resistance will rise during discharge due to the active materials within the battery being used<sup>2</sup>. However, the rate of change during discharge is not consistent but is affected by external factors like temperature which affects internal resistance. In colder temperatures the chemical reactions in the battery occur slowly due to slow movement of electrolytes which in turn increase internal resistance but reduce when temperature increases. This is particularly important with solar cells because of constant exposure to sunlight in space.

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<sup>2</sup> Energizer - <http://data.energizer.com/PDFs/BatteryIR.pdf> (Last Accessed: 08/04/10)



The disadvantage of internal resistance can be seen in the headlamps of cars. If a driver tries to start a car with the headlamps on, the starter motor requires a large current from the battery, the battery's terminal p.d. drops, and the headlamps dim. This is because the more current the power source supplies, the more its terminal p.d. will decrease. To get efficient transfer of energy from a source of e.m.f. to an external resistor, the internal resistance should be small compared to the external resistance<sup>3</sup>.

## Environmental

As of late, majority of people are concerned with the supply of energy needed to sustain Human activity and the threat of Global warming. Scientists are looking into alternatives to current methods and one of them is making use of solar cells. Solar cells are carbon neutral and potentially, an unlimited source of energy. It looks promising but as with most things the solar cells have their disadvantages. Firstly, the solar cells are powered by sunlight but sunlight doesn't last throughout the day. Another disadvantage is that the solar cells cannot make use of all the energy provided by the sun. This including internal resistance and other factors reduce the efficiency of the solar cell. To compensate for this, large solar cells covering acres of land need to be used to provide sufficient and economical amounts of energy. This is undesirable and is a major factor ruining the potential of solar cells. The challenges to scientists are to produce cost effective, efficient and portable solar cells. Some companies have made advances in tackling the problems of solar cells like with the recent news of 'silicon ink' from Innovalight. The company *first got noticed in 2007 for perfecting a process in which it could essentially ink-jet-manufacture solar cells using a proprietary silicon ink it had developed. The solar cells are created by pouring an ink solution incorporated with silicon nanoparticles and then decanting the excess liquid to leave behind a crystalline silicon structure*<sup>4</sup>.

Figure 2 Energizer - <http://data.energizer.com/PDFs/BatteryIR.pdf>. (Last Accessed: 08/04/10)

<sup>3</sup> David S, Keith G, Robert H. (2000) Physics 1, Cambridge: Cambridge University Press.

<sup>4</sup> Cnet - [http://news.cnet.com/8301-11128\\_3-10355500-54.html?part=rss&subj=news&tag=2547-1\\_3-0-20](http://news.cnet.com/8301-11128_3-10355500-54.html?part=rss&subj=news&tag=2547-1_3-0-20) (last Accessed : 08/04/10)

## Sources

- ActewAGL Always - [http://www.actewagl.com.au/education/\\_lib/images/energy/energy07.jpg](http://www.actewagl.com.au/education/_lib/images/energy/energy07.jpg). (Last Accessed: 08/04/10)

This source of information is from the website of an Australian Energy Company. Information on the website is to educate their clients of the products and future prospects the company are supplying. I found information from the website to be reliable and simple to understand.

- How Stuff Works - <http://science.howstuffworks.com/solar-cell1.htm>. (Last Accessed: 08/04/10)

How Stuff Works, '*a wholly owned subsidiary of Discovery Communications, is the award-winning source of credible, unbiased, and easy-to-understand explanations of how the world actually work*'. The website provides information for the public to access so as to improve their knowledge on different topics. As with the ActewAGL Always company website the information was easy to understand and, with some cross referencing with other sources, to be very reliable. The website also includes video explanations making it easier to understand the information.

- Energizer - <http://data.energizer.com/PDFs/BatteryIR.pdf>. (Last Accessed: 08/04/10)

Energizer is a company that produces portable power sources in the form of batteries. The website provides technical details about the performances of their products. Information are reliable but very difficult to understand.

- Energizer - <http://data.energizer.com/PDFs/BatteryIR.pdf> (Last Accessed: 08/04/10)

- Cnet - [http://news.cnet.com/8301-11128\\_3-10355500-54.html?part=rss&subj=news&tag=2547-1\\_3-0-20](http://news.cnet.com/8301-11128_3-10355500-54.html?part=rss&subj=news&tag=2547-1_3-0-20) (last Accessed: 08/04/10)

Cnet is a website dedicated to providing the latest technology and gadget news. As a regular reader information from the website is most of the time accurate and reliable but from time to time, I found that the information can be wrong.

- David S, Keith G, Robert H. (2000) Physics 1, Cambridge: Cambridge University Press. (Last Accessed: 08/04/10)