Developing a Portable & Rechargeable Battery Pack

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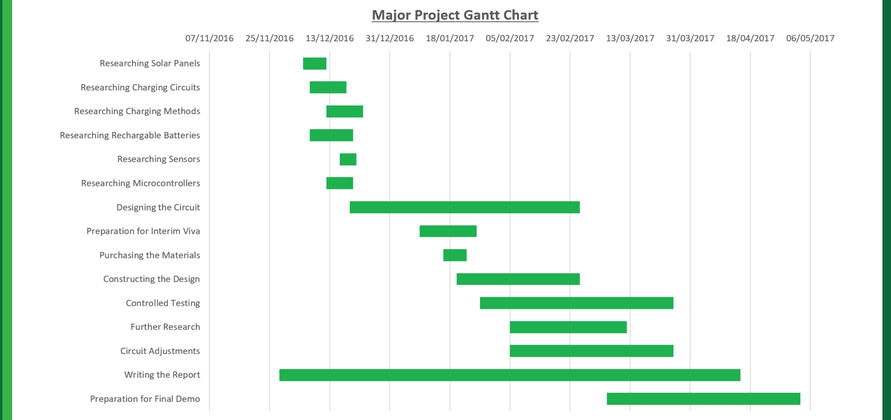
This proejct focuses on existing solar charging solutions as well as how to develop a portable & rechargeable battery pack. This is achieved by producing a Gantt Chart which will be used to plan out how time will be allocated for each major task such as Research, Circuit Design & Testing so that all deadlines are met.

The aims and objectives of this project include:

- Investigate & research existing solutions
- Investigate & research major components and techniquies used
- Develop a prototype which generates power using a solar panel
- Store the generated power using a battery pack
- Monitor and regulate the charging process

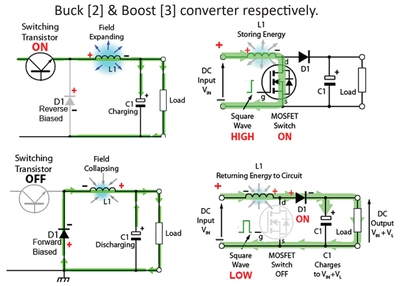
The research carried out focuses on common techniques used such as Constant Current, Trickle Charging and Negative Delta V, as well as the components used such as how a PIC Microcontroller can be used to monitor and regulate the charging process as well as the different types of rechargeable batteries available including Lithium Ion, Nickel-Metal Hydrate & Nickel-Cadmium.

This research is used to make informed choices when selecting the components that will be used to create the initial circuit design.
These decisions include selecting the type of battery, the output capacity of the solar panel, values for any resistors, capacitors & inductors, the specifications needed for the Microcontroller and any additional components and features that could be added during development



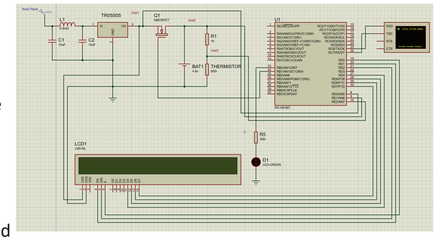
Buck & Boost converters, or Step-Down & Step-Up converters, are types of circuits which specialize in greatly increasing the voltage or current of the source while decreasing the opposing value depending on the converter used. For example, a Buck converter will increase the current while lowering the voltage and a Boost converter will do the opposite.

Diagram showing the operation of a Buck [2] & Boost [3] converter respectively.

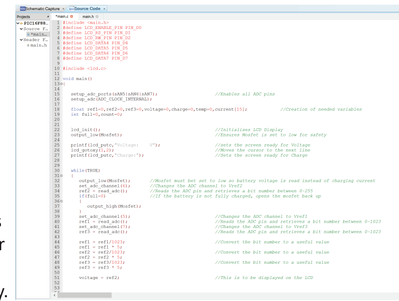


Both of these circuits operate by creating an electromagnetic field which then shortly collapses soon after. This is done because when the magnetic field collapses, it releases the built up energy collected and delivers it to the connected load. For example, when the magnetic field collapses in a Buck converter, the polarity of the diode in the circuit switches, allowing for the direction of current flow to change and be redirected back towards the load along with the energy collected from the capacitor, increasing the current. A similar event also occurs in the Boost converter as when the MOSFET is turned off, collapsing the magnetic field, the energy gets redirected towards the load, increasing the voltage as the energy from the source and the magnetic field is additive.

The development carried out uses software called Proteus to design & develop an initial circuit which could be simulated before being assembled.
This software includes a vast library of components to choose from so any solution can be tested before the components are purchased and assembled.
The software allows the code used in the PIC Microcontroller to be created using CCS Compiler instead of Assembler for ease of use.

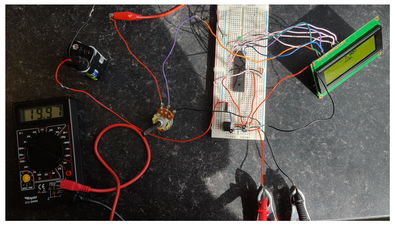


The code used in the PIC Microcontroller was created with the intention to monitor the battery so that the user is informed of how the battery is progressing and to also protect the battery from overcharging, which could damage the battery.
The PIC communicates with the connected LCD display in regular intervals so that the infromation is accurate. This is done by printing the information in the variables to the display at set intervals within the code.
The PIC also monitors the circuit using the built in Analogue-Digital Converter which reads several voltages within the circuit and reads these values as a bit number between 0-1023. The code used will convert this value into a voltage so that it can be printed to the LCD display.



These values are also used to control the different states the circuit is in such as signalling if the circuit is charging the battery, if the battery is full and when the battery is at risk of being overcharged. This is achieved by comparing the voltage readings to a set value, checking the total current absorbed by the battery and checking the temperature. All of these are used as flags which can trigger the state which they are assigned to.

The circuit is assembled and tested to see if it performs as expected. This is done by monitoring each conection within the circuit using a multimeter to ensure that the correct voltages and current is being generated.
During testing, several issues arised such as inaccurate reading being displayed on the LCD as well as a less than satisfactory rate-of-charge being used to charge the battery. Because of the limited time frame, not all of these issues could be corrected and the prototype produced does not perform as well as intended.



A solar panel operate by using two silicon layers, each of which are charged of opposite polarities. When a photon passes through these layers, it releases the energy collected from the n-type layer into the p-type layer, which then travels towards the negative terminal of the solar panel. This action powers the load as it travels back towards the positive terminal and back into the p-type layer.

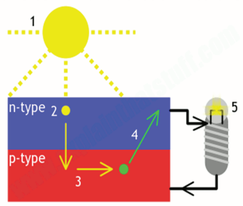
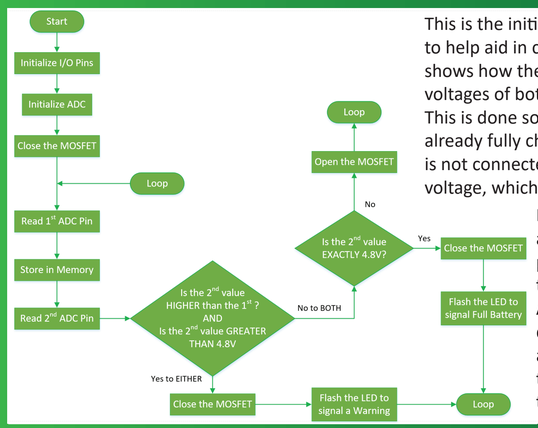


Diagram showing the operation of a Solar Panel [1]



This is the initial version of the software flowchart used to help aid in creating the software code. The flowchart shows how the circuit would function by reading the voltages of both the charging current and the battery. This is done so that the battery is checked to see if it is already fully charged and also to ensure that the battery is not connected to a source which is at a much higher voltage, which could damage the battery.

During development, an LCD display was added to show the voltage readings, percentage from empty to full and the total current absorbed by the battery. Another addition that was made during development was a thermistor which acted as a temperature threshold so that the charging process would be halted if the battery reached a certain temperature.

The outcome of the project did not go as expected as a while a prototype was developed, it does not pereform well enough to be called a success. Additional time would be needed to improve the prototype further and fix the remaining issues as well as produce a clear set of results such as the time taken to fully charge the battery pack, total power generated over a 12-hour period and the power transfer from the solar panel to the battery pack.

Other stages of the project such as collecting the necessary research, planning the design and creation of the circuit & code in simulation software progressed as planned and were all completed with very few issues. Because of this, there is little doubt that with additional time that this project could be very successful once the remaining issues have been fixed and the prototype is further developed.

Overall, the project has served as an important learning experience on what aspects need to be taken into consideration when carrying out a development project. The key skills developed during the project such as proper time allocation, planning the design using diagrams & flowcharts, simulating the design & created code to test for flaws as well as analysing the physical circuit for possible errors, can be used to improve the process and success of future projects.

[1] C. Woodford, "Solar Cells," 17th June 2016. [Online]. Available: http://www.explainthatstuff.com/solarcells.html. [Accessed December 2016].

[2] E. Coates, "Buck Converters," 2016. [Online] Available: http://www.learnabout-electronics.org/PSU/psu31.php. [Accessed December 2016].

[3] E. Coates, "Boost Converters," 2016. [Online]. Available: http://www.learnabout-electronics.org/PSU/psu32.php. [Accessed December 2016].