Helios: Solar Powered Cell Phone Charger

By Nathalie Belmore | Spring 2024 Capstone Project | Electrical and Computer Engineering

Abstract

An energy storage system (ESS) and power supply system (PSS) allow a small electronic device to charge itself independent from the main power grid via:

1) The ESS interfaces with two solar panels and a DIY DC-DC step down converter to store solar energy in a source battery

2) A PSS uses the source battery to power a load rated at 5 Volts and up to 2 A.

Problem Statement

Many inhabitants of developing nations spend hours, even days, walking to charge their mobile phones b/c they don't have electricity in their homes, according to *The Ecomonist,* 2016.

Features

- MPPT extracts maximum available solar power
- Estimated charge time in sunny conditions: 4 hrs
- USB-C port to charge phones
- Estimated run time on source battery: 3.5 hours for 5V load at 500 milliAmps
- Protection against overloads for safe operation
- ESS and PSS systems work independently

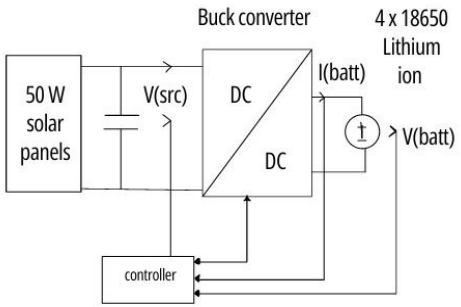
Components

- 2 x 50 Watt solar panels
- 2 x DC-DC step-down power converters
- 2 x 14V Lithium-ion battery banks
- Arduino control systems

References

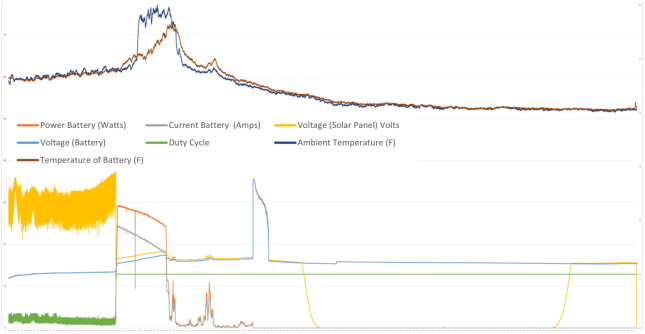
Curio Res. 2022. How to Build An Arduino Controller Solar Charger. [Video]. Available: youtu.be/1oFlc4jv2-g?si=cOZhhQUDMVOmRpq

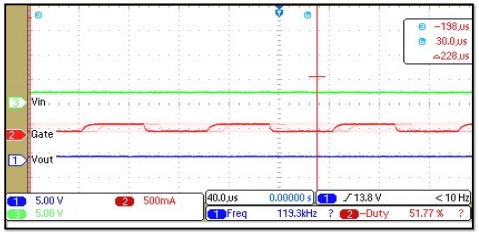
System Design and Results



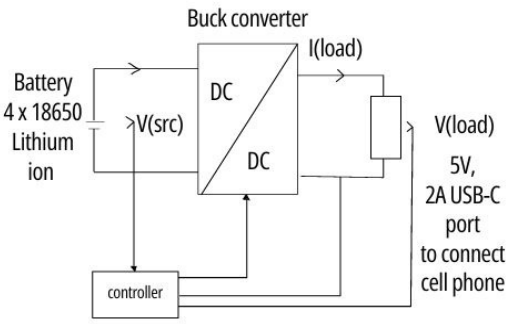
Battery charger
Energy Storage System (ESS)

MPPT Tracking data across 20 hours 12 PM – 8 AM May 23, 2024



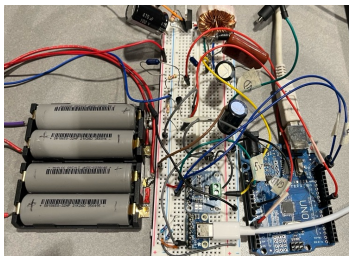


LEFT: PWM signal/duty cycle (red waveform). DC voltage at solar panels (green). Source battery's DC voltage maintains at 14 V as designed (blue).

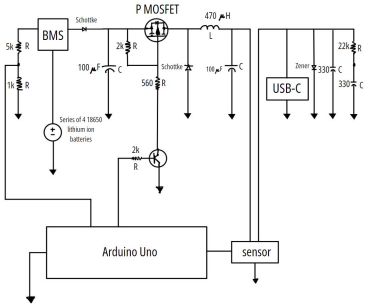


Phone charger
Power Supply System (PSS)

ABOVE: Blue line (Vout) shows the DC voltage at the load side of the PSS when the battery is 92% charged and powering a TracPhone. Green line shows voltage at the USB-C port maintains and is regulated at 5V as designed. The red waveform shows the PWM signal which controls the duty cycle in the same way the PWM signal functions in the ESS. The PWM switches the system on and off, such that the average Voltage "duty cycle" is exhibited at the load.



ABOVE: Four 18650 lithium-ion batteries configured in series supply about 16 V to a DIY DC-DC buck converter. A BJT transistor drives an Arduino Uno to control a PWM that steps supply down to 5 V to power a USB-C port for phones



ABOVE: Schematic of DIY step-down converter, or buck converter, in PSS. A p-channel MOSFET switches on and off and a transistor drives the Arduino control, which sends the PWM signal to adjust duty cycle according to an if-then statement that maintain 5 Volts at the USB-C port.

ESS Results/Conclusion

Average sensor readings for ESS on a sunny day: Charge current drawn averages 180 milliAmps at the load/battery; maximum voltage at the battery reaches 15.92 V; solar panels begin at approximately 30 V and gradually get bucked down to match voltage at the battery.

PSS Results/Conclusion

An average of the system's sensor readings across 60 seconds while batteries (power supply) charges a TracPhone and the batteries are fully charged:

490 milliWatts at the load (USB-C port)
147 mAmps at the load (USB-C port)
Duty Cycle: 15%
Voltage at power supply: 15.69 V
Voltage at the USB-C port is regulated at 5V, as designed.

Future Work

The Power Supply System's efficiency is measured at 83.01%. Therefore, supplying power to anything larger than a small electronic device would likely cause overheating. Scaling the system up in order to power a vital household appliance would require much greater efficiency.

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