Developing a Linear DC-DC Converter for Solar Powered Phone Chargers

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Abstract

Motivation:

- Renewable energy sources decrease the use of fossil fuels and sustainably power the grid
- Photovoltaic (PV) panels use solar energy to supply power to different loads

Goals:

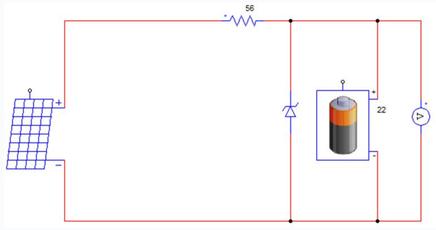
- Develop a linear converter to use the energy generated from a photovoltaic panel to charge a Li-ion battery
- Simulate the design using PSIM software, where we also tested factors such as:
  - Irradiation level
  - Temperature
  - Variable load
- Find the ideal conditions for maximized output power

Results:

- Converter changes the input DC voltage to a different amplitude DC voltage
- To obtain maximum output power, there is an ideal temperature, irradiation level, and load
- Various converters can be used within circuits: voltage divider linear converters, transistor based converters, switching converters

Background

- **Power Electronics** - branch of electrical engineering that involves the processing of voltages and currents for different applications
- **Power** - rate at which energy is transformed or transferred, dependent on:
  - **Current** - the rate electrons flow through a point
  - **Voltage** - the potential energy difference between two points
- Linear converter includes a capacitor, resistor, and zener diode
  - Capacitor temporarily stores energy
  - Resistor limits electron flow
  - Zener diode allows current to flow when a specific “Zener voltage” is reached; it is used as a measure of protection

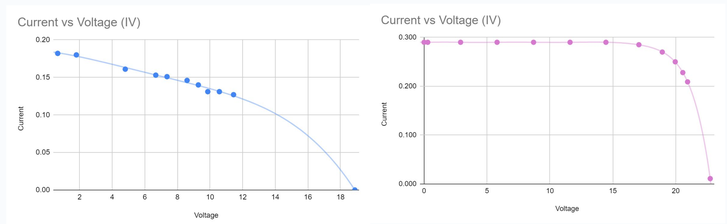


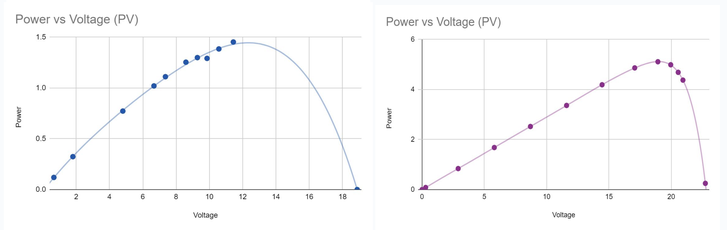
- Engineers are working on increasing the life of current converters, while decreasing their size and expense
- The goal of our project was to maximize the output of the photovoltaic panel and converter to effectively charge a battery

Experimental Methods

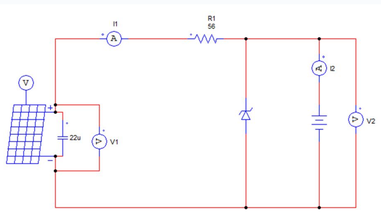
- Solar panel was tested in direct sunlight
  - Found optimal angle, tested for voltage and current at varying resistances using multimeter and variable resistor
  - Experimental data collected and graphed in google sheets to calculate maximum power point
- Simulated PV module on PSIM
  - Measured voltage and current (PV panel had same attributes programmed in)
  - PSIM data collected and graphed in google sheets
  - Varied resistance, irradiance, and temperature while keeping the remaining two constant
- Power = (current)(voltage)
  - Used to calculate power in sheets
- Ohm’s Law
  - Voltage = (current)(resistance)
  - Used to calculate resistances needed in converter
- Converters
  - Voltage divider linear converter and transistor based linear converter modeled in PSIM
  - Voltage divider linear converter made with soldering gun

Results

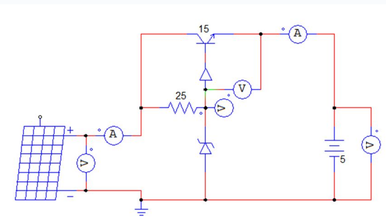




Experimental PSIM

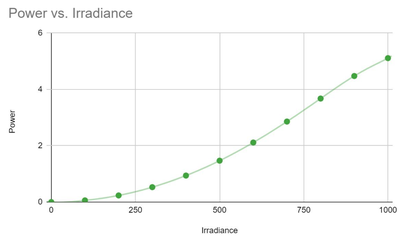


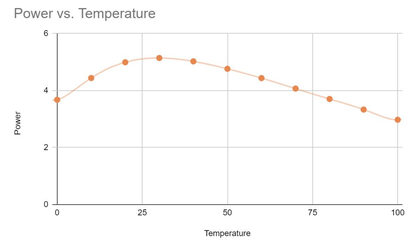
Voltage Divider Linear Converter



Transistor Based Linear Converter

Voltage Current





Results and Future Steps

Results:
Maximum Power Point (PSIM): 5.14 watts
Highest power extracted at:

- Irradiance: 1000 W/m^2
- Temperature: 30 ℃
- Resistance: 70 Ω

Future Steps:

- Voltage divider linear converters are inefficient, but other variations such as the transistor based linear converter and switching converters are more reliable
- The development of universal power converters

References

Amirabadi, M. (2021, February 11). *CAREER: Universal SiC-Based Power Converters for Renewable Energy Systems*. NSF AWARD SEARCH: Award # 2047213 - career: Universal SIC-based power converters for renewable energy systems. https://www.nsf.gov/awardsearch/showAward?AWD_ID=2047213&HistoricalAwards=false

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