SOLAR POWERED CONVERTER EDUCATION DISPLAY

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Outline

- Introduction of project
- Objectives
- Individual subsystems
- Successes and Challenges
- Ethical Considerations
- Recommendations

Introduction of Project

- Renewable energy vital for environment
- Allows individuals to see circuitry that converts sun’s rays into usable power
- Compares to the mechanical power of the hand crank

Objectives

- Charge a battery with a solar panel to power circuitry
- Key values from both the hand crank and solar panel displayed on mobile app
- 120VAC at the output
- Seven switches each connected to a resistor will allow for varying load

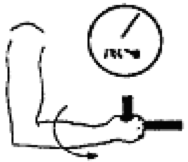
Hand Crank

- Used to compare power produced by the solar panel
- Represents a conventional mechanical method
- 12V DC motor connected to an 8.5 cm shaft through a gear box with a 65.5:1 ratio

Hand Crank Testing

- Used information from NASA and halved the torque of the average adult

Maximum Torque Type	Unpressurized suit, bare handed	
	Mean Nm (lb-in)	SD Nm (lb-in)
Maximum Torque Supination	13.73 (121.5)	3.41 (30.1)

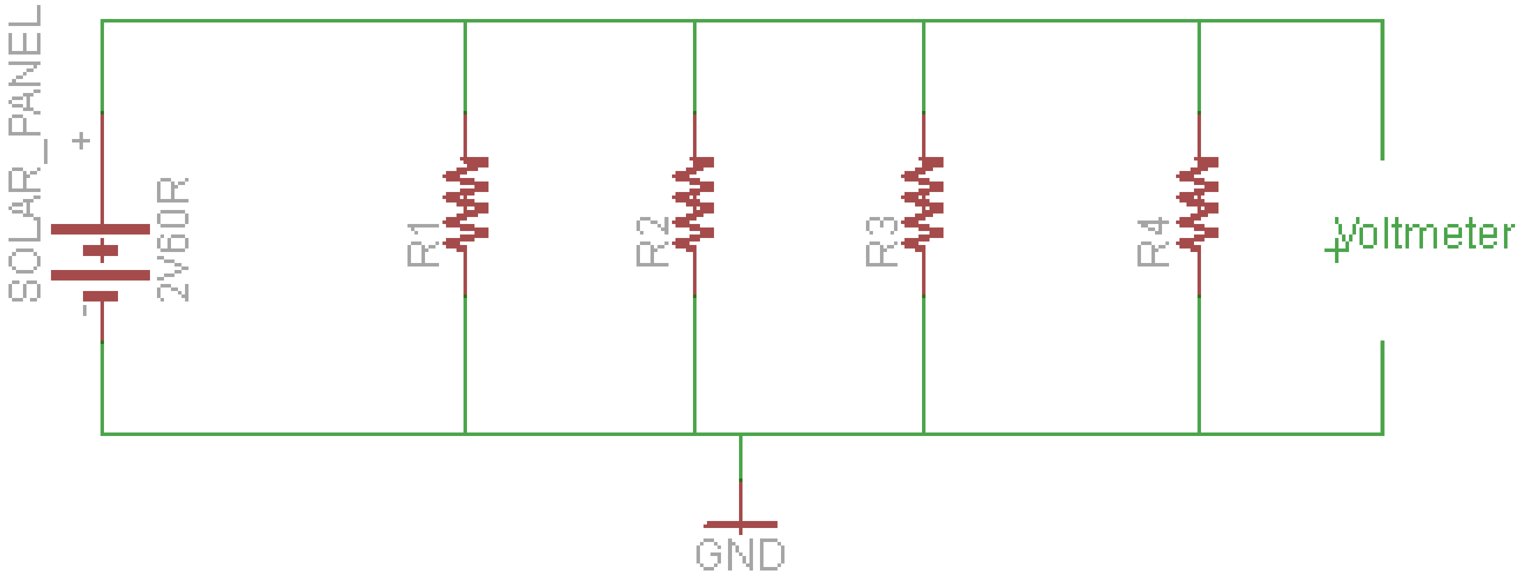


- $P = \tau \times \omega$
- When spinning at 114 rpm average voltage=11V
- Used a 1kΩ resistor

- $I = \frac{11}{1000} = 0.011A$
- $P = 0.011 \times 11 = 0.121W$
- $\tau = \frac{0.121}{2\pi * \left(\frac{114}{60}\right)} = 0.0101Nm$

Solar Panel

- Six cell white panel from the Power Group
- Needed to understand the IV-characteristics
- Schematic for finding the open circuit voltage and short circuit current

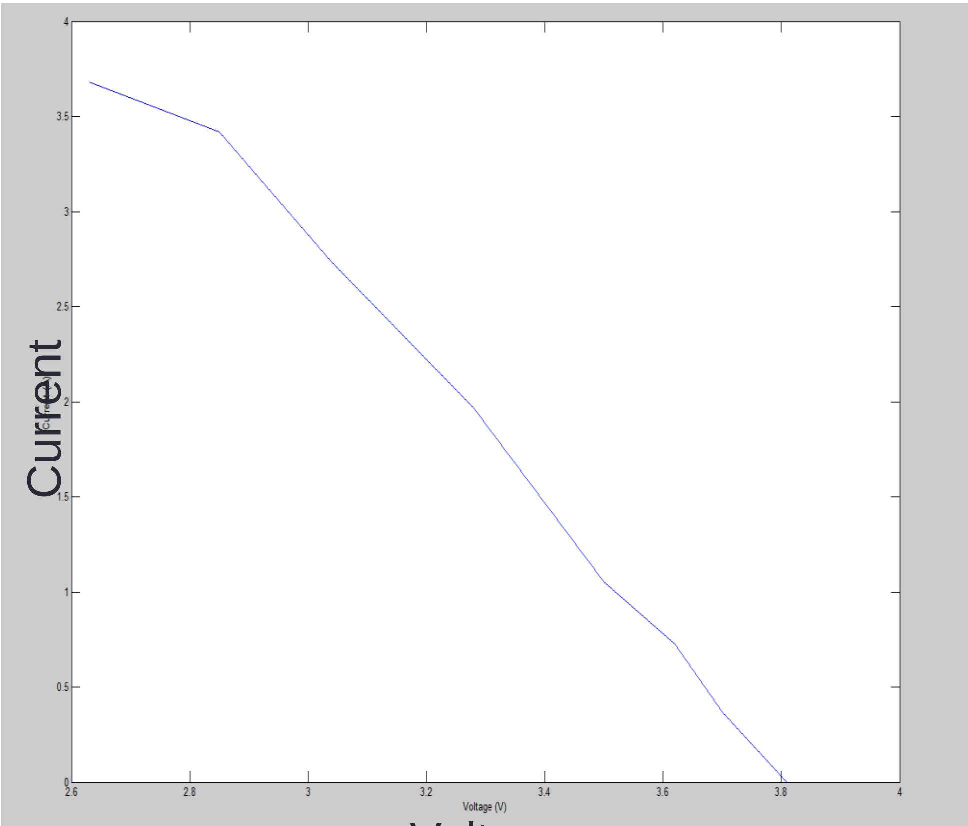


Solar Panel Testing

- Three tests were completed on separate days
- The third test was the most useful

Test 3 on March 9th								
Ohms	Open Circuit	10	5	3.33	1.67	1.11	0.83	0.71
Voltage	3.81	3.7	3.62	3.5	3.28	3.04	2.85	2.63
Current	0	0.37	0.72	1.05	1.97	2.74	3.42	3.682
Power	0	1.37	2.62	3.68	6.46	8.32	9.747	9.68

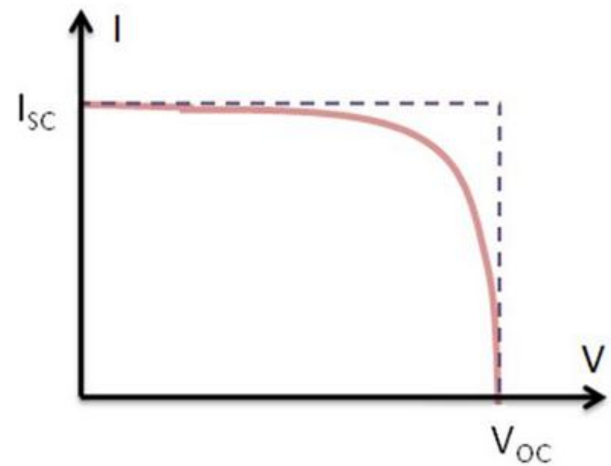
Solar Panel Testing



Voltage

Actual Curve

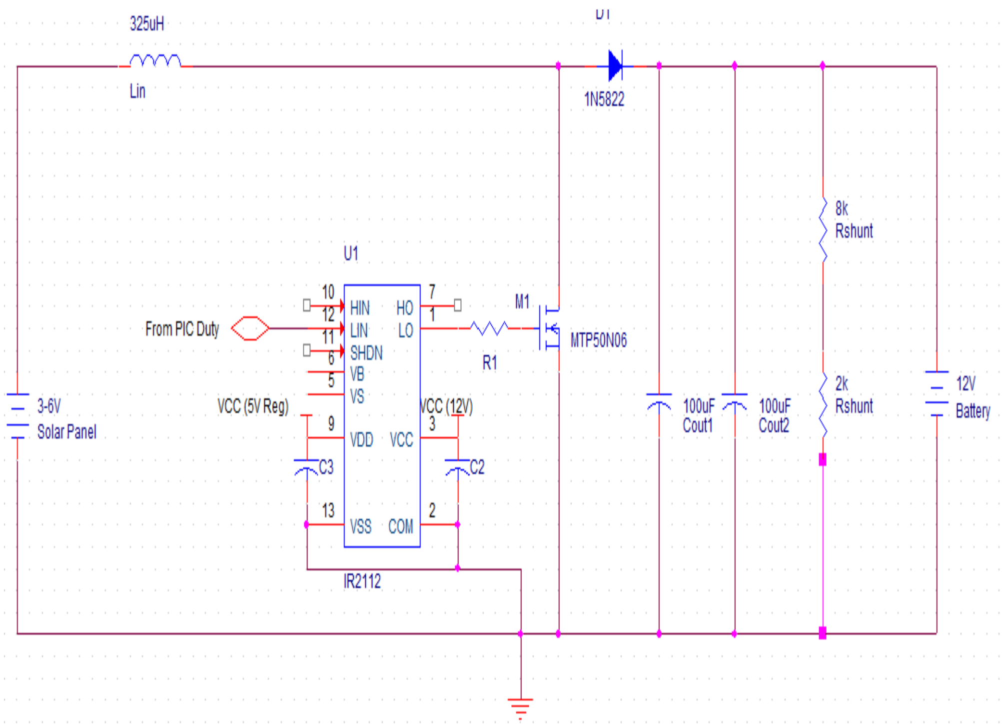
Actual curve is close to the ideal IV curve



Ideal Curve

Charging Circuit Specifications

- V_{in} = 3-6V
- V_{out} = 13.7V
- V_{ripple} = +/- 0.1V
- f = 100kHz
- Receive switching signal from PIC



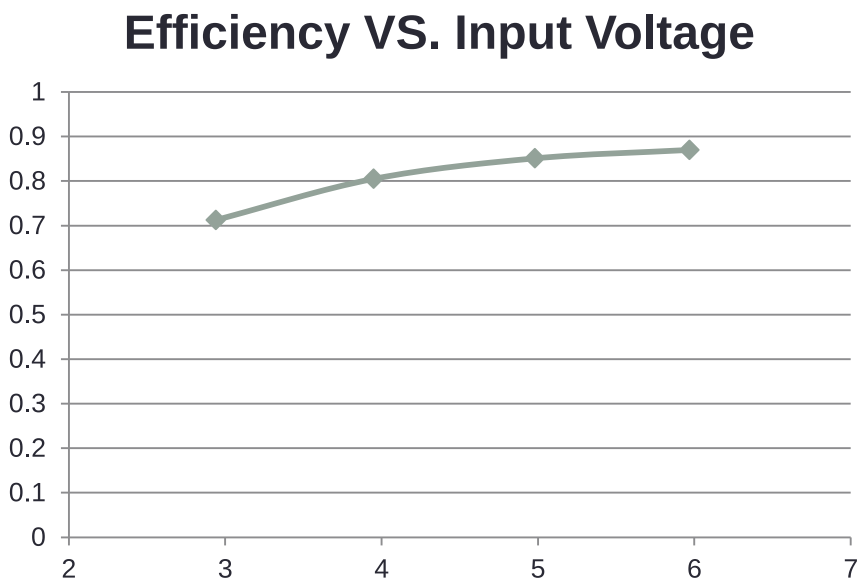
Charging Circuit Design Considerations

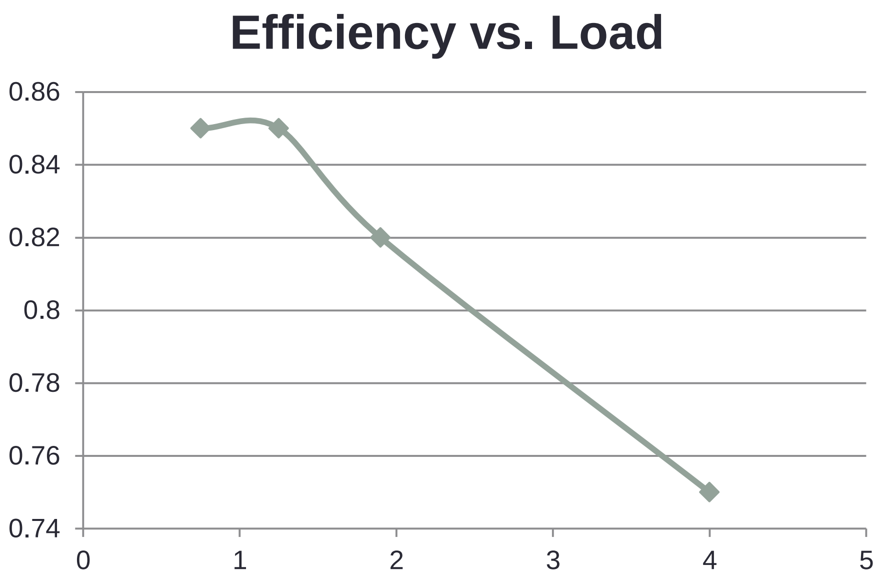
- IR2112 Low Side Gate Driver
- MTP50N06 (50V, 60A)
  - Well Oversized. Selected due to its small $R_{ds,on}$ = .028Ω
- 1N5822 Schottky Rectifier
  - Selected for its small forward voltage drop
  - V_f = 0.525V
- C = 100μF
- L = 300μH

$$C = i_c * \frac{\Delta t}{\Delta V}$$

$$L = V_L * \frac{\Delta t}{\Delta i}$$

Charging Circuit Testing



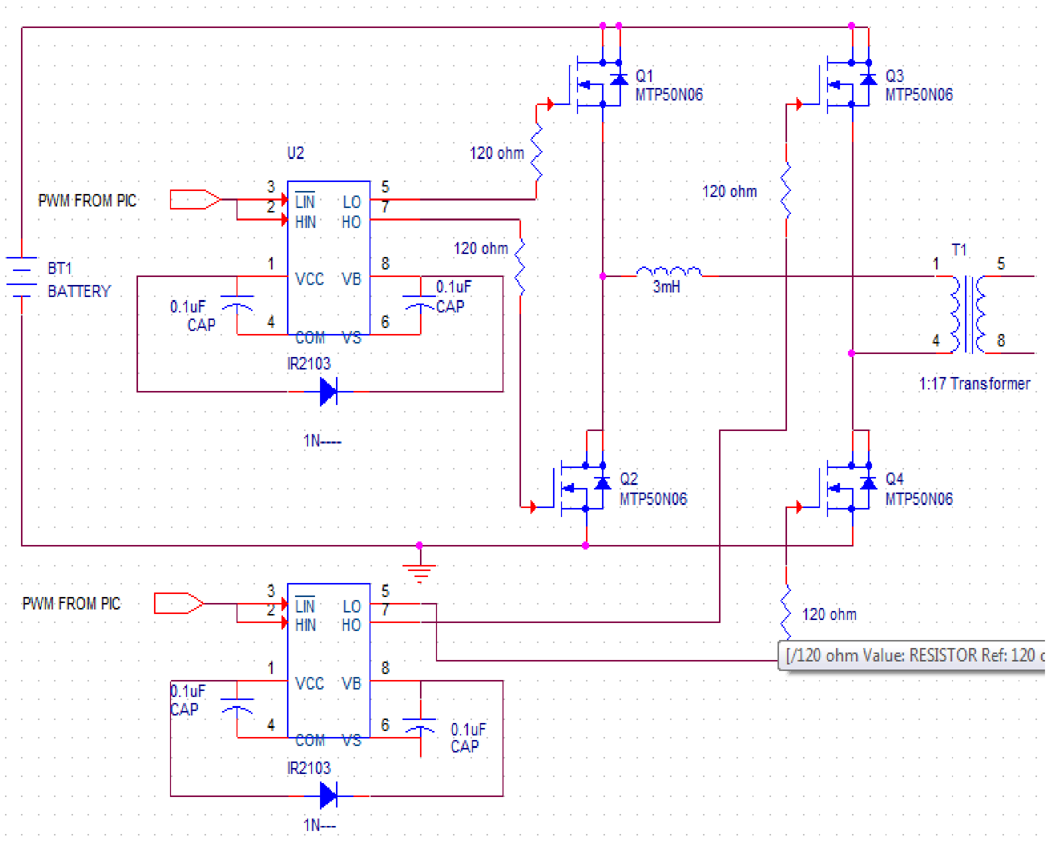


Vin	Vout	Delta V	Efficiency
2.94	13.71	0.1	0.71
3.95	13.68	0.15	0.8
4.98	13.76	0.14	0.85
5.97	13.72	0.11	0.87

Vin	Vout	Pin	Pout	Efficiency
4.98	13.71	0.87	0.74	0.85
4.98	13.76	1.48	1.26	0.85
4.95	13.72	2.32	1.91	0.82
4.89	13.73	5.2	3.9	0.75

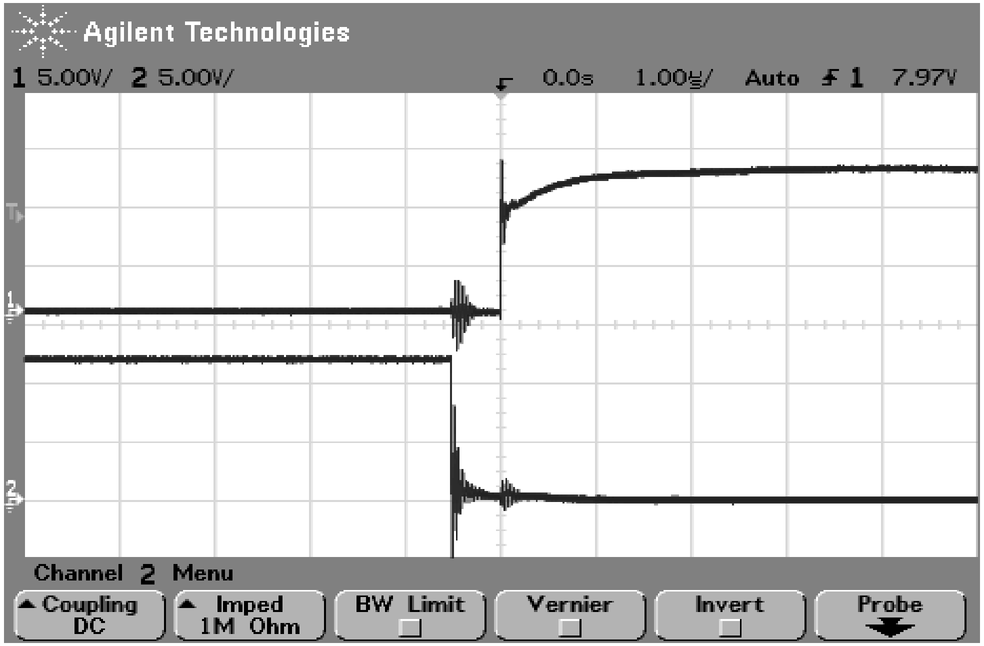
Inverter Circuit Specifications

- V_{in} = 13.7V +/- 0.1V
- V_{out} = 120VAC
- f 60Hz



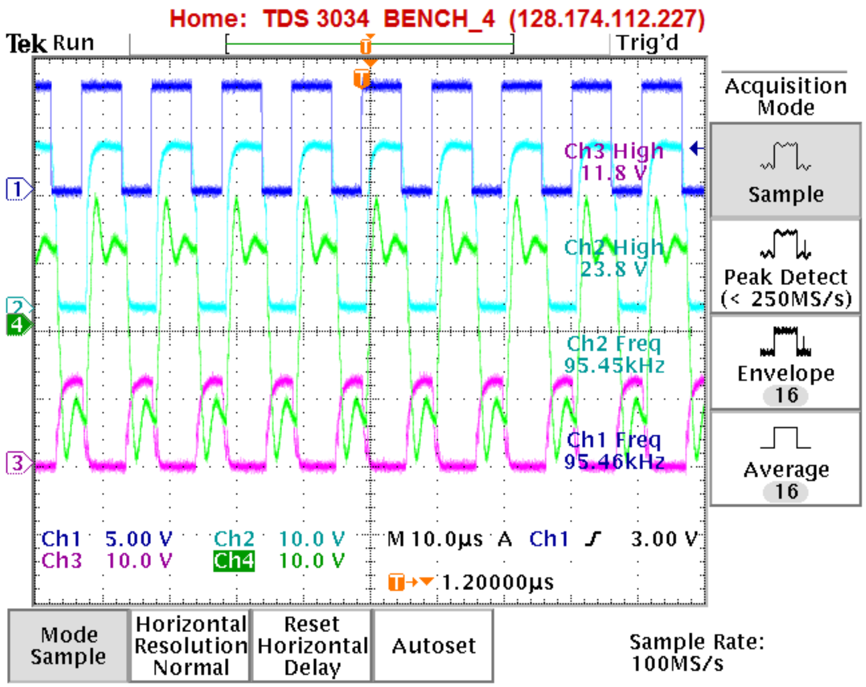
Inverter Circuit Design Considerations

- IRS2003 Low/High Gate Driver
  - Selected due to built in delay time
- MTP50N06 MOSFET (50V, 60A)
  - Must handle 12V peak and 8.33A current.
  - $R_{ds,on} = 0.028\Omega$



Inverter Circuit Testing

- Ch1 = Switching Signal Reference
- Ch 2 = High Side Gate Drive
- Ch 3 = Low Side Gate Drive
- Ch 4 = Output Voltage Waveform



Inductor Design

turns count > core\/number	A_L*	10	20	30	40	50	60	70	80	90
		inductance in millihenries								
FT-23 -77	396	.040	.158	.356	.634	.990	1.43	1.94	2.53	3.21
FT-37 -77	884	.088	.354	.796	1.41	2.21	3.18	4.33	5.66	7.16
FT-50 -77	1100	.110	.440	.990	1.76	2.75	3.96	6.39	7.04	8.91
FT-50A -77	1200	.120	.480	1.08	1.92	3.00	4.32	5.88	7.68	9.72
FT-50B -77	2400	.240	.960	2.16	3.84	6.00	8.64	11.7	15.4	19.4
FT-82 -77	1170	.117	.467	1.05	1.87	2.93	4.21	5.73	7.49	9.48
FT-114 -77	1270	.127	.508	1.14	2.03	3.18	4.57	6.22	8.13	10.3
FT-114A-77	2340	.234	.936	2.13	3.74	5.85	8.42	11.4	15.0	21.4
FT-140 -77	2250	.225	.900	2.03	3.60	5.63	8.10	11.3	14.4	18.2
FT-240 -77	2740	.274	1.10	2.47	4,38	6.85	9.86	13.4	17.5	22.2

- Inverter (Ferrite Material 77)

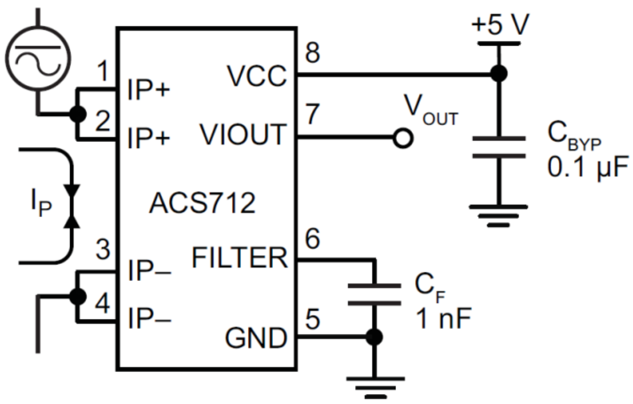
IRON POWDER TOROIDAL CORES

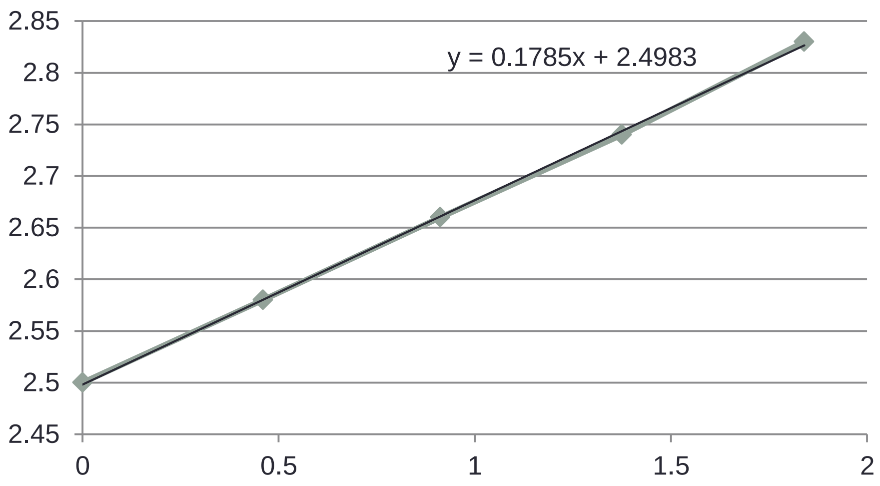
MATERIAL #26 Inductance (uH) vs. Size, Material and Number of Turns

Turns / Size	10	20	30	40	50	60	70	80	90	100	110	120	130	140
T-106	9	38	[illegible]	144	[illegible]	[illegible]	[illegible]	374?	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T-94	8	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T-80	5	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T-68	4	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T-50	3	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T-37	2.7	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

- Charging Circuit (Iron Powder Material 26)

Current Sensor Testing

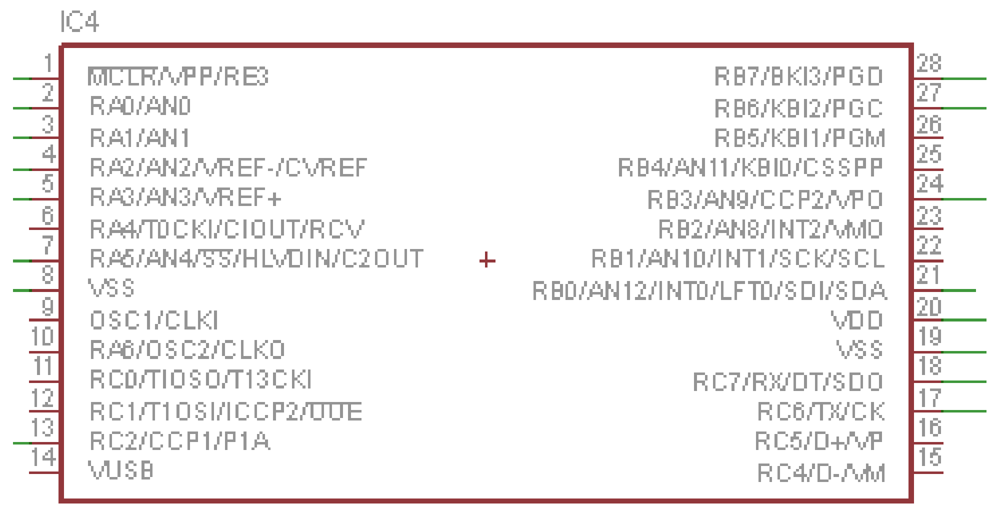




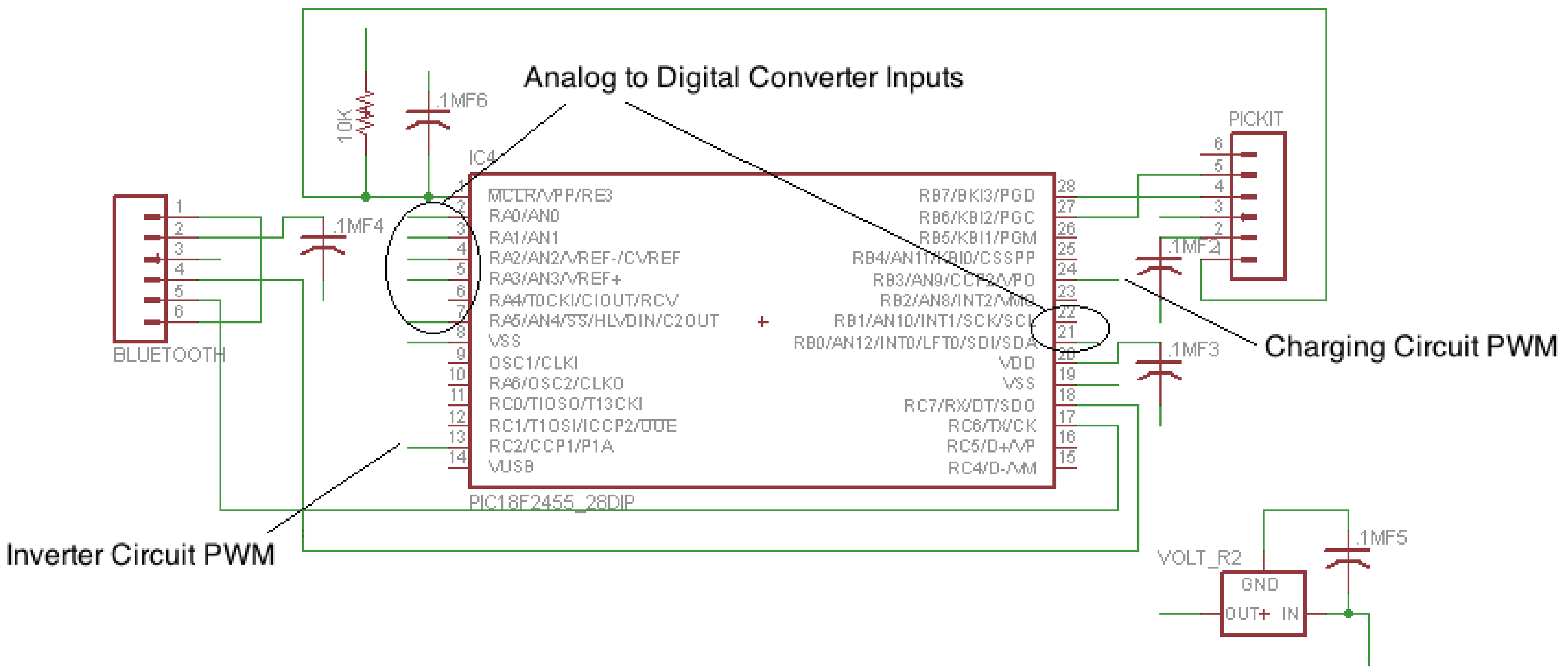
Current sensor testing March 29					
Voltage	Resistance	Measured Current	Vout Expected	Vout	% Error
2.26	1.13	1.84	2.868	2.83	1.32%
1.7	1.13	1.375	2.775	2.74	1.26%
1.13	1.13	0.912	2.6824	2.66	0.84%
0.56	1.13	0.46	2.592	2.58	0.46%
0	1.13	0	2.5	2.5	0.00%

PIC Circuit Specifications

- 12V to 5V Voltage Regulator
- Feedback controlled PWM signal for Charging Circuit
- 50% duty cycle signal for Inverter Circuit
- Analog to Digital Converter (ADC)
- Bluetooth connection

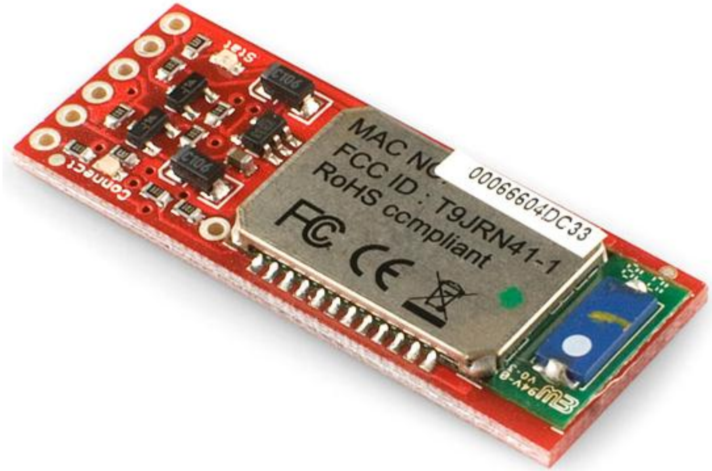


PIC Schematic



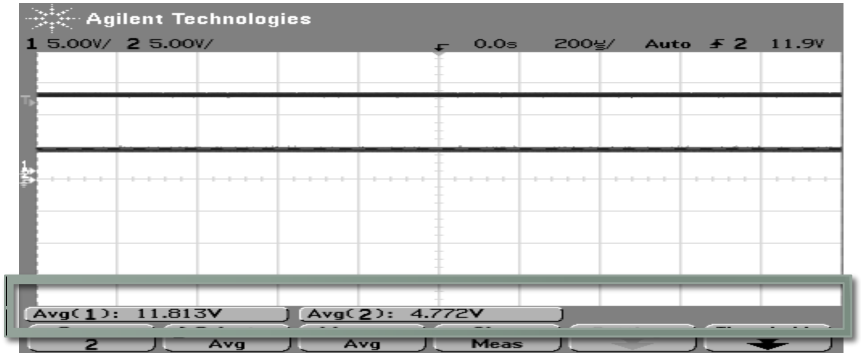
PIC Circuit Testing

- Analyze regulator voltage on oscilloscope
- Analyze Charging Circuit PWM and Inverter Circuit PWM for frequency, duty cycle, and Vpp on oscilloscope
- Confirm known values from ADC with does on the app
- Confirm Bluetooth connection in Android App Testing Section

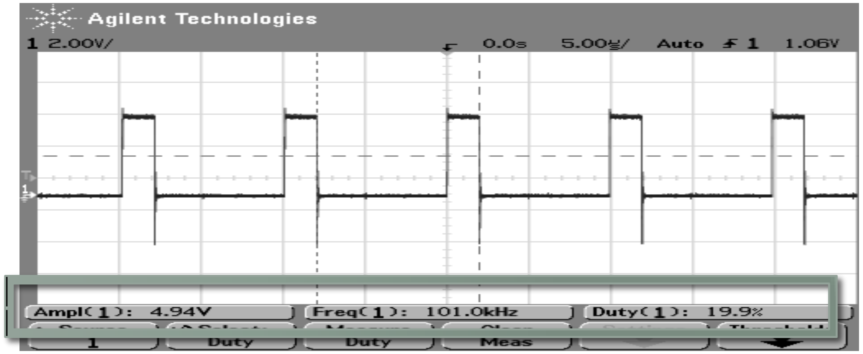


PIC Circuit Test Results

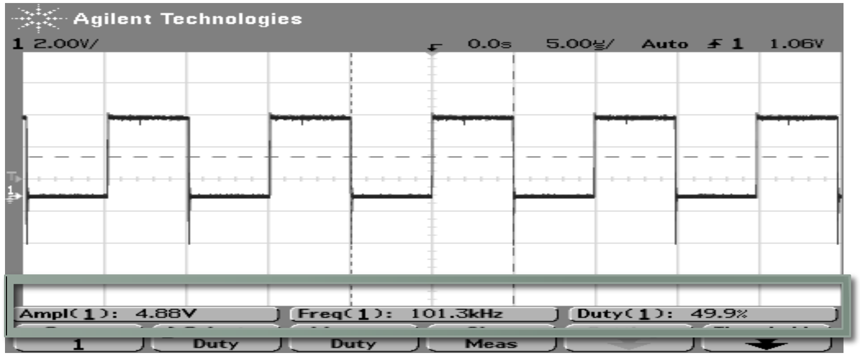
12V to 5V Voltage Regulator



Charging Circuit PWM



Inverter Circuit PWM



PIC Circuit Test Results (cont.)

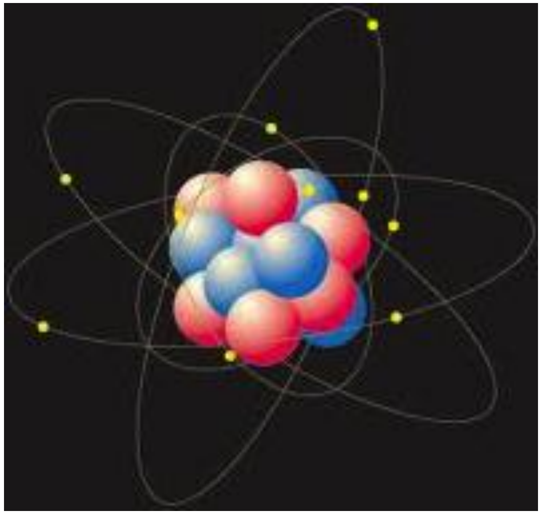
Actual Voltage	ADC Voltage	Percent Error
1	1	0.00%
2	2	0.00%
3	3	0.00%
4	4	0.00%
5	5	0.00%
6	6	0.00%
7	8	14.29%
8	9	12.50%
10	11	10.00%
14	16	14.29%

Android App Specifications

- Bluetooth connectivity
- Provide data such as:
    - ✓ Voltage
    - ✓ Current
    - ✓ Power
    - ✓ Duty Cycle
- Provide summary information on:
    - ✓ Charging Circuit
    - ✓ Inverter Circuit
    - ✓ 120VAC Variable Load Station
    - ✓ Hand Crank Station
    - ✓ Battery

Android App Testing

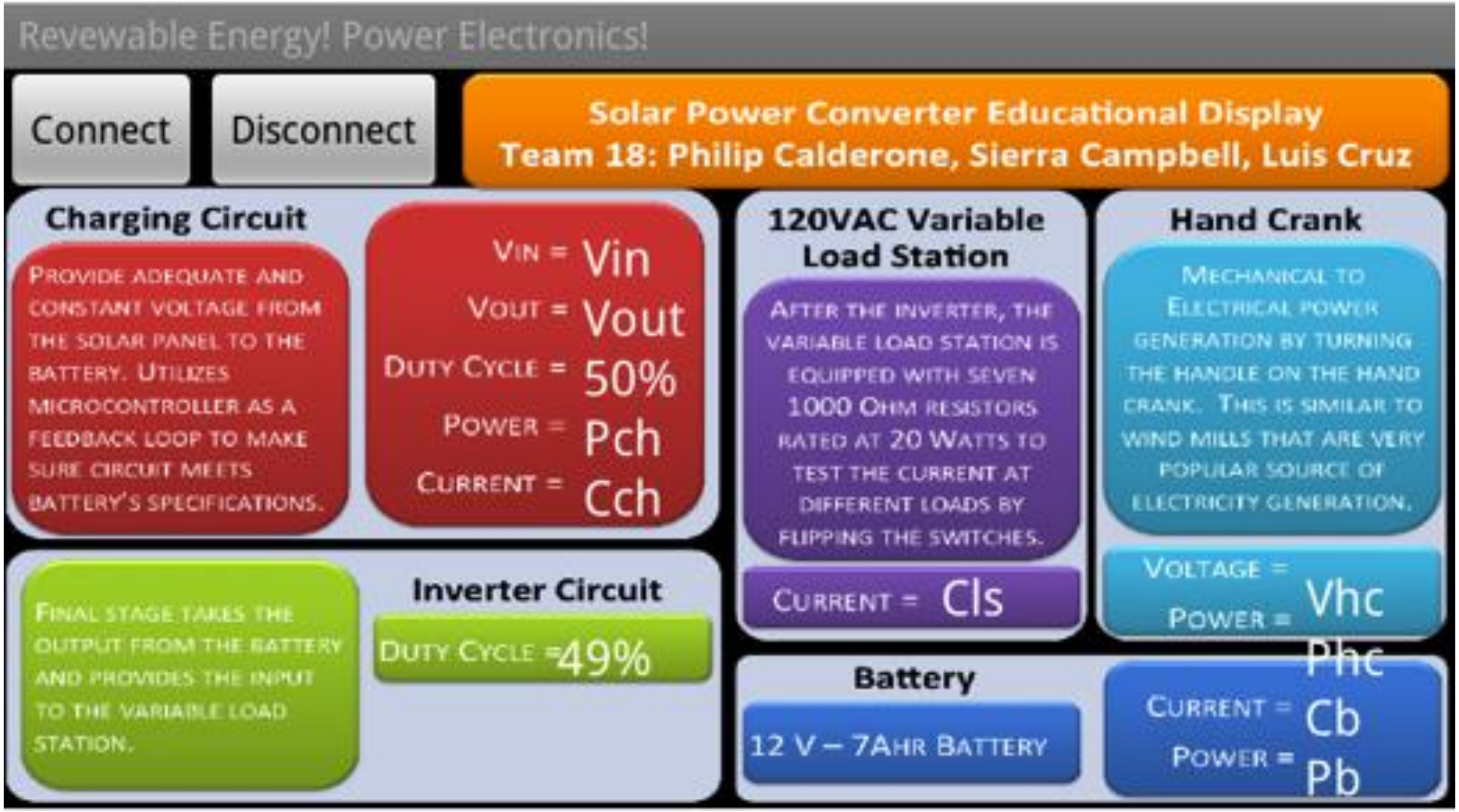
- Test Bluetooth connection to phone
- Test Bluetooth connection through Android App
- Confirm app layout includes data and summary information



Android App Test Results

- Bluetooth connection confirm with phone using Blue Term App
- Bluetooth connection through App confirmed through real-time updated variables

Android App Test Results (cont.)



Successes

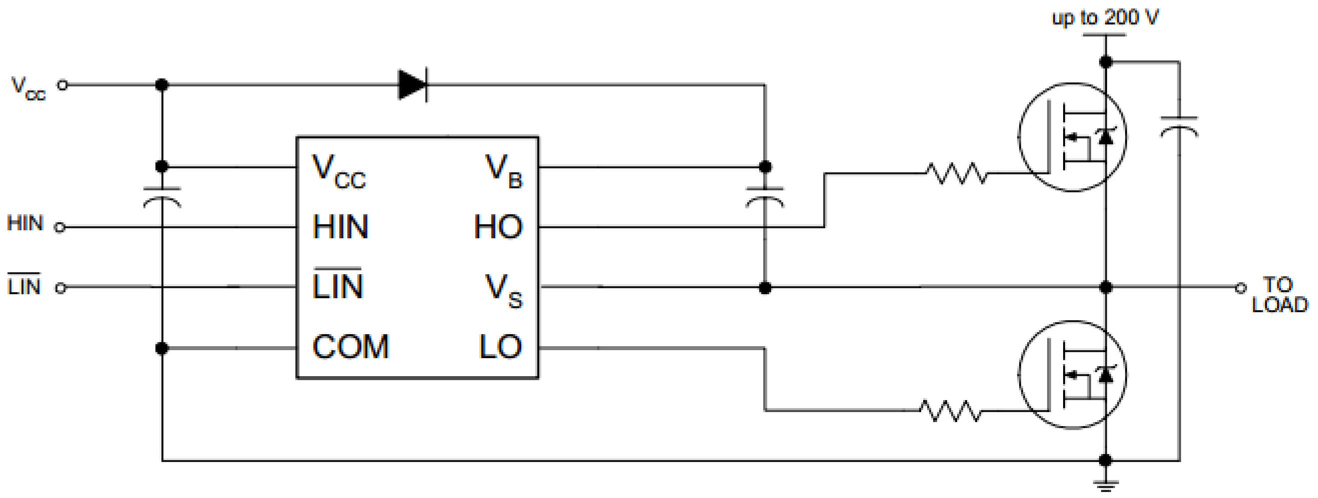
- The team was able to have individual blocks working
- Android application functional and updated in real time
- Customized box allows a person to see the circuitry
- Once PCB is recreated, the full circuitry should work

Challenges

- Mislabeled part in Eagle created a short on the PCB and caused chips to malfunction
- Connection of PWM where output of boost circuit should have been on PIC
- Hand made transformer was not working
- The light from the panel not enough to illuminate light bulbs

Lessons Learned

- Read not only the datasheets but the ***Application Notes*** as well
  - Bootstrap Capacitor
- Check pin connections on PCB



Ethical Considerations

- Follow IEEE Code of ethics
- Needs to be safe for all individuals
  - Ensured that case was enclosed so that shock would not occur
  - Make sure wires are not exposed
  - Limit voltage
- Accurately give information regarding each component

Recommendations

- Variable light source that mimics solar radiation pattern
- Maximum power point tracking of the solar panel
- A more realistic 60Hz sine wave at the output with a transformer
- Provide real-time pricing of electricity to be displayed on the mobile app

Thank You

- Prof. Carney
- Justine Fortier
- Prof. Krein
- Kevin Colravy
- ECE Parts Store
- Electronic Shop
- Machine Shop

Questions?