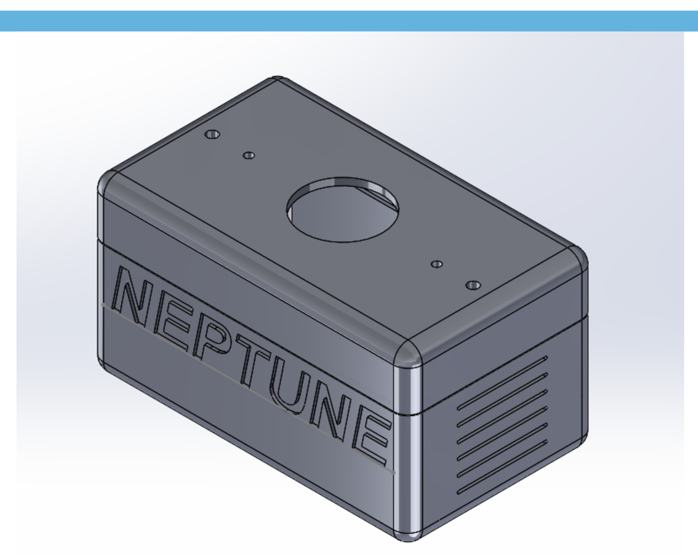
SMART POWER MONITORING NETWORK

MAY1725

Introduction

We have created a wireless power meter plug which monitors the power usage of different electronic devices that appear around the house. This allows people to compare the power usage of different devices around the house in real time, and can help people be more efficient with their power usage. Our power meter plug reports the power usage back to the user via a user-friendly web application. There is a central hub acting as the middleman between the sensors and web application, and all this will be connected via the user's wifi network. Our device can monitor power continuously by itself, and will automatically update when the user opens the web application.



Design Requirements

Hardware requirements:

1. Maximum power consumption of device itself must be below 5 W.
2. Handle bidirectional current ranging from 100 mA to 15 A RMS.
3. Power measurement error must be below 5%.
4. Must have integrated fuse and varistor for protection.

Software requirements:

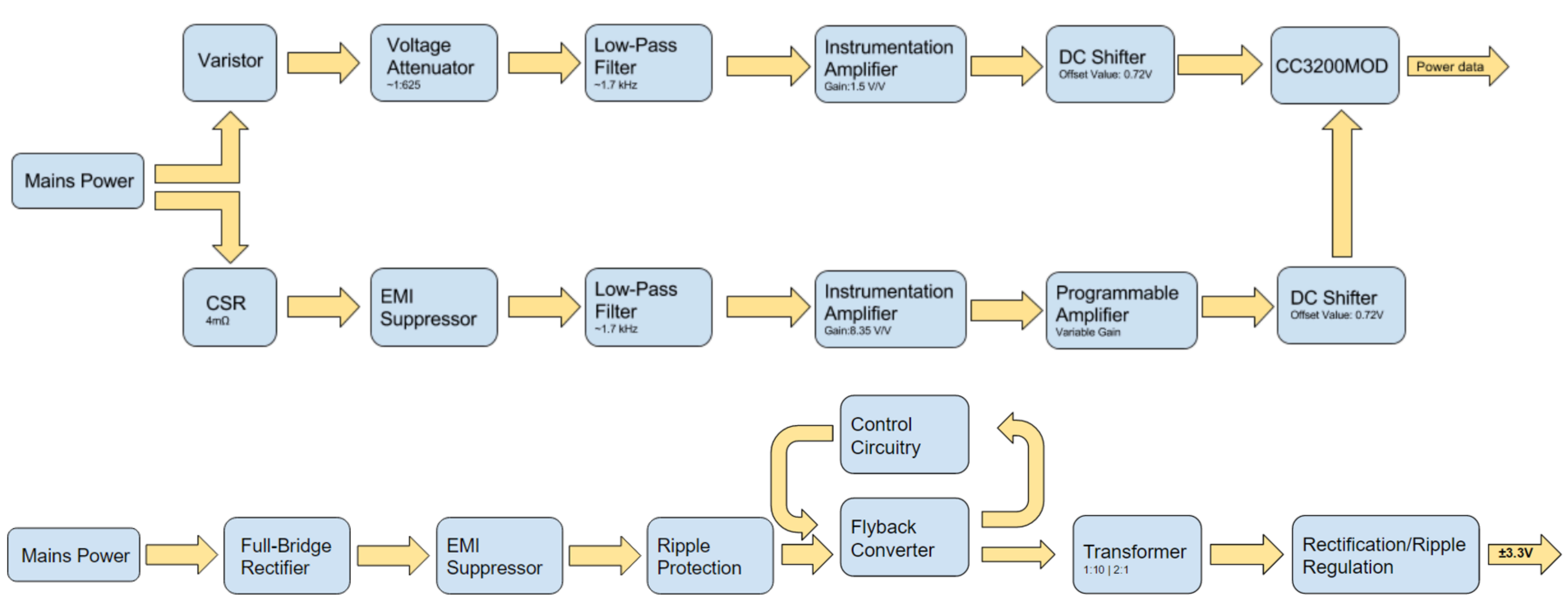
1. Easy-to-use and friendly design web application.
2. Allow the user to change the period of energy data collection.
3. Show the user energy graphs over a selectable time range.
4. Show a list of all connected monitoring stations.
5. Provide the user the cost of power consumption for each connected appliance.

Intended Users

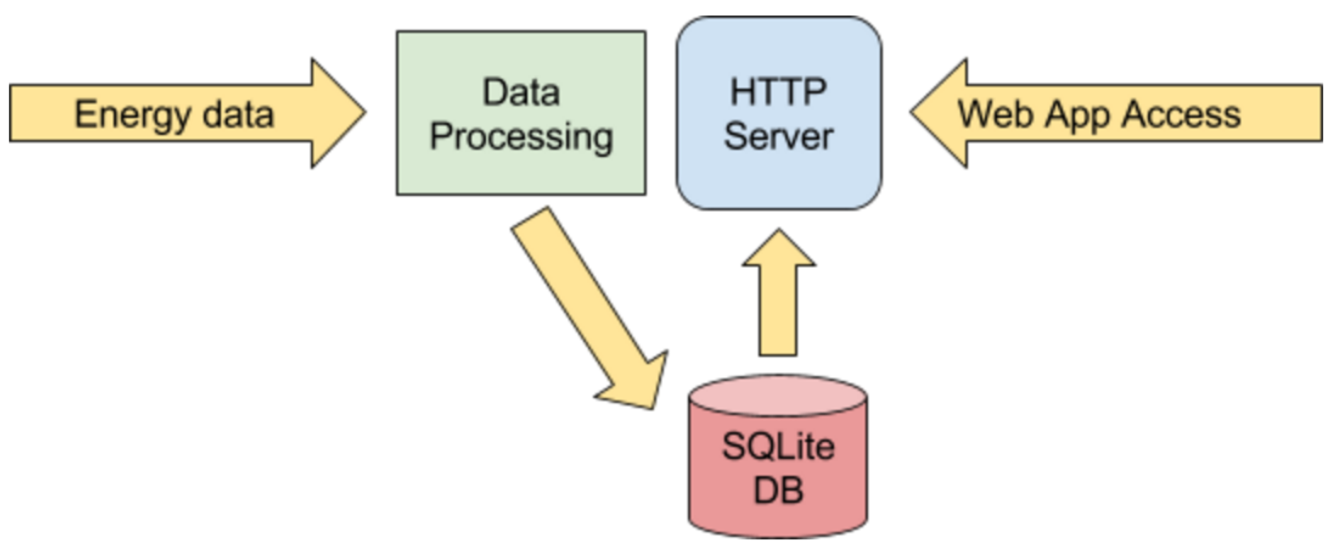
The designed power meter plug can handle up to 15 amperes, making it suitable for residential use. Typical home appliances are:

- Refrigerator, heater, lightbulb …
- Computer, printer, cellphone charger…

Design Approach and Technical Details



- In our proposed circuit, we are using a 4 mΩ resistor on the low side of the load. This resistor produces a voltage drop across it proportional to the current that the load draws. Through a series of controlled amplifiers, we can vary the gain to detect currents ranging from 100 mA - 15 A. Our circuit also tracks an attenuated line-voltage waveform to cross-reference against the current waveform and calculate a power factor.
- The outputs are designed to be unmodulated waveforms centered at 0.72 V and can swing from 0 V to 1.5 V, depending on the load. These values ensure we will use the full capabilities and prevent damage to the CC3200's ADC.
- Using an AC-to-DC flyback converter we can supply ±3.3 V to the circuit. This voltage is regulated by control logic overlooking the auxiliary winding of the transformer.



The software consists of three main pieces of code:

- The data processing portion is a UDP server than continuously listens for incoming energy packets and inserts them into a database. Every time a sample is received, it's timestamped and then put into the table of all power values.
- The HTTP server creates a RESTful interface that allows web applications to access the power data stored in the database. Through HTTP requests, the data from any given timeframe and any given station ID can be accessed.
- Web application a Javascript app that creates HTTP requests, retrieves power data, and provides a graphical interface to view and analyze the data.

Implementation

Figure 1: Hardware design

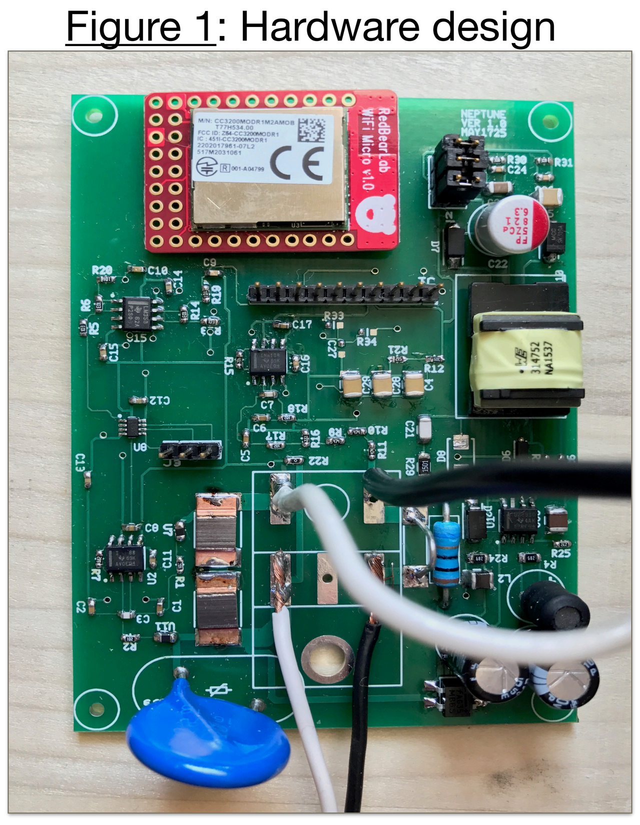
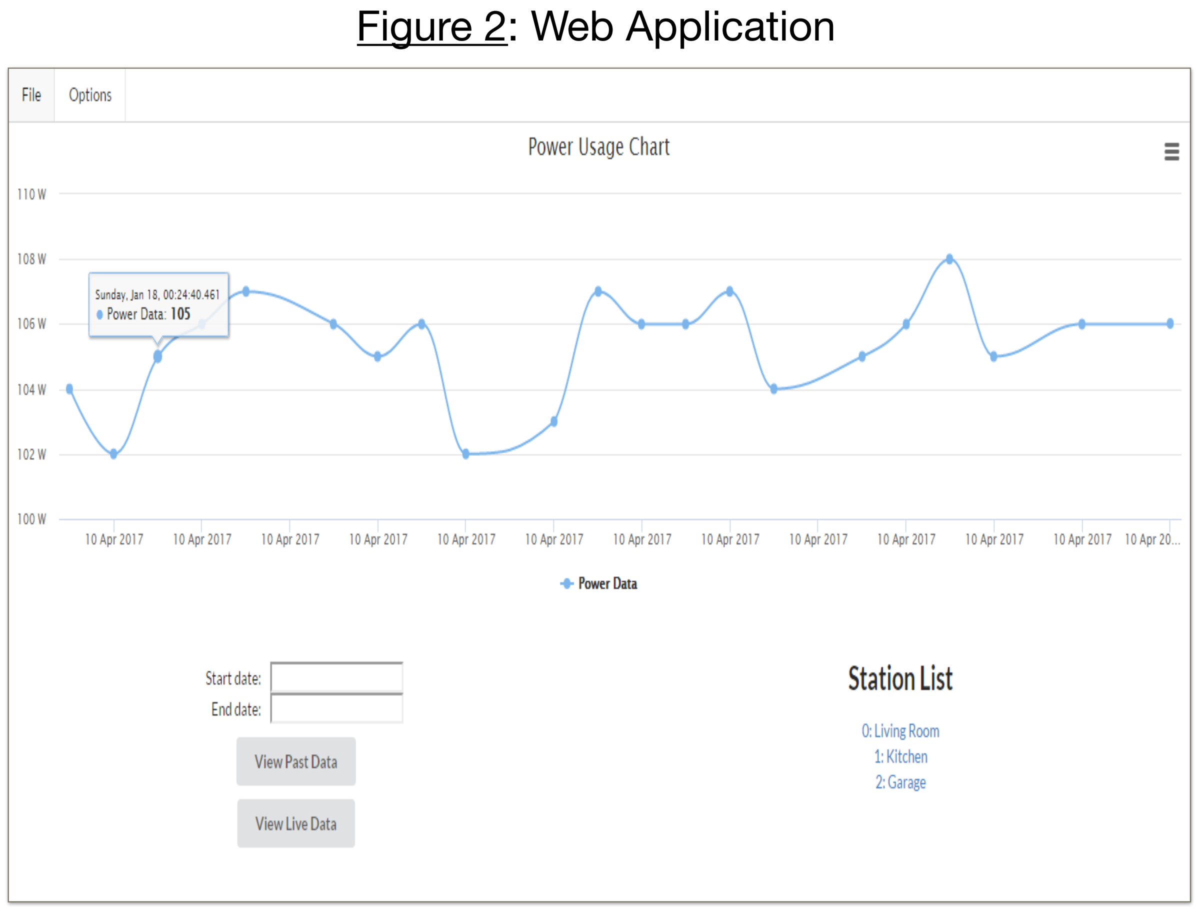


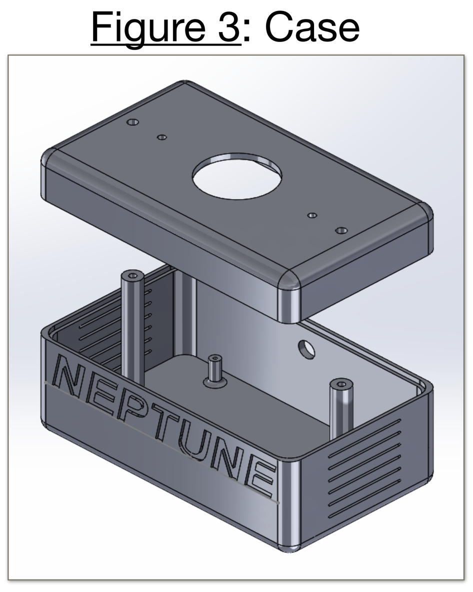
Figure 2: Web Application



Device Enclosure:

- Houses an outlet for power connection, the PCB, and CC3200MOD
- Fabricated using the Form 2 SLA 3D Printer with "tough" printing material
- Provides isolation from potential high voltages

Figure 3: Case



Project Resources

- Total Hours: 650
- Softwares: Multisim, Ultiboard, Matlab, SolidWorks, Code Composer Studio, Energia.

Device Cost	
PCB	$12.00
CC3200MOD	$10.63
Passive Components	$24.08
Active Components	$9.01
Case and Miscs	$50.00
Total	**$105.72**

Testing

- Using a NEMA 5-15 interface, we measured calibrated loads ranging from 1 W to 1800 W. We examined the output power readings of the CC3200MOD versus the expected values; the resulting error can be seen in *Figure 4*. As it can be seen, our meter can achieve an accuracy within ±5%.
- Using a multimeter, we can measure the power consumption of the power meter itself under different scenarios: typical load and maximum load. The results can be seen in *Figure 5*.

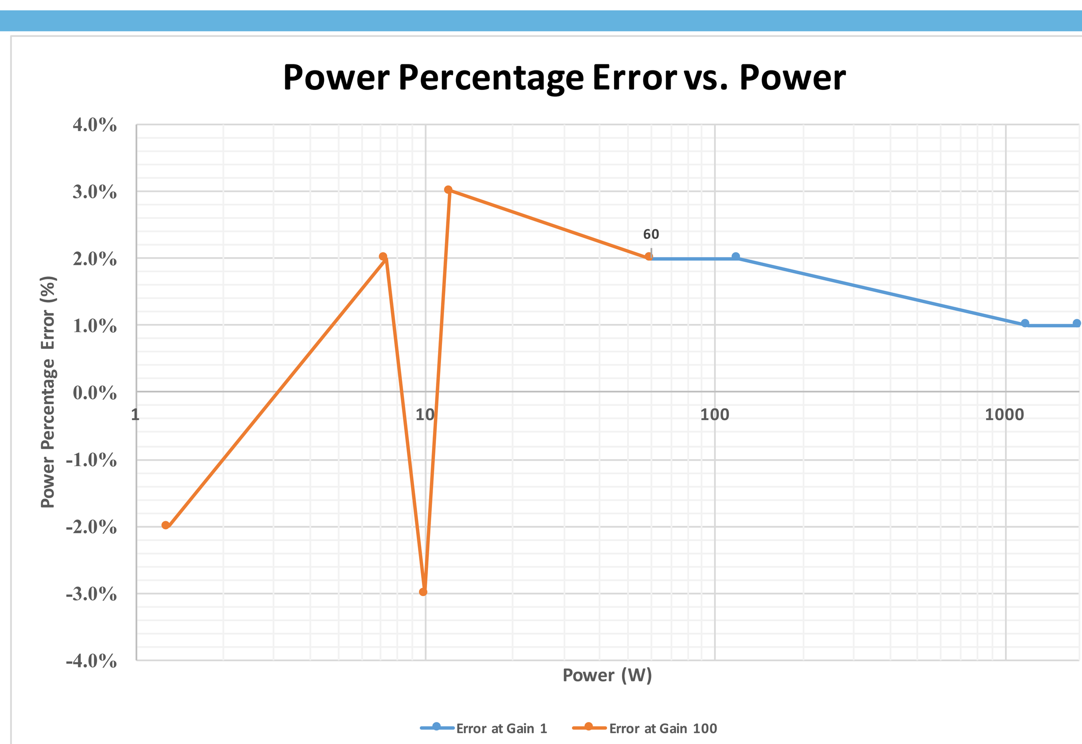


Figure 4: Power Percentage Error vs. Power

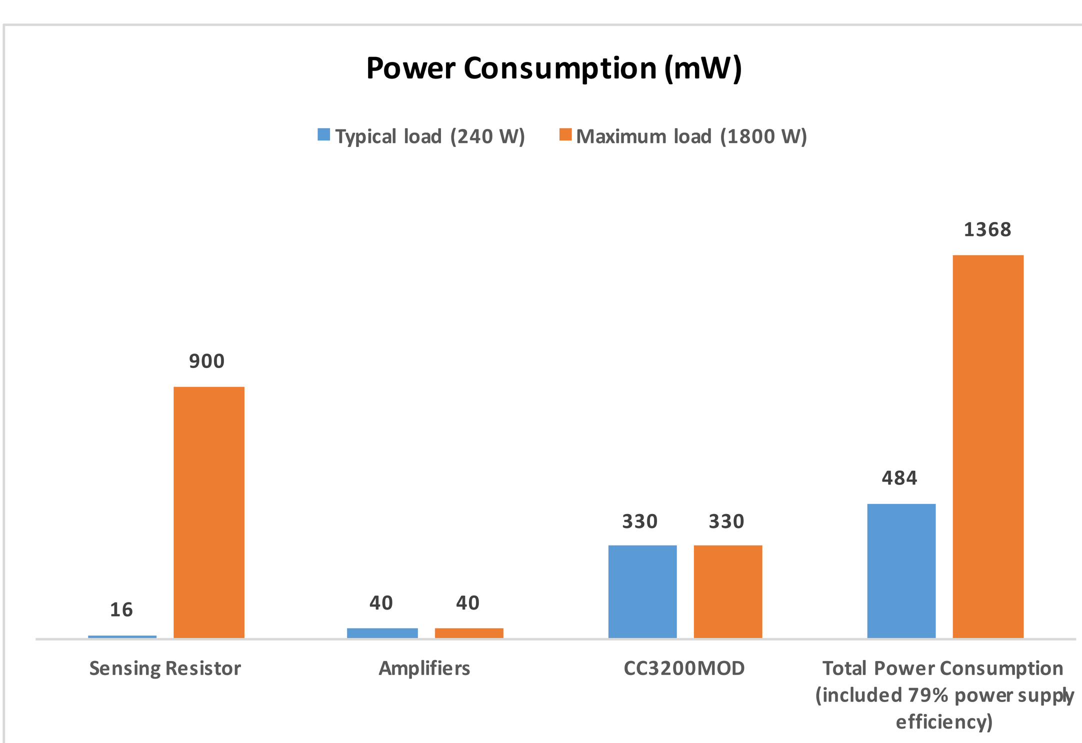


Figure 5: Power Consumption

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Client: Commercial Product