Wireless Building Power Monitor (System Design)

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Xerox Engineering Research Fellows Poster Presentation, July 27, 2012

Aim

To contribute to the “Smart Grid” by assembling a system to monitor power usage and quality at the consumer-end, and wirelessly transmit this information for storage and processing using cloud computing.

My work focuses on programming the Arduino board to interface with the metering chip and testing the accuracy and reliability of the metering chip’s measurements.

“Smart Grid”

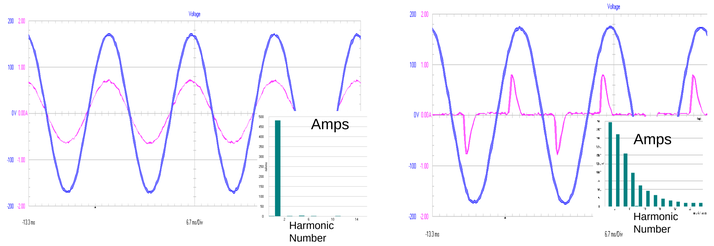
Uses two-way communication devices between the utility and different points in the grid to:

- Monitor voltage levels and power quality
- Detect and isolate faulty connections/equipment
- Record energy usage
- Incorporate multiple feed-in points for renewable energy sources
- Make automated adjustments in response to dynamic energy demands and system faults for a more resilient and efficient grid

Power Quality

The measure of electrical parameters that enables electrical systems to operate safely and reliably within the grid. Principal parameters include:

- Voltage levels
- Harmonic distortion
- Load balancing
- Power factor

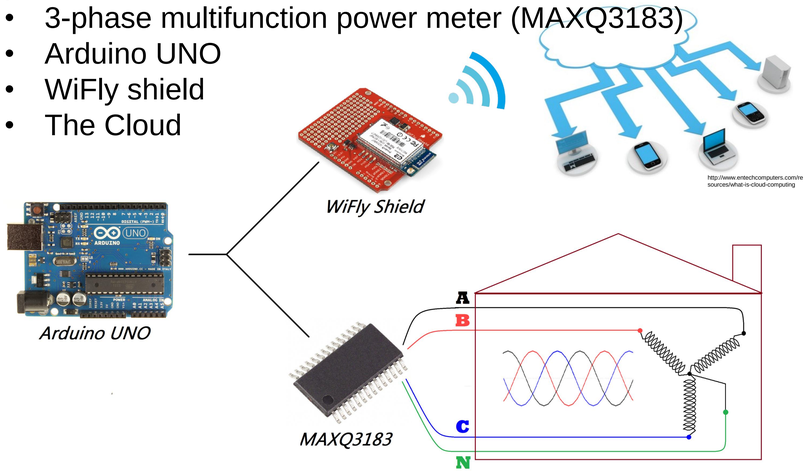


Voltage (blue) and current (purple) waveforms of an incandescent light bulb (left) and a typical CFL bulb (right). Current harmonic spectrums (teal) are in the lower-right of each graph.

Wireless Power Monitor

The wireless power monitor system consists of four main parts:

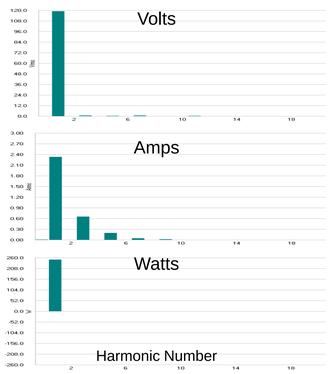
- 3-phase multifunction power meter (MAXQ3183)
- Arduino UNO
- WiFly shield
- The Cloud



The Arduino Platform

The Arduino is an open-source prototyping platform. The UNO version used in this project includes an ATmega328 microcontroller. In our design, it serves as the host (master) with the following functions:

- Communicates with, configures, and controls the metering chip and WiFly Shield (slaves) through a Serial Peripheral Interface Bus (SPI)
- Controls the WiFly Shield to send data to and receive commands from the Cloud through WiFi.



Harmonic components in the current waveform do not contribute to the time-average power because they do not have corresponding harmonic components in the voltage waveform.

Why the “Cloud”?

It is an emerging service ideally suited to this system’s needs:

- Large data storage capacity
- Ease of access / availability
- Processing power

Controversies

- Privacy concerns
- Computerized controls can be susceptible to cyber attacks

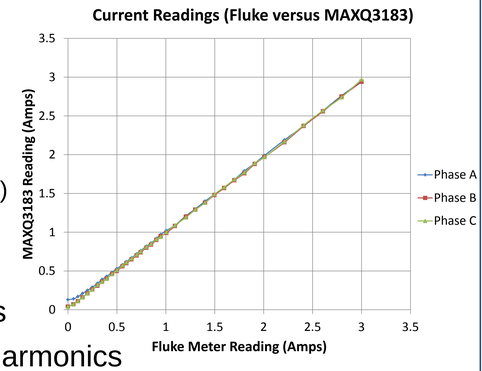
MAXIM MAXQ3183 Metering Chip

It is a dedicated AC power metering chip.

- 3 Phase (3 wire or 4 wire) meter
- Integrated ADC measures 7 external differential inputs every 360µs (2778 samples per second)
- 8MHz operation clock
- Integrated DSP calculates a host of power quality values and stores them on onboard registers
- Communicates through SPI

Our current prototype circuit using this chip has available accurate readings for:

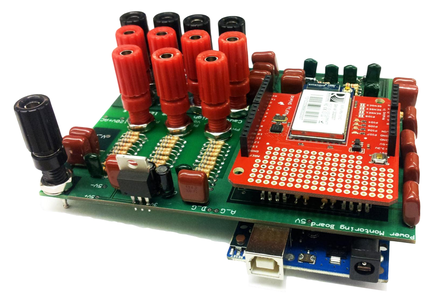
- 3 Phase RMS voltage
- 3 Phase RMS current
- 3 Phase power
  (real, reactive, and apparent)
- Power factor
  (real over apparent)
- Voltage Phasor Angles
- Current and Voltage Harmonics



The prototype circuit is mounted on a custom PCB board, with the Arduino and the WiFly shield stacked on. The PCB board is currently providing good noise immunity; however, further testing and refining needs to be done before it is field-ready.

Ongoing Work

- Design housing to hold the entire circuit
- Incorporate the wireless and cloud part with the metering circuitry
- Refine the programming and design a GUI.



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Acknowledgements

This work is supported in part by the National Energy Technology Laboratory (STEPS program) of the U.S. Department of Energy. We thank Professor Wendi Heinzelman for her assistance with the wireless and Cloud part of the design. We would also like to acknowledge Gabriel Unger, Lucas Crandall and Sara Lickers for their contributions to this project.

University of Rochester

The David T. Kearns Center for Leadership and Diversity in Arts, Sciences and Engineering

This research was funded by a generous gift from the Xerox Corporation.