

A PLC-Based Simulated Electrical ◦ Load Management System for Smart-meter Application

By

Jon Kline & Derek Boissy

Department of Electrical, Computer, and Information Technology
College of Engineering, Technology, and Computer Science
Indiana University – Purdue University Fort Wayne

Project Advisor- Professor Paul Lin
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Overview

- Problem Statement
- Current Solutions from Indiana, Michigan Power (I&M)
- Simulated Electrical Load Management System (SELMS) Solution
- Design Process
 - Block Diagram
 - Flow Chart

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Overview (Continued)

- The Five Loads
- Scenario
- Parts List
- Building and Testing Prototype
- Cost
- Lessons Learned
- Q/A
- Demo

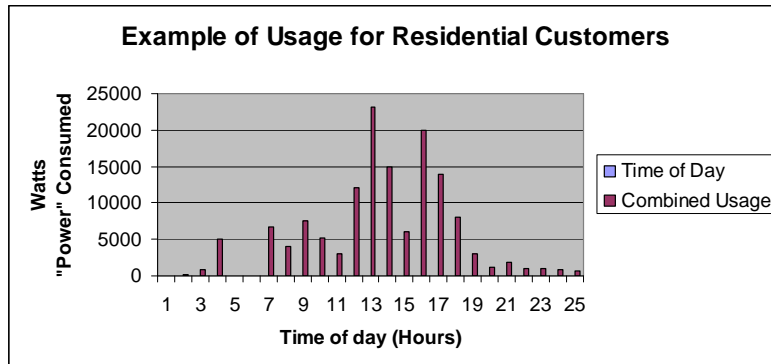
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Problem

- Excessive use of electricity puts stress on the power grid.
 - During peak demands, additional generation is needed.
 - Increase cost for the power company to manage peak loads.

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Power Consumption



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Current Solution

- There are currently some programs out there that customers can sign up for, to help with this problem.
 - Residential Peak Reduction
 - SMART Shift
- These programs scare off customers.
 - Fear of the power company having full control over their power.
 - Fear of losing privacy since the power company is able to view power habits of appliances.

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Current Solution (Continued)

- Residential Peak Reduction
 - <https://www.indianamichiganpower.com/save/programs/ResidentialPeakReduction.aspx>
- SMART Shift
 - <https://www.indianamichiganpower.com/save/programs/smartshift.aspx>

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Simulated Electrical Load Management System (SELMS) Solution

- **Simulated Electrical Load Management System (SELMS)**
 - Manage consumers power consumption.
 - Customer's define a set point and are in full control.
 - Protects customers privacy.
 - Doesn't shut off the power to appliances.
 - Manages when appliances can turn on.

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Simulated Electrical Load Management System (SELMS) Solution(Continued)

- Main function of our system is the “Wait-mode.”
 - If the load is above the set point, any appliance that wishes to turn on is set into the wait-mode.

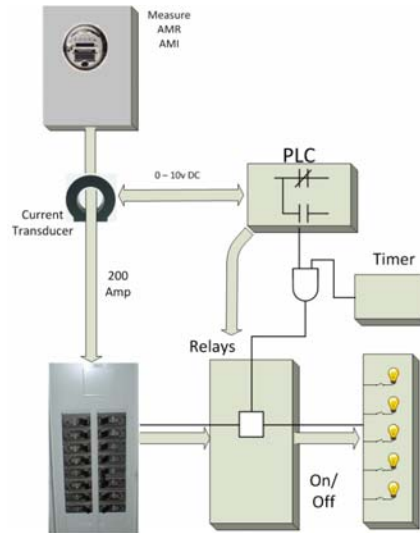
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Simulated Electrical Load Management System (SELMS) Solution (Continued)

- Our system has a set priority
 - Most important things will not have to wait long.
 - Less important things can be in wait-mode longer.
- Main goal is to reduce peak loads while letting the user to feel like there's no restraints.

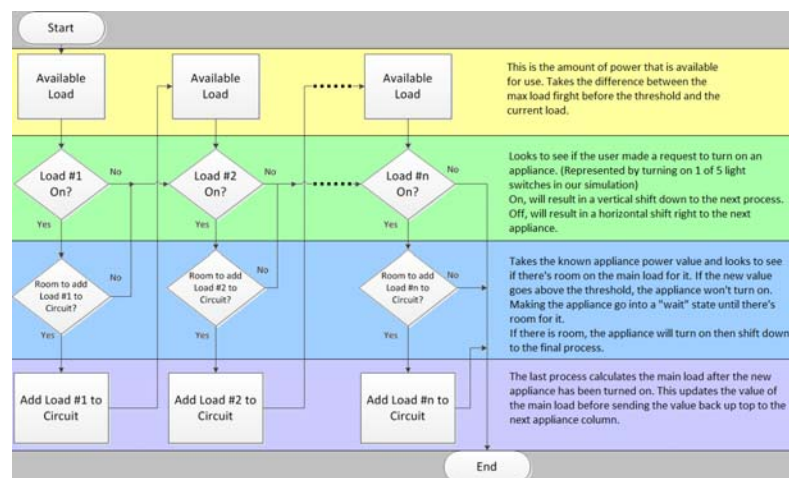
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Block Diagram



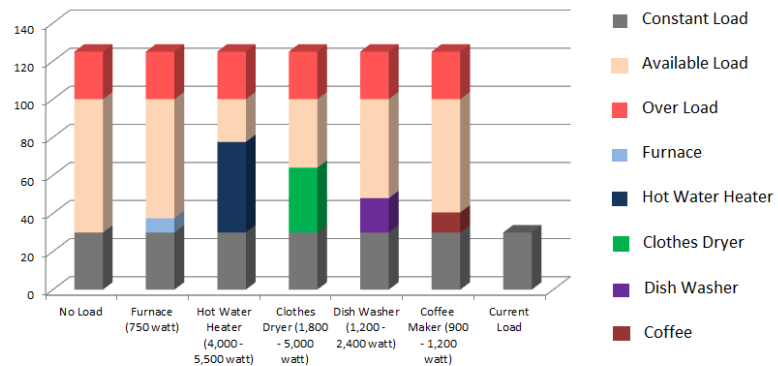
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Flow Chart



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Load Chart



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The Five Loads

I. Furnace

- consumes 750 watts of power and is our lowest load value.
- The house ventilation is on the load constant – load that is free from SELMS control.
 - This allows the house to circulate heat while the furnace is off.

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The Five Loads (Continued)

2. **Hot Water Heater**

- Ranges from 4,000 – 5500 watts.
 - Averages out to 4,750 watts of power and is our heaviest load.

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The Five Loads (Continued)

3. **Clothes Dryer**

- Ranges from 1,800 – 5,000 watts depending on the machine.
 - Averages out to 3,400 watts of power and is our second heaviest load.

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The Five Loads (Continued)

4. Dish Washer

- Ranges from 1,200 – 2,400 watts depending on the machine.
 - Averages out to 1,800 watts of power.

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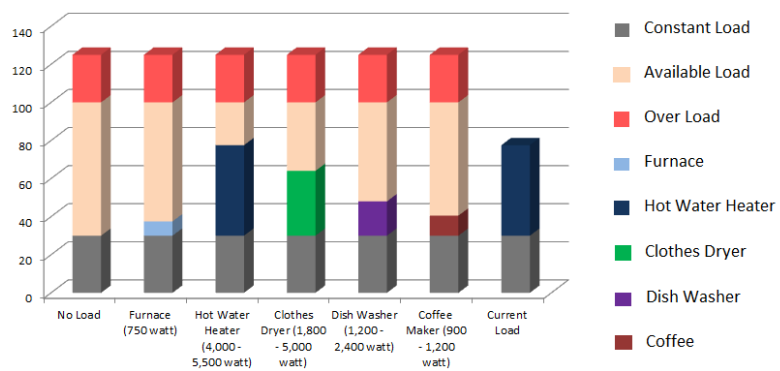
The Five Loads (Continued)

5. The Coffee Maker

- Ranges from 900 – 1,200 watts depending on the machine.
 - Averages out to 1,050 watts of power.

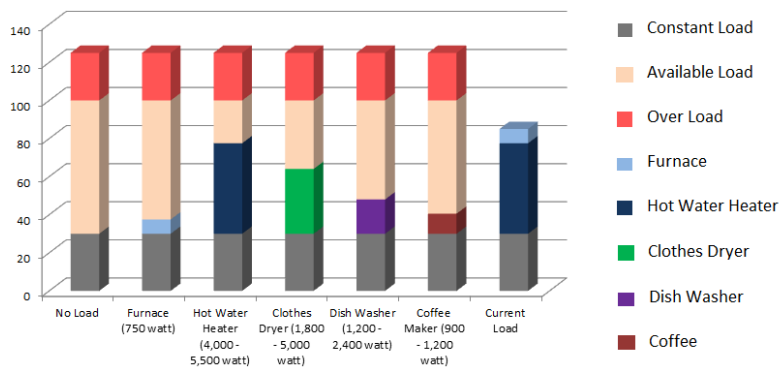
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Hot Water Heater: On



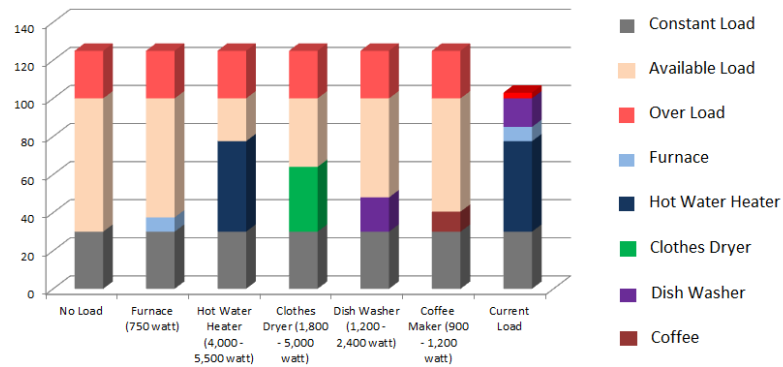
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Hot Water Heater & Furnace: On



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Overload- “Enter wait-mode”



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Parts List

- Purchased the needed materials and parts for our design.
 - Slick-500 PLC with
 - Power supply (1606-xlp, 72 watt)
 - SPDT Relays
 - H723LC Current Transducer (Hawkeye H723LC) 100 amp 1-phase panel
 - 15 amp single pole circuit breakers (x5)
 - Outlet boxes with outlets and covers (x2)
 - Switch boxes with switches and covers (x5)

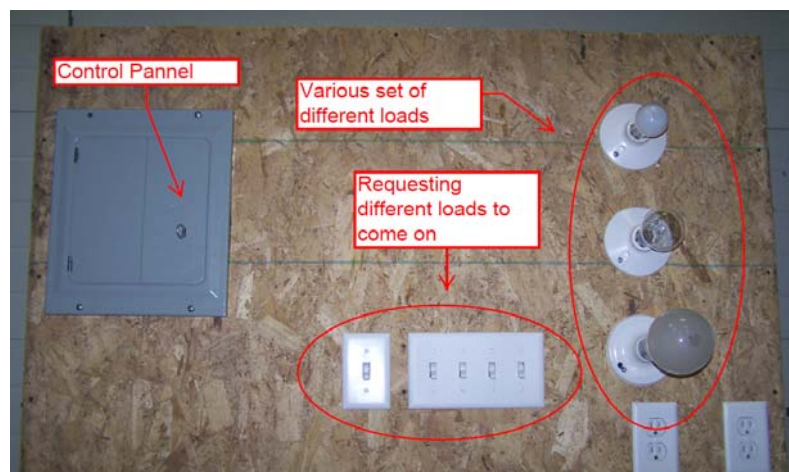
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Parts List (Continued)

- Lighting boxes outlets with plastic lighting bases (x3)
- 25 feet of 14-2 with ground wire to wire from panel, to light sockets, and outlets
- Light Bulbs of various watts (3x)
- Kill-A-Watt display meter
- Portable heater
- Vacuum Cleaner

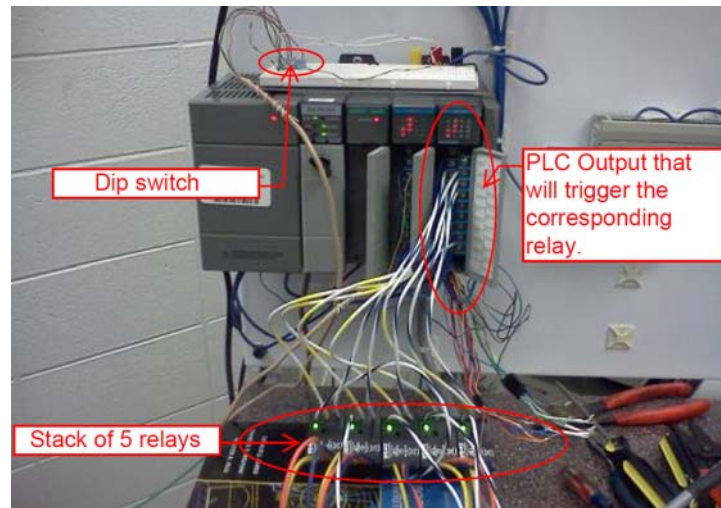
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Prototype display board



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PLC

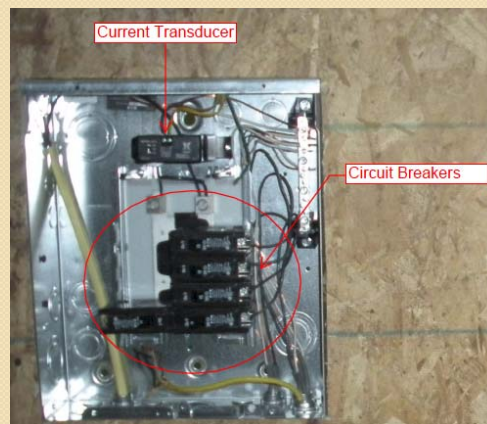


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INSIDE CONTROL PANEL

Current Transducer (CT) – Measures the incoming load and outputs a linear DC voltage for use to the PLC.

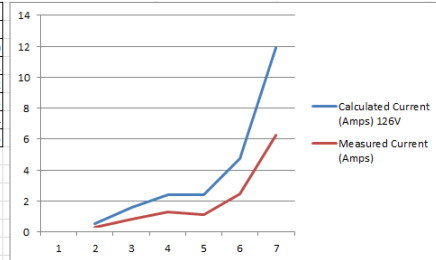
Circuit Breakers – Used to interrupt fault current on the branching circuits.



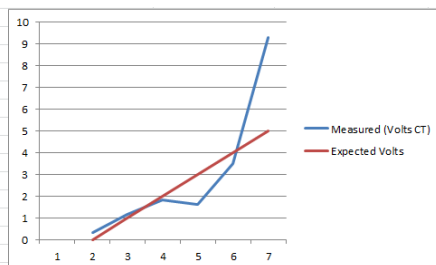
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Current Transducer Testing

| Measured (Volts CT) | Expected Volts |
|---------------------|----------------|
| 0.346 | 0 |
| 1.159 | 1 |
| 1.821 | 2 |
| 1.615 | 3 |
| 3.517 | 4 |
| 9.283 | 5 |
| | |
| | |
| | |
| | |
| | |



| Calculated Current (Amps) 126V | Measured Current (Amps) |
|--------------------------------|-------------------------|
| 0.555555556 | 0.297 |
| 1.587301587 | 0.84 |
| 2.380952381 | 1.285 |
| 2.380952381 | 1.14 |
| 4.761904762 | 2.43 |
| 11.9047619 | 6.28 |
| | |
| | |
| | |
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Prototype display board (Load I: on)



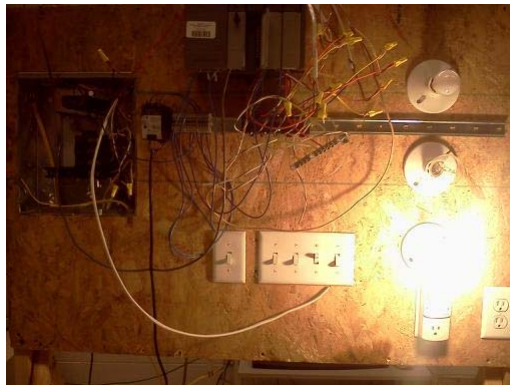
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Prototype display board (Load 2: on)



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Prototype display board (Load 3: on)



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COST

| Senior Design Project | | | |
|--|-----------------------|-----------|----------|
| Electrical Load Management System Expenses | | | |
| Expenses | | | |
| Material | | | |
| | | \$ Amount | |
| | | Estimated | Actual |
| 1) | 100 amp panel | \$175.00 | \$30.00 |
| 2) | 5-15 Amp breakers | \$25.00 | \$15.00 |
| 3) | 2-Outlet boxes | | \$5.00 |
| 4) | 5-Switch boxes | | \$5.00 |
| 5) | 3-Lighting boxes | | \$6.00 |
| 6) | Wire | \$30.00 | \$25.00 |
| 7) | Switches | \$80.00 | \$5.00 |
| 8) | Lights | \$20.00 | \$10.00 |
| 9) | Enclosure | | \$30.00 |
| 10) | Kill-A-Watt Wattmeter | \$35.00 | \$25.00 |
| 11) | Current Transformer | | \$100.00 |
| 12) | SPDT Relays | | \$100.00 |
| | Total: | \$365.00 | \$358.00 |

Expense for this project is on budget with our expected expenditures.

Since we were able to use the PLC lab supplies, we did not have to purchase a controller.

These savings allowed us to spend on items we did not consider (switches and outlets).

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Lessons Learned

- Phase one
 - Taught us how a project goes from an idea to a working project.
 - The importance of planning, risk assessments, breaking tasks into a Gantt chart timeline.

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Lessons Learned (Continued)

- Phase Two

- Time management
 - Keep on task
 - How to catch up without sacrificing quality work.
- Money
 - Procurement of needed materials at reasonable cost.
- Knowledge
 - Having previous experience helps in completing tasks.
 - Importance of research prior and development prior to starting project.

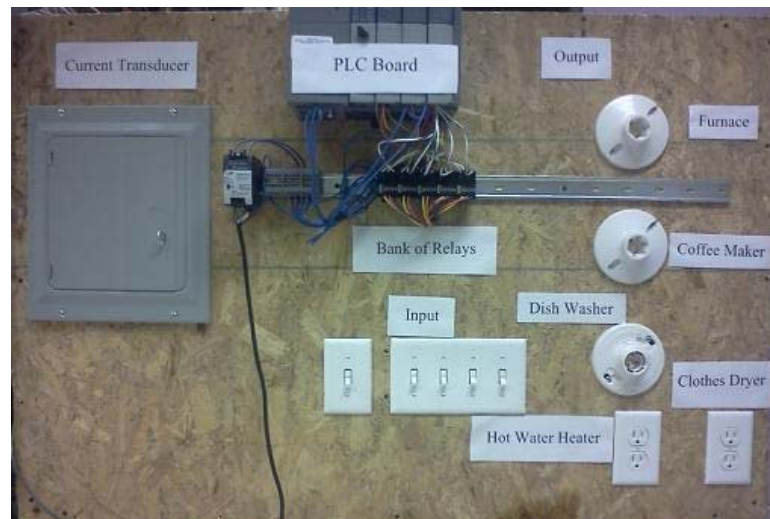
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Q/A



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Demo



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