Control and Automation in Solar-Powered Homes

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Conclusion

After designing a bench-top model of a lighting system, we were able to control and automate it using remote software and keypad capabilities. From it, we got a better understanding of how this technology, which is intended for residential/commercial use, can be implemented in our solar-powered house. Also, we were able to accurately document these procedures for future installation.

Background

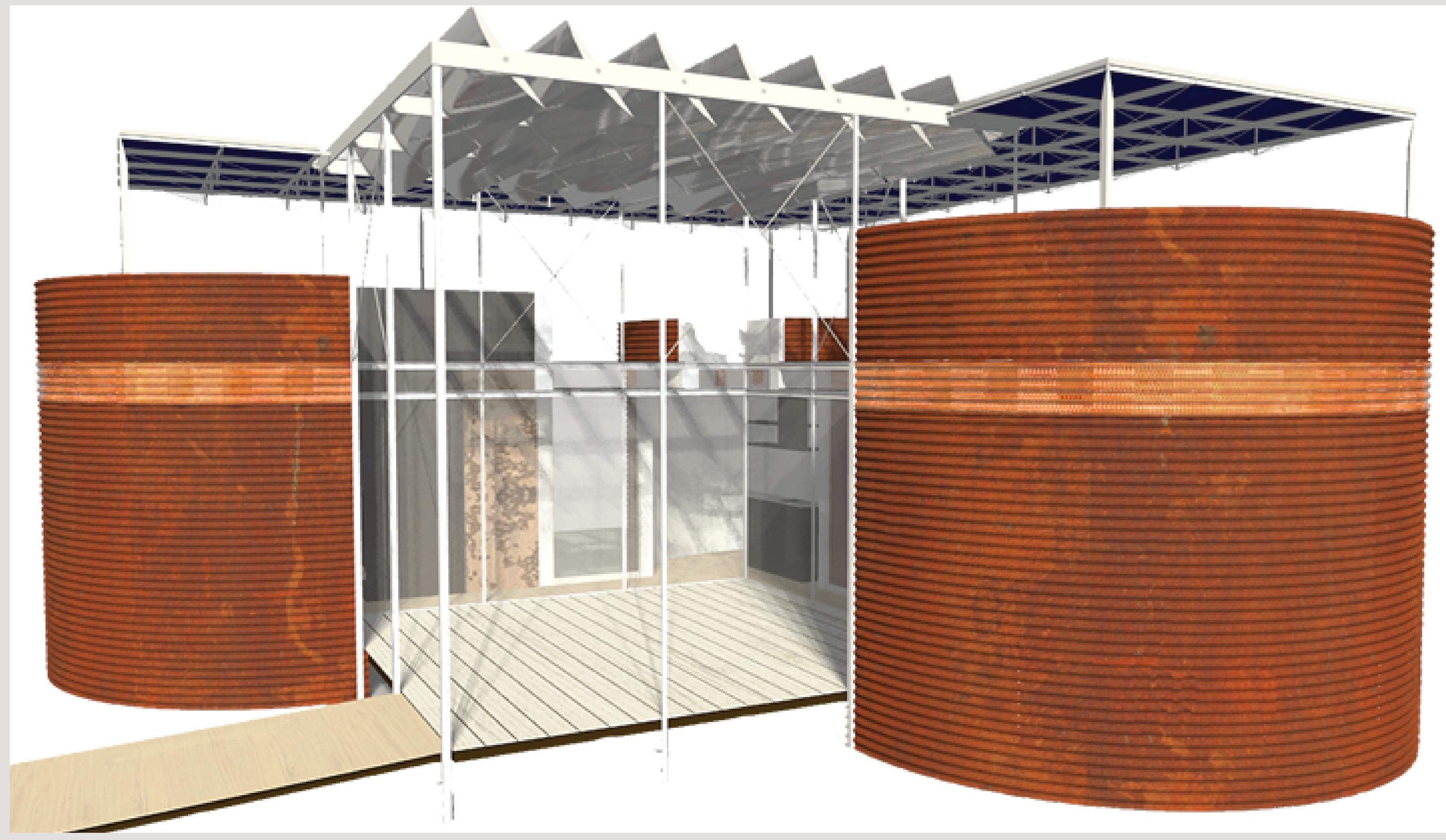
The Cornell University Solar Decathlon (CUSD) team consists of a number of students that work together to design and build a functioning house that is completely solar-powered.

This year the 2009 CUSD Engineering Team wanted to get started early on designing a control system that will regulate, control, and automate lighting for the home. However, because the house is still in the design phase and won't undergo costruction until next year, we cannot build the system directly into the house.

Objective

To build a bench-top model of a system that is easily extensible and will control the lighting of a typical household.

To develop an easy-to-follow protocol that allows for the flexibility to install the control system into the solar house.



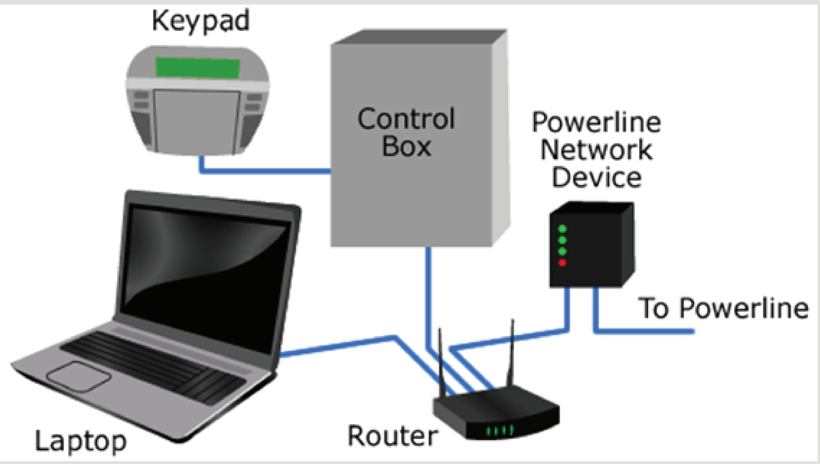
Top: A 3D rendition of the 2009 CUSD House. This house was designed by undergraduate architects and engineers. It features three cylindrical rooms joined together by a central courtyard. The solar panels are situated on the roof of the structure.

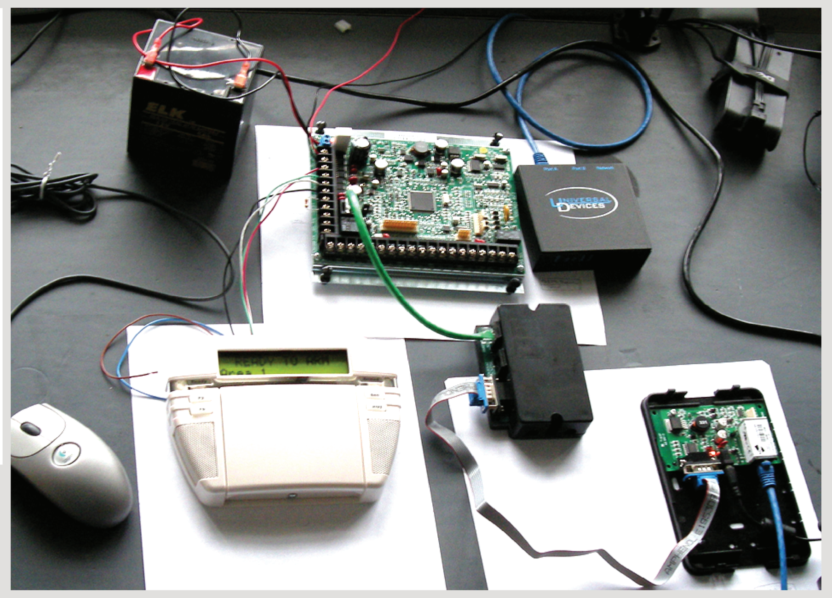
Hardware Methodology

The first task was developing the control system "backbone" which consisted of three parts that are all connected via a router:

- A user interface (keypad and laptop) for remote control.
- A control box for storing programs and executing tasks.
- A powerline network for communication with lighting.

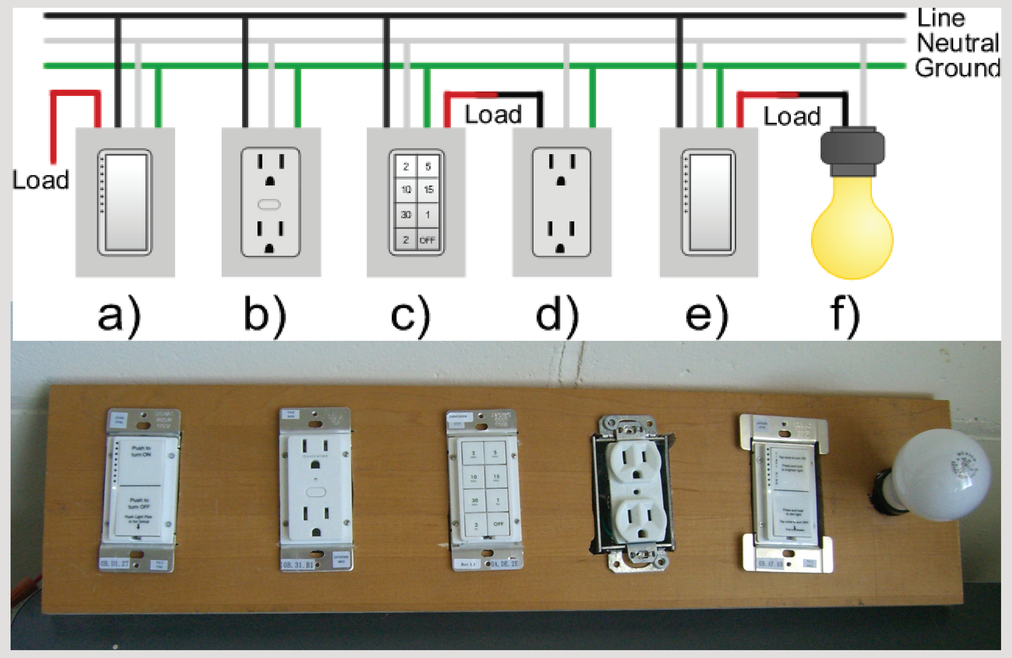
These parts work together so that the control-lighting system can be controlled manually, remotely, and automatically.





Top: A diagram and photo of the control system backbone.

The second task was to design and construct a bench-top model of the three different lighting configurations that will be used.



- ***A*** linked to ***B*** and remotely controlled.
- ***C*** hardwired to ***D*** and indirectly controlled.
- ***E*** hardwired to ***F*** and directly controlled.

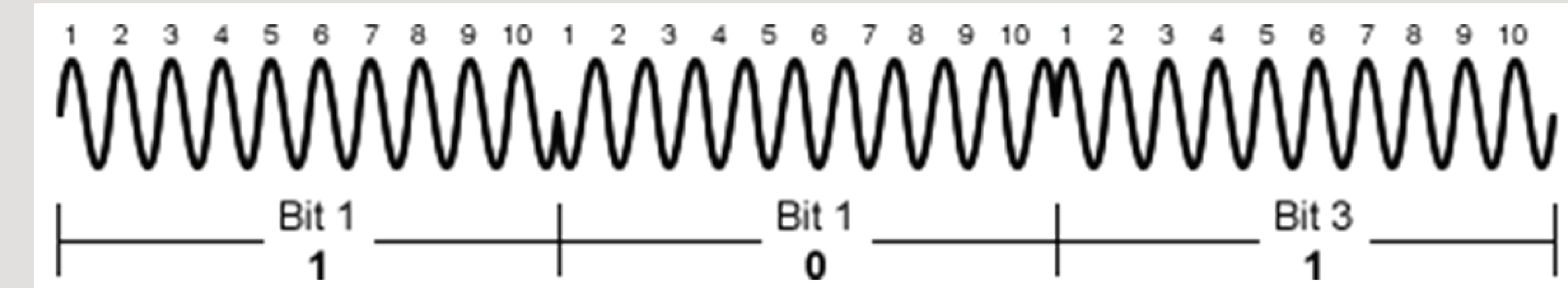
Left: Wiring diagram and photo of the model lighting system.

Engineering Design

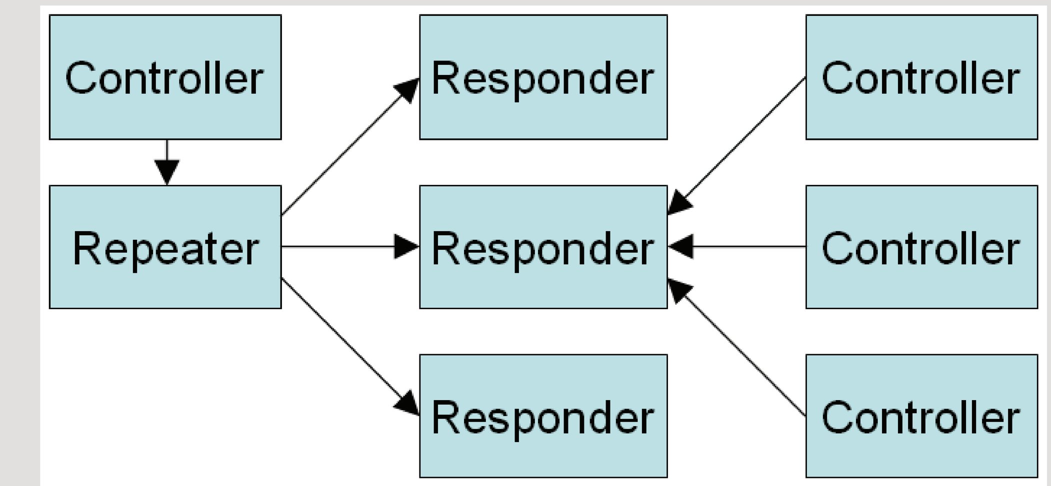
Insteon devices communicate on the powerline by adding a carrier frequency to the powerline voltage (110 VAC). Data is modulated onto the carrier frequency using a binary phase-shift keying (BPSK).

Each Insteon device is a peer, meaning it performs three tasks:

- Controller (sends information)
- Responder (receives information)
- Repeater (relays information)



Top: Insteon Powerline carrier signal (with frequency of 131.65 kHz) with BPSK modulation, wis ideal for performance in the presence of noise. Note that Insteon uses ten cycles of carrier for each bit of data.



Left: Peer-to-peer network of Insteon devices. This flexible network allows one controller to send messages to multiple responders and similarly, many controllers to send messages to one responder.

Test Results

After finally connecting the control system backbone with the model lighting system, we conducted four tests:

- ***Manual Test:*** Manually toggling switches to activate their corresponding outlets/bulb - **SUCCESSFUL**
- ***Remote Access Test:*** Being able to toggle switches through keypad and remote software - **SUCCESSFUL**
- ***Simple Automation Test:*** Program to toggle switches/outlets every two minutes - **SUCCESSFUL**
- ***Interoperability Test:*** Takes temperature readings and turns on outlet-controlled fan when temperature is high - **SUCCESSFUL**

After all the tests passed successfully, we were able to compile a detailed,10-page intallation manual with step-by-step, photo instructions and reference guides.

Acknowledgements

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