Control and Automation in Solar-Powered Homes

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• About Cornell Solar Decathlon (CUSD)
  – Undergraduate students (all backgrounds/majors)
  – Build completely solar-powered house
  – Competes with other schools

• About the Engineering Team
  – Design control system for house (lighting, HVAC)
  – Early Start = No House (no HVAC) = Big Challenge!
The Bigger Picture

• Floor Specifications
  – 460 sq. ft.
  – Three Cylindrical Silos
    • 1 Bedroom
    • 1 Bath
    • 1 Living Room
    • Kitchen w/ Island
    • 15’ x 15’ Courtyard
  – Meant for 1-2 residents

• Design Specifications
  – PV Panels on Roof
  – Mechanical Closet
  – Corrugated Steel Wall
Background

• The Goal to reach by end of Summer:
  – Design & Build bench-top model to simulate control system
  – Develop easy-to-follow protocol for installation

• Donated Equipment
  – ELK Products
  – Smart Homes Insteon
Hardware Methodology

“Putting It Together”

Implementing Hardware

– Control Box
  • Ethernet Interface
  • Serial Interface
  • Control Board

– Two Controllers
  • Keypad
  • Computer Software

– Powerline Network Device
• Three Configurations (but anything controls anything)
  – A controls B
    • Not Hardwired
    • Network-Linked
  – C controls D
    • Regular outlet
    • Hardwired
  – E controls F
    • Regular bulb
    • Hardwired
Engineering Design

“How It Works”

• User’s Perspective
  – Centralized Control
  – Remote Control (Virtual & Real Keypad)
  – GUI Software = Easy-to-Use Interface
**Engineer’s Perspective**

- Add carrier frequency (131.65 kHz) to powerline voltage.
- Data is modulated on carrier frequency using Binary Phase-Shift Keying (BPSK).

- 10 cycles per bit
• Engineer’s Perspective
  – Peer-to-Peer Networking
    • Controller (sends data)
    • Responder (receives data)
    • Repeater (relays data)
Results
“Did It Work?”

• Initial Malfunctions/Discrepancies
  – Main Control Board
  – Bad Powerlinc Modem
  – Broken SwitchLinc Dimmer

• Debugging the Control Board/Modem
  – Able to connect (ping)
  – Not able to communicate

• Cooperative Vendors
Results
“Did It Work?”

• Manual Test
  – Testing switches to turn on corresponding outlets/bulb

• Remote Access Test
  – Being able to turn on/off switches through keypad and rules we wrote

• Simple Automation Test
  – Program to toggle switches/outlets every two minutes

• Interoperability Automation Test
  – Takes temperature readings
  – If it gets warm, control turns on fan and shuts off lights
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