Wind Speed Data Logger

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Project Outline

- Introduction
- Problem Statement/Solution
- System design
- Hardware design
- Software design
- Integration
- testing
- Conclusion

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Introduction

- Wind Speed Data Logger project supports the renewable energy market
- Large wind generator installations are located in Indiana and Ohio
- Average wind speed site surveys predict wind generator return on investment
- Test towers erected at potential wind generator sites to gauge average wind conditions
- Residential wind generator installations have the potential to be profitable
- Wind speed data logger project provides affordable tool for residential wind survey

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Problem Statement/Solution

- Viable wind energy exists in our area
- Wind generator output power is dependent on
  - Structures
  - Site topology
- Industrial wind survey equipment is expensive
- Wind speed data logger provides affordable easy to use tool for residential wind survey

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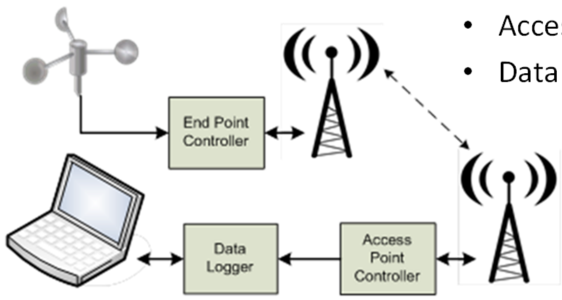
System Design



- Anemometer
- End point controller
- Access point controller
- Data logger controller

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System Requirements

- The prototype shall measure wind speed
- The prototype shall transfer wind speed information from sensor to data logging device
- The prototype shall store wind speed information in non-volatile memory
- The prototype shall accept operator input and display wind speed
- The prototype shall be capable of measuring wind speeds between 5 and 50 miles per hour

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System requirements (Cont.)

- The anemometer output shall be electrically conditioned to logic levels
- The pulse stream from the anemometer shall be converted to one pulse per second at a wind velocity of 2.5 miles per hour
- The anemometer shall be designed for pole mounting
- Outdoor based electronics shall be mounted in an enclosure
- The electronics shall operate off of standard household AC power
- Information shall be transferred from the anemometer to a processing element via a data link, either cabled or RF

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Hardware Design

- Commercial Off The Shelf (COTS)building blocks
  - Vortex anemometer
  - Texas Instruments eZ430 evaluation module
  - Atmel AVR32 EVK1100 development module
  - RS232 adaptor

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Hardware Design (Cont.)

Vortex Anemometer Specifications

- Sensor type
  - 3-Cup rotor reed switch/magnet provides 1 pulse per rotation
- Output
  - 1 pulse per rotation at 2.5 mph
- Rotor diameter
  - Approximately 5 inches
- Speed range
  - Approximately 3 mph to 125+ mph

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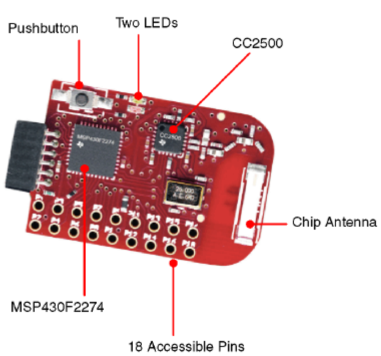
Hardware Design (Cont.)

eZ430 Module Specifications



- MSP430F2274
  - 16-bit RISC architecture
  - Internal calibrated oscillator
  - 16-bit timers A and B with capture/compare registers
  - UART
- CC2500
  - 2.4 GHz to 2.4835 GHz output
  - +1 dBm output level (~1.3mW)
  - Multiple modulation formats
  - SPI digital interface

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Hardware Design (Cont.)
EVK1100 Development Module Specifications

- AT32UC3A0512 processor
  - 32-bit RISC architecture
  - Real Time Operating System (RTOS)
  - 512 Kbytes Flash memory
- Peripherals
  - RS232 (x2)
  - USB
  - LCD
  - Ethernet
  - Secure Digital memory slot

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Hardware Design (Cont.)
RS232 to TTL Adaptor Module Specifications

- MAX232A device from Maxim-ic
  - Logic level serial data receive and transmit pins
  - RS232 level serial receive and transmit pins
  - 0.1” center stakes for logic signal connection to custom circuit board
  - Standard 9-pin D connector for RS232 cable connection

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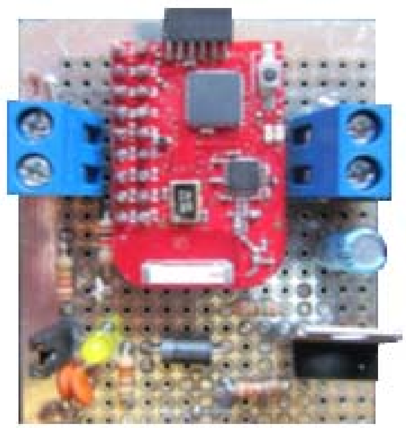
Hardware Design (Cont.)
End point controller Construction



- Custom built module
  - eZ430 module
  - 6 VDC to 40 VDC input, 3.3 VDC output linear regulator circuit
  - Anemometer cable termination circuit
  - Power indicator LED
  - Terminal blocks for external power supply and anemometer connections

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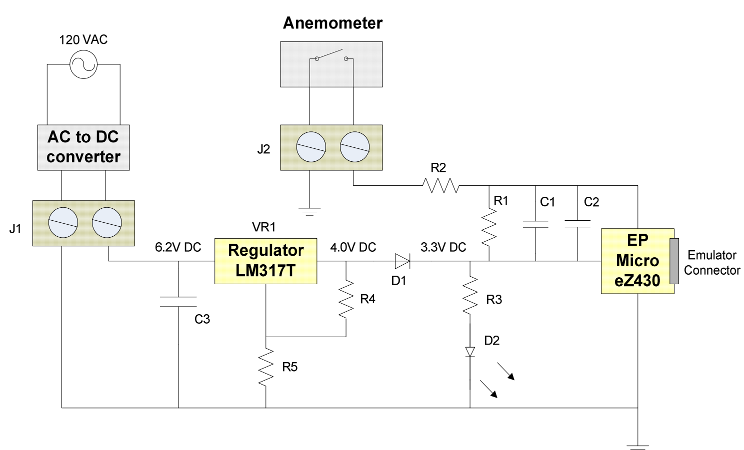
Hardware Design (Cont.)
End point controller Schematic



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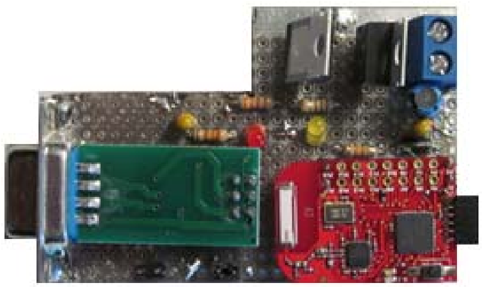
Hardware Design (Cont.)

Access point controller Construction



- Custom built module
  - eZ430 module
  - 6 VDC to 40 VDC input, 3.3 VDC output linear regulator circuit
  - 6 VDC to 40 VDC input, 5.0 VDC output linear regulator circuit
  - Power indicator LED (x2)
  - Terminal block for external power
  - TTL to RS232 adaptor module

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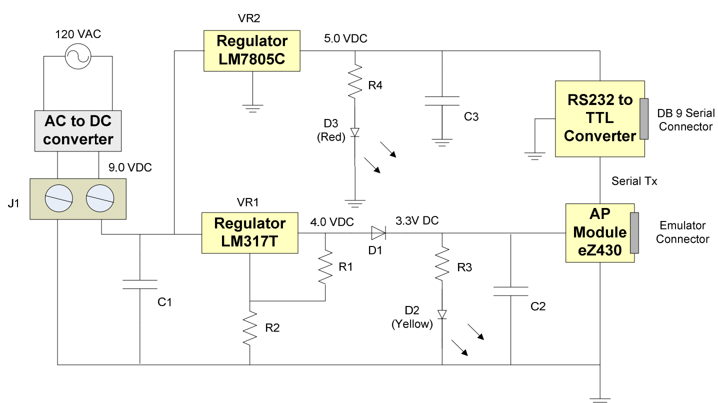
Hardware Design (Cont.)

Access point controller Schematic



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Software Design Overview

- End point controller function
  - Join radio network as end point
  - Measure anemometer and calculate wind speed
- Access point controller function
  - Control radio network as access point function
  - Receive information from all end point controllers and send to data logger
- Data logger function
  - Provide UART shell interface to allow access to display and SD memory peripherals
- Software design tools
  - Code Composer Studio v4
  - AVR Studio 5.0

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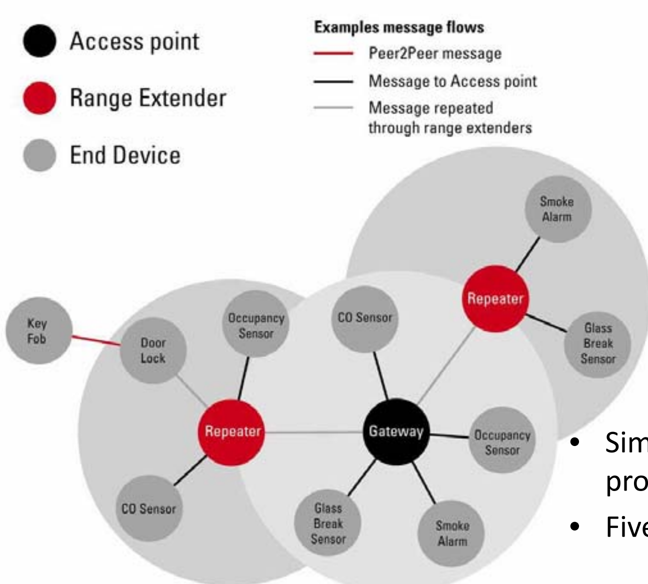
Software Design (Cont.)



- SimpliciTI network protocol
- Five command API

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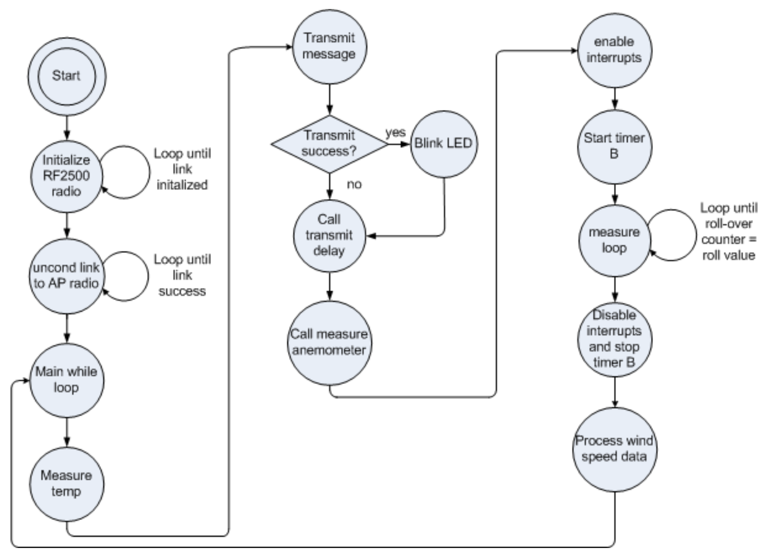
Software Design (Cont.)

End Point Controller



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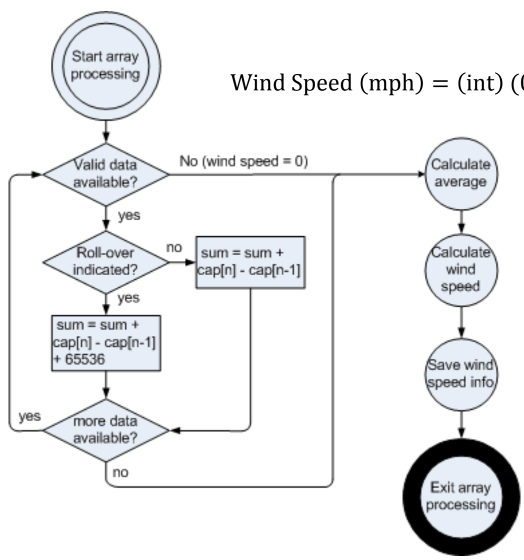
Software Design (Cont.)

End Point Controller Data Processing

$$\text{Wind Speed (mph)} = (\text{int})\ (0.5 + \frac{25}{(\text{average count} * 0.000008)})$$



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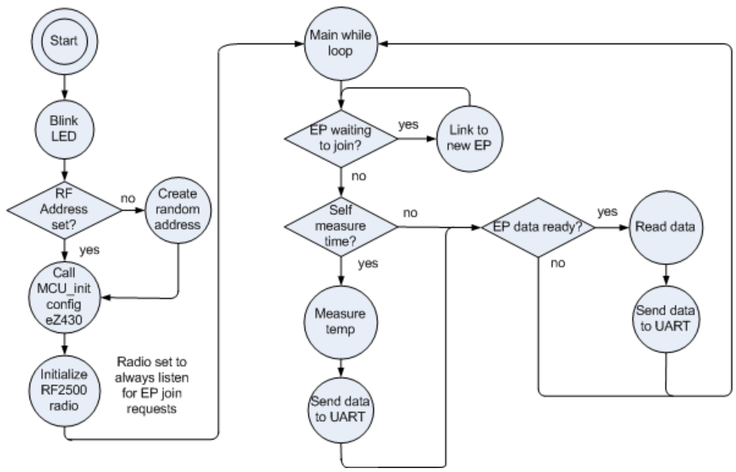
Software Design (Cont.)
Access Point Controller



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Software Design (Cont.)
Data Logger Controller

- Real Time Operating System (RTOS) example program
- Shell tasks provided for UART, Ethernet, and USB ports
- Modified memory control task to include system time on memory append command
- Four commands used by access point to control data logger
  - Write string to LCD line four
  - Select drive B (SD memory module)
  - Append string to log file
  - ^q (exit append and save file)

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Integration

- Pole assembly constructed from $1\frac{1}{2}$ inch PVC pipe
- Exterior electrical box included for end point electronics

Integration (Cont.)

- Anemometer mounted to top of pole with cable coiled inside top section of pipe
- End point electronics module and power adaptor located in center box

Integration (Cont.)

- Access point controller connected to data logger module
- Null modem adaptor used to reverse transmit and receive signals

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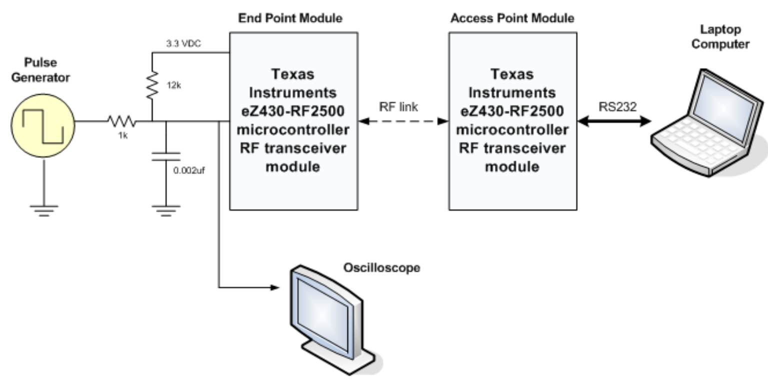
RF Subsystem Testing



- Signal generator used to emulate anemometer input signal
- Testing from 5 mph to 50 mph in 5 mph steps indicated a maximum error of 0.4 mph

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System Testing

- System installed in outdoor location for 6 days
- Unit ran continuously through rain and cold weather
- Recorded 90,225 data entries during test
- Log file size at end of test was 4,848 Kbytes
- Example data from log file
  - EP 1, TEMP = 60.4 F,RSSI = 016, WS = 00.0 mph201203242137000
  - EP 1, TEMP = 61.1 F,RSSI = 017, WS = 02.9 mph201203242137000
  - EP 1, TEMP = 60.4 F,RSSI = 017, WS = 03.2 mph201203242137000
  - EP 1, TEMP = 60.4 F,RSSI = 017, WS = 03.2 mph201203242137000
  - EP 1, TEMP = 60.4 F,RSSI = 016, WS = 03.3 mph201203242138000
  - EP 1, TEMP = 60.4 F,RSSI = 016, WS = 02.8 mph201203242138000
  - EP 1, TEMP = 61.1 F,RSSI = 017, WS = 00.0 mph201203242138000
  - EP 1, TEMP = 60.4 F,RSSI = 015, WS = 02.9 mph201203242138000

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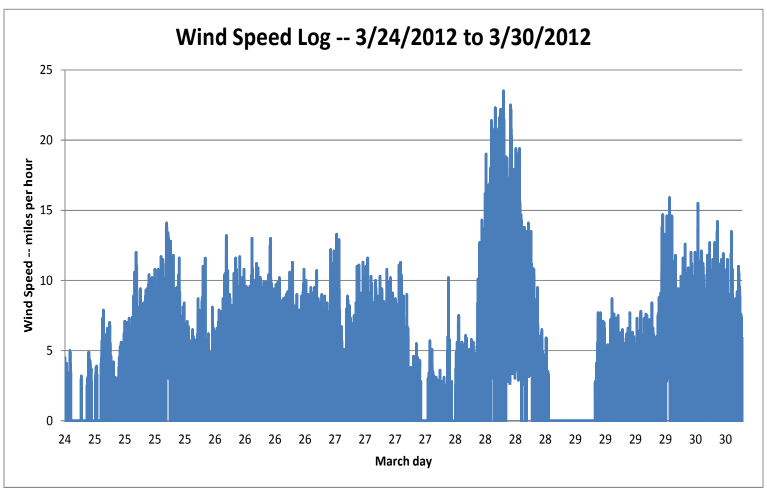
System Testing (Cont.)

6 day test data plotted using Microsoft Excel



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Conclusion

- Project exceeded all requirements
- Completed on time and under budget
- Future versions could eliminate EVK1100 module to save money

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Questions?

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Demonstration

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