

Wind Speed Data Logger

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1

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Project Outline

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

2

Introduction

- Project supports the renewable energy market
- Industrial wind generators located in Indiana and Ohio
- Average wind speed used to predict generator output
- Test towers measure average wind conditions
- Residential wind generator installations benefit from survey
- Wind speed data logger project provides affordable tool for residential wind survey

3

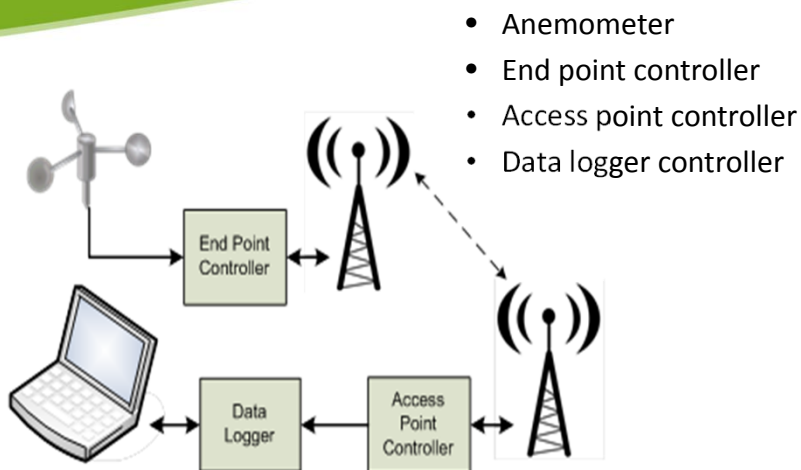
Problem Statement/Solution



- Viable wind energy exists in our area
- Wind generator output dependent on location
- Existing wind survey equipment is expensive
- Wind speed data logger provides affordable alternative

4

System Design



5

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

6

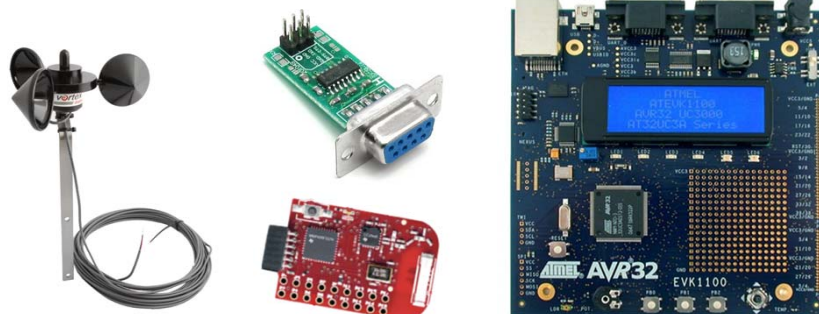
System requirements (Cont.)

- 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

7

Hardware Design

- Commercial Off The Shelf (COTS) building blocks
 - Vortex anemometer
 - Texas Instruments ez430 evaluation module
 - Atmel AVR32 EVK1100 development module
 - RS232 adaptor



8

Hardware Design (Cont.)

Vortex Anemometer Specifications

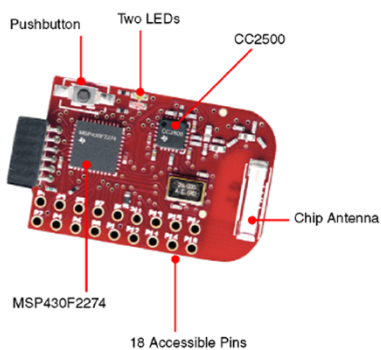


- Sensor type
 - 3-Cup rotor reed switch/magnet provides 1 pulse per rotation
- Output
 - 1 pulse per rotation at 2.5 mph
- Rotor diameter
 - Approximately 5 inches
- Speed range
 - Approximately 3 mph to 125+ mph

9

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

10

Hardware Design (Cont.)

EVK1100 Development Module Specifications

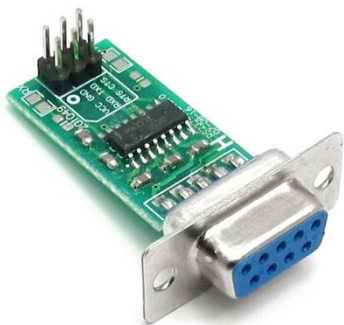


- AT32UC3A0512 processor
 - 32-bit RISC architecture
 - Real Time Operating System (RTOS)
 - 512 Kbytes Flash memory
- Peripherals
 - RS232 (x2)
 - USB
 - LCD
 - Ethernet
 - Secure Digital memory slot

11

Hardware Design (Cont.)

RS232 to TTL Adaptor Module Specifications

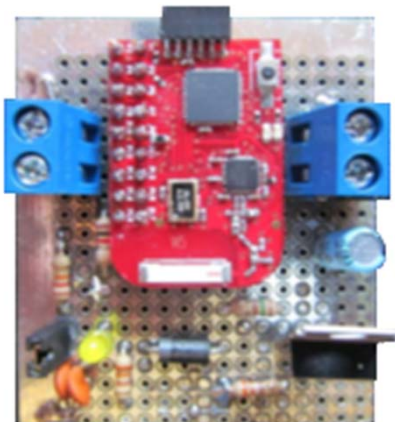


- MAX232A device from Maxim-ic
 - Logic level serial data receive and transmit pins
 - RS232 level serial receive and transmit pins
 - 0.1" center stakes for logic signal connection to custom circuit board
 - Standard 9-pin D connector for RS232 cable connection

12

Hardware Design (Cont.)

End point controller Construction

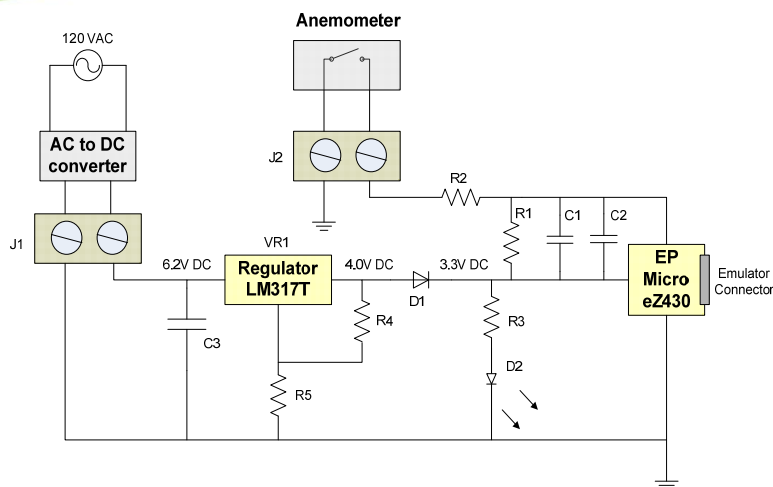


- Custom built module
 - eZ430 module
 - 6 VDC to 40 VDC input, 3.3 VDC output linear regulator circuit
 - Anemometer cable termination circuit
 - Power indicator LED
 - Terminal blocks for external power supply and anemometer connections

13

Hardware Design (Cont.)

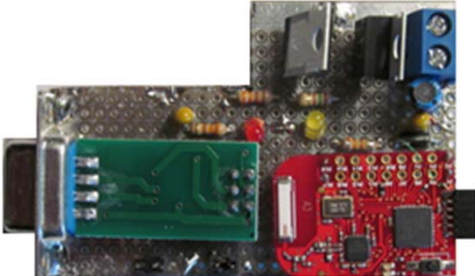
End point controller Schematic



14

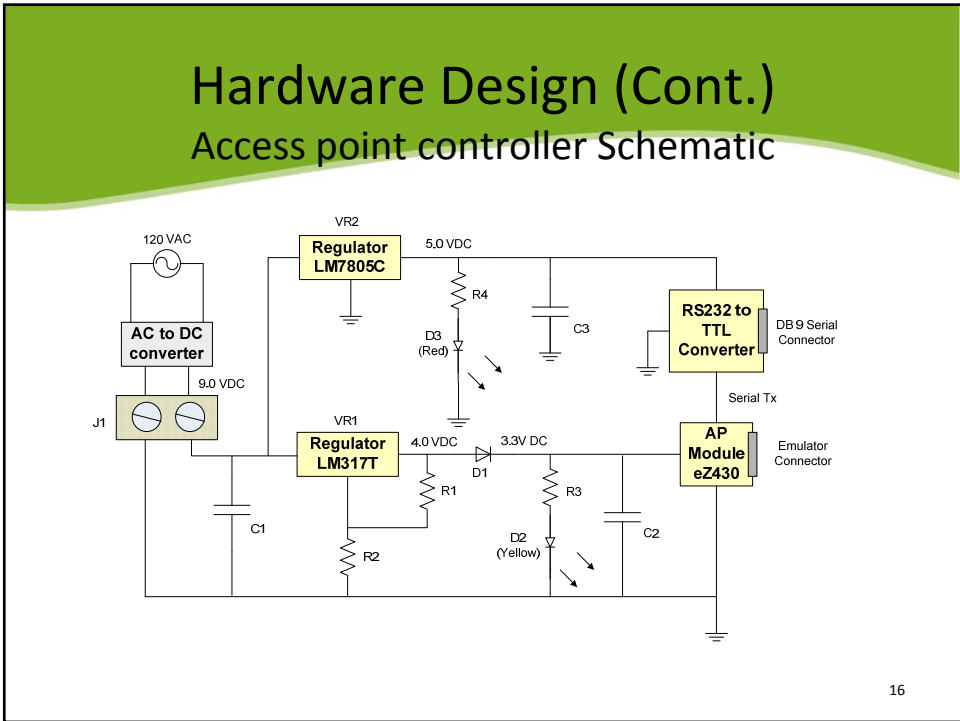
Hardware Design (Cont.)

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

15



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

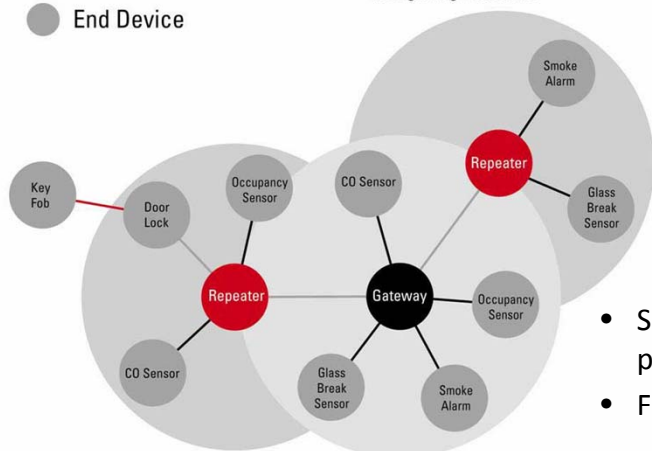
17

Software Design (Cont.)

- Access point
- Range Extender
- End Device

Examples message flows

- Peer2Peer message
- Message to Access point
- Message repeated through range extenders

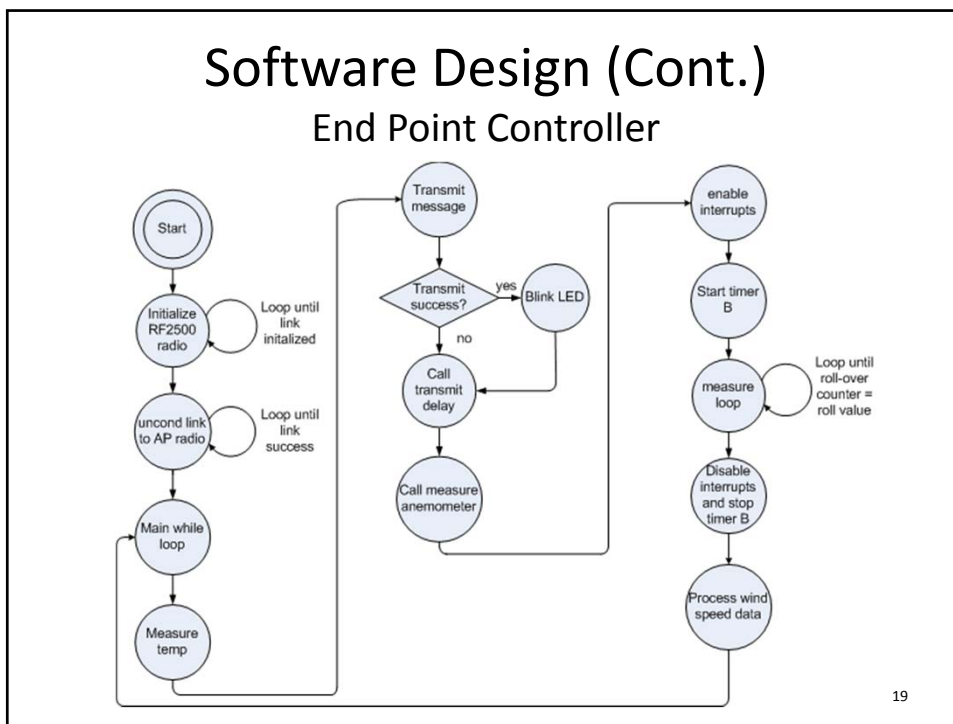


- SimpliciTI network protocol
- Five command API

18

Software Design (Cont.)

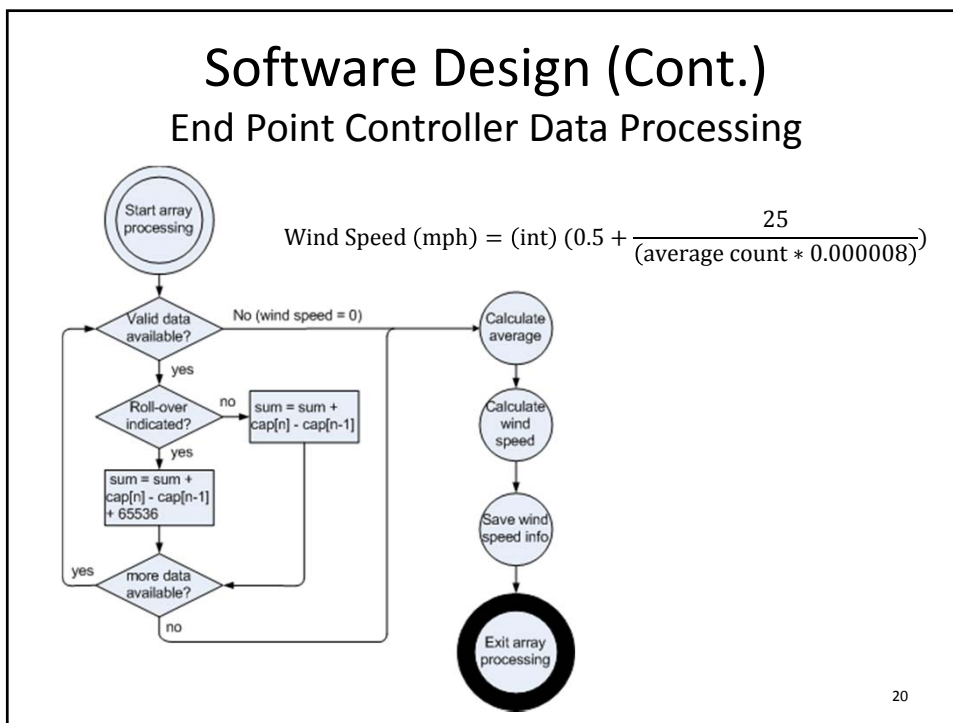
End Point Controller



19

Software Design (Cont.)

End Point Controller Data Processing

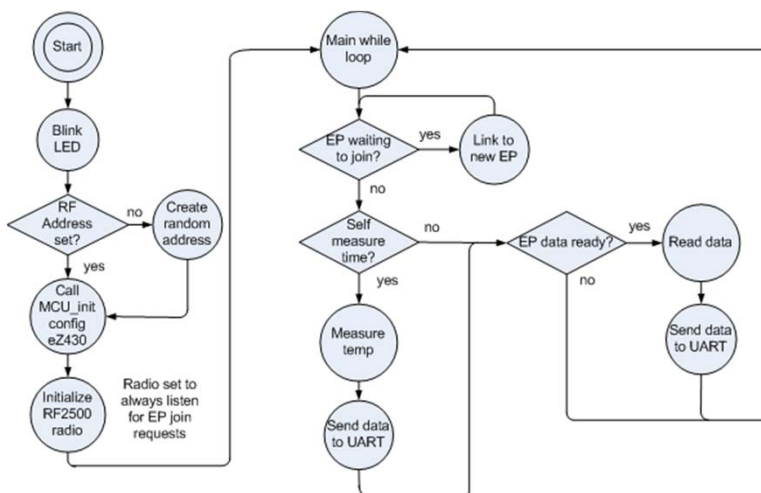


$$\text{Wind Speed (mph)} = (\text{int}) \left(0.5 + \frac{25}{(\text{average count} * 0.000008)} \right)$$

20

Software Design (Cont.)

Access Point Controller



21

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)

22

Integration



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

23

Integration (Cont.)



- Anemometer mount
- End point module and power adaptor located in center box

24

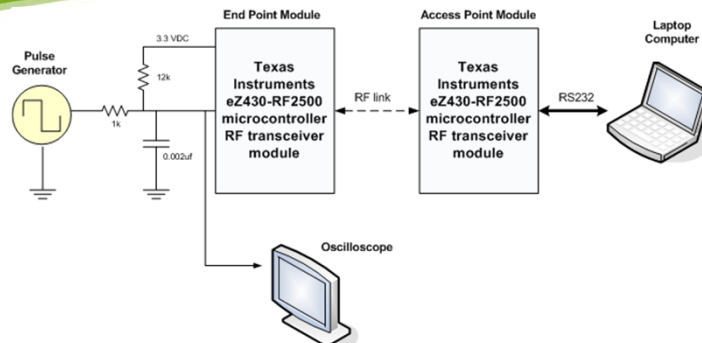
Integration (Cont.)



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

25

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

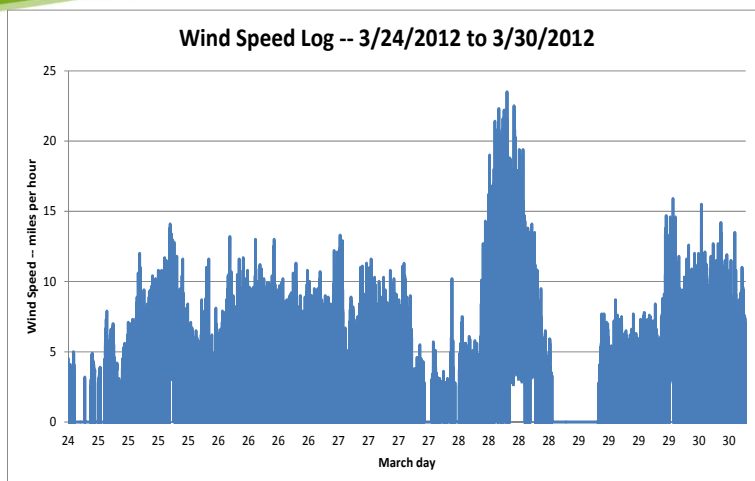
26

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

27

System Testing (Cont.)



28

Conclusion

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

29

Questions?



30
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Demonstration



31