EE 491 Senior Project Description
WWU Wind Feed

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Summary

The WWU Wind Feed is a tool to deliver wind information to users of the WWU boathouse on Lake Whatcom. The system will collect wind speed (and possibly other) data and upload it to the Internet at regular intervals. The device utilizes an off the shelf marine anemometer, and does information processing and communication with an embedded microcontroller and a Wi-Fi module. The system will be powered by the grid.

1 Project Requirements

- The device must publish the current wind speed for Lake Whatcom's third basin on a webpage that is easily available for PC and smartphone access.
- The wind feed website will be hosted on the device.
- Online information must be updated every 30 minutes.
- Published wind speed information must be accurate to within 1 knot with a resolution of 0.5 knots.
- The device must operate to specifications in wind speeds from 1 knot to 60 knots.
- The device must operate in temperatures from -18 to 40 degrees Celsius.
- All outdoor components, the wind speed instrument and cable, must withstand year round weather conditions.
- The device must cost less than 200USD to implement from the supply side.
- The device must interface with the local internet router via Wi-Fi protocols IEEE 802.11 b/g/n, and must be able to meet security constraints for network access.
- The device must be powered by a standard 120VAC outlet and draw less than a typical Wi-Fi router, about 50 mA (for 6Watts).
- The device must be the roughly the size of a standard internet router/modem, roughly 4 inches by 6 inches by 1 inch.

2 System Design Formulation and Specifications

The product collects weather data via an anemometer instrument. The instrument is a transducer from wind speed to a linear voltage output from 0.4 to 2V DC. The anemometer requires a 12VDC power supply. This signal is sampled by the ADC of the microcontroller, and the wind speed is calculated based on the input signal. Wind speed data is passed to the Wi-Fi module using UART. The Wi-Fi module has integrated TCP/IP protocols to communicate with the local Wi-Fi network. The device accesses the network in order to serve the webpage which displays current wind conditions. This website is hosted by the device.

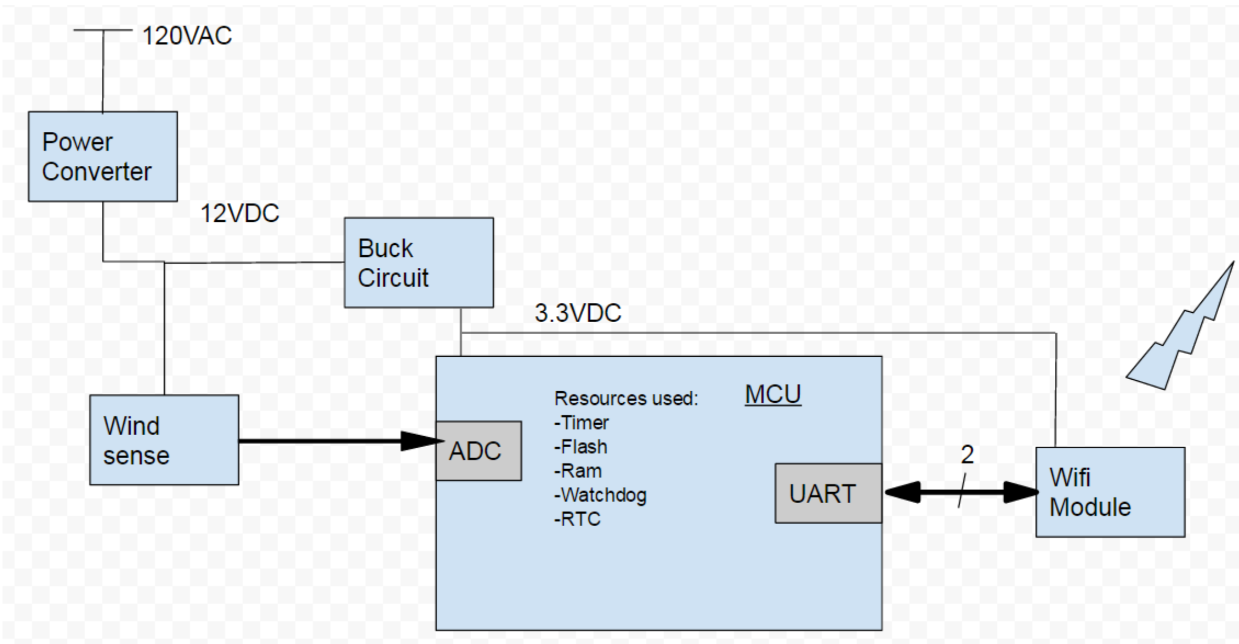

Figure 1: Preliminary System Block Diagram

a. Hardware

Microcontroller Specs: For this project I require at least 38kB ROM, 0.1 kB RAM, an ADC range of 193 levels, so 9 bit resolution. The project requires an MCU with UART capabilities. The MCU listed in appendix A meets these requirements, but has some superfluous features: 64kB ROM, 16kB RAM, UART, 16 and 24 bit ADCs.

Resources: The MCU resources I will use for this project are the ADC to sample the wind speed instruments voltage output, UART for communication between the MCU and the Wi-Fi module, a timer for the periodic updating of wind information, the watchdog timer, since the device will run continuously, to reset the system in the case of an error, and the RTC if I implement a timestamp publication.

Other components: the Wi-Fi Module must operate at the same supply voltage as the MCU, in this case 3.3V. The Wi-Fi module must also either be a Surface mount component or have a form factor small enough to fit in the form described above. The Wi-Fi module must communicate using the IEEE 802.11 b/g/n protocol for compatibility with the in-place Wi-Fi system. The wind speed transducer must be weatherproof for continued outdoor operation, and must produce a voltage signal between 0 and 3.3V for use with the MCU ADC. Ideally the transducer would be self-powered, but the self-powered instruments are proprietary and expensive. The sensors I considered had a minimum supply voltage of 12VDC, so I will supply 12V to the sensor.

Power Supply Specs: The 120VAC to 12VDC must supply 500mA. The system is estimated to draw about 80mA from the 120 to 12 converter, I am using a very conservative margin of error. The 12VDC to 3.3VDC must supply a minimum of 200mA, but again I will use 500mA to ensure performance.

PCB size Requirements: The device as a whole must resemble a Wi-Fi router in form. This means the device must be roughly 4 inches wide by 6 inches long by 1 inch tall. This leaves room for a 3.5 inch by 5.5 inch PCB if necessary. I used these dimensions in my parts list, but I will attempt to use a smaller PCB to save cost.

b. Software

Programming languages: I will program the board in Kinetis Design Studio, which uses C. For the webpage I will use HTML.

Real time kernel Type: uC/OS by Micrium is the kernel I have experience with, so I will most likely use it for software multitasking.

Major algorithms: The Wi-Fi module has integrated TCP/IP, I will be coding using HTTP to serve the webpage.

3 Development Plan

a. Prioritized list of device features

Primary	
1.	Make current wind speed available to WWU boaters.
Secondary	
2.	Provide timestamp with wind speed, display historical wind data.
3.	Publish wind data in the optimal format for user consumption (i.e. social via social media).

Table 1: Prioritized list of features

b. Description of project development tasks and sequence

Winter Quarter 2017 - Hardware Design		
Week	**Dates**	**Tasks**
1	Jan 4-6	Verify hardware block diagram as optimum design
2	Jan 9-13	Order parts essential to prototyping such as the wind sensor, simulate circuitry to verify design integrity.
3	Jan 16-20	Begin characterizing wind sensor output, Learn Altium tool
4	Jan 23-27	Buy and test as many components as possible.
5	Jan 30-Feb 3	Develop prototype of major device functions for onsite testing
6	Feb 6-10	Finalize circuit layout, produce complete schematic of system **Hardware Design Reviews Feb 7th**
7	Feb 13-17	Review schematic for PCB fabrication
8	Feb 20-24	Order PCB
9	Feb 27-March 3	Breadboard whatever possible while waiting for PCB
10	March 6-10	Assemble hardware for testing.
11	March 13-17	*Catch up*
Spring Quarter 2017 - Software Design		
Week	**Dates**	**Tasks**
1	March 28-31	Formulate top level block diagram
2	April 3-7	Research web servers, TCP/IP, static websites, possible publishing media **PCB Fully Assembled and Tested April 4th**
3	April 10-14	Formulate detailed block diagrams of modules **Software System Design Reviews April 11th**
4	April 17-21	Develop basic prototype for testing
5	April 24-28	*Catch up*
6	May 1-5	*Catch up*
7	May 8-12	Implementation
8	May 15-19	Implementation
9	May 22-26	Implementation and prepare presentation **Code Reviews May 23**
10	May 29- June 2	*Catch up*
11	June 5-9	**Project Demonstrations June 7th** (subject to changes)

Table 2: Project development plan

c. Description of development hardware and software including source

Software: I will be using Kinetis Design Studio to program the MCU, Altium for PCB layout, Multisim for circuit simulation. I will utilize online weather forecasts in order to verify the accuracy of the device.

Hardware: I will need to find a wind speed meter to fine tune my accuracy and to verify the required resolution. I will utilize oscilloscopes, power supplies, multimeters, and fabrication supplies to build and test hardware and software systems. For prototyping, I will use as many components from the EE stock room as possible to avoid lead times and cost.

d. Prototype description

The prototype demonstration will occur in the EE labs. I will have a wind speed instrument set up with the online publishing occurring much faster than otherwise specified, likely every 30 seconds or so. A person will move the wind speed sensor, perhaps by blowing/a fan/ hand manipulation and watch as the webpage updates. Ideally I would have the final device in place at the boathouse for a real world demonstration, but I do not want to pay for two prototypes unless necessary.

4 User Interface Requirements

The user interface for this project takes the form of a web page. This web page should be viewable by users on a PC or smart phone. The UI is very simple since it only publishes data. There is no user control, only observation.

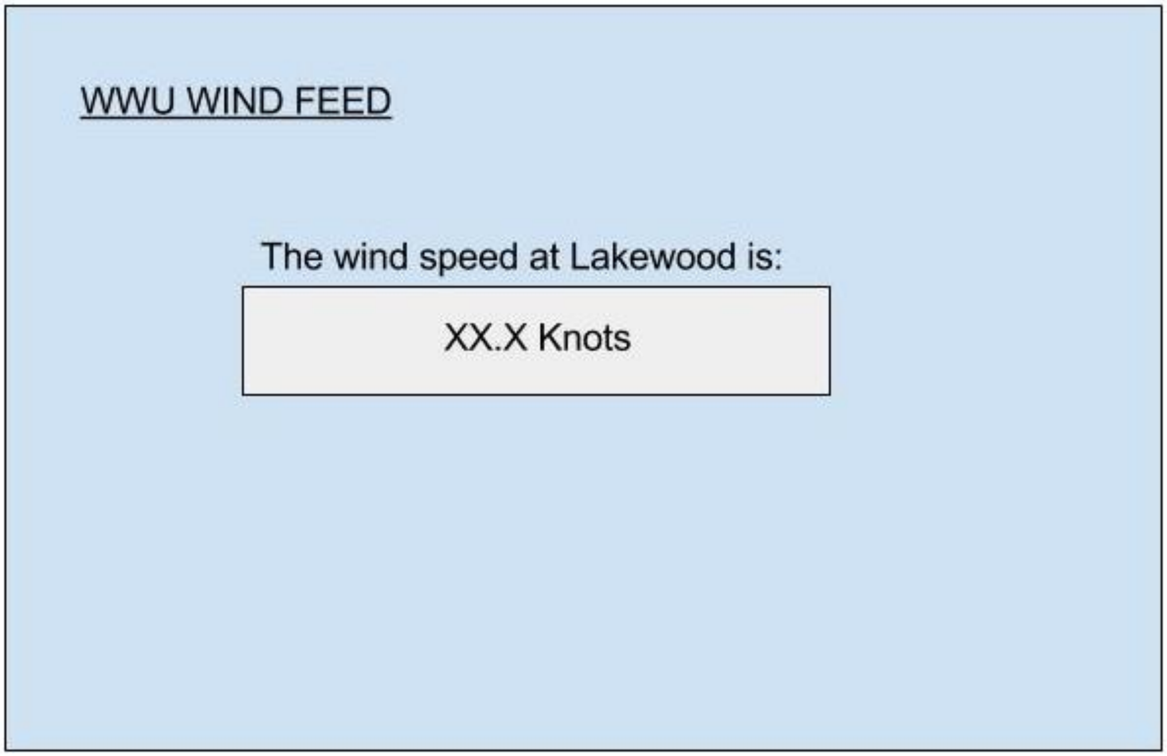

Figure 2: Sketch of website user interface

Appendix A – Preliminary Parts List

Part number	Quantity	Description	Cost(USD)	Lead time	Current consumption (mA)	Power dissipation (W)	URL
120VAC to 12VDC converter							
TOL-09442	1	Wall Adapter Power Supply - 12VDC 600mA	5.95	1-2 weeks	600mA	Assume 85% efficiency	https://www.sparkfun.com/products/9442
Supplied by 120VAC to 12VDC converter							
1733	1	Anemometer Wind Speed Sensor w/Analog Voltage Output	44.95 each	1-2 weeks	4-20	0.240	https://www.adafruit.com/product/1733
12 to 3.3VDC converter							
TPS62172DSGR	1	Buck Switching Regulator IC Positive Fixed 3.3V 1 Output 500mA 8-WFDFN Exposed Pad	1.56	1-2 weeks	526	6.312	http://www.digikey.com/product-detail/en/texas-instruments/TPS62172DSGR/296-39449-1-ND/5143397
PJ-035-SMT-TR	1	DC barrel Jack	1.34	1-2 weeks	N/A	N/A	http://www.digikey.com/product-detail/en/cui-inc/PJ-035-SMT-TR/CP-035PJCT-ND/1530992-ltTikw66e-BR-Y4oCKYaRoCikTw_wcB
80-T322C106K15AT	1	Tantalum Capacitors - Solid Leaded 15V 10uF 10%	1.96	1-2 weeks	N/A	0.1	http://www.mouser.com/ProductDetail/Kemet/T322C106K015AT/?qs=sGAEpiMZZMsh%252b1woXyUXj2MEbxGkEkhEwwHS%2fNM7xfA%3d
TLCU226M006XTA	1	Tantalum Capacitors - Solid SMD 6.3volts 22uF 20%	2.81	1-2 weeks	54 (@100kHz)	0.178	http://www.mouser.com/ProductDetail/AVX/TLCU226M006XTA/?qs=sGAEpiMZZMsh%252b1woXyUXj2BG3d9BWqHTUCbLPZ3%2fYBY%3d
TFM201610ALM-2R2MTAA	1	Fixed Inductors 2.2uH 146mohms 2.1A Thin Film Metal	0.69	1-2 weeks	2100	6.9	http://www.mouser.com/ProductDetail/TDK/TFM201610ALM-2R2MTAA/?qs=sGAEpiMZZMukHu%252bjC5l7YXWyGFGQPUf1VJZQeiZdbQI%3d
ESR10EZPJ104	1	Thick Film Resistors - SMD 0805 100Kohm 5% Anti Surge AEC-Q200	0.10	1-2 weeks	N/A	N/A	http://www.mouser.com/ProductDetail/ROHM-Semiconductor/ESR10EZPJ104/?qs=sGAEpiMZZMtlubZbdhIBIGrVcSH3vih4Eh1TPh5CImY%3d
Supplied by 12 to 3.3VDC converter							
MOD-WIFI-ESP8266-DEV (or CC3100MOD)	1	Wi-Fi / 802.11 Development Tools WIFI MODULE ESP8266 DEV BOARD	6.91	3 weeks	170	0.561	http://www.mouser.com/search/ProductDetail.aspx?qs=QGk6feVlqMIuCsvdBN17og%3d%3d&utm_source=findchips&utm_medium=aggregator&utm_campaign=909-WIFI-ESP8266-DEV&utm_term=ESP8266
MKM14Z64ACHH5	1	ARM Microcontrollers - MCU Kinetis M 32-bit MCU, ARM Cortex-M0+ core, 64KB Flash, 50MHz, MAPBGA 44	3.12	8 weeks	11.5 run mode, with peripherals	0.038	http://www.mouser.com/ProductDetail/NXP-Freescale/MKM14Z64ACHH5/?qs=dTl%2FGK1lAHKE9y6dPqmtiQ%3D%3D
Two layer PCB Prototyping service	1	Prototype PCB,FR4 substrate,ENIG finish, 1.6mm thick	(5 per sq.in. set of 3) For 5.5x3.5in., 96.25	12 days	N/A	N/A	http://docs.oshpark.com/services/

Appendix B – Cost Breakdown

The total cost of all components listed is: \$225.64. My time is worth a wage of \$100, 40 hours per week for 22 weeks: \$88,000. There is a cost involved with using the development tools on campus. These will be ignored for now. The preliminary total cost: **\$88,225.64.**

Appendix C – Power Budget Calculations

To compute overall power consumption, I will begin at the dissipation of peripherals and work back upstream. I will assume an 85% efficiency of all switching voltage regulators. In order to calculate power consumption of components, as listed in Appendix A, I will use the following formulas: $\mathbf{P = I^2R = IV}$.

Power supplied by the 12 to 3.3VDC converter is: **0.599 W**

Power supplied to the 12 to 3.3VDC converter is: 0.599 / 0.85 = **0.705 W**

Power supplied by the 120VAC to 12VDC converter is: 0.705 + 0.24 = **0.945 W**

Power supplied to the 120VAC to 12VDC converter is: 0.945 / 0.85 = **1.11W**

Total power consumption = **1.11W**

Total current at outlet = 1.11W / 120VAC = **9.26 mA**