

Group 9

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# INTELLATURBINE

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# Motivation

- ⦿ Functional wind generation system
  - Capable of removing average house holds from the power grid
- ⦿ Maximum Power Point Tracking (MPPT) Charge Controller
- ⦿ Data logging and display capabilities
  - Monitoring performance
  - Testing
  - Maintenance

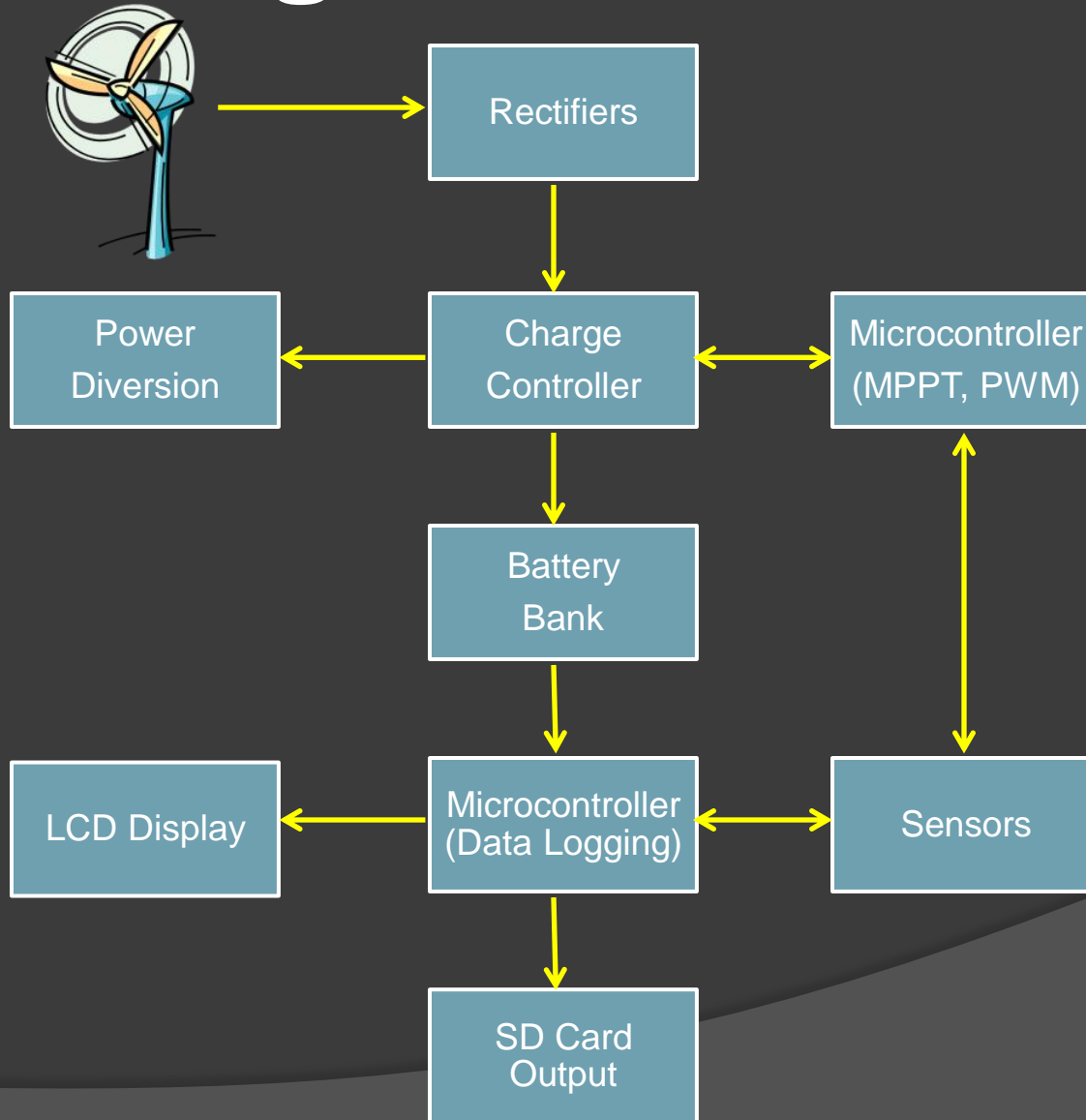
# Goals

- ⦿ User friendly
  - Display
  - Data logging
  - Self sufficient
- ⦿ High efficiency power generation
  - MPPT
- ⦿ Capable of supporting different voltage battery banks
  - 12 & 24 Volts

# Specifications

- ① 500 Watt System
- ① 12 & 24 Volt battery bank
  - Capable of at least 400Ah
- ① Approximately 90% efficient
- ① Change in design due to availability of turbine

# Design Overview



# Wind Turbine

- Length: 3' 6", Width: 2' 4", Diameter: 11"
- Weight: 68lbs

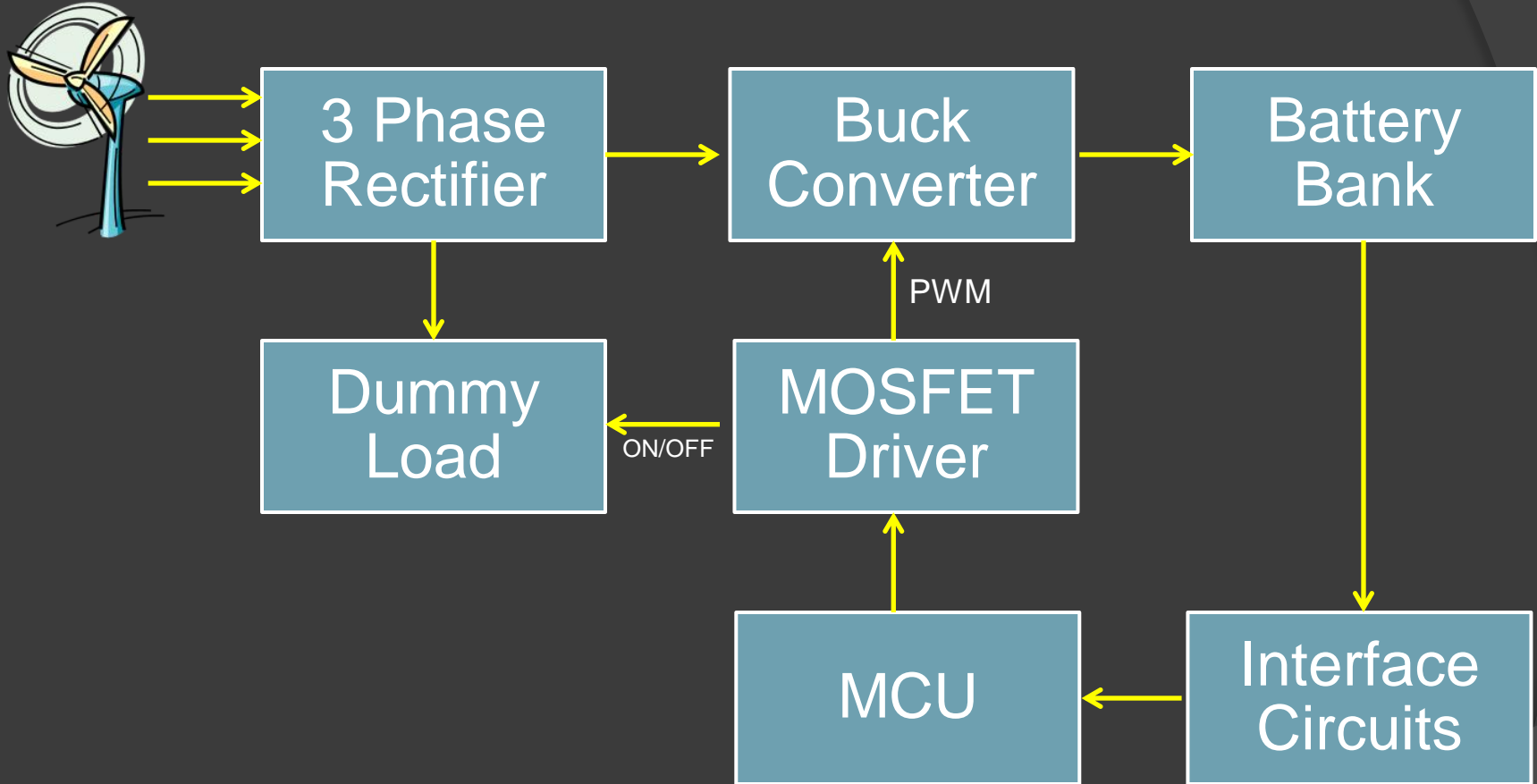


# Wind Generator

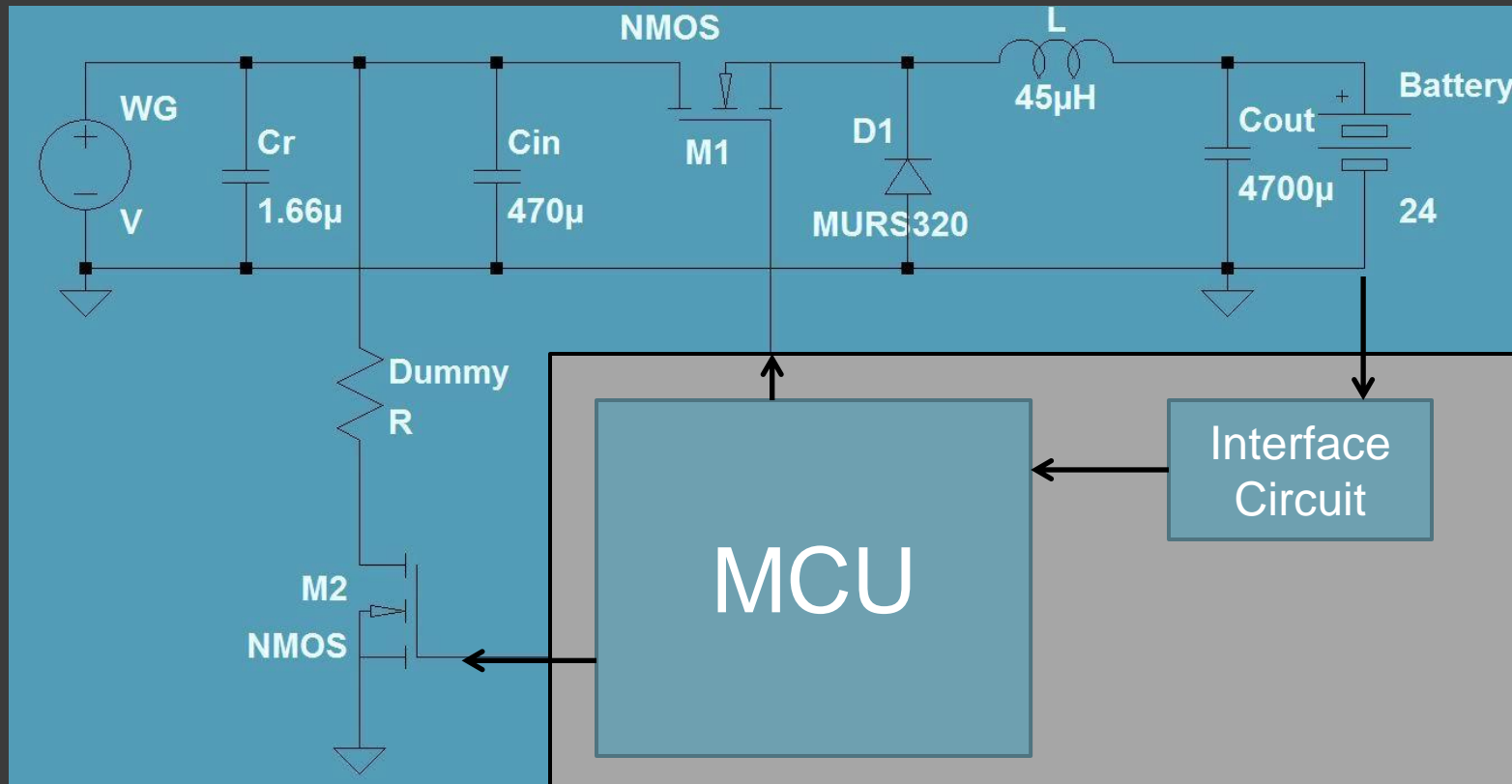
- ◎ TLG 500 Alternator
  - Rated at 500 watts

| <b>Wind Speed<br/>MPH +/- 2</b> | <b>Amps into<br/>Battery Bank +/-<br/>0.5</b> | <b>Battery Voltage<br/>+/- 1</b> | <b>Average Watts</b> |
|---------------------------------|---|----------------------------------|----------------------|
| 7 MPH                           | 1 Amp   | 24.0 Volts                       | 24 Watts             |
| 9 MPH                           | 2 Amp   | 24.0 Volts                       | 48 Watts             |
| 15 MPH                          | 5 Amp   | 24.8 Volts                       | 124 Watts            |
| 20 MPH                          | 10 Amps                                       | 25.2 Volts                       | 254 Watts            |
| 25 MPH                          | 15 Amps                                       | 26.8 Volts                       | 402 Watts            |
| 34 MPH                          | 23 Amps                                       | 27.1 Volts                       | 623 Watts            |
| 40 MPH                          | 30 Amps                                       | 28.2 Volts                       | 846 Watts            |
| 45 MPH                          | 39 Amps                                       | 28.5 Volts                       | 1111 Watts           |
| 50 MPH                          | 50 Amps                                       | 29.8 Volts                       | 1490 Watts           |

# Charge Controller



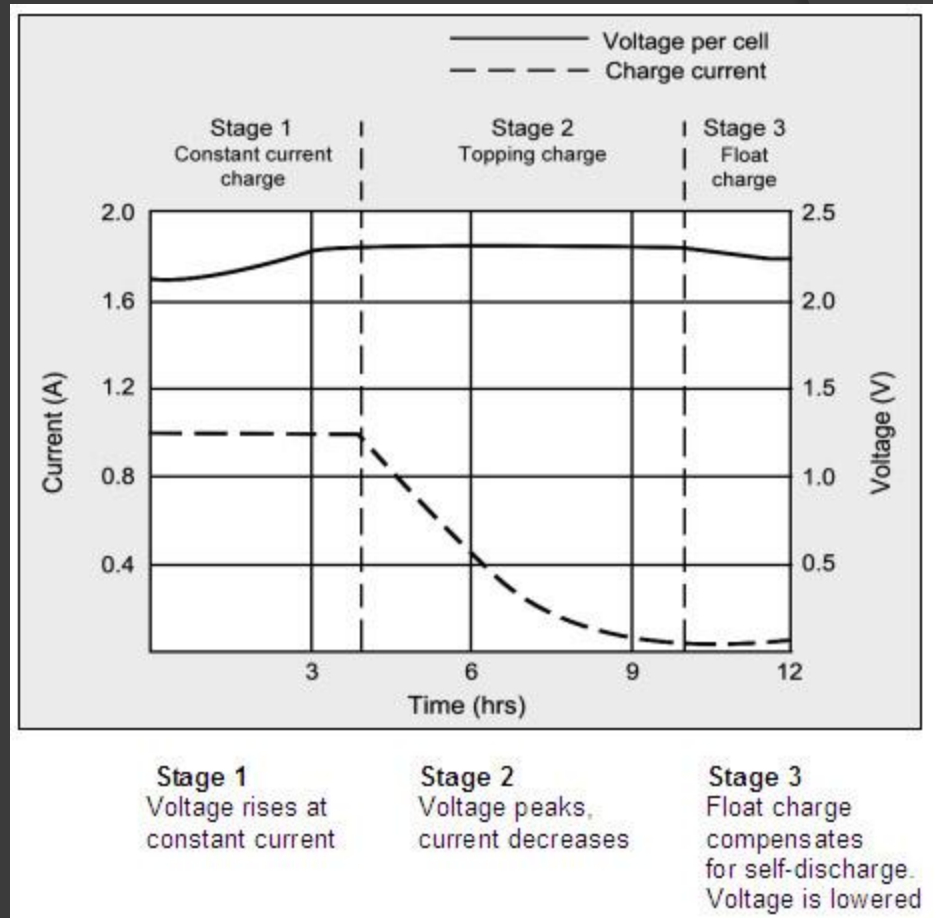
# Charge Controller Design



# Charge Controller Design

## ⦿ Charging Stages

- Bulk charging stage
- Absorption stage
  - $t = 0.42 \frac{C}{I}$
- Float stage



# Maximum Power Point Tracking

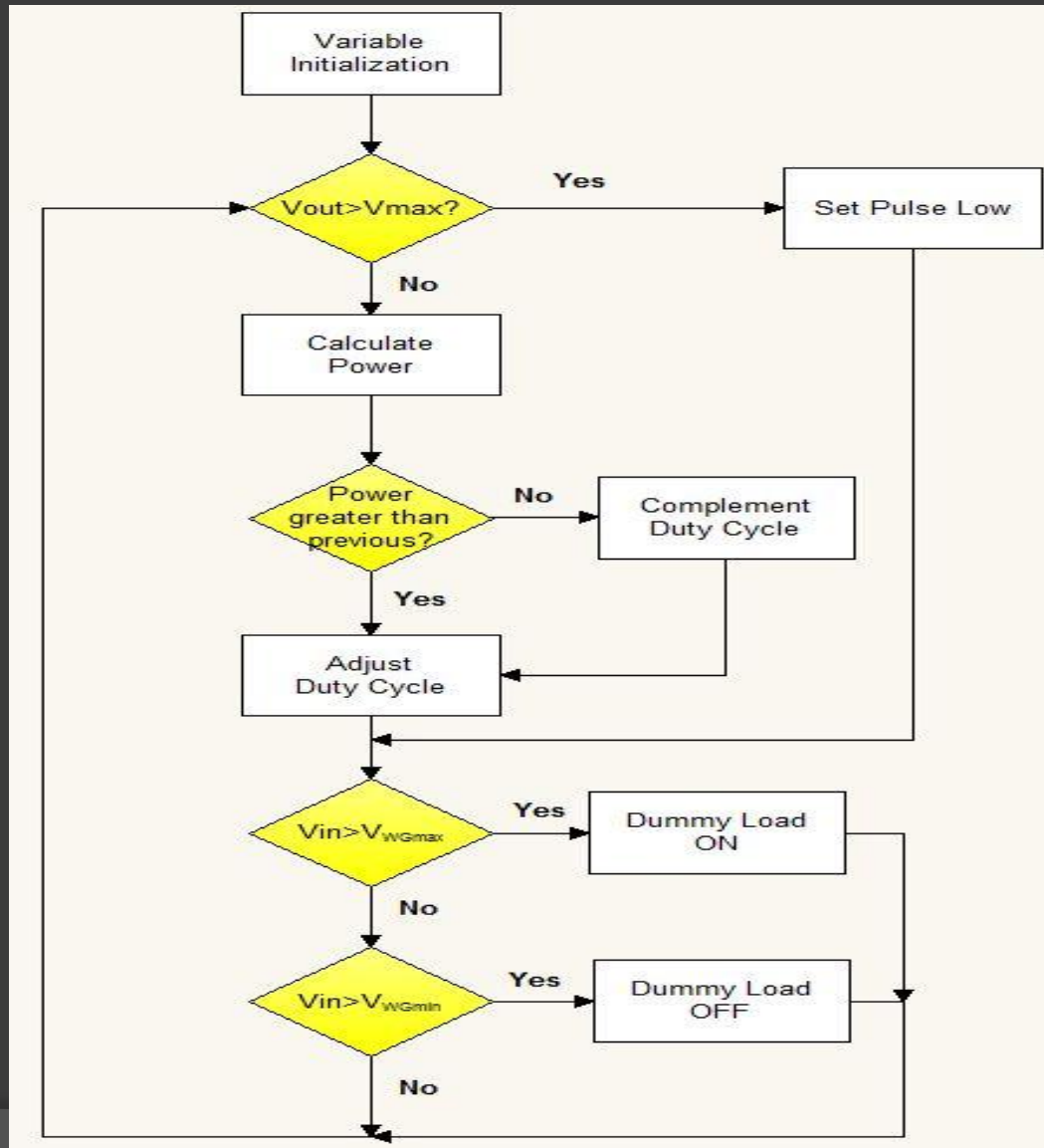
## ⦿ Method

- Constant current method

## ⦿ Advantages

- No knowledge of the wind turbine characteristics
- No measurement of wind needed

# MPPT Flowchart



# MPPT Microcontroller

- ◎ Two ATmega328P
  - MPPT algorithm
  - MOSFET drivers
  - PWM duty cycle adjustment
  - Interacts with current and voltage sensors
  - Also used for data logging and display.

# MOSFET Drivers

## ⦿ IR2121

- Control the MOSFET for dummy load switching

## ⦿ IR2104

- Control the PWM duty cycle for the buck converter

# Battery Bank

- 12 & 24 Volt battery bank
- Four 6V Lead Acid Flooded
- Length: 12", Width: 7", Height: 17"
- Weight: 127lbs
- 400Ah

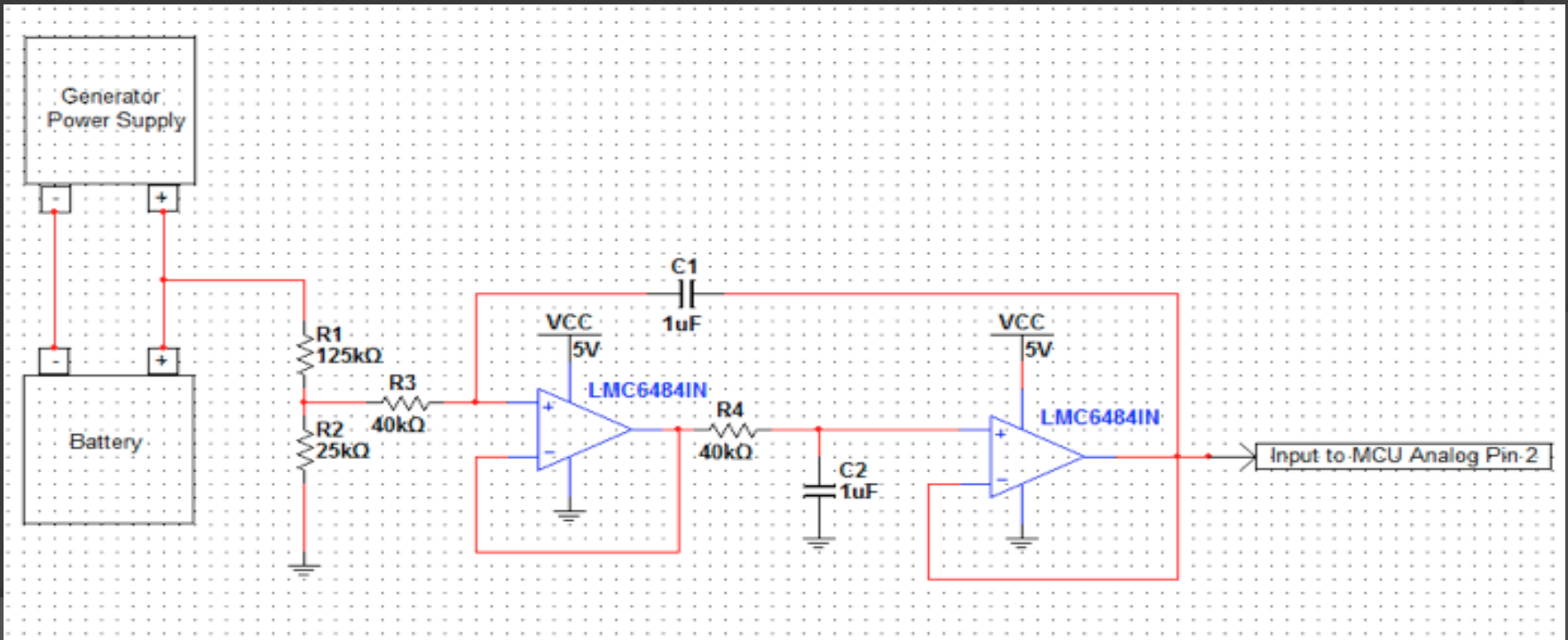


# Positional Control System

- ⦿ Tracking wind direction and speed
- ⦿ Preventing overspinning of turbine rotor
- ⦿ Servomotor

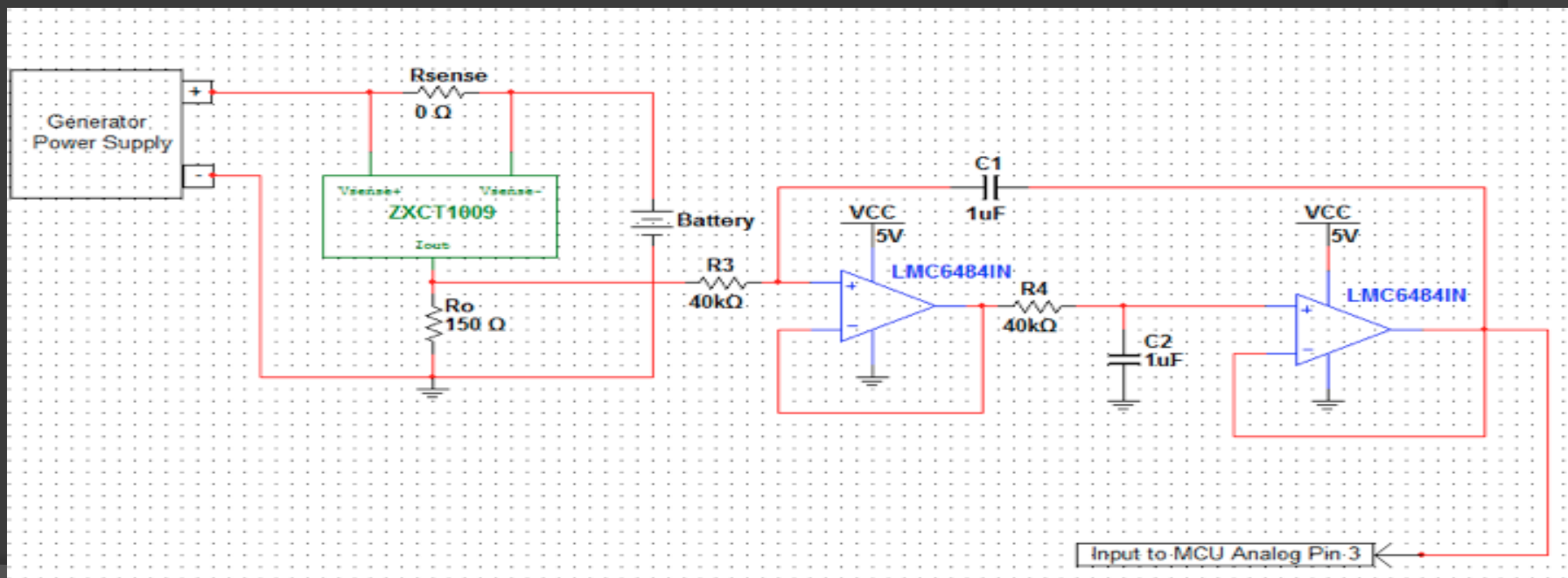
# Voltage Sensor

- Voltage divider circuit
- 2<sup>nd</sup> order Butterworth LPF
- Cutoff frequency of 1 Hz and unity gain



# Current Sensor

- RMCF1/100R zero ohm resistor
- ZXCT1009 high-side current monitor
- 2<sup>nd</sup> order Butterworth LPF
- Cutoff frequency of 1 Hz, unity gain

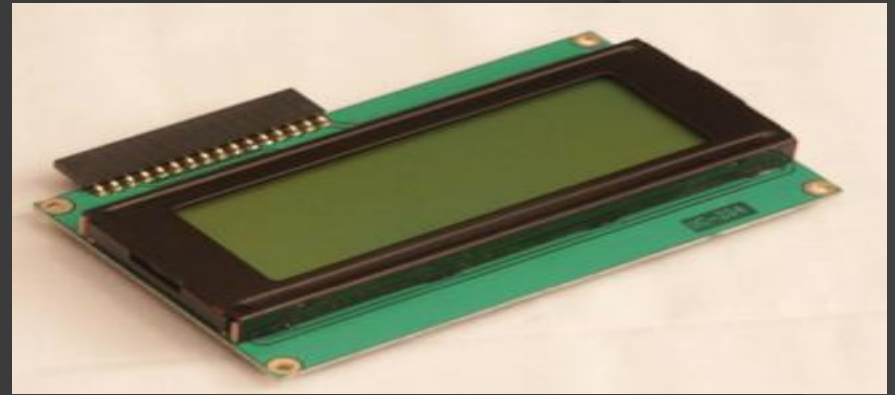




# Data-logging/Display MCU

- Atmega328P
- High performance
- Low power consumption
- 32-lead TQFP
- 20 MHz at 4.5 – 5.5V

# LCD Display



- Hitachi HD44780
- Four lines 20 characters wide
- Low power consumption
- Two main interface modes
  - Four bits of data sent at a time
  - Eight bits of data sent at a time.

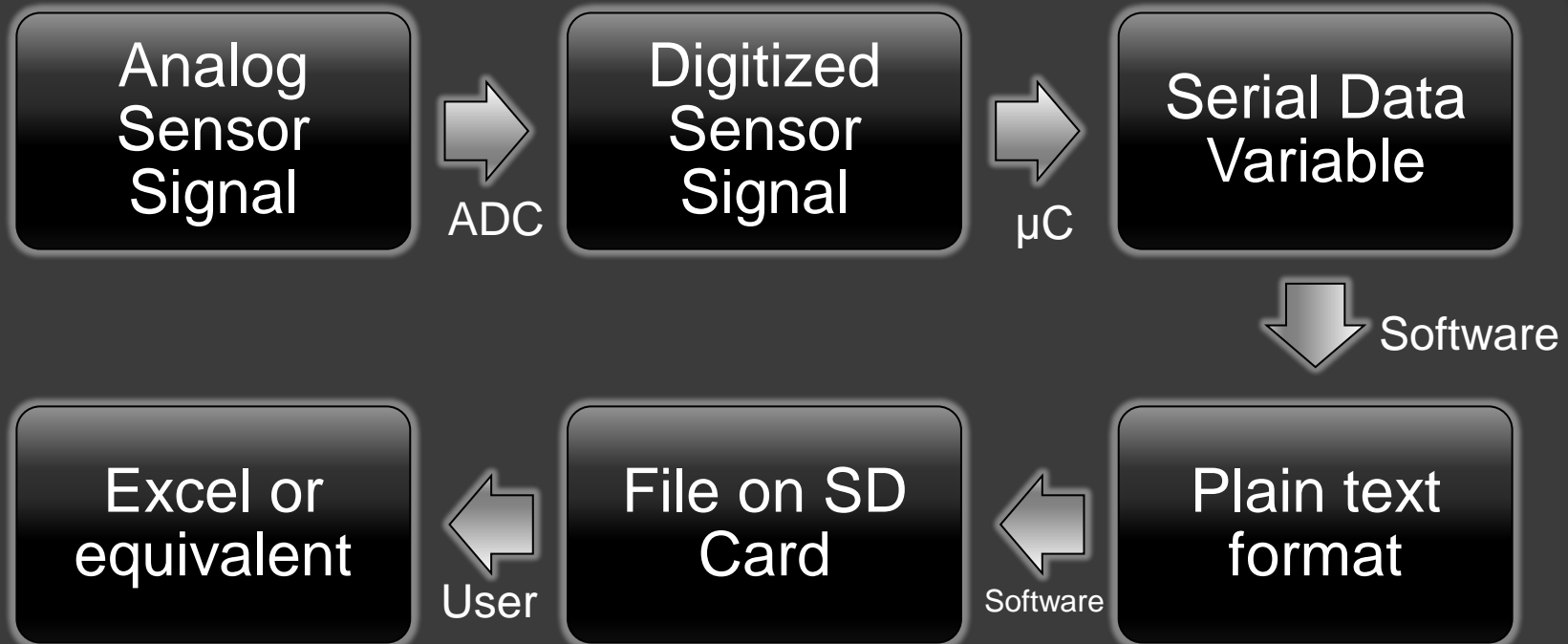
# LCD Display (cont.)

- `void lcd_set_type_data()`
- `void lcd_set_type_command()`
- `void lcd_write_nibble(char c)`
- `void lcd_write_byte(char c)`
- `void lcd_write_data(char c)`
- `void lcd_clear_and_home()`

# PCB Design Software

- ◎ Altium Designer 10
  - Schematic capture
  - PCB layout
  - 3D PCB
  - FPGA development
  - Embedded software
  - Simulation
  - CAM

# Data Logging Subsystem



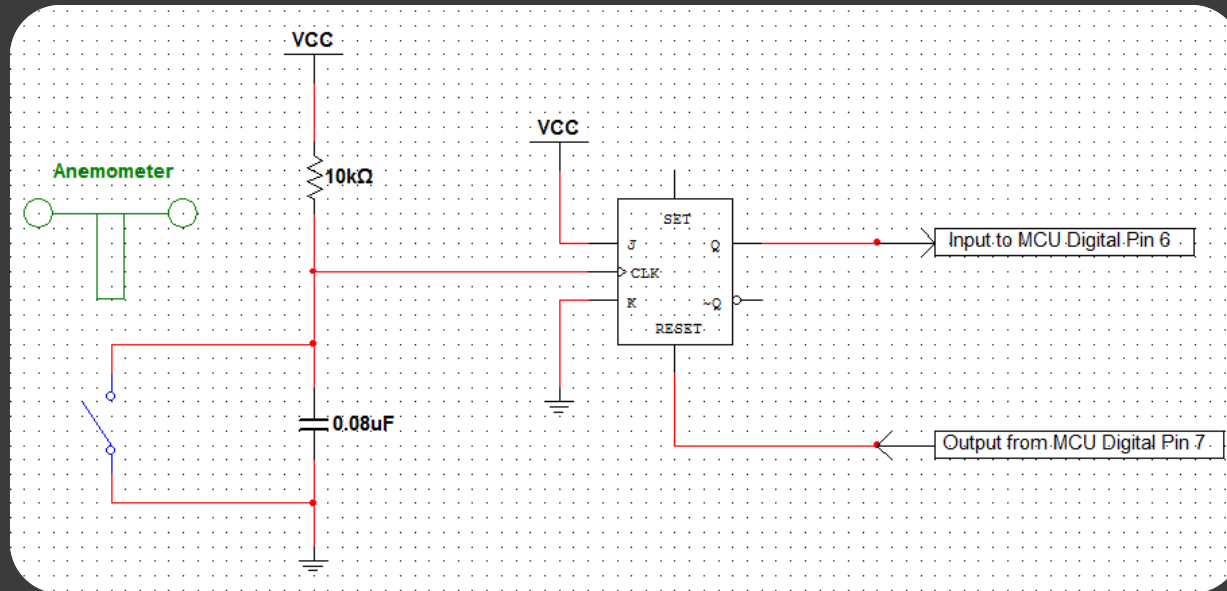
- Analog Inputs: Current & Voltage Sensors, RTC
- Digital Inputs: Wind Speed Sensor, SD

# Wind Speed Sensor

- InSpeed Vortex
  - 3-cup rotor
  - Mounting bracket
  - One pulse per rotation
  - 2.5 mph / Hz
  - 6" x 6" x 10"
  - 1.5 lbs



# Wind Sensor Interface



- Capacitor for de-bounce
- Q defaults to high at each falling clock edge
- $\mu$ C resets flip-flop after each pulse

# Data Logging Design

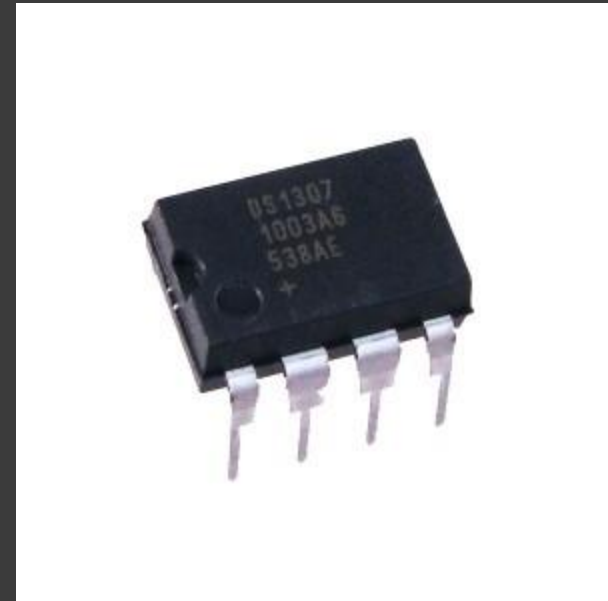
- ⦿ The second Atmel  $\mu$ C will be utilized
  - Arduino bootloader
- ⦿ Begins logging only when SD is inserted
- ⦿ Will log these data in order:
  - The present date (MM/DD/YY)
  - The present time (HH:MM:SS)
  - Wind speed (mph)
  - Current from generator (A)
  - Voltage in battery (V)
  - Delimited by commas

# Data Logging Peripherals

- ◎ SD/MMC Socket
  - Will utilize the open-source SD library
  - Formatted for FAT32
  - Safe Voltage Level: 3.3 V
- ◎ LT1761ES5-3.3
  - Low-Dropout Linear Regulator
  - 5 V supply voltage to 3.3 V
  - Used to prevent damage to the SD

# Data Logging Peripherals

- ⦿ DS1307 Real-time Clock
  - $I^2C$  interface to  $\mu C$
  - BCD Calendar & Clock
  - Internal backup battery
  - Accounts for leap years
- ⦿ Must be interfaced with the Atmel via the correct software libraries

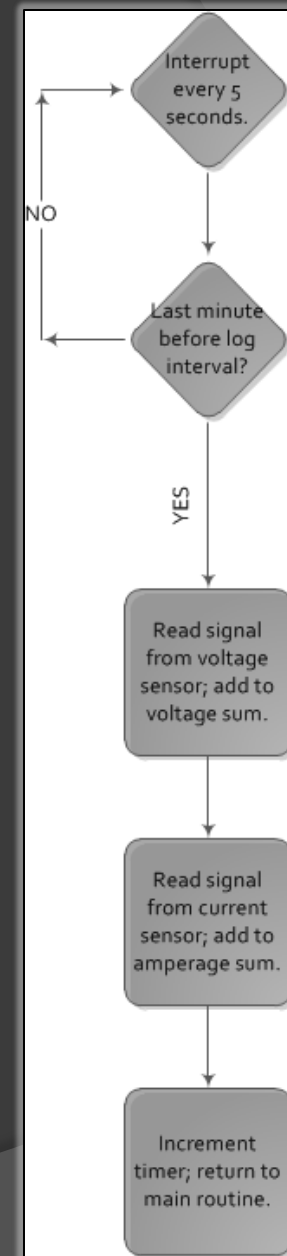
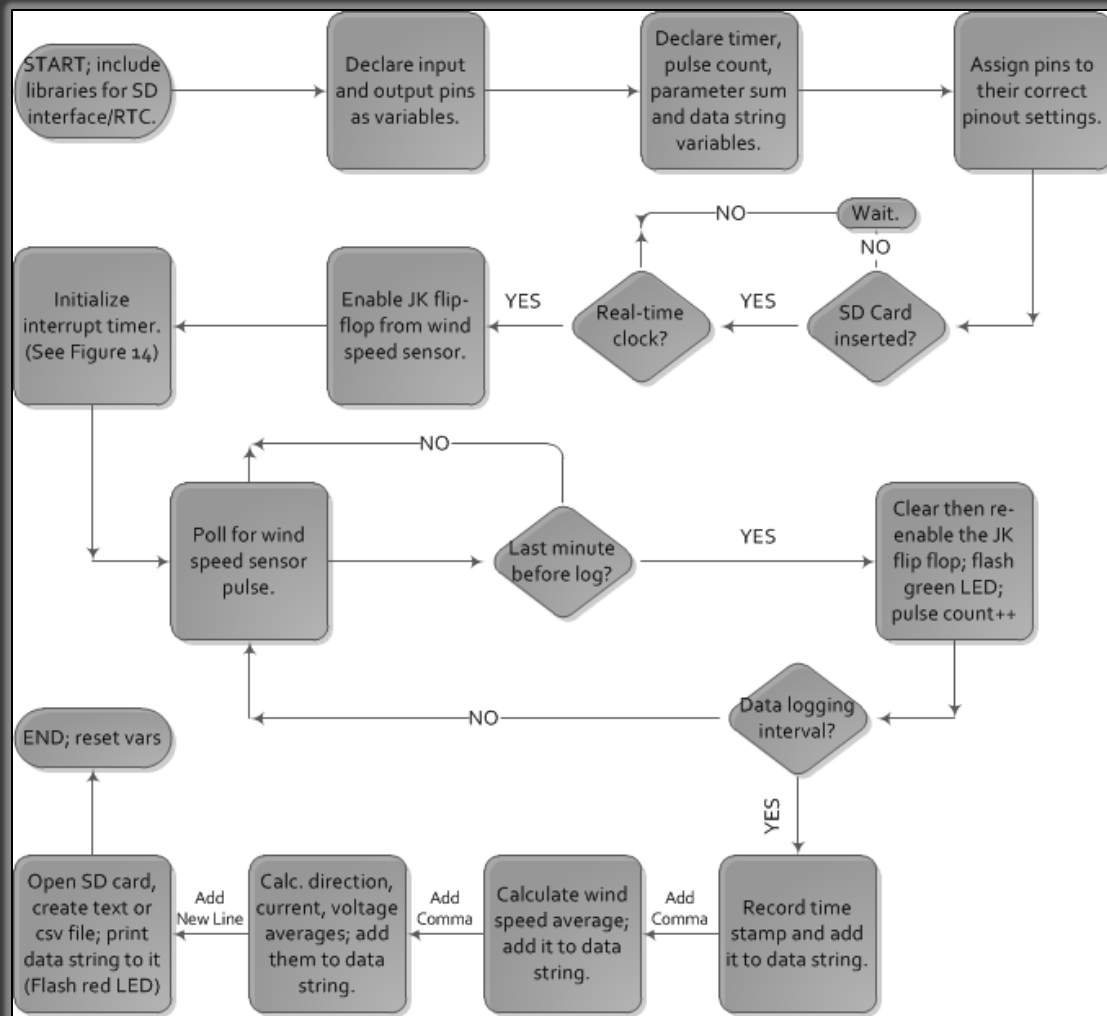


# Data Logging Routine

- ⦿ Interrupt-based
- ⦿ Interrupt subroutine runs at 5-second intervals
  - Takes readings of current and voltage
  - Accumulates over a 1-minute period
- ⦿ Wind speed pulses also counted

| Variable Name | Variable Type | Description   |
|---------------|---------------|---|
| chipSelect    | int           | Hardware chip select for SD card reader                     |
| windSpeedIn   | int           | Hardware pin that reads from wind speed sensor              |
| windSpeedOut  | int           | Pin that resets JK flip-flop on wind speed sensor           |
| currentSignal | int           | Pin that reads from current sensor                          |
| voltageSignal | int           | Pin that reads from voltage sensor                          |
| gLedIn        | int           | Green LED pin   |
| rLedIn        | int           | Red LED pin   |
| logTimer      | int           | Counter until data logging interval                         |
| logInterval   | int           | User-specified data logging interval                        |
| pulseCount    | int           | Counts pulses from wind speed sensor for a minute           |
| checkPin      | int           | Poll windSpeedIn to check if can clear flip-flop            |
| iSum          | longint       | Running sum of raw amperage signal readings from ADC3       |
| vSum          | longint       | Running sum of raw voltage signal readings from ADC2        |
| gLEDStatus    | boolean       | Green LED on or off   |
| rLEDStatus    | boolean       | Red LED on or off   |
| dataString    | string        | Forms plain text output to file on SD                       |
| dateTime      | string        | Time stamp value from RTC chip                              |
| windSpeed     | float         | Sensor constant * (pulseCount / minute )                    |
| iAvg          | float         | Calculated average of current signal readings over a minute |
| vAvg          | float         | Calculated average of voltage signal readings over a minute |

# Data Logging Routine



# Work Distribution

Dwayne

- Wind Turbine
- Charge Controller
- MPPT

Joaquim

- Battery Bank
- Charge Controller
- Sensors

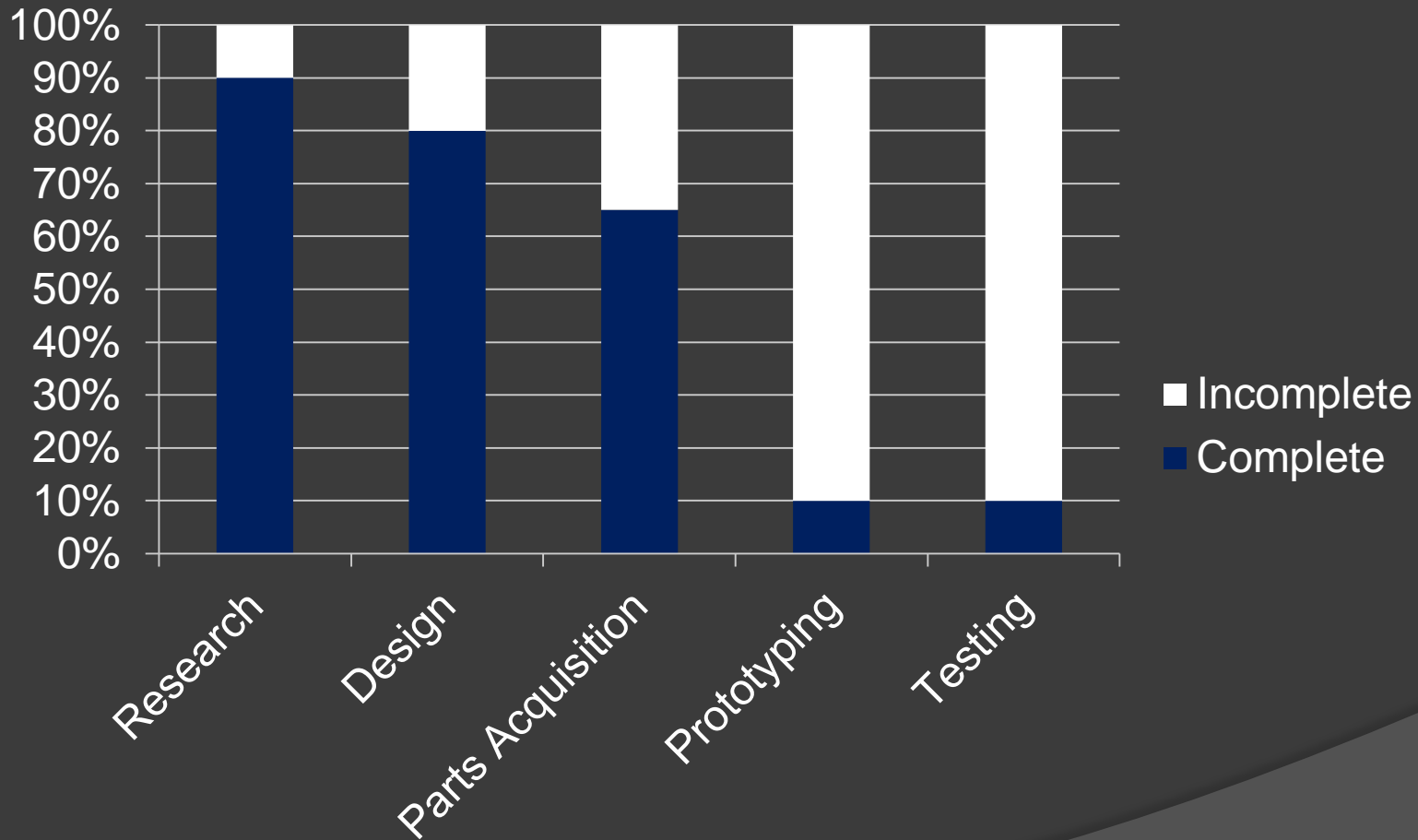
Tim

- Sensors
- Data Logging
- Microcontroller Peripherals

Jose

- PCB Design
- Display
- Regulators

# Progress



# Bill of Materials

| Part              | Quantity | Cost   |
|-------------------|----------|--------|
| TLG 500           | 1        | \$1575 |
| Batteries         | 4        | \$1400 |
| PCB               | 2        | \$100  |
| ATmega328P        | 2        | \$5    |
| Display           | 1        | \$3    |
| Regulators        | 2        | \$10   |
| Wires/Connectors  | -        | \$80   |
| MOSFETs/Drivers   | 7        | \$7    |
| V/I Sensors       | 2        | \$3    |
| Wind Speed Sensor | 1        | \$55   |
| Miscellaneous     | -        | \$150  |
| Total             | -        | \$3388 |
| Initial Budget    | -        | \$4000 |

# Milestones

| <b>Objectives</b> | <b>Date</b> |
|-------------------|-------------|
| Parts Acquisition | 6/15        |
| Assembly          | 6/20        |
| Order PCB         | 6/20        |
| Testing           | 6/27        |

# Complications

- ⦿ High power requirements
- ⦿ Difficulty of real world testing
- ⦿ Heat dissipation

Questions?