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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

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

Design Overview

Rectifiers

Power Diversion

Charge Controller

Microcontroller (MPPT, PWM)

Battery Bank

LCD Display

Microcontroller (Data Logging)

Sensors

SD Card Output

Wind Turbine

- Length: 3’ 6”, Width: 2’ 4”, Diameter: 11”
- Weight: 68lbs

Wind Generator

- TLG 500 Alternator
  - Rated at 500 watts

Wind Speed MPH +/- 2	Amps into Battery Bank +/- 0.5	Battery Voltage +/- 1	Average Watts
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

3 Phase Rectifier

Buck Converter

Battery Bank

PWM

Dummy Load

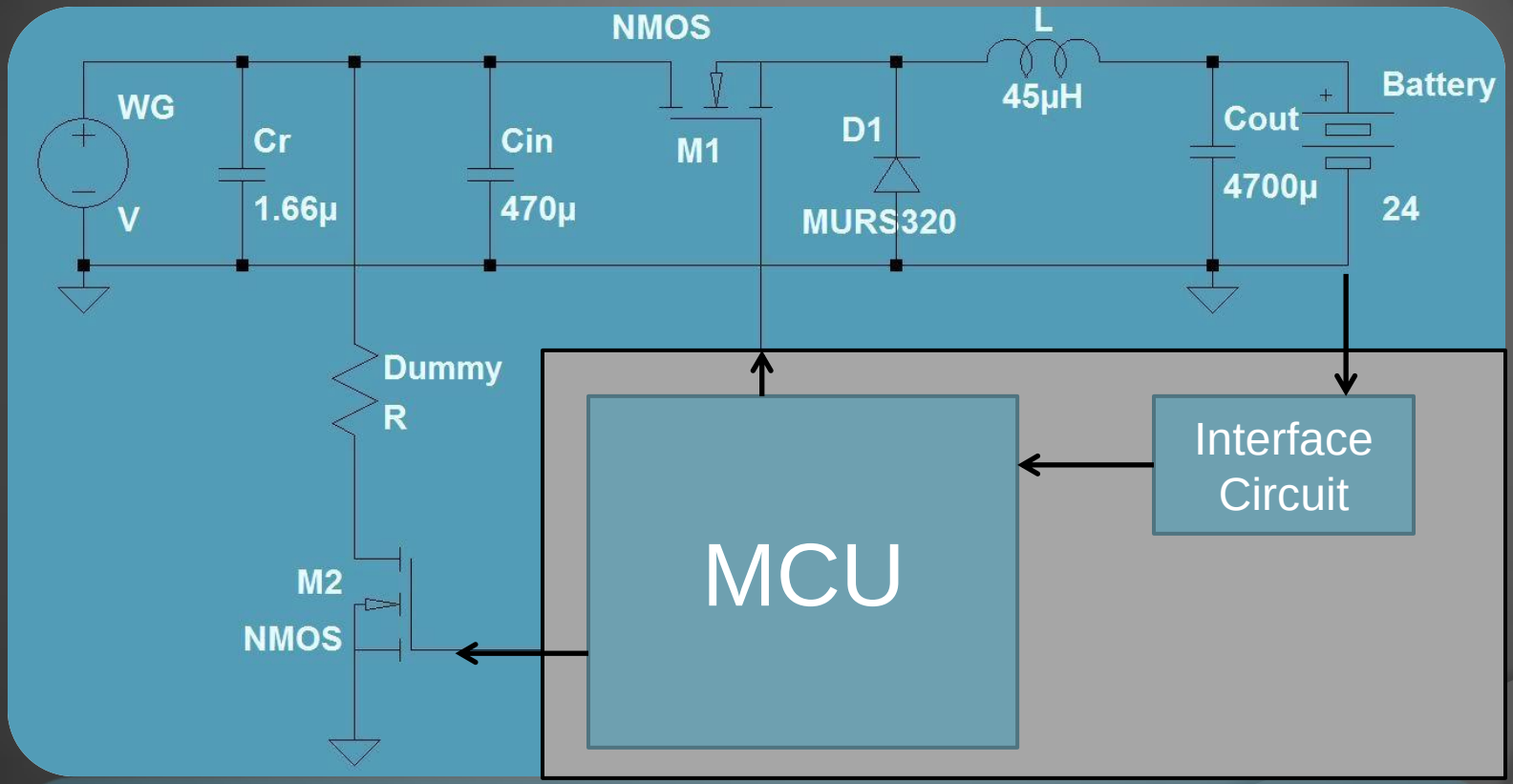
ON/OFF

MOSFET Driver

MCU

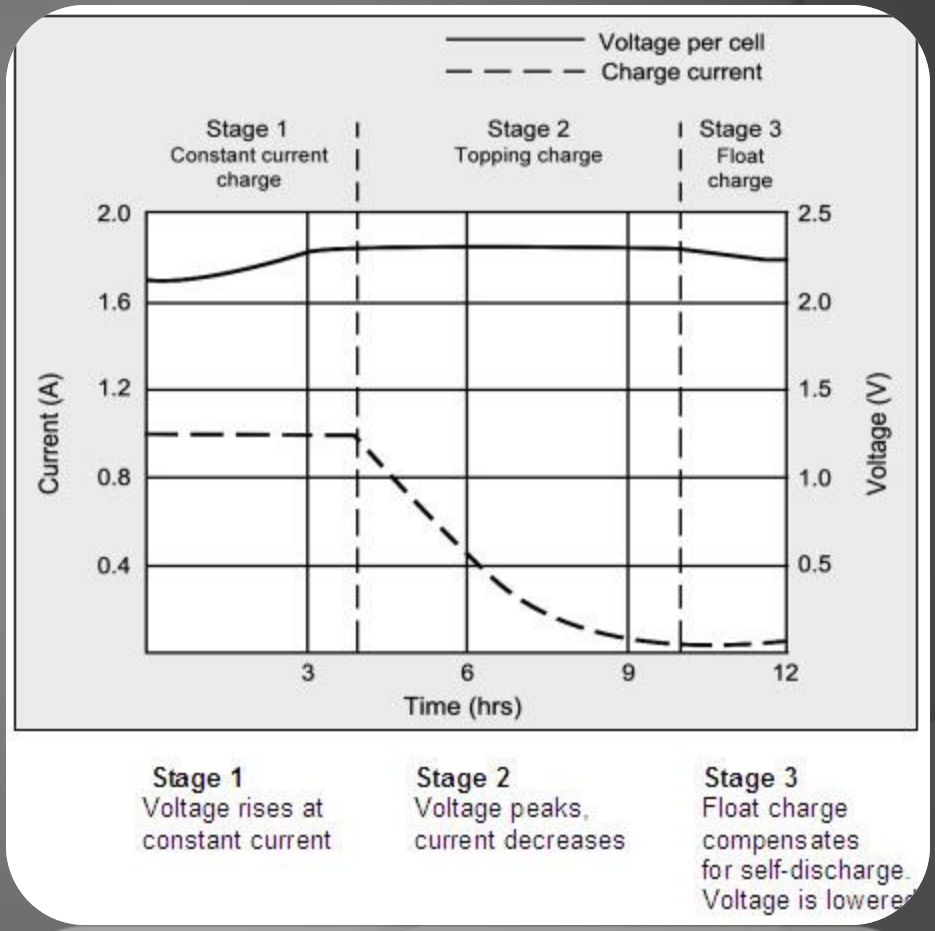
Interface Circuits

Charge Controller Design



Charge Controller Design

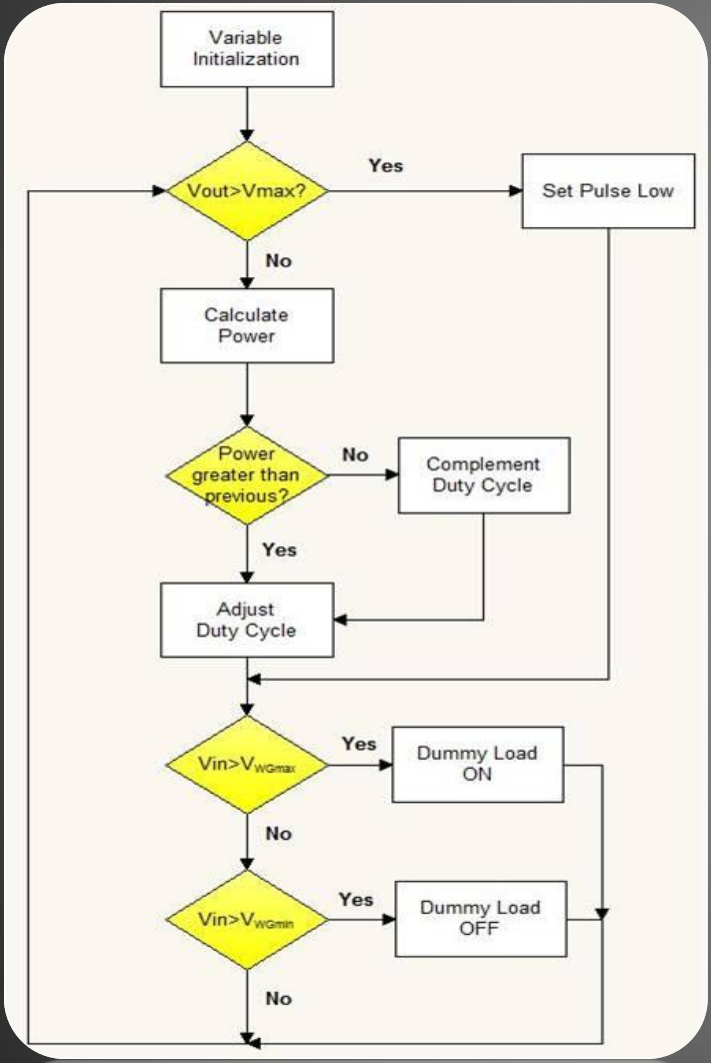
- Charging Stages
  - Bulk charging stage
  - Absorption stage
    - $t = 0.42\frac{C}{I}$
  - Float stage



Maximum Power Point Tracking

- Method
  - Constant current method
- Advantages
  - No knowledge of the wind turbine characteristics
  - No measurement of wind needed

MPPT Flowchart



- Microcontroller-based battery monitoring
- When the battery reaches a set voltage a dummy load is used

MPPT Microcontroller

- Two ATmega328P
  - One used for MPPT algorithm
  - MOSFET drivers
  - PWM duty cycle adjustment
  - Interacts with current and voltage sensors
  - Second MCU used for data logging

MPPT Algorithm

- Vout = a*Vin
  - Vout > Vin
- a = C, N
  - C – Buck and Absorption constant
  - N – Float constant

MOSFET Drivers

- MIC5011
  - Control the MOSFET for dummy load switching
- IR2104
  - Control the PWM duty cycle for the buck converter

Battery Bank

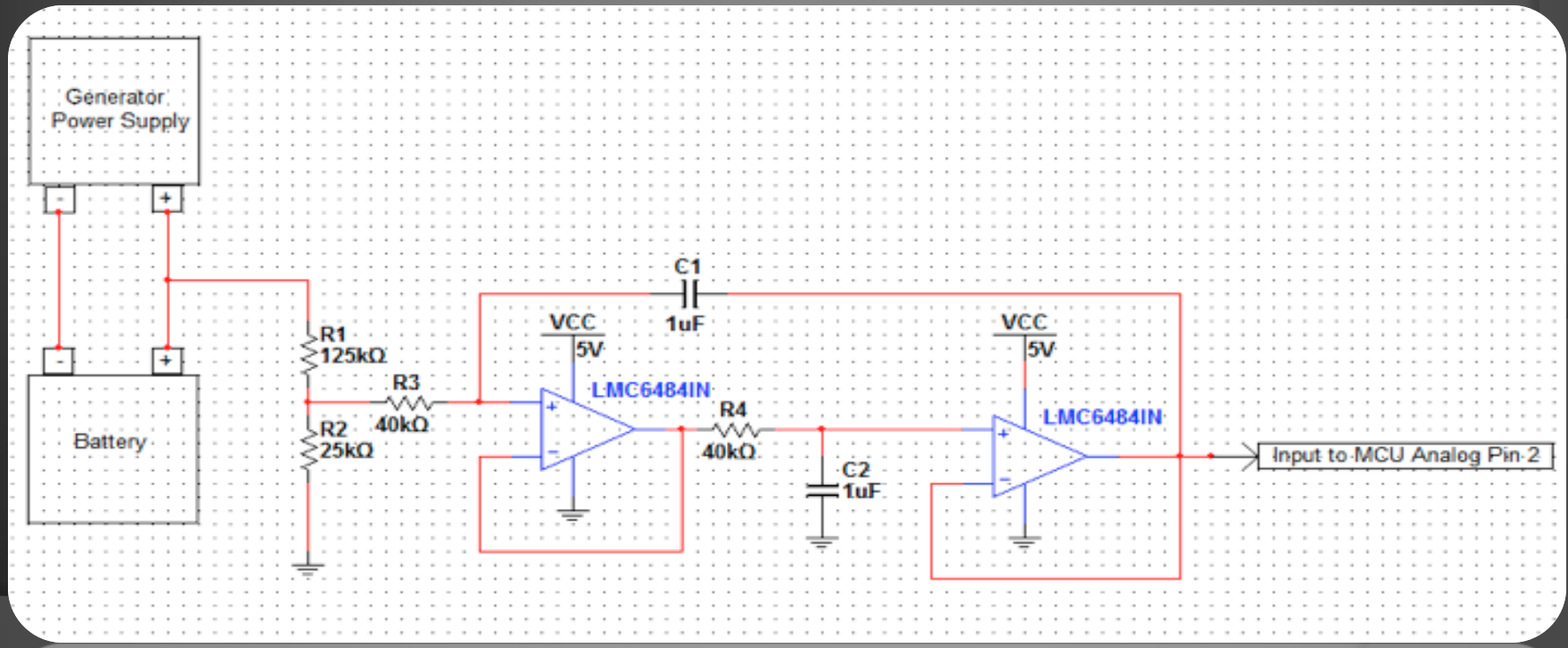
- 12 & 24 Volt battery bank
- Four 6V Lead Acid Flooded in series
- Length: 12”, Width: 7”, Height: 17”
- Weight: 127lbs
- 400Ah

Positional Control System

- Was to be used for:
  - Tracking wind direction and speed
  - Preventing over-spinning of turbine rotor
  - Servomotor
- Ultimately not implemented

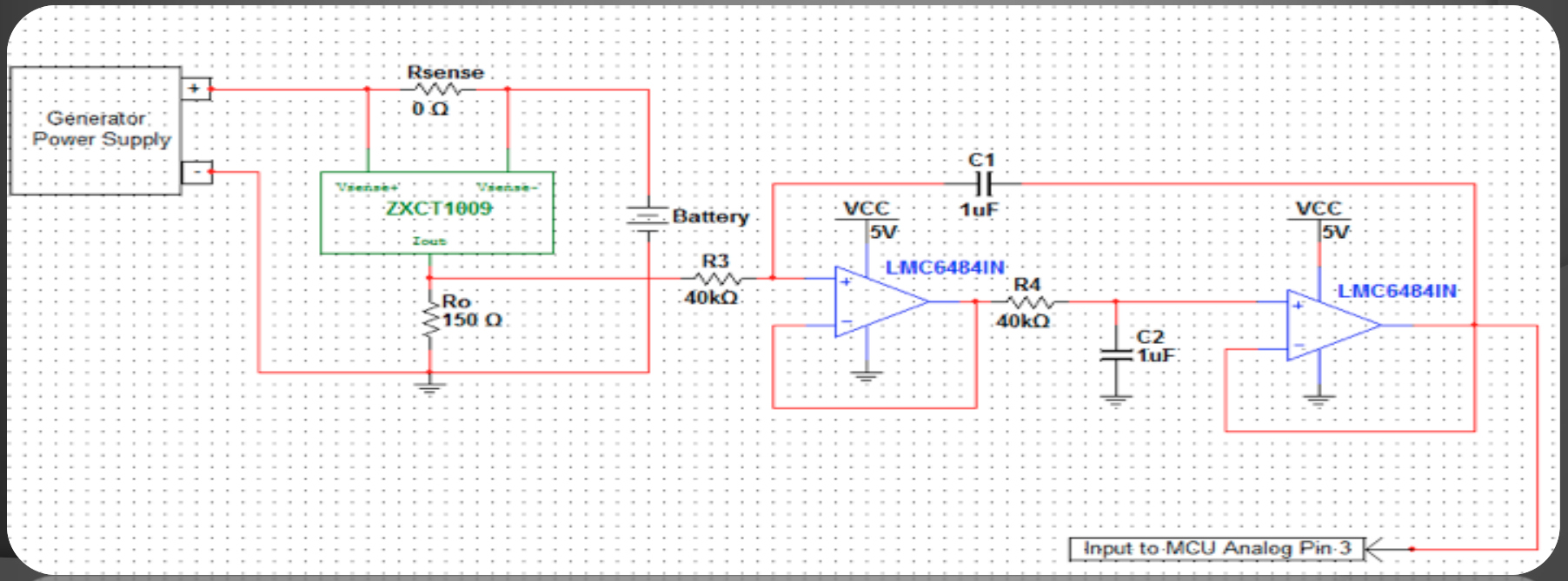
Voltage Sensor

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



Current Sensor

- LOB-5 0.01 Ohm Resistor
- 2nd order Butterworth LPF
- Cutoff frequency of 1 Hz, unity gain

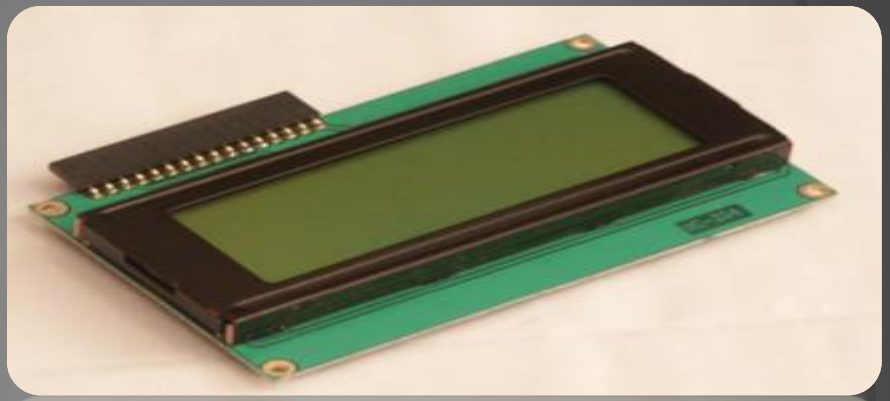


Data Logging MCU

- Atmega328P
- High performance
- Low power consumption
- 28-lead PDIP
- 16 MHz at 4.5 – 5.5V

LCD Module

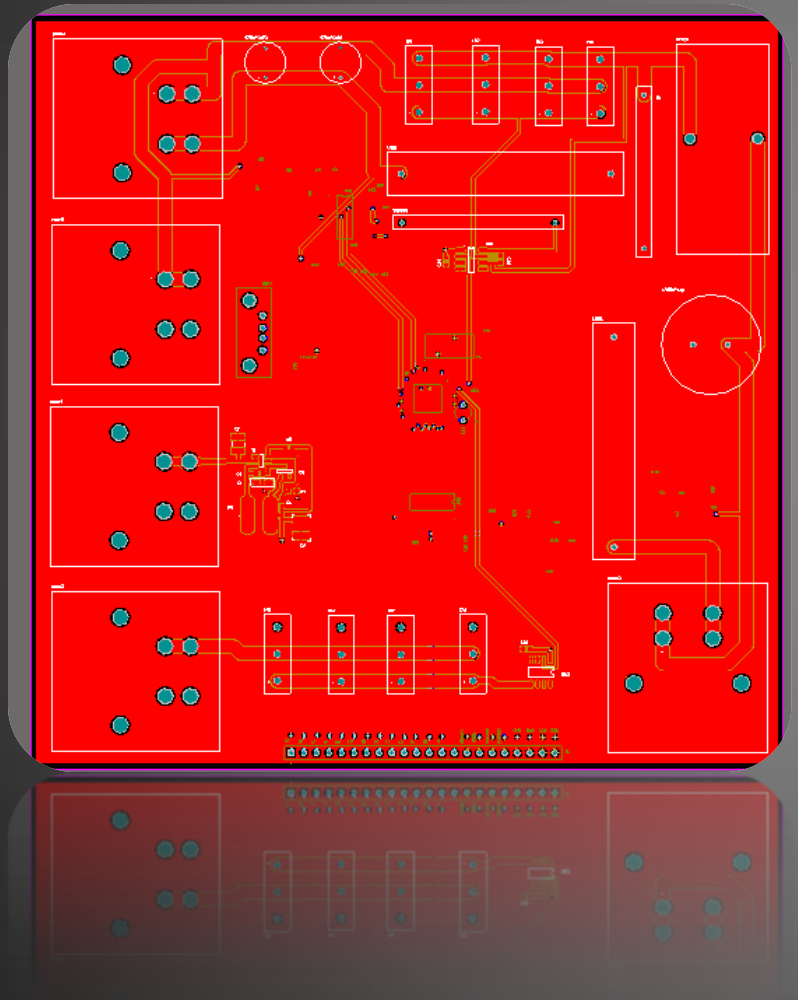
- Hitachi HD44780
- Four lines 20 characters wide
- Low power consumption
- Two main interface modes
  - Four bits of data sent at a time
  - Eight bits of data sent at a time.



PCB Design Software

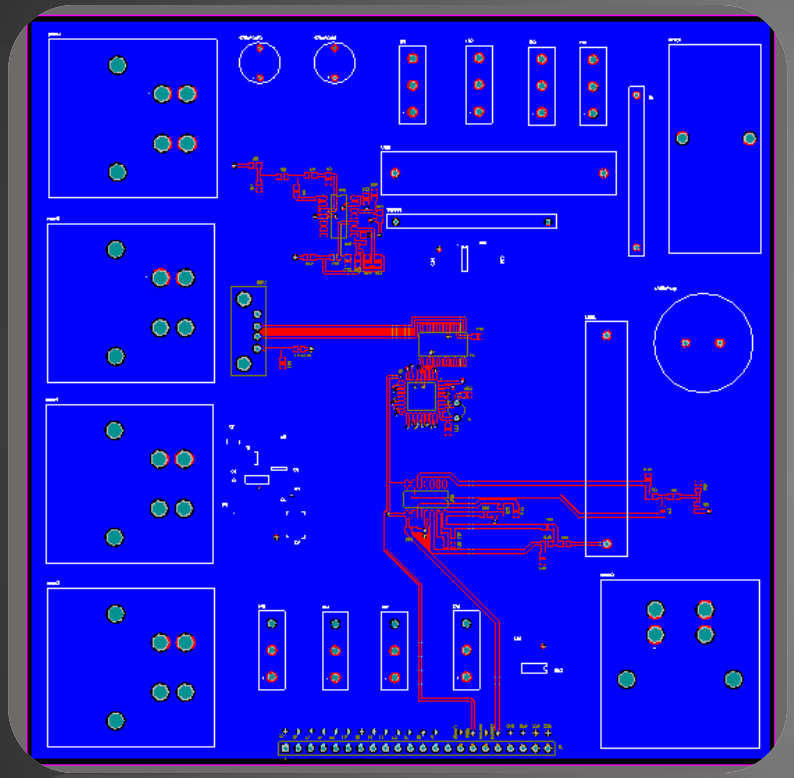
- Altium Designer 10
  - Schematic capture
  - PCB layout
  - 3D PCB
  - FPGA development
  - Embedded software
  - Simulation
  - CAM

Initial PCB Layout



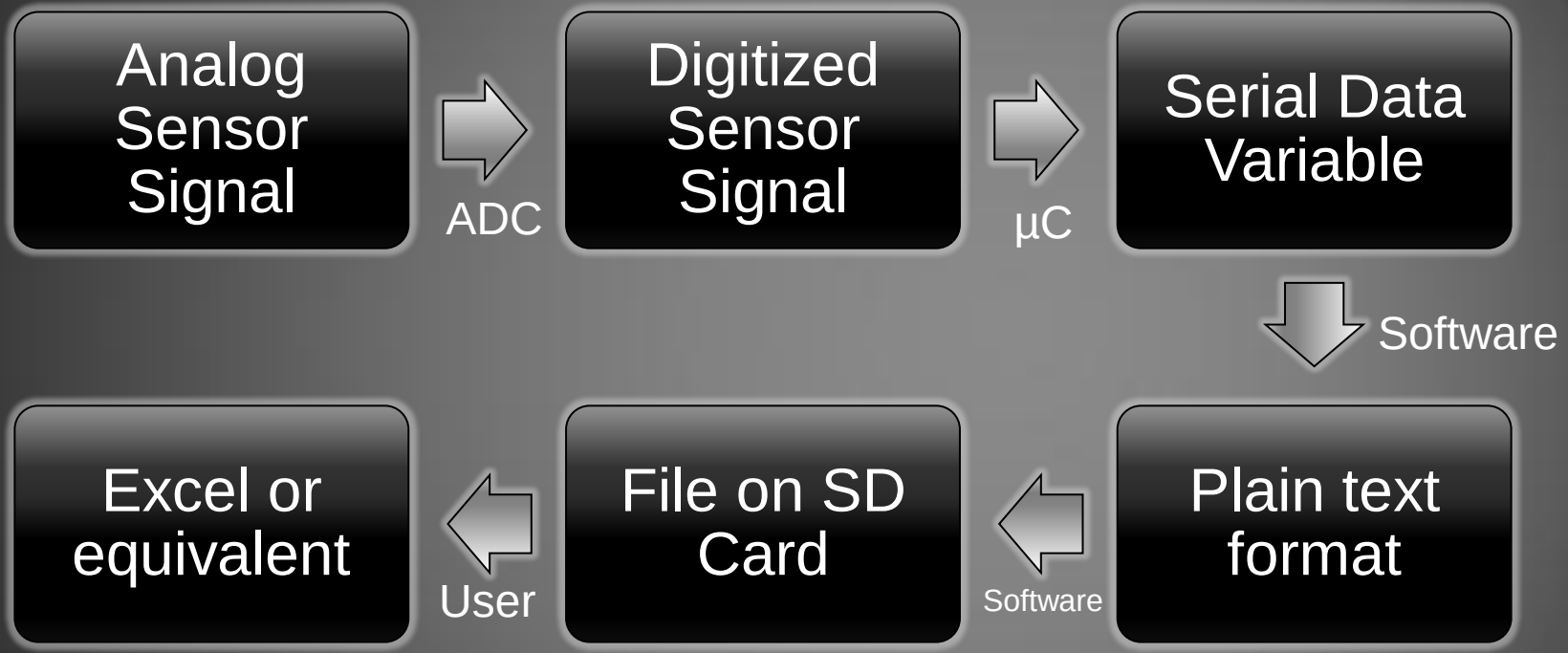
- Top layer: High power elements, MOSFETs, and connectors
- 6 in. x 6 in.
- 4 oz. Copper traces

Initial PCB Layout (contd.)



- Bottom Layer: Sensing circuits, filters, interface circuits
- Atmel microcontroller in middle

Data Logging Subsystem

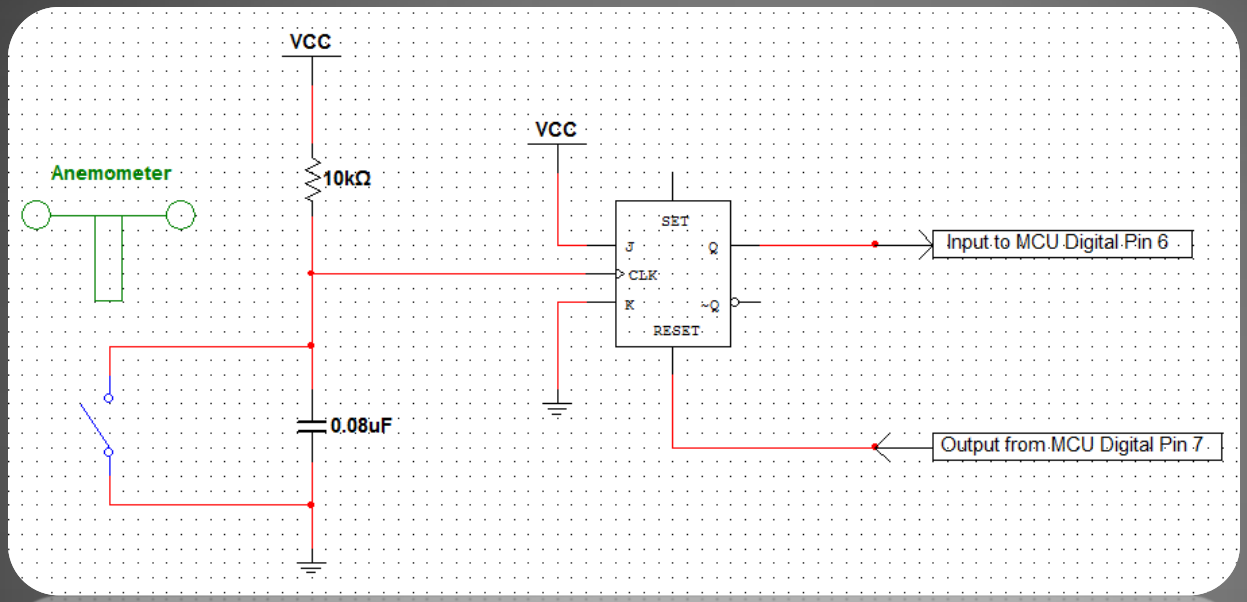


- Analog Inputs: Current & Voltage Sensors, RTC
- Digital Inputs: Wind Speed Sensor, SD

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 & pull-up resistor for debounce
- Q defaults to high at each falling clock edge
- µC resets flip-flop after each pulse

Data Logging Design

- The second Atmel µC 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
- MCP-1700-330
  - Low-Dropout Linear Regulator
  - 5 V supply voltage to 3.3 V
  - Used to prevent damage to the SD
  - Level Shifter used to switch between 5 and 3.3 volt power supplies

Data Logging Peripherals

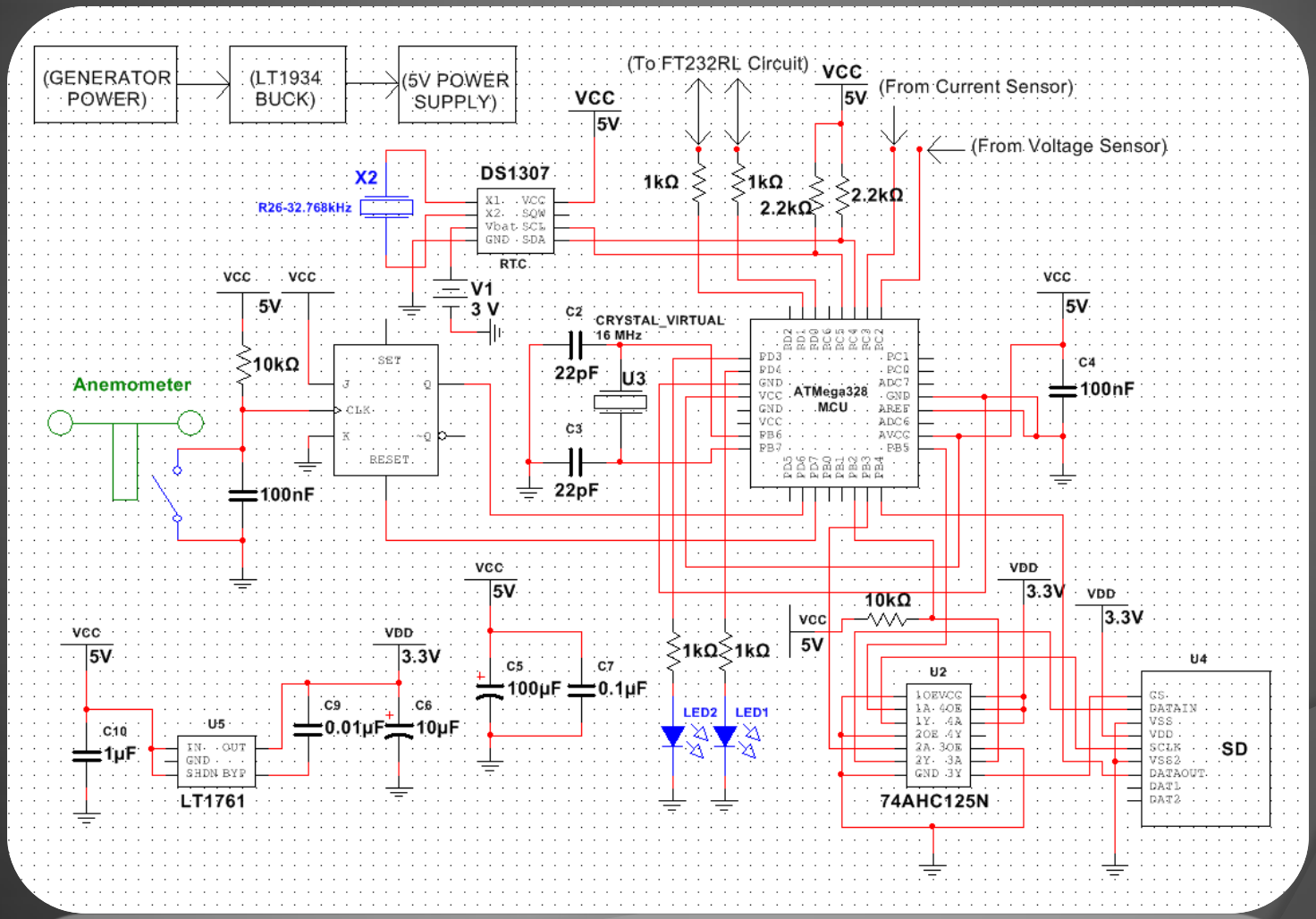
- DS1307 Real-time Clock
  - I^2C interface to µC
  - BCD Calendar & Clock
  - Internal backup battery
  - Accounts for leap years
- Must be interfaced with the Atmel via the correct software libraries

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 Circuit



Work Distribution

Dwayne
- Wind Turbine
- Buck Converter
- Battery Bank

Joaquim
- MPPT Algorithm
- Charge Controller
- MOSFETs

Tim
- Wind Sensor
- Data Logging Routine
- Microcontroller Peripherals

Jose
- PCB Design
- Display
- Sensing Circuits

Bill of Materials

Part	Quantity	Cost
TLG 500	1	$1575
Batteries	4	$1400
PCB	2	$120*
ATmega328P	2	$5
Display	1	$3
Regulators	2	$10
Wires/Connectors	-	$80
MOSFETs/Drivers	7	$7
V/I Sensors	4	$6
Wind Speed Sensor	1	$55
Misc. (Inductor, etc.)	-	$250
Total	-	$3511
Initial Budget	-	$4000

Complications

- High power requirements
- Difficulty of real world testing
- Heat dissipation
- Budget Concerns

Questions?

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Part #: SeniorD	Revision:	Date: 7/27/2012	Quote #: 3285771
Customer Name: UCF			

CUSTOM SPEC Price Matrix:

1. The Custom Spec Matrix reflects pricing for the EXACT SPECS you QUOTED .
2. All files receive full CAM review and inspection to IPC-A-600G, Class 2 or 3 standards based on customer request and quote.
3. INCLUDES UL markings and date codes. 94V-0 is added if requested at time of order entry or if noted in files. Finished hole tolerance +/- .003" (if requested). Unit price does not include shipping and handling. AC Terms and Conditions apply.

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Qty	Same Day	1-day	2-day	3-day	4-day	1-week	2-week	3-week	4-week
1	N/A	$3,611.26	$2,041.76	$1,649.39	$1,413.96	$1,335.49	$1,178.54	$1,021.59	$864.64
2	N/A	$1,840.40	$1,042.66	$843.23	$723.56	$683.68	$603.90	$524.13	$444.36
5	N/A	$777.88	$443.20	$359.53	$309.33	$292.59	$259.13	$225.66	$192.19
8	N/A	$513.35	$294.44	$239.71	$206.87	$195.92	$174.03	$152.14	$130.25

Tooling NRE = $300.00 (Tooling waived when re-ordered) Testing = $358.00

Part #	SeniorD	Revision #		Layer count	4
X Dimension	6	Y Dimension	6	Array	☐