USB-Based Data Acquisition System for Current and Temperature Monitoring of DC Motor

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Motivation

- Overheating is one of the most common cause of failure in DC motors. It can lead to bearings failure (motor jam), winding-isolation (short-circuit), and degradation of the magnets.
- The amount of current drawn and the temperature generated by DC motor are crucial in understanding the performance and reliability of motors.
- Provide a low cost and effective tool for measuring the amount of current drawn and heat generated by DC motors.

Goals

- Provide a cost effective mechanism for acquiring temperature and current data.
- Allow the operator to determine when to perform preventive maintenance.
- Record the temperature and current data to a host computer.
- Display current and temperature data on LCD
- Design a compact, portable, and user friendly system.

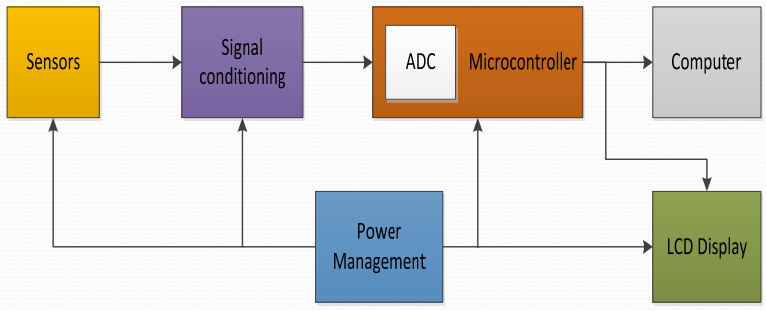
Functional Requirements

- Measure the heat (temperature) generated by the motor.
- Measure the amount of current drawn by the motor.
- Record temperature and current data to a host computer for later analysis.
- Display current and temperature data on LCD display.

Specification

- Measured temperature shall be in the range of 0 to 300 degrees Fahrenheit.
- Measured current shall be in the range of 1 to 15 A.
- The temperature accuracy shall be within +-2 degrees Fahrenheit.
- The current accuracy shall be within +-100 mA
- Both temperature and current should be transmitted to a host computer every 60 seconds.
- The operating temperature shall be between 0 and 100 degrees Fahrenheit.
- The system shall not exceed 4 lbs.

System Block Diagram



Subsystems

- Sensors module
- Power supply module
- Microcontroller module
- Data display module
- Data storage module
- Signal conditioning module

Sensors Selection Criteria

- Transfer function must be linear
- Response time must less than 100 ms
- Must have great accuracy
- Noise level must be less than 100 mV
- Dynamic range must be between 0 A and 15 A
- Must be easy to use

TLS 15-NP Current Sensor

- Type: Hall Effect
- Maximum measure current: 15 A
- Supply voltage: 5V
- Supply current: 1.6 mA
- Output type: voltage
- Response time: <100 ns
- Sensitivity: 41.6 mV/A

TLS 15-NP

CSLA2CD Current Sensor

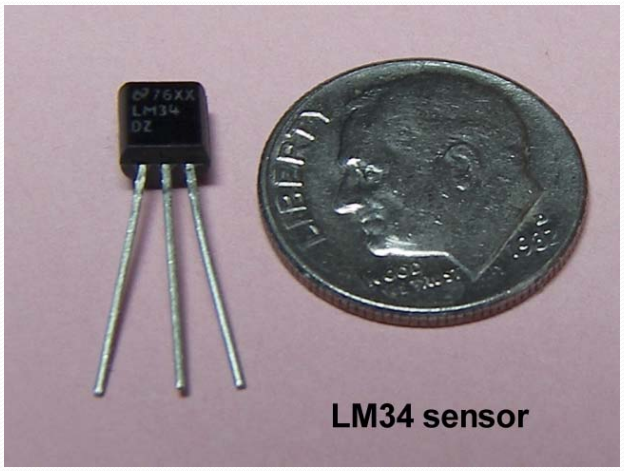
- Type: Hall Effect
- Max Current: 72 A
- Supply Current: 10 uA
- Supply Voltage: 8V – 13.2V
- Output type: Voltage
- Response Time: 3us
- Sensitivity: 32.7 mV/A

CSLA2CD Sensor

Sensors (Continued)

- Temperature Sensor (LM34)
  - Internally calibrated
  - Linear Output: 10mV/Degree Fahrenheit
  - Supply Voltage: 5V to 30V
  - Supply Current: 75 uA
  - Response Time: 750 mS
  - Measurement Range: -50 to 300 Degrees Fahrenheit
  - Accuracy: +-2 Degrees

LM34 Sensor



DS1820

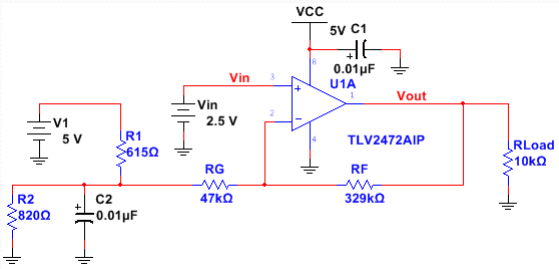
- Dynamic range: -67 to 257
- Accuracy: 0.5 degrees Fahrenheit
- Resolution: 10 bits
- Cost: $6.00

DS1820

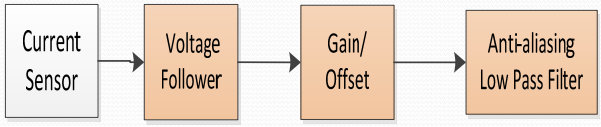
Op Amp Selection

- LM 741
  - Dual power supply
  - Well balanced
  - Easy to use
- CMP601
  - Single supply
  - Requires virtual ground
  - Hard to design

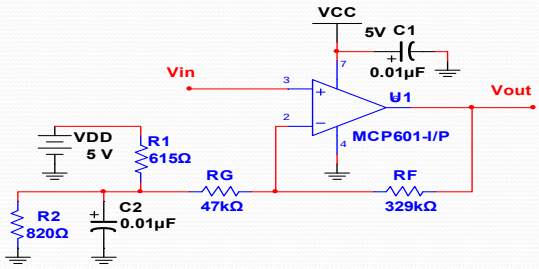
Single Supply Op Amp



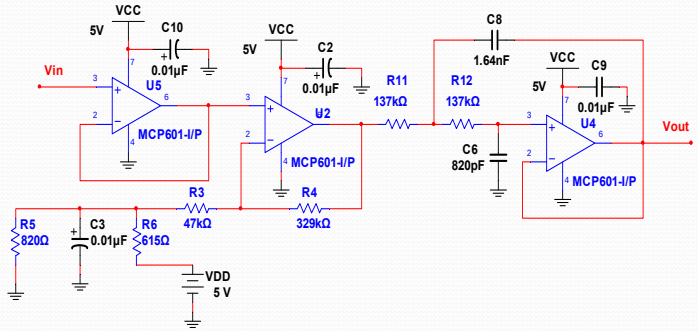
Signal Conditioning Module



Temperature Sensor Signal Conditioning Circuit



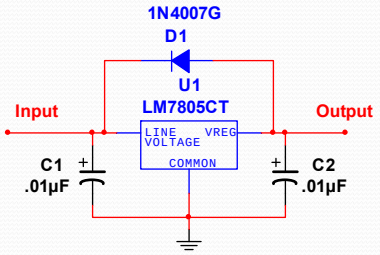
Current Sensor Signal Conditioning Circuit



Power Supply

- Wall adapter
  - Input: 110V – 125V
  - Output: 12V
  - Current: 1A
- Regulator
  - Type: LM7805
  - Voltage: 5V
  - Current: 1A

Power Supply Schematic

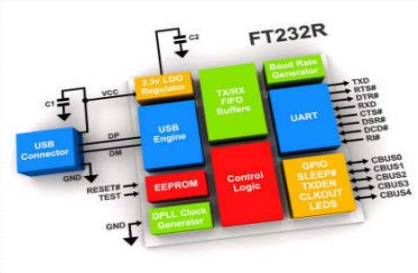


USB Communication Module

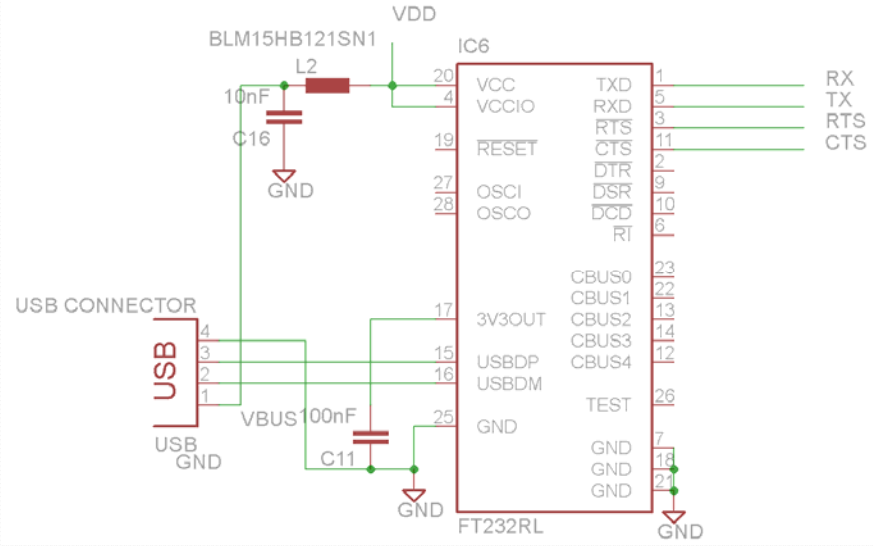
- FT232R Controller
  - Provides communication channel between the MCU and the host computer.
  - Converts USB port to Virtual COM port in the host computer.
  - Manages enumeration and other USB bus communication requirements in hardware.
  - No USB specific firmware required.
  - Supports Bus-powered and Self-powered.
  - USB 2.0 full-speed compatible.

USB Controller (continued)

- Operating temperature: -40 to 85 degrees C.
- Supply voltage: 1.8V to 5.25V.
- Supply current: 15mA
- Data transfer: 300 baud to 3 Mbaud.



USB Controller Schematic

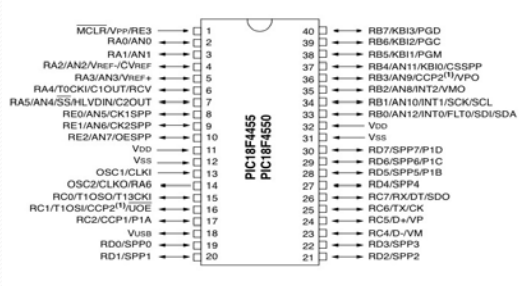


Microcontroller

- PIC18F4550
  - Analog-to-digital conversion (ADC)
  - Process temperature and current data.
  - Transfers temperature and current data to the host computer.
  - Display temperature and current data on LCD display.

Microcontroller

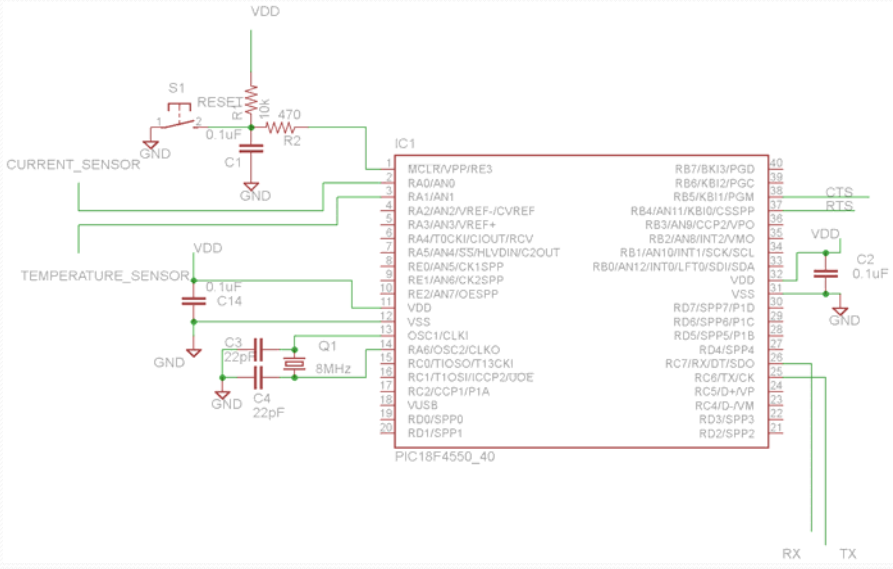
- Communication With USB Controller
- Communication With DAC
- Communication with LCD display



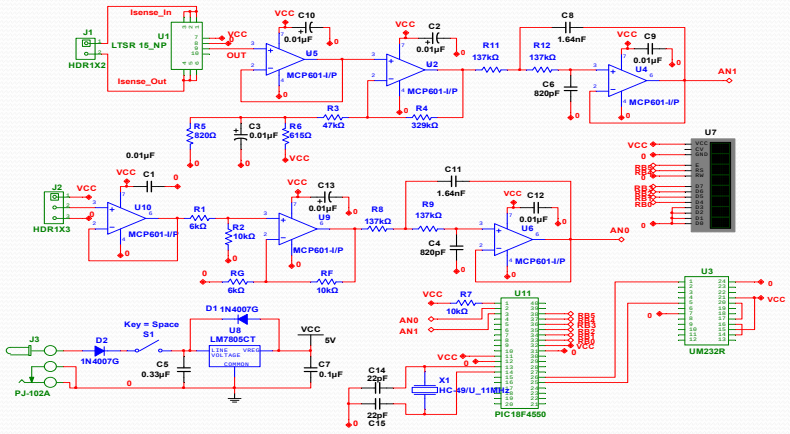
Microcontroller (continued)

- Supply voltage: 2V to 5.5V
- Supply current: 5.8 uA
- Sink/source current: 25mA
- Clock: Internal and external oscillator.
- Timers: 4
- ADC resolution: 10-bit
- Analog channels: 13
- Interrupt sources: 20

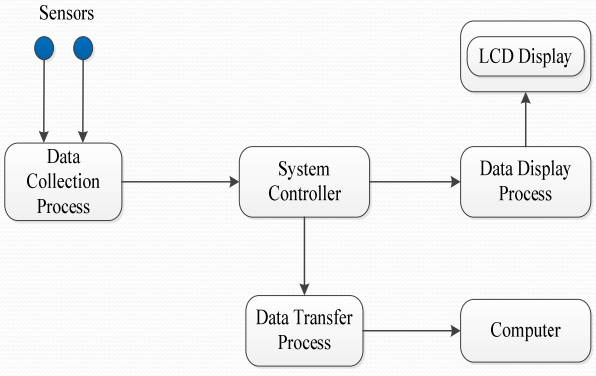
Microcontroller Schematic



System Integration



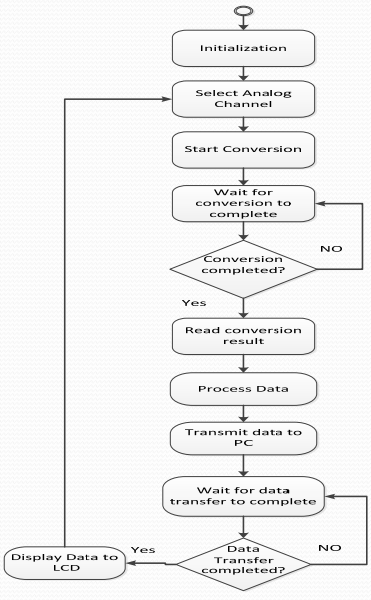
Software Architecture



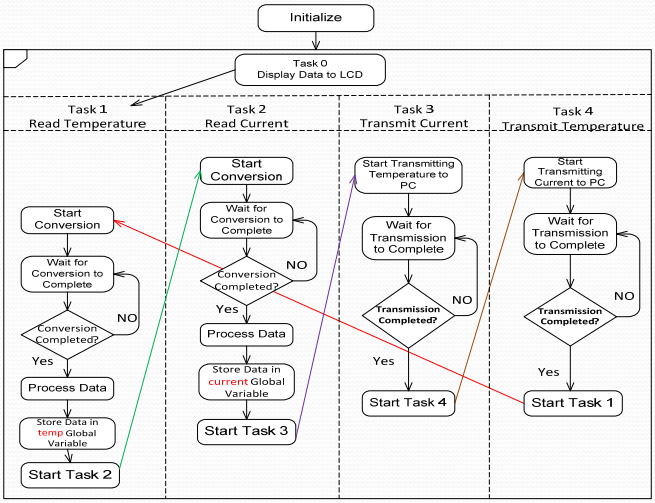
Software: Microcontroller

- Programming language: C
- Program
  - Initialization
    - Configure ports
    - Configure ADC
    - Configure USART
  - ADC Conversion
    - Reads data from analog channels
    - Format data
  - Data transfer/display
    - Transfer data to the host computer
    - Display data on LCD display

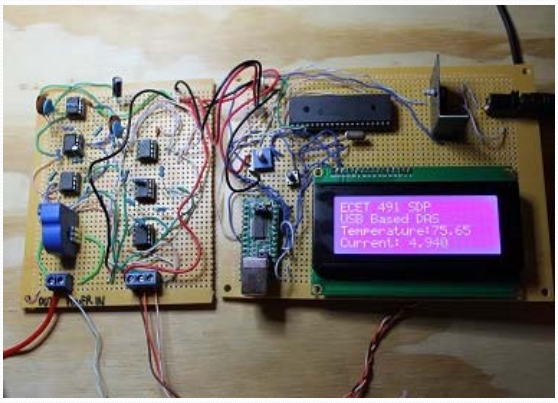
Algorithm: Microcontroller



Statechart



Testing and Validation



Testing and Validation

Cost and Resource Management

Part Name	Quantity	Price Per Unit	Total Cost	Actual Amount of Money Spent
MCP601 Op Amp	6	$0.60	$3.60	$3.60
TLS 15-NP Current Sensor	1	$17.00	$17.00	$17.00
LM34DZ Temperature sensor	1	$6.60	$6.66	$6.60
Resistors	17	$12.00(per kit)	$12.00	$0.00 (Had it)
Capacitors	15	$9.00 (per kit)	$9.00	$0.00 (Had it)
UM232R USB-to-UART Converter	1	$11.00	$11.00	$21.00
PIC18F4550	1	$6.90	$6.90	$0.00(Had it)
Terminal Blocks	2	$1.00	$2.00	$0.00 (removed from power supply)
Barrel power Jack	1	$3.00	$3.00	$0.00 (removed from an old router)
Diode	2	$6.00 (per kit)	$12.00	$0.00 (purchased two years ago)
Oscillator	1	$4.00	$4.00	$0.00 (Had the part in my tool box)
Total			$97.16	$48.20

Risks

- The microcontroller not sending data to PC
- The temperature sensor not being attached to the motor

Lesson Learned

- Project management
  - Planning is key to a successful project
  - Always buy extra components in case one get damaged
- Gained valuable experience in analog signal conditioning
- Gained experience programming PIC microcontroller

Conclusion

- All features of the USB Based Data Acquisition System were successfully implemented
- The cost of designing the UBS Based Data Acquisition System was well bellow $100
- Did not have enough time to focus on the project as given my work related responsibilities
- Overall, this was a very rewarding experience

Thank you.

Questions?