Project Plan

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Logging DC Wattmeter

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Need Statement

Power consumption has become an important issue in designing electronic devices. When designing analog circuits and precise devices, people always need to measure the DC power consumed on those devices accurately. Most of the traditional analog wattmeter measure the power based on Electrodynamics. This kind of wattmeter has good performance in larger power measurement. However, the traditional analog wattmeter has a significant error in measuring the contemporary electronic devices because most of these devices are running on DC with small power consumption. In addition, since the traditional analog wattmeter works based on electrodynamics, it is easy to be disturbed by an external magnetic field. Our project is aimed at developing a prototype of digital DC wattmeter working based on the microcontroller to accurately measure the power consumed by other devices running on DC. This device will be used for measurement the power usage of any electronic device in a vehicle, the output of solar arrays overtime, or charging devices like cell phones/pads/laptops.

Concept Sketch

According to the project goal, this device will be connected between a DC supply and a load. The basic sketch is shown in the Figure 1.

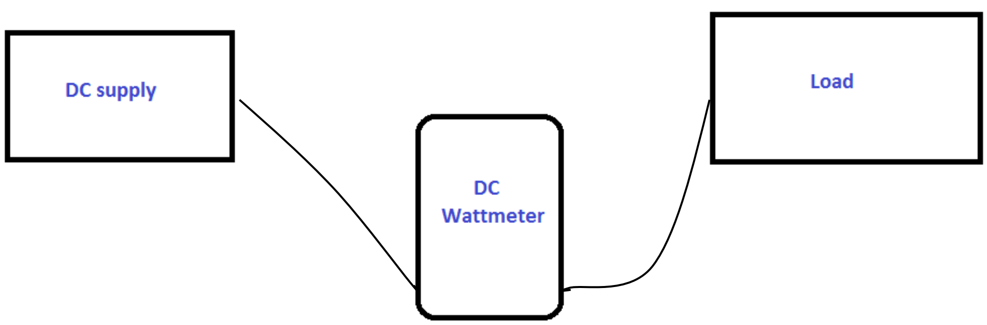

Figure 1: basic running sketch

System Description

The system block diagram is shown in Figure 2. Since the device is connect in serious between DC supply and load, our design should satisfy that the watt meter cannot disturb the normal power consumption of the load. In other words, we need to measure the output port voltage and current rather than the input port.

Block diagram

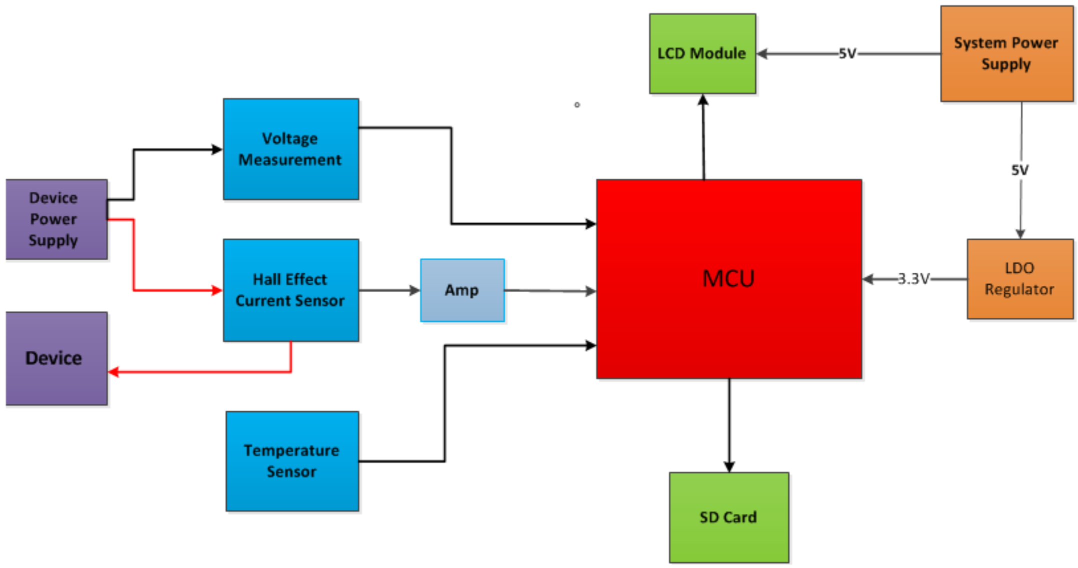

Figure 2: System Block Diagram

Operating System

This device is designed for accurately measuring the power consumed by other devices running on DC. So the device will be used as a measurement instrument widely. In order to make this device more versatile, designer needs to give a larger input/output voltage range and current range to the system. The following is the designed operating environment of the DC wattmeter.

- input/output DC voltage : Minimum value 1V , Maximum 24V
- current measurement range: Minimum value 0.5 mA, Maximum value 3A
- logging time(interval): Minimum value 100ms, Maximum value 10 min

In addition, all the measurement data will be stored to SD card automatically.

User Interface Description

Users can read the measurement result directly from the LCD screen. On the LCD screen, there will be instantaneous current, voltage, power and temperature on the screen. The user can also set the logging time by the push buttons. The logging time can be set between 100ms to 10min. In addition, SD card will be used to store all the measurement data. Once turning on the device, it will begin to record the data automatically.

Requirements statement

The device to be designed will test the power consumed by other devices running on DC. And it is necessary to set up the functional requirements.

The device will be connected in series between a DC supply and load where it can accurately measure and log the data needed to computer power usage. Example it can be used to measure how much power that use the computer to change the phone.

Functional requirement

Compliance Requirements:

- The system shall accept as close to a 1-24 VDC range
- Source the same 1-24V out the other side with a minimal voltage drop through the device
- Need the resolution to measure currents from 0.5mA to 3A
- Logs voltage, current, time ,temperature
- Have a programmable logging time ideally from 100ms to 10min
- Log the saved data to a removable SD card in a format easy to import with MS Excel
- The device needs the ability to run on battery power so that it doesn’t distort the measurement being made.

Interface Requirements:

- For user to easy use device, need an interface
- Interface display the data
- Have buttons easy turn on/off

Non-functional requirement

- Simple connect in series between DC supply and load
- Provide easy user interface
- Lower price, < $50
- Pass the relative quality and legality test or certification before entering the market
- Durable shell to protect from outside environment

Market/Literature Survey

In the market, the "Kill A Watt" which measure AC power is to be used as test equipment. Our group designs a device similar as the "Kill A Watt" measure DC power. The devices can be marketed to the normal citizen. The U.S Department of Energy reports that 20% of our electric bills come from items that are left plugged in when they are not in use, or items that are in standby mode. With the Kill A Watt P4400 we can monitor the energy eaters in our homes and cut down our electric bills at the same time. Plug whatever item you want into the device and it will tell you the efficiency of that item by displaying the kilowatt per hour. This device will help you determine which items are costing you the most to run. The Kill A Watt also calculates voltage, line frequency, current, and power factor. You can calculate your electric bill before you even receive it from the electric company. [1]

Deliverables

Design Specifications

The design specification document will be used by Garmin to evaluate the plan of action before production of the prototype begins. It will also be used as an outline for how the device should function.

Inside the design specification document the operation of the device will be strictly defined. The document will list different settings that could be changed on the device and their intended uses. Additionally, the design specification will describe how the Watt Meter will function. This will include a listing of expected input power parameters and their ranges.

Operating constraints and performance specifications will also be detailed in this document. These performance specifications will ensure that the Watt Meter has the necessary characteristics that make it compatible with the power source it is measuring. These constraints will be rigidly defined and will include topics such as maximum power usage for any power source, operating temperature range, expected battery life under certain conditions, and cost.

Once a draft of the design specification has been completed, it will be submitted to Garmin for evaluation and revision. In this way, the aspects of the design may be evaluated by the customer before production of the prototype begins. The ultimate goal of this document is to define the characteristics of the design to ensure that the delivered product is successful.

Engineering Report

The Engineering Report document will be used to describe the different methods and techniques used to solve the problems encountered during the design of the Watt Meter. This

[1] Find out How much Electricity You're Using P3 International P4400 Kill A Watt Electricity Usage Monitor

will include justification and description of the type of implementation chosen. By describing the problem and the approach taken in solving the problems, the document will show the best solution was implemented. This report will refer to the constraints and operations outlined in the design specification document.

The Engineering report will also have a recommended path for improvements that can be made. This will include ways to get better performance out of the device and a direction that further research might take as well. Additionally, suggested ways to lower the cost of production will include in this report.

Operating Prototype

The operating prototype will be a Watt Meter that can operate reliably within a specific temperature range measuring a given power source. It will be some form of integrated circuits and digital logic that will have practical inputs and outputs, and a display for showing the measured characteristics of the power source.

Once constructed, the prototype will be tested against the design document to ensure that it meets all of the given constraints and has all the necessary features. The operating prototype will then be tested under a wide range of power sources and conditions to ensure that it continues to function properly at all times.

Work Plan

Work breakdown structure

Research 20%

Research is an important part of design. According to the project goals, first of all is to understand how the DC wattmeter is working and then come up with the structure of the whole project design. Based on the design constraints, it is essential to look for the best technical approaches and tools to accomplish the design such as the test equipment, simulation tools and devices choices. At the same time, the cost of design is also considered in this design.

Design 30%

After identifying the project goals, a device could be designed to perform like a DC wattmeter. This may include current sensor design, voltage senor design, analog to digital converter design, microcontroller implement and PCB drafting. The most important parts of design are current senor circuit and voltage senor circuit. To minimize the error in measurement, it is necessary to figure out the best method to design the circuit.

Implementation 30%

Once obtain the desired circuit, the implementation is to make sure the correctness of design. The first step is to pick up a simulation tool such as Cadence to test circuit. If the circuit is acceptable and practical, the next step is to build circuit by hands. The devices involved in this project depend on the previous research results. The implementation is to combine all of these elements together and then to see if we can get the desired results. After the PCB drafting and fabrication, the last step is to test the final project.

Debugging/validation 20%

In the implementation section, the design should have been evaluated. If there are any errors in the design, they should be revised and then meet the requirements of the design specification.

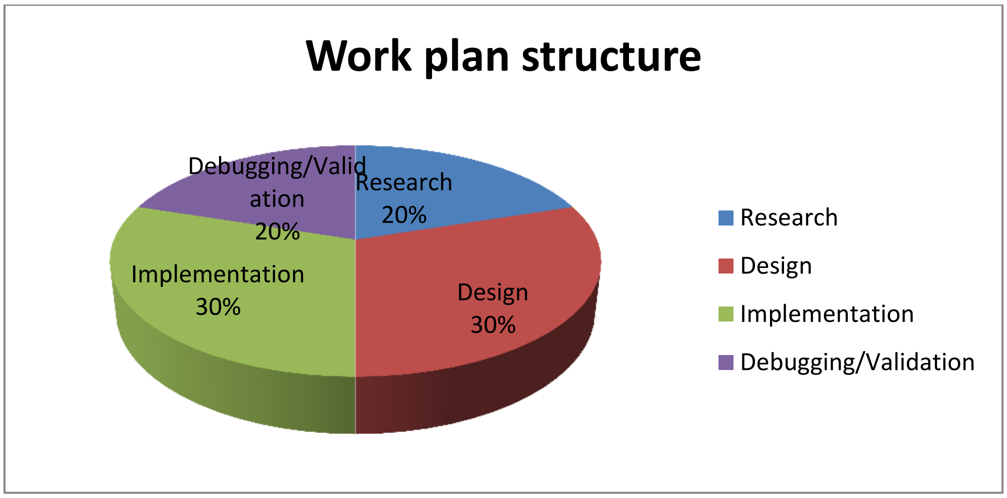

Figure 3: Work Plan Structure

Schedule

Our schedule is divided up into weekly segments, in which we desire to accomplish the main goal listed below. The timeline is as follows:

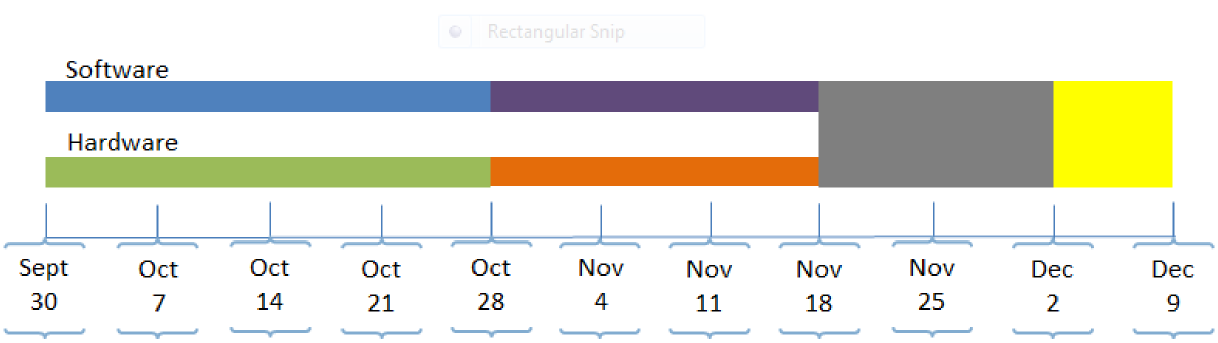

Figure 4: Time Table for fall semester

Project Plan

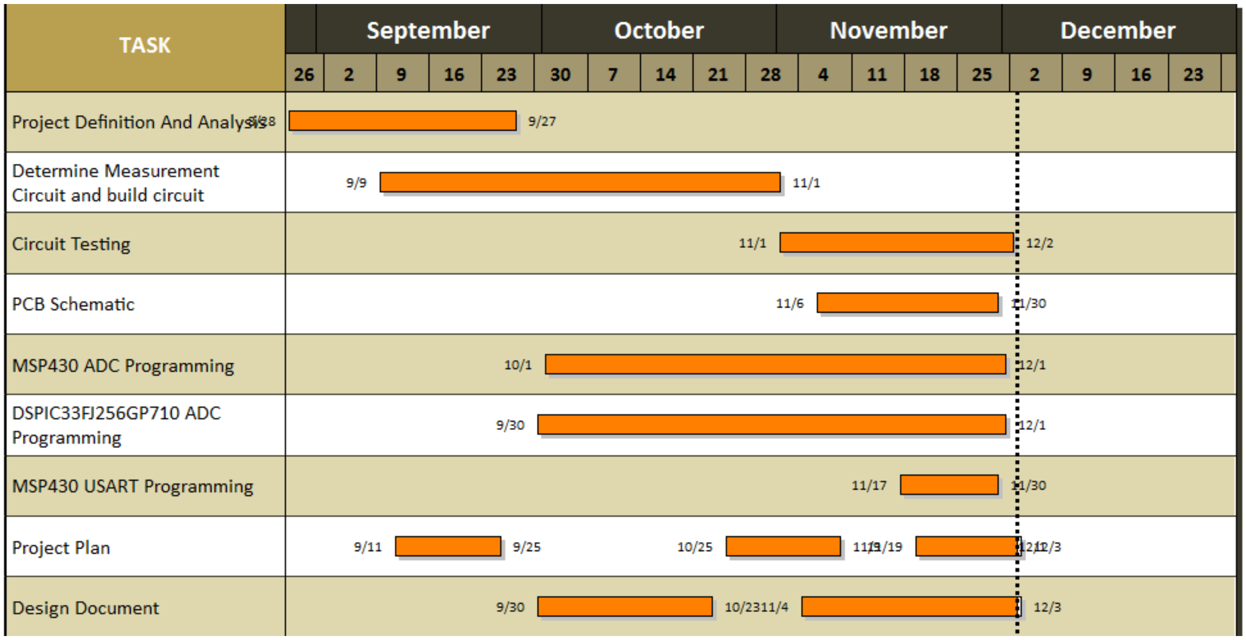

Figure 5: Timeline for whole project

During this period of time, the software team will focus on getting a system established by which we can send a voltage to an ADC pin, and have the MCU interpret the data correctly and send it to the SD memory card. This step will include setting up the values tied to each ADC reading, converting it to a digital signal, manipulating it to produce the actual reading we desire, and then sending that value through the UART serial bus to the SD card in a file format that can be read later by excel.

The hardware team will focus on producing a circuit that can be simulated to produce a range transformation for the voltage readings and current readings, into a range that can be read by the ADC. This will be done by utilizing our Cadence Virtuoso simulation software and schematic designer. The plan for the circuits is to use an operational amplifier to convert the range in an accurate manner. For the current reading side of the circuit, we will use a current sensor chip with the voltage range converter to send a reading to the ADC.

At this point, the software team will have completed the ADC to SD card communication. They will then begin focus on the LCD screen implementation into the MCU. This will involve communication to the LCD from the UART serial port of the MCU.

The hardware team will focus on determining real world parts to try implementation of the voltage range circuit. This will include finding the parts that will suit our needs, and running breadboard testing. This will also include implementation of the current measuring sensor as well and confirming that it is accurate enough in measurements for our needs.

This process will combine the hardware and software teams to bring together the components into a working demonstration of the Wattage measurement system. Also included in this time period will be the designing of the GUI, including buttons to turn on/off the system and change modes.

This will be the week in which we finish up our proof-of-concept design and put together our presentation that will be given in “Dead Week”. We would also need to get together documentation that will be required for prototyping in the spring semester, including diagrams, pictures, and schematics.