Monitoring Battery Life with a Microcontroller

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Abstract:

Microcontrollers are prevalent in all aspects of human life today. They are found in washing machines, ATMs, cars, and many other common electronic devices people interact with every day. These microcontrollers provide a large range of functions and are extremely versatile and useful. Microcontrollers are also a cheap and effective way to accomplish simple tasks like controlling a thermostat, blender, or refrigerator. Monitoring battery life is an important function that needs to be implemented in most applications that use batteries as their power source. This application note explains the concept of battery monitoring and how to use a microcontroller to monitor the remaining charge in a 12V lead-acid battery.

Introduction:

Lead-acid batteries are very effective at powering many different applications. They are easy to obtain, relatively inexpensive, and provide a lot of power to whatever they are hooked up to. These batteries are also used in multiple designs because of their versatility and high power output. Unfortunately, if there is nothing monitoring the charge, the battery will eventually run out of power. Lead-acid batteries are not designed to be fully discharged, so if a battery is run dry, it will be damaged. In order to determine the charge of a battery, the current voltage of the battery is needed. A 12V battery is not exactly 12V when fully charged; at full charge, it is closer to 12.7V. Depending on the output voltage of the battery, the approximate charge of the battery can be estimated. In Figure 1, the relationship between charge percentage and output voltage is shown. The value of 10.5V is chosen for zero percent charge because a lead-acid battery will be damaged if it is discharged below 10.5 volts. Figure 2 shows the same information in a graphical form for multiple models of a certain lead-acid 12V battery.

State of Charge	12 Volt Battery Output Voltage	Volts Per Cell
100%	12.7	2.12
90%	12.5	2.08
80%	12.42	2.07
70%	12.32	2.05
60%	12.2	2.03
50%	12.06	2.01
40%	11.9	1.98
30%	11.79	1.96
20%	11.58	1.93
10%	11.31	1.89
0%	10.5	1.75

Figure 1: Voltage and Charge Percentage

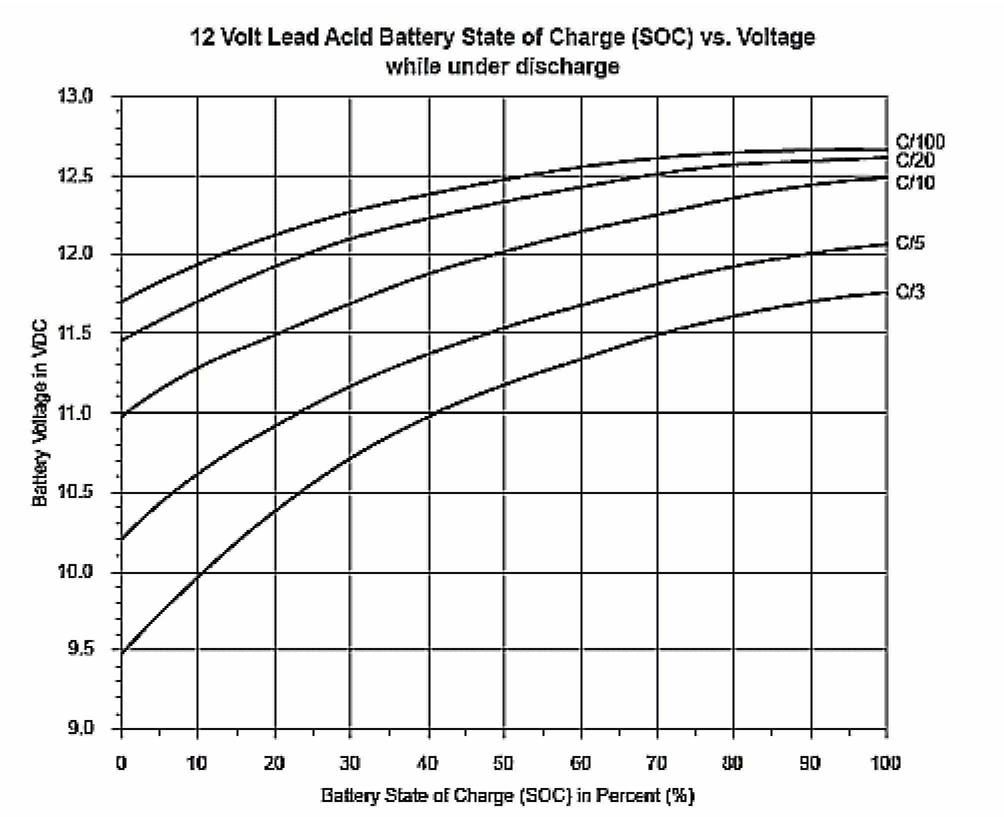

Figure 2: Graphical Representation of Voltage vs. Charge Remaining

A microcontroller is a small computer located on a single integrated circuit (IC) containing a processor, memory, and input/output options. Figure 3 shows a basic block diagram of a microcontroller, outlining the different components of a microcontroller. This microcontroller has flash memory as well as random access memory (RAM) that is used for program execution, four input/output (I/O) ports, and a central processing unit (CPU). Many microcontrollers have an analog to digital converter (ADC) used to translate an analog voltage signal into a series of bits that the microcontroller can then process. For a battery monitor, the output voltage of the battery can be used as an ADC input, and the current charge of the battery can be determined.

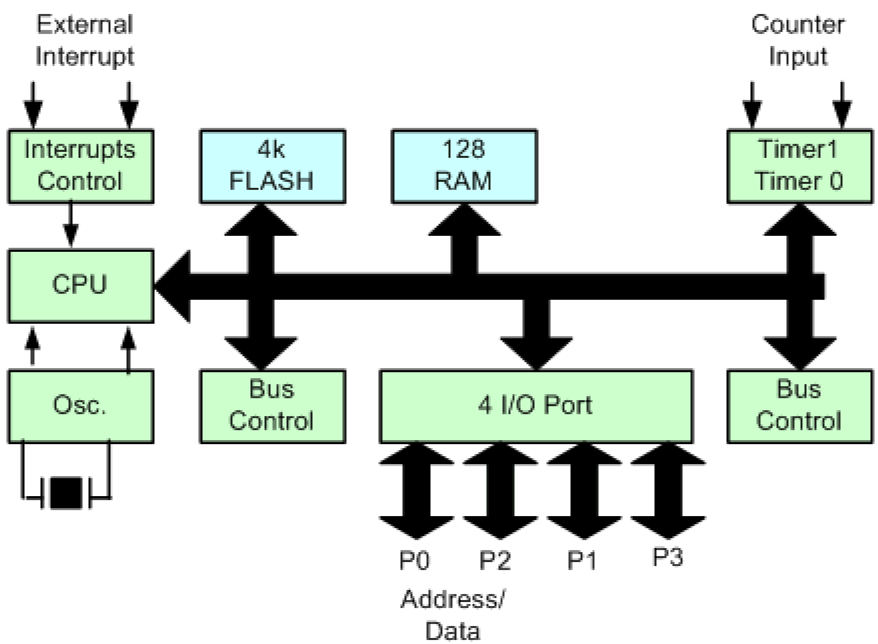

Figure 3: Block Diagram of a Microcontroller

Implementation:

In order to implement this design, a microcontroller with an ADC is required. Many microcontrollers do not support voltages above 2.5V or 5V reference voltage for their ADC, so a voltage divider is needed in order to step down the voltage to something the ADC can work with. Figure 4 shows how to take the 12.7V from a fully charged lead-acid battery and step it down to a more useable voltage. Resistor R in Figure 4 can be configured depending on the reference voltage the microcontroller requires (Vout), and Vin, where Vin is the 12.7V from the fully charged lead-acid battery. Resistor R would then be 50000 / (Vin / Vout - 1). Therefore, the range of voltages obtained at Vout will be between 0V and whatever logic high is for the microcontroller. Then all that is needed is to connect the Vout portion of the voltage divider circuit to the ADC pin on the microcontroller, and to do some calculations.

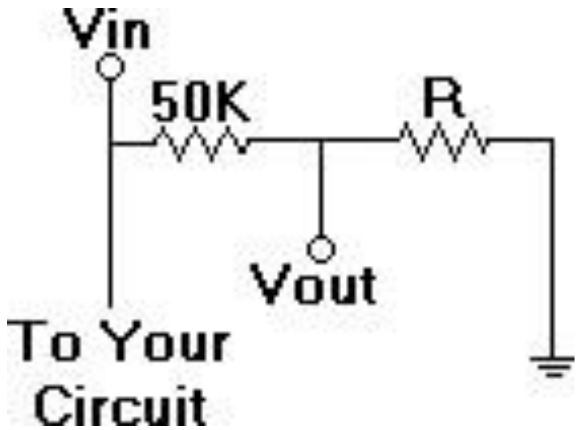

Figure 4: Voltage Divider

The code for the microcontroller will not be that difficult to write. Since the ADC will convert the input voltage to a value between 0 and 1023, a fully charged 12V battery should be near the 1024 value, and this value will decrease as the battery discharges. If a 5V reference is used, then the lowest value that the ADC should see would be 847, because that would be 10.5V, which is the lowest the battery should go before serious damage could occur. Mapping this 847 to 1023 range to a percent scale results in a charge scale that can be used to determine the life left in a battery.