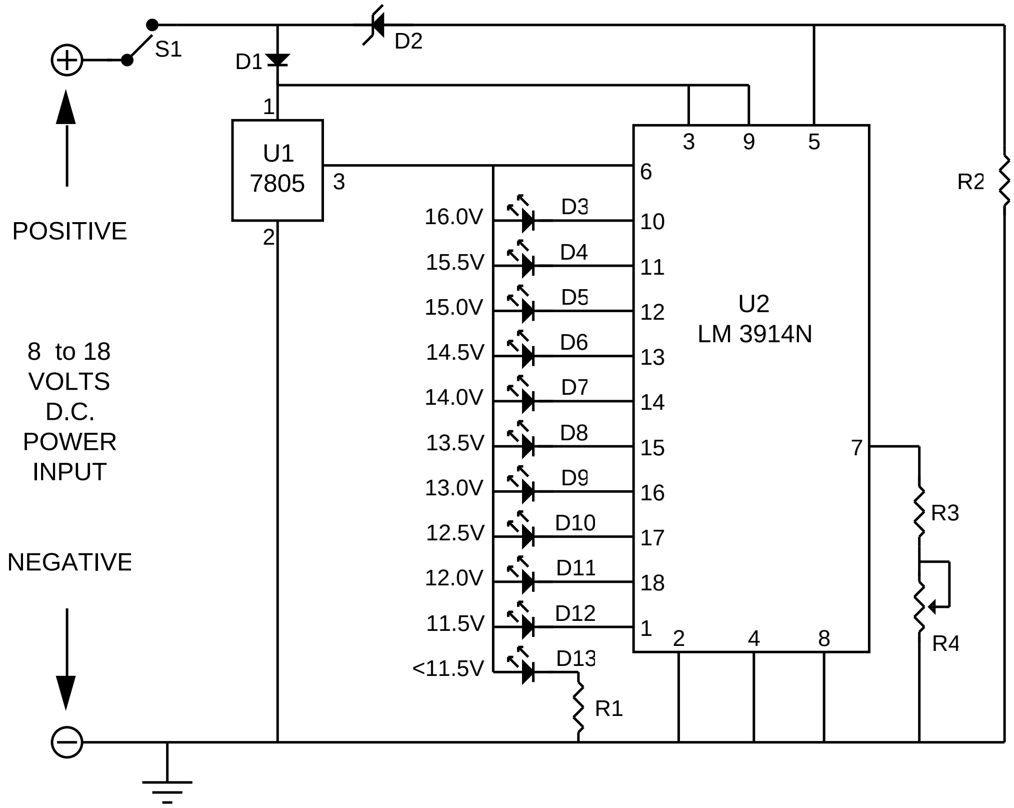
12 Volt Lead-Acid Battery "Gas Gauge"

or the "BAT-O-METER"



Parts List

Integrated Circuits

U1- 7805, 5VDC, 1A. Voltage Regulator

U2- LM 3914N, LED Bar/Dot Driver

Diodes

D1- 1N4002, 1 A. Silicon

D2- 1N5241B, 11VDC Zener

D3-Amber LED indicates 16.0 VDC

D4- Amber LED indicates 15.5 VDC

D5- Amber LED indicates 15.0 VDC

D6- Green LED indicates 14.5 VDC

D7- Green LED indicates 14.0 VDC

D8- Green LED indicates 13.5 VDC

D9- Green LED indicates 13.0 VDC

D10- Green LED indicates 12.5 VDC

D11- Green LED indicates 12.0 VDC

D12- Amber LED indicates 11.5 VDC

D13- Red LED indicates <11.5 VDC

Resistors

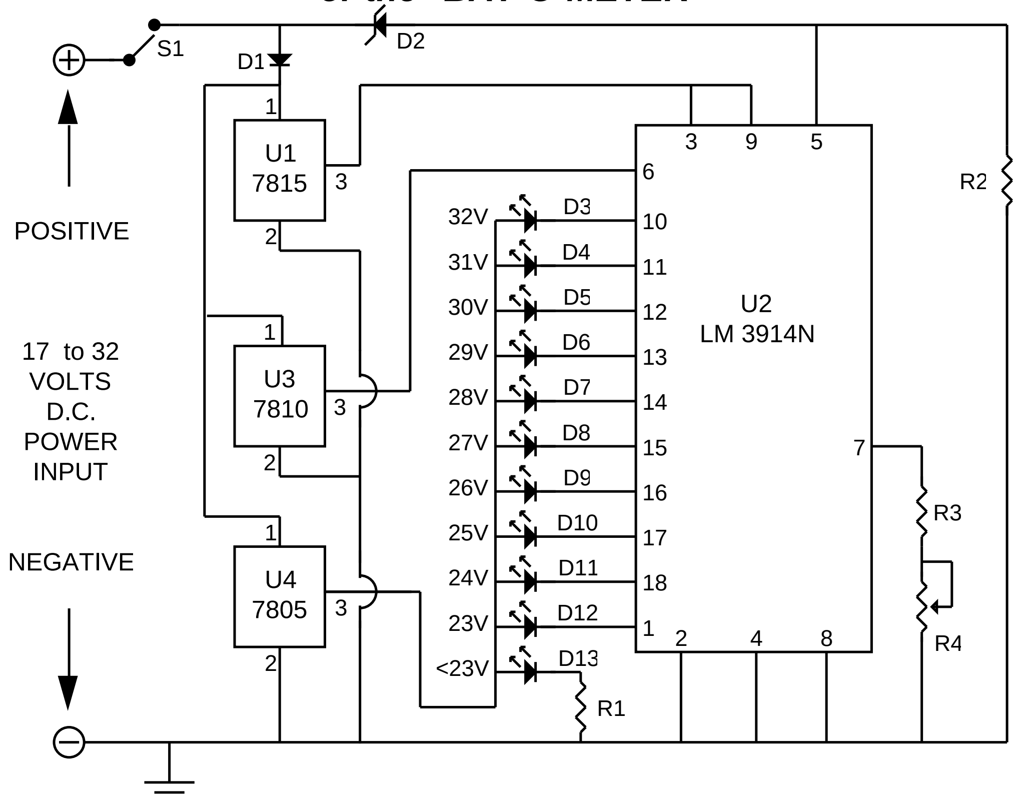
R1- 390Ω, 1/4W.

R2- 390Ω, 1/2W.

R3- 1.4kΩ, 1/4W.

24 Volt Lead-Acid Battery "Gas Gauge"

or the "BAT-O-METER"



Parts List

Integrated Circuits

U1- 7815,15VDC Voltage Regulator

U2- LM 3914N, LED Bar/Dot Driver

U3- 7810, 10VDC Voltage Regulator

U4- 7805, 5VDC Voltage Regulator

Diodes

D1- 1N4004, 1 A. Silicon

D2- 1N5251B, 22 VDC, 1/2 W. Zener

D3-Amber LED indicates 32 VDC

D4- Amber LED indicates 31 VDC

D5- Amber LED indicates 30 VDC

D6- Green LED indicates 29 VDC

D7- Green LED indicates 28 VDC

D8- Green LED indicates 27 VDC

D9- Green LED indicates 26 VDC

D10- Green LED indicates 25 VDC

D11- Green LED indicates 24 VDC

D12- Amber LED indicates 23 VDC

D13- Red LED indicates <23 VDC

Resistors

R1- 390Ω, 1/4W.

R2- 820Ω, 1/2W.

R3- 1.4kΩ, 1/4W.

R4- 10kΩ trimmer potentiometer

Build your own Battery State of Charge Meter

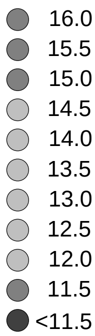
Richard Perez

Here's a simple, home-brew, project that indicates how much energy is remaining in your batteries. It's a "gas gauge" for lead-acid batteries, we call it the "Bat-O-Meter". It is an LED bar graph voltmeter with an expanded scale. It can tell you the state of charge of your batteries from across the room, even in the dark. The Bat-O-Meter is not only very simple to build, but also very inexpensive-less than $10. in parts and about an hour of your time are all that's needed. And, in addition to the 12 Volt model, we've designed a 24 Volt model (we hear you 24 Volters out there).

What is a Bat-O-Meter?

It is a vertical column made up of 11 Light Emitting Diodes (LEDs). It's like a thermometer, the greater number of LEDs that are lit, the higher the column gets, and this indicates higher system voltage and more energy in the battery. Here's the scheme for a 12 Volt system. The bottom red LED indicates battery voltage below 11.5 VDC. The next, amber, LED up the column lights when battery voltage above 11.5 VDC. The next, a green LED, lights up when the voltage is above 12 VDC. And so on in 1/2 Volt increments until the uppermost LED and all the ones under it are lit when the voltage reaches 16 VDC. The scale is setup much the same for 24 VDC systems, except the first LED indicates below 23 VDC, the final LED indicates 32 VDC, and there are 1 Volt increments between the individual LEDs.

The range and spacing of the bar graph is set to function within the voltage range of a lead-acid battery storage system. The battery voltage in a just about exhausted 12 Volt battery is less than 11.5 VDC, so this is the bottom of our scale. When the voltage is above 15 VDC, the battery is full, and almost all the LEDs in the string are lit. Color coding of the LEDs makes it easy to see what happening in the system at a glance.



How the Bat-O-Meter works

Here's some information on how the circuit actually works. Please remember that it is much more difficult to understand how this circuit works than it is to build it. While the understanding is fun and rewarding, you can build this puppy from the schematic and it'll work whether you know how it works or not. Ain't electronics wonderful? So if you're not interested in learning the theory, just skip to the construction part below.

The LM 3914N is an integrated circuit (IC) that contains 10 LED drivers working together across a 10 equal step voltage divider network. The range of this network is set by the voltage fed the upper end of the divider network (pin 6). The voltage of an incoming signal (in our case the battery's voltage) is compared to the voltage across the divider string. The LEDs are lit by comparison of the incoming signal to the various voltages steps across the divider.

Let's start first with the LED called D13 because it is the only LED not controlled the the LM 3914N. The anode of D13 is sourced by the 7805 regulator, just like all the other LEDs. But the cathode of D13 is not controlled by the chip, hence this LED is lit all the time. This is the default LED and it indicates system voltage below 11.5 VDC in a 12 Volt system, or system voltage below 23 VDC in a 24 Volt system. We included this LED because the first LED activated by the LM 3914N is D12, which turns on at 11.5 VDC or above. Well, what about a system with totally depleted batteries. In this case the system voltage will be below 11.5 and we need to indicate that the batteries are empty. Without this default LED the display would be totally dark at voltages below 11.5 VDC (23 VDC in a 24 Volt system). If D13 is the **only** LED lit in the bar graph, then the batteries are empty.

The high end of the voltage divider network is Pin 6 on the LM 3914N, and the low end of the divider chain is pin 4. We are feeding the high end of the divider 5 VDC from the 7805 voltage regulator. The low end of the divider (pin 4) is grounded. Thus we have established 5 VDC across the divider, and the LM 3914N automatically divides this 5 Volts into 10 equal steps, each 0.5 VDC. This establishes the full scale voltage of the meter (all LEDs lit) and the increment between each LED.

The incoming battery voltage (our signal) is too high in voltage to be fed directly to the LM 3914N. We've referenced its voltage divider to 5 VDC and battery voltage is always much greater than this. So we must process the incoming battery voltage signal. We accomplish this by inserting an 11 Volt zener diode in series with the incoming signal. This zener diode (1N5241B) subtracts 11 Volts from the incoming signal. For example, if the battery has a voltage of 12 VDC, then once the zener has processed the incoming signal, its voltage is 1 VDC. This gyration is necessary so that the meter starts reading at 11 Volts and not a lower voltage. This incoming signal processing expands the scale of the resulting bar graph. R2 is a ballast resistor for the zener. It continually draws current through the zener and makes the voltage drop (11 Volts) across the zener more stable.

The resistor network (R3 & R4) from Pin 7 of the LM 3914N to ground determines the brightness of all LEDs except D13. Now LEDs can be power hungry kinda guys. If you turn the brightness control (R4) all the way up, then each LED is consuming 10 milliAmperes of current. With the brightness control all the way down each LED is consuming less than 3 milliAmperes. R4 allows adjustment of the LEDs' brightness, and thereby the overall power consumption of the meter.

The 7805 (U1) is an integrated circuit voltage regulator. You can feed any DC voltage (<35 VDC) into it and it will only output 5 VDC at up to 1 Ampere. We are using it for two purposes in this circuit. First is to establish a stable 5 VDC reference for the voltage divider/ comparator network in the LM 3914N. Second, the 7805 feeds the anodes of the LEDs. While the anodes of the LEDs could be fed directly from ambient voltage, this places a strain on the LM 3914N display driver chip. The LM 3914N controls the amount of current that flows through the LEDs. If the LEDs are fed more than 8 VDC, then the LM 3914N starts to get hot. The LM 3914N has a total device dissipation of around 600 milliWatts. In order to get the LEDs brightly lit without overheating and ruining the display driver, we fed them a lower voltage. This allows us to run the LEDs at high brightness without french frying the LM 3914N.

Two other parts are worthy of mention. D1 is not strictly necessary, but protects all the electronics if you should hook up the meter backwards (reverse polarity). If the meter is hooked up to the battery backwards, it will not work, BUT it won't be damaged. S1 is a switch. This switch is in the schematic because this meter can consume an appreciable amount of power if you turn the LEDs brightness way up. For example, let's look at the worst case- all LEDs lit and at maximum brightness. In this situation the meter will consume about 130 milliAmperes or 3.12 Ampere-hours in a day. So Switch 1 allows you to shut off the meter if you wish to save power. Use a momentary switch for S1 and the meter will only function when you are depressing its switch. Power consumption of this meter can also be controlled by turning the brightness down on the LEDs. For example, consider 3 LEDs lit and the brightness turned down. In this case the meter consumes less than 20 milliAmperes or about 0.5 Ampere-hours a day.

Notes on the 24 Volt Bat-O-Meter

It's a bit tougher to get the Bat-O-Meter on 24 VDC than onto 12 VDC. We need to add two more voltage regulators (about 75¢ each). The 7815 regulates the overall circuit and protects the LM 3914N from overvoltage. The 7810 establishes a 10 VDC reference for the voltage divider/comparator in the LM 3914N. The 7805 performs the same function in both the 12 and 24 Volt models. Note that there are different resistor values in the 24 Volt model.

Constructing the Bat-O-Meter

The parts can be purchased from your local Radio Shack or from Digi-Key, POB 677, Thief River Falls, MN 56701-0677 • tele: 1-800-344-4539. Digi-Key stocks just about everything electronic and their quality is higher and prices lower than Radio Shack. I based my component cost estimate of $9.58 on the latest Digi-Key catalog.

Use a 2 inch by 3 inch piece of perforated circuit board to construct the Bat-O-Meter. Arrange the LEDs in a vertical column, starting with D13 at the bottom. All parts are mounted on the perfboard and there is no wiring to the enclosure. Use an 18 pin DIP socket for the LM 3914N, don't solder directly to the IC unless you are a good hand with electronics work. It's easy to damage the LM 3914N by overheating it with a soldering iron. Use a heatsink on U1 as it'll warm up under high LED brightness and high system voltage.

How you enclose the meter is up to you. Or even if you put it in an enclosure- I've had one running for years- perfboard nailed to the wall. I liked mounting the finished perfboard, using standoffs, on a piece of oak. Use more standoffs to mount a piece of lucite or plexiglass over the unit- The visible Bat-O-Meter.

You only have to adjust R4 to the brightness you desire, and your Bat-O-Meters functional.

Using the Bat-O-Meter

One factor that will affect the accuracy of the Bat-O-Meter is where the meter is placed in the system. While the meter can be located anywhere on the DC wiring, it will work best if it is directly wired to the batteries or the main battery/bus terminals. If the Bat-O-Meter is located on wiring that is feeding other appliances, then it will indicate the voltage loss in the wiring when these other appliances are working. Since the resolution of this meter is rather coarse (0.5 VDC), losses in wiring won't affect the reading very much unless the appliance is very large or the wiring undersized.

Using the Bat-O-Meter is simple. The more LEDs illuminated, the more power you have. During periods when the batteries are being recharged by whatever source you have available, the bar graph will indicate this by lighting more LEDs. If you turn on an appliance, the system voltage is depressed by this load, the voltage goes down, and so does the number of LEDs lit by the Bat-O-Meter.

The color coding of the LEDs also means something. The bottom red LED indicates that you're out of power, batteries empty. The next LED up is amber and it indicates that you're getting low. The next 5 LEDs are green and mean you have power, the more green LEDs lit, the more power. The amber LEDs at the top of the scale (15, 15.5, & 16 VDC in a 12 Volt system) indicate high voltage and possible failure of regulators or other incoming power control equipment. If you normally run your system at 15 VDC under charge (we do), then change D5 from an amber LED to a green one.

A word of disclaimer. The Bat-O-Meter is designed to be a simple, non-technical, indicator of a battery's state of charge. It doesn't read out in numbers that need to be referred to a graph to give you the info you want. It's made to be simple and easy to read. It is not designed to replace an accurate voltmeter, but as an "at a glance" supplement to the info provided by a digital meter or such like. After living with our Bat-O-Meter for a while, we find that it tells us all we really need to know and in colors no less. Red- out of power, Amber- caution, & Green- go go go…