Desulfator Circuit II

Introduction

Car Batteries are essential in any electrical system that stands alone off the power grid, operates on renewable power, is highly efficient, and almost never fails. Your first independent power system is already installed in your car, so this is where you can most easily start making improvements of efficiency and reliability that promote a better life style based on using less. The knowledge can be applied to developing a solar powered home.

Chemical Reactions

Lead-acid batteries have internal, chemically-reactive plates, lead sponge anodes and lead peroxide sponge cathodes. The sponge structure consists of tiny spheres sintered together to produce consists of tiny spheres sintered together to produce a very large reactive surface. The electolyte is sulfuric acid. On discharge, sulfate ions in the water combine with lead from the plates to form lead sulfate crystals all over the plates surfaces. This starts the sulfate clogging process. On charging, the reactions reverse, but unfortunately, batteries rarely get 100 percent fully recharged, so residual sulfate crystals gradually accumulate. After about 4-5 years of normal use, the battery becomes too clogged to function, and with the sulfate ions recmoved from the electrolyte, the wate can freeze. This is the cause of roughly 75 percent of battery failures.

Lead-acid batteries can also fail for other reasons. Sulfate crystals accumulating in the spongy plates can exert forces that warp the plates and cause them to touch and short out, sulfation can cause pasts of plates to spall off, the original sponge structure gradually disappears, discharged batteries crack open when they freeze, and ordinary tap water with dissolved foreign chemicals added to batteries can wreak havoc with the batter chemistry. However, all of the clogging, warping, and spilling problems caused by lead sulfate buildup can be prevented by zapping the battery with short, ihgh voltage charge pulses.

Desulfator Circuit and Theories

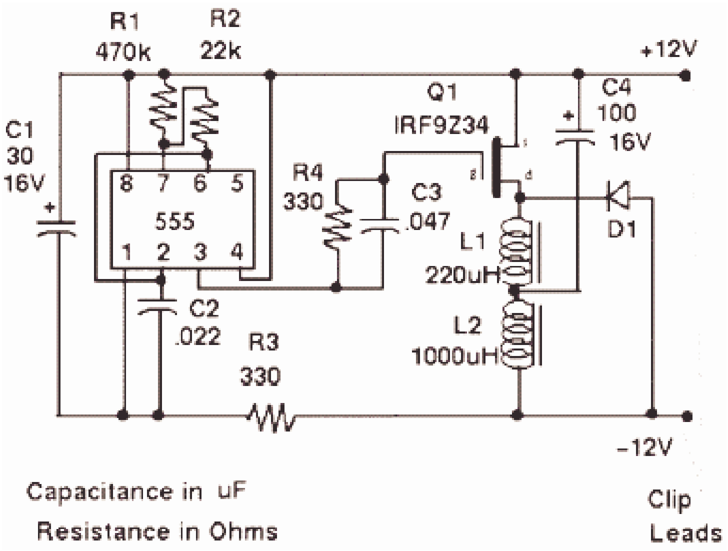

Figure 2-1: 12 volts battery desulfator

Note: In the battery desulfator design, the value for C2 should have been 0.0022 µF, not 0.022 µF.

The usual practice in maintaining a battery in good condition is to apply a periodic equalization charge over and above what would be a normal full charge. Unfortunately, this is an energy-wasting tactic. It ultimately results in clean battery plates, but at a steep price, especially if the energy must come from a generator.

The technique used in this circuit relies on a little known aspect of lead-acid batteries. They possess what is called a “resonant frequency,” at a surprisingly high frequency. The frequency is dependent on various physical details of the battery’s construction, but it is on the order of 2 to 6 megahertz, which is in the low ranges of the shortwave radio bands.

This resonance is just like that of a stringed musical instrument, where a pluck of the string creates a vibration of a specific tone. In the case of the battery, sulfur ions dissolved in the electrolyte take the place of the string. A sufficiently energetic electrical “pluck,” or pulse, will cause a similar vibration of these ions, back and forth throughout the electrolyte.

When this vibrational state is occurring, there are uncountable collisions between the ions in the electrolyte and the battery plates, as the back and forth vibration continues.

It is this rhythmic beating of the plates which causes the breakup of the crystalline deposits, slowly but surely, for as long as the electrical pulsations are applied.

It is not unlike sandblasting a rough surface, but on a micro-physical level. This is an advantage of electrical methods over the use of chemicals like EDTA. Rather than dissolving the sulfate deposit and allowing it to settle on the bottom of each cell, as with EDTA, the pulse technique returns the sulfate back into solution again.

Desulfator Parts List

Table 2-1: Parts Listing

Item	Component	Description	Cost (US$)
Q1	IRF9Z34	P channel MOSFET	1.82
U1	LM555CN	Timer IC	0.42
D1	GI826CT	Fast recovery diode, >6A, 100V	0.77
C1	30uF, 16	Electrolytic	0.23
C2	0.0022uF	Disk ceramic	0.38
C3	0.047uF	Disk ceramic	0.54
C4	100uF, 16V	Electrolytic, low impedance type	0.44
R1	470kOhm	1/4 W	0.15
R2	22kOhm	1/4 W	0.15
R3	330Ohm	1/4 W	0.15
R4	330Ohm	1/4 W	0.15
L1	22uH (nominal)	Ferrite inductor 6+ A peal	2.08
L2	1000uH	Ferrite choke, 100mA	3.12
	Case	Aluminum project box	5.44
	Clip leads	Alligator type, insulated (RS)	1.00
	Board material	0.1” spaced copper pads	3.00
		Total (estimate)	19.84
		Total (actual)	10.40

Circuit Descriptions

The circuit is in essence a very widely used form of switching DC to DC converter, which can take a DC voltage and step it up to a higher level. Figure 1 shows the version, which is specifically for 12 volts systems. The basic pulse rate is set by the venerable 555 timer chip, U1, which switches the MOSFET Q1 at a 1 kHz rate. When Q1 is in the non-conducting state, current is drawn from the battery through L2 so that capacitor C4 can be charged slowly. Then Q1 is turned on for a brief 50 microseconds, causing the charge stored in C4 to start flowing through L1.

When Q1 is turned off again, the stored inductive energy in L1 has to continue to flow somewhere, so it pulses back into the battery through diode D1. This current pulse can get as high as 6 amps. The use of an inductor to supply this pulse is what makes it possible to restore badly sulfated batteries with a high internal resistance. The peak voltage drop across the battery can initially be as high as 50 volts. With continued treatment, this peak voltage will decrease as the battery's internal resistance gradually declines.

To further check the progress, you could do a discharge test, using a known load, to determine the useful capacity. This would involve measuring the length of time taken by the load to drop the battery voltage from a high level to a low level. If you repeat this test, a gradual lengthening of this interval should be noted.

Testing and Measurements

First Measurement and Setups (Power Supply)

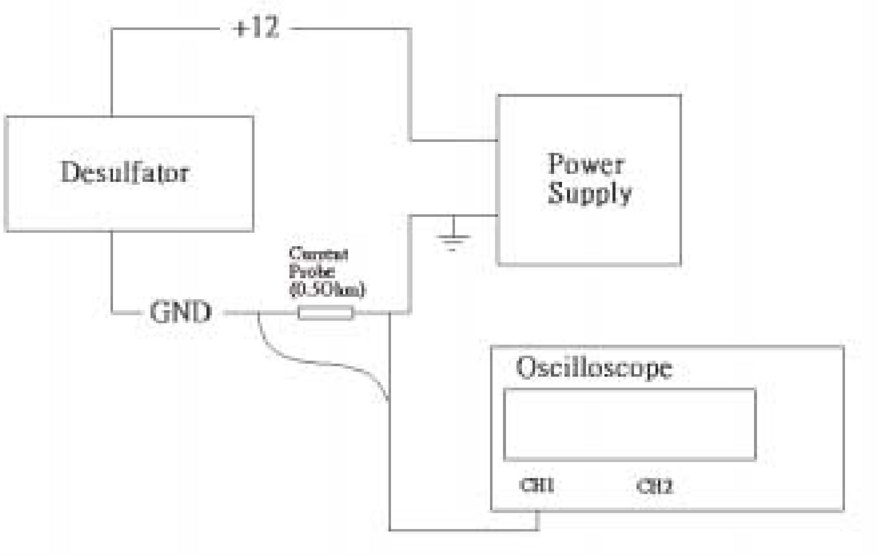

Figure 2-2: Test the prototype circuit with power supply

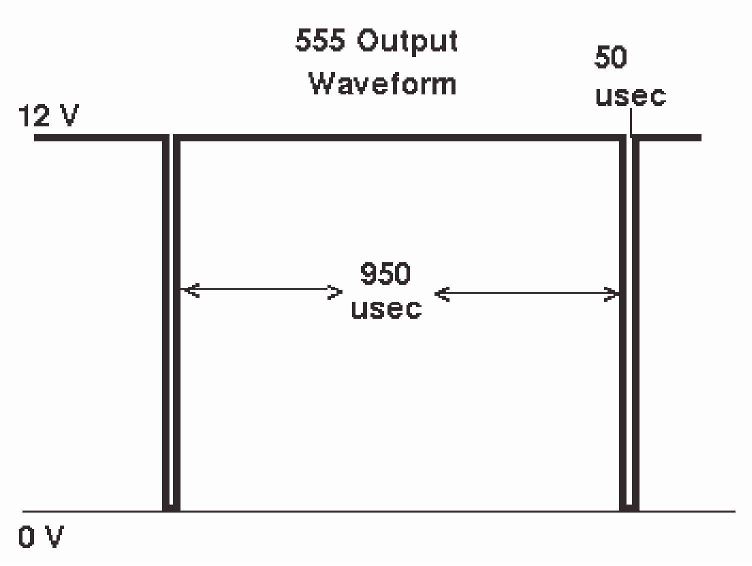

Figure 2-5: Reference Waveform on 555 Output (Expected Waveform)

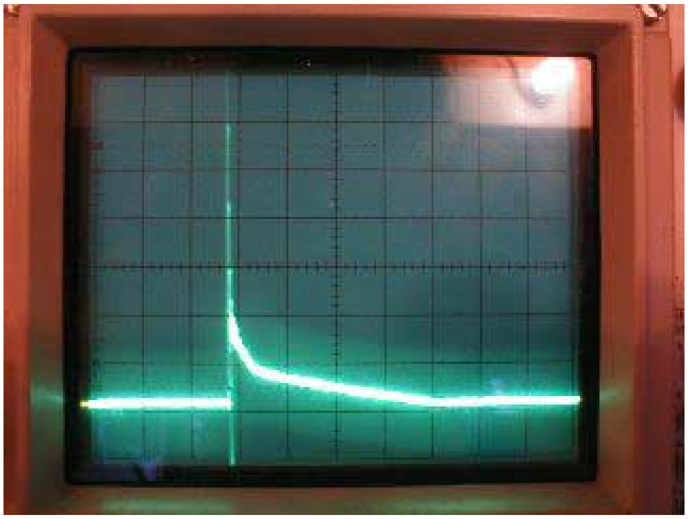

Figure 2-6: Reference Waveform on diode (Expected Waveform)

The frequency of the pulse is close to 1000 Hz. The width of the narrow, negative going part controls how long the MOSFET is turned on. The longer it is turned on, the higher is the peak amperage delivered to the battery, up to a point. At present, it isn't known whether it is better to pulse frequently with a small amperage pulse, or whether a slower, higher peak pulse is better.

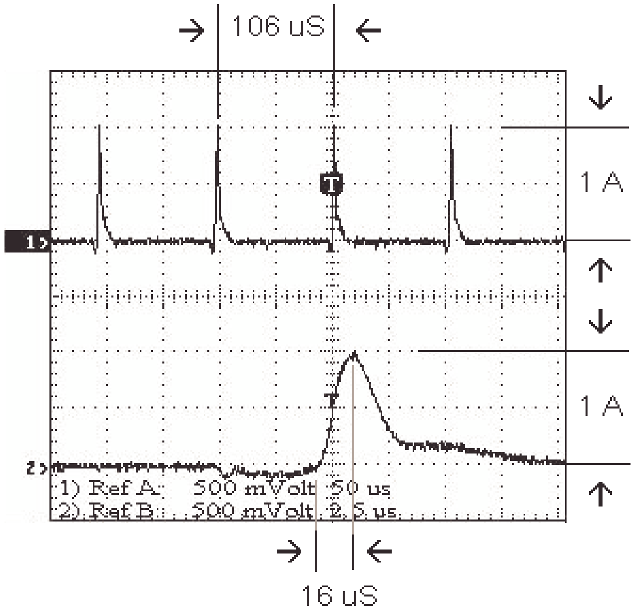

Figure 2-8: Current Probe measurement of commercial circuit
Ref B is the enlarge of Ref A

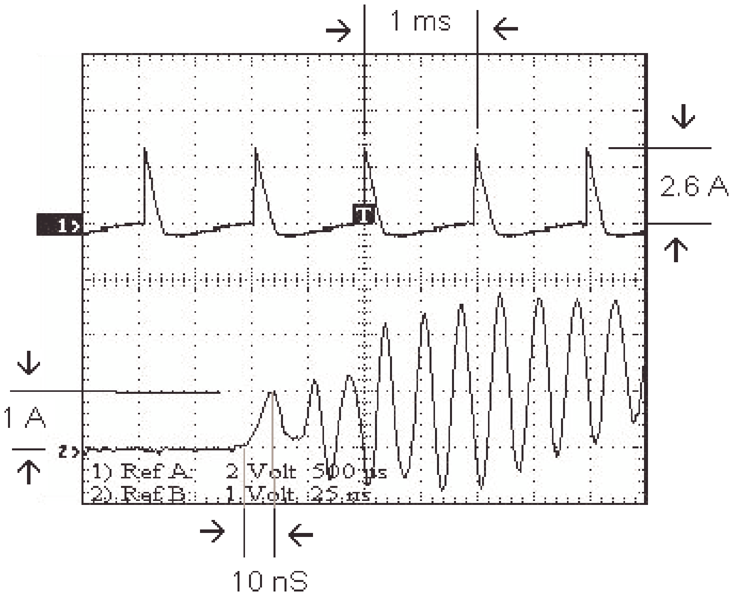

Figure 2-9: Current Probe measurement of circuit 2
Ref B (Burst) is the enlarge of Ref A

Notice the reference waveform in figure 2-12, the desulfator burst is also enlarged from the reference waveform in figure 2-11.

Table 2-2: The comparison of all measurements

	Measurements with first setup (Power Supply)	Measurements with second setup (Car Battery)	Reference Values
Period	1.0 ms	1.0 ms	1.0 ms
Frequency	1.0 kHz	1.0 kHz	1.0 kHz
Peak Voltage	1.34 volts	1.30 volts	600 mV
Current Probe Impedance	0.5 Ohm	0.5 Ohm	0.25 Ohm
Current Flow	2.68 Amps	2.6 Amps	2.4 Amps #

Sample Calculation

Current Flow = 600mV/0.25Ohm = 2.4Amps

Table 2-3: The comparison between the commercial and circuit 2 measurements

	Commercial Circuit	Circuit 2
Current Flow	1.0 Amps	2.6 Amps
Burst	NO	YES
Period	106 us	1 ms

As we can see from table 2-3, the commercial circuit has a higher frequency but lower current flow on the probe. On the other hand, our prototype circuit 2 has a higher current flow on the probe but lower frequency. These are the major differences between two circuits. The commercial circuit is mainly producing the frequency to desulfate out the clogging and warping, and our circuit 2 does the same thing by producing the high current pulse.

Conclusion

In this project, we built and tested the desulfator circuit we found on the website. The measured values are perfectly agreed with the expected values from the website. However, we had trouble with wiring and power dissipating problems. We have to build the circuit again on the prototype circuit instead of breadboard because the breadboard would not afford with that much current the desulfator produces.

We had another problem with one of the component in the circuit. The value of C2 in figure 2-1 should be 0.0022uF instead of 0.022uF. This mistake may make about 10 times higher on the output frequency, and we suffered quite a bit from this.

The finals problem we had is the 50us pulse width on figure 2-5, it is likely that the 50usec pulse width is too long as things getting too hot, resulting in L1 in figure 2-1 saturating. Also, C4 should not get warm, but will if it is a marginal unit with too much effective series resistance.

After many troubleshooting and testing, our measurement agrees with the expected values from the website. It proves our circuit (prototype circuit 2) works properly. However, due to the time problem, we could not test on the performance of the desulfator by actually charge up the car battery.

References

http://www.flex.com/~kalepa/lowpower.htm
http://courses.ncsu.edu:8020/ece480/common/htdocs/480_555.htm
http://www.flex.com/~kalepa/

Research Machine
http://www.google.com/