Care and Feeding of Gel Cell Batteries

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The name "gel cell" refers to the fact that this battery uses a gelled electrolyte rather than a liquid one. It is a type of SLA or sealed lead acid battery.

The 6V and 12V models are the two most useful for amateur radio applications. The problem most often experienced by hams is a shortened battery life due to improper charging methods and excessive discharging.

Although exact values vary from one manufacturer and battery type to another, the data printed on the battery or on the manufacturer's spec sheet may look like this:

Battery type: Sterling H7-12 12V 7Ah C20 to 1.75V/C, 25C/77F Float charge 13.60-13.8VDC; Cycle charge 14.50-14.90VDC; 77F/25C

12V 7Ah	12V battery rated for a maximum 7A discharge rate over 1 hour.
C20	indicates a charge rate of 7A/20 or 0.35A (350ma) is recommended.
to 1.75VDC	indicates the minimum voltage for this battery is 1.75V per cell. This would work out to (1.75x6=) 10.5V for the battery.
25C/77F	indicates that these values are valid for a battery temperature of 25C/77F As the temperature increases above 25C, the float voltage must be reduced
Float charge	in this case, 13.6-13.8V is the voltage the battery can be indefinitely float-charged at to keep it ready for use.
Cycle charge	the 14.5-14.9V value is the maximum charge voltage, the battery should only be charged for a short time at this voltage.
77F/25C	again, this is the battery temperature that these values are valid.

This particular battery is a newer design which recommends higher float and cycle charge voltages than most gel cells you will find. A more typical recommended float voltage is 13.4 to 13.5VDC and a maximum charge voltage of 14.1 to 14.4 VDC, also a minimum discharged voltage of 11VDC is more likely. As the battery temperature increases above (in this case) 25C, the float and cycle voltages must be reduced slightly. Likewise, as the battery temperature decreases below 25C, these two values can be increased slightly. You will have to refer to the manufacturer's data to find the temperature/voltage curves for your battery.

What all this means for amateur radio use

The most useful setup is to have one (or more) 12V gel cell battery packs always attached to a suitable 13.5VDC power supply - float charging. The 12V pack can be either two 6V batteries connected in series, or a single 12V unit. The 13.5VDC float voltage will keep the batteries ready for use, and they could be left attached like this for years without overcharging them. Most 13.8V power supplies have a voltage set control on the circuit board which can be used to reduce the voltage to 13.4 to 13.5VDC.

Note that if the gel cells you are using specifically state that you can use a higher float voltage such as 13.8V, then you can substitute this voltage where ever I mention 13.5V. I found an inexpensive 3A power supply in a metal case, probably made to power a CB radio, which had

an internal voltage adjustment. It is recommended to use a digital volt meter for measuring and setting these voltages, an analog meter can have an error of half a volt or more. If your batteries can use a 13.8V float charge, then you can use the option of connecting it (through a current limiting resistor) to your existing 13.8V ham station supply. Just make sure that the power supply circuit doesn't discharge the battery when it is turned off. Never consider using any type of automotive/motorcycle/ski-do charger on a gel cell – this is instant death for the battery. Some motorcycle batteries may look like a gel cell, but are a different type of sealed lead acid battery.

Problems can arise when one (or more) battery packs have been used and are in various states of discharge. Due to the recommended charge current of 350ma (some batteries can handle up to 500ma), a resistor must be installed in each battery's wiring harness to limit the maximum current to that battery. This resistor can be about 1 ohm, you may need to measure the charge current with a current meter. This method of connecting the discharged gel cell to 13.5V will generally work to return the batteries to near full charge and place them in a float charging state.

To bring a previously discharged battery up to full charge requires that you connect it to an approximately 13.8VDC power supply (through the current limiting resistor) for a period of time. You will have to monitor the battery terminal voltage to see when it reaches 13.8VDC and then immediately remove the battery from 13.8V and return it to the 13.5V float voltage (unless the float voltage for your battery is 13.8V).

To further complicate things, after many discharge/charge cycles, the different cells in the battery pack will begin to discharge/charge differently. To "equalize" the cells in the battery, it is temporarily connected to 14.1 to 14.4VDC for a short time (until the battery terminal voltage comes up to this value) and then connected to the 13.5V float supply. Some newer batteries such as the Sterling model, state that they can be float-charged at up to 13.8V, and that the equalize voltage can be 14.5 to 14.9V. The general rule is to equalize the battery for no more than 0.5 hours per ampere hour of battery capacity – but never more than 4.5 hours. For a 7 Ahr battery this would work out to a maximum equalize time of 3.5 hours.

If a gel cell battery is not kept connected to a float charger, then it must be charged up at approximately one month intervals. A new battery will come fully charged from the manufacturer, but internal leakage will discharge a fully charged gel cell battery in a matter of a few months which can permanently damage it. Do not leave a gel cell for any length of time in a discharged state (this can really shorten its life), recharge as soon as possible. If you are buying used Gel Cell batteries at a flea market for example, be sure to have your digital voltmeter with you (and a load such as a small automotive 12V light bulb). After a gel cell battery has been removed from the charger, the terminal voltage will gradually decrease to a nominal 12.6VDC. If you only buy used batteries equal to or higher than 12.6V, then you know it has recently been charged and is probably OK. If the terminal voltage is at or below 10V for a 12V battery or 5V for a 6V battery, then it is not worth buying. When you apply a load (use something that draws ½ amp or less – the 561 bulb draws about 1 amp), the voltage should sag very little.

Currently the setup I use can charge/float charge at least 4 battery packs (each made up of two 6V batteries taped together and connected in series). I have my power supply set at about 13.6V output, and each battery is charged through a current limiting "resistor". This "resistor" limits the current to around 350ma to a discharged battery.

The advantage of this configuration is that I can attach fully discharged and fully charged batteries at the same time. The addition of diodes in series with each resistor (set the supply float voltage 0.7V higher) would prevent the charged packs from trying to charge the discharged ones – this could occur if the power supply AC was turned off (power failure). Rather than find 1 ohm resistors, I use type 561 automotive 12V light bulbs from Canadian Tire (part number 20-2651) which have a cold DC resistance of about 1 ohm and appear to limit the maximum charging current to an optimum 300 to 400 ma. The added advantage is short circuit protection – if the wires which are attached to the battery are accidentally shorted together, all that happens is that the light comes on. If you wish to add diodes, type 1N4001 will work well.

Once the terminal voltage on the recharging battery has reached 13.6V, I can use a (500ma or less) "wall-wart" DC supply that I have added several diodes in series and a resistor to reduce the no-load output voltage to about 14.4V; to equalize my battery if I wish. I connect a volt meter where I can keep an eye on it and disconnect the battery when it reaches 14.4 VDC, I then reconnect it to the 13.6V supply; where it remains connected until I next use it.

Note that a gel cell battery is not designed for high current applications (use a liquid SLA battery for this). A fuse should be installed to prevent high current discharge, for example a 10 amp or smaller fuse for a 7Ahr battery pack. If you are using two 6V batteries, the fuse holder can be used to connect them in series.

In an emergency (or if no other means is available), recharging a gel cell can also be done from an automobile lighter outlet (through a current limiting resistor). Typically the car voltage will be between 13.8 and 14.5VDC with the engine running – just don't leave it connected too long (check the gel cell terminal voltage). Again you can add a diode in series if you find that the alternator voltage is a little high (maybe even a switch to bypass the diode if equalization is required). Also, don't leave the gel cell plugged into the lighter outlet when the engine is off or when you are starting the engine. There is one advantage to adding a diode, the gel cell can't discharge into the car electrical system, and it will only charge when the car voltage is above 14.2V which would allow you to keep it plugged in all the time.

In the first two charger designs given below, there is still a requirement to limit charge current. If the gel cell has been fully discharged (10.5 to 11 VDC), it may attempt to recharge at too high a current level when connected to the 13.5 VDC supply, so a current limiting resistor/light bulb at the power supply output may be required.

In the first circuit which uses a LM7812 with two diodes to raise the output from a regulated 12.0V up to approximately 13.4V; a third diode could be added in series to raise the output another 0.7V. This would allow you to have more than one battery pack connected, each through its own diode and resistor.

In the second circuit, resistor R2 could be replaced by a 1K variable resistor to allow the output to be adjustable to a higher voltage.

The third circuit is an advanced design using the MAX712 battery charging IC.

Schematic for 12 v Gel Cell charger, by KB2OTY



This will charge gel cells and maintain a float charge of 13.4 volts.

The bridge rectifier will accept an input of either AC or DC from the wall wart. With the rectifier bridge on the input you don't have to worry about the output polarity of the wall wart.

The diodes raise the ground terminal of the 7812 about 1.4 volts above ground. Each diode has a .7 volt drop. Therefore 12 + .7 + .7 = 13.4 volts.

Gel cells should normally be charged at 1/10 to 1/20 their rated output.

One added component - a diode (such as a 1N4001 or 1N4002) – is needed to protect the 7812 regulator from damage when the input voltage is disconnected while the battery is being charged. Connect it between the input and output pins of the 7812 (stripe facing the input pin). Normally the input voltage is at least 3 volts higher than the output, if the output is higher than the input, the diode will shunt the current around the 7812. This scheme is used in the second charger circuit on the next page. <VE3RRD>

The data sheet for the LM7812 can be found at http://www.national.com/ds/LM/LM340.pdf#page=2

LM317T Variable Voltage Regulator

The LM317T is a adjustable 3 terminal positive voltage regulator capable of supplying in excess of 1.5 amps over an output range of 1.25 to 37 volts. The device also has built in current limiting and thermal shutdown which makes it essentially blow-out proof.

Output voltage is set by two resistors R1 and R2 connected as shown below. The voltage across R1 is a constant 1.25 volts and the adjustment terminal current is less than 100uA. The output voltage can be closely approximated from Vout=1.25 * (1+(R2/R1)) which ignores the adjustment terminal current but will be close if the current through R1 and R2 is many times greater. A minimum load of about 10mA is required, so the value for R1 can be selected to drop 1.25 volts at 10mA or 120 ohms. Something less than 120 ohms can be used to insure the minimum current is greater than 10mA. The example below shows a LM317 used as 13.6 volt regulator. The 988 ohm resistor for R2 can be obtained with a standard 910 and 75 ohm in series.

When power is shut off to the regulator the output voltage should fall faster than the input. In case it doesn't, a diode can be connected across the input/output terminals to protect the regulator from possible reverse voltages. A 1uF tantalum or 25uF electrolytic capacitor across the output improves transient response and a small 0.1uF tantalum capacitor is recommended across the input if the regulator is located an appreciable distance from the power supply filter. The power transformer should be large enough so that the regulator input voltage remains 3 volts above the output at full load, or 16.6 volts for a 13.6 volt output.



The LM317 data sheet can be found at http://www.national.com/pf/LM/LM317.html

12V Gel Cell Charger by N1HFX

Recently, a fellow amateur was looking for a gel cell charger which would first charge at a fixed rate and then later switch to a trickle charge when the cell was fully charged. After reviewing several catalogs and web sites, the MAX712 IC was discovered. This IC meets all the requirements for almost any type of battery charging system. The circuit in Figure 1 was designed specifically for 12 volt gel cells.

When a discharged gel cell is connected, the charger goes into a fast charge mode at a fixed rate of 400 ma. After the chip detects the voltage leveling off or when 4 1/2 hours has elapsed. (which ever happens first.) the fast charge will stop. After the fast charge has ended, the IC goes into a trickle charge rate of about 50 ma. This trickle charge continues until 13.8 volts is reached which will stop all charging current since the cell is now fully charged. If the cell voltage should drop for any reason, either a fast charge or trickle charge (IC will detect what is needed) will start again.

When constructing this circuit, be sure to attach a small heat sink to Q1. Apply a DC (partially filtered) voltage of at *least* 15.3 volts. The voltage must never go below this level even under load conditions. Many of the DC wall transformers available will work just fine as long as they meet the minimum voltage requirement. The input voltage can be as high as 24 volts. If the input voltage must be in the 30 volt range, increase R1 to about 820 ohms.

The output voltage must be aligned prior to use. Disconnect the battery from the circuit and apply power. Connect a digital volt meter or other accurate volt meter to pin 2 (positive lead) and to pin 12 (negative lead). Adjust R7 until exactly 13.8 volts is read.

Because this circuit will not overcharge a gel cell, the battery can be connected indefinitely. This circuit is designed primarily as a 12 backup system and can be connected to the load provided the device to be powered only draws current during power line interruptions. Use a diode from the battery to load if needed. This circuit makes an excellent battery backup to an amateur transceiver.

The MAX712 IC and the .62 ohm resistor are available from Digi-Key, 701 Brooks Ave, Thief River Falls, MN 56701 (1-800-344-4539). Order part numbers MAX712CPE-ND and 0.62W-1-ND respectively. All other parts are available at Radio Shack.

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PARTS LIST

C1	MAX712 Battery Fast-Charge Controller IC (Cost is \$6.27 from Digi-Key)
R1	680 ohm 1/2 watt resistor (Blue Gray Brown)
R2	150 ohm resistor (Brown Green Brown)
R3	68K resistor (Blue Gray Orange)
R4	22K resistor (Red Red Orange)
R5	.62 ohm 1 watt resistor (Blue Red Silver) (Cost is 27 cents from Digi-Key)
R6	1.8K resistor (Brown Gray Red)
R7	10K PCB trimmer resistor (103)
R8	470 ohm resistor (Yellow Violet Brown)
C1	1 microfarad tantalum capacitor (observe polarity)
C2,C4	.01 microfarad capacitor (103)
C3,C5	10 microfarad electrolytic capacitor (observe polarity)
Q1	TIP42 PNP transistor or similar (attach heat sink)
D1	1N4001 Diode (observe polarity)
LED1,LED2	2 volt standard LED (observe polarity)



Figure 1