How To Fix Your NiCd Battery

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By H.Khan

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INTRODUCTION

This book will give you the required information on your NiCd batteries to help you better understand the lifecycle of NiCd. It will also show you how to re-energize and revive these batteries through the “RVD” (Re-vitalization through Vaporization of Dendrites) process. We will also discuss the effect of RVD process on the NiCd. We strongly suggest that you read the whole book before subjecting your NiCd batteries to the RVD process.

At the end of their usual life-cycle, NiCd batteries often die in such a way that they no longer take a charge and have zero voltage. This usually means they're shorted out by crystal dendrites growth. We will explain what these crystals and how they are formed. By eliminating the accumulated dendrites, the NiCd batteries can be given extended lease on life! We will show you how desirables results can be achieved through the RVD process. The RVD process works on a simple principle of using electric pulses to vaporize crystal dendrites from the cell plates, thus making the battery rechargeable again. One can use a car battery as a power source. Other choices might include a battery charger, a DC power supply, a welder, or almost anything with some DC voltage. Charged-up capacitors are also useful to provide the required surge for the RVD process as quick electrical pulses can be sent through them while still limiting the maximum surge.

We live in the wireless age. Cordless drills, cellular and portable phones, Electric toothbrushes, cordless shavers, and many other home appliances rely on rechargeable batteries to keep them wireless. We all have faced the dilemma of what to do with a given appliance, big or small, when the batteries run out of juice. We want to be fiscally responsible and environment friendly, but what good is a device without power? Should we throw it out and just buy ourselves a new gadget? Most of us do just that as cost of replacing the battery, often times, is so ridiculously high that getting a new device is a no-brainer. Well, not anymore!

Now you can give a new life to your NiCd batteries that don't hold charge by re-energizing them using our RVD process. 99% of NiCad batteries can be re-incarnated and given a new lease on life including: Black and Decker, Dewalt, Ryobi, Panasonic, Makita, Porter Cable, Bosch, Craftsman etc .

When a Firestorm or Versapak NiCad battery would no longer hold a charge or is close to being useless, just apply the RVD process. Your wallet and the environment would thank you!

We hope you will find the information useful, and will take the safety precautions during all your RVD processes. Special precautions must be taken to avoid NiCd battery ***fire up or explosion*** that can cause serious injuries.

OVERVIEW

Nickel Cadmium (NiCd) is one of the most established amongst the various commercially available rechargeable battery systems. The energy density of NiCd batteries are lower than the newer battery systems, such as Nickel Metal Hydride and Lithium-Ion. However, the robust NiCd batteries are very durable, reliable, easy-to-use and economical. They remain a popular choice for many electrical and electronic applications that emphasize lower cost while maintaining good performance.

NiCd PRINCIPLE

As with any other rechargeable battery systems, NiCd batteries operate on the principle that electrochemical reactions at each of the electrodes are reversible; this enables energy to be stored during charging and released during discharging. In the event of deep discharge, depreciation of battery performance may occur. To minimize the possibility of damage, the "antipolar material" (i.e. the active material used in the negative electrode) is added in the positive electrode to prevent the generation of hydrogen gas, which can increase the internal pressure and may destroy the seal or at least cause water loss with resealing valves.

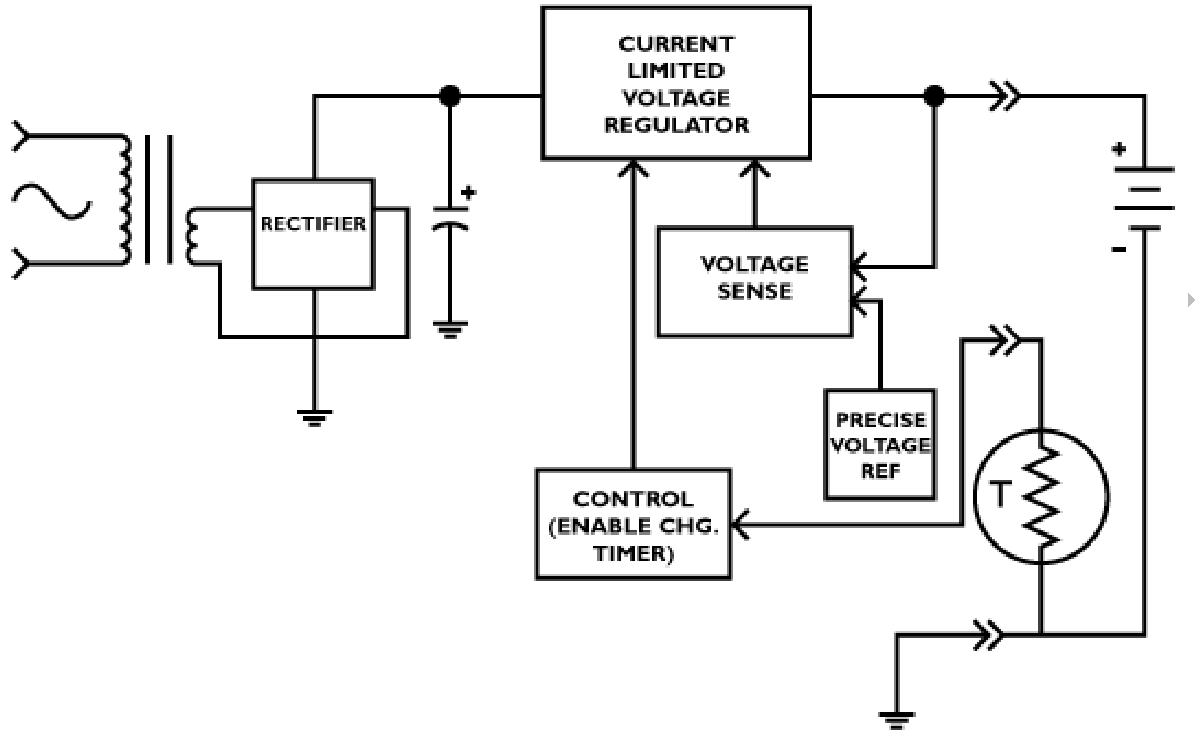
NiCd PERFORMANCE

There are five major characteristics of NiCd battery that we should look at, which are charging, discharging, storage, cycle life and safety.

CHARGING

A battery should always remain cool during charging because high temperatures shorten battery life. Some temperature rise with nickel-based batteries cannot be avoided. The time during which the battery temperature remains elevated should be as short as possible. The temperature rise occurs in the second half of the charge cycle. The battery should cool to room temperature when on trickle charge. If the temperature remains above room temperature after a few hours in ready mode, the charger is performing incorrectly. In such as case, remove the battery when ready.

Most rechargeable cells are equipped with a safety vent to release excess pressure if over-charged. The safety vent on a nickel-based cell opens between 10-13 Bar (150-200 psi). (The pressure of a car tire is about 2.3 Bar or 35 psi.) With a reseal able vent, no damage occurs after venting. Some electrolyte is lost and the seal may leak afterwards. A white powder accumulating at the vent opening indicates venting activities.

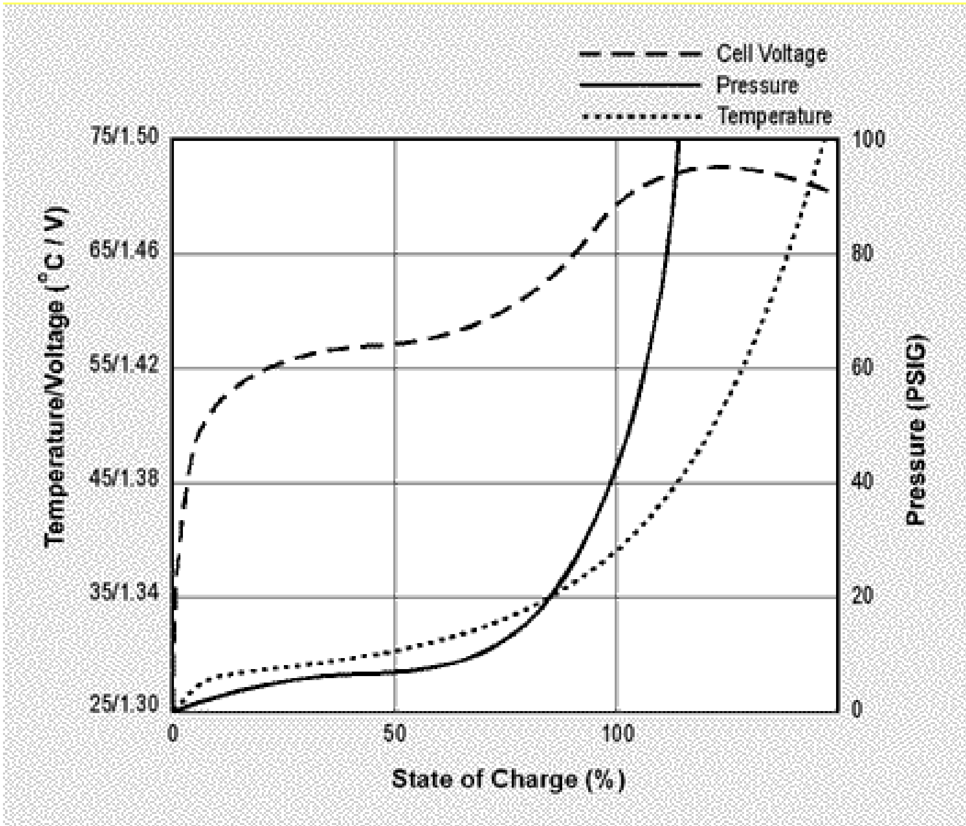


CHARGING METHOD

The main concern in charging a NiCd battery is the build-up of temperature and internal pressure due to high overcharge rates. The cell design applies the concept of oxygen recombination in lowering the battery's internal oxygen level during standard charging. However, if the cell is subjected to severe charging conditions (such as overcharging at a current rate over 1C), the rate of oxygen evolution from the positive electrode increases rapidly, exceeding the recombination reaction rate. As the oxygen recombination reaction is exothermic, this results in excessive oxygen pressure and increased temperature. The excessive pressure will then be released through the safety vent causing a reduction in the cell electrolyte; the excessive heat will eventually degrade the cell's internal contents. These two factors are considered to be the major limitations to the battery's service life.

The overall charge efficiency of nickel-cadmium is about 90% if fast charged at 1C. On a 0.1C overnight charge, the efficiency drops to 70% and the charge time is 14 hours or longer.

The C-rate is a unit by which charge and discharge currents are scaled. A charge current of 1000mAh, or 1C, will charge a 1000mAh battery in slightly more than one hour. A 1C discharge lasts one hour.



Charge characteristics of a nickel-cadmium cell.

In the initial 70% of charge, the charge acceptance of a healthy nickel-cadmium battery is close to 100%. The battery remains cool because all energy is absorbed. Currents of several times the C-rating can be applied without heat buildup. Ultra-fast chargers use this phenomenon to charge a battery to the 70% level within minutes. Past 70%, the battery gradually loses the ability to accept charge. The pressure and temperature increase. Figure below illustrates the relationship of cell voltage, pressure and temperature while nickel-cadmium is being charged.

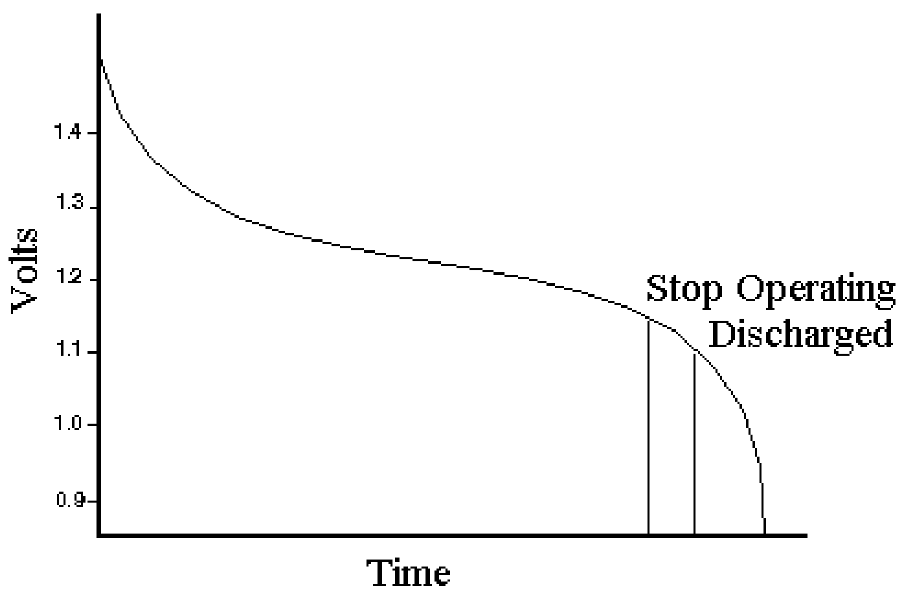
CHARGING GUIDELINES

- Avoid getting the battery too hot during charge. The temperature should only rise for a short moment at full charge, then cool off. Nickel-based batteries prefer fast-charge. Lingering slow charges cause crystalline formation (memory).

- If not used immediately, remove the battery from the charger and apply a topping-charge before use. Do not leave nickel-based battery in the charger for more than a few days, even if on trickle charge.

DISCHARGING

The nominal discharge voltage of a NiCd battery is 1.2V at 0.2C discharge which is affected by current and ambient temperature. The discharge voltage is depressed at lower temperature. This is because NiCd batteries employ an aqueous electrolyte system, resulting in decreased ionic mobility at lower temperatures. At higher currents, the discharge voltage is also depressed since the electrodes are more polarized.



STORAGE

The battery loses its energy during storage even without loading. The energy is lost through small, self-discharge currents inside the battery. The nickel hydroxide is relatively unstable in a charged state and tends to return to a discharge state with the slow release of oxygen. The released oxygen then reacts with the cadmium in the negative electrode, thus establishing an internal discharge path. The reaction rate increases with higher temperatures.

CYCLE LIFE

Cycle life is the number of charges and discharges a battery can achieve before the discharge capacity. Cycle life is affected by ambient temperature, as well as depth of charge and discharge. A common phenomenon is faster self discharge rate upon cycling due to formation of cadmium dendrite, especially at the end of cycle life.

SAFETY

If pressure inside the battery rises as a result of improper use, such as overcharge, short circuit, or reverse charging, a resealable safety vent will function to release the pressure, thus protecting the battery from bursting. However you must take all safety precautions when handling a battery.

NiCd HANDLING

Knowledge of battery maintenance is crucial to a working battery, helping to provide a longer period of operation. On the other hand, improper battery handling or maintenance may lead to unnecessary battery defects or problems, such as electrolyte leakage or cell bulging. In order to get the most out of using NiCd rechargeable batteries, special care should be considered.

NiCd MAINTENANCE

Periodic visual inspection of the battery is recommended. It is also advisable to store the battery at room temperature, with low humidity, when the battery is not expected to be used for a long period of time; the aim of which is to prevent cell leakage and rust.

Bear in mind that self-discharge has to be taken into consideration when storing a charged battery. The remaining battery capacity should be at least 50% after a month of storage at room temperature for a fully charged battery. High storage temperatures will accelerate the self-discharge, and reduce the remaining capacity.

In order to maintain battery performance when being stored for an extended period of time, cycling (charging and discharging) of the battery within a 6 to 9-month period is recommended. This procedure is recommended to maximize performance of the battery.

Memory: MYTH OR FACT?

The word 'memory' was originally derived from 'cyclic memory'; meaning that a nickel-cadmium battery could remember how much energy was drawn on preceding discharges. On a longer than scheduled discharge, the voltage would rapidly drop and the battery would lose power. Improvements in battery technology have virtually eliminated this phenomenon.

The problem with nickel-cadmium is not so much the cyclic memory but the effects of crystalline formation. The active cadmium material is present in finely divided crystals. In a good cell, these crystals remain small, obtaining maximum surface area. With memory, the crystals grow and conceal the active material from the electrolyte. In advanced stages, the sharp edges of the crystals penetrate the separator, causing high self-discharge or electrical short.

When introduced in the early 1990s, nickel-metal-hydride was promoted as being memory-free. Today, we know that this chemistry is also affected but to a lesser degree than nickel-cadmium. The nickel plate, a metal that is shared by both chemistries, is partly to blame. While nickel-metal-hydride has only the nickel plate to worry about, nickel-cadmium also includes the memory-prone cadmium plate. This is a non-scientific explanation why nickel-cadmium is affected more than nickel-metal-hydride.

The stages of crystalline formation of a nickel-cadmium cell are illustrated in Figures below. The enlargements show the cadmium plate in a proper functioning crystal structure, crystalline formation after use (or abuse) and restoration.

New nickel-cadmium cell. The anode is in fresh condition. Hexagonal cadmium hydroxide crystals are about 1 micron in cross section, exposing large surface area to the electrolyte for maximum performance.

Cell with crystalline formation. Crystals have grown to 50 to 100 microns in cross section, concealing large portions of the active material from the electrolyte. Jagged edges and sharp corners may pierce the separator, leading to increased self-discharge or electrical short.

Restored cell. After RVD, the crystals are reduced to 3 to 5 microns, an almost 100% restoration.

Crystalline formation is most pronounced if a nickel-based battery is left in the charger for days, or if repeatedly recharged without a periodic full discharge. Since most applications do not use all energy before recharge, a periodic discharge to 1 volt per cell (known as exercise) is essential to prevent memory.

Nickel-cadmium in regular use and on standby mode (sitting in a charger for operational readiness) should be exercised once per month. Between these monthly exercise cycles, no further service is needed. Based on the reduced crystalline buildup, applying a full discharge once every three months appears right.

RESTORE YOUR BATTERY THROUGH RVD PROCESS

According to experts, "*Revitalization through Vaporization of Dendrites (RVD) Process*" works reliably ONLY with nickel-cadmium cells. There are no apparent side effects to RVD, however, the battery manufacturers remain non-committal. No scientific explanation is available and only little is known.

The RVD process may be repeated until the NiCd battery holds a dependable charge but wait 20 minutes before starting over the RVD. It allows the NiCd battery to cool, if you repeat the procedure without waiting, the cells could explode inside the battery.

TOOLS YOU NEED

GLOVES

VOLT METER

SAFETY GOGGLES

BATTERY CHARGER

DEAD NICAD BATTERY

ELECTRIC WIRE (Lamp cord thickness or larger)

ALLIGATOR CLAMPS OR ELECTRIC TAP (Optional)

VOLTAGE SOURCE FOR RVD process (DC Power Source; It could be your car battery, other tool batteries, welder or battery charger)

RVD CHART

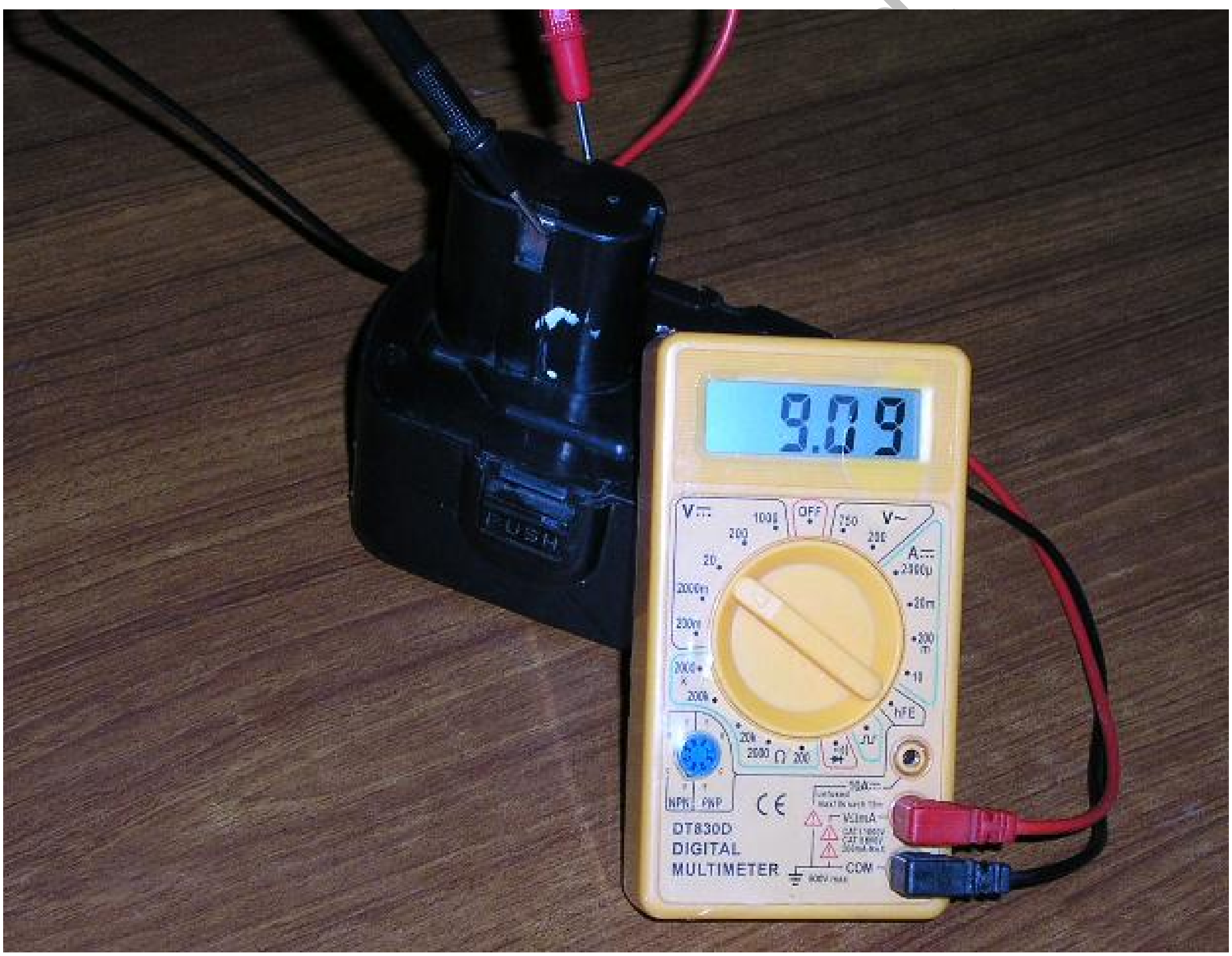
Before start the procedure please check the chart below to determine the RVD process time as per your tool battery and power source.

Tool Battery	1.1 to 1.2 Volts	1.3 to 3.6 Volts	3.7 to 7.1 Volts	7.2 to 9.6 Volts	9.7 to 12 Volts	12.1 to 14.5 Volts	14.6 to 18.5 Volts	18.6 to 30 Volts
Power Source 12 Volts	RVD Time 2 Seconds	RVD Time 5 Seconds	RVD Time 7 Seconds	RVD Time 10 Seconds				
Power Source 24 Volts	RVD Time 1 Seconds	RVD Time 3 Seconds	RVD Time 5 Seconds	RVD Time 6 Seconds	RVD Time 8 Seconds	RVD Time 9 Seconds	RVD Time 10 Seconds	
Power Source 36 Volts			RVD Time 1 Seconds	RVD Time 3 Seconds	RVD Time 4 Seconds	RVD Time 5 Seconds	RVD Time 6 Seconds	RVD Time 8 Seconds

HOW TO INITIATE THE RVD PROCESS

STEP1.

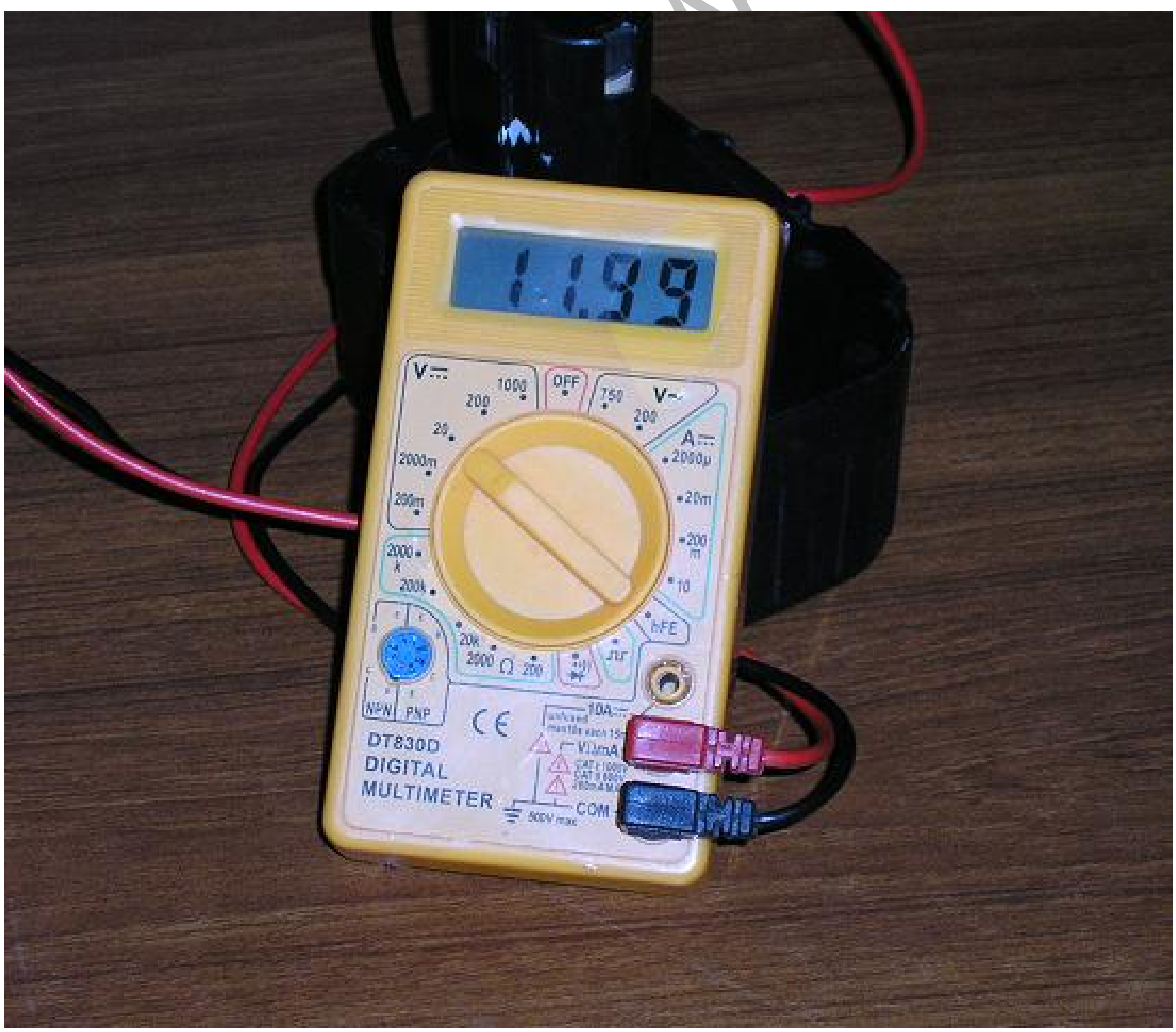
CHECK VOLTAGE AND POLARITY (+, -): First charge your NiCd battery for 4 hours on regular charge or 1 hours on rapid charger, to make sure it's charged. If you suspect your charger isn't working you can trickle-charge it from a different voltage source. Now you are sure your battery has had a fair chance to charge, check the voltage with your multimeter. If the voltage is lower than the label says it should be, then it should be subjected to the RVD process.



An 18Volt Battery Before Charge.

Check Polarity (+,-): Make sure you have identify the positive and negative terminals of the tool battery. You can see a "-" and "+" on tool battery terminal. If you cant see them, use multimeter. Sometimes NiCd battery has more then 2 terminals, if this is the case, then you have to subject only 2 terminals that register voltage to the RVD process.

PLEASE NOTE, RVD WILL NOT WORK IF PERFORMED BACKWARD, AND TOOL BATTERY CAN BE EXPLODE.

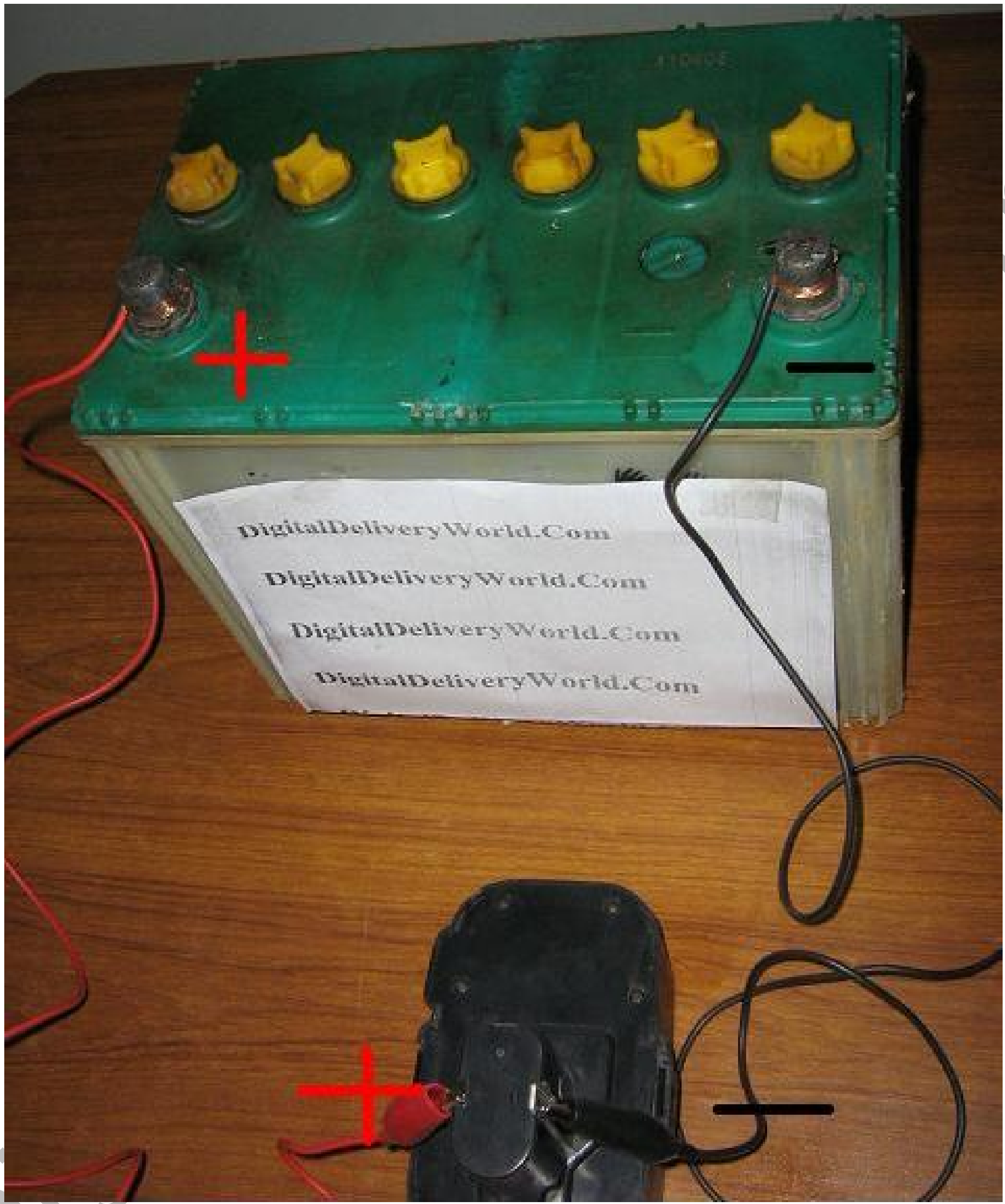


An 18Volt Battery After 4 Hours Charge.

STEP2.

ARRANGE POWER SOURCE (From 1.1Volts to 9Volts)

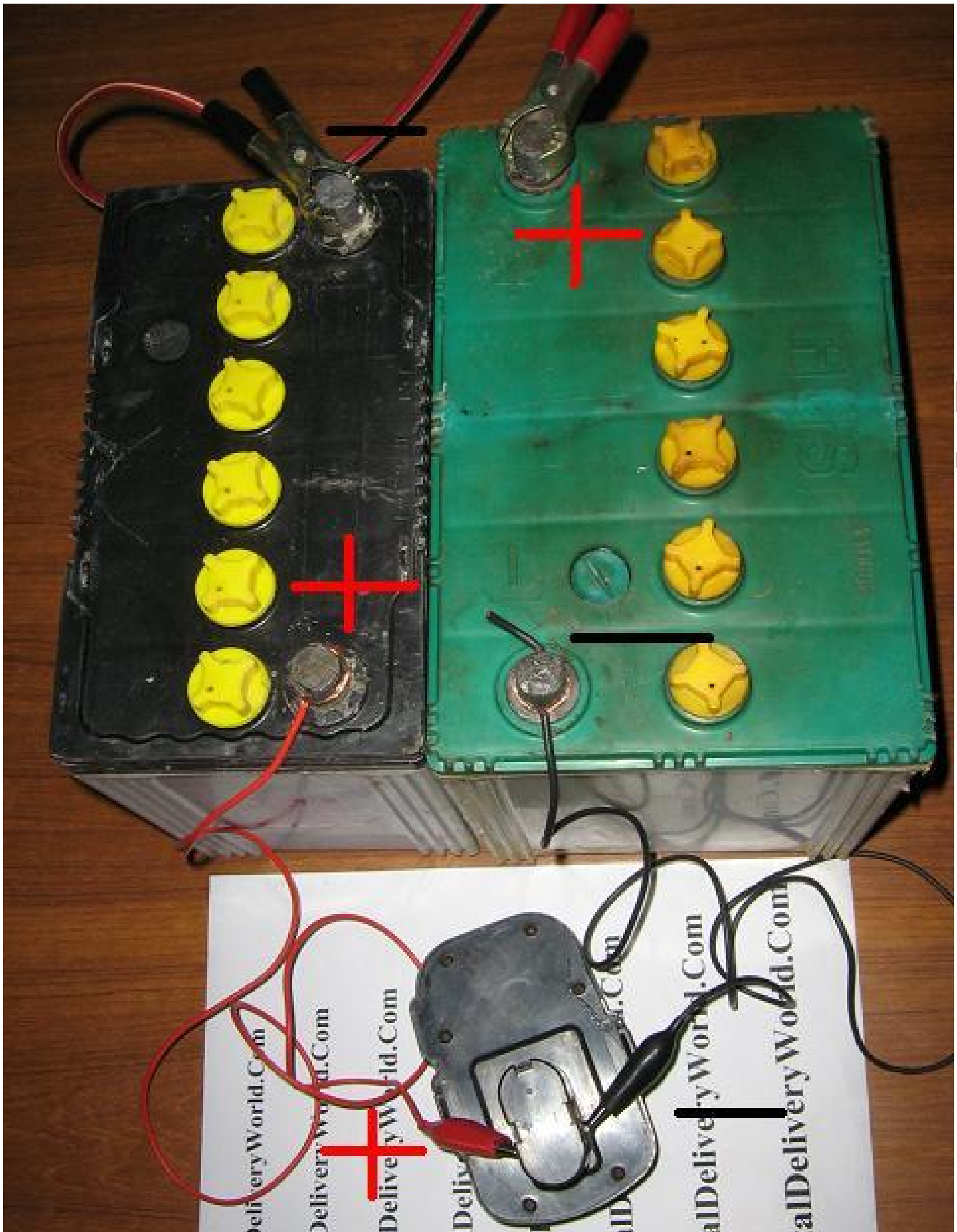
Now arrange the Power source according to your requirement.



RVD Set up for tool batteries from 1.1 to 9 volts.

In this setup power source is 12 volt battery, This setup can work for any tool battery from 1.1 to 9 volts. As you can see we have run 2 wires from the power battery. Black wire is connect to negative (-) terminal (also known as ground) of the battery, while red wire is connect to positive (+) terminal. Both wires should be strapped on the ends.

Now connect the other end of the negative wire on the tool battery's negative terminal. You can use the electric tap to hold the wire on power battery. Hold the positive wire for RVD. Now you are ready for RVD process. **Go to Step 3.**



RVD Set up for tool batteries from 1.1 to 18.5 volts.

In this second setup power source is 24 volts, To achieve 24 volts we have arrange 2 batteries (each one is 12 volts) in series. This setup can work for any tool battery from 1.1 to 18.5 volts. To arrange the batteries in series, connect one end of a wire to positive terminal of battery "A" (the first battery) and second end to the negative terminal of battery "B" (the second battery). Then we have run 2 wires from these batteries for RVD. Black wire is connect to negative (-) terminal (also known as ground) of battery "A" (first battery), while red wire is connect to positive (+) terminal of battery "B" (second battery). Both wires should be strapped on the ends.

Now connect the other end of the negative wire on the tool battery's negative terminal. You can use the clamps to hold the wire on power battery. Hold the positive wire for RVD. Now you are ready for RVD. **Go to step 3.**

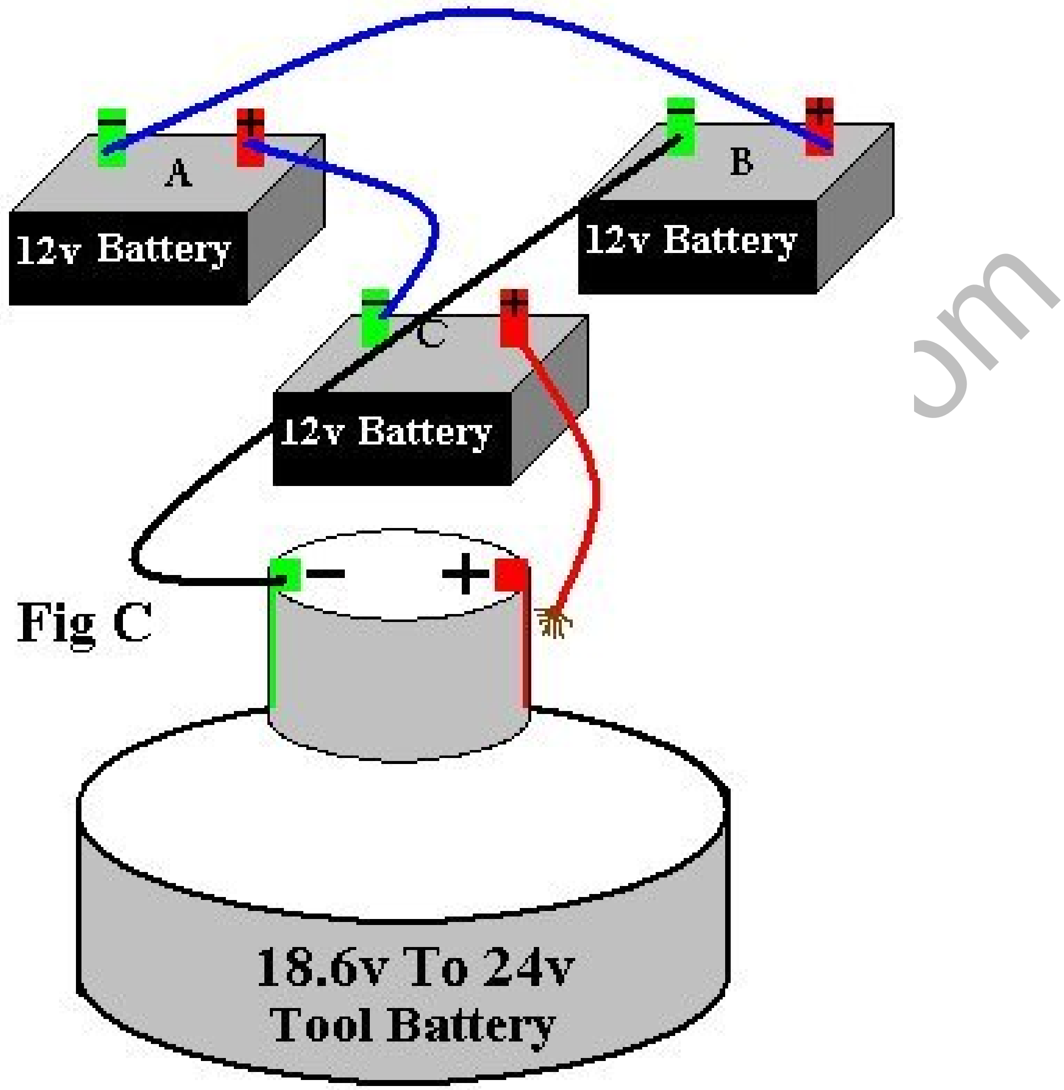


Fig C

Set up for tool batteries from 18.5 to 24 volts.

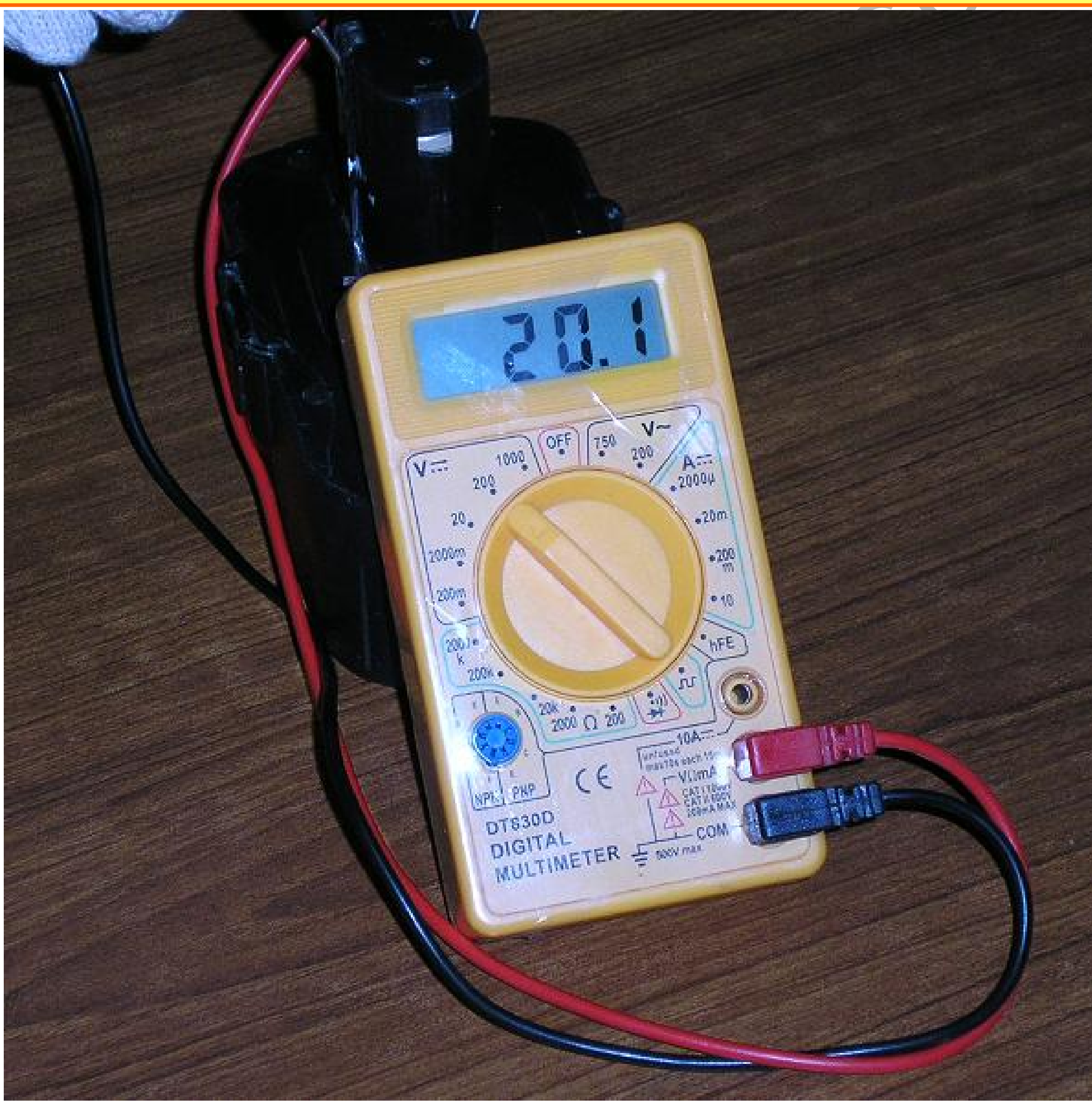
In this third setup power source is 36 volts, To achieve 36 volts we have arranged 3 batteries (each one is 12 volts) in series. This setup can work for any tool battery from 1.1 to 24 volts. To arrange the batteries in series: Connect one end of a wire to negative terminal of battery "A" (the first battery) and second end to the positive terminal of battery "B" (the second battery). Now take second wire and connect one end to positive terminal of battery "A" (the first battery) and other end to negative terminal of battery "C" (the third battery). Then we have to run 2 wires from these batteries for RVD. Black wire is connected to negative (-) terminal (also known as ground) of battery "B" (Second battery), while red wire is connected to positive (+) terminal of battery "C" (the third battery). Both wires should be strapped on the ends.

Now connect the other end of the negative wire on the tool battery's negative terminal. You can use the clamps to hold the wire. Hold the positive wire for RVD. Now you are ready for RVD. **Go to step 3.**

STEP3. START RVD

At this point make sure you have taken all safety measures i.e. goggles, gloves on. Hold the negative end to the NiCd tool battery's minus terminal, Tap the positive end of your car battery to the "plus" terminal of your NiCd battery 2 - 3 times per second. For duration of time please check the RVD time chart above.

At this point make sure you have taken all safety measures i.e. goggles, gloves on.



An 18Volt Battery After RVD.

Try out your battery. It ought to be much better almost immediately. Once again check the voltage of your NiCd battery with voltage meter, the voltage is now equal to rated voltage or high. If its not, then wait for 20 minutes and repeat the RVD process. Apply RVD to the tool battery without waiting may result in the cell explosion, so take special caution while repeating the RVD. The success ratio of RVD process is almost 99%. If after 15 RVD attempts, your battery is still not working, it means they can not be revitalized fix again. Most tool batteries need one or two RVD cycles, but extremely damaged batteries may take up to 15 cycles.

After the this process allow 20 minutes to cool down the NiCd battery, and then place it on charger for 3 to 4 hours. Check the volts with volt meter, write it down, and let the battery sit on room temperature. After 2 hours, check the volts again to make sure that there is no drain. If you notice a low volt, it indicates a short in NiCd battery cell/s. Its very rare, but it could happen. In this case you have to open the battery pack and follow the procedure below.

However in very rare case, after RVD the tool battery about 15 times, your battery is still not charging, then you are either not performing the procedure correctly, or your battery has gone too far. The most common mistake is improper polarity, if you are applying the tool battery backwards this process will not work.

REBUILDING NiCd RECHARGEABLE BATTERY PACKS

Special Thanks to Dave Bonandrini for this section.

Besides saving money, why would I want to rebuild a battery pack?

Reason number one is that usually only one or two cells in the whole pack are bad. So when you throw them out (please recycle your batteries!) you are throwing out twelve or more batteries that are still good!

Reason number two is that you can put higher capacity batteries in the packs and create packs with up to four times the runtime of the originals.

HOW DO I KNOW WHEN MY PACK NEEDS REBUILDING?

When you only get a few minutes of runtime out of your pack, you get that sinking feeling that you are out another $90 bucks. But you can do some checking long before it gets this bad with a Volt Meter.

When you first take a pack off the charger it should read higher than the voltage printed on the pack. NiCd batteries loose about 25% of their charge in a month of sitting on a shelf. This is called “self discharge”. So, you really need to check your pack with a fresh charge.

A good condition battery that is 18V might read 21V fresh from the charger. A 14.4V might give you 16V. As long as it is higher than the rating, you are in good shape.

Your battery that only gives a few minutes of runtime might read only 10V when it is rated for 14.4V, this is a problem.

A 14.4V pack that reads over 16V — very nice!

A 14.4V pack that reads 12V fresh off the charger. This is not good.

HOW DO I OPEN THE PACK FOR SERVICE?

There are some screws along the pack that allow it to be opened. Sometimes they are Star or Security head screw. If you can't find a way to get a grip on them, get a Security bit set at Harbor Freight. Rub your fingers over the label to see if some of the screws are hidden underneath it.

On some cheaper import packs, they are glued together and have to be carefully cut apart. Don't even think of trying this without a vise to securely hold the pack. Run a brand new razor blade along the seam until you can rock the pack apart. This will take some time. But it will give you time to think about buying American tools too.

WHAT IS INSIDE?

Inside you will find a number of "Sub C" battery cells. Each cell reads about 1.2V. So an 18V pack will have 15 cells in it. The cells are taped or shrink-wrapped together, to keep vibration from loosening the contacts. You will need to cut off this tape. You will rewrap it when you are done with the repair.

The cells inside a battery pack.

HOW DO I KNOW WHAT CELLS ARE BAD?

Again, we are going to use the Volt Meter. Place one lead at the bottom and top of each cell. Cells that read 1.3V (remember this is with a fresh charge) are good. You do not have to separate any of the cells to test them. Cells that read 1.1V are going and any cell under 1V is bad. Some cells may be totally dead and not read anything. With a Sharpie, mark good cells with a “G” and put an “X” on bad cells.

Showing Bad Cell.

You may think why bother replacing cells that are almost good, like the 1.1V ones. If you taking the time to do a quality repair, why would you want to repeat the same process in a few months when the cell finally goes? Do the job once, and do it right. But for any other reason you may RVD to them.

RVD THE BAD CELLS

When you identify the bad cell/s (with low voltage) you have to apply RVD to them, make sure you have identify the negative and positive end of each cell, because cells are rotated so the positive and negative must be identify correctly. Make sure you have taken all safety measures i.e. put your safety goggles and gloves on. Now use a 12 volt car battery to subject bad cell/s to RVD. Hold the negative wire to the negative side of the cell and then hold the positive wire to the positive side of the cell for 3 seconds. Not more then 3 seconds. Repeat the procedure for all bad cells.

DO NOT SUBJECT CELL TO RVD FOR MORE THAN 3 SECONDS.

Check the cells again. If its showing 1 volt or more, then your battery is good again.

Bad Cell After RVD - It's Good Now.

HOW DO I GET THE BAD CELLS OUT?

As you have probably noticed, the cells are spot welded together. I have never seen a pack where actual solder was used. Take a small, sharp wood chisel and push between the tab and the top of the battery. You may have to lift a little. Take your time on the first one; the rest will go like butter once you have the feel for it. Leave the tabs behind on the good batteries.

These cells have been removed. You can see the marks from the spot welds.

INSTALLING THE NEW CELLS

Using electrical tape, wrap the cells tightly so they will stay in place while you solder. This will be the cells "final resting place", so get the formation right, they have to fit back in the plastic housing. Remember these cells get warm in use, so use real UL listed tape, not masking tape or crap you got at the dollar store. Make sure you get the polarity right. All of the cells go together head to tail, positive to negative. Use solder with a low wattage iron. Heat the tab AND the battery top so you get a good joint.

When you are done, check the contacts at the top of the pack to make sure you get the correct voltage. If you get some odd reading, you have soldered one of the batteries in backwards! Fix this right away. If your spouse or kids put the pack in the charger, it could explode or cause a fire.

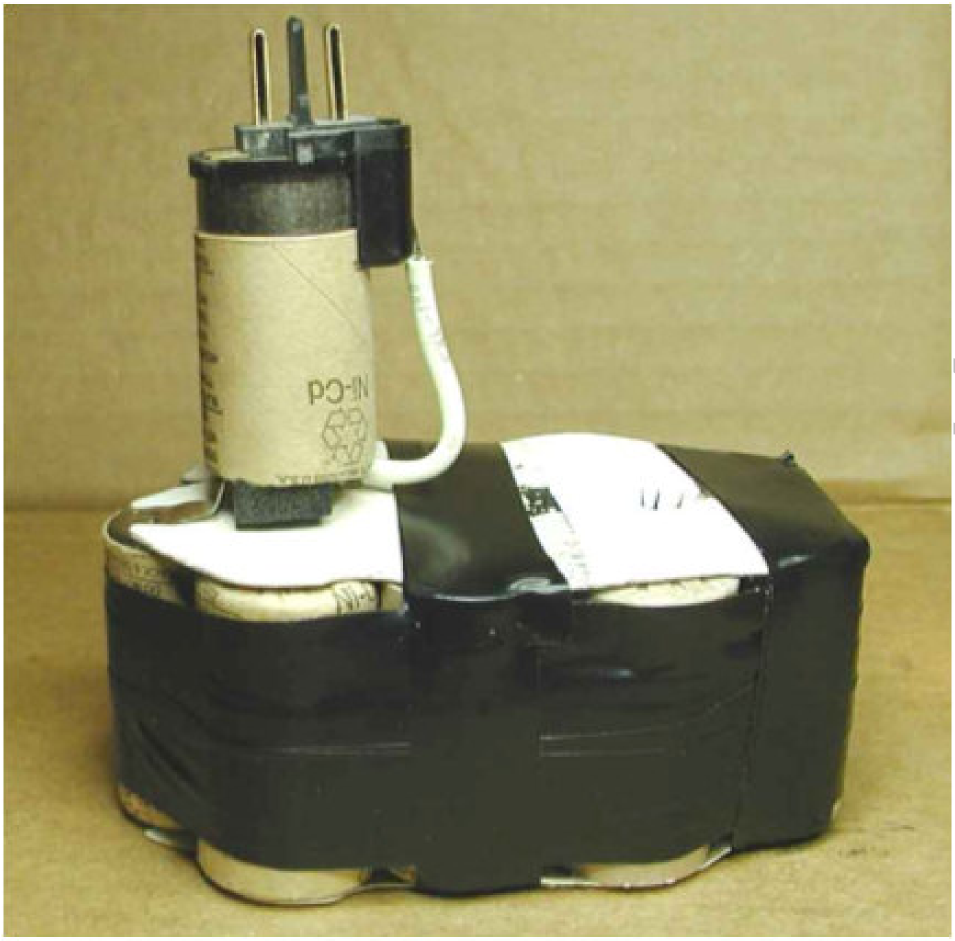
Here the new cells have been installed.

THE BIG WRAP UP

Now all you have to do is reassemble the pack. Make sure all the cells are wrapped together tight with electrical tape. They should not move or shift around. Screw everything back in place and test the contacts one more time for proper voltage.

If you had a pack that had to be cut apart to open it, use PVC cement to glue it back together.

Place the pack in the charger and charge it up. It may well be a good idea to keep an eye on it the first time; you can never be too safe.



All wrapped up and ready to go – Joey Ramone

WHERE DO I GET REPLACEMENT CELLS FROM - FOR FREE?

Remember earlier when I told you that most dead packs only have a few bad cells? All of your friends have dead packs sitting around their houses. Just ask them to give their dead packs to you. It does not matter if they have 9.6V, 18V or 24V; you are just going to take them apart for the 1.2V cells. Most people will never get around to taking those packs to the recycler, so you are doing them (and the Earth) a favor.

These packs have often been sitting for quite a while, so have your friend charge them up before you open them. Your own charger may or may not fit your friends pack. This way you can see which cells hold a charge.

WHERE DO I BUY CELLS FROM?

If you have burned every bridge between you and your so called friends, you may need to actually buy some cells. Or maybe you want to build a “super pack” with higher capacity cells that will outlast the manufacture’s original pack. The problem is that you can’t just call DeWalt and order cells; they want you to buy a $90 battery pack.

On the net, I found lots of places that sell “Sub C” NiCd cells.

www.hosfelt.com

www.allelectronics.com

www.bgmicro.com

www.ebay.com There were many high amp hour choices here.

www.onlybatteries.com

Many of these cells cost $2.50 each. Even if you had to buy 15 new ones, you would have spent less than $38 total. I have never seen a pack with more than three bad cells in it, so the average repair might be under $10, a handsome savings over the price of a new pack.

The higher the milliamp hour of the battery, the longer runtime it will provide. A 4500mAh battery will run three times longer than a 1300mAh battery. Many OEM packs are filled with 1200mAh batteries from the factory. Ones marked “Extra run time” often have 2400mAh batteries in them (like the DeWalt XRP packs). They usually don’t state the mAh anywhere on the packaging; you have to call customer service and get transferred around a few times.

HOW TO GET THE MOST OUT OF YOUR PACKS

- Keep batteries out of extreme heat or cold. High temperatures age the chemicals inside batteries prematurely.

- Never run a battery all the way down. The moment you notice a change or slowdown, it is time to swap packs.

- Top off batteries before storage. When done with the day’s work, recharge your packs before putting them away. Many modern chargers have a “deep-charge” mode that conditions batteries when left in the charger overnight. Consult your manual to see if your charger has this feature.

- Charge up side down. Your charger creates a lot of heat when it is charging, especially if the pack is really low. Flip the charger so the battery is on the bottom and the charger is on top. This lets the heat from the charger rise and dissipate without further heating the battery.

Save some coin and save the Earth at the same time.

Clear Skies,
-David Bonandrini

RVD OF VERSAPAK BATTERIES

Sealed batteries like the Versapak do not require any disassembly and can be RVD'd in seconds. VersaPak batteries have three 1.2 volt cells inside of them so they should register 3.6 volts. The versapak batteries are very simple to RVD. Simply hold the negative wire from the battery to the outside housing of the battery which is its negative or ground. Then rapidly RVD the positive wire to the inside of the battery for 3 seconds, but no more then that. Now it should register 3.6 volts or higher.

You can repeat the process one more time if necessary but wait 20 minutes before start the procedure again.

You can also use a jumper cable to do the RVD. First put on safety goggles and gloves. The + positive end of the Versapak battery is inside a hole on one end of the battery and the outside of the battery is negative. Take a bolt that would fit in the +positive hole and held the bolt in the jaws of the jumper cables. Then put the - negative jumper clamp around the battery itself. Stuck the bolt in the hole, you will see some small sparks. Your versapak is live again. Check the volts with volt meter.

Warning

If you are not completely sure what you are doing, don't apply what is described below. In any case we do not have any responsibility in any way to the consequences that this guide may have. Read it at your own risk. Please don't continue reading if you don't agree with the above.

How to rebuild a Li-Ion battery pack

Did you recently notice poor performance of your notebook Li-Ion battery? Don't be taken aback, this is happening even to the best battery! Now days Li-Ion batteries are widely used in portable devices due to there excellent energy to weight ratio and for the reason they are not suffering from "memory effect".

These two reasons make them the best choice on portable devices, but not suffering from "memory effect" doesn't mean it will last for ever! Chemical conversions inside the battery make it to produce electric energy but these chemical reactions aim to attenuate as time and charge cycles pass over.

When the battery life drops significantly it's time to search for a replacement, but you will recently find out that most of notebook batteries cost almost 1/3 to 1/2 the price of the laptop at the time you will need to replace the battery. So if you want to keep your laptop but don't want to spend much money for battery replacement it's time to think about rebuild it your own, replacing each individual cell inside the pack.

But before step on this you must consider many parameters messing around Li-Ion batteries, about the way they are charged and the way you must handle them. Special **precautions must be taken** to avoid Li-Ion battery **fire** up or **explosion** that can cause serious injuries. This is because Lithium when comes in contact with air burns violently.

In this article we will discuss how to handle Li-Ion batteries to avoid any malfunction, the precautions you must take, the way Li-Ion batteries are charged, the protection circuits used and finally you can find a step by step guide on how to reconstruct a Fujitsu - Siemens Lifebook S-Series **FPCBP25 battery pack**

This guide can also be read as a tutorial on how to rebuid other kind of Li-Ion battery packs except the one we will use here.

It's recommended to read the following details in order to understand how a Li-Ion battery must be handled to avoid any injury, before proceed to the reconstruction of the pack.

Overview

Li-Ion (and Li-Po) batteries are leading edge battery technology and consists ideal selection in use on portable computers and cellular phones due to their high energy density and high voltage. A typical Li-Ion cell is rated at 3,6V and this is three times more than the typical NiCd or NiMH cell voltage (1,2V).

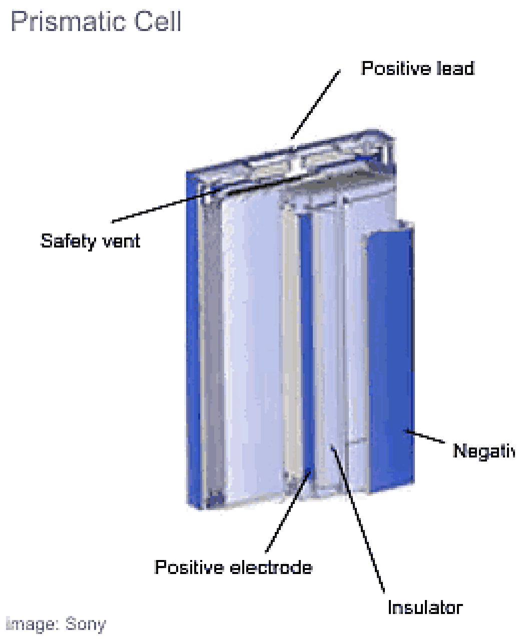
Structure

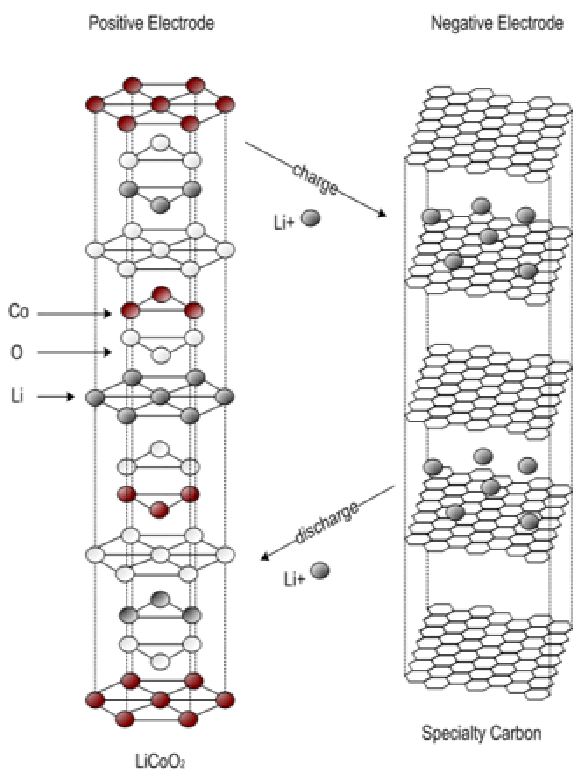
Li-Ion cell has a tree layer structure. A positive electrode plate (made with Lithium Cobalt oxide - cathode), a negative electrode plate (made with specialty carbon - anode) and a separator layer.

Inside the battery also exists a electrolyte which is a lithium salt in an organic solvent.

Li-Ion is also equipped with a variety of safety measures and protective electronics and/or fuses to prevent reverse polarity, over voltage and over heating and also have a pressure release valve and a safety vent to prevent battery from burst.

Never short circuit, reverse polarity, disassemble damage or heat over 100 degrees Celsius a Li-Ion cell. That can be really dangerous.





Working Principle

Lithium battery uses lithium cobalt oxide as positive electrode - cathode - and a high crystallized special carbon as negative electrode - anode.

Also an organic solvent specialized to be used with the specific carbon works like electrolytic fluid.

The chemical reaction that takes place inside the battery is as follows, during charge and discharge operation:

$$LiCoO_2 + C_6 \underset{\text{discharge}}{\overset{\text{charge}}{\rightleftharpoons}} Li_{1-x}CoO_2 + C_6Li_x$$

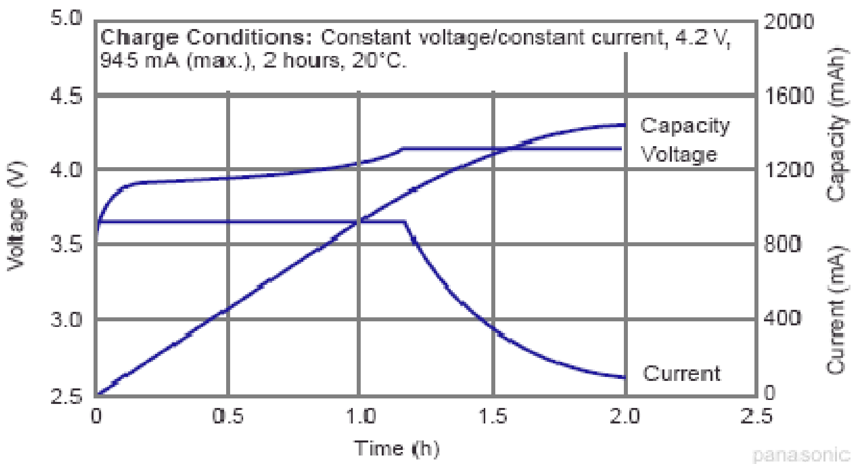
The main principle behind the chemical reaction is one where lithium in positive electrode material is ionized during charge and moves from layer to layer in the negative electrode (as illustrated to the left image). During discharge Li ions move to the positive electrode where embodies the original compound.

Features of lithium Ion batteries

- High energy density that reaches 400 Wh/L (volumetric energy density) or 160Wh/Kg (mass energy density).
- High voltage. Nominal voltage of 3,6V or even 3,7V on newer Li-Ion batteries.
- No memory effect. Can be charged any time, but they are not as durable as NiMH and NiCd batteries.
- High charge currents (0,5-1A) that lead to small charging times (around 2-4 hours).
- Flat discharge voltage allowing the device to stable power throughout the discharge period.
- Typical charging Voltage 4,2 ± 0,05V.
- Charging method: constant current - constant voltage (CV-CC).
- Typical operation voltage 2,8V to 4,2V
- Recommended temperature range 0-40 ºC

Charging Characteristics

Charging method is constant current - constant voltage (CV-CC). This means charging with constant current until the 4.2V are reached by the cell (or 4,2V x the number of cells connected in series) and continuing with constant voltage until the current drops to zero. The charge time depends on the charge level of the battery and varies from 2-4 hours for full charge. Also Li-Ion cannot fast charge as this will increase their temperature above limits. Charging time increases at lower temperatures.

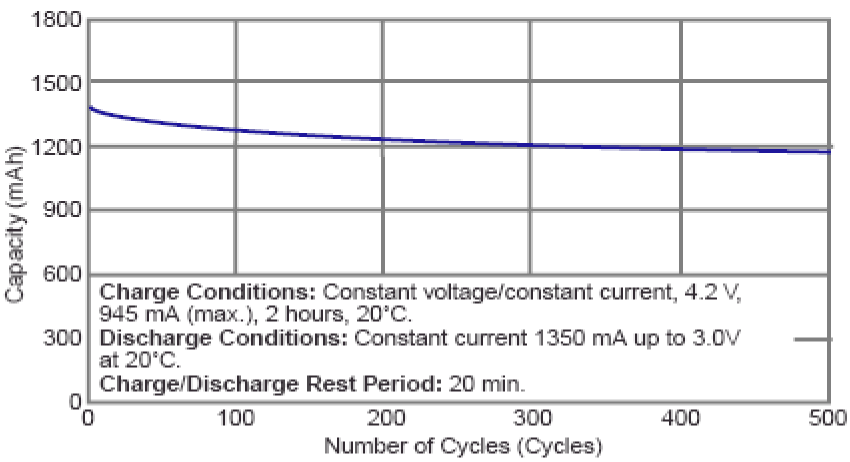


Typical charging characteristic

Charge current is recommended to be set at 0,7CmA (where C is battery capacity). If voltage is below 2,9V per cell it's recommended to charge at 0,1CmA. Charging environment must have a temperature between 0-40 ºC. Maximum discharge current must not exceeds 1.0CmA and discharge voltage must not go below 3,0V

Capacity

At a typical 100% charge level at 25 ºC, Li-ion batteries irreversibly lose approximately 20% capacity per year from the time they are manufactured, *even when unused*. (6% at 0 ºC, 20% at 25 ºC, 35% at 40 ºC). When stored at 40% charge level, these figures are reduced to 2%, 4%, 15% at 0 ºC, 25 ºC and 40 ºC respectively. Every deep discharge cycle decreases their capacity also.



Typical capacity characteristic over charge cycles

100 cycles leave the battery with about 75% to 85% of the original capacity. When used in notebook computers or cellular phones, this rate of deterioration means that after three to five years the battery will have capacities too low to be still usable.

Tip: To increase battery life store it at 40% level at low temperatures (even to the refrigerator but not below 0 degrees Celsius) and never discharge it full. Charge it early and often. Excess heat can damage the battery. Also charge once a year to prevent over discharge.

Self discharge

One great advantage of Li-Ion batteries is their low self-discharge rate of only approximately 5% per month, compared with over 30% per month and 20% per month in nickel metal hydride batteries and nickel cadmium batteries respectively.

Chemistry Type	Ni-Cd	Ni-MH	Lead acid	Li-ion Cylindrical	Li-ion Prismatic	Li-Po
Nominal Voltage (V)	1.2	1.2	2,1	3.6	3.6 / 3.7	3.6
Specific Energy (Wh/Kg)	50	70	30	80	100-160	140
Specific Energy (Wh/L)	150	200	-	-	250-360	-
Cycle Life (Times)	500	560	-	1000	1000	-
Environmental hazard	low	medium	medium	high	high	high
Safety	High	High	medium	low	low	low
Cost	low	medium	low	high	high	high
Self-Discharge Rate (%/month)	25-30	30-35	-	6-9	6-9	-
Memory Effect	yes	yes	yes	no	no	no

Comparison table of the most common batteries types

Precautions

Be sure to follow the safety rules listed below (PANASONIC recommendations):

• Do not place the battery in fire or heat the battery.
• Do not install the battery backwards so that the polarity is reversed.
• Do not connect the positive terminal and the negative terminal of the battery to each other with any metal object.
• Do not carry or store the batteries together with necklaces, hairpins, or other metal objects.
• Do not pierce the battery with nails, strike the battery with a hammer, step on the battery, or otherwise
subject it to strong impacts or shocks.
• Do not solder directly onto the battery.
• Do not expose the battery to water or salt water, or allow the battery to get wet.
• Do not disassemble or modify the battery. The battery contains safety and protection devices which, if damaged, may cause the battery to generate heat, rupture or ignite.
• Do not place the battery on or near fires, stoves, or other high-temperature locations. Do not place the battery in direct sunshine, or use or store the battery inside cars in hot weather. Doing so may cause the battery to generate heat, rupture, or ignite. Using the battery in this manner may also result in a loss of performance and a shortened life expectancy

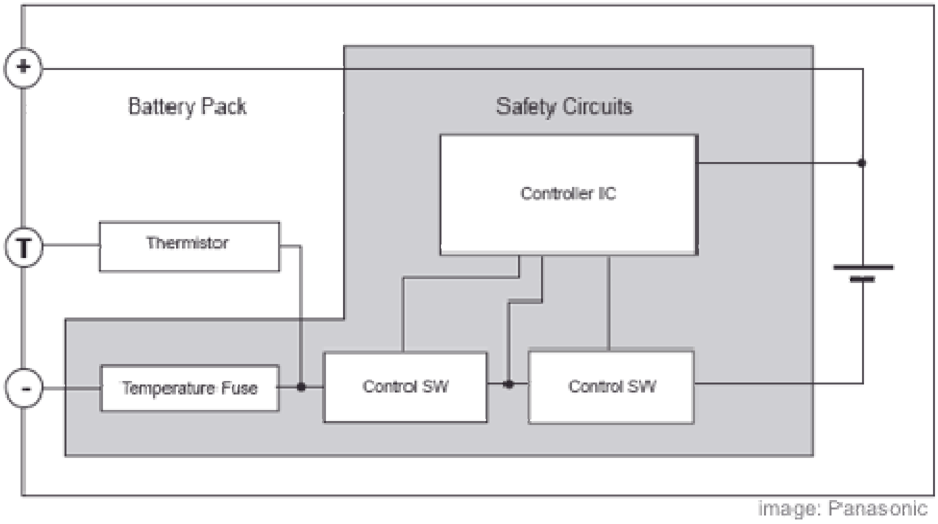
Use common sense precautions. Do not short circuit, overcharge, crush, mutilate, nail penetrate, incinerate, reverse polarity, heat above 100 degrees Celsius, solder directly on the metal can. Dispose them following local batteries disposal rules.

Safety circuits inside a Li-Ion battery pack

Inside a Li-Ion pack there is always a safety circuit that consists of four main sections:

1. The controller IC that monitors each cell (or parallel cells) voltage and prevents the cells to overcharge or overdischarge controlling accordingly the cutoff switches. Also the voltage across the switches is monitors in order to prevent over current.
2. The control switches that usually comprises FET structures that cutoff the charge or discharge depending on the control signals of the controller IC.
3. The temperature fuse that cutoff the current if the control switches experience abnormal heating.

This fuse is not recoverable.
4. The thermistor (usually PTC) that measure the battery temperature inside the pack. It's terminals are connected to the charger so it can sense the temperature of the pack and control the charge current until the battery it's full charged.



A typical structure of Li-Ion battery pack (block diagramm)

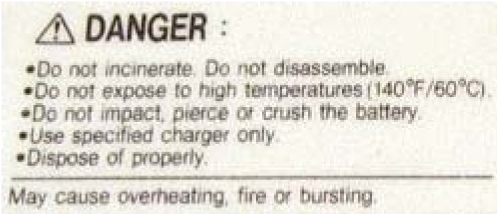
Battery packs made from Li-Ion cells always have protective circuits and PTC elements to monitor battery status any time. **Never** remove this circuitry as this will cause ignition.

Now you have read and understand all the above information you see that charging a Li-Ion pack can't be done with simple charge methods used in other type of batteries. So never charge a Li-Ion cell if you are not completely sure what you do.

Now it's time to continue to the step by step guide to see how we can safely reconstruct a Li-Ion pack.

The Li-Ion battery pack we will rebuild replacing it's individual cells it's a **FPCBP25 battery pack** manufactured from Fujitsu - Siemens and used in Lifebook S-Series notebooks like Fujitsu-Siemens S4510, S4542, S4546, S4572 and S4576 ect. S-series of Fujitsu-Siemens notebooks are really nice so that's another reason you may don't like to replace your notebook with a new one. You may also find this pack listed with the number FMVNBP104 or CP024486-01. The nominal voltage is 10,8V and capacity is 2600mAh

The battery pack looks like in the above photo. You can read on the label the product number and the type of the battery (Li-Ion). You must also read all warnings listed and be sure to follow them, expect the disassemble one that we can't do it in another way:



It is strongly recommended not to proceed to the following operations if you are not sure what are you doing. Continue reading with your own risk. We advice you to work in a fire safe place and take all the necessary fire safety measures.

Disassemble

The pack is sealed to make it's disassemble hard. The cover is glued so it may be hard to remove it.

Take a screwdriver and put it in the split between the two covers of the battery pack, that's beside the cover. Try to turn the screwdriver and unglue a small side.

You may need to apply enough force to achieve this. Continue this operation to the entire pack. That's not too difficult, but for sure you will scratch the plastic. After someminutes you are victorious!

Now you have a clear view of the interior. You see that the pack comprises from 6 Li-Ion cells and a circuit board that contains all the safety circuits.

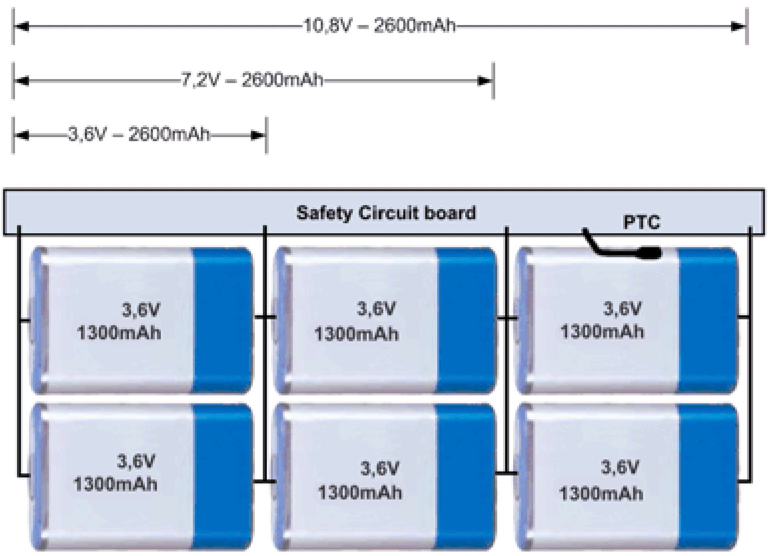
After a more detailed examination you will find that the batteries and connected in three series of two batteries each one. Look at the following image to understand the actual structure.

As you see the expected characteristics of each cell, according to the connection and the entire pack characteristics, are 3,6V and 1300mAh capacity.

Identifying the cells

On top of each cell is a part number **CGP345010** ( ) that's a Panasonic's Li-Ion prismatic cell. As you can see in the datasheet this cell has a nominal voltage 3,7V and 1400mAh.

That's above the expected value of each cell as calculated according to the battery pack characteristics, but the part number of each cell are identical (and both manufactured by Panasonic). So what's is happening?



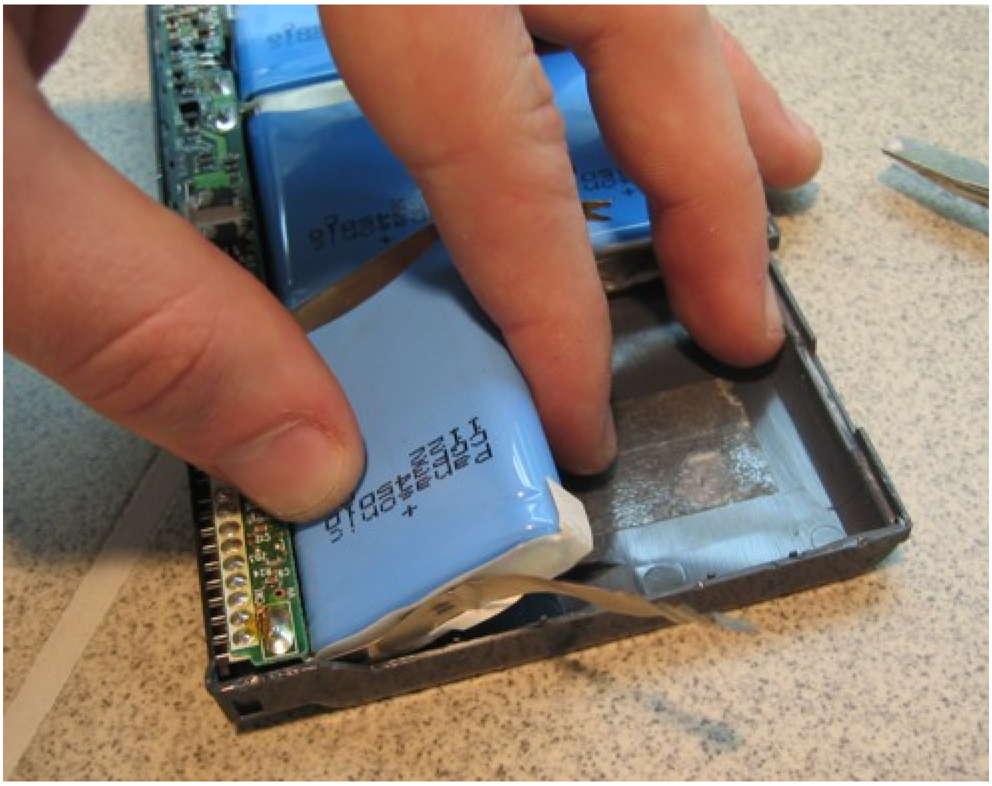
The most possible explanation is that Fujitsu has rated it's battery pack a little bit lower than the actual nominal ratings for a reason. The cell is for sure the same.

Find the cells

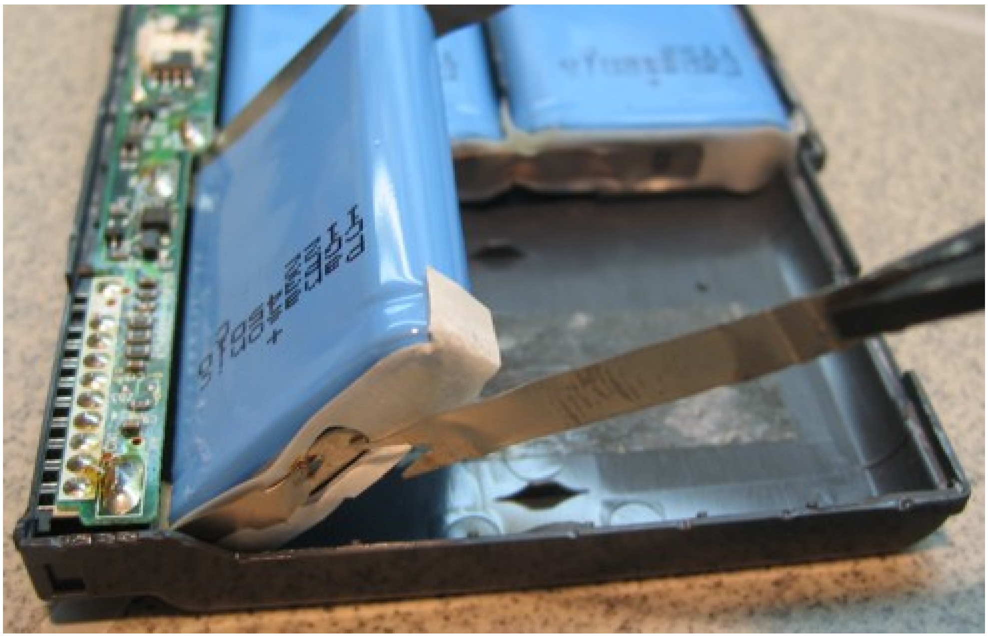
Now we have identified the cells that comprises the pack it's time to check if we can find them in market. Now you need to be lucky. We found the cells on **www.AllElectronics.com** at a reasonable price. That's exactly the cells we need with an additional protection circuit that we don't need and we are going to remove it.

Take the battery out

With the help of a screwdriver lift the first battery and cut the first connector as seen on the left photo.



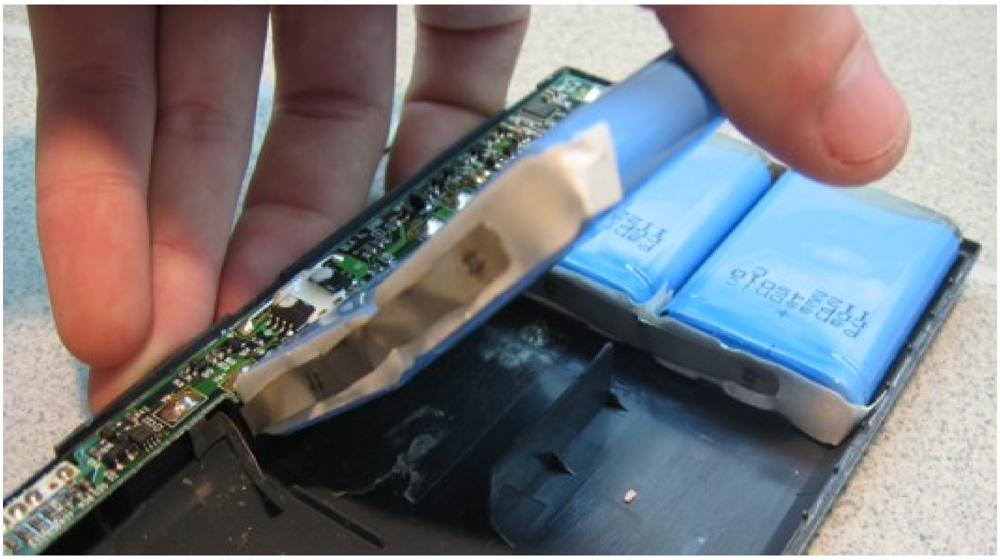
Lift carefully the second cell trying not to damage the circuit board.



With the help of a cutter, cut the remaining metallic contact and keep it as you will need it later.

Now cut the other side of the contact that goes to the pcb.

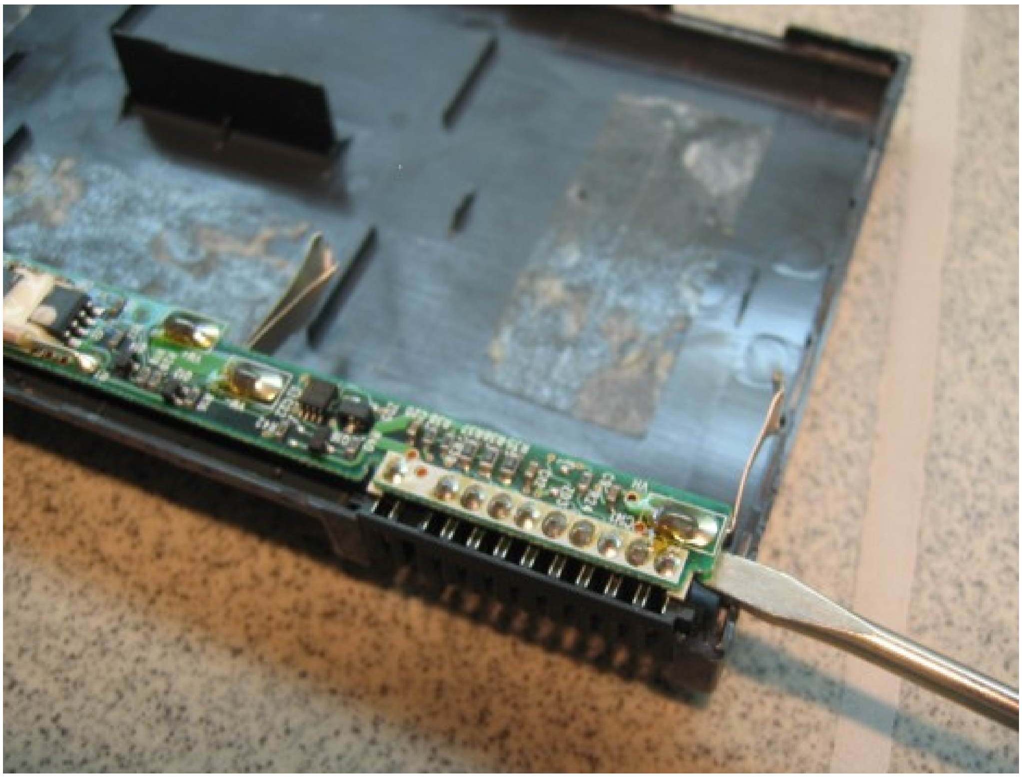
Continue cutting the other edge of the contact.



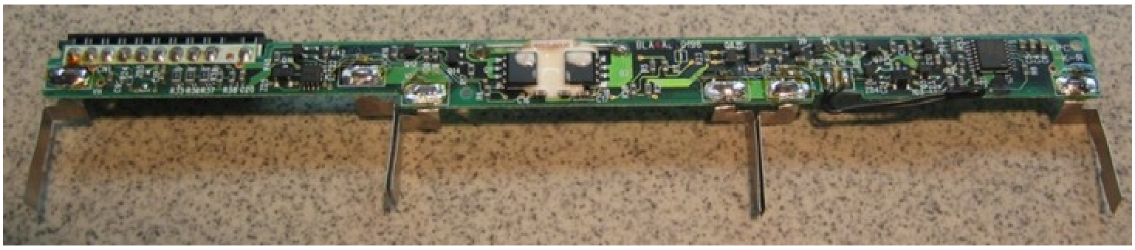
Continue removing the next cells in series.

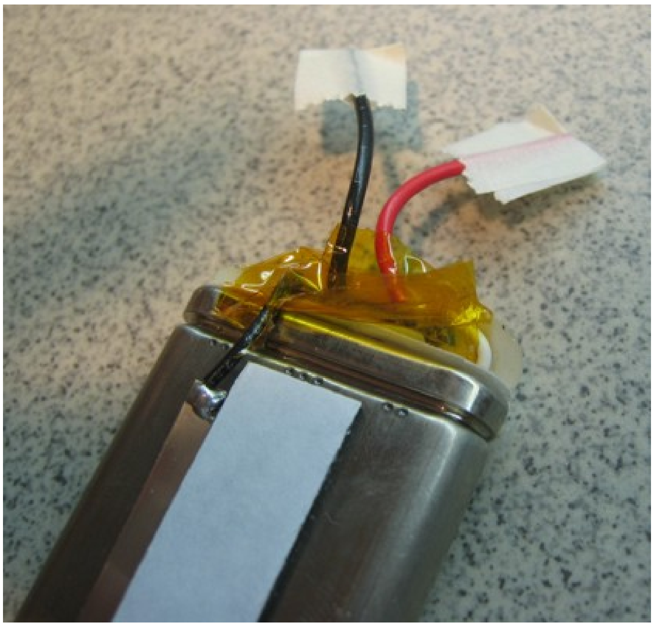
In the final cell you must pay more attention because there is a PTC attached on top of it. Carefully remove the adhesive tape and free it from the cell. Now you can also remove this cell.

Place all cells in a distance so there is no chance to short circuit them. Don't throw away old ones as you will need them later.



Finally remove carefully the safety circuit board without damaging it, as we will use it again!

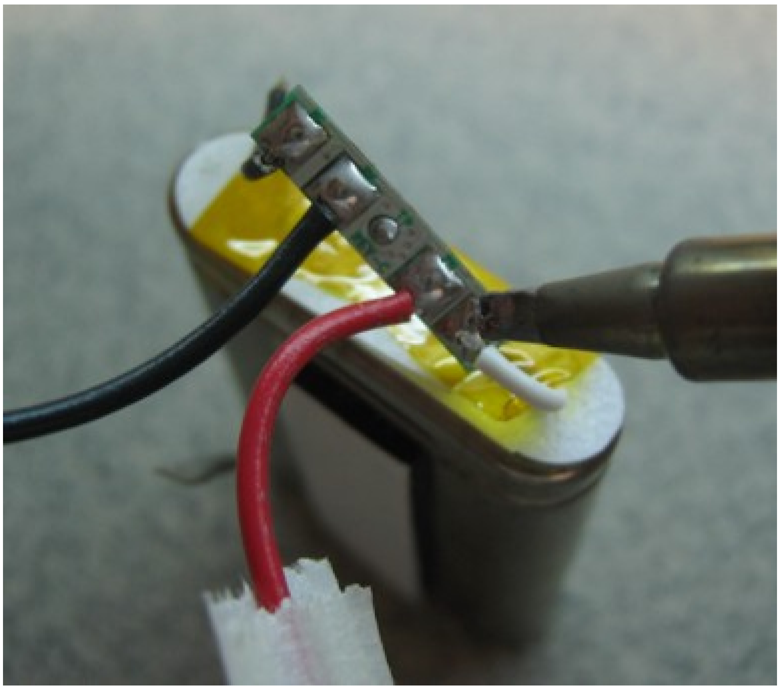




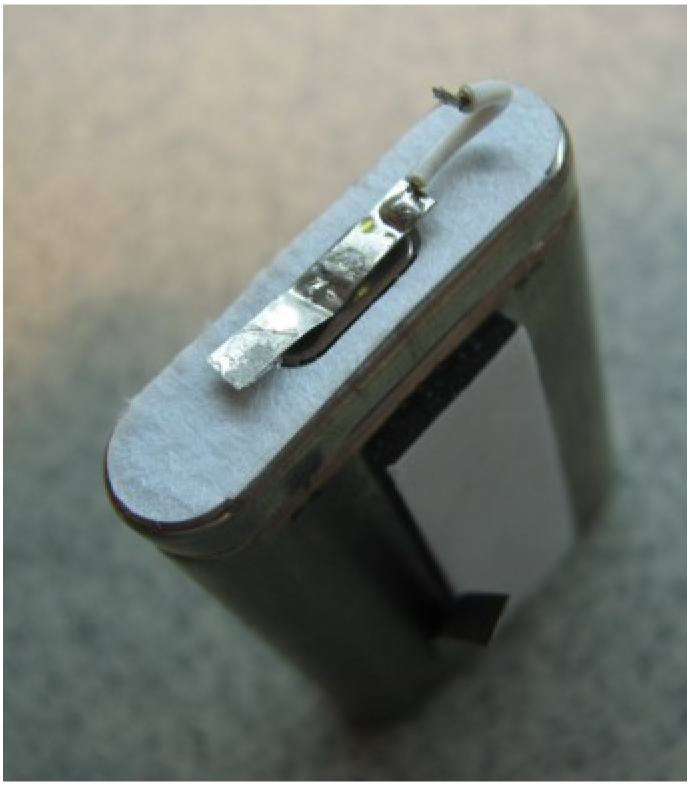
Take a new cell. As you see there is a small circuit board connected on top of the battery under the orange tape.

Start heating your soldering iron

Remove the orange tape to free the board.



Desolder both contacts of the leads that are attached to the battery cell.

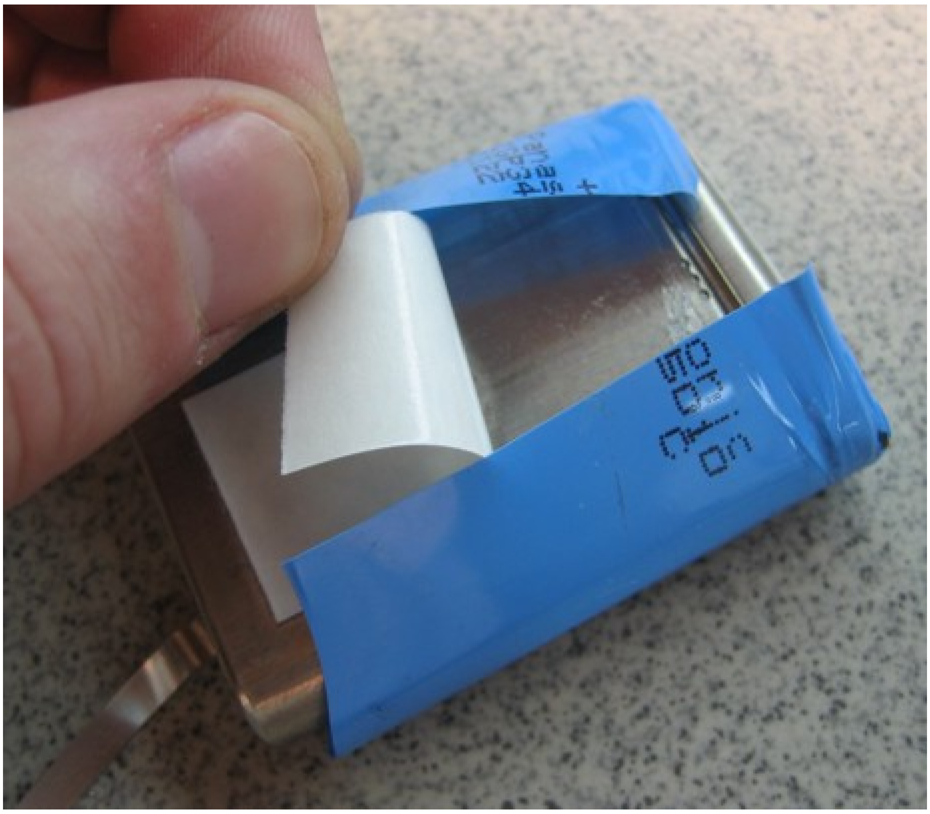


Now you battery should look like this. Remove the white cable but don't remove the white coating that protects the battery terminals from short circuit.

Remove the double sided adhesive tape as it's too thick and needs to be removed so battery fits back to it's place.

Now take the old batteries and remove the top white coating

and the blue heat shrinkable plastic as we are going to use it to the new batteries.



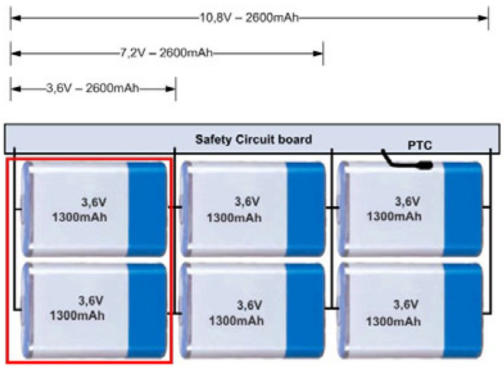
Now place the blue plastic on a new battery so the cut side faces the thin adhesive tape that we haven't removed.

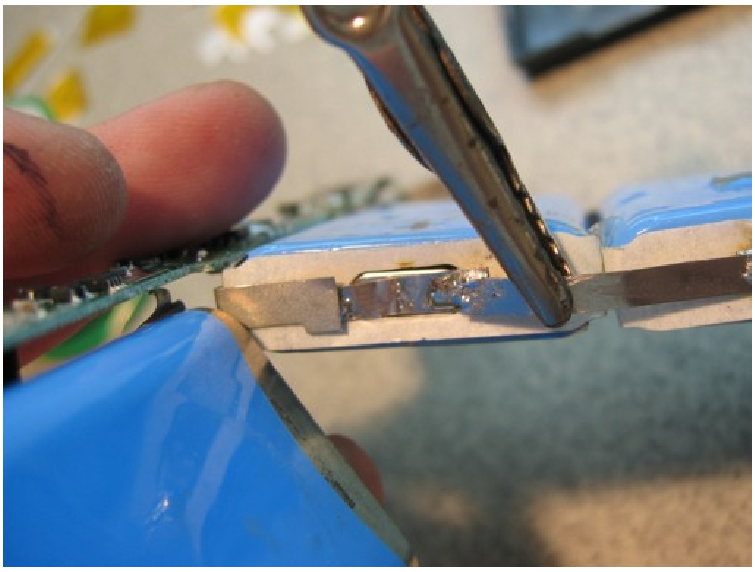
Press the plastic to glue on top of the tape

Next attach the white protective coating you have removed from the old batteries.

Repeat all the steps for all the batteries. Now you must have six ready to solder batteries.

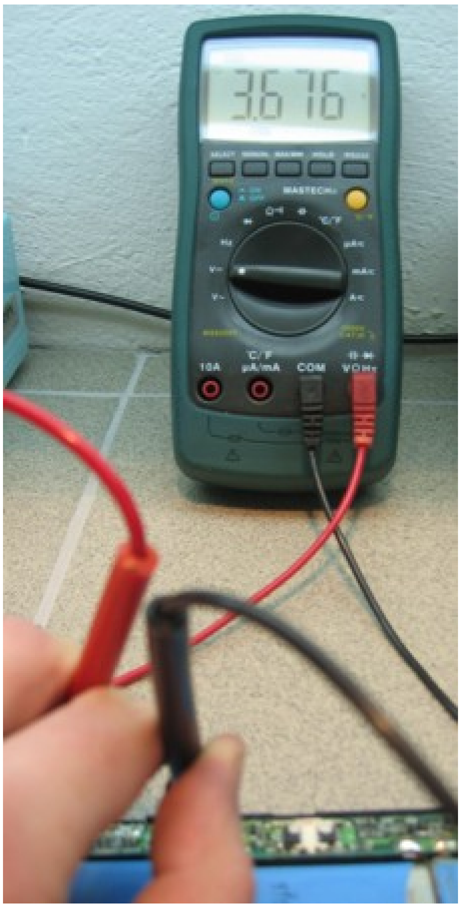
Solder the batteries in series of two. As on the diagram in page one. Repeat this step to make three sets of two batteries in series.



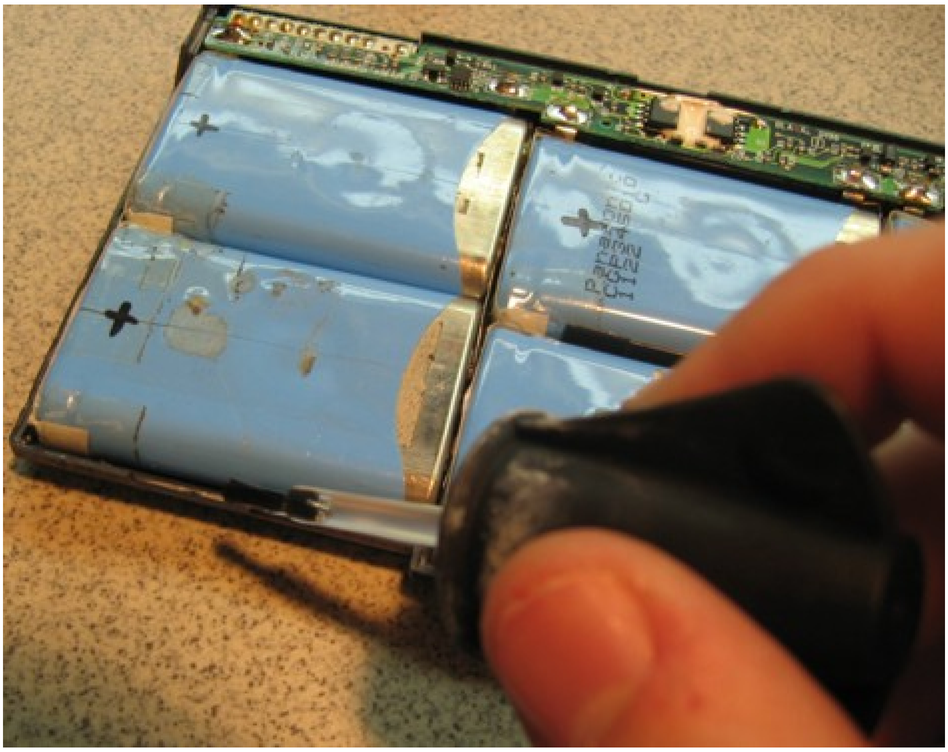


Now solder the sets on the circuit board paying attention to the polarity

Place the pcb with the batteries soldered in the original plastic box. You should have try if they fit the box in your steps while soldering.



Use a multimeter to check for short circuits. Measuring the cells you will see that are not fully discharged it's recommended to store Li-Ion cells in a 40-50% charge level.



If everything looks good, apply some glue around the plastic case.

You can also use clamps to glue the plastic enclose tautly

As long as the glue takes to dry place the old cell on a separate small plastic bag and depose to a battery recycling bucket. Don't throw them along with ordinary rubbish.

Now it the big time! Place the pack back in your notebook. If everything is ok the indicator should saw that the battery is charging normally. The arrow in the above image shows this.

The first charge took around 2.30 hours to complete and the first discharge last about 2.45 hours. That's good results! Now your notebook looks like new!

During the first 3-4 charge cycles don't let the notebook charge in another room that this you are so you can observe for any malfunctions that can cause excess heat during charging - discharging.

.: Resources

References about Panasonic CGP345010 Cell

- Panasonic rechargeable lithium ion battery OEM products
- Online Li-Ion cells at AllElectronics.com
- CGP345010 3,7V-1400mAh Panasonic Prismatic Cell - Datasheet
- Li-Ion rechargable Cell Thermal-Vacuum Test Results
- An Innovative Low-Cost Communication Sattelite using CGP345010 cells (PDF)
- Nanosatellite Final Design Report

Li-Ion Charger Application Notes

- Charging Simplified for High Capacity Batteries - Microchip application note
- A Li-Ion battery charger using TSM102A - ST Microelectronics
- Highly Integrated Single-Cell Li-ion/Li-Polymer battery charger - Intersil
- Off-line Li-Ion battery charger with P89LPC916 - Philips
- LM3647 Reference Design User’s Manual - National
- How to Design Battery Charger Applications that Require External Microcontrollers - MAX846A

News Sites

- Power ICs Charge Ahead In One-Cell Li-Ion Applications
- More Li-Ion Charger ICs