Fuel Gauge Recalibration

If fuel gauge recalibration is needed, the red LED on a calibrating charger will flash upon insertion of the battery.
This provides feedback on the accuracy of the fuel gauge and avoids unnecessary calibration cycles.

The user can either calibrate the fuel gauge and charge the battery, or just charge the battery.
Calibration takes longer than charging & it may not be convenient to go through the calibration cycle.

To recalibrate the fuel gauge, press the button on the front of the charger.
The charger will automatically begin to charge the battery if the button is not pressed.

The blue LED will flash to indicate that the battery is undergoing the recalibration cycle.
During calibration the discharge resistors will be cooled by the fan. Removing the battery, or pressing the calibration button again will re-start the process from the beginning.

At the end of this procedure the blue LED will stay constant indicating a fully calibrated fuel gauge.
Warm environments can cause calibration failure - keep the charger away from direct sunlight or heat sources.

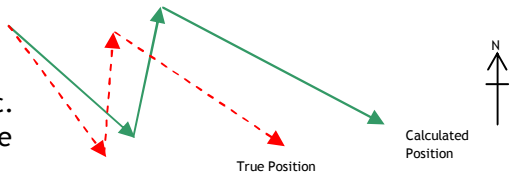
How Does the Battery Fuel Gauge Work?

We have two types of fuel gauge, ***Coulomb-Counters*** found in older batteries & ***Impedance Trackers*** in newer ones.

Coulomb-Counter Fuel Gauges use a voltmeter, ammeter and time clock inside the battery to measure the energy in & out of the battery pack. In addition there are algorithms to compensate for the effects of discharge rate, discharge temperature, self-discharge and charging efficiency etc.

If a battery with a coulomb-counter fuel gauge only sees partial charges and discharges, then it may not get the benefit of a "full" or "empty" reference point for some time and must rely increasingly on its calculated figure. So its accuracy may drift during use.

This is analogous to navigating by dead reckoning - you take a compass bearing & set off on a heading to your waypoint & then change course etc. After a few changes in course, the minor errors in your course can become amplified and your true position can drift from your calculated position.



Impedance Tracking Fuel Gauges estimate the remaining capacity by monitoring the internal impedance of the cells and comparing this to a table of values. As with coulomb-counters, the effects of discharge rate, discharge temperature, self-discharge and charging are all included in the assessment. Impedance measurement is more accurate when the battery is at rest & as a result, impedance trackers use periods of inactivity to self-recalibrate. This reduces the need for fuel gauge recalibration.

What is Recalibration & why is it needed?

As the battery ages and is used, its available capacity shrinks - so with each cycle, your device's runtime gets a little bit less. *Imagine if the fuel tank in your car got smaller as your car got older - you'd need to occasionally recalibrate your car's fuel gauge too.*

A good rule of thumb is that Li Ion batteries lose 5% capacity per 100 cycles & 5% per year.

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The fuel gauge not only provides the battery's remaining capacity, it also gives an estimated accuracy figure known as the "Max-Error". This keeps track of the overall accuracy of the system. In this way the battery can tell the device not only how much capacity is remaining, but also how reliable this estimate is. When an Inspired Energy battery achieves a Max-Error of 10%, the recalibration-bit is set. This is an electronic flag which tells the system that the fuel gauge is in or out of calibration.

Some devices use this recalibration-bit to trigger a note on the device screen to tell the user to recalibrate their battery. Other systems simply put a note in their instruction manual to recalibrate the battery every so often. Our calibrating chargers use the recalibration-bit to flash the red LED & tell the user that recalibration is advisable.

How Is Recalibration Accomplished?

Impedance tracking fuel gauges retain accuracy longer than coulomb-counters & can even self-recalibrate in use as long as there are periods of inactivity in the cycle so that the impedance measurement can be made more accurately. If no periods of rest are present in the cycle then the Impedance tracking fuel gauge will accumulate the Max-Error at a rate of 1% every 20 cycles. (This is rare in most real-life applications, but is common in laboratory cycling tests).

Impedance-Tracking fuel gauge recalibration is achieved by charging the battery, allowing it to rest, discharging it & allowing it to rest again as shown below:

- Charge the battery to at least 50% remaining capacity & allow it to rest for at least 2.1hrs.
- Discharge the battery by at least 37% & allow it to rest for 5.1hrs
  Note: the rest periods can not be in the flat portion of the discharge curve (cell voltages between 3.7 & 3.8V)
- At this point the fuel gauge is calibrated, but the battery is partially discharged & will require a recharge.

Coulomb-Counters use a different profile:

- Fully charge the battery
- Carry out a controlled discharge until the battery is fully discharged
- At this point the fuel gauge is calibrated, but the battery is fully discharged & will require a recharge.

In both cases the temperature during the process must remain between 10°C & 40℃.

As you can see, impedance tracking fuel gauges are more likely to encounter suitable conditions for self-recalibration in their everyday operation whereas a continuous uninterrupted discharge from full to empty is much less likely & hence coulomb-counters require more frequent fuel gauge calibration using external methods such as the Inspired Energy calibrating chargers.

So recalibration is used to re-set the fuel gauge to match the actual capacity in the battery. In this way, even as the battery ages and things change, the accuracy and reliability of the fuel gauge can be retained throughout the life of the battery. The latest impedance tracking fuel gauges need fewer recalibrations because they have the capability to self-calibrate however the need for recalibration is not completely eliminated. The latest Inspired Energy calibrating chargers have the capability to maintain fuel gauge accuracy on all types of fuel gauge used in the full range of “N”-Series Inspired Energy smart SMBus battery packs. For more details on smart charging and recalibration go to:

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