Battery discharge characteristics

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On high load and repetitive full discharges, reduce stress by using a larger battery. A moderate DC discharge is better for a battery than pulse and heavy momentary loads. A battery exhibits capacitor-like characteristics when discharging at high frequency. This allows higher peak currents than is possible with a DC load.

Ability to deep discharge. There is a logarithmic relationship between the depth of discharge and the life of a battery, thus the life of a battery can be significantly increased if it is not fully discharged; for example, a mobile phone battery will last 5-6 times longer if it is only discharged 80% before recharging.

Battery discharge curves are based on battery polarization that occurs during discharge. The amount of energy that a battery can supply, corresponding to the area under the discharge curve, is strongly related to operating conditions such as the C-rate and operating temperature.

Batteries are complex electrochemical and thermodynamic systems, and multiple factors impact battery performance. Of course, battery chemistry is at the top of the list. Still, factors such as charge and discharge rates, operating temperatures, storage conditions, physical construction details, and more come into play when understanding which battery best suits a specific application. To begin, several terms need to be defined:

Battery discharge curves are based on battery polarization that occurs during discharge. The amount of energy that a battery can supply, corresponding to the area under the discharge curve, is strongly related to operating conditions such as the C-rate and operating temperature. During discharge, batteries experience a drop in Vt. The drop in Vt is related to several factors, primarily:

A flat discharge curve may simplify certain application designs since the battery voltage remains fairly constant throughout the discharge cycle. On the other hand, a sloping curve can simplify the estimation of SoC since the battery voltage is closely related to the remaining charge in the cell. However, for Li-ion cells with flat discharge curves, the estimation of SoC requires more complex methods such as Coulomb counting that measures the discharging current of a battery and integrates the current over time to estimate SoC.

In addition, the power from cells with a downward sloping discharge curve falls throughout the discharge cycle. It may be necessary to "oversize" batteries to support high power applications towards the end of the discharge cycle. A boost voltage regulator is often needed to power sensitive devices and systems using a battery with a steeply sloping discharge curve.

The discharge curves for a Li-ion battery below show that the effective capacity is reduced if the cell is discharged at very high rates (or conversely increased with low discharge rates). This is called the capacity offset, and the effect is common to most cell chemistries.

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Operating temperature is an important parameter impacting battery performance. At very low temperatures, batteries with aqueous electrolytes may freeze, placing a lower limit on the operating temperature range. Li-ion batteries undergo lithium plating of the anode at low temperatures, permanently reducing capacity. At high temperatures, chemicals can break down, and the battery ceases to function. In between freezing and chemical destruction, battery performance typically varies widely with temperature.

A Ragone plot compares the specific power versus the specific energy of various energy storage technologies. For example, when considering electric vehicle batteries, specific energy relates to the range while specific power corresponds with acceleration.

Ragone plots are based on gravimetric energy and power densities and do not include any information related to volumetric parameters. While metallurgist David V. Ragone developed these plots to compare the performance of various battery chemistries, a Ragone plot is also useful for comparing any group of energy-storage devices and energy devices such as engines, gas turbines, and fuel cells.

The ratio between the specific energy on the Y-axis and the specific power on the X-axis is the number of hours that a device can be operated at its rated power. The device’s size does not impact that relationship since larger devices would have proportionally larger power and energy contents. The iso curves indicating constant operating times on a Ragone plot are straight lines.