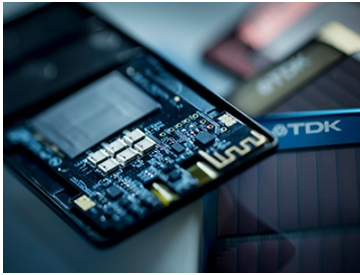


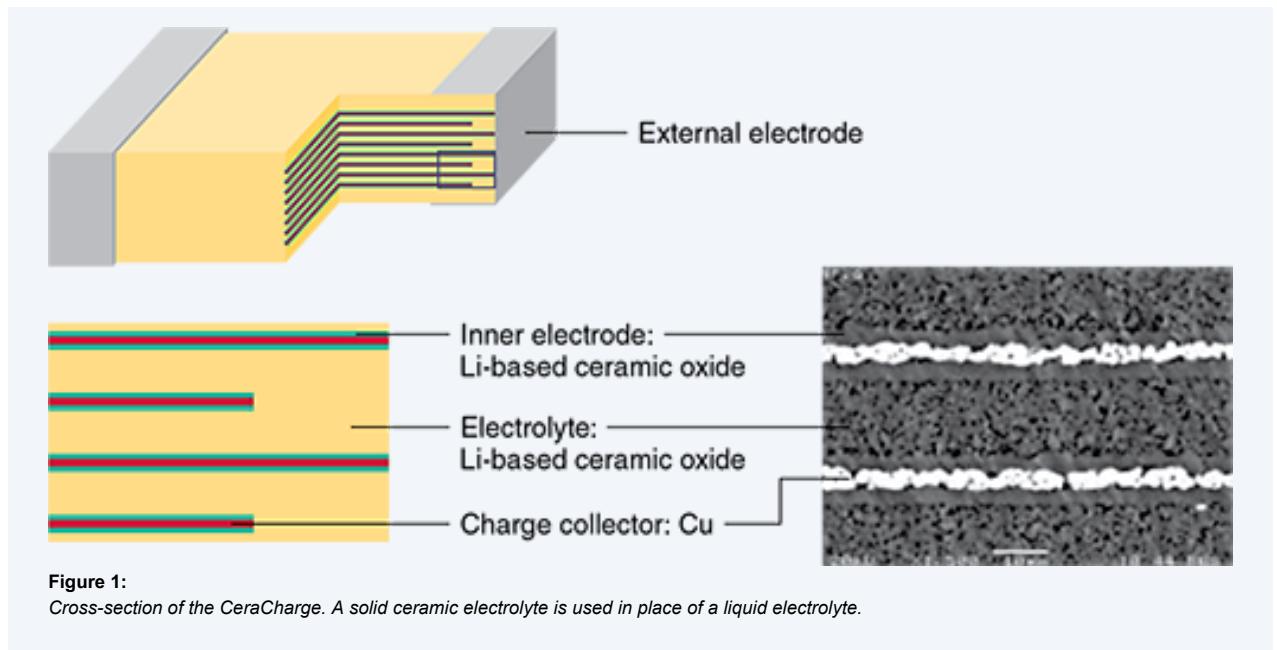
# Rechargeable solid-state SMD battery for IoT applications



From simple gadgets to complex devices for the industrial IoT – they all require compact, reliable and extremely safe power supplies. CeraCharge™, the world's first rechargeable solid-state SMD battery, is a new technology that meets all these demands.

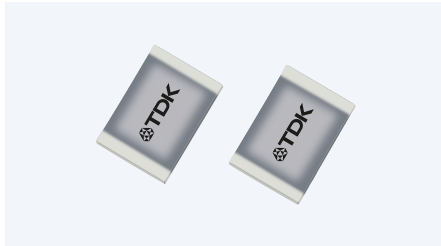
Life today would be unimaginable without batteries using a wide variety of technologies and with widely differing capacities. The Internet of Things in all its facets will in future require billions of special power supplies tailored to the requirements of new ultra-low-power semiconductors and sensors. These devices must function for years, independently of external power supplies, by using energy-harvesting technologies. The demands made on energy storage media are as follows: small dimensions, rechargeability, intrinsically safe, easy to assemble, low cost and long service life. Not all of these requirements can be met simultaneously using currently available technologies. For many applications, the TDK CeraCharge now offers a way out of this dilemma. Unlike most common

technologies, this involves a solid-state rechargeable battery with no liquid electrolyte through which the lithium ions move during charging or discharging. CeraCharge is based on a multilayer technology, similar to MLCCs, as shown in Figure 1.



Thanks to this technology, a relatively high energy density and smallest volume are combined with the safety and high volume manufacturing benefits of ceramic multilayer components. In addition, the use of a solid ceramic electrolyte rules out the risks of fire, explosion, or the leakage of liquid electrolyte.

## Simple process thanks to SMT-compatible design



CeraCharge is the world's first rechargeable battery to be designed as an SMT-compatible component. Accordingly, this results in further advantages such as easy placement of components and the use of conventional reflow soldering processes, which in turn reduces the production costs of the devices using CeraCharge. Initially, the CeraCharge is available in an EIA 1812 package (4.5 mm x 3.2 mm x 1.1 mm). This component offers a capacity of 100  $\mu\text{Ah}$  at a rated voltage of 1.4 V and an initial internal resistance of  $<200\ \Omega$ . The key technical data of CeraCharge is shown in Table 1.

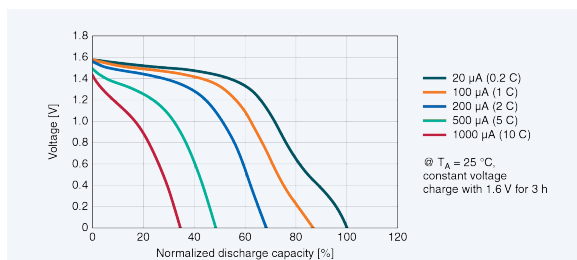
**Table 1: Key technical data of CeraCharge rechargeable solid-state SMD battery in a EIA 1812 package**

|                            |                        |             |
|----------------------------|------------------------|-------------|
| Rated voltage              | [V]                    | 1.4         |
| Operating voltage          | [V]                    | 0 to 1.6    |
| Nominal capacity           | [ $\mu\text{Ah}$ ]     | 100         |
| Nominal discharge current  | [ $\mu\text{A}$ ]      | 20          |
| Operating temperature      | [ $^{\circ}\text{C}$ ] | -20 to +80  |
| Initial inner resistance * | [ $\Omega$ ]           | $<200$      |
| Weight                     | [g]                    | $\sim 0.04$ |

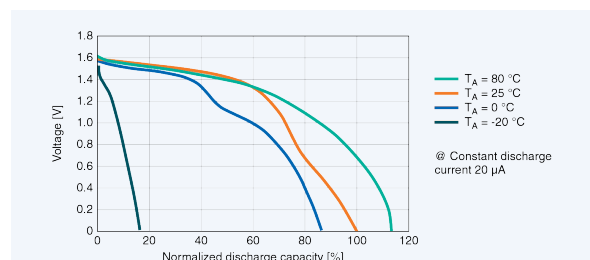
\* @ ambient conditions of  $25\ ^{\circ}\text{C}$  and relative humidity  $<60\%$

The typical discharge characteristics are shown in Figure 2. The nominal discharge current for CeraCharge is 20  $\mu\text{A}$ , but one CeraCharge is also able to support a continuous discharge 1 mA (10 C).

Compared to conventional batteries, rechargeable or otherwise, CeraCharge offers a very wide temperature range of between  $-20\ ^{\circ}\text{C}$  and  $+80\ ^{\circ}\text{C}$ , making it suitable for outdoor use, for example in weather stations. The typical temperature characteristics for a constant current discharge of 20  $\mu\text{A}$  are shown in Figure 3.



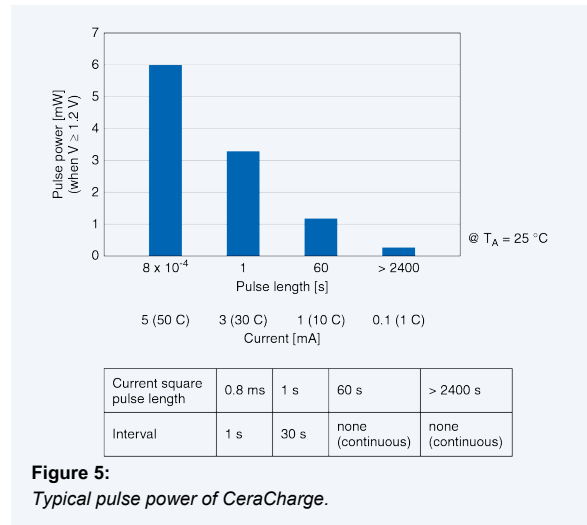
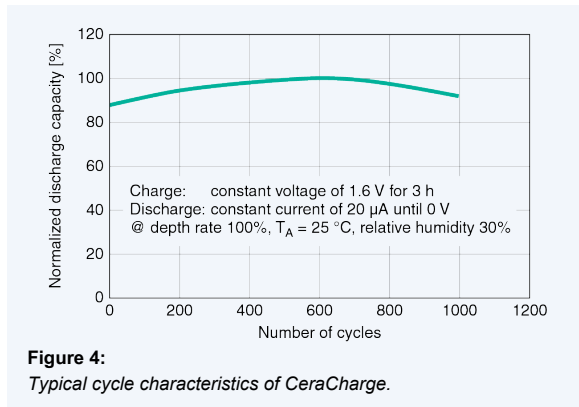
**Figure 2:**  
Typical discharge characteristics of CeraCharge.



**Figure 3:**  
Typical temperature characteristics of CeraCharge.

Depending on the requirements, the number of charge/discharge cycles that CeraCharge is able to perform ranges from several dozens of to up to 1000 without any significant losses in terms of electrical parameters (up to 80 percent of the initial values). Figure 4 shows the typical cycle characteristics for CeraCharge for charging at a constant voltage of 1.6 V for 3 h and discharging with a constant current of 20  $\mu\text{A}$ .

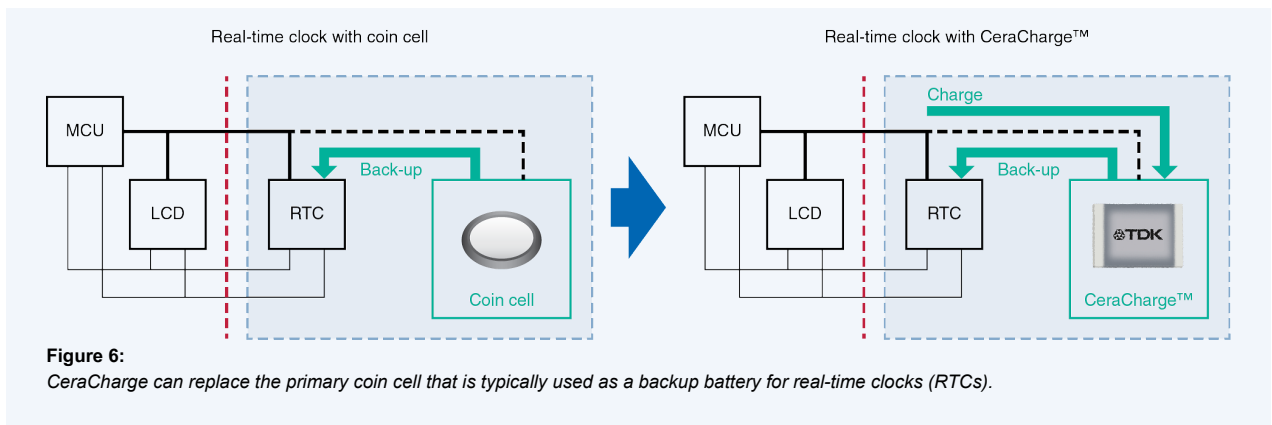
For short periods or in pulsed operation – when supplying a Bluetooth beacon module during transmission, for example – one CeraCharge can supply currents with magnitude of about 3 mA/s (Figure 5).



## Extremely wide range of possible applications

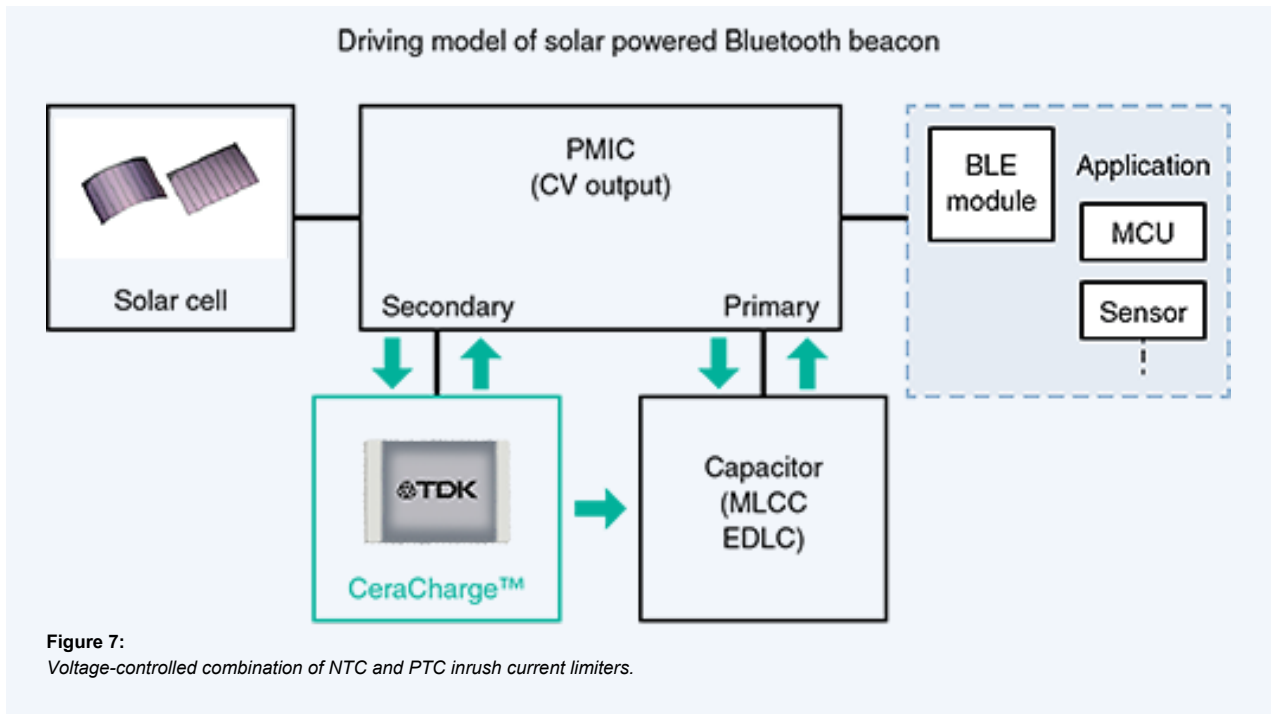
To increase the capacity and the voltage, any number of individual CeraCharge components can be connected in series and parallel. This opens up a wide range of possible applications, for example, as the backup battery for real-time clocks (RTC) or energy storage for Bluetooth beacon transmission.

In most cases primary cells (coin cells) are used as the battery for RTCs. The major disadvantage of this conventional solution is that users must eventually change the battery. Because a VSB (supply voltage to battery) exists in an RTC, replacing the primary cell the RTC module with a rechargeable battery such as CeraCharge overcomes this problem (Figure 6). The RTC generally needs power from the backup battery for less than one hour at a time, and one CeraCharge can back up the RTC function for 1 to 2 weeks without recharging.



## Solar powered beacon with CeraCharge

The prerequisite for the IoT (Internet of Things) is the ability to connect all kinds of appliances and devices with the Internet. Solar powered Bluetooth Low Energy (BLE) beacon technology is emerging as the connectivity solution of choice because of its miniature space requirements and low power consumption. Figure 7 shows a driving model for a solar powered BLE beacon. In this circuit, the solar cell first charges a capacitor (either an MLCC or EDLC), which provides the primary power for the BLE module. CeraCharge serves to store energy in order to charge the capacitor, when the solar cell is not active. It is charged with a surplus energy after the capacitor is fully charged, and discharges to the capacitor when it's empty. This enables the solar powered beacon to operate continuously. The number of parallel CeraCharge units needed in the circuit depends on the maximum the BLE module must be powered without the solar cell.



Apart from the SMD type currently available in EIA size 1812, TDK will in future also develop CeraCharge types in other sizes such as EIA 0603 and with other capacities, in order to cover an even wider range of applications. Some examples include energy storage for energy harvesting, often in combination with a capacitor, or as a sub-battery in wearables to smooth current and voltage levels during momentary periods of high demand.