

Calculation of Discharge Time

① For constant current discharge

$$t = \{C \times (V_0 - V_1)\} / I$$

t : Discharge time (sec.)

C : Capacitance (F)

V_0 : Charge voltage (V)

V_1 : Discharge voltage (V)

V_b : Nominal battery voltage (V)

② For constant power discharge

$$t = 0.5 \times C \times (V_0^2 - V_1^2) / P$$

I : Discharge current (A)

R : Discharge resistance (Ω)

P : power (W)

③ For constant resistance discharge

$$t = -C \times R \times \ln(V_1 / V_0)$$

④ For converting to nominal battery capacitance

$$Ah = 0.5 \times C \times V_0^2 / (3600 \times V_b)$$

* In the case of large current discharge, it needs to consider the IR drop, which is caused during the early discharge stage derived from capacitor's IR (direct current resistance) and the discharge current.

* In the case of small current discharge, it needs to consider the discharge current of the capacitor (self-discharge).

Calculation of necessary Capacitance

① For constant current discharge

$$C = I \times t / (V_0 - V_1)$$

t : Discharge time (sec.)

C : Capacitance (F)

V_0 : Charge voltage (V)

② For constant power discharge

$$C = 2 \times P \times t / (V_0^2 - V_1^2)$$

V_1 : Discharge voltage (V)

I : Discharge current (A)

R : Discharge resistance (Ω)

P : power (W)

③ For constant resistance discharge

$$C = -t / \{R \times \ln(V_1 / V_0)\}$$

- * In the case of large current discharge, it needs to consider the IR drop, which is caused during the early discharge stage derived from capacitor's IR (direct current resistance) and the discharge current.
- * In the case of small current discharge, it needs to consider the discharge current of the capacitor (self-discharge).

Calculation for Constant Current Discharge

The motion back up, such as RAM and RTC is generally constant current.

As an example, charging DB series 5.5V 1F with 5V and discharge until 3V with 1mA of constant current. The discharging time would be that charging voltage of V0 is 5.0V, the voltage V1 becomes 3.0V after discharge. Also since the discharge current I is 1mA, it would be 0.001A.

From Calculation ①, discharge time $t = \{C \times (V0 - V1)\} / I = \{1F \times (5.0V - 3.0V)\} / 0.001A = 2000$ seconds. Therefore it would calculate 33 minutes of backup.

As another example – calculating the necessary capacitance for 1-hour back up with RTC, which works with 2.0V to 1.0V of motion voltage range and 10 μ A of used current.

From Calculation ①, the capacitance would be: $C = I \times T / (V0 - V1)$. From the conditions, it would be:

$$C = (10 \times 10^{-6}A) \times 3600s / (2.0V - 1.0V) = 0.036F$$

Therefore, it would be able to work with 3.3V0.07F (Size $\Phi 4.8 \times 1.4$ mm) from DSK series.

However, it needs to consider the decrease rate of voltage from the self discharge in the case of micro-current. It is recommend to check the working duration with RTC and the capacitors.

Calculation for Constant Power Discharge

In general, it is common to use constant power for discharge in the conditions, such as driving motors, lighten LED by DC-DC converter with maintained output voltage, etc.

As an example, by using DZ series 2.5V 100F, calculating the operation time for turning on LED with 5V 10mA consecutively for the rage of 2.5V to 1.0V with DC-DC converter to increase to 5V.

The power needed for LED would be $5V \times 10mA = 0.05W$.

From the calculation②, $t = 0.5 \times C \times (V_0^2 - V_1^2) / P = 0.5 \times 100F \times (2.5V^2 - 1.0V^2) / 0.05W = 5250$ seconds, which means about 87 minutes. It would allow consecutively turning on for about 87 minutes. In reality, it is necessary to calculate the converting rate of DC-DC converter; therefore, it would be 70 minutes with 80% of the efficiency rate.

Then it is expected to have 3500 minutes (about 58 hours) since it operates only for 20m sec. per 1 second.

As another example – calculating the required capacitance to operate 10 minutes for the range of 2.5V to 1V with 1W.

By using the formula ②, $C = 2 \times t \times P / (V_0^2 - V_1^2)$. With the requirements, the calculation would be: $C = 2 \times 600s \times 1W / (2.5V^2 - 1.0V^2) = 228F$

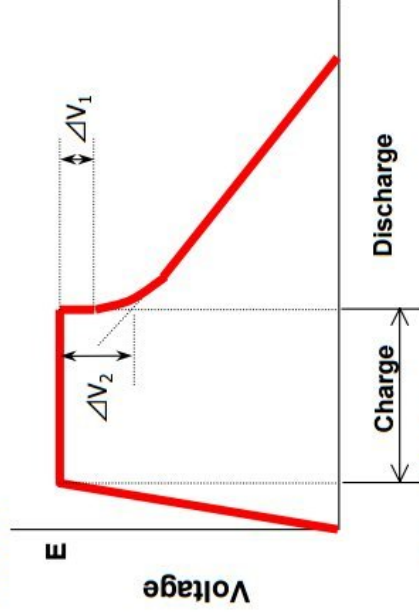
Therefore, by choosing ELNA's DZH series 2.5V 300F (size $\phi 35 \times 50mm$), it would allow to operate for around 13 minutes.

*Please confirm the following when there is a difference at actual discharge time and the calculated discharge time.

Measuring DC Resistance and IR Drop

If the discharge current is large, IR drop occurs from the accumulation of DC internal resistance and the electric current.

For the short time, IR drop can be assumed as ΔV_1 ; however, the DC internal resistance is required to be calculated from $\Delta V_2/I$ by IEC standard



$$R_d = \Delta V_2 / I$$

R_d : DC Internal Resistance (Ω)

ΔV_2 : Descending Voltage (V)

I : Discharge current (A)

Effect of Self-discharge

DLC has self-discharge with small electrical current. Therefore, when DLC needs to operate for long time with small electricity after charging, it is necessary to calculate the discharge time with consideration of self-discharge.

By adding the decrease of voltage derived from the self discharge, the calculation would be closer to the voltage perseverance characteristics data. Also, the self-discharge depends on the charging time and the ambient temperature.

