

Protection Circuits

電機 26 級 陳亮宇

Outline

- 鋰電池
- **Over Current Protection**
 - eFuse
- **Over Voltage Protection**
 - Zener Diode

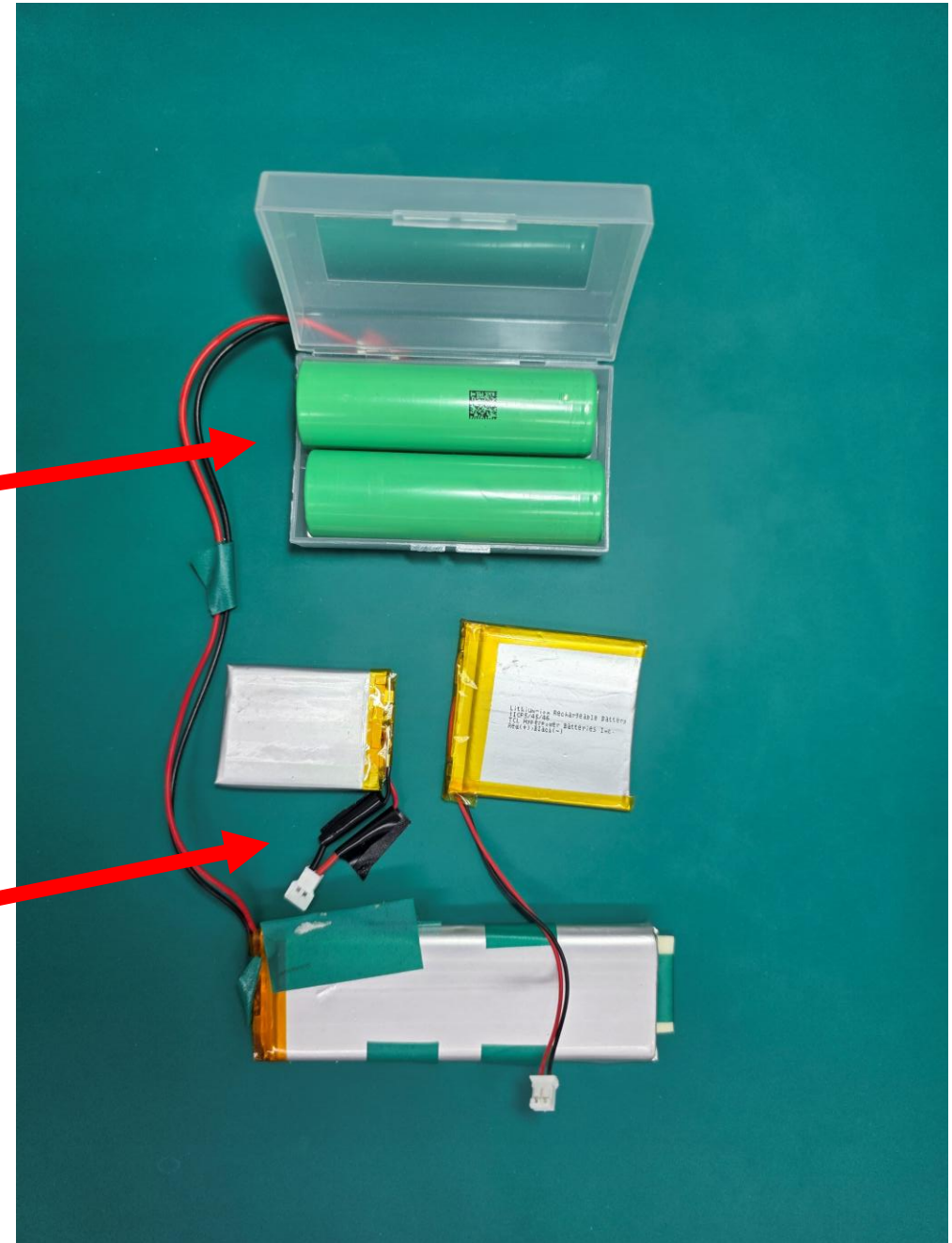
鋰電池

鋰離子電池 Li-ion

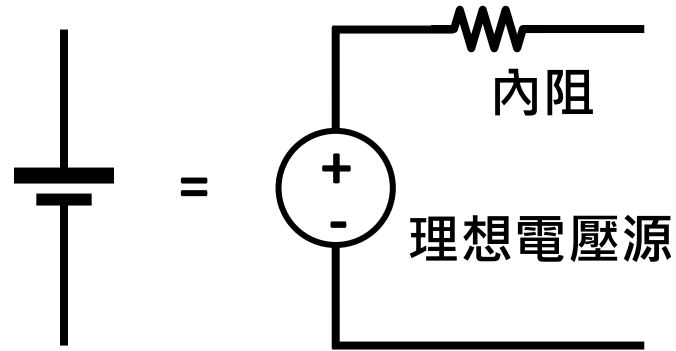
比較堅固，常見尺寸：
18650、21700

鋰聚合物電池 Li-po

又稱軟包電池，
有各種奇怪的形狀



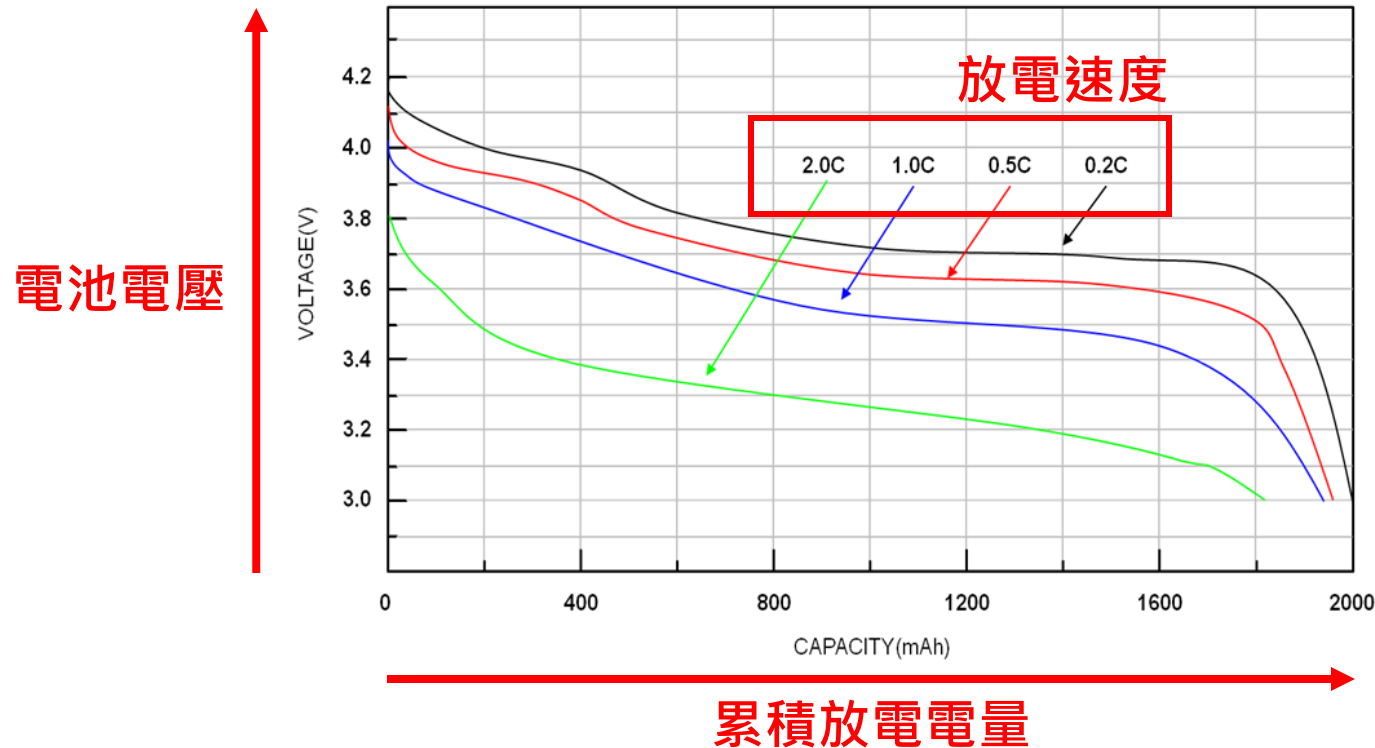
放電曲線



一般鋰電池充飽是 4.2V
放電到沒電大概 3.0V

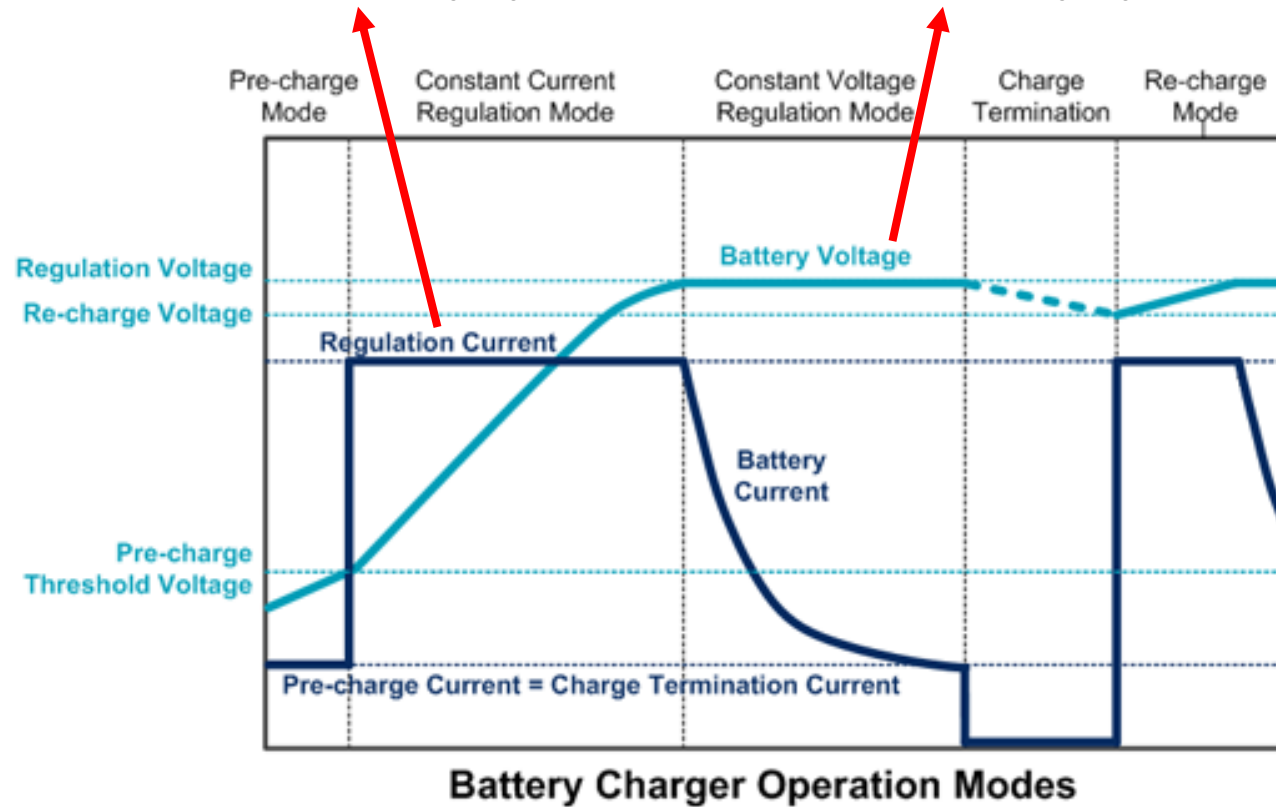
放電速度的 C 數是指
電流是額定容量的幾倍
假設額定 2000 mAh
0.1C -> 200mA
1.0C -> 2A

電流大的時候電池內阻
造成電池電壓下降

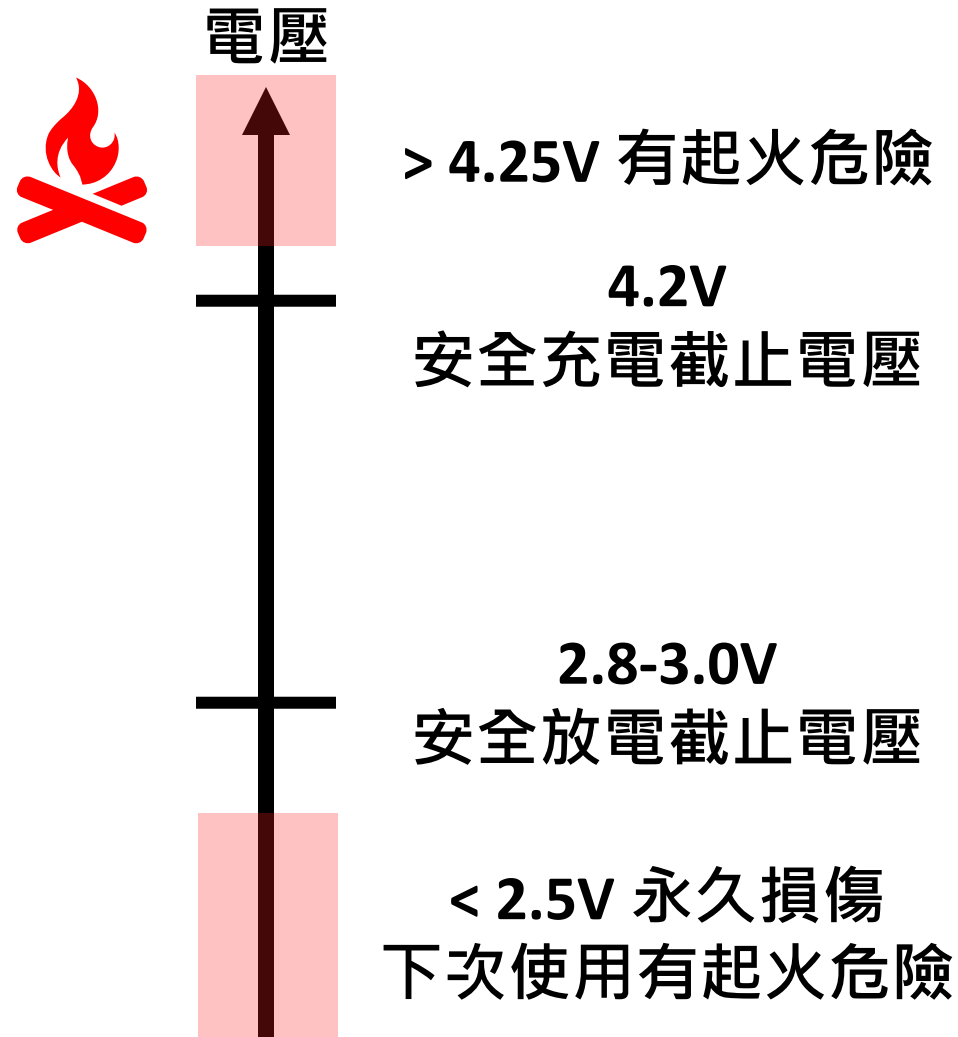
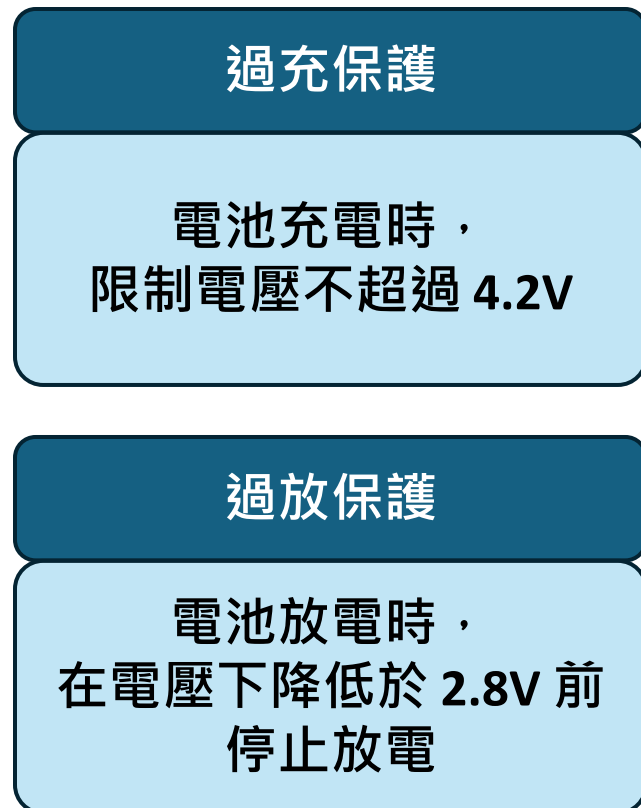


電池充電過程

先以固定電流(cc)充到快滿，再以固定電壓(cv)充到全滿



過充、過放



不同鋰電池(Li-ion, Li-po, LiFePO₄)的各個電壓會稍微不一樣，設計電路前務必確認

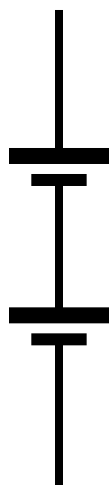
鋰電池串聯

串聯前須確認
每顆電池電壓相同

放電時須確認
每顆電池電壓高於 2.8V

用 Charge Balancing IC
確保每顆電池充放電電壓相同

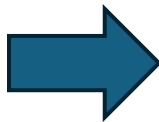
錯誤示範：



串聯前電壓 3.7V

串聯前電壓 3.2V

放電



放電後電壓 3.0V

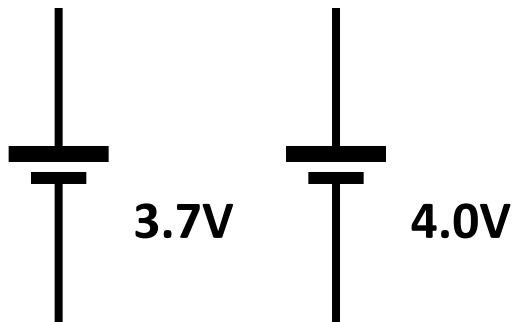
串聯前電壓 2.5V



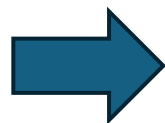
鋰電池並聯

並聯前須確認
每顆電池電壓相同

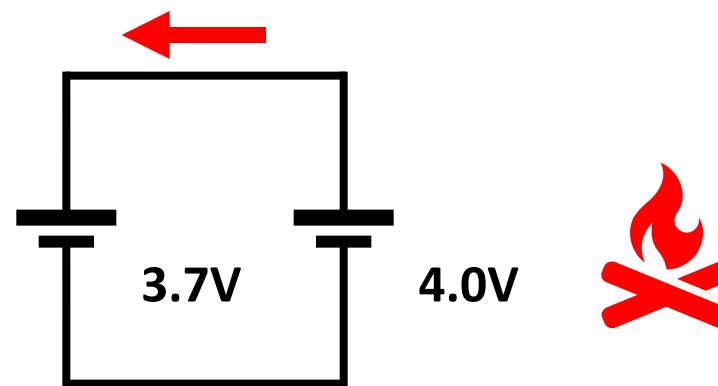
錯誤示範：



並聯



鋰電池內阻非常小，
會有非常大的電流

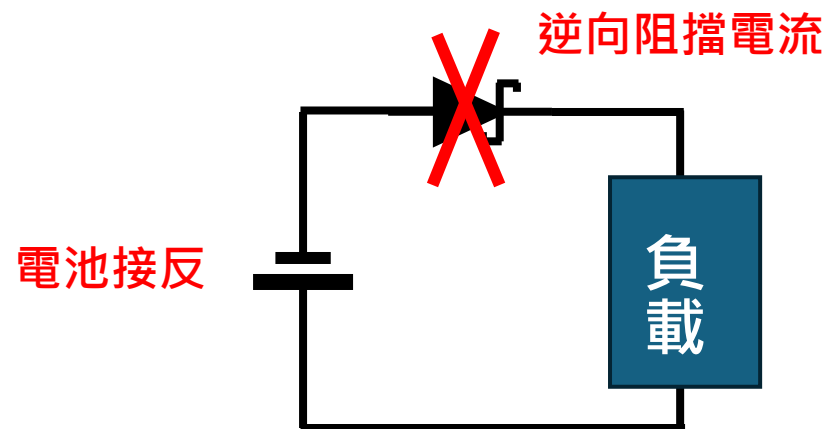
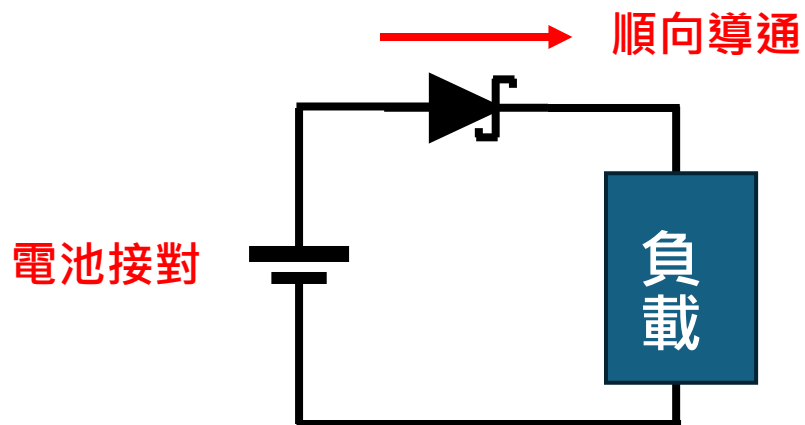


電池反接保護

使用者把電池接反的時候，
保護其他電路不要被負電壓傷害。

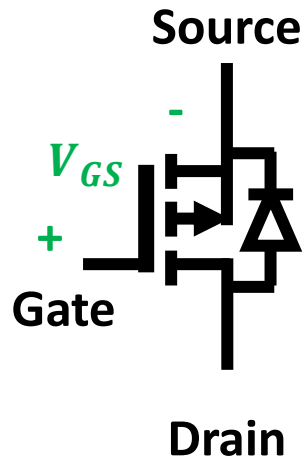
第一種：
串聯 Schottky Diode

缺點是 Schottky Diode 順向導通的時候
會吃 0.3V forward bias，電流大時會有不少損耗

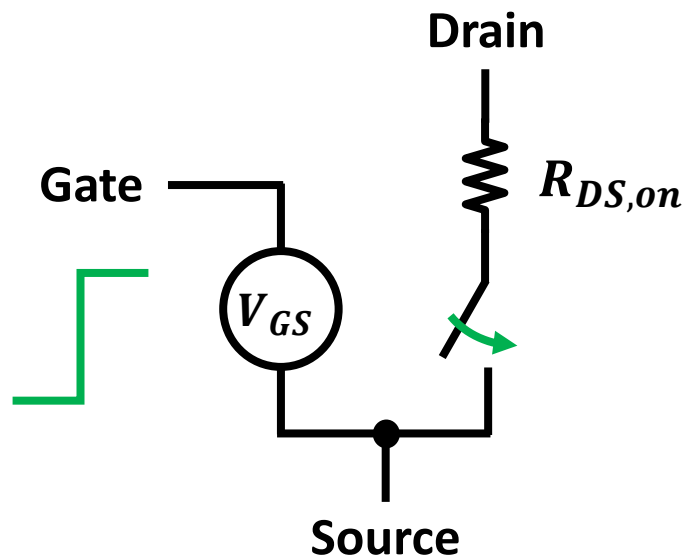
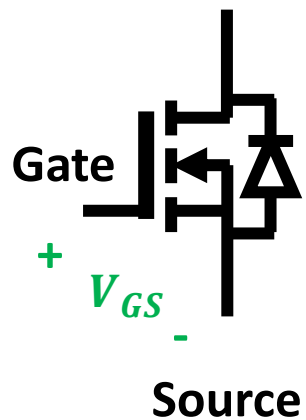


複習一下 MOSFET

PMOS



NMOS



不管 NMOS / PMOS ,
都是 $|V_{GS}| > |V_{TH}|$ 導通

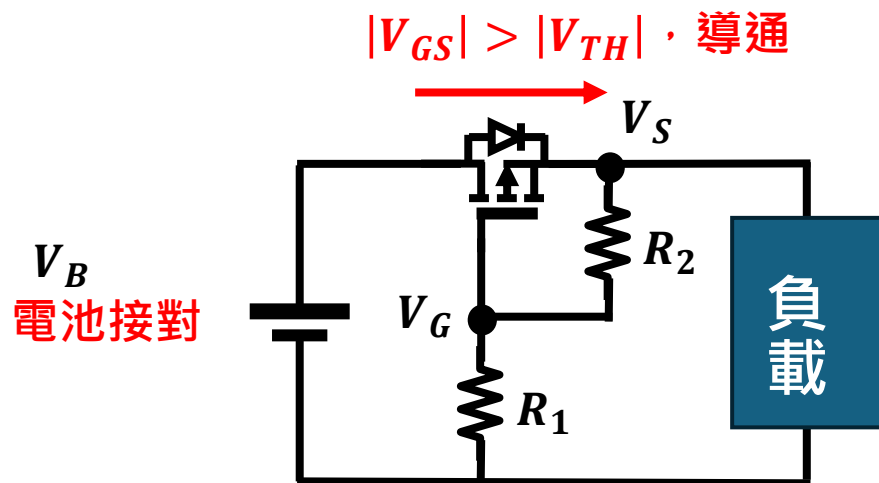
但是：
NMOS 的 $V_G > V_S$
PMOS 的 $V_G < V_S$

電池反接保護

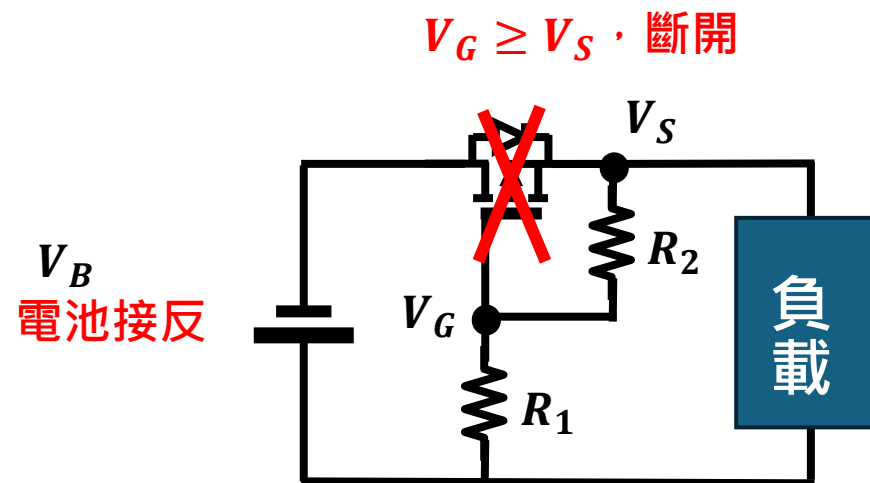
使用者把電池接反的時候，
保護其他電路不要被負電壓傷害。

第二種：
串聯 PMOS

請注意這顆 PMOS 是反過來接的
(body diode 由高電位往低電位指)



剛開機的時候電流先走 body diode，
把 V_{GS} 建立到 $\frac{R_2}{R_1+R_2} \cdot V_B$ ，打開 PMOS

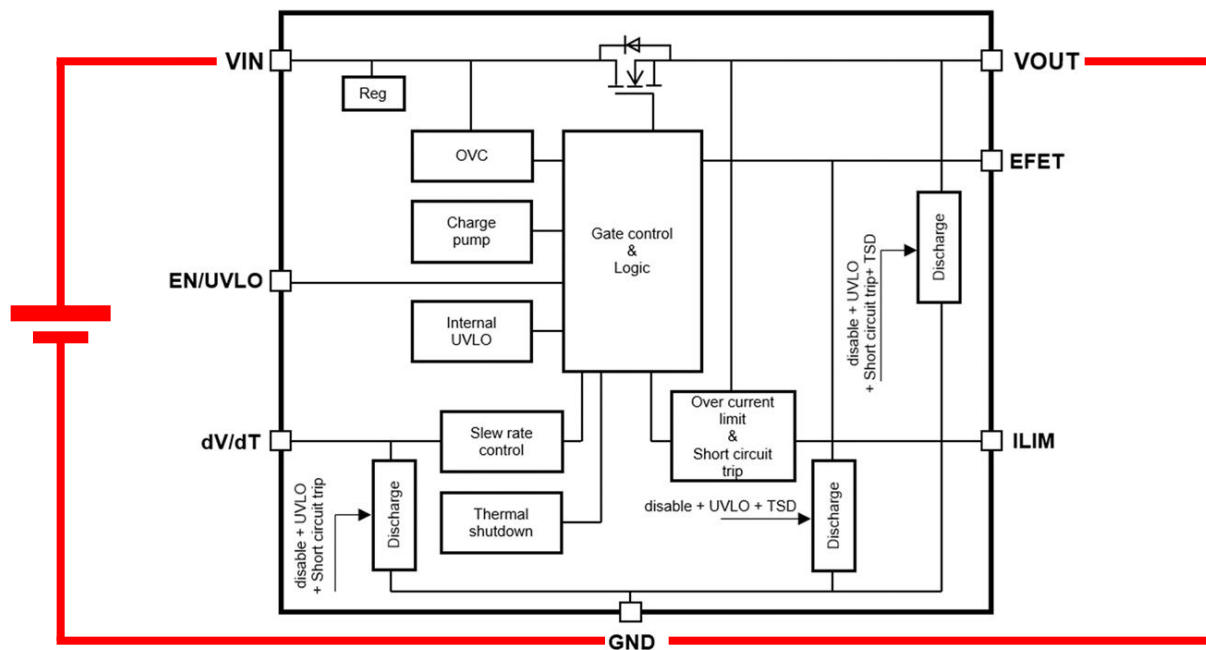


電池接反，body diode 逆向截止，
 R_2 沒電流無法建立電壓，PMOS斷開

Over Current Protection (OCP)

eFuse 電子保險絲

電流太大的時候把電路關掉



TCKE8xx Series

18 V, 5A eFuse IC with **Adjustable Overcurrent Protection** and Reverse Current Blocking FET Control

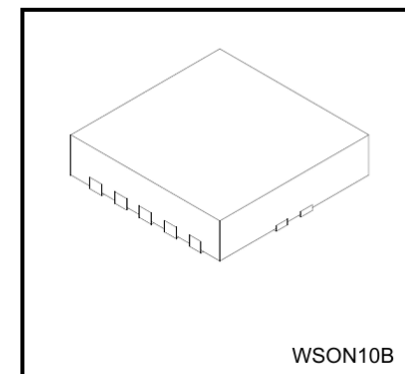
可調的過大電流保護

1. Description

The TCKE8xx series is 18 V high input voltage Single Input-Single Output eFuse ICs. It can be used as a reusable fuse, and includes protection features like adjustable over current limit by an external resistor, short circuit protection, over voltage clamp, adjustable slew rate control by an external capacitance, under voltage protection, thermal shutdown and reverse current blocking by external MOSFET control circuit.

Switch ON resistance is only 28 mΩ (typ.), high output current is up to 5.0 A, and wide input voltage operation characteristics makes this series ideal for power management applications such as in the power supply circuit of hard disk drive and battery charging applications.

This series is available in 0.5 mm pitch small package WSON10B (3.0 mm x 3.0 mm, t: 0.7 mm (typ.)). Thus this series is ideal for various applications such as portable electronics that require high-density soldering



Weight : 19.3mg (typ.)

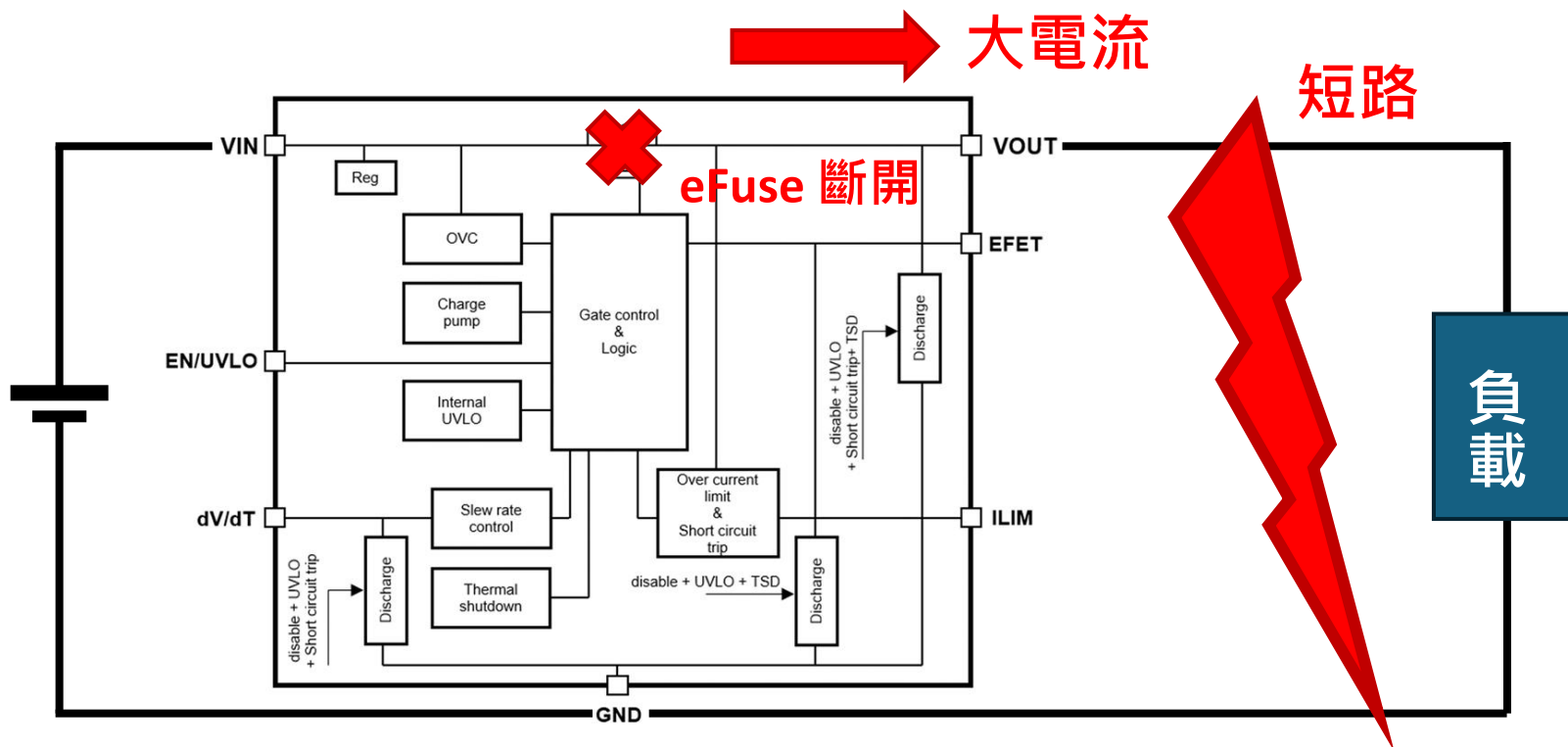
2. Feature

- High input voltage: $V_{IN\ max} = 18.0\ V$
- High output current: $I_{OUT\ (DC)} = 5.0\ A$
- Low ON resistance : $R_{ON} = 28\ m\Omega\ (typ.)$
- Adjustable overcurrent limit : up to 5.0 A (Max)
- Fixed over voltage clamp
5 V power rail TCKE805 : $V_{OVC} = 6.04\ V\ (typ.)$
12 V power rail TCKE812 : $V_{OVC} = 15.1\ V\ (typ.)$
TCKE800 : No over voltage clamp
- Programmable slew rate control by external capacitance for inrush current reduction
- Programmable under voltage lockout by external resistor
- Reverse current blocking support by built in MOSFET driver
- Thermal shutdown
- Auto-discharge
- Small package:
WSON10B (3.0 mm x 3.0 mm, t: 0.7 mm (typ.))

選 IC 的時候注意：
最大電壓電流、
斷開電流值調整範圍、
Latch-off 還是 auto-retry

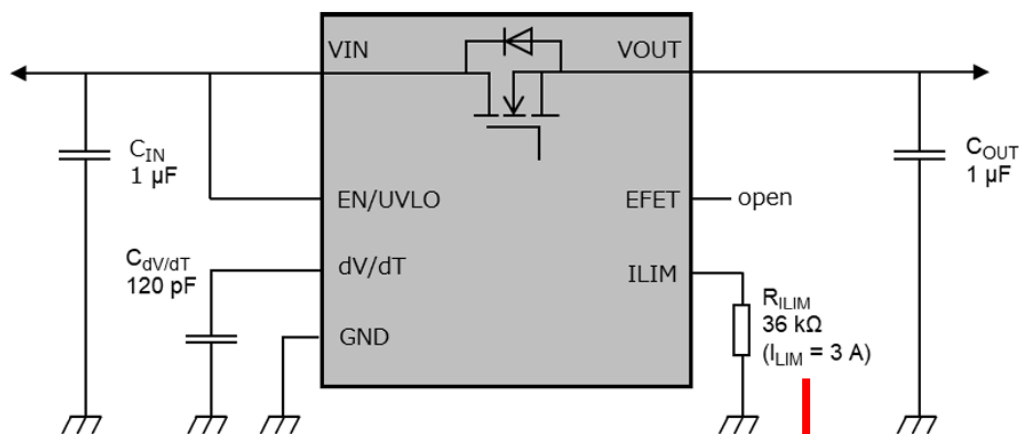
eFuse 電子保險絲

電流太大的時候把電路關掉



Design Example

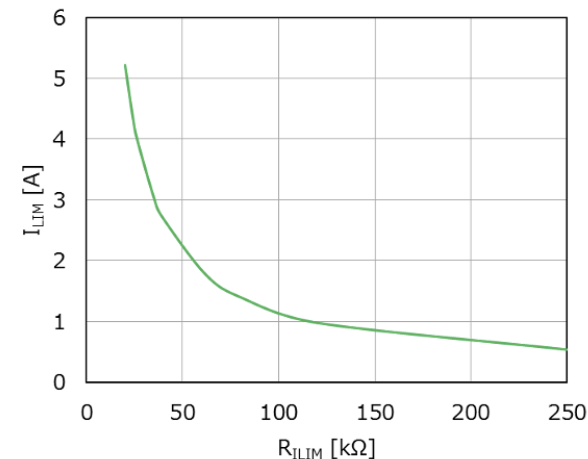
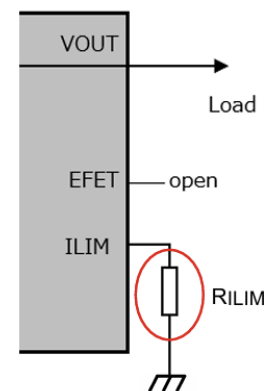
Datasheet 範例電路：



設計 R_{ILIM} 的數值來設定
eFuse 切斷的電流值

Datasheet 提供公式：
$$I_{LIM}(A) = 0.13 + \frac{101.8}{R_{ILIM}(k\Omega)}$$

The following is a diagram of the peripheral circuitry of the ILIM terminal and the relation between R_{ILIM} and I_{LIM} .



ILIM Terminal External Circuits

R_{ILIM} - I_{LIM} Characteristics

For reference table below shows the resistivity of the R_{ILIM} and the current I_{LIM} .

R_{ILIM} (kΩ)	I_{LIM} (A) (typ.)	Conditions
20	5.15	$V_{IN}-V_{OUT}=1\text{ V}$
24	4.38	
36	3.00	
62	1.78	
120	0.96	
250	0.5	
0	0.64	
OPEN	0.64	

Latch-Off vs. Auto-Retry

Latch-Off

電流超過觸發 eFuse 之後，
eFuse 會保持斷開直到重新開機
或是重新給 enable 訊號

Auto-Retry

電流超過觸發 eFuse 之後，
過一段時間 eFuse 會嘗試啟動

TOSHIBA

TCKE8xx Series

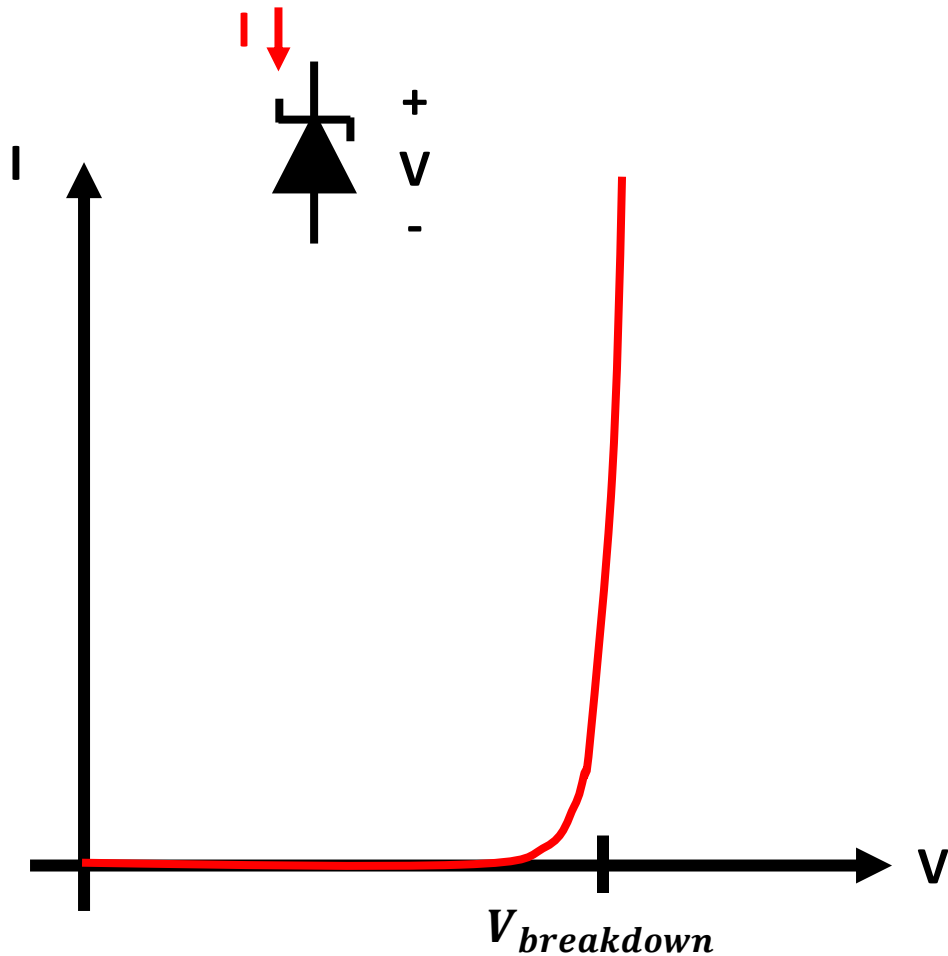
7. Product list

Part number	Over voltage Clamp	CE function	Fault Response	Top Marking	Package
TCKE800NA	N/A	Active High	Auto-retry	800NA	WSO10B (3.0 mm x 3.0 mm, t: 0.7 mm (typ.))
TCKE800NL	N/A	Active High	Latched	800NL	WSO10B (3.0 mm x 3.0 mm, t: 0.7 mm (typ.))
TCKE805NA	6.04V (typ.)	Active High	Auto-retry	805NA	WSO10B (3.0 mm x 3.0 mm, t: 0.7 mm (typ.))
TCKE805NL	6.04V (typ.)	Active High	Latched	805NL	WSO10B (3.0 mm x 3.0 mm, t: 0.7 mm (typ.))
TCKE812NA	15.1V (typ.)	Active High	Auto-retry	812NA	WSO10B (3.0 mm x 3.0 mm, t: 0.7 mm (typ.))
TCKE812NL	15.1V (typ.)	Active High	Latched	812NL	WSO10B (3.0 mm x 3.0 mm, t: 0.7 mm (typ.))

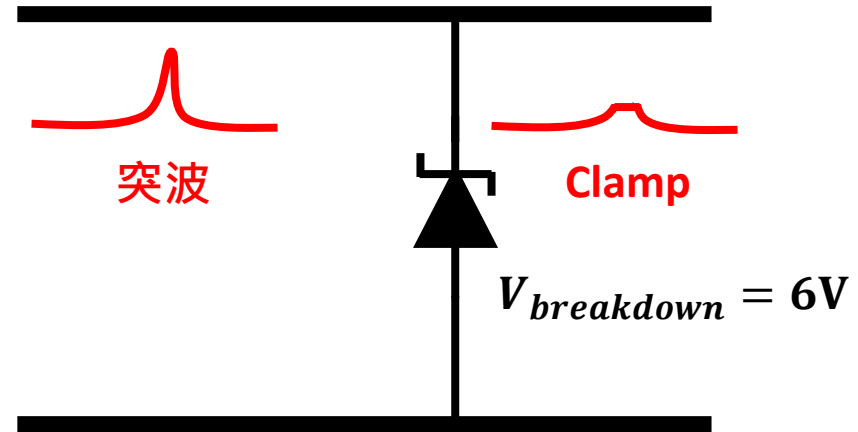
Over Voltage Protection (OVP)

Zener Diode

用於防止電壓超過正常值太多
造成的傷害



正常電壓 5V



在正常情況下都要
reverse bias