# SMD861D Application Note

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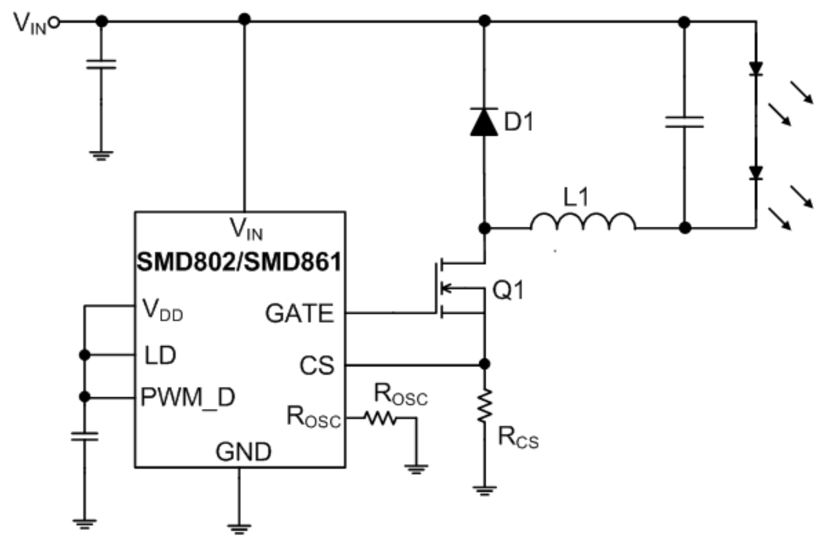
# Advantages and Disadvantages of Peak Current Mode




The Peak Current Mode of Buck converter used in SMD802

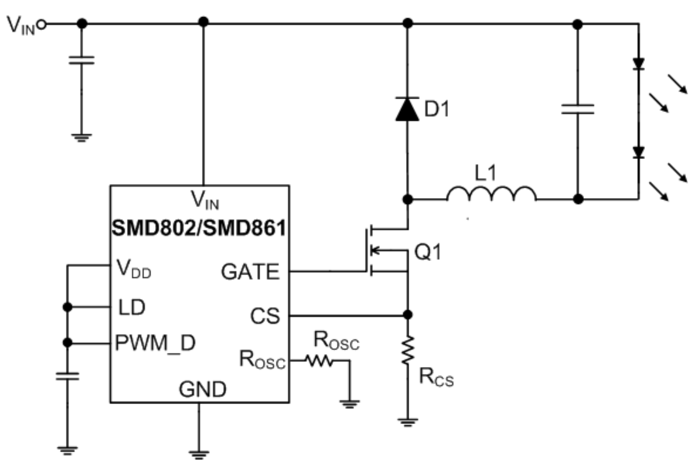
The advantages of Peak current mode:

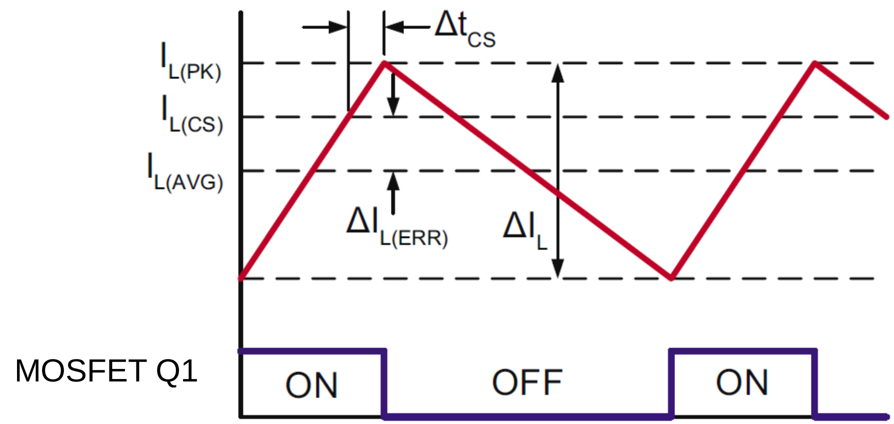
- Simple open loop buck circuit
- Easy and Low cost design

The disadvantages of Peak current mode:

- Constant current accuracy
- Line and Load regulation problems

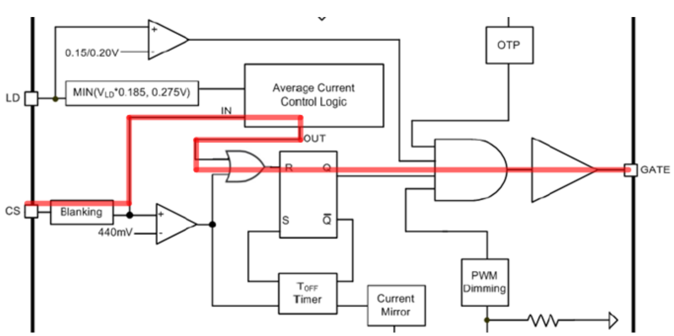
# Peak Current Mode Problems




The peak-to-average current error $\Delta I_{L(ERR)}$ caused by:

- The ripple current in the output inductor
- The propagation delay in the current sense comparator




$$I_{L(PK)} - I_{L(AVG)} = \frac{1}{2}\Delta I_L = \frac{V_O t_{OFF}}{2L}$$

Where
the peak inductor current: $I_{L(PK)}$
the average current: $I_{L(AVG)}$

Considering the current sense comparator delay $\Delta t_{CS}$

$$\Delta I_{L(ERR)} = \frac{V_O t_{OFF} - 2V_{IN}\Delta t_{CS}}{2L}$$

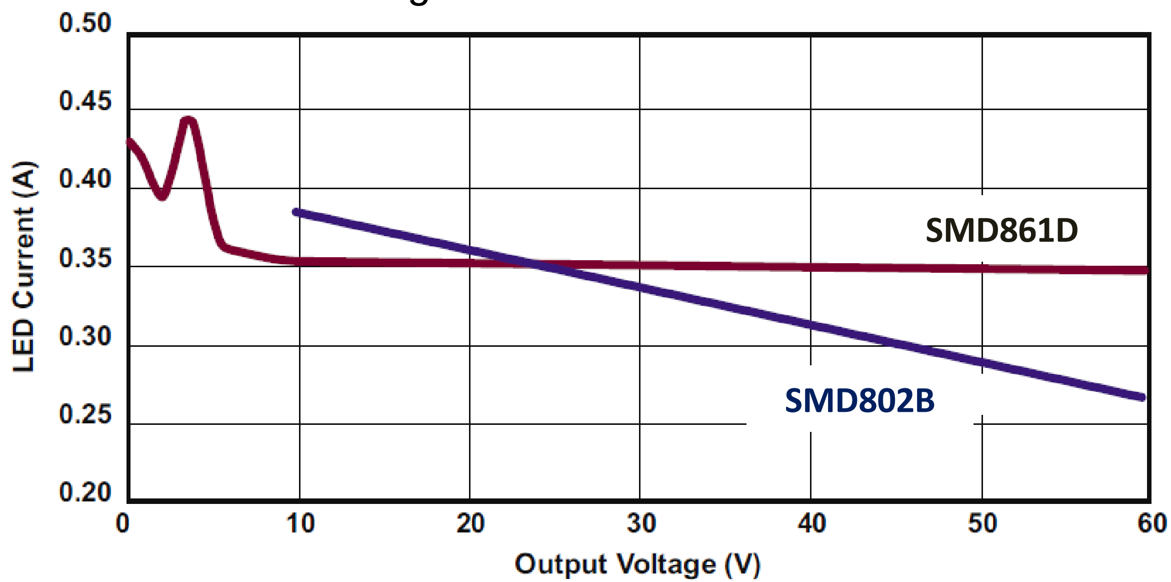
**The average inductor current suffers poor load and line regulation.**

# Average Current Mode

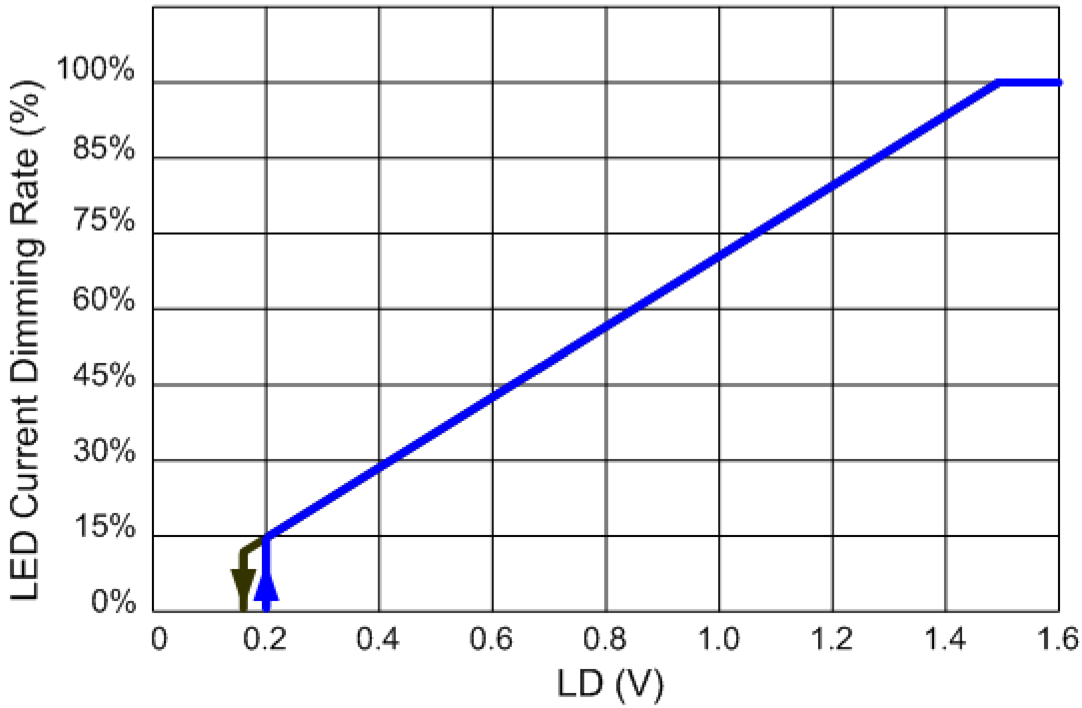
SMD861D overcomes the drawbacks of Peak Current Mode.

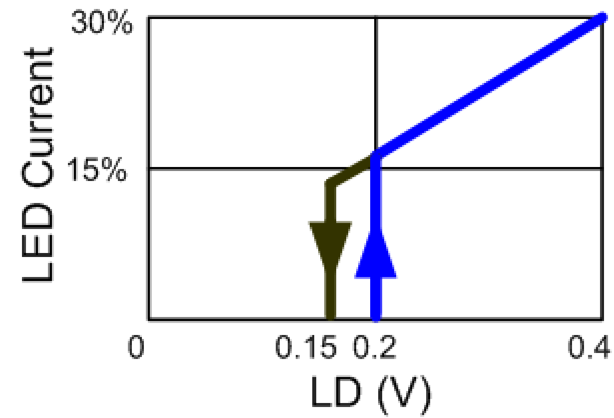
- Regulates the average inductor current directly
- Accuracy within ± 3%
- Gate duty cycle D : 0.1 < D < 0.75
- Auto-zero circuit at CS pin cancels the propagation and offset errors

Load Regulation SMD802B vs SMD861D



# Linear Dimming Characterictics




**When the LD voltage $V_{LD} \geqq 1.5V$**

$$I_{LED(AVG)} = \frac{272mV \pm 3\%}{R_{CS}}$$

**When the LD voltage $0.15V < V_{LD} < 1.5V$**

$$I_{LED(AVG)} = \frac{V_{LD} \pm 3\%}{5.5 \times R_{CS}}$$

$$I_{LED(AVG)\_dimming}\ \% = \frac{V_{LD}}{1.5V}\ \%$$

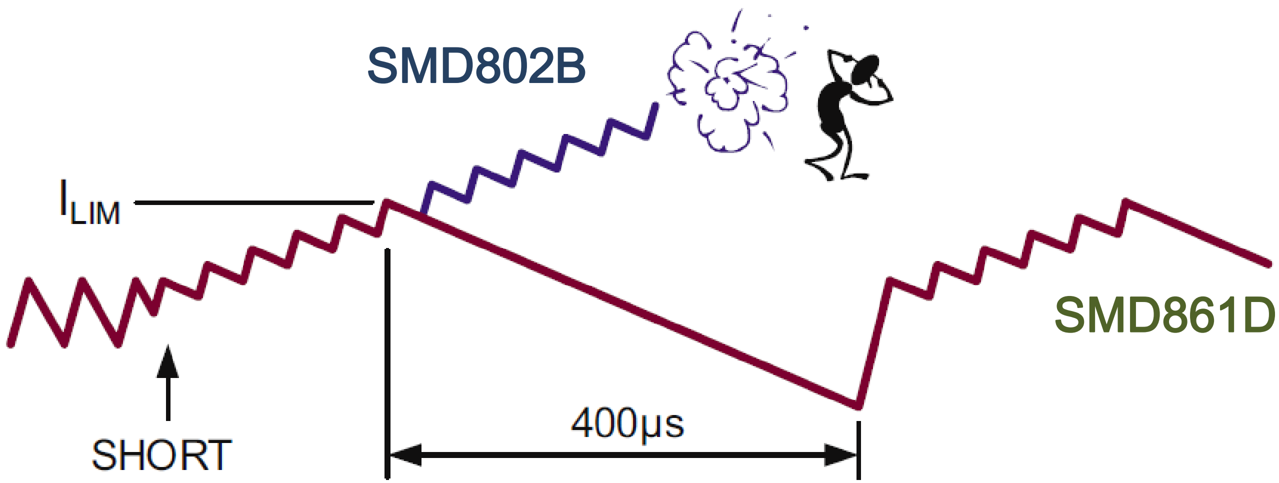
**When the LD voltage $V_{LD} < 0.15V$**

$$I_{LED(AVG)} = 0$$

**The GATE switching resumes when $V_{LD} > 0.2V$**

$$I_{LED(AVG)} = \frac{V_{LD} \pm 3\%}{5.5 \times R_{CS}}$$

# Short Circuit Protection

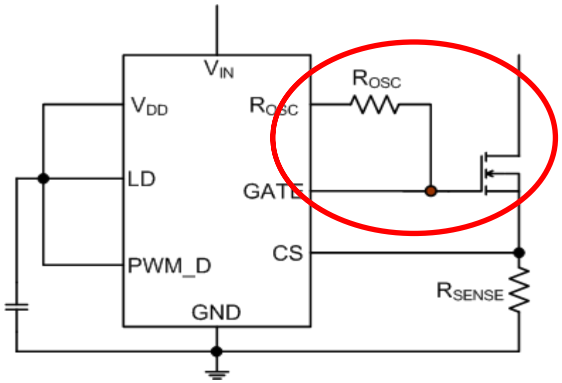



When a short circuit is applied at the output of the buck converter, the inductor current will keep rising every switching cycle.

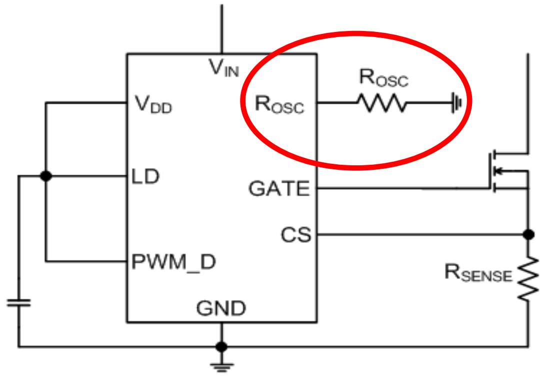
The second threshold $I_{LIM} = 0.44V/R_{CS}$ was designed to protect the stair-case saturation. When this threshold is reached, the GATE Output is disabled for 400µs, thus the inductor current ramp down to a safe level.

# Fixed Freq. Mode vs Constant-Off Time Mode

| Product / Mode | SMD802B | | SMD861D | |
|---|---|---|---|---|
| | Frequency Equation | $R_{OSC}$ wiring | Frequency Equation | $R_{OSC}$ wiring |
| Fixed Frequency Mode | $t_{OSC}$ = 40pF x $R_{OSC}$ + 0.88μs | $R_{OSC}$ wired to GND | NA | NA |
| Constant-Off Time Mode | $t_{OFF}$ = 40pF x $R_{OSC}$ + 0.88μs | $R_{OSC}$ wired to GATE | $t_{OFF}$ = 40pF x $R_{OSC}$ + 0.3μs | $R_{OSC}$ wired to GND |



SMD802B constant-off time mode



SMD861D constant-off time mode,
SMD802B fixed frequency mode

# Maximum Duty Cycle

$$\text{Duty Cycle} = \frac{t_{ON}}{t_{OSC}} = \frac{t_{ON}}{t_{OFF} + t_{ON}}$$

| | SMD802B | SMD861D |
|---|---|---|
| Fixed Frequency Mode | 50% | NA |
| Constant-Off Time Mode | 90% | 75% |

The Regulation of the average inductor current of SMD861D is limited to

$$D_{max} \leqq 0.75,$$

When the the duty cycle is exceeded, the functionality of SMD861D will approach SMD802B, the LED current will drop.

# SMD802B vs SMD861D

| Feature | SMD802B | SMD861D |
|---|---|---|
| Fixed Frequency Mode | Resistor from ROSC to GND | NA |
| Fixed-Off Time Mode | Resistor from ROSC to GATE | Resistor from ROSC to GND |
| Current Threshold | 250mV or $V_{LD}$ | 272mV or $V_{LD}$/5.5 |
| Current Threshold Accuracy | 10% | Auto-zero |
| LED Current Accuracy | Depends on inductance and switching frequency variation | Independent of inductance and switching frequency variation |
| LED Current Regulation | Poor<br>LED current depends on input and output voltage | Good |
| LD Input Range | 0 to 250mV | 0.2V(0.15V) to 1.5V |
| Residual LED Current at $V_{LD}$=GND | 5%(typ.) of $I_{LED}$ @ $V_{LD}$=250mV | 0A |
| Current Limit Threshold | none | 440mV |
| Hiccup Time | NA | 400μS |
| Minimum On-Time | 465ns | 1000ns |
| Maximum Duty Cycle | 0.5(fixed freq.), 0.9(fixed $T_{OFF}$) | 0.75 |