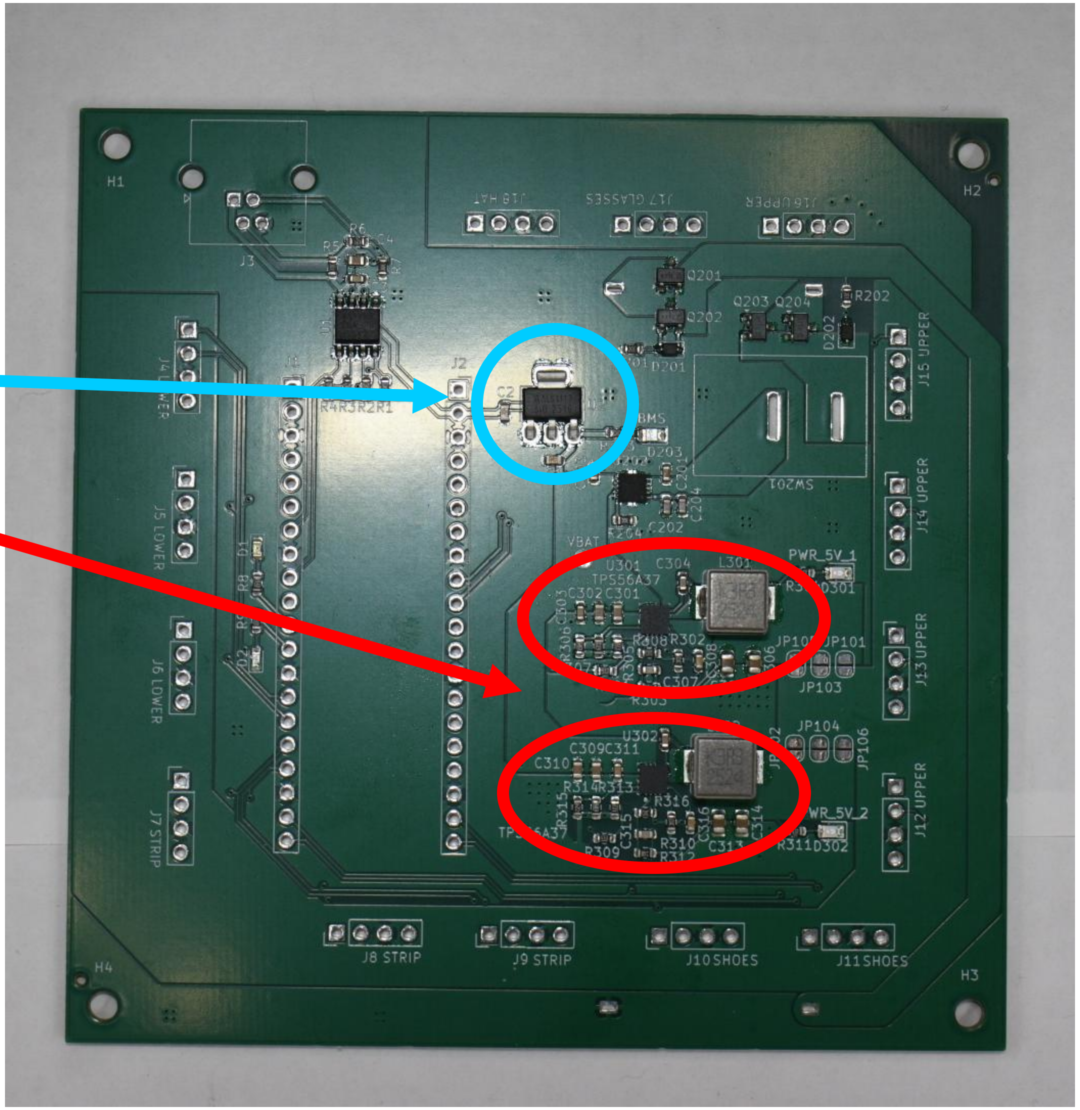
Power Supply

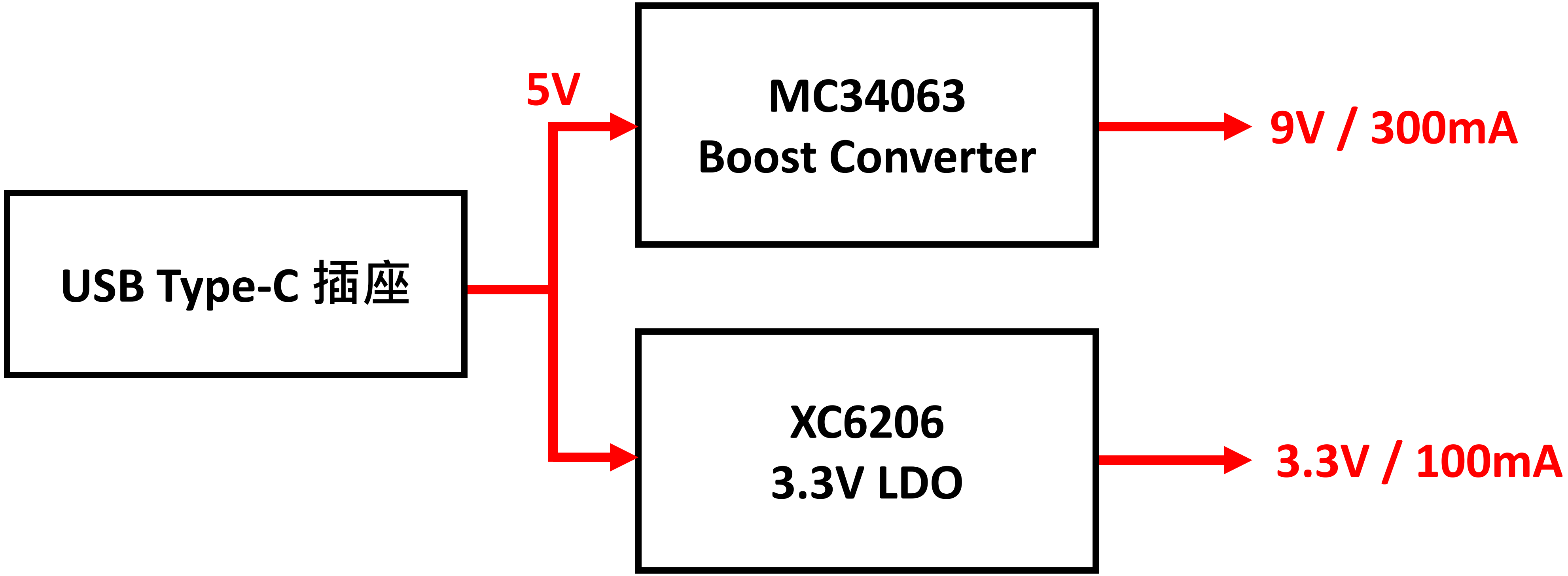
Design Exercise

目標

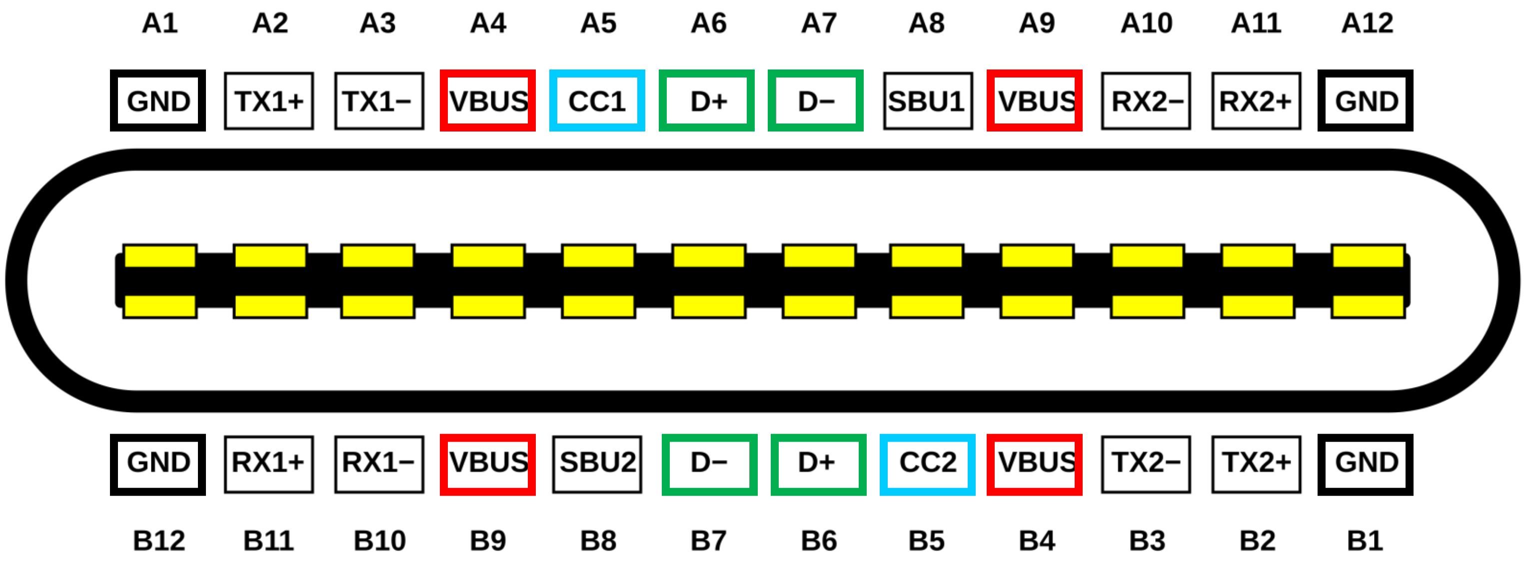
- 做一張迷你版的電夜板子
- **Linear Voltage Regulator**
- **Switch Mode Power Supply**
- **從 USB Type-C 取電**



系統架構


5V
MC34063
Boost Converter
9V / 300mA
USB Type-C 插座
XC6206
3.3V LDO
3.3V / 100mA

USB Type-C



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供電

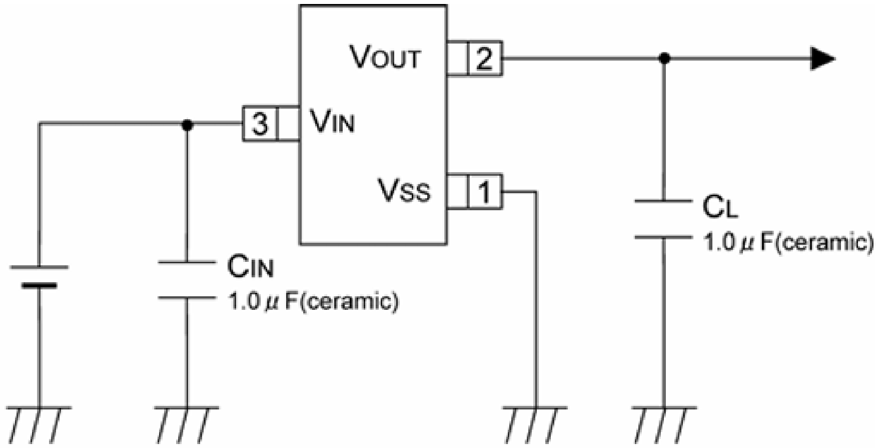
通訊訊號線

CC 訊號線/
方向偵測

要從 USB Type-C 取電，
需要設定 CC 訊號線

把 CC1/CC2 分別接
5.1kΩ 到 GND，
可以取得 5V 電源

XC6206 3.3V LDO



最大電流 200mA
Dropout 0.25V @ 100mA

固定輸出 3.3V 電壓，
只需要外接兩顆電容

MC34063 切換式電源 IC

onsemi

DATA SHEET
www.onsemi.com

Inverting Regulator - Buck, Boost, Switching

1.5 A

MC34063A, MC33063A, SC33063A, NCV33063A

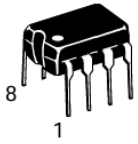
The MC34063A Series is a monolithic control circuit containing the primary functions required for DC–to–DC converters. These devices consist of an internal temperature compensated reference, comparator, controlled duty cycle oscillator with an active current limit circuit, driver and high current output switch. This series was specifically designed to be incorporated in Step–Down and Step–Up and Voltage–Inverting applications with a minimum number of external components. Refer to Application Notes AN920A/D and AN954/D for additional design information.

Features

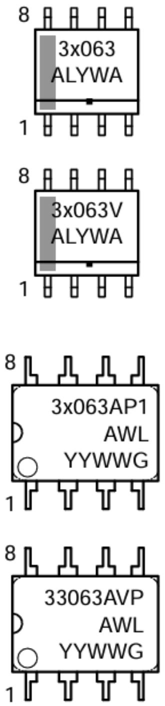
- Operation from 3.0 V to 40 V Input
- Low Standby Current
- Current Limiting
- Output Switch Current to 1.5 A
- Output Voltage Adjustable
- Frequency Operation to 100 kHz
- Precision 2% Reference

MARKING DIAGRAMS

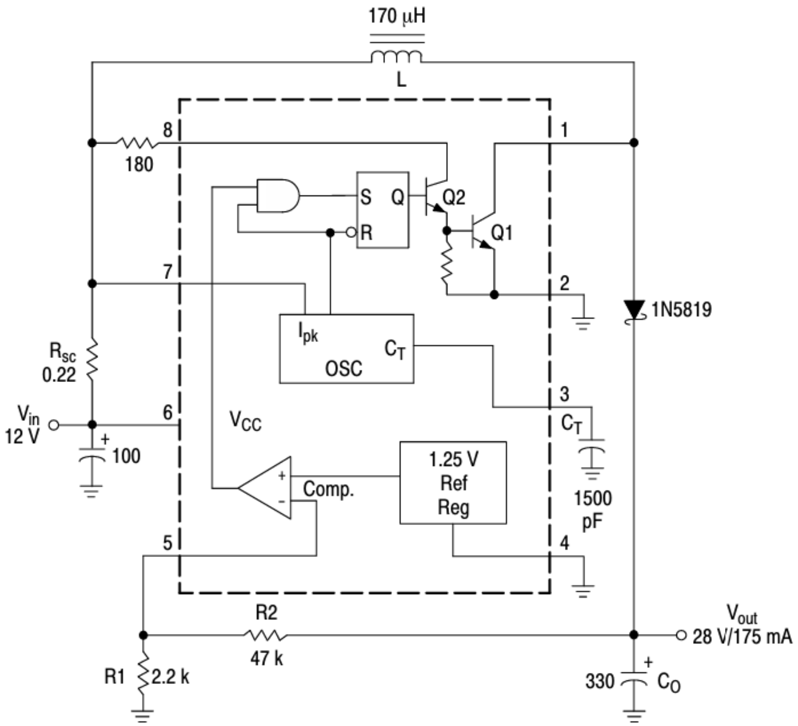
SOIC–8
D SUFFIX
CASE 751



PDIP–8
P, P1 SUFFIX
CASE 626

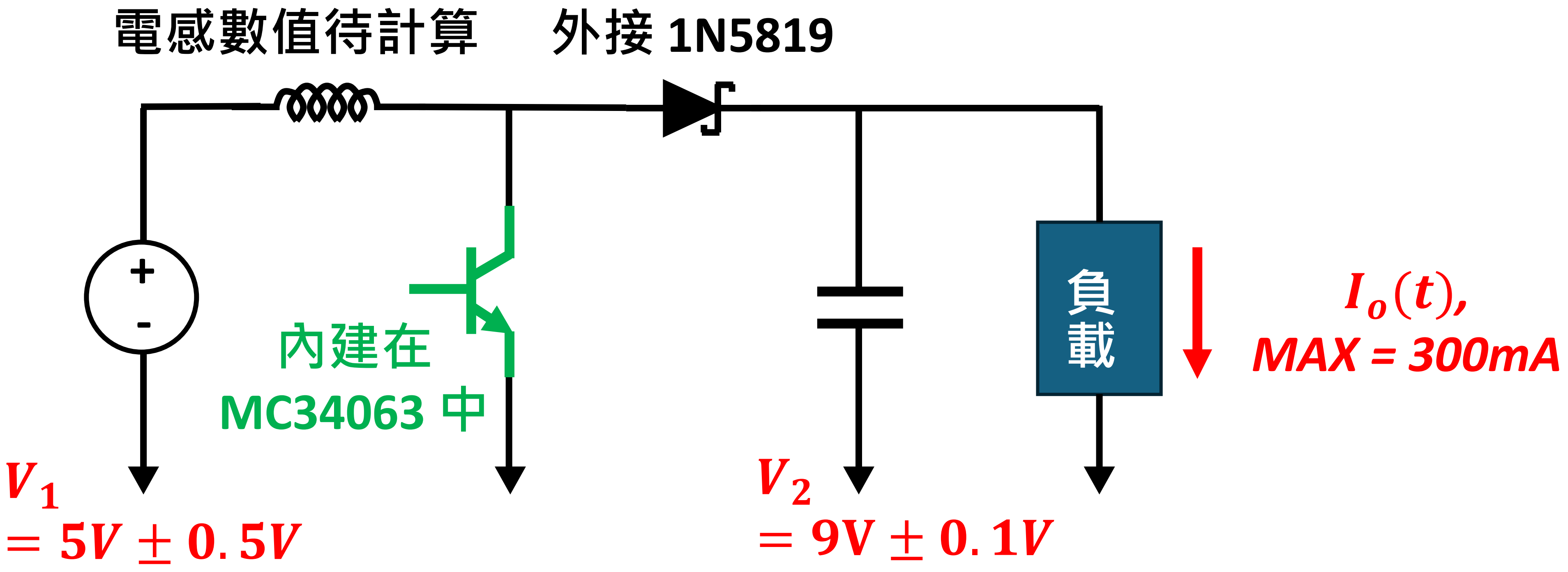


x = 3 or 4
A = Assembly Location
L, WL = Wafer Lot

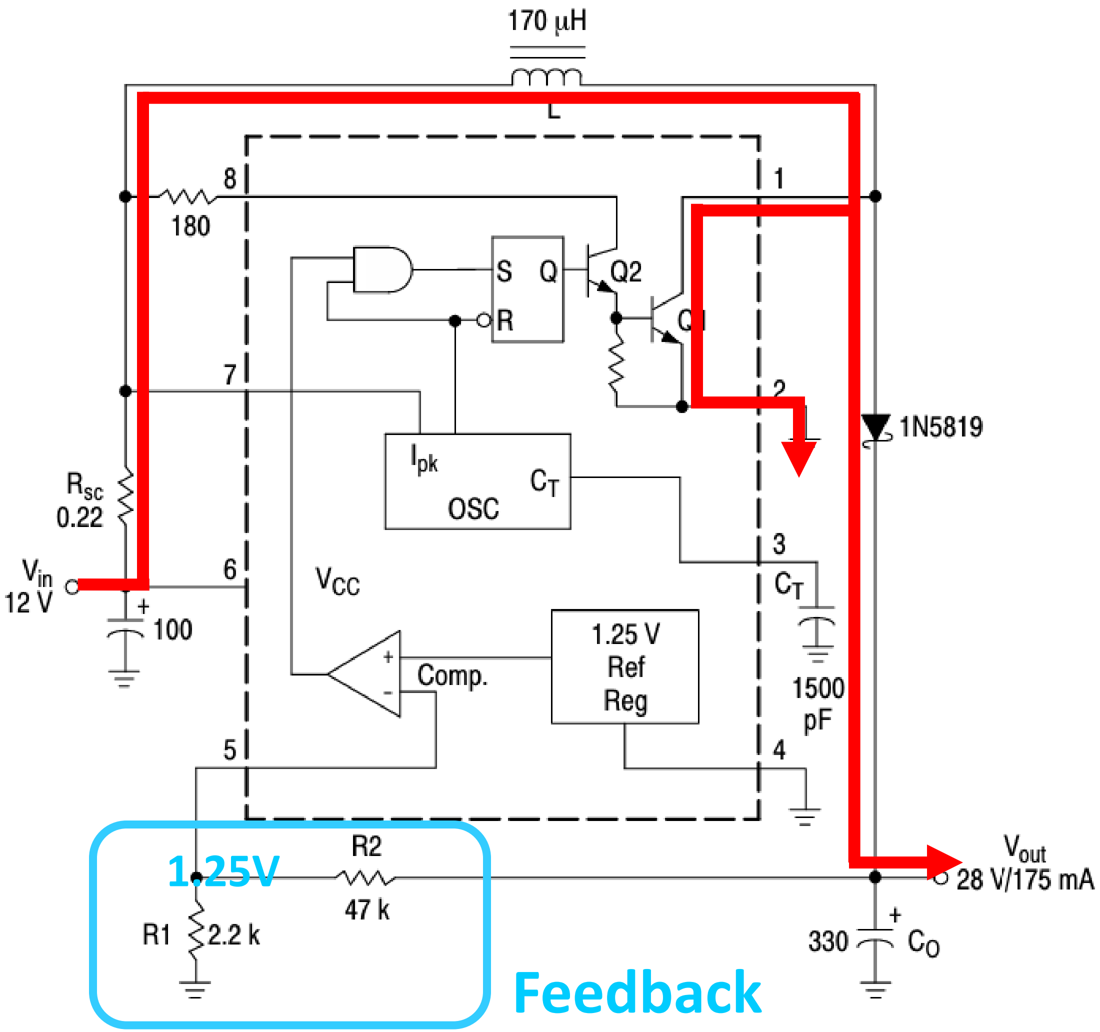


Datasheet Boost 範例電路

升壓轉換器 Boost Converter



MC34063 Boost Converter



$$V_{OUT} = V_{FB} \cdot \frac{R_1 + R_2}{R_2}$$

$$V_{FB} = 1.25\text{V}$$

我們目標輸出 $V_{out} = 9V$

$\frac{R_2}{R_1} = \frac{31}{5}$, choose:

$\mathrm{R}_2 = 62\mathrm{k}\Omega, \mathrm{R}_1 = 10\mathrm{k}\Omega$

Calculation Table

Calculation	Step–Up	Step–Down	Voltage–Inverting
t_{on}/t_{off}	$\dfrac{V_{out} + V_F - V_{in(min)}}{V_{in(min)} - V_{sat}}$	$\dfrac{V_{out} + V_F}{V_{in(min)} - V_{sat} - V_{out}}$	$\dfrac{\|V_{out}\| + V_F}{V_{in} - V_{sat}}$
$(t_{on} + t_{off})$	$\dfrac{1}{f}$	$\dfrac{1}{f}$	$\dfrac{1}{f}$
t_{off}	$\dfrac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$	$\dfrac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$	$\dfrac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$
t_{on}	$(t_{on} + t_{off}) - t_{off}$	$(t_{on} + t_{off}) - t_{off}$	$(t_{on} + t_{off}) - t_{off}$
C_T	$4.0 \times 10^{-5}\, t_{on}$	$4.0 \times 10^{-5}\, t_{on}$	$4.0 \times 10^{-5}\, t_{on}$
$I_{pk(switch)}$	$2I_{out(max)}\left(\dfrac{t_{on}}{t_{off}} + 1\right)$	$2I_{out(max)}$	$2I_{out(max)}\left(\dfrac{t_{on}}{t_{off}} + 1\right)$
R_{sc}	$0.3/I_{pk(switch)}$	$0.3/I_{pk(switch)}$	$0.3/I_{pk(switch)}$
$L_{(min)}$	$\left(\dfrac{(V_{in(min)} - V_{sat})}{I_{pk(switch)}}\right) t_{on(max)}$	$\left(\dfrac{(V_{in(min)} - V_{sat} - V_{out})}{I_{pk(switch)}}\right) t_{on(max)}$	$\left(\dfrac{(V_{in(min)} - V_{sat})}{I_{pk(switch)}}\right) t_{on(max)}$
C_O	$9\dfrac{I_{out}t_{on}}{V_{ripple(pp)}}$	$\dfrac{I_{pk(switch)}(t_{on} + t_{off})}{8V_{ripple(pp)}}$	$9\dfrac{I_{out}t_{on}}{V_{ripple(pp)}}$

V_{sat} = Saturation voltage of the output switch.
V_F = Forward voltage drop of the output rectifier.

The following power supply characteristics must be chosen:

V_{in} – Nominal input voltage.
V_{out} – Desired output voltage, $|V_{out}| = 1.25\left(1 + \dfrac{R2}{R1}\right)$
I_{out} – Desired output current.
f_{min} – Minimum desired output switching frequency at the selected values of V_{in} and I_O.
$V_{ripple(pp)}$ – Desired peak–to–peak output ripple voltage. In practice, the calculated capacitor value will need to be increased due to its equivalent series resistance and board layout. The ripple voltage should be kept to a low value since it will directly affect the line and load regulation.

Calculation Table

t_{on}/t_{off} $\Big|$ $$\frac{V_{out} + V_F - V_{in(min)}}{V_{in(min)} - V_{sat}}$$

開關的時間比

$$\frac{t_{on}}{t_{off}} = \frac{49}{40} = 1.225$$

這種不理想性造成的數值
通常會故意稍微高估

Schottky Diode 的 Forward Voltage
$V_F = 0.4\text{V}$ (by 1N5819 datasheet)

NPN 電晶體的 Saturation VCE
$V_{sat} = 0.5\text{V}$ (by datasheet)

輸出電壓
$V_{out} = 9.0\text{V}$

最低輸入電壓
$V_{in(min)} = 5.0 - 0.5 = 4.5\text{V}$

Calculation Table

$(t_{on} + t_{off})$	$\frac{1}{f}$
t_{off}	$\dfrac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$
t_{on}	$(t_{on} + t_{off}) - t_{off}$

切換頻率(用最高)

$\mathrm{f} = 100\mathrm{kHz}$

這只是在算 t_{on}, t_{off} 分別是多少，別怕

$$t_{on} \approx 4.49\mu s$$
$$t_{off} \approx 5.51\mu s$$

Calculation Table

用來設定切換頻率的電容數值，算完之後選最近的 **E12** 數值

開關的峰值電流

C_T	$4.0 \times 10^{-5}\, t_{on}$
$I_{pk(switch)}$	$2I_{out(max)} \left(\frac{t_{on}}{t_{off}} + 1 \right)$
R_{sc}	$0.3/I_{pk(switch)}$

過載保護電阻(本次忽略)

$$C_T \approx 220\text{pF}$$

$$I_{pk} = 1.335\text{A} \boxed{< 1.5\text{A}}$$

Check datasheet

最高輸出電流

$$I_{out(max)} = 300\text{mA}$$

Calculation Table

$L > 16.5\mu H \Rightarrow \boxed{22\mu H}$

$C > 74.4\mu F \Rightarrow \boxed{100\mu F}$

如果手邊剛好有比較大的，
可以用比較大的

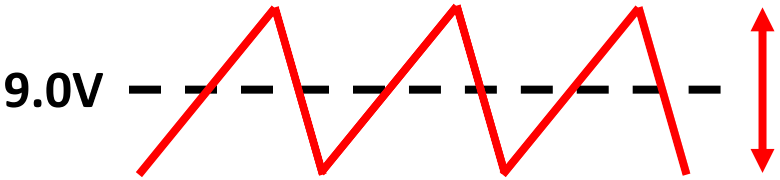
最小電感數值

不要管這個 max

$L_{(min)}$	$\left(\frac{V_{in(min)} - V_{sat}}{I_{pk(switch)}}\right) t_{on(max)}$
C_O	$9 \frac{I_{out} t_{on}}{V_{ripple(pp)}}$

輸出電容

實際輸出電壓波型



峰對峰 < 200mV

輸出峰對峰電壓漣波

$V_{ripple(pp)} = 200\text{mV}$

電感、電容數值算完之後往上抓一些