

# Regulated 5V Charge Pump In SOT-23

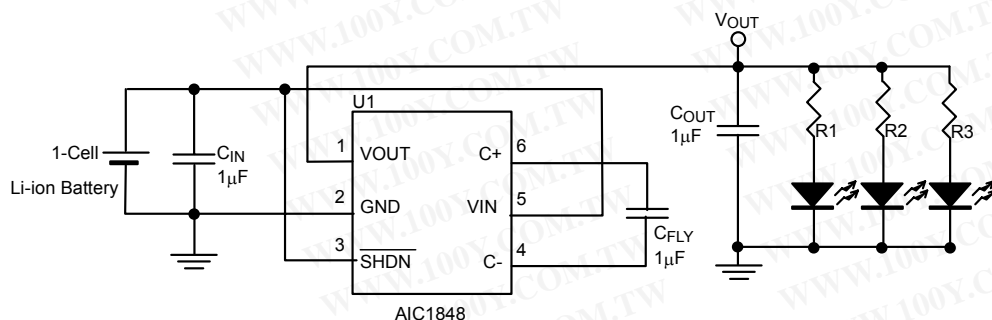
## FEATURES

- Regulated  $\pm 4\%$  Output Voltage
- Output Current: 100mA at  $V_{IN}=3.1V$
- Input Range: 2.7V to 4.5V
- No Inductors Required
- Very Low Shutdown Current:  $<1\mu A$
- 1.8MHz Switching Frequency
- Short-Circuit and Over Temperature Protection
- Low Profile Package: SOT-23-6

## APPLICATIONS

- White LEDs Backlighting
- SIM Interface Supplies for Cellular Telephones
- Li-Ion Battery Backup Supplies
- Local 3V to 5V Conversion
- Smart Card Readers
- PCMCIA Local 5V Supplies

## TYPICAL APPLICATION CIRCUIT



Regulated 5V Output from 2.7V to 4.5V Input

WLED series number: NSPW310BS,  $V_F=3.6V$ ,  $I_F=20mA$

$$R = \frac{V_{OUT} - V_F}{I_F}$$

$C_{IN}$ ,  $C_{FLY}$ ,  $C_{OUT}$ : JMK107BJ105KA, TAIYO YUDEN

## DESCRIPTION

The AIC1848 charge pump is a micropower charge pump DC/DC converter that produces a regulated output voltage from 2.7V to 4.5V input voltage. Low external-part count (one flying capacitor and two small bypass capacitors) makes the AIC1848 ideal for small, battery-powered applications.

The AIC1848 operates as a constant frequency mode switched capacitor voltage doubler to produce a regulated output and features with thermal shutdown capability and short circuit protection.

The AIC1848 is available in a space-saving SOT-23-6 package.

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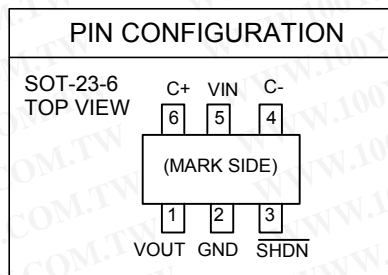
## ■ ORDERING INFORMATION

AIC1848-XXXX

PACKING TYPE  
 TR: TAPE & REEL  
 BG: BAG

PACKAGE TYPE  
 G: SOT-23-6

C: COMMERCIAL  
 P: LEAD FREE COMMERCIAL



Example: AIC1848CGTR

→ in SOT-23-6 Package & Taping &  
 Reel Packing Type

AIC1848PGTR

→ in Lead Free SOT-23-6 Package &  
 Taping & Reel Packing Type

### ● SOT-23-6 Marking

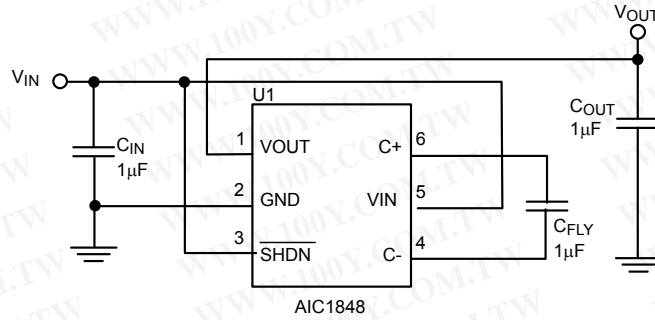
Part No.	Marking	Part No.	Marking
AIC1848CG	BP50	AIC1848PG	BP50P

## ■ ABSOLUTE MAXIMUM RATINGS

VIN to GND	6V
VOUT to GND	6V
All Other Pins to GND	6V
VOUT Short-Circuit Duration	Continuous
Operating Temperature Range	-40°C to 85 °C
Maximum Junction Temperature	125°C
Storage Temperature Range	-65°C to 150 °C
Lead Temperature (Soldering 10 Sec.)	260°C

**Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.**

## TEST CIRCUIT



## ELECTRICAL CHARACTERISTICS

( $T_A=25^{\circ}\text{C}$ ,  $C_{FLY}=1\mu\text{F}$ ,  $C_{IN}=1\mu\text{F}$ ,  $C_{OUT}=1\mu\text{F}$ , unless otherwise specified.) (Note 1)

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Input Voltage		$V_{IN}$	2.7		4.5	V
Output Voltage	$2.7\text{V} \leq V_{IN} < 4.5\text{V}$ , $I_{OUT} \leq 40\text{mA}$	$V_{OUT}$	4.8	5	5.2	V
	$3.1\text{V} \leq V_{IN} \leq 4.5\text{V}$ , $I_{OUT} \leq 100\text{mA}$		4.8	5	5.2	
Supply Current	$2.7\text{V} \leq V_{IN} \leq 5.0\text{V}$ , $I_{OUT}=0$ , $\overline{\text{SHDN}}=V_{IN}$	$I_{CC}$	1	3	5	mA
Shutdown Current	$2.7\text{V} \leq V_{IN} \leq 5.0\text{V}$ , $I_{OUT}=0$ , $\overline{\text{SHDN}}=0\text{V}$	$I_{\overline{\text{SHDN}}}$		0.01	1.0	$\mu\text{A}$
Efficiency	$V_{IN}=2.7\text{V}$ , $I_{OUT}=30\text{mA}$	$\eta$		85		%
Switching Frequency	Oscillator Free Running	$f_{OSC}$		1.8		MHz
Shutdown Input Threshold	High	$V_{IH}$	1.4			V
	Low	$V_{IL}$			0.3	V
Shutdown Input Current	$\overline{\text{SHDN}}=V_{IN}$	$I_{IH}$	-1		1	$\mu\text{A}$
	$\overline{\text{SHDN}}=0\text{V}$	$I_{IL}$	-1		1	$\mu\text{A}$
Vout Turn On Time	$V_{IN}=3\text{V}$ , $I_{OUT}=1\text{mA}$	$t_{ON}$		50		$\mu\text{s}$
Output Short Circuit Current	$V_{IN}=3\text{V}$ , $V_{OUT}=0\text{V}$ , $\overline{\text{SHDN}}=V_{IN}$	$I_{SC}$		300		mA

**Note 1:** Specifications are production tested at  $T_A=25^{\circ}\text{C}$ . Specifications over the  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  operating temperature range are assured by design, characterization and correlation with Statistical Quality Controls (SQC).

## TYPICAL PERFORMANCE CHARACTERISTICS

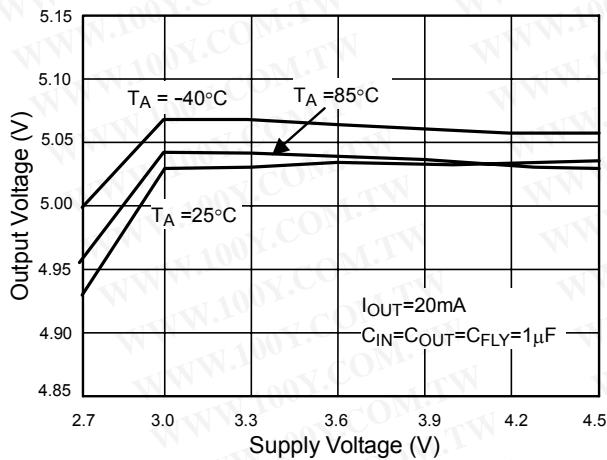


Fig. 1 Output Voltage vs. Supply Voltage

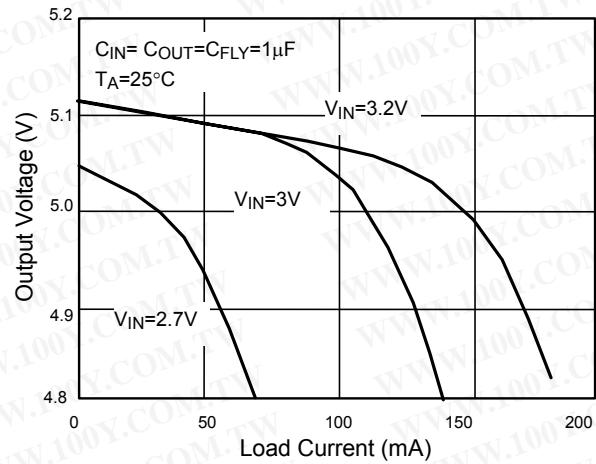


Fig. 2 Output Voltage vs. Load Current

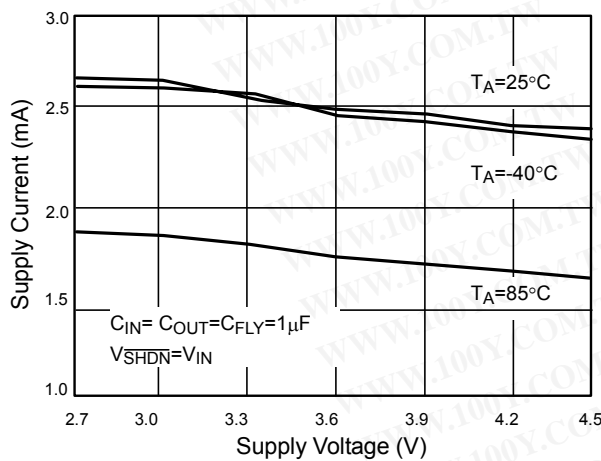


Fig. 3 No Load Supply Current vs. Supply Voltage

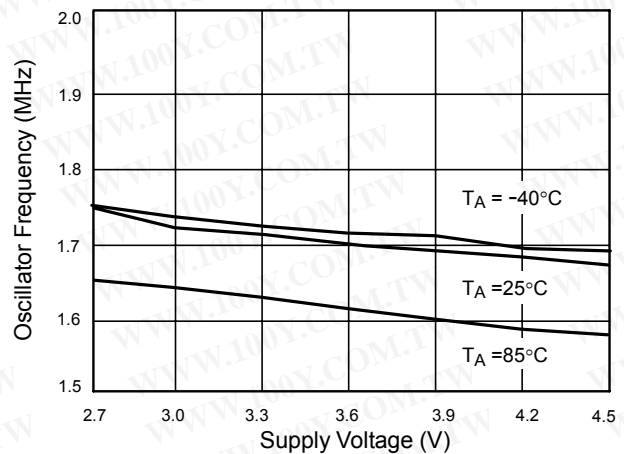


Fig. 4 Oscillator Frequency vs. Supply Voltage

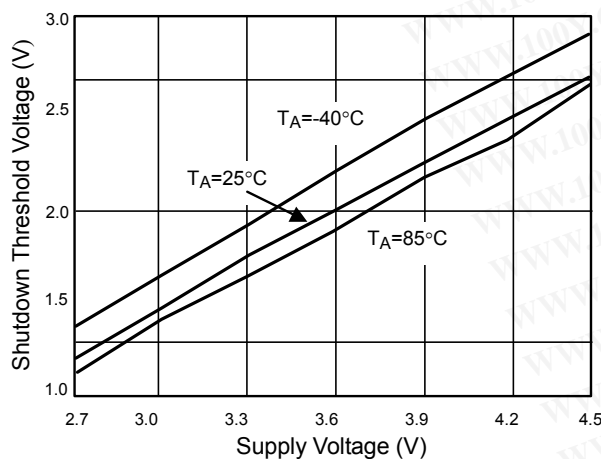


Fig. 5  $V_{SHDN}$  Threshold Voltage vs. Supply Voltage

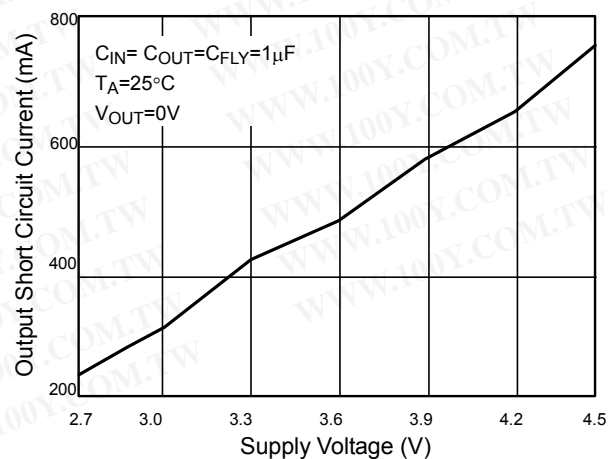


Fig. 6 Short Circuit Current vs. Supply Voltage



## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

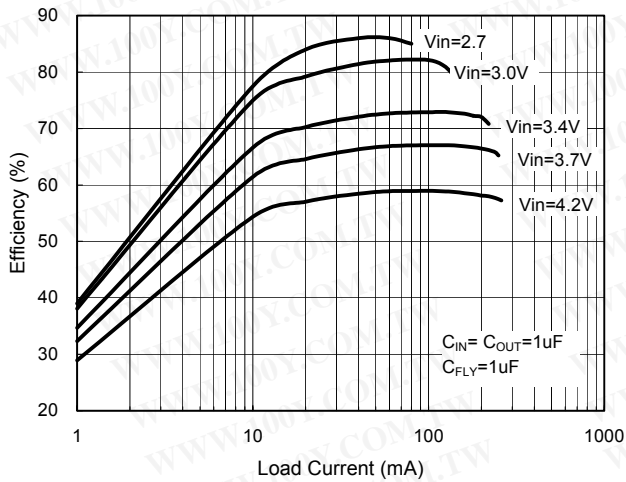


Fig. 7 Efficiency vs. Load Current

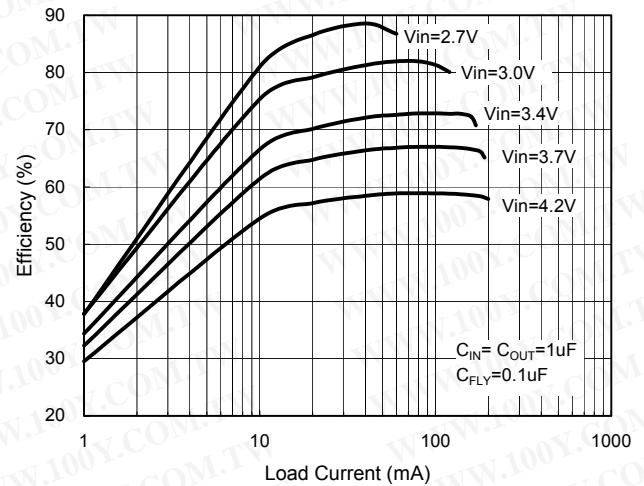


Fig. 8 Efficiency vs. Load Current

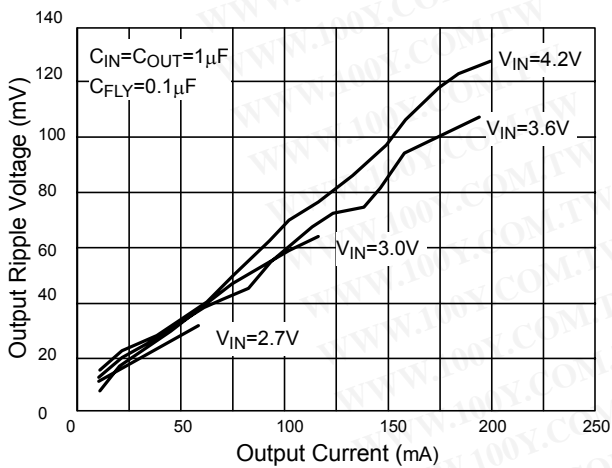


Fig. 9 Output Ripple Voltage vs. Output Current

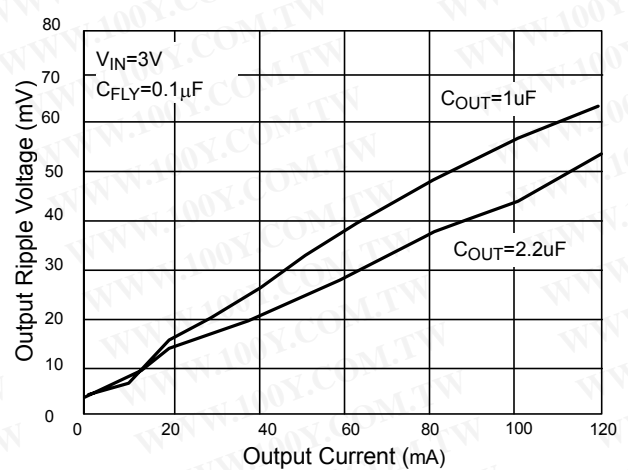
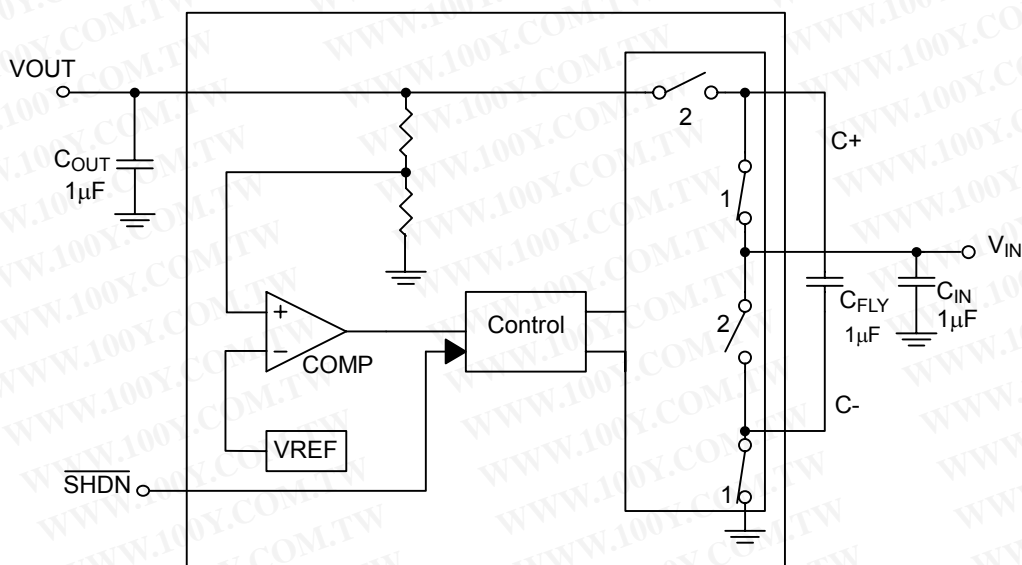


Fig. 10 Output Ripple Voltage vs. Output Current

## BLOCK DIAGRAM



## PIN DESCRIPTIONS

- PIN 1: VOUT - Regulated output voltage. For the best performance,  $V_{OUT}$  should be bypassed a  $1\mu F$  (min.) low ESR capacitor with the shortest distance in between.
- PIN 2: GND - Ground. Should be tied to ground plane direct for best performance.
- PIN 3:  $\overline{SHDN}$  - Active low shutdown input. Tie to higher than 1.4V to enable device, 0.3V or less to disable device.

- $\overline{SHDN}$  pin is not allowed to float.
- PIN 4: C- - Flying capacitor negative terminal.
- PIN 5: VIN - Input supply voltage.  $V_{IN}$  should be bypassed a  $1\mu F$  (min.) low ESR capacitor with the shortest distance in between.
- PIN 6: C+ - Flying capacitor positive terminal.

## APPLICATION INFORMATION

### Introduction

AIC1848 is a micropower charge pump DC/DC converter that produces a regulated 5V output with an input voltage range from 2.7V to 4.5V. It utilizes the charge pump topology to boost  $V_{IN}$  to a regulated output voltage. Regulation is obtained by sensing the output voltage through an internal resistor divider. A switched doubling circuit enables the charge pump when the feedback voltage is lower than the internal comparator point, and vice versa. When the charge pump is enabled, a two-phase non-overlapping clock activates the charge pump switches.

### Operation

This kind of converter uses capacitors to store and transfer energy. Since the capacitors can't change to the voltage level abruptly, the voltage ratio of  $V_{OUT}$  to  $V_{IN}$  is limited. Capacitive voltage conversion is obtained by switching a capacitor periodically. Refer to Fig. 11, during the on state of internal clock,  $Q_1$  and  $Q_4$  are closed, which charges  $C_{FLY}$  to  $V_{IN}$  level. During the off state,  $Q_3$  and  $Q_2$  are closed. The output voltage is  $V_{IN}$  plus  $V_{CFLY}$ , that is,  $2V_{IN}$ .

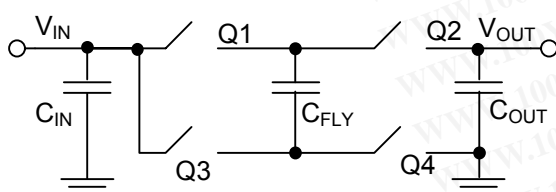


Fig. 11 The circuit of charge pump

### Short Circuit/Thermal Protection

AIC1848 obtains built-in short circuit current limiting and over temperature protection. During the short circuit condition, the output current is automatically constrained at approximately 300mA. Continued current limit will cause internal

IC junction temperature increased. When the temperature of device exceeds  $150^{\circ}\text{C}$ , the thermal protection will shut the switching down and the temperature will reduce afterwards. Once the temperature drops below  $135^{\circ}\text{C}$ , the charge pump switching circuit will re-start. If the fault doesn't eliminate, the above protecting operation will repeat again and again. It allows AIC1848 to continuously work at short circuit condition without damaging the device.

### Shutdown

In shutdown mode, the output is disconnected from input. The input current gets extremely low since most of the circuitry is turned off. Due to high impedance, shutdown pin can't be floated.

### Efficiency

Refer to Fig. 12 and Fig. 13, they shows the circuit of charge pump at different operation states.

$R_{DS-ON}$  is the resistance of the switching element at conduction.

ESR is the equivalent series resistance of the flying capacitor  $C_{FLY}$ .

$I_{ON-AVE}$  and  $I_{OFF-AVE}$  are the average current during on state and off state, respectively.

D is the duty cycle, which means the proportion the on state takes.

Let's take advantage of conversation of charge for capacitor  $C_{FLY}$ . Assume that the capacitor  $C_{FLY}$  has reached its steady state. The amount of charge flowing into  $C_{FLY}$  during on state is equal to that flowing out of  $C_{FLY}$  at off state.

$$I_{ON-AVE} \times DT = I_{OFF-AVE} \times (1-D)T \quad \text{.....(1)}$$

$$I_{ON-AVE} \times D = I_{OFF-AVE} \times (1-D) \quad \text{.....(2)}$$

$$\begin{aligned} I_{IN} &= I_{ON-AVE} \times D + I_{OFF-AVE} \times (1-D) \\ &= 2 \times I_{ON-AVE} \times D \quad \text{-----(3)} \\ &= 2 \times I_{OFF-AVE} \times (1-D) \end{aligned}$$

$$\begin{aligned} I_{OUT} &= I_{OFF-AVE} \times (1-D) \\ I_{IN} &= 2 \times I_{OUT} \quad \text{-----(4)} \end{aligned}$$

For AIC1848, the controller takes the PWM (Pulse Width Modulation) control strategy. When the duty cycle is limited to 0.5, there will be:

$$\begin{aligned} I_{ON-AVE} \times 0.5 \times T &= I_{OFF-AVE} \times (1-0.5) \times T \\ I_{ON-AVE} &= I_{OFF-AVE} \end{aligned}$$

According to the equation (4), we know that as long as the flying capacitor  $C_{FLY}$  is at steady state, input current is double of output current. The efficiency of charge pump is given below:

$$\eta = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times I_{IN}} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times 2I_{OUT}} = \frac{V_{OUT}}{2V_{IN}}$$

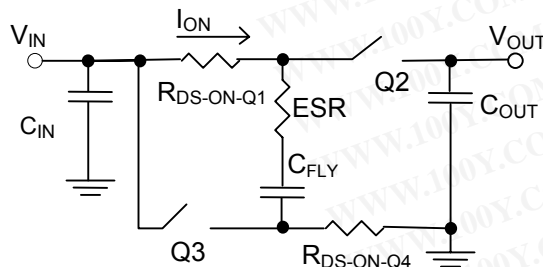


Fig. 12 The on state of charge pump circuit

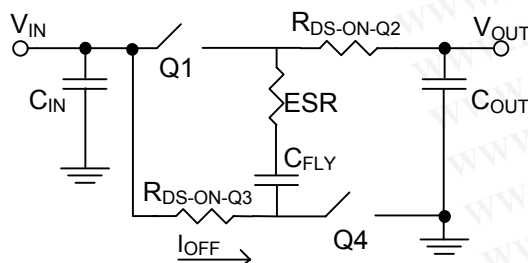


Fig. 13 The off state of charge pump circuit

## External Capacitor Selection

Three external capacitors,  $C_{IN}$ ,  $C_{OUT}$  and  $C_{FLY}$ , determine AIC1848 performances. Optimum performance can be obtained by using low ESR ceramic capacitors. Due to high ESR, tantalum and aluminum capacitors are not recommended for charge pump application.

To reduce noise and ripple, low ESR ceramic capacitor is recommended for  $C_{IN}$  and  $C_{OUT}$ . The value of  $C_{OUT}$  determines the amount of output ripple voltage. An output capacitor with larger value results in smaller ripple.

$C_{FLY}$  is critical for the charge pump. The larger  $C_{FLY}$  is, the larger output current and smaller ripple voltage obtain. However, large  $C_{IN}$  and  $C_{OUT}$  are required when large  $C_{FLY}$  applies. The ratio of  $C_{IN}$  (as well as  $C_{OUT}$ ) to  $C_{FLY}$  should be approximately 10:1.

## Layout Considerations

Due to the switching frequency and high transient current of AIC1848, careful consideration of PCB layout is necessary. To achieve the best performance of AIC1848, minimize the distance between every two components and also minimize every connection length with a maximum trace width. Make sure each device connects to immediate ground plane. Fig. 14 to Fig. 16 show the recommended layout.



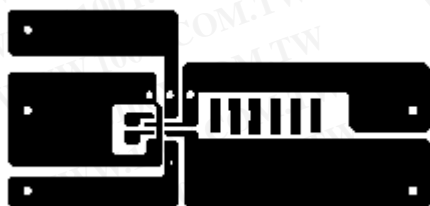


Fig. 14 Top layer



Fig. 15 Bottom layer

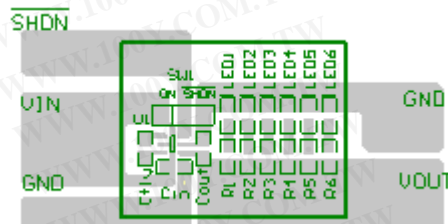


Fig. 16 Top-over layer

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## APPLICATION EXAMPLES

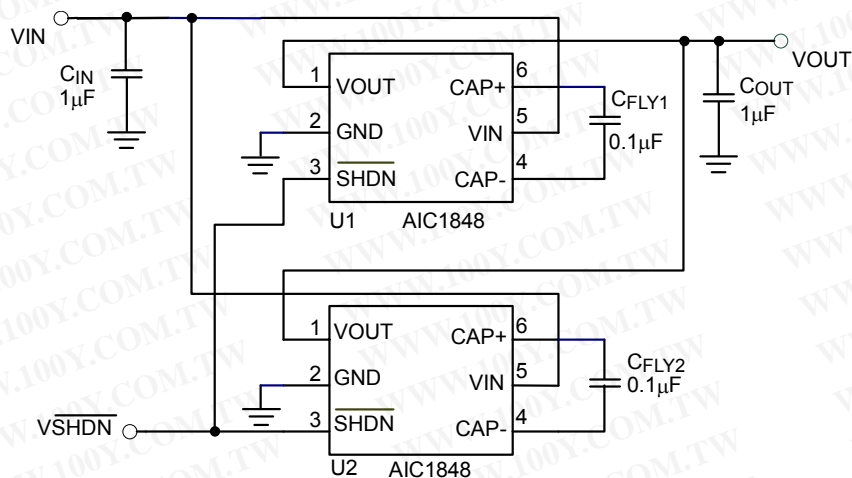


Fig. 17 Parallel Two AIC1848 to Obtain the Regulated 5V Output with large output current.

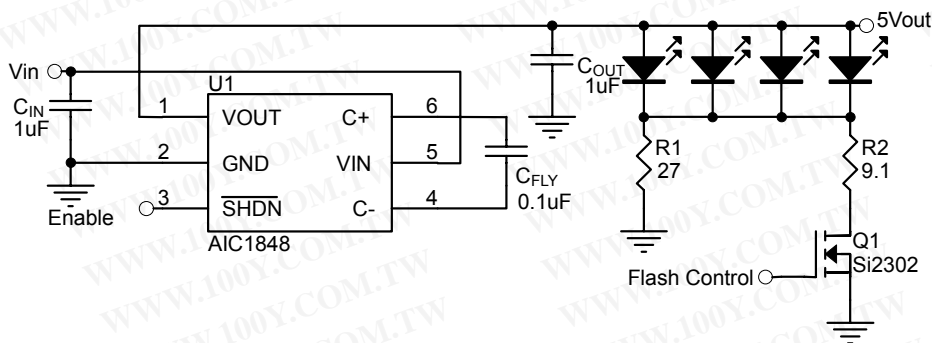


Fig. 18 Flash WLED Application

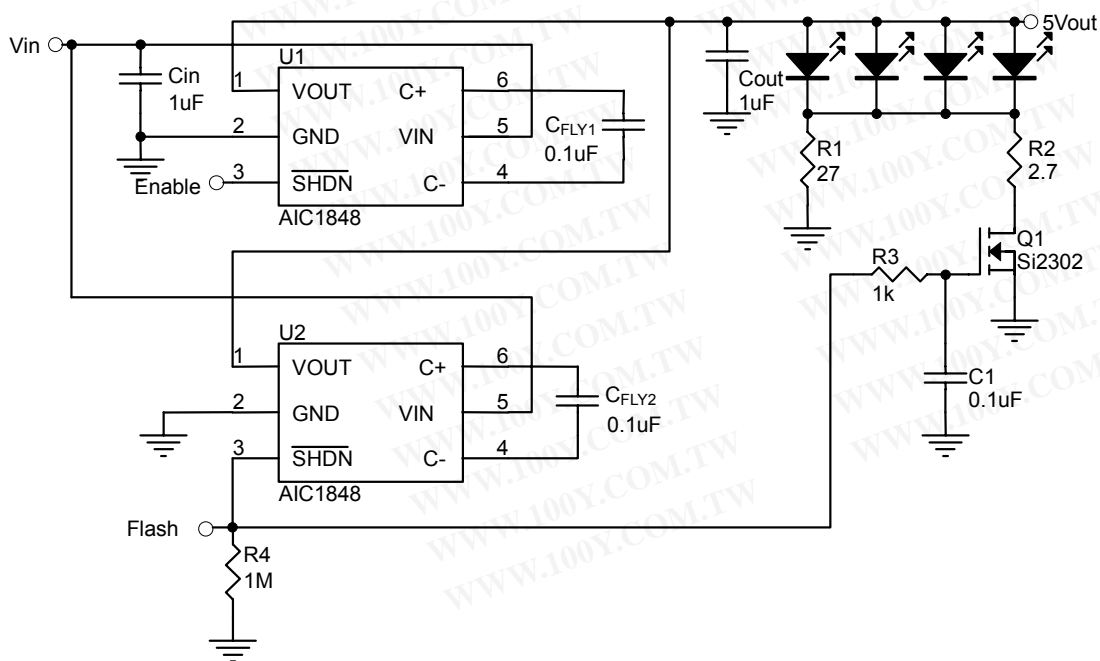
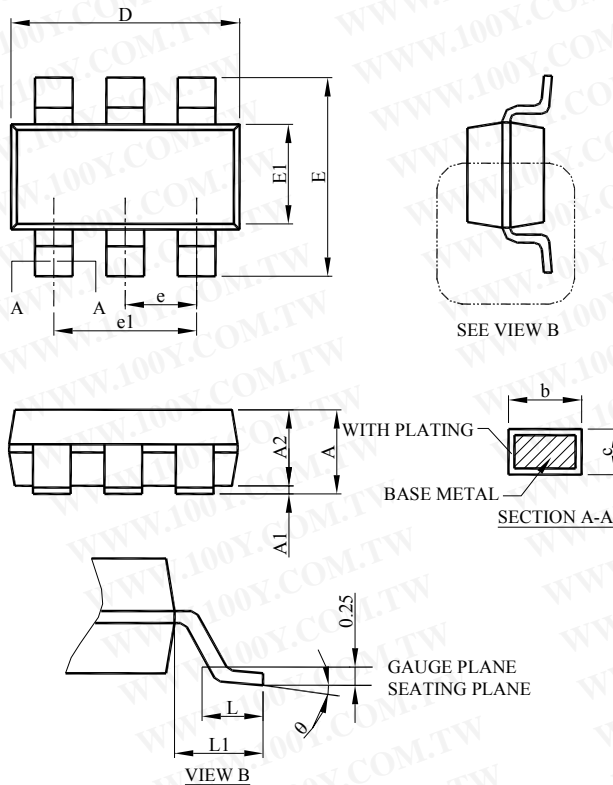


Fig. 19 Flash WLED Application with Parallel Two AIC1848

## PHYSICAL DIMENSIONS (unit: mm)

### SOT-23-6



SYMBOL	SOT-26	
	MILLIMETERS	
	MIN.	MAX.
A	0.95	1.45
A1	0.05	0.15
A2	0.90	1.30
b	0.30	0.50
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
L1	0.60 REF	
θ	0°	8°

#### Note:

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