IT1602

2A, 24V, 310kHz Asyn. Step-Down LED Driver

Description

IT1602 is a PWM step-down converter designed to meet maximum 2A constant current for high power LED driving application, with a fixed switching frequency of 310kHz and a wide input supply range of 3.6V~24V. The 0.25V low feedback voltage reduces the power dissipation of the constant current setting resistor so that the high conversion efficiency up to 94% can be achieved. Moreover, a built-in low $R_{DS(ON)}$ power PMOSFET is also included to obtain a low conduction loss under heavy load conditions.

Not only providing excellent line/load regulations, IT1602 also features other functions, such as: external ON/OFF control, cycle-by-cycle current limit, and thermal shutdown protection. With the maximum duty cycle of 100%, IT1602 is also suitable for low drop-out conditions. This device is available in standard SOP-8L package.

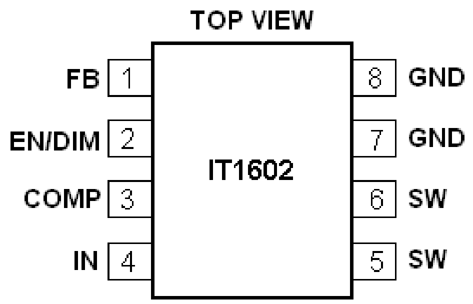
Features

- 3.6V to 24V Wide Input Voltage Range
- 0.25V Low Feedback Reference Voltage
- 2A Continuous Load Current Capability
- Up to 95% Efficiency
- 310kHz Fixed Switching Frequency
- 1.1mA/0.2uA Supply/Shutdown Current
- Cycle-by-Cycle Current Limit
- 100% Maximum Duty Cycle
- Built-in Low $R_{DS(ON)}$ Power PMOSFET
- Thermal Shutdown
- Standard SOP-8L Package

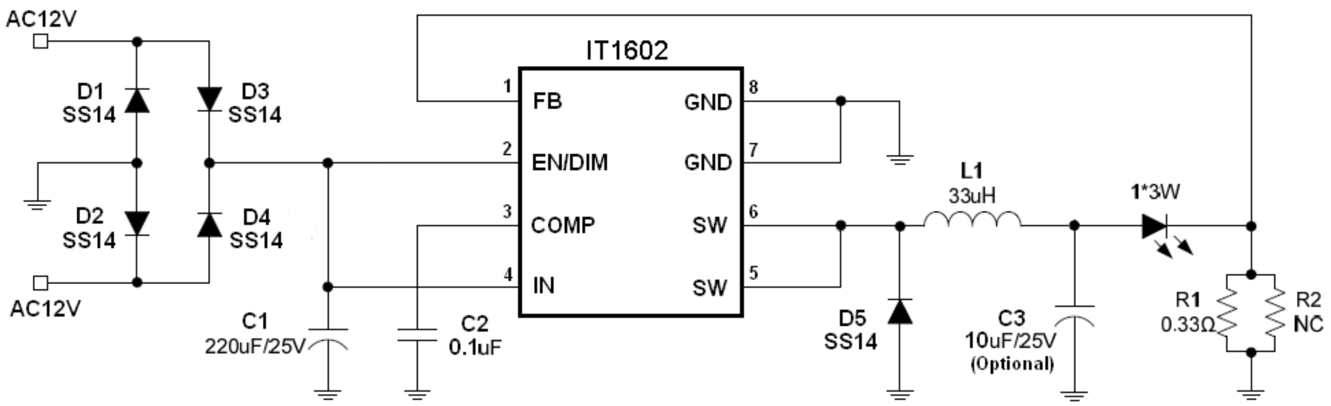
Applications

- High Power LED Driver
- MR16 & GU10 Solution
- Constant Current Source
- General Lighting Solutions

Pin Configuration



Typical Application



Pin Functions

Pin #	Name	Description
1	FB	Feedback. This pin senses the feedback voltage to set the LED current.
2	EN/DIM	On/off control input. Pull EN/DIM above 0.8V to turn the device on.
3	COMP	Error amplifier compensation output.
4	IN	Supply voltage. The IT1602 operates from a +3.6V to +24V unregulated input.
5, 6	SW	PMOS high current output. This pin is the switching node that supplies power to the output.
7, 8	GND	Ground. Connect this pin to the circuit ground.

Absolute Maximum Ratings (1)

Parameter	Value	Unit
Input Supply Voltage	-0.5 ~ 28	V
EN / SW Pin Voltage Range	-0.3 ~ 28	V
FB / COMP Pin Voltage Range	-0.3 ~ +6.0	V
Storage Temperature Range	-65 ~ 150	℃
Junction Temperature Range	150	℃
Lead Soldering Temperature Range	260	℃

Recommended Operating Conditions

Parameter	Value	Unit
Input Supply Voltage	3.6 ~ 24	V
Ambient Temperature Range	-40 ~ 85	℃
Junction Temperature Range	-40 ~ 125	℃

Package Information

Parameter	Package	Value	Unit
Thermal Resistance (Junction to Case)	SOP-8L	20	℃/W
Thermal Resistance (Junction to Ambient)		60	℃/W

Notes:

(1) Exceeding these ratings may damage the device.

(2) The maximum allowable power dissipation is a function of the maximum junction temperature $T_{J(MAX)}$, the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation is calculated by $P_{D(MAX)} = (T_{J(MAX)} - T_A)/\theta_{JA}$. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown.

Electrical Characteristics

V_{IN}= V_{EN}=12V, T_A=25℃, unless otherwise specified.

Parameters	Symbol	Conditions	Min.	Typ.	Max.	Units
Input Voltage Range	V_{IN}		3.6		24	V
Feedback Voltage	V_{FB}	I_{LOAD}=0.2A		0.249		V
Feedback Current	I_{FB}			< 0.1		μA
Power PMOSFET On Resistance	$R_{DS(ON)}$	V_{IN}=5V, V_{FB}=0V		70	150	mΩ
		V_{IN}=12V, V_{FB}=0V		50	90	mΩ
Current Limit (3)	I_{LIM}	Output short to GND		4.5		A
Oscillation Frequency	f_{SW}			310		kHz
Fold-back Frequency (3)	f_{SCP}	Output short to GND		77.5		kHz
Maximum Duty Cycle	D_{MAX}	V_{FB}=0.2V (force driver ON)		100		%
Minimum Duty Cycle	D_{MIN}	V_{FB}=0.5V (force driver OFF)		0		%
EN Input Low Voltage	V_{ENL}				1.79	V
EN Input High Voltage	V_{ENH}		1.81			V
EN Input Current	I_{EN}			< 0.1		μA
Supply Current (Shutdown)	I_{SD}	V_{EN}=0V		0.2		μA
Supply Current (Quiescent)	I_Q	V_{FB}=0.5V		1.1		mA
Thermal Shutdown (3)	T_{SD}			150		℃
Thermal Hysteresis (3)	T_{HYS}			40		℃
Line Regulation (4)		V_{IN}=4V~24V, I_{LOAD}=0.2A		0.04		%/V
Load Regulation (5)		I_{LOAD}=0.2A~2A		0.51		%/A

Notes:

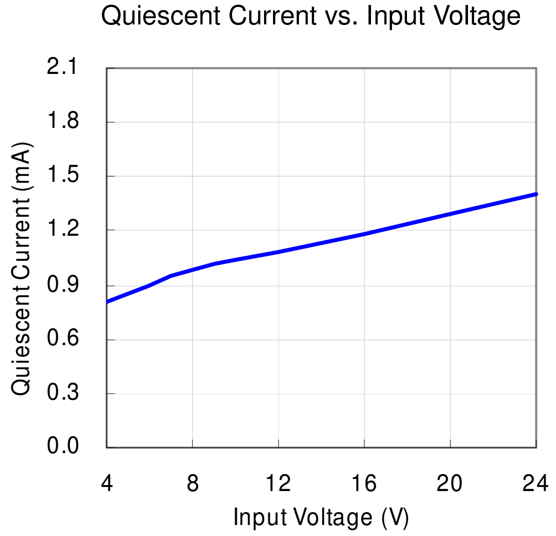
(3) Guaranteed by design.

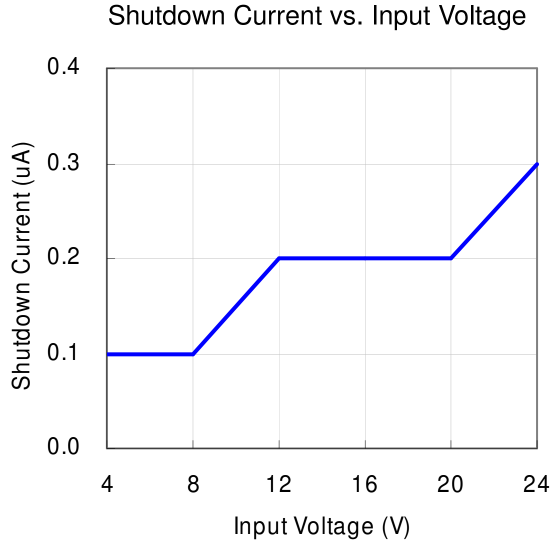
(4) The line regulation is defined as $\frac{(\Delta V_{FB}/V_{FB})\times 100\%}{\Delta V_{IN}}$

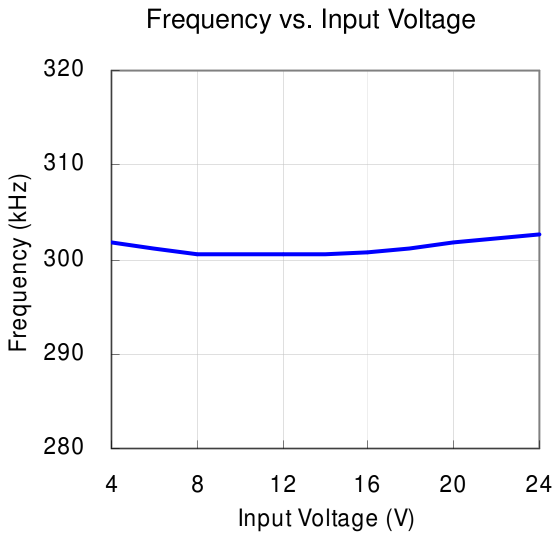
(5) The load regulation is defined as $\frac{(\Delta V_{FB}/V_{FB})\times 100\%}{\Delta I_{LOAD}}$

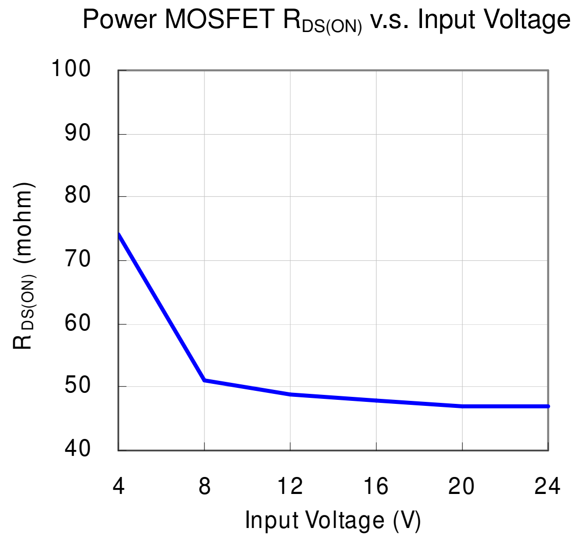
Typical Performance Characteristics

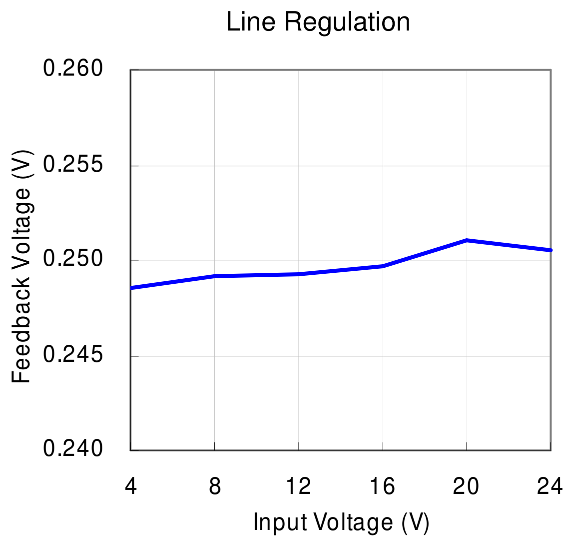
V_{IN} = 12V, V_{FB} = 0.25V, L = 47µH, TA = +25ºC, I_{LOAD}=0.2A, unless otherwise specified.

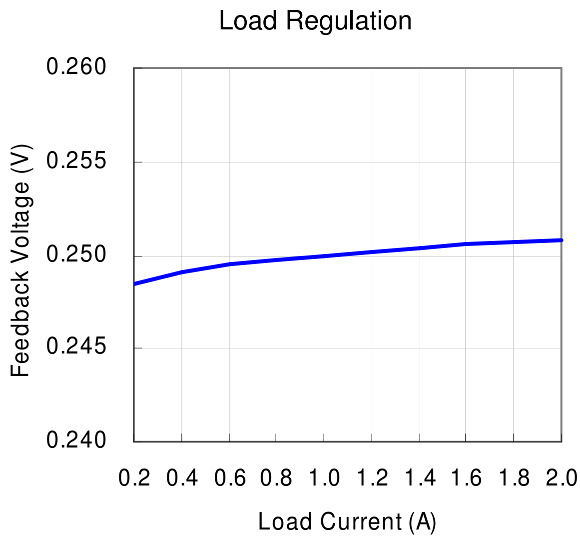




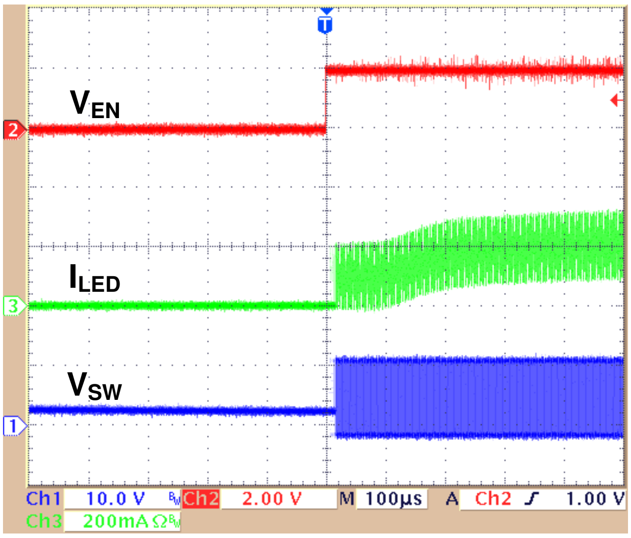




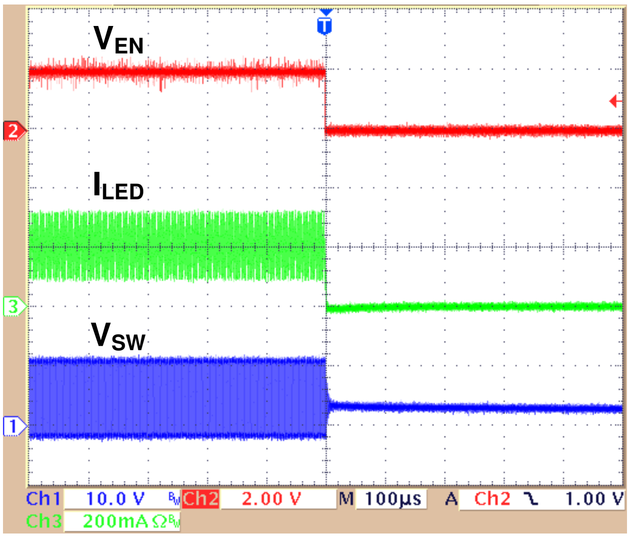




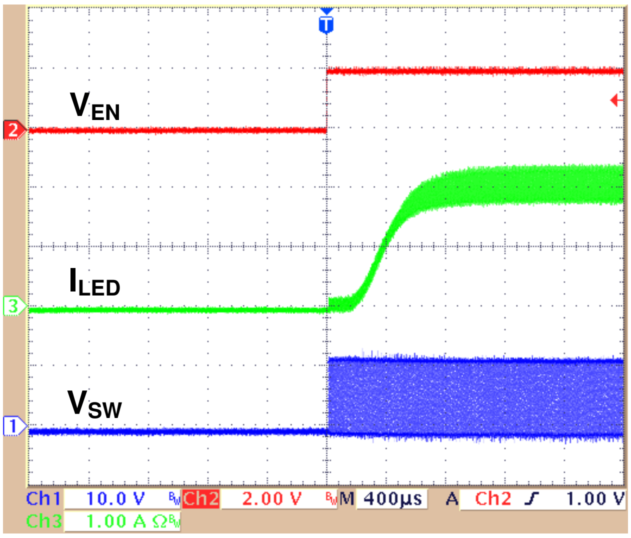
Startup through Enable (I_{OUT}=0.2A)



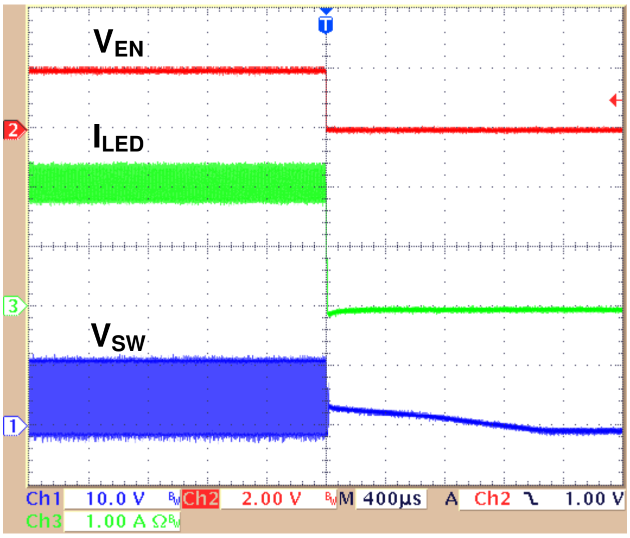
Shutdown through Enable (I_{OUT}=0.2A)



Startup through Enable (I_{OUT}=2A)



Shutdown through Enable (I_{OUT}=2A)



Operation

Voltage Reference

The internal PWM control circuits of IT1602 are supplied by the internal regulator with its output voltage of 5.5V. The accurate 0.25V voltage is generated from an internal bandgap voltage reference.

Output Voltage

The output voltage is primarily determined by the number of LEDs(n) connected from V_O to FB pin and therefore V_O can be written as:

$$V_O = ((n \times V_F) + V_{FB})$$

where V_F is the forward voltage of one LED under the set LED current condition.

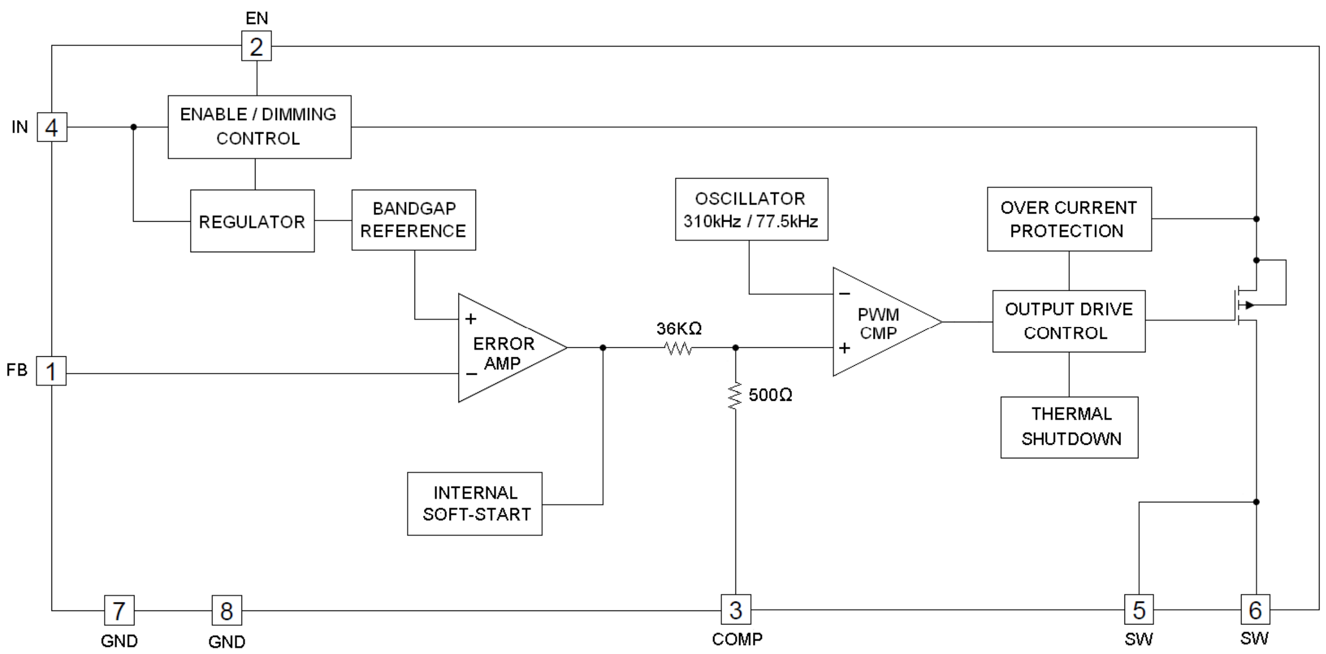
Thermal Protection

The thermal protection is activated once the internal junction temperature exceeds 150℃, which is referred as an over-temperature (OT) condition. The OT condition may due to a extraordinary high load current and/or high ambient temperatures. Once OT condition is detected, IT1602 output will be turned off. IT1602 will recover to normal operation when the junction temperature is lower than 110℃.

Over Current Protection

IT1602 employed a cycle-by-cycle current limit function to prevent the internal power PMOSFET from being damaged. During each switching cycle, a current limit comparator detects if the power switch current exceeds the predetermined peak current, which is typically 4.5A. Once the over-current (OC) condition occurs, the switching frequency is decreased to 77.5kHz to prevent the current limit runaway issue. IT1602 recovers to normal 310kHz switching frequency until the OC condition is removed.

Functional Block Diagram



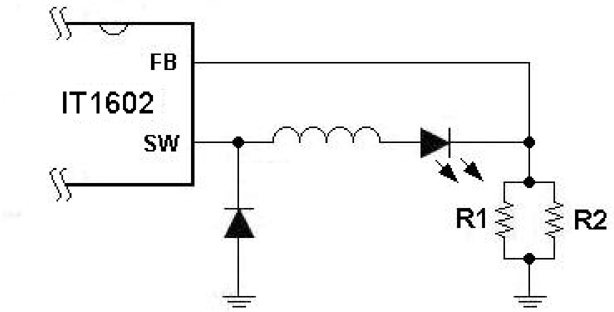
Application Information

LED Current Setting

Using IT1602 as a constant current LED driver, the LEDs are connected between V_O and FB pin as illustrated in the typical application circuit. The FB pin is regulated at ~0.25V, and thus the LED current I_F is set by V_{FB} and the total resistance between FB to GND. Therefore, I_F can be expressed as below

$$I_F = \frac{V_{FB}}{R1 // R2}.$$

It should be noted that I_F should be kept less than 2A, which implies the total resistance between FB and GND, which is R1//R2 in the following figure, should be larger than 0.125Ω.



Dimming Control

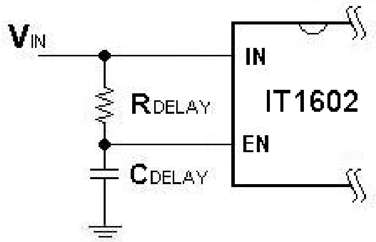
Using PWM signal for pulling EN/DIM pin to High/Low to turn ON/OFF IT1602, dimming control function can be implemented. The output LED current will be proportional to the duty cycle of EN/DIM. To obtain better current accuracy, it is recommended that the PWM frequency is less then 100Hz.

Delay Start-up

The following circuit uses the EN/DIM pin to provide a time delay from the input voltage is applied to the output voltage is settled. At the rising edge of of the input voltage, the charging of capacitor C_{DELAY} pulls the EN/DIM pin low, keeping the device off. Once the capacitor voltage rises above the EN/DIM threshold voltage of 1.81V, the device is turned ON. The start-up delay time can be calculated by the following formula:

$$V_{IN} \times (1 - e^{\frac{-T}{R \times C}}) > V_{EN},$$

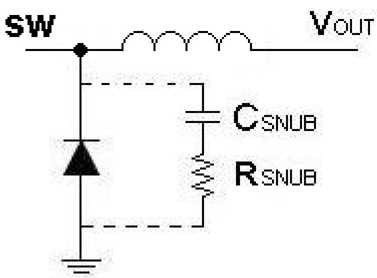
where T is the start-up delay time, R is R_{DELAY}, C is C_{DELAY}, and the typical V_{EN} is 1.81V.



The feature is useful in situations where the input power source is limited in the amount of current it can deliver. It allows the input voltage to rise to a higher voltage before the device starts operating.

Using Snubber Circuit (Optional)

The high frequency ringing and overshooting at the SW pin is due to fast switching transition and the resonating circuit formed by parasitical LC elements. It may generate EMI and degrades the circuit performance. The RC snubber circuit, as shown below, can be employed for voltage transient and ringing suppression.



Selecting Inductor (L1)

The inductor connected between the LED and the pin SW is an important device to keep the high frequency energy from being delivered to output as a waste since the high-frequency energy is unnecessary at LED. Considering the DC resistance of the inductor strongly affects the power efficiency, IT1602 recommends a low DC resistance inductor. Also, we recommend the inductor value as 47uH to meet the desired the performance. The minimum value of inductor can be determined by the minimum LED current, inductor peak current, and minimum duty ratio.

Selecting Input Capacitor (C1 & C2)

The input bypass capacitor reduces the surge current drawn from the supply and the switching noise from the device. The input capacitor impedance at the switching frequency should be less than the input source impedance to prevent high frequency switching current from passing through the input. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. For most applications, a 10µF capacitor is sufficient.

Selecting Output Capacitor (C3, Optional)

The output capacitor C3 is employed for filtering high-frequency component of SW node and reducing the output voltage ripple. The low ESR capacitors are preferred to obtain less output ripple voltage as well as the ripple conduction loss. The output ripple voltage can be calculated as below:

$$\Delta V_{OUT} = \Delta I_L \times (R_{ESR} + \frac{1}{8 \times f_S \times C_{OUT}})$$

For IT1602, the recommended output capacitance is 10uF.

Selecting the Schottky Diode

The Schottky-Barrier Diode (SBD) provides a current path for the inductor when the internal power MOSFET turns off. Therefore, the current rating of the SBD must be larger than 3A to avoid damages. The low forward-voltage drop can reduce the conduction loss. The power loss of SBD, P_{SD}, can be evaluated by the following equation

$$P_{SD} = I_{LED} \times V_F \times (1 - D),$$

where V_F is the forward voltage drop of the SBD, I_{LED} is the output current, and 1-D is the duty cycle that the SBD is conducting.

PCB Layout Guide

PCB layout is very important to achieve stable operation. The layout guidelines are listed below:

1) Keep the path of switching current short and minimize the loop area formed by input cap, high-side MOSFET and Schottky diode.

2) Keep the connection of Schottky diode between SW pin and input power ground as short and wide as possible.

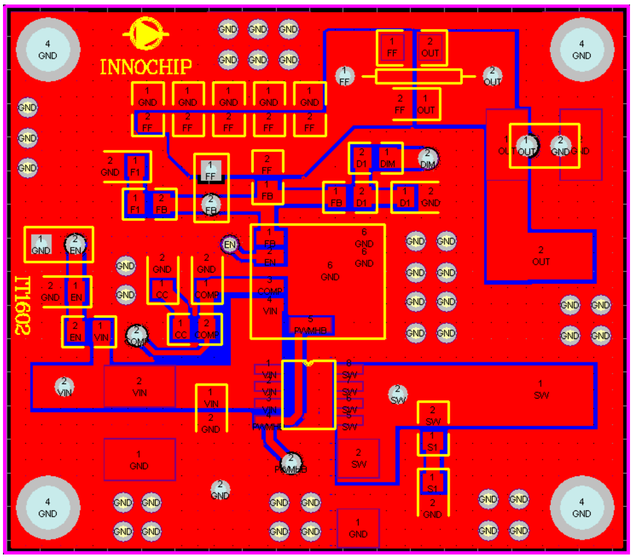
3) Ensure the feedback connections are short and direct. The feedback resistors and compensation components should be as close to the chip as possible.

4) SW should be far away from FB and COMP.

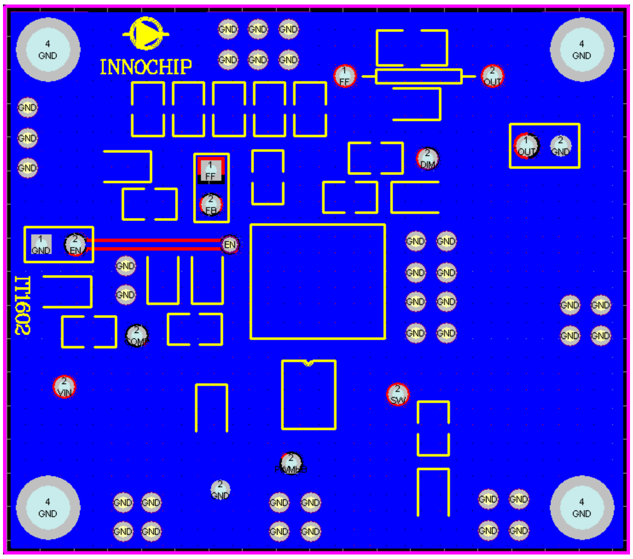
5) Connect IN, SW, and GND respectively to a large copper area to cool the chip for improving thermal and long-term reliability.

6) The capacitor between COMP to GND should be as close to IT1602 as possible.

According to the above layout guideline, a PCB layout example is also given below for customer’s reference.



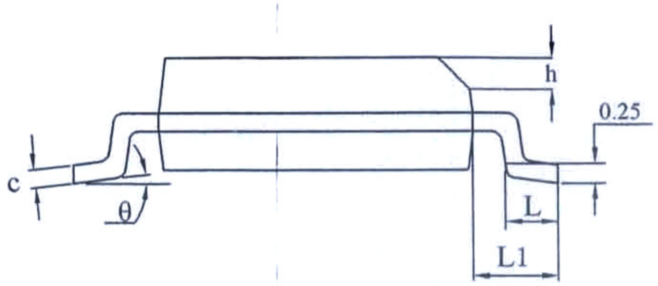
TOP layer

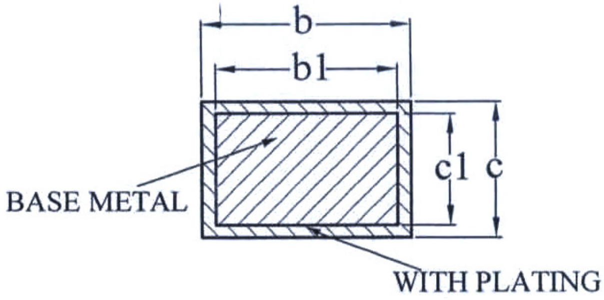


BOTTOM layer

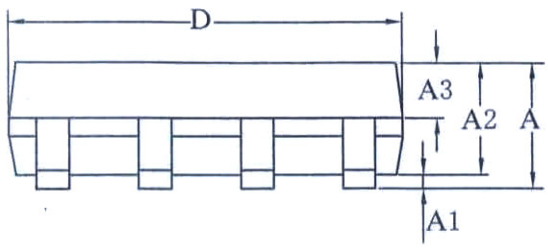
Package Information

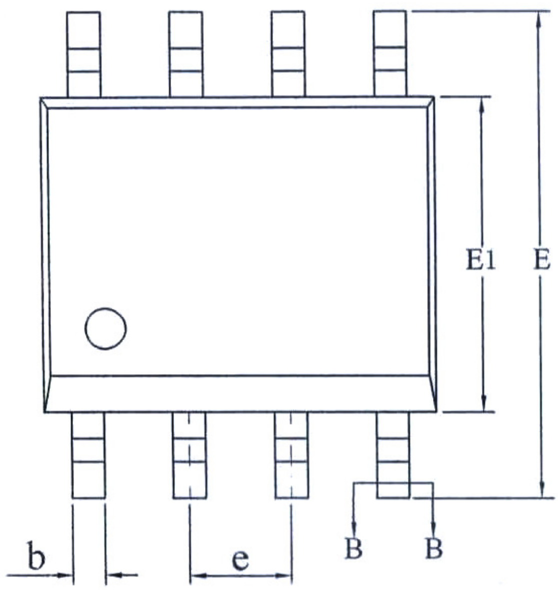
SOP-8L





SECTION B-B





SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.75
A1	0.10	—	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	—	0.48
b1	0.38	0.41	0.43
c	0.21	—	0.26
c1	0.19	0.20	0.21
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
h	0.25	—	0.50
L	0.50	—	0.80
L1	1.05BSC		
θ	0	—	8°
L/F载体尺寸 (mil)	80*80	90*90	95*130