

## Step-Down Power LED Driver

### GENERAL DESCRIPTION

The PT4105 is CMOS-based fixed frequency step-down DC/DC converter designed to operate as a constant source. An external sense resistor in series with the LOAD monitors output current allowing accurate current regulation, ideal for driving high current LEDs.

It consists of a PWM control circuit, a high precision band-gap voltage reference, a soft-start circuit, an oscillator, an error amplifier with internal compensation network and input voltage detection circuits. The built-in fault condition protection circuits including current limiting, UVLO and thermal shutdown prevent itself from potentially unstable operation and burn-out.

Due to its ultra low feedback voltage, a low current ripple, high efficiency of up to 90% step-down power LED driver can be easily composed of with additional several external components such as an inductor, a diode, a few resistors and capacitors.

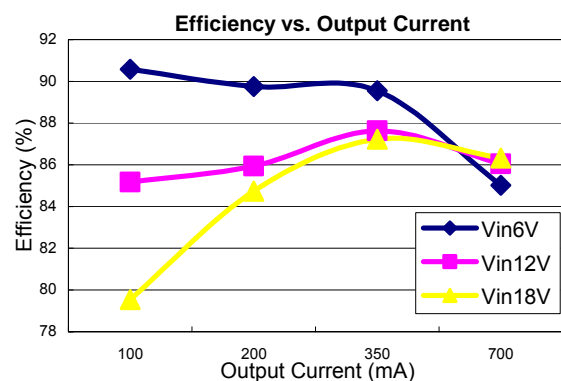
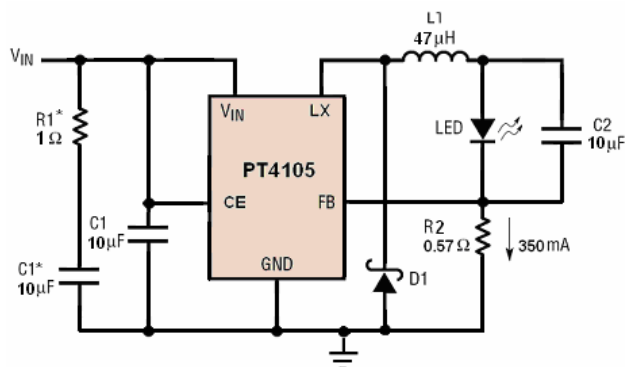
### FEATURES

- Wide Range Of Input Voltage: 2.5V~18V
- Low Feedback Voltage: 200mV
- Oscillation Frequency: 500kHz
- Standby Current: Typical 0.1μA
- High Efficiency: Typical 88%
- Low Temp. Coefficient of Feedback Voltage: Typical ±100ppm/°C
- Built-in Soft-start and UVLO
- Thermal Shutdown
- Package: SOP-8

### APPLICATIONS

- Architecture Detail lighting
- Constant Current Source
- Hand-held lighting

### TYPICAL APPLICATION



L: CR105-470MC (Sumida, 47μH) or Equivalent

D1: RB063L-30(Rohm) or Equivalent

LED: LUXREON-I/III

C1, C2: 10μF, Ceramic Type

R2: 0.57Ω (0.25W, for LUXREON-I)

0.28Ω (0.25W, for LUXREON-III)

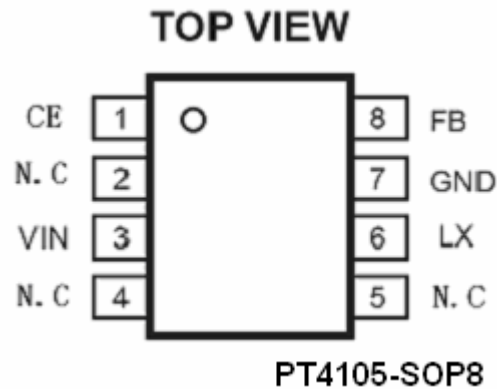
R1\*: 1Ω

C1\*: 10μF, Ceramic Type

**Note:** Please add on R1\* and C1\* when VIN exceeds 12V for robust operation

**Step-Down Power LED Driver**
**ORDERING INFORMATION**

Package	Temperature	Part Number	Transport Media
SOP8	-40°C to 85°C	PT4105ESOP	Tape and Reel

**PIN CONFIGURATION**

**PIN DESCRIPTIONS**

Names	Pin No.	Description
CE	1	Chip Enable. Active with "H"
$V_{IN}$	3	Power Supply
LX	6	Output of Internal Power Switch
GND	7	Ground
$V_{OUT} / (V_{FB})$	8	Feedback Voltage for Output Current Regulation
N.C	2, 4, 5	Not Connected

**ABSOLUTE MAXIMUM RATINGS**

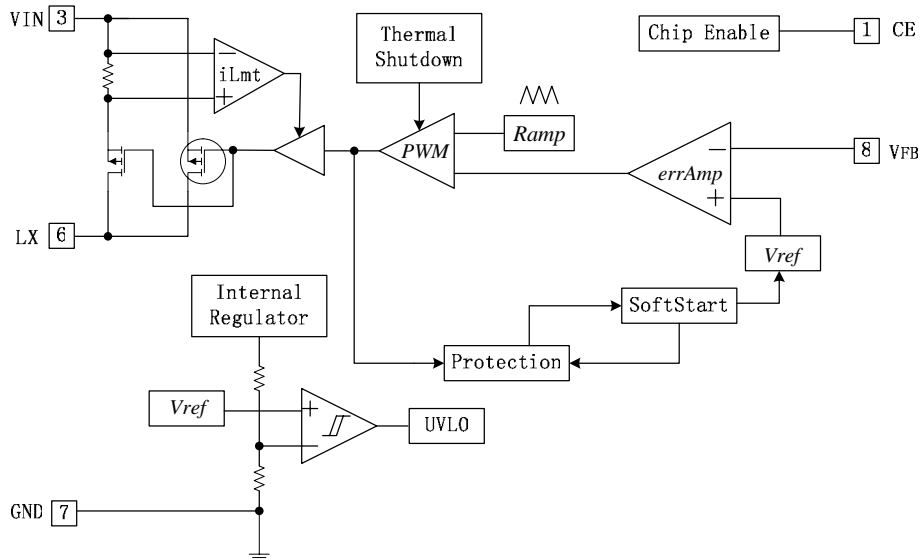
Symbol	PARAMETER	VALUE	UNIT
$V_{IN}$	$V_{IN}$ Supply Voltage	20	V
$V_{LX}$	LX Pin Output Voltage	-0.3~ $V_{IN} + 0.3$	V
$V_{CE}$	CE Pin Input Voltage	-0.3~ $V_{IN} + 0.3$	V
$V_{FB}$	$V_{FB}$ PIN Input Voltage	-0.3~6	V
$I_{LX}$	LX Pin Output Current	1.5	A
$T_{OPT}$	Operation Temperature Range	-40~85	°C
$T_{STG}$	Storage Temperature Range	-55~125	°C

**Step-Down Power LED Driver**
**RECOMMENDED OPERATING RANGE**

Symbol	PARAMETER	VALUE	UNIT
$V_{IN}$	$V_{IN}$ Supply Voltage	5~18	V
$V_{LX}$	LX Pin Output Voltage	-0.3~ $V_{IN}$ +0.3	V
$V_{CE}$	CE Pin Input Voltage	-0.3~ $V_{IN}$ +0.3	V
$V_{FB}$	$V_{FB}$ PIN Input Voltage	-0.3~5.5	V
$I_{LX}$	LX Pin Output Current	≤700	mA

**ELECTRICAL CHARACTERISTICS**
 $T_{OPT}=25^{\circ}\text{C}$ , Unless Otherwise Noted.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Operating Voltage	$V_{IN}$		2.5		18	V
Feedback Voltage	$V_{FB}$	$V_{IN}=V_{CE}=8\text{V}$ , $I_{FB}=350\text{mA}$	180	200	220	mV
Feedback Voltage Temperature coefficient	$\frac{\Delta V_{FB}}{\Delta T}$	$-40^{\circ}\text{C} < T_{OPT} < 85^{\circ}\text{C}$		±100		ppm/ °C
Supply Current	$I_{Q1}$	$V_{IN}=V_{CE}=18\text{V}$ , $V_{FB}=2\text{V}$		100	200	μA
Shutdown Current	$I_{Q2}$	$V_{IN}=18\text{V}$ , $V_{CE}=V_{FB}=0\text{V}$		0.1	1	μA
Oscillator Frequency	$f_{OSC}$	$V_{IN}=V_{CE}=8\text{V}$ , $I_{FB}=350\text{mA}$	400	500	600	kHz
Maximum Duty Cycle	$D_{MAX}$		100			%
Minimum Duty Cycle	$D_{MIN}$				0	%
CE "H" Input Voltage	$V_{CEH}$	$V_{IN}=8\text{V}$ , $V_{FB}=0\text{V}$	1.5			V
CE "H" Input Voltage	$V_{CEL}$				0.3	V
UVLO Voltage	$V_{UVLO1}$	$V_{IN}=V_{CE}=2.5\text{V} \rightarrow 1.5\text{V}$ , $V_{FB}=0\text{V}$	1.75	2.0	2.25	V
UVLO Release Voltage	$V_{UVLO2}$	$V_{IN}=V_{CE}=1.5\text{V} \rightarrow 2.5\text{V}$ , $V_{FB}=0\text{V}$		$V_{UVLO1} + 0.1$	2.35	V
Delay time by soft-start	$T_{SST}$	$V_{IN}=8\text{V}$ , $I_{FB}=10\text{mA}$ , $V_{CE}=0\text{V} \rightarrow 2.5\text{V}$	1	2	4	ms
Switch on resistance	$R_{DS(ON)}$	$V_{IN}=18\text{V}$		0.3		Ω
Switch current limit	$I_{LMT}$	$V_{IN}=18\text{V}$		1.3		A
Thermal Shutdown	$T_{TSD}$			160		°C

**BLOCK DIAGRAM**

**OPERATION DESCRIPTION**

The PT4105 is a fixed frequency, voltage mode step-down switching regulator with internal power MOSFET capable of 1A constant output current. With the external sensing resistor, it operates as a high precision constant current source especially suitable for driving high current LEDs. To best understand its operation principle, some basis of a PWM switching regulator is firstly introduced since PT4105 acts essentially as a step-down DC/DC converter except for its current sensing scheme in feedback network.

The power stage of a step-down PWM switching regulator can be seen as an input voltage chopping circuit followed by an L-C filter. Unlike the linear regulator which operates the power transistor in the linear mode, the PWM switching regulator operates the power transistor either in saturation or cutoff regions. Due to the voltage-ampere product of power transistor under these two operation modes keeps low, high efficiency can be easily achieved. The DC input voltage is firstly chopped into square waves whose magnitude is the same as input voltage and whose duty cycle is manipulated by the switching regulator, hereby is PT4105. With the use of following appropriately chosen L-C filter, such square wave modulation could be eliminated and ripple free DC voltage equal to the average of the duty cycle modulated DC input voltage results. The regulated output voltage is maintained by sensing the DC feedback voltage and controlling duty cycle in a negative-feedback loop, the DC output current could be regulated against input line and output load changes.

As in PT4105 based high current LED driver, the regulated output current can be maintained by sensing the DC feedback voltage produced by load current flowing through the sensing resistor which is in series with the LOAD and controlling duty cycle in a negative-feedback loop. Therefore an alternative usage of a step-down DC/DC converter as constant current source comes into being.

## Step-Down Power LED Driver

### APPLICATION INFORMATION

- To avoid parasitic current into each pin, make sure voltage applied to CE pin should be no more than the voltage level of VIN pin.
- It's highly recommended applying PT4105 to the condition with VIN is equal or more than 4V for high efficiency.
- The output current is controlled by feedback resistor, and the output current can be calculated by equation as shown below, in which the  $V_{FB}$  is equal to 200mV.

$$I_{LOAD} = V_{FB} / R_{FB}$$

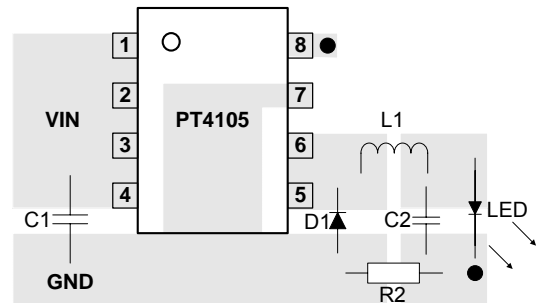
Here are several examples for feedback resistor value selection:

$I_{LOAD}(mA)$	$R_{FB}(\Omega)$
350	0.57
700	0.28

**Note:** choose  $R_{FB}$  of which maximum rated power dissipation is no less than 1/4W

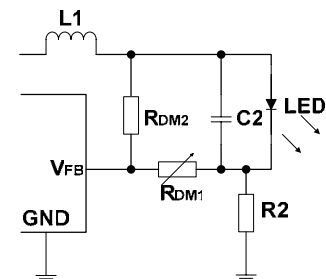
- **PCB Board Layout**

As with all switching regulators, careful attention must be paid to the PCB board layout and component placement. To maximize efficiency, switch rise and fall times are made as short as possible. To prevent electromagnetic interference (EMI) problems, proper layout of the high frequency switching path is essential. The voltage signal of the SW pin has sharp rise and fall edges. Minimize the length and area of all traces connected to the SW pin and always use a ground plane under the switching regulator to minimize interplane coupling. In addition, the ground connection for the feedback resistor R2 should be tied directly to the GND pin and not shared with any other component, ensuring a clean, noise-free connection. Recommended component placement is shown in right Figure.



- **Dimming Control**

PT4105 can apply a resistor divider formed by  $R_{DM1}$  and  $R_{DM2}$  for dimming control. As the  $R_{DM1}$  increase, the voltage drop on  $R_{DM1}$  increases and the voltage drop on R2 decreases. Thus the LED current decreases. In general, choose  $R_{DM2}$  and  $R_{DM1}$  equal to 100K and 10K respectively so that current through LED will change from 0mA to its nominal value.



## EXTERNAL COMPONENTS

- **Inductor**

The inductor's RMS current rating must be greater than the maximum load current and its saturation current should be at least 30% higher. For highest efficiency, the series resistance (DCR) should be less than 0.2. The optimum inductor for a given application may differ from the one indicated by this simple design guide. A larger value inductor provides a higher maximum load current, and reduces the output voltage ripple. If your load is lower than the maximum load current, then you can relax the value of the inductor and operate with higher ripple current. This allows you to use a physically smaller inductor, or one with a lower DCR resulting in higher efficiency. Be aware that the maximum load current will depend on input voltage. In addition, low inductance may result in discontinuous mode operation, which further reduces maximum load current.

The current in the inductor is a triangle wave with an average value equal to the load current. The peak switch current is equal to the output current plus half the peak-to-peak inductor ripple current. The PT4105 limits its switch current in order to protect itself and the system from overload faults. Therefore, the maximum output current that the PT4105 will deliver depends on the switch current limit, the inductor value, and the input voltages. When the switch is off, the potential across the inductor is the output voltage plus the catch diode drop. This gives the peak-to-peak ripple current in the inductor

$$\Delta I_L = \frac{V_{OUT} + V_F}{L \cdot f_{OSC}}$$

where  $f_{OSC}$  is the switching frequency,  $V_F$  is voltage drop of the diode and  $L$  is the value of the inductor. The peak inductor and switch current is

$$I_{L,peak} = I_{OUT} + \frac{\Delta I_L}{2}$$

Choosing an inductor value so that the ripple current is small will allow a maximum output current near the switch current limit.

- **Input Capacitors**

The combination of small size and low impedance (low equivalent series resistance or ESR) of ceramic capacitors makes them the preferred choice to bypass the input of PT4105. In general, a 10 $\mu$ F ceramic type capacitor is enough for stable operation.

Be aware of input voltage ringing if the power supply is suddenly applied to the system especially in the case of  $V_{IN}$  exceeding 12V. This will permanently do harm to PT4105 because of the LC tank effect at input node. Please add on R1\* and C1\* as shown in typical applications for reliability consideration. Actually, this phenomenon will not take place no matter the input voltage is if the inductance of input source is quite low, i.e., batteries.

- **Output Capacitors**

For most LEDs, a 10 $\mu$ F 6.3V ceramic capacitor (X5R or X7R) at the output results in very low output voltage ripple and good transient response. Other types and values will also work but may harm efficiency more or less.

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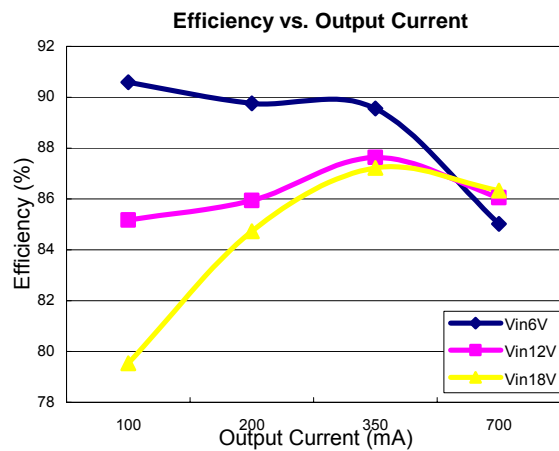
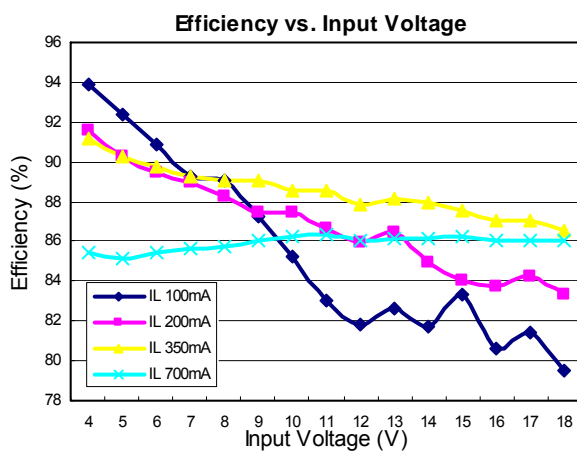
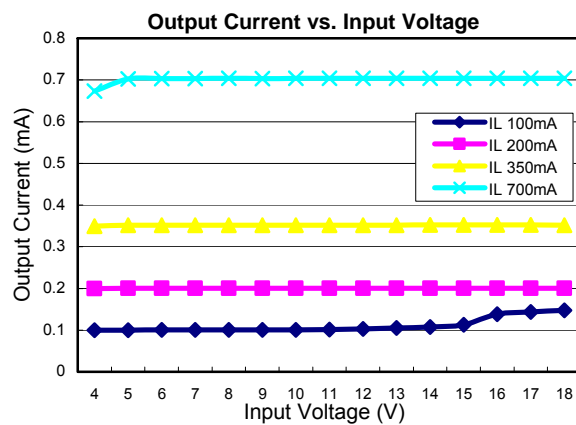
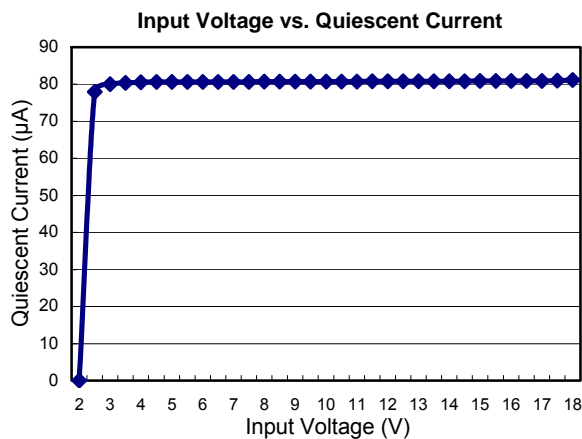
- Diode**

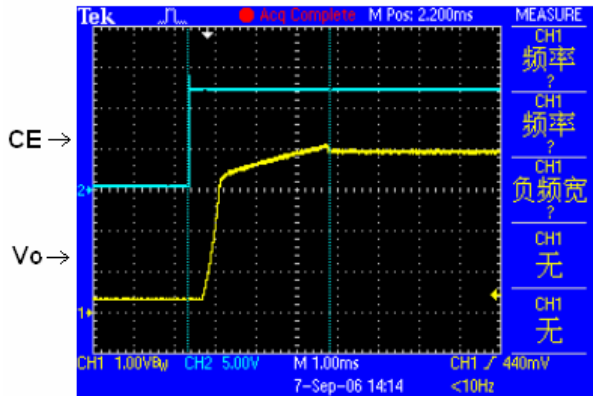
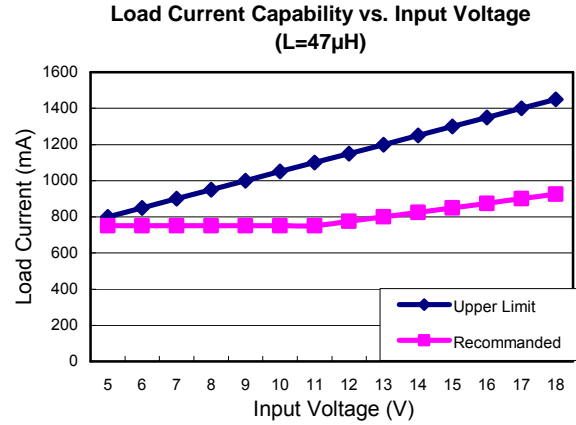
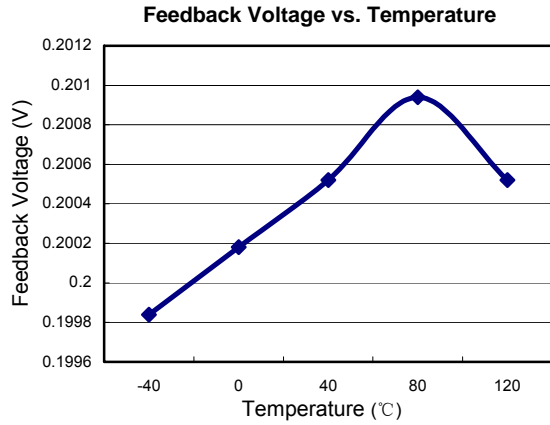
Use a diode with low  $V_F$  (Schottky diode is recommended) and high switching frequency. Reverse voltage rating should be more than  $V_{IN}$  and current rating should be larger than  $I_{L,peak}$ .

### TYPICAL PERFORMANCE CHARACTERISTICS

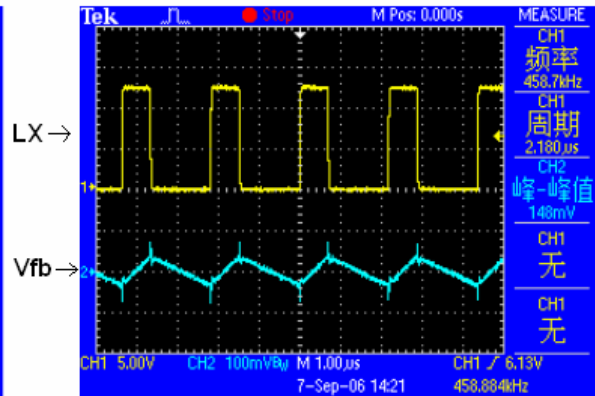
Note: Typical characteristics are obtained with using the following components:

L:	CR105-470MC (Sumida, 47 $\mu$ H) or Equivalent	R2:	0.57 $\Omega$ (0.25W, for LUXREON-I)
D1:	RB063L-30(Rohm) or Equivalent		0.28 $\Omega$ (0.25W, for LUXREON-III)
LED:	LUXREON-I/III	R1*:	1 $\Omega$
C1, C2:	10 $\mu$ F, Ceramic Type	C1*:	10 $\mu$ F, Ceramic Type



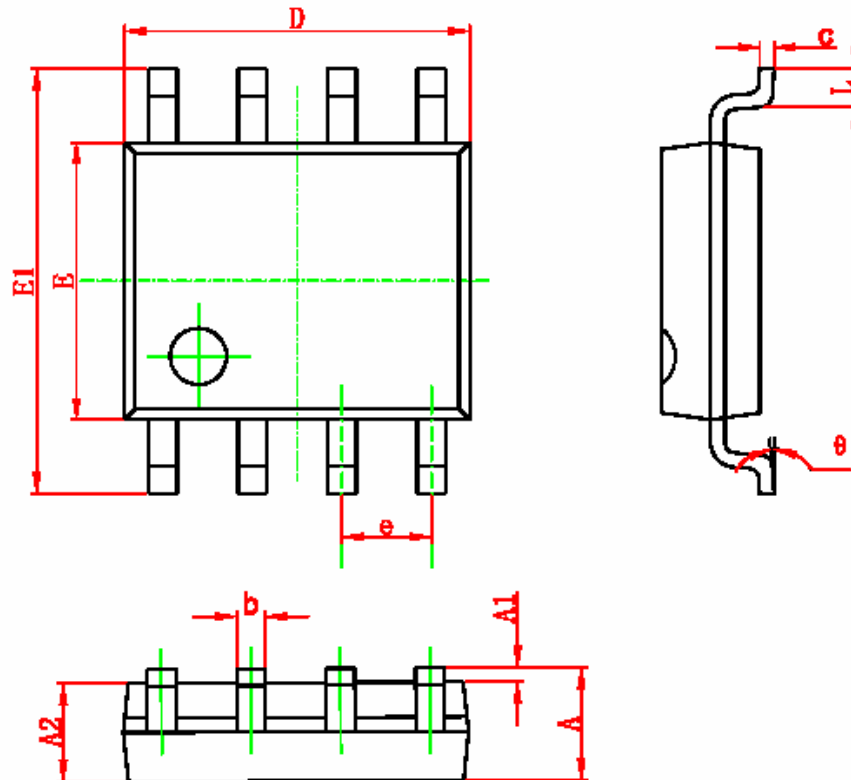
**Step-Down Power LED Driver**


PT4105 Soft-start, Vin=12V, ILED=700mA



CL=10uF, L=47uH, ILED=700mA



**PACKAGE INFORMATION**
**SOP8 PACKAGE OUTLINE DIMENSIONS**


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
theta	0° to 8°		0° to 8°	



PT4105

Step-Down Power LED Driver

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## REVISION HISTORY