PT4105

Step-Down Power LED Driver

GENERAL DESCRIPTION

The PT4105 is a step-down DC/DC converter designed to operate as a high current LED driver. The PT4105 uses a voltage mode, fixed frequency architecture that guarantees stable operation over wide range of supply voltages and load conditions. The PT4105 senses the output current by measuring the voltage across an external resistor in series with the high current LED. This voltage is then fed back to the PT4105 to control the PWM signal that drives the switching device to achieve accurate current regulation. The low 200mV feedback voltage greatly reduces the power dissipation on the external current sensing resistor and therefore improves the overall efficiency. The value of the external resistor can be adjusted to program the LED current. Using the PT4105 with a few external components, a buck power LED driver with efficiency of up to 90% can be easily constructed.

The PT4105 has the built-in protection functions including current limiting, UVLO and thermal shutdown, which prevent the device from damage caused by potential fault conditions. The PT4105 is available in SOP8 packages.

FEATURES

- Wide Range Of Input Voltage: 4.5V~12V
- Low Feedback Voltage: 200mV
- Oscillation Frequency: 500kHz
- Standby Current: Typical 0.1µA
- High Efficiency: Typical 88%
- Low Temp. Coefficient of Feedback Voltage:
- Typical ±100ppm/℃
- Built-in Soft-start and UVLO
- Thermal Shutdown
- Package: SOP-8

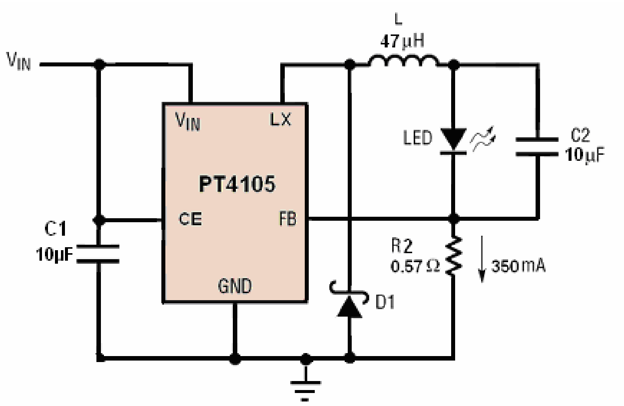
APPLICATIONS

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

ORDERING INFORMATION

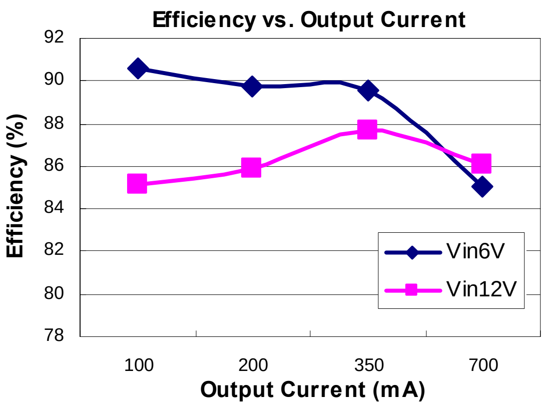
PACKAGE	TEMPERATURE	PART NUMBER	TRANSPORT MEDIA
SOP8	-40℃ to 85℃	PT4105BSOH	Tape and Reel

TYPICAL APPLICATIONS



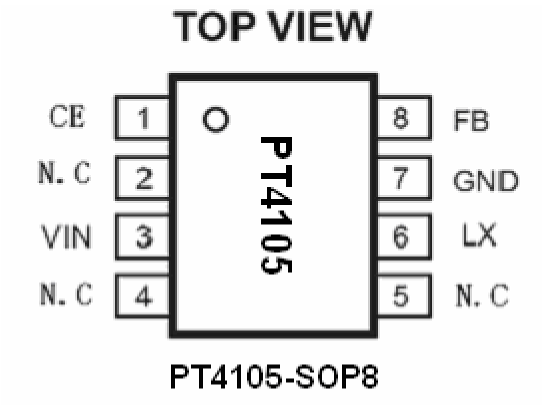
L: CR105-470MC (Sumida, 47µH) or Equivalent
D1: RB063L-30(Rohm) or Equivalent
LED: LUXREON-I/III

KEY PERFORMANCE CHART



C1, C2: 10µF, Ceramic Type
R2: 0.57Ω (0.25W, for LUXREON-I)
0.28Ω (0.25W, for LUXREON-III)

PIN ASSIGNMENT



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 (Note 1)

SYMBOL	ITEMS	VALUE	UNIT
V_{IN}	V_{IN} Supply Voltage	18	V
V_{LX}	LX Pin Output Voltage	-0.3~VIN +0.3	V
V_{CE}	CE Pin Input Voltage	-0.3~VIN +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	℃
T_{STG}	Storage Temperature Range	-55~125	℃

RECOMMENDED OPERATING RANGE (Note 2)

SYMBOL	ITEMS	VALUE	UNIT
V_{IN}	V_{IN} Supply Voltage	5~12	V
V_{LX}	LX Pin Output Voltage	-0.3~VIN +0.3	V
V_{CE}	CE Pin Input Voltage	-0.3~VIN +0.3	V
V_{FB}	V_{FB} PIN Input Voltage	-0.3~5.5	V
I_{LX}	LX Pin Output Current	≤700	mA

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.
Note 2: Recommended operating Range indicates conditions for which the device is functional, but does not guarantee specific performance limits.

ELECTRICAL CHARACTERISTICS (Note 3,4,5)

T_{OPT}=25℃, Unless Otherwise Noted.

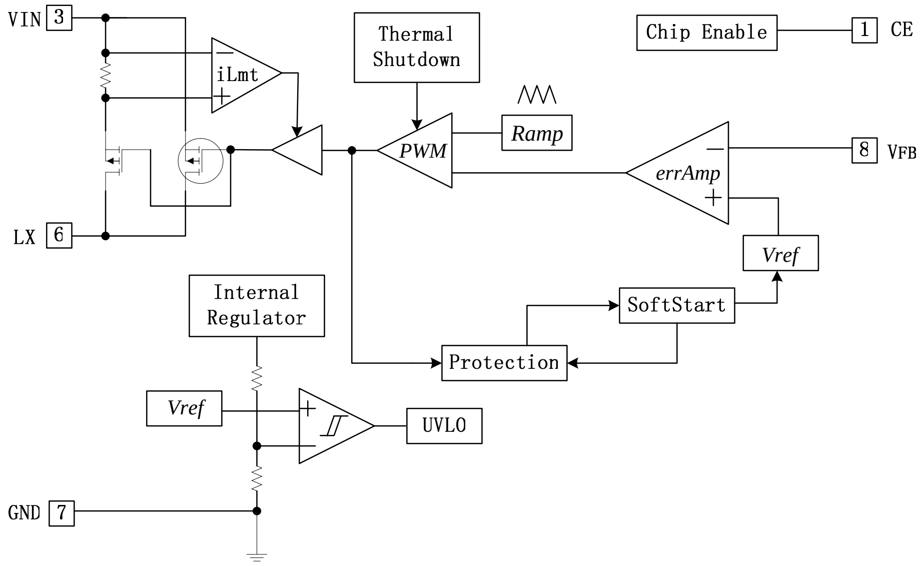
SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNITS
V_{IN}	Operating Voltage		4.5		12	V
V_{FB}	Feedback Voltage	$V_{IN}=V_{CE}$=8V, I_{FB}=350mA	180	200	220	mV
$\frac{\Delta V_{FB}}{\Delta T}$	Feedback Voltage Temperature coefficient	-40℃<T_{OPT}<85℃		±100		ppm/℃
I_{Q1}	Supply Current	V_{IN}= V_{CE}=12V, V_{FB}=2V		100	200	μA
I_{Q2}	Shutdown Current	V_{IN}= 12V, $V_{CE}=V_{FB}$=0V		0.1	1	μA
f_{OSC}	Oscillator Frequency	$V_{IN}=V_{CE}$=8V, I_{FB}=350mA	400	500	600	kHz
D_{MAX}	Maximum Duty Cycle		100			%
D_{MIN}	Minimum Duty Cycle				0	%
V_{CEH}	CE “H” Input Voltage	V_{IN}=8V, V_{FB}=0V	1.5			V
V_{CEL}	CE “H” Input Voltage				0.3	V
V_{UVLO1}	UVLO Voltage	$V_{IN}=V_{CE}$=3.5V->1.5V, V_{FB}=0V	1.7	2.0	2.9	V
V_{UVLO2}	UVLO Release Voltage	$V_{IN}=V_{CE}$=1.5V->3.5V, V_{FB}=0V		V_{UVLO1} +0.1	3.0	V
T_{SST}	Delay time by soft-start	V_{IN}=8V, I_{FB}=10mA , V_{CE}=0V->4.5V	1	2	6	ms
$R_{DS(ON)}$	Switch on resistance	V_{IN}=12V		0.3		Ω
I_{LMT}	Switch current limit	V_{IN}=12V		1.3		A
T_{TSD}	Thermal Shutdown			160		℃

Note 3: Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the recommended operating Range. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Note 4: Typicals are measured at 25˚C and represent the parametric norm.

Note 5: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

SIMPLIFIED BLOCK DIAGRAM



OPERATION DESCRIPTION

The PT4105 is a fixed frequency, voltage mode step-down switching regulator with internal power MOSFET capable of conducting up to 1A constant output current. With the external sensing resistor, the PT4105 operates as a high precision constant current source especially suitable for driving high current LEDs. To best understand its operation, 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 the 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 where the power transistor operates in the linear mode, the power transistor in a PWM switching regulator operates either in saturation or cutoff regions. Since the voltage-ampere product of the power transistor in these two operation modes remains low, high efficiency can easily be achieved in a switching regulator. The DC input voltage is firstly chopped into square waves with the same magnitude as the input voltage and duty cycles determined by the load conditions. Then with a succeeding L-C low pass filter, the high frequency components in the square waves are filtered out and a ripple free DC voltage equal to the average of the duty cycle modulated DC input voltage results. The output voltage remains regulated by sensing the DC feedback voltage and controlling the duty cycle in the negative-feedback loop.

As in a 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 resister 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.

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 10μF ceramic type capacitor is enough for stable operation.

- **Output Capacitors**

For most LEDs, a 10μF 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.

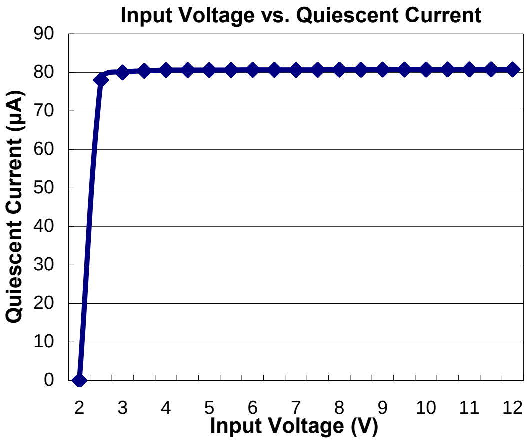
- **Diode**

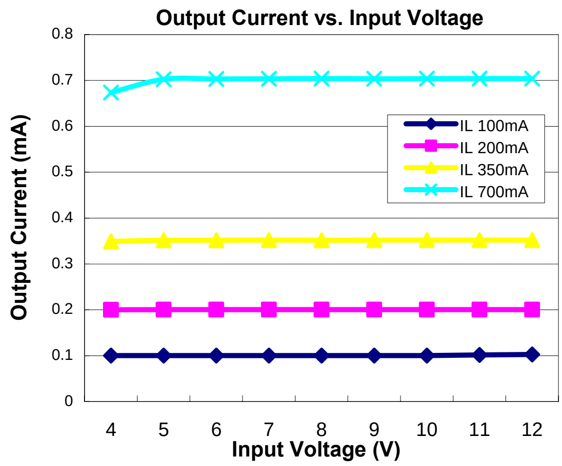
Use a diode with low V_F (Schottky diode is recommended) and high switching frequency. Reverse voltage rating should be more than V_{IN} and current rating should be larger than $I_{L,peak}$.

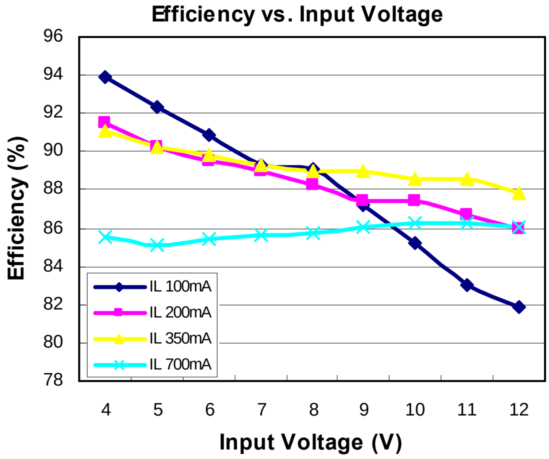
TYPICAL PERFORMANCE CHARACTERISTICS

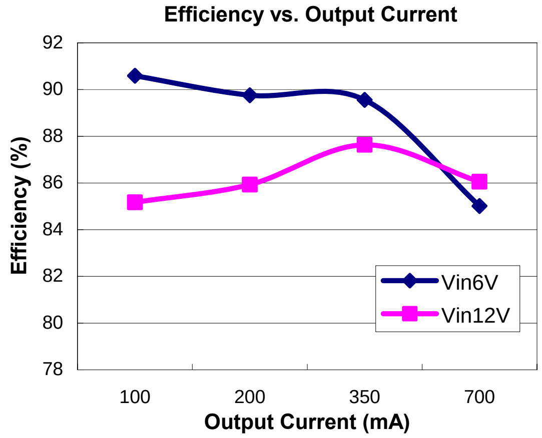
Note: Typical characteristics are obtained with using the following components:

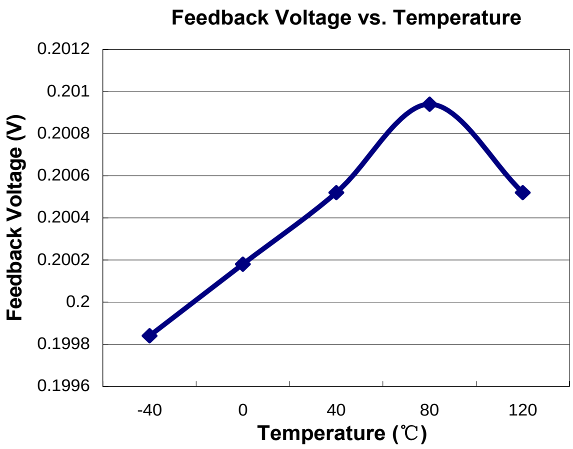
L:	CR105-470MC (Sumida, 47µH) or Equivalent	C1, C2:	10µF, Ceramic Type
D1:	RB063L-30(Rohm) or Equivalent	R2:	0.57Ω (0.25W, for LUXREON-I)
LED:	LUXREON-I/III		0.28Ω (0.25W, for LUXREON-III)

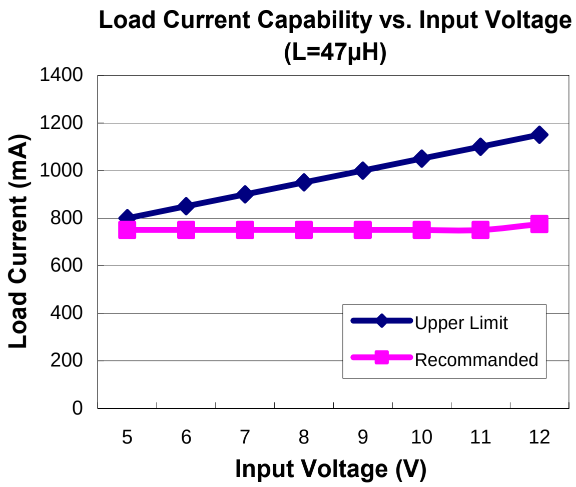




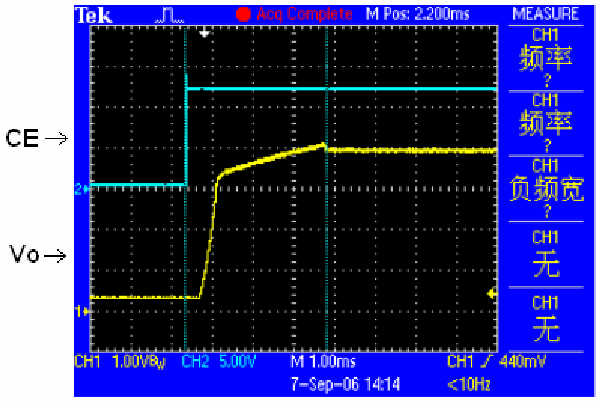




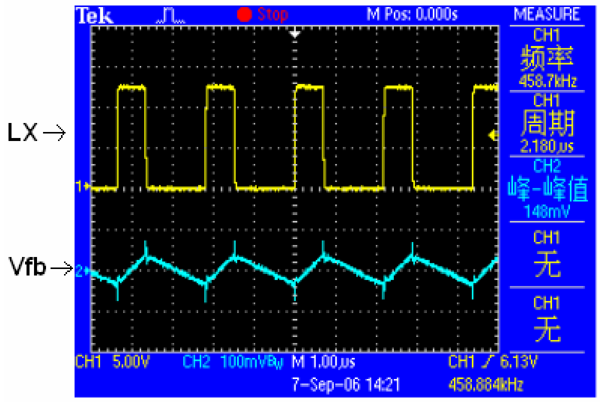




TYPICAL PERFORMANCE CHARACTERISTICS



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



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

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 5V 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.

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

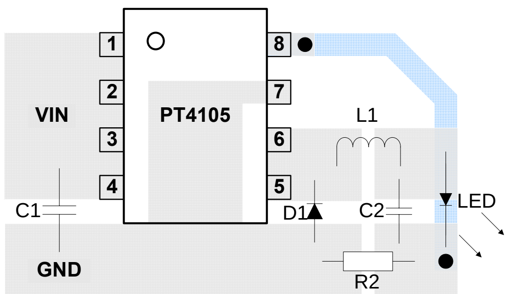
Here are several examples for feedback resister value selection:

I_{LOAD}(mA)	R_{FB}(Ω)
350	0.57
700	0.28

Note: choose RFB of which maximum rated power dissipation is no less than 1/4W

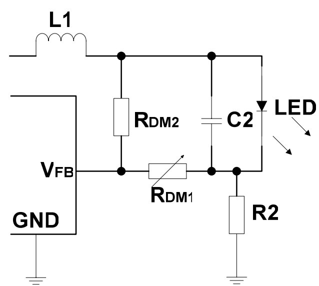
- **PCB Board Layout**

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. Attention should be paid to make sure the current density of the path is higher than 2.5A/mm^2. 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.

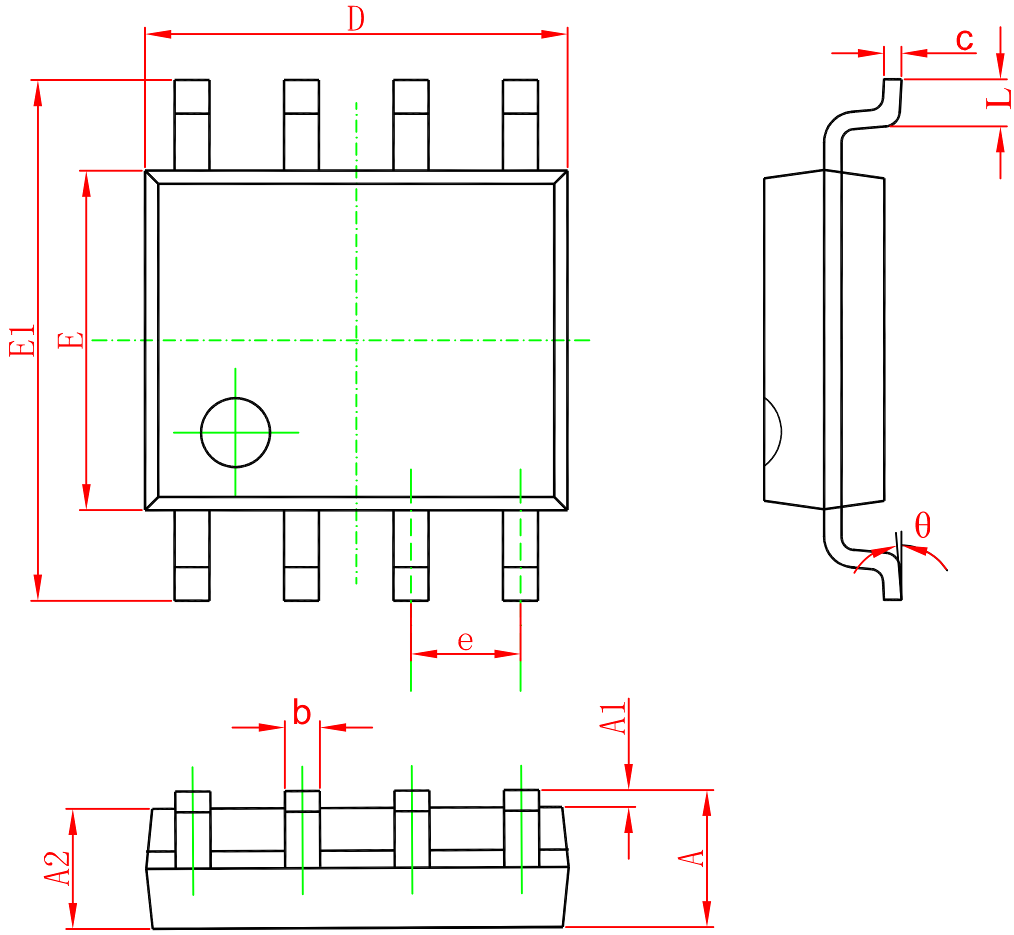


- **Dimming Control**

PT4105 can apply a resister 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.



PACKAGE INFORMATION



SYMBOL	DIMENSIONS IN MILLIMETERS		DIMENSIONS IN INCH	
	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
θ	0°	8°	0°	8°