GENERAL DESCRIPTION

The PT4105 is 18V high-voltage CMOS-based fixed frequency step-down DC/DC converter designed to operate as a constant source. 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, the Power MOSFET and the input voltage detection circuits. An external sense resistor in series with the LOAD monitors output current allowing accurate current regulation, ideal for driving high current LEDs. The built-in fault condition protection circuits including current limiting, UVLO and thermal shutdown prevent itself from potentially unstable operation and burn-out.

The PT4105 is ideal for single 1W or 3W LED drivers. Moreover, its high operating voltage and output current make it capable of driving up to three serial 3W LEDs and up to 9 serial-parallel 1W LEDs. Thanks 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.

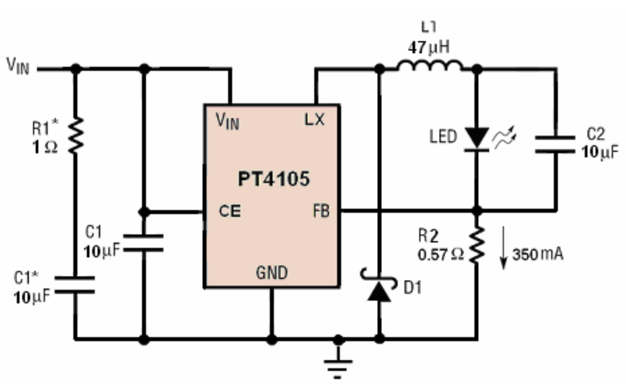
FEATURES

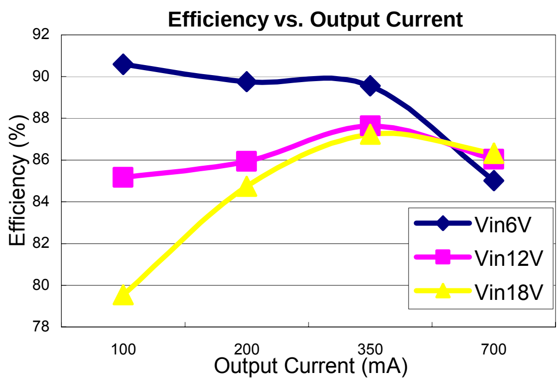
- Wide Range Of Input Voltage: Max 18V
- Low Feedback Voltage: 200mV
- High Output Capacity: >600mA @ 5V Vin;
  >1A @ 12V Vin
- Oscillation Frequency: 500kHz
- Standby Current: Typical 0.1μA
- High Efficiency: 90% for 1W LED
- Low Temp. Coefficient of Feedback Voltage:
  Typical ±100ppm/℃
- Built-in Soft-start
- Thermal Shutdown
- Package: SOIC8

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

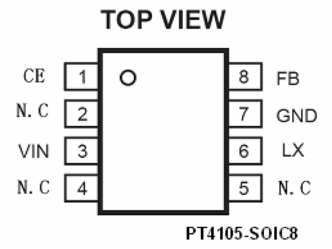
R2: 0.57Ω (0.25W, for LUXREON-I)
0.28Ω (0.25W, for LUXREON-III)
R1*: 1Ω
C1*: 10μF, Ceramic Type

Note: Please add on R1* and C1* when V_{IN} exceeds 12V for robust operation

ORDERING INFORMATION

PT4105ESOP

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~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	℃

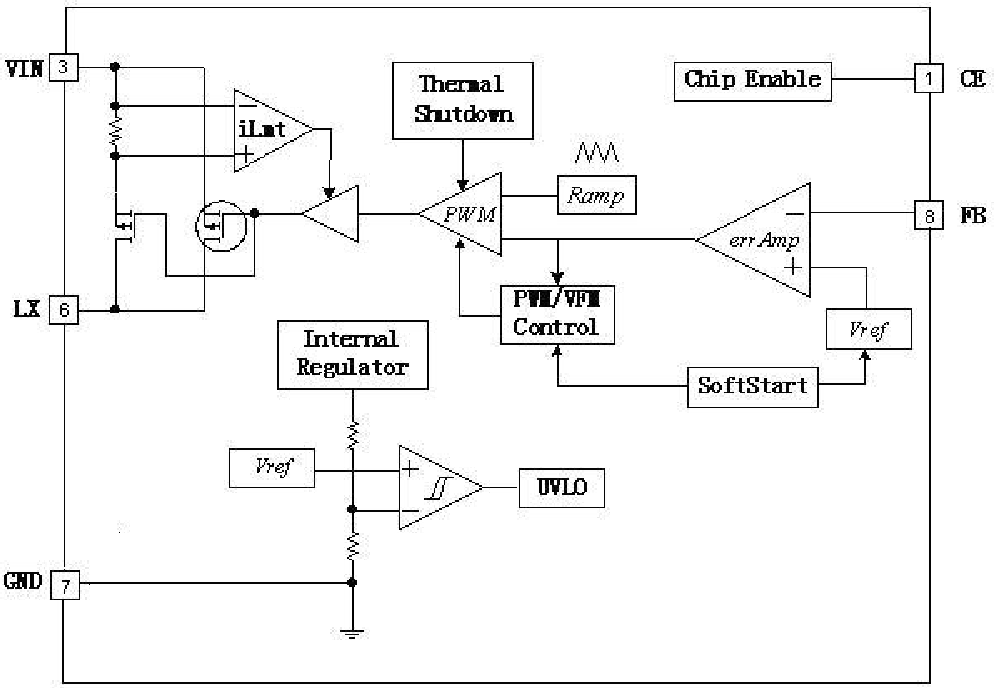
RECOMMANDED OPERATING RANGE

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

ELECTRICAL CHARACTERISTICS(T_{OPT}=25℃, Unless Otherwise Noted.)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_{IN}	Operating Voltage		2.5		18	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}=18V, V_{FB}=2V		100	200	μA
I_{Q2}	Shutdown Current	V_{IN}= 18V, 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}=2.5V->1.5V, V_{FB}=0V	1.75	2.0	2.25	V
V_{UVLO2}	UVLO Release Voltage	V_{IN}=V_{CE}=1.5V->2.5V, V_{FB}=0V		V_{UVLO1} +0.1	2.35	V
T_{SST}	Delay time by soft-start	V_{IN}=8V, I_{FB}=10mA , V_{CE}=0V->2.5V	1	2	4	ms
$R_{DS(ON)}$	Switch on resistance	V_{IN}=18V		0.3		Ω
I_{LMT}	Switch current limit	V_{IN}=18V		1.3		A
T_{TSD}	Thermal Shutdown			160		℃

BLOCK DIAGRAM



OPERATION DESCRIPTION

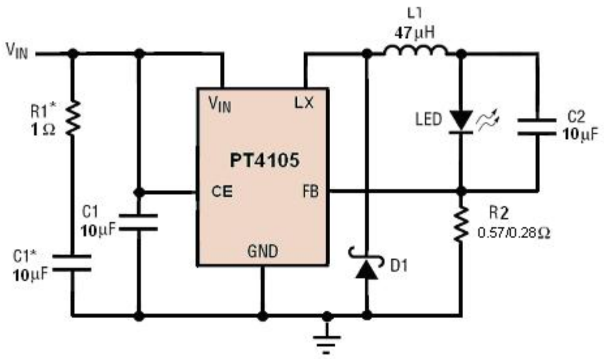
The PT4105 is a fixed frequency, voltage mode step-down switching regulator with internal power MOSFET capable of 1A constant output current. With the external sensing resistor, it operates as a high precision constant current source especially suitable for driving high current LEDs. To best understand 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.

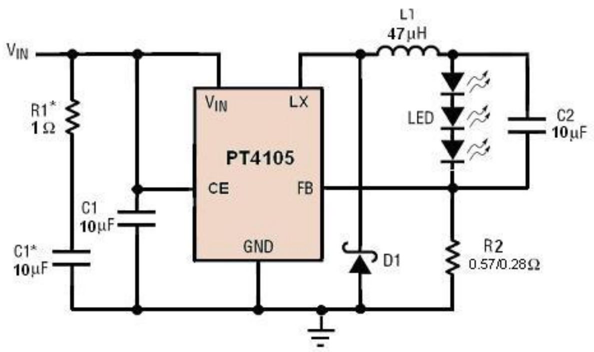
As in PT4105 based high current LED driver, the regulated output current can be maintained by sensing the DC feedback voltage produced by load current flowing through the sensing resister which is in series with the LOAD and controlling duty cycle in a negative-feedback loop. Therefore an alternative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

APPLICATION CIRCUITS

1. Typical Application Circuit for Single 1W or 3W LED Lighting



2. Application Circuit for 3X1W or 3W LED Lighting



APPLICATION INFORMATION

- **LED Current Setting**

Referring to the typical application circuit, the LED current is controlled by the feedback resistor R2. As the voltage on FB pin of the PT4105 is fixed to 200mV and the current sinking into the pin is zero, the value of R2 can be calculated by equation as shown below:

$$I_{LOAD} = V_{FB} / R_{FB} = 200 / R_2 ----------------(mA)$$

Here are several examples for feedback resister value selection.

I_{LED} (mA)	R1 (Ω)	P_{R1} (mW)
350	0.57	70
700	0.286	140

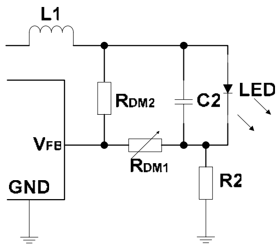
Note: choose R_{FB} of which maximum rated power dissipation is no less than 1/4W

- **Dimming Control**

There are three ways to control dimming for PT4105.

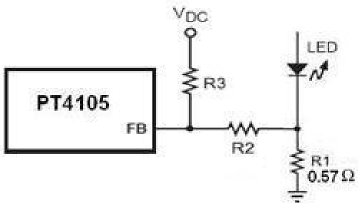
(1) By Variable Resistor

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.



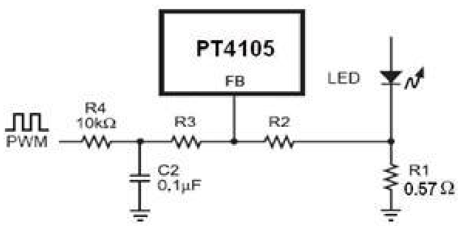
(2) By Variable DC voltage source

A variable DC voltage can be used to control the LED brightness as shown in the following figure. The LED current I_{LED} decreases as V_{DC} increases and vise versa. R2 and R3 should meet a ratio of 1:24 if V_{DC} changes from 0V to 5V, thus can be set to 5KΩ and 120KΩ, respectively.



(3) By filtered PWM Signal

A filtered PWM signal can be seen as a variable DC voltage, so that it can be used for PT4105 dimming control.



- **Soft-start**

The PT4105 has internal soft-start to limit the amount current through Vin at startup and to also limit the amount of overshoot on the output. The typical soft-start time is 2ms.

Selection of 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, VF 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.

Be aware of input voltage ringing if the power supply is suddenly applied to the system especially in the case of VIN 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 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 VF (Schottky diode is recommended) and high switching frequency. Reverse voltage rating should be more than VIN and current rating should be larger than ILpeak.

- **Others**

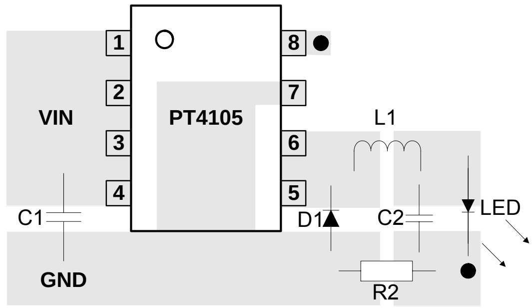
1. To avoid parasitic current into each pin, make sure voltage applied to CE pin should be no more than the voltage level of VIN

pin.

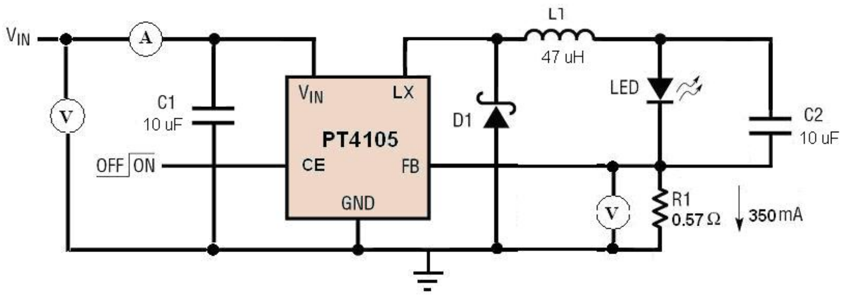
2. It's highly recommended applying PT4105 to the condition with VIN is equal or more than 4V for high efficiency.

- **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.



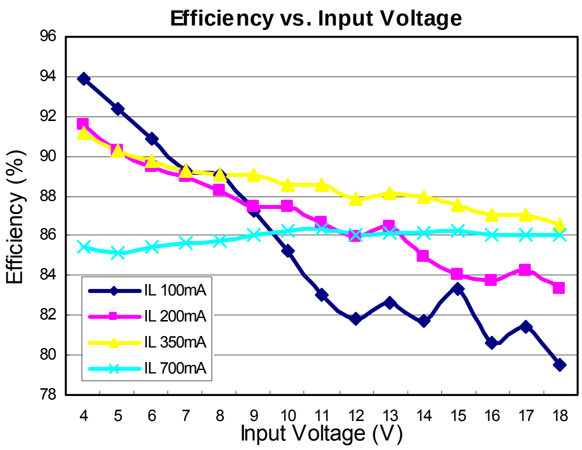
TESTING CIRCUIT

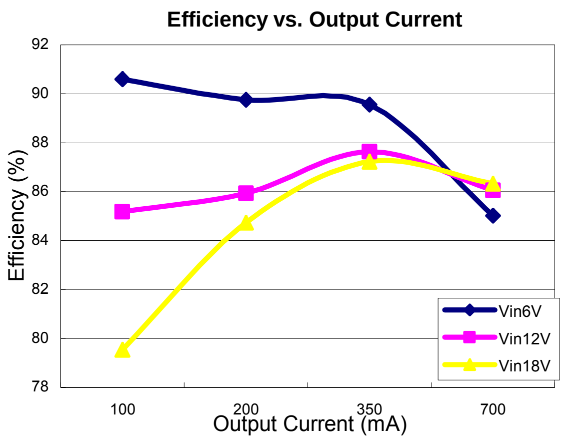


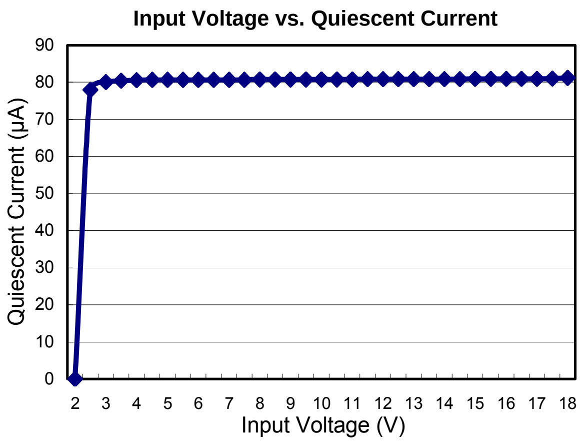
TYPICAL PERFORMANCE CHARACTERISTICS

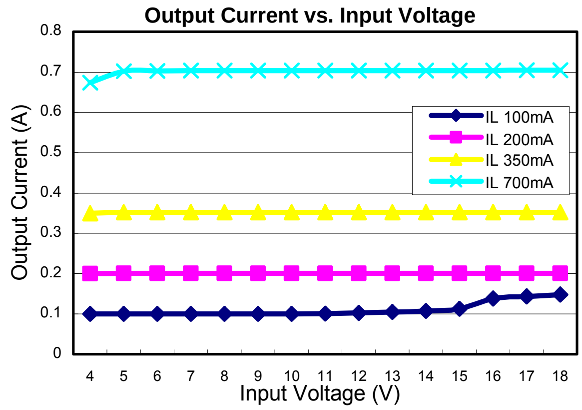
Note: Typical characteristics are obtained with using the following components:

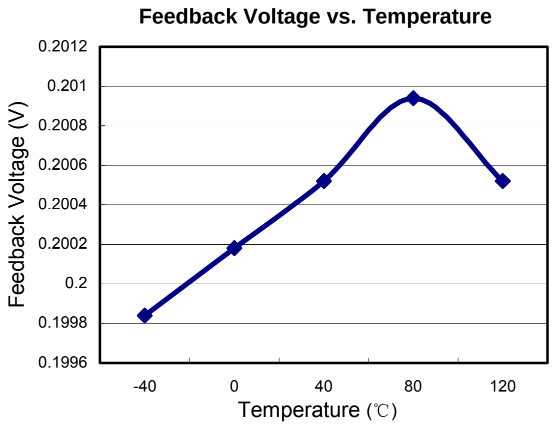
L:	CR105-470MC (Sumida, 47μH) or Equivalent	C1:	10μF, Ceramic Type
D1:	RB063L-30(Rohm) or Equivalent	R1:	0.57Ω (0.25W, for LUXREON-I)
LED:	LUXREON-I/III		0.28Ω (0.25W, for LUXREON-III)

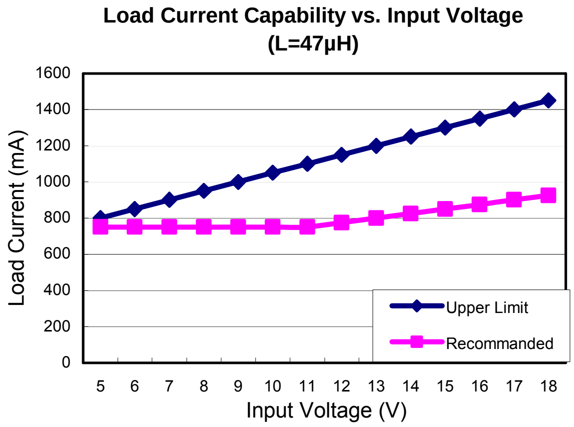


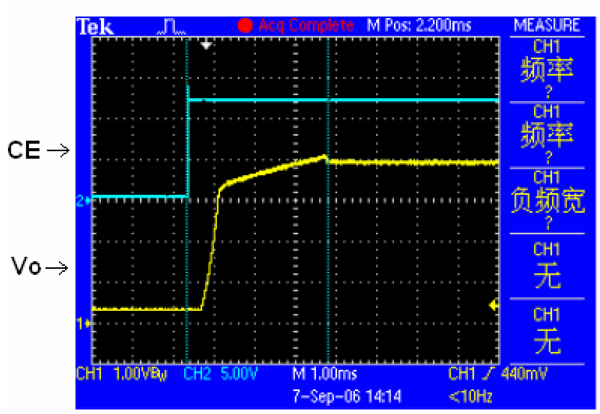




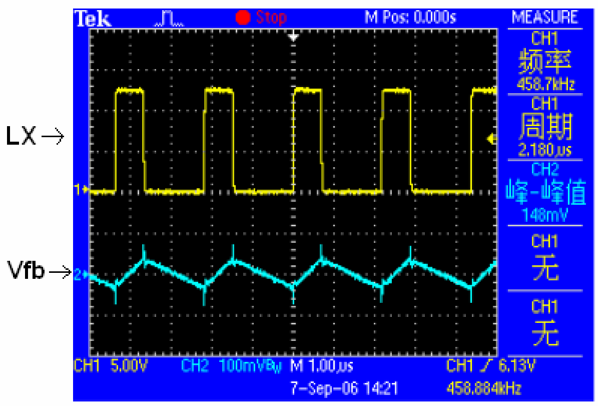






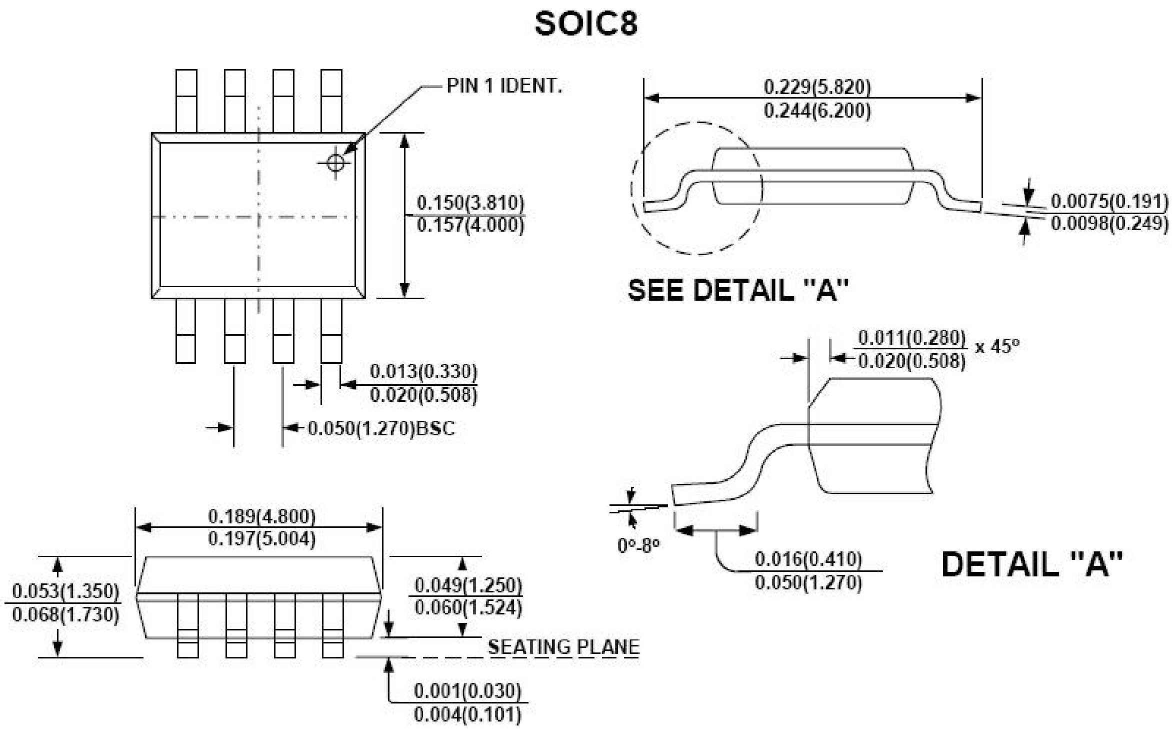


PT4105 Soft-start, Vin=12V, ILED=700mA



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

PACKAGE INFORMATION



NOTE:
1) Control dimension is in inches. Dimension in bracket is millimeters.