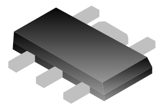
32V/1A, HIGH-EFFICIENCY HYSTERESIS LED DRIVER WITH BUILT-IN MOSFET

DESCRIPTION

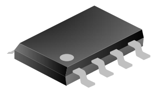
SD42525 is a step-down constant current converter with inductance current continuous-conduction mode, it is used for driving LED or LEDs in series. The output current is adjustable which is up to 1A in 6~32V input voltage range. LED whose power is tens of watts can be driven by SD42525 with different input voltages and peripheral elements. With built-in power switch, average current of LED can be set through external high-side current sensing. Analog dimming and wide range PWM dimming are available through pin DIM and soft-start time can be set by capacitor value which is connected between pin DIM and ground.

It adopts two patent technologies: output current compensation when input voltage varies and current limiting through maximum duty factor when difference between input/output voltages is small.

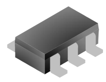
For SD42525, package of SOP-8-225, SOT-23-6L and SOT-89-5L (no dimming) are available.



SOT-89-5L



SOP-8-225-1.27



SOT-23-6L

FEATURES

* Few peripheral elements
* Built-in 36V power MOSFET
* Wide input voltage range: 6V~32V
* Maximum 1A output current
* Excellent output current accuracy: ±3%
* Multiplex pin DIM is used for chip switch, analog dimming and PWM dimming.
* Soft start function
* LED open/short-circuit protection
* High efficiency up to 96%
* Output constant current which is adjustable

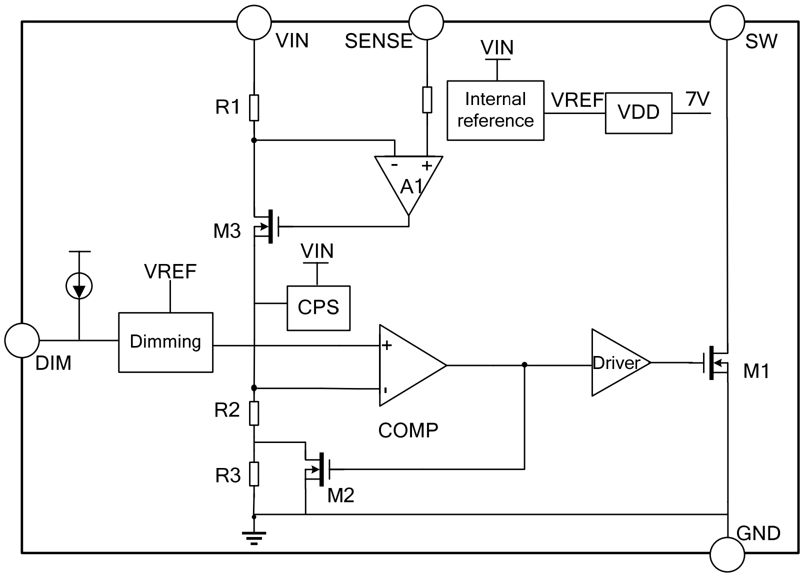
APPLICATIONS

* Low-voltage LED spotlight, replacing Halogen lamp
* Car-mounted LED lamp
* LED backup lamp
* LED signal lamp

ORDERING INFORMATION

Part No.	Package	Marking	Material	Packing
SD42525	SOP-8-225-1.27	SD42525	Pb free	Tube
SD42525TR	SOP-8-225-1.27	SD42525	Pb free	Tape & Reel
SD42525ETR	SOT-89-5L	525E	Pb free	Tape & Reel
SD42525KTR	SOT-23-6L	525K	Pb free	Tape & Reel

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATING (T_{amb}=25°C)

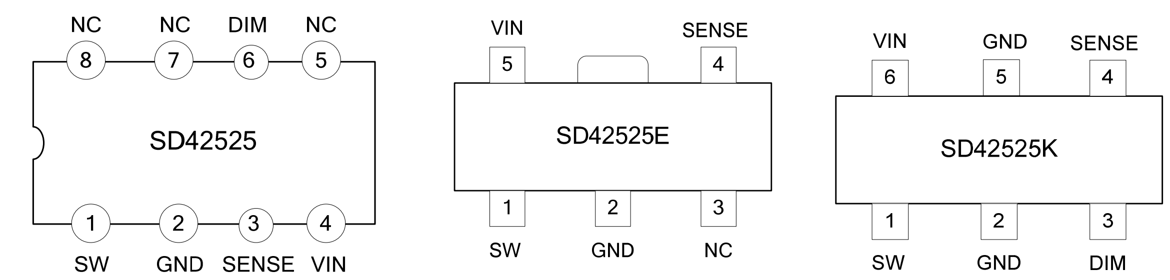
Characteristics	Symbol	Ratings	Unit
Supply Voltage	V_{IN}	-0.3 ~ +40	V
Switch Voltage	V_{SW}	-1~V_{IN}+1	V
DIM voltage	V_{DIM}	-0.3 ~ +100	V
SENSE voltage	V_{SENSE}	-0.3~V_{IN}	V
Junction Temperature	T_j	150	°C
Lead Temperature	T_L	260	°C
Operating Temperature Range	T_{OPR}	-40~+85	°C
Storage Temperature Range	T_{STG}	-40~+125	°C

ELECTRICAL CHARACTERISTICS (Unless otherwise specified, V_{IN}=12V, I_{OUT}=700mA, T_{amb}=25°C)

Characteristics	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Supply Voltage	V_{IN}		6		32	V
Operating Current	I_{IN}	V_{IN}=6/40V, V_{DIM}=6V	0.3	0.5	0.8	mA
Maximum operating frequency	f_{osc}				800	kHz
Maximum Duty Cycle	D_{max}	3LED, V_{IN}=9.5V	--	96	96	%
Current sensing						
Average sense voltage	V_{IN}-V_{SENSE}	12V input; 1 LED	97	100	103	mV
Sense voltage hysteresis	V_{SENSE}-hys			±15		%
Power MOSFET						
Leakage current of power MOSFET	I_L	V_{SW}=36V		2	10	μA

Characteristics	Symbol	Test Condition	Min.	Typ.	Max.	Unit
On resistance of power MOSFET	R_{ON}	V_{IN}=32V, 1 LED, I_{OUT}=1A	--	0.6	0.7	Ω
DIM input						
internal operating voltage	V_{DIM}	DIM floating		6.5		V
DIM input high level	V_{DIM-H}	PWM dimming	1.4			V
DIM input low level	V_{DIM-L}	PWM dimming			0.25	V
DIM dimming range	V_{DIM-DC}		0.4		1.3	V
PWM dimming frequency	F_{PWM}	Fosc =500KHz			20	KHz
D_{PWM-LF}	Low-frequency dimming ratio	F_{DIM} =100Hz		2000:1		
D_{PWM-HF}	High-frequency dimming ratio	F_{DIM} =10KHz		20:1		
I_{DIM}	V_{DIM}	DIM ground current	8	9	10	μA
Over temperature protection						
threshold value for temperature protection	T_{SD}			160		°C
temperature protection hysteresis	T_{SD}-hys			30		°C

PIN CONFIGURATION



PIN DESCRIPTION

Pin No.			Pin Name	I/O	Description
SD42525	SD42525E	SD42525K			
1	1	1	SW	I/O	Switch pin. Inductor is connected between this pin and negative of LED.
2	2	2/5	GND	I/O	Ground
3	4	4	SENSE	I	Current sense pin.
4	5	6	VIN	I	Input supply voltage.

Pin No.			Pin Name	I/O	Description
SD42525	SD42525E	SD42525K			
6	/	3	DIM	I/O	Dimming pin, used for chip switch, analog dimming and PWM dimming.
5/7/8	3	/	NC	I/O	NC

FUNCTION DESCRIPTION

SD42525, sense resistor R_S and inductor L constitute the self-oscillation step-down LED controller with inductance current continuous-conduction mode.

When V_{IN} is power on, current through R_S and L is zero, output current of LED is also zero. And output of internal comparator is high, internal power MOSFET is on and SW level is low. Current flows form V_{IN} to ground through R_S, L, LED and internal power MOSFET, and its rising slope is decided by V_{IN}, L and voltage drop on LED. When V_{IN}-V_{SENSE} (V_{SENSE} is voltage drop on R_S) is higher than 115mV (this value is obtained according to the typical value), output of internal comparator is low and power MOSFET is off; Current flows from R_S, L, LED to diode D with the falling slope which is determined by L and voltage drop on LED. When V_{IN}-V_{SENSE} is lower than 85mV (this value is obtained according to the typical value), power MOSFET is on again.

Few external elements are needed with high-side current sense structure, sense resistor with accuracy of 1% is adopted and the accuracy of LED output current is ±3%. PWM dimming function is available through pin DIM. When DIM voltage is lower than 0.25V, LED is off and when DIM voltage is higher than 1.3V, LED is on. PWM dimming frequency is range from 100Hz to 20KHz.

LED current can be adjusted through DC voltage on pin DIM (analog dimming), and maximum LED current is decided by sense resistor R_S. The effective DC voltage for dimming is 0.4 ~1.3V. LED current, whish is decided by R_S., is constant when DC voltage is higher than 1.3V.LED current can also be adjusted through a resistor connected between pin DIM and ground with a pull-up current source, and DOM voltage is decided by the pull-up current and resistor.

Pin DIM can be floating during normal work of the chip. When DIM voltage is lower than 0.25V, internal power MOSFET is off and LED current is decreased to zero. Thermal resistor NTC can be used for temperature detecting to adjust LED current and to protect the LED when it is placed close to LED.

1. Output current setting

The LED current is determined by the sense resistor and setting voltage. The average value of sense voltage V_{IN}-V_{SENSE}(Drop voltage on R_S) is 100mV, and LED current can be adjusted through adjusting the sense resistor R_S (refer to Typical Application Circuit).

$$I_{OUT} = \frac{V_{IN} - V_{SENSE}}{R_S} \quad (R_S > 0.1\Omega)$$

Condition for equation above: pin DIM is floating or external DC voltage is higher than 1.3V (lower than 6.5V). Actually, maximum LED current is decided by R_S, and the LED current can be adjusted to arbitrary value which is lower than the maximum value through pin DIM.

2. Analog dimming

LED output current can be adjusted through DC voltage, and the maximum LED current is decided by $0.1/R_S$.

$$I_{OUT} = \frac{0.1 * V_{ADJ}}{1.3 * R_S} \quad (0.4V \le V_{DIM} \le 1.3V)$$

When $1.3V \le V_{DIM} \le 7V$, LED current is 100% of $I_{OUT} = \frac{0.1}{R_S}$.

3. PWM dimming

Maximum LED current is decided by R_S, and PWM dimming can be available through pin DIM, expressed as below:

$$I_{OUT} = \frac{0.1 * D}{R_S} \quad (0 \le D \le 100\%,\ 1.3V \le V_{DIM} \le 6.5V)$$

Where, D is the PWM duty factor.

LED current changes from 0%~100% of $0.1/R_S$ and LED luminance is decided by PWM duty factor, for example, if PWM duty factor is 30%, then the average LED current is 30% of $0.1/R_S$,. PWM dimming frequency should be higher than 100HZ to avoid obvious flashing which can be realized by eyes. Advantage of PWM dimming is dimming without changing (correlated color temperature) CCT. PWM dimming frequency of SD42525 can be up to 20KHz.

4. Shutdown mode

When DIM voltage is lower than 0.25V, the system will be shutdown and it restarts when DIM voltage is higher than 0.35V. Pin DIM can be floating during normal work.

5. Soft start

Proper capacitor is connected to pin DIM for rising slowly of DIM voltage, so LED current rises slowly for soft start.

6. LED short-circuit protection

When LED is short-circuit, current through R_S will be increased, if voltage drop on R_S is higher than 115mV (this is obtained according to the typical value), power MOSFET is off to guarantee the safety of IC and peripheral elements.

7. Output current compensation

Because of the delay of internal comparator and all the system, output current will vary following change of LED quantity or input voltage, and there is 10%~15% change in output current when the input voltage range is 6~32V. Output current compensation is adopted to decrease current change within ±3% which is caused by vary of input voltage.

8. Maximum duty factor setting

Duty factor in Hysteresis Loop Control mode is decided by input voltage and voltage drop on LED. Duty factor will be increased to 100% when LED voltage drop value is close to input voltage, and output current is much higher than the normal value. the maximum duty factor setting module is used for limiting the duty factor not higher than 96% and for stable output current.

9. Temperature compensation

High luminance needs temperature compensation for stable operation. For SD42525, thermal resistor (NTC) or diode (negative temperature coefficient) can be placed close to LED for temperature monitoring and adjusting LED current for guaranteeing. DIM voltage decreases when temperature increases, and LED current decreases for system temperature compensation.

10. Over temperature protection

TSD is adopted for stable working of the system. When the temperature is higher than 160°C, the protection occurs to stop current output, and when the temperature is lower than 140°C, IC works again.

COMPONENTS SELECTION

1. Input capacitor selection

The input capacitor provides the pulse current when the power MOSFET is on, and charge the capacitor when the power MOSFET is off, keeping the stability of the input voltage. It is recommended to adopt input capacitor with higher than 10µF to reduce the peak current drawn from input source and the switch noise. The input capacitor should be near to the input pin in real routing.

2. Inductance selection

It is recommended to adopt inductor with value of 22µH ~ 68µH. The selected effective current (RMS current rating)of inductance current should be bigger than the maximum output current, and the saturation current should be bigger than maximum output current by 30%. In order to improve the efficiency, the series-wound resistor (DCR) of inductance should be smaller than 0.2Ω. Large inductance value is recommended when the LED current is low. Inductor value should be as large as possible when current is enough for better constant current output. Inductor should be placed close to VIN and SW in routing to avoid efficiency loss caused by parasitic resistance.

Recommended inductance value

Output current	R_S	Inductance value	Saturation current
350mA	0.28 Ω	47µH	1.3~1.5 times of output current
700mA	0.14 Ω	22µH	

Resistor can be specially ordered if needed.

The operating frequency should be considered in inductor selection, expressed as:

$$f_{SW} = \frac{(V_{IN} - n \times V_{LED}) \times n \times V_{LED} \times R_S}{V_{IN} \times \Delta V \times L}$$

Where, f_{SW}—operating frequency, V_{IN}—input voltage, n—LED quantity, V_{LED}—LED voltage drop, R_S—resistance, L—inductance, ΔV=ΔI*RS, ΔI—current p-p value, ΔI—30% of maximum average output current.

3. Diode selection

SD42525 is the hysteresis step-down adjuster, so the diode should provide continuous current when the power MOSFET is off. Because the forward voltage of Schottky diode is small, and the reverse continuous current time is short, so it is usually used for continuous current. During the power MOSFET is conducting, reverse voltage of diode is high, so the reverse voltage of selected diode should be bigger than the input voltage.

The average current through the diode is I_D:

$$I_D = (1 - D) * I_{LED}$$

I_{LED} --- the current of LED.

When the input voltage is high, duty factor is small and I_D increases, so the maximum continuous current of selected diode should be higher than the output current.

4. Reducing output ripple

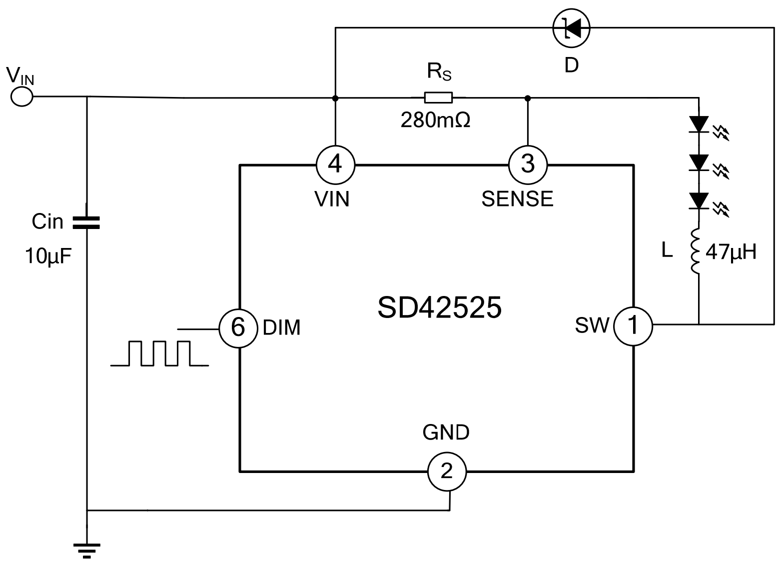
An effective method to reduce output current ripple is to connect capacitor to LED in parallel, and operating frequency and efficiency will not be effected by this capacitor, but the start-up time will be increased because of reduced rising speed of LED voltage. It is recommended to adopt capacitor with value of 2.2µF or larger.

5. PCB routing

PCB routing is important for stability and low noise, and multi-layer PCB is an effective method. SW is the node of fast switch, all the lines connecting SW should be as short as possible. And GND should be well grounded.

In PCB routing, Inductor should be close to its two connecting points to avoid effect on efficiency, and lines connecting Rs should be short to decrease parasitic resistance for accuracy of sense current.

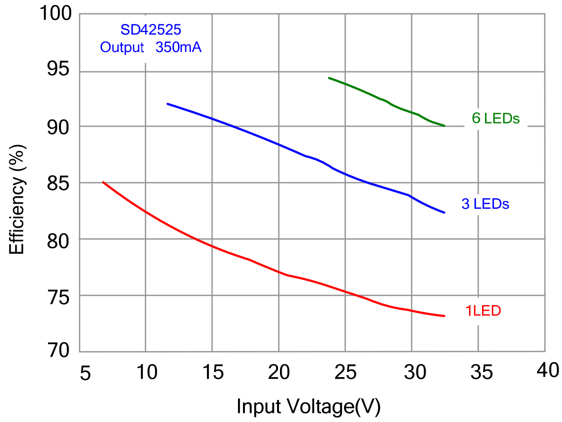
TYPICAL APPLICATION CIRCUIT



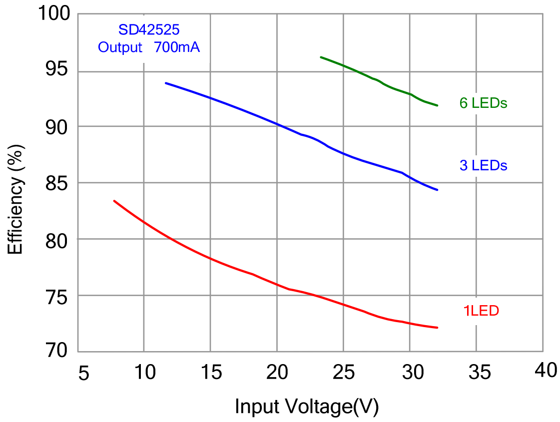
LED driver with 6~32V input and 350mA output

Note: the circuit and parameter above are only for reference, please set the parameter according to practical circuit.

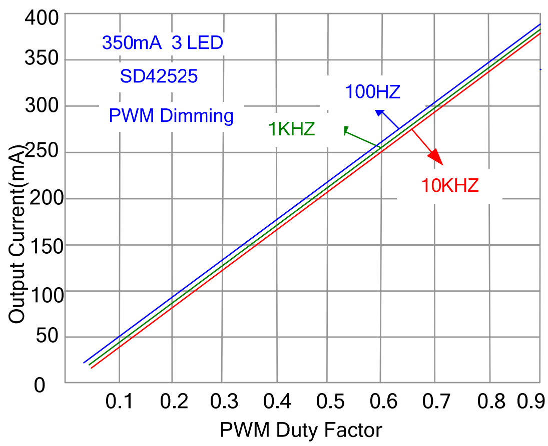
ELECTRICAL CHARACTERISTICS CURVE



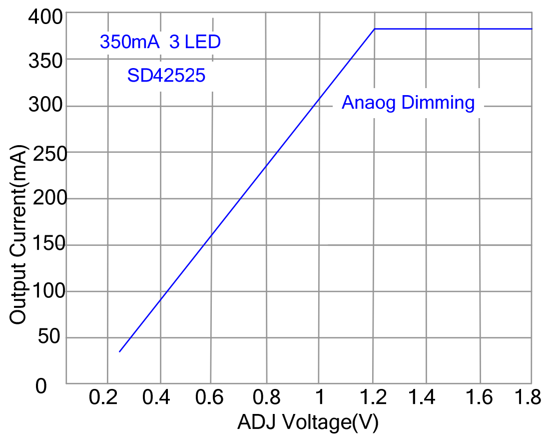
Efficiency vs. input voltage (350mA)



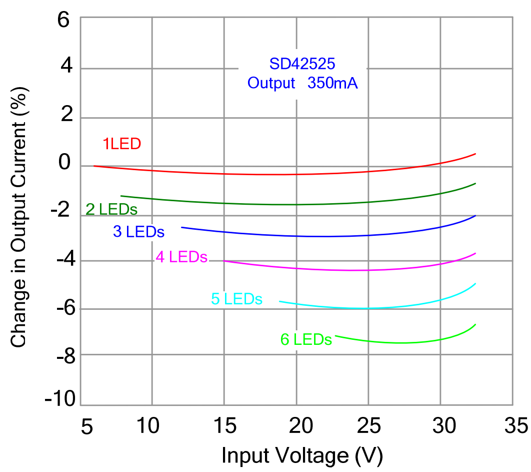
Efficiency vs. input voltage (700mA)



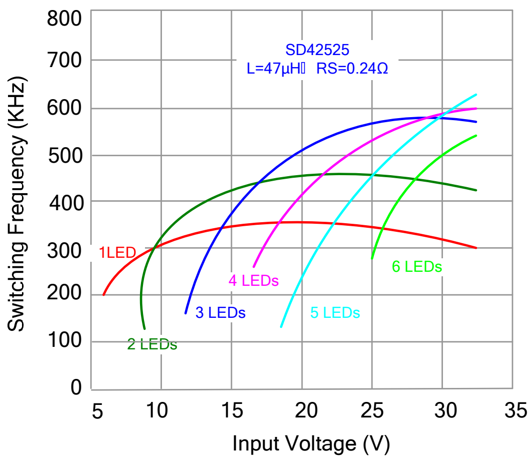
Output current vs. PWM duty factor (350mA)



Output current vs. DIM voltage (350mA)

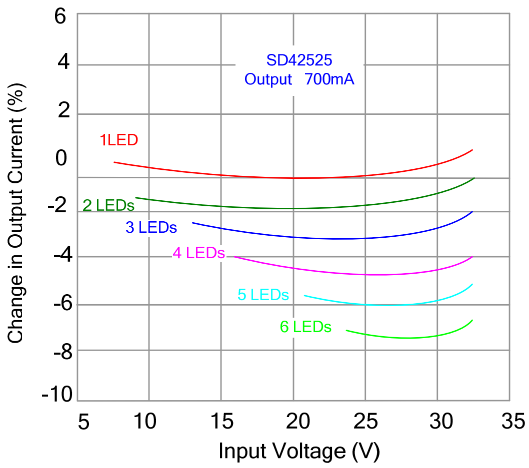


Output current change vs. input voltage (350mA)

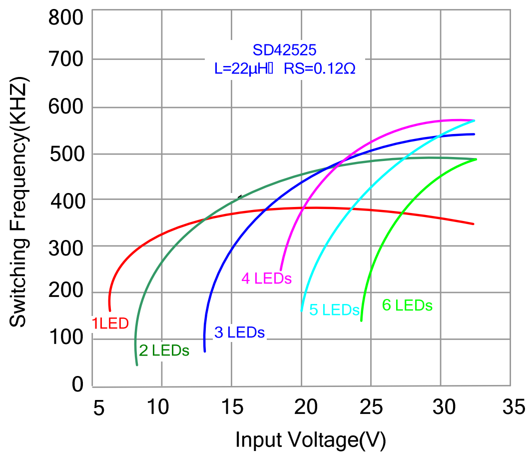


Switching frequency vs. input voltage (350mA)

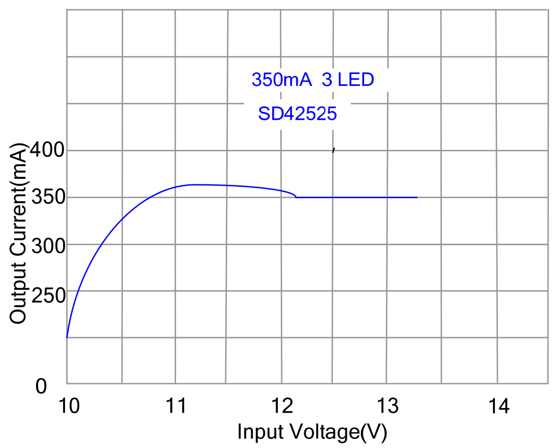
ELECTRICAL CHARACTERISTICS CURVE (continued)



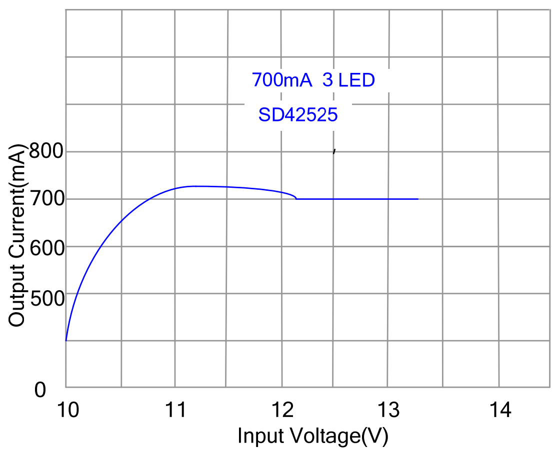
Output current change vs. input voltage (700mA)



Switching frequency vs. input voltage (700mA)



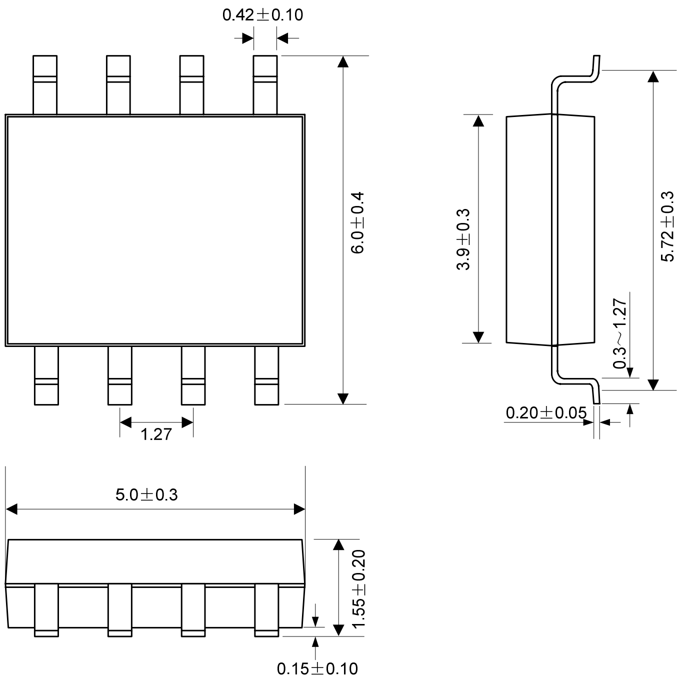
Output current vs. input voltage when input voltage is similar to output voltage (350mA)



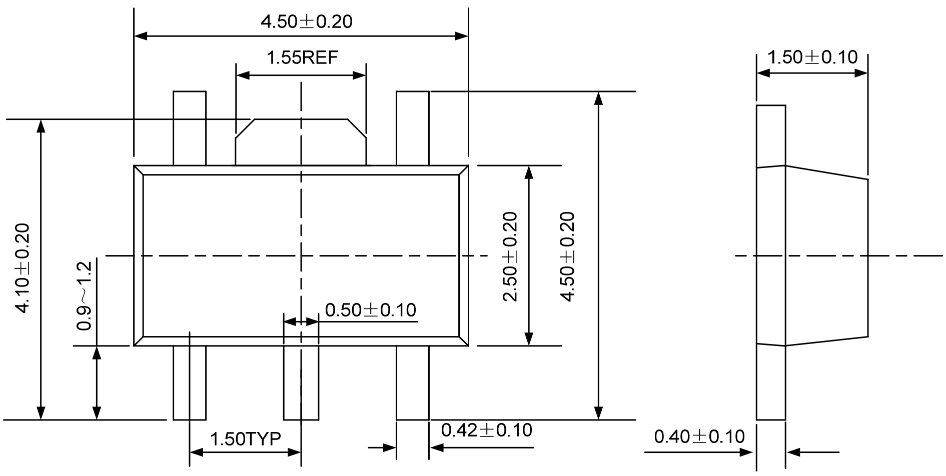
Output current vs. input voltage when input voltage is similar to output voltage (700mA)

PACKAGE OUTLINE

SOP-8-225-1.27 **Unit: mm**

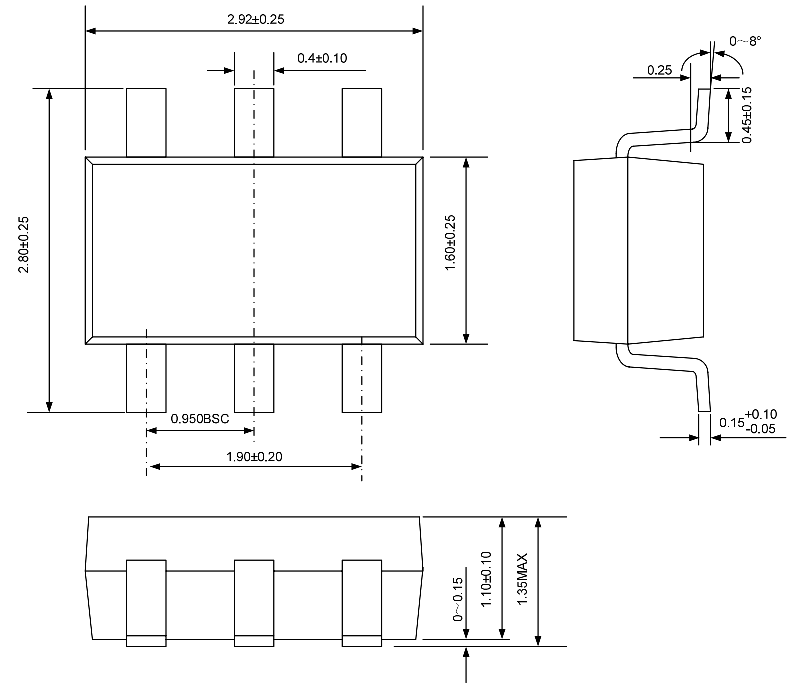


SOT-89-5L **Unit: mm**



PACKAGE OUTLINE(continued)

SOT-23-6L **Unit: mm**



HANDLING MOS DEVICES:

Electrostatic charges can exist in many things. All of our MOS devices are internally protected against electrostatic discharge but they can be damaged if the following precautions are not taken:

- Persons at a work bench should be earthed via a wrist strap.
- Equipment cases should be earthed.
- All tools used during assembly, including soldering tools and solder baths, must be earthed.
- MOS devices should be packed for dispatch in antistatic/conductive containers.

ATTACHMENT

Revision History

Date	REV	Description	Page
2010.12.13	1.0	Original	