High Efficiency
High Power LED Driver

ADT6750

General Description

The ADT6750 is a PWM high-efficiency LED driver with a built-in internal power MOSFET capable of driving up to 1.2A with excellent constant current regulation.
It is specifically designed for LED lighting like MR16 applications with two kinds of input power range – 6VDC to 40VDC and 12VAC to 24VAC.
With enhanced protection functions, ADT6750 operates safely against abnormal circumstance.

The ADT6750 is available in ESOP8(with exposed pad) package.

Features

- Maximum 1.2A constant output current
- Wide input voltage range : 6V to 40V
- Up to 97% high efficiency
- PWM or DC dimming control
- Output current precision : ±3%
- Typical ±5% output current accuracy
- Multiple protection supported
  (Thermal, UVLO, Soft-start, LED open protection)
- Package : ESOP8

Applications

- High power LED/IR-LED Lighting
- LED MR16 lighting
- Automotive lighting
- Architecture lighting
- Appliances interior lighting

Typical Application Circuit

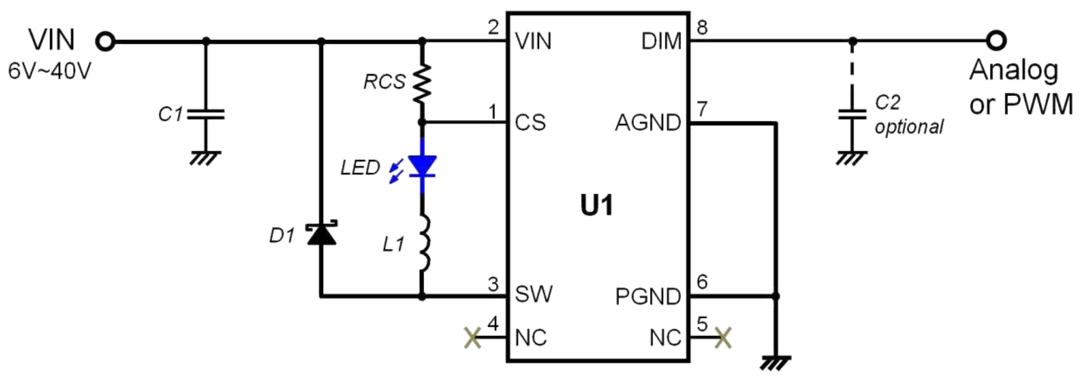


Figure 1. Typical Application Circuit

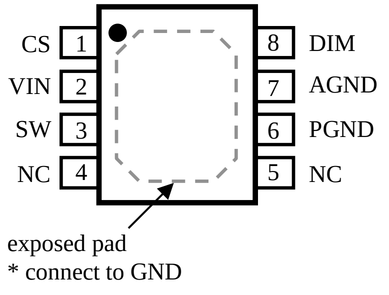
Part List

Component	Value	Description	Size	Part No.	MFR
U1	-	IC, 1.2A/40V, LED driver	ESOP8	ADT6750	ADTech
D1	-	Schottky Barrier Diode (2A, 60V)	3216	RB060M-60TR	Rohm
L1	68uH	Inductor, SMD, 1.5A, 220mΩ	12x12x5	PIC1204-680	EROCORE
C1	47uF	Capacitor, Electrolytic, 50V, 20%	6.6x6.6x7.7	EEEFK1H470XP	Panasonic Electronic Components
C2	10nF	Capacitor, Ceramic	1608	-	-
RCS	0.143Ω	Resistor, Chip, 1%, 700mA I_LED	3216	-	-

Note. For component selection, refer to the 'APPLICATION INFORMATION' section.

Pin Description

Pin No	Pin Name	Description
1	CS	Current sensing node. Connect resistor RCS from VIN to CS pin.
2	VIN	Power supply input. Bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC.
3	SW	Switching node. Drain of the integrated Power Switch.
4	NC	No Connection
5	NC	No Connection
6	PGND	Power switch transistor ground.
7	AGND	Analog ground.
8	DIM	Dimming input terminal. Low : LED driver is off. High : LED driver is enable.
×	E-PAD	Exposed Pad. Connect to both PGND and AGND.



Package outline

* This specifications are subject to be changed without notice

Functional Block Diagram

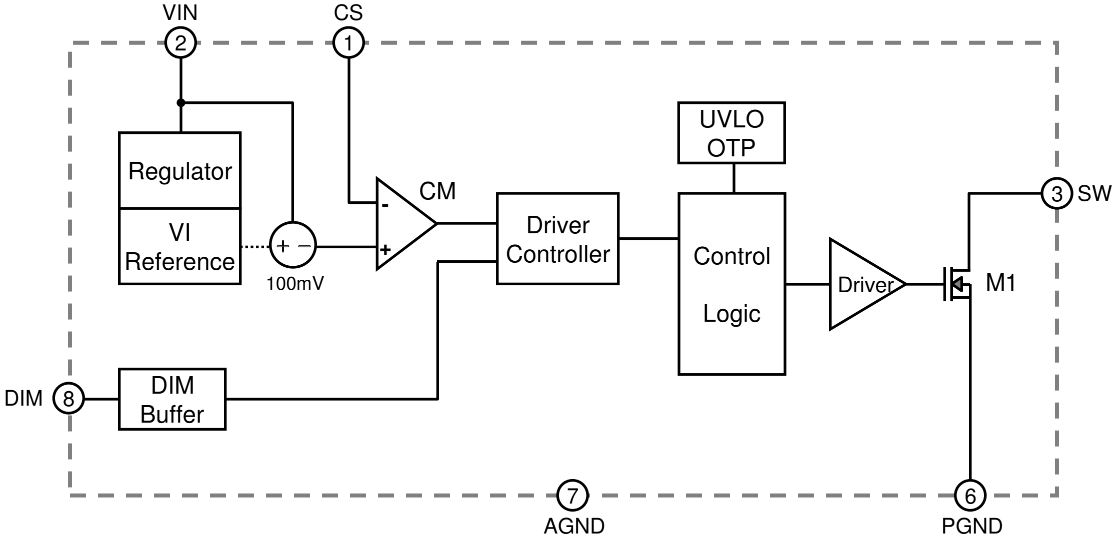


Figure 2. Functional Block Diagram

Absolute Maximum Ratings (Note1)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Power supply voltage	V_{IN}	-0.3	-	40	V
SW pin voltage	V_{SW}	-0.5	-	40	V
CS pin voltage	V_{CS}	-0.3	-	40	V
All Other Pins	-	-0.3	-	6.0	V
Max. power dissipation : ESOP8 (Ta=25℃) (Note2)	P_D	-	-	2.08	W
Thermal resistance : ESOP8 (Note3)	Θ_{JA}	-	60	-	℃/W
Storage junction temperature	T_{STG}	-65	-	+150	℃
Junction temperature	$T_{J.MAX}$	-	-	+150	℃

Note1. Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device.
Note2. Derate 17mW/℃ above +25℃. This is recommended to operate under this power dissipation specification.
Note3. Measured on JESD51-7, 4-layer PCB

Operating Ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit
Power supply voltage	V_{IN}	6.0	12.0	40.0	V
Operating temperature	T_{OPR}	-40	-	+85	℃
Junction temperature	T_J	-40	-	+125	℃

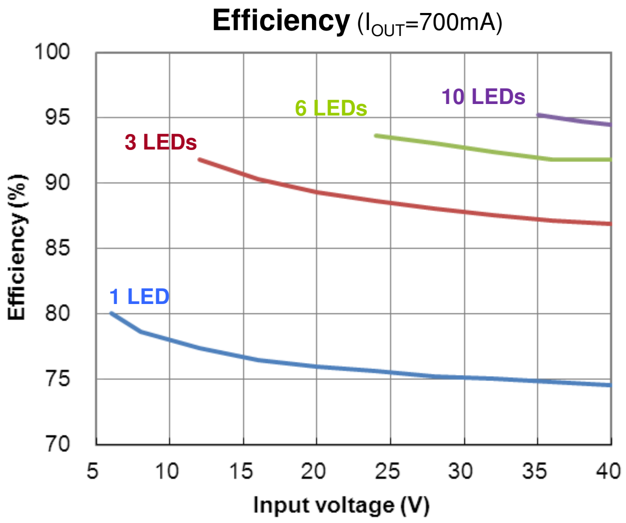
Electrical Characteristics (Ta=25℃, VIN=12V, IOUT=700mA, unless otherwise noted)

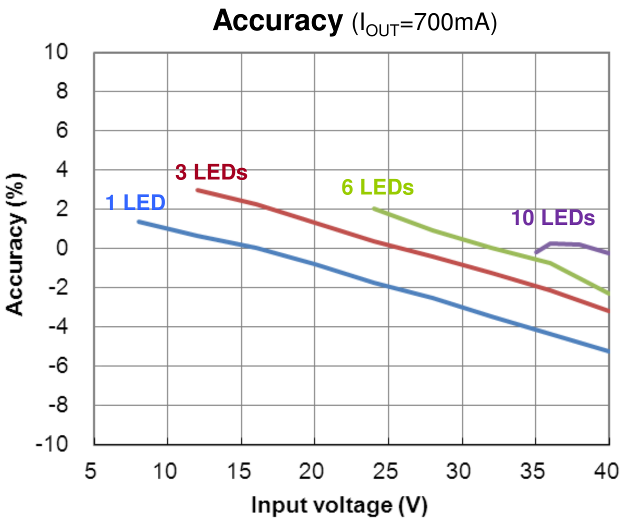
Parameters	Symbol	Condition	Min.	Typ.	Max.	Unit
UVLO rising threshold	V_{UVLO}	V_{IN} rising	-	4.8	-	V
UVLO threshold hysteresis	V_{UVLO_HYS}	V_{IN} falling	-	900	-	㎷
Maximum switching frequency	F_{SW}	-	-	-	1.0	㎒
Operating Current						
Supply current (OFF)	I_{OFF}	DIM=GND	-	120	200	㎂
Current Sense						
Current Sense threshold voltage	V_{CS}	Mean (VIN - V_{CS})	97	100	103	㎷
Sense threshold hysteresis	V_{CS_HYS}	-	-	±15	-	%
DIM Input						
Input High Voltage	V_{IH}	-	2.5	-	5	V
Input Low Voltage	V_{IL}	-	0	-	0.3	V
Maximum DIM Input Frequency	F_{DIM}	-	-	-	50	㎑
Analog DIM Input range	V_{DIM}	-	0.5	-	2.5	V
RDIM (DIM Pull up Resistor)	RD	-	-	250	-	㏀
Switching TR						
Switch On Resistance (Note4)	R_{ON}	-	-	0.39	-	Ω
Switch Leakage Current	I_{LEAK}	-	-	0.5	5	㎂
Continuous Switch Current (Note4)	I_{LIMIT}	-	-	-	1.2	A
Thermal Operation						
Thermal shutdown (Note4)	T_{OT}	-	-	140	-	℃
OTP hysteresis (Note4)	T_{OP_HYS}	-	-	25	-	℃

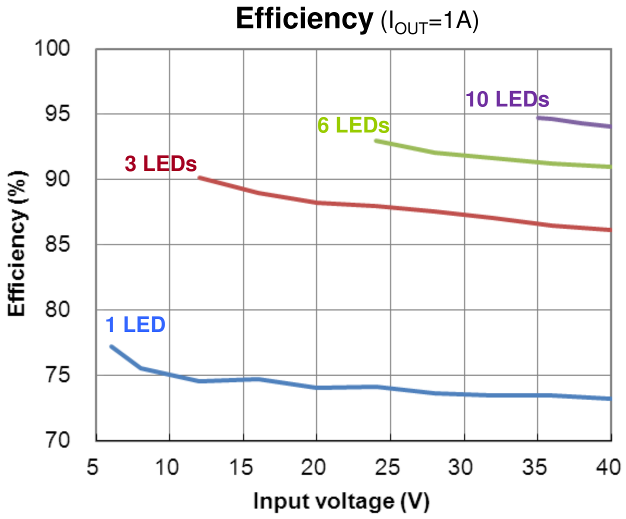
Note4. guaranteed by design.

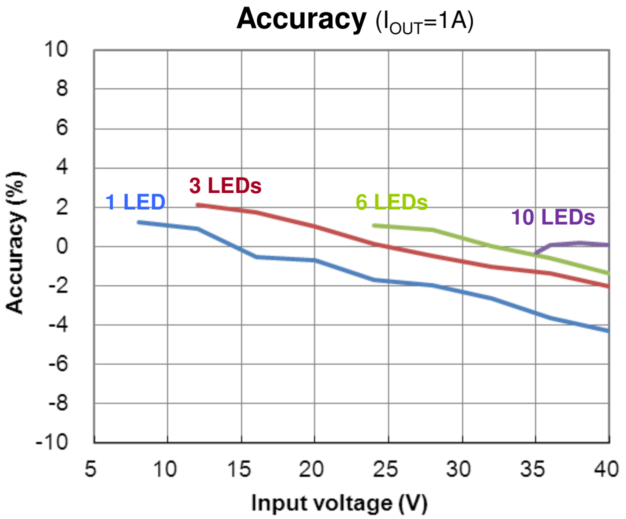
Typical Operating Characteristics

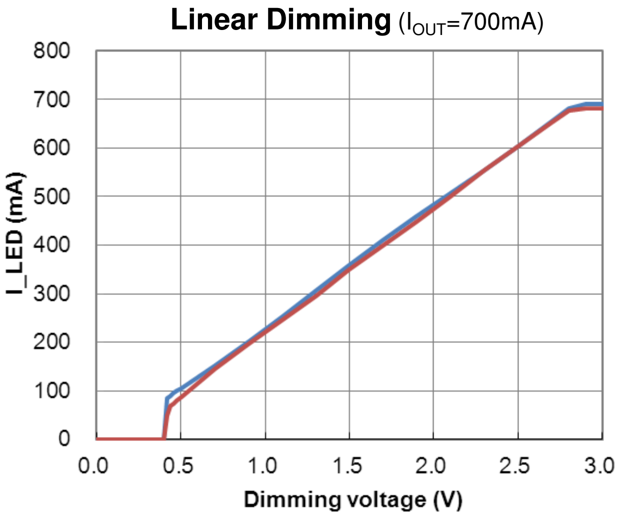
V_{IN}=12V, C1=47uF, L1=68uH and Ta=25℃, unless otherwise noted

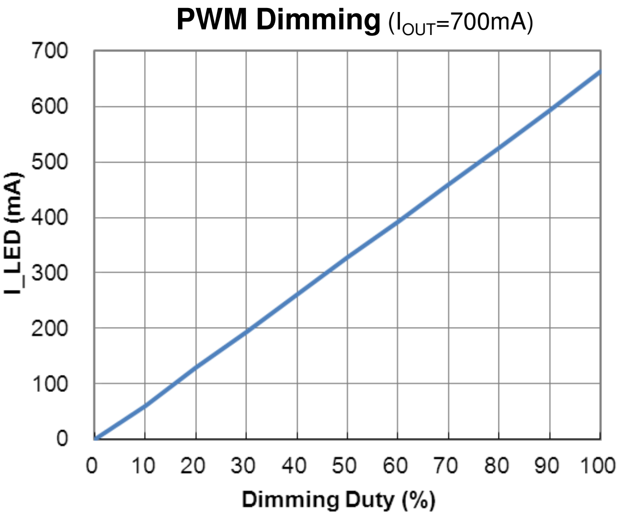












OVERVIEW (refer to Figure 2. Functional Block Diagram)

The ADT6750 is a hysteretic mode step-down converter with integrated low side NMOS power switch. It operates from a 6V to 40V input voltage range and supplies up to 1.2A of output current. Features include protection functions such as under voltage lockout, soft start and thermal shutdown protection.

The ADT6750 uses hysteretic mode control to regulate the output current. The output current is sensed from VIN to CS pin with the external resistor. This sensed current is compared by the reference current (or voltage) until predetermined threshold level. When the (VIN-VCS) voltage is above the upper threshold level, M1 switch is OFF. And then M1 switch is ON when the (VIN-VCS) voltage is below the lower threshold level. By this repeated operation, the averaged LED current regulated constantly.

DETAILED DESCRIPTION

PWM dimming

The LED brightness can be controlled by applying a pulse-width modulation(PWM) signal to the DIM pin. When DIM pin voltage is high level, the device is working normally. When DIM pin voltage is low level, internal power switch is off. When DIM pin is open, its level is high and the device operates normally. By this function, output current is controlled by the duty of external PWM signal. The average value of output current is given by:

IOUT(average) ≒ (0.1 x Duty of PWM) / RCS , where RCS is the external sensing resistor value.

Recommended PWM dimming frequency is 100Hz to 1kHz range to get a good dimming linearity.

For 700mA LED current, available maximum PWM dimming frequency can be up to 2kHz and maximum dimming ratio is up to 500:1. The lower LED current, the higher available PWM dimming frequency.

Linear dimming

With the same DIM pin, linear dimming of the LED current is possible. Linear dimming input voltage range is from 0.5V to 2.5V. Below 0.5V, ADT6750 comes into the disable state and LED current is zero. Above 2.5V, ADT6750 is on the normal operating state.

With these response to the DIM pin voltage, ADT6750 is possible to operates both PWM dimming or linear dimming control at one DIM pin.

The nominal average output current is given by:

1) V(DIM) $\geq$ 2.5V, output current = 0.1 / RCS
2) 0.5V $<$ V(DIM) $<$ 2.5V, output current = (0.1 / RCS) x (V(DIM) / 2.5)
3) V(DIM) $\leq$ 0.5V, output current ~ 0.0 mA.

Thermal protection

The ADT6750 has thermal protection function. This function protects the IC from over temperature 140˚C. When the chip temperature is decreased to 115˚C, the IC is operated again.

Soft start

An external capacitor from the DIM pin to ground will provide additional soft start delay time. With the input resistance of DIM pin and externally added capacitor, it operates to control linear dimming in a given delay time interval. So, it is possible to protect abrupt LED current rising and falling. The delay time is 0.8ms/nF typically.

APPLICATION INFORMATION

Figure 1 is the typical ADT6750 application circuit. And Figure 2 is the functional block diagram of the ADT6750. For the application information, refer to the Figure 1 & 2 unless otherwise noted.

LED Current Resistor Selection

The nominal average output current in the LED(s) is determined by the value of the external current sense resistor RCS connected VIN pin and CS pin. RCS is recommended to use 1% tolerance or better resistor. LED current is calculated by the below equation.

$$I\_LED = 100mV / RCS \quad \text{for } RCS \geq 0.083\Omega$$

Note that RCS = 0.083ohm is the minimum allowed value of sense resistor under these conditions to maintain switch current below the specified maximum value.

The table below gives values of nominal average output current for several preferred values of current setting resistor RCS in the typical application circuit :

RCS	Nominal average output current
0.083 Ω (0.1Ω // 0.5Ω)	1200 mA
0.01 Ω	1000 mA
0.14 Ω	714 mA
0.33 Ω	303 mA

The above values assume that the DIM pin is floating or high level. In this condition, analog dimming function is not available. It is possible to use different values of RCS if the DIM pin is driven from an external voltage for analog dimming function.

Inductor Selection

The inductor required to supply constant current to the output load when it is driven by a switching voltage. Higher inductance gives low inductor ripple current but requires larger size inductor to avoid saturation. Low ripple current reduces inductor core losses. Also it reduces RMS current through inductor and switches, which results in less conduction loss. Usually, the selected effective current (Rated Current, Max) of inductor should be bigger than 20% to 30% of the max. output current. Make sure it is capable to handle the peak current without saturation.

The inductor value should be chosen to maintain operating duty cycle and switch 'on'/'off' times within the specified limits over the supply voltage and load current range. The following equations can be used as a guide.

SW switch 'on' time :

$$T_{ON} = \frac{L \times \triangle I}{V_{IN} - V_{LED} - I_{AVG} \times (RCS + R_L + R_{ON.SW})}$$

SW switch 'off' time :

$$T_{OFF} = \frac{L \times \triangle I}{V_{LED} + V_D + I_{AVG} \times (RCS + R_L)}$$

APPLICATION INFORMATION (continued)

Where,
L is the coil inductance (H)
R_L is the coil resistance (Ω)
RCS is the current sensing resistance (Ω)
I_{AVG} is the required LED current (A)
△I is the coil peak to peak ripple current (A), internally set to 0.3 x I_{AVG}.
V_{IN} is the supply voltage (V)
V_{LED} is the total LED forward voltage (V)
$R_{ON.SW}$ is the switch on resistance (Ω), 0.39Ω nominal.
V_D is the diode forward voltage at the required load current (V)

Surface mount inductors in different shape and styles are available from TDK, EROCORE, TOKO and Murata. Shielded inductors are small and radiate less EMI noise. But they cost more than unshielded inductors. The choice depends on EMI requirement, price and size.

Input Capacitor Selection

The input capacitor is used to filter out discontinuous, pulsed input current and to maintain input voltage stable. Therefore input capacitor should be able to supply the AC current to the converter. The voltage rating of input capacitor must be greater than the maximum input voltage plus ripple voltage. Since the input capacitor absorbs the input switching current, it requires an proper ripple current rating. The RMS current in the input capacitor can be approximated by:

$$I_{CIN.RMS} \fallingdotseq I_{AVG} \times \sqrt{\frac{V_{LED}}{V_{IN}} \times \left[1 - \frac{V_{LED}}{V_{IN}}\right]}$$

The worst-case condition occurs at $V_{IN} \sim 2 \times V_{LED}$ (50% duty condition), and its worst RMS current is approximately half of the I_{AVG}. For reliable operation and best performance, the input capacitors must have current rating higher than I_{CIN_RMS} at worst operating conditions.

The input capacitor is recommended to be more than 47uF. And the input capacitor should be positioned as close to the VIN pin as possible. For maximum stability over temperature and voltage, capacitors with X7R, X5R, or better dielectric are recommended. Capacitors with Y5V dielectric are not suitable for decoupling in this application and should not be used.

Diode Selection

When the low side switch is off, the storage current in inductor freewheels to the VIN. The forward voltage and reverse recovery times of the freewheeling diode are the key loss factors, so schottky diode is mostly used for the freewheeling diode. Choose a diode whose maximum reverse voltage rating is greater than the maximum input voltage, and whose current rating is greater than the maximum load current.

The average current through the diode is :

I_Diode = (1 – Duty of PWM) x LED current

APPLICATION INFORMATION (continued)

Thermal Management

The ADT6750 contains an internal thermal sensor that limits the total power dissipation in the device and protects it in the event of an extended thermal fault condition. When the die temperature exceeds +140˚C typically, the thermal sensor shuts down the device, turning off the converter to allow the die to cool. After the die temperature falls by 25˚C typically, the device automatically restarts to operate normally.

The ADT6750 is available in a thermally enhanced SOP package and can dissipate up to 2.0W at room temperature condition. The exposed pad should be connected to ground externally, preferably soldered to a large ground plane to maximize thermal performance. Maximum available power dissipation should be de-rated by 17mW/℃ above Ta=25℃ not to damage the device.

PCB Layout Consideration

PCB layout is very important to achieve clean and stable operation. It is highly recommended to follow below guidelines for good PCB layout.

1. Input capacitor (C1) should be placed as near as possible to the IC and connected with direct traces.

2. Keep the high current paths as short and wide as possible.

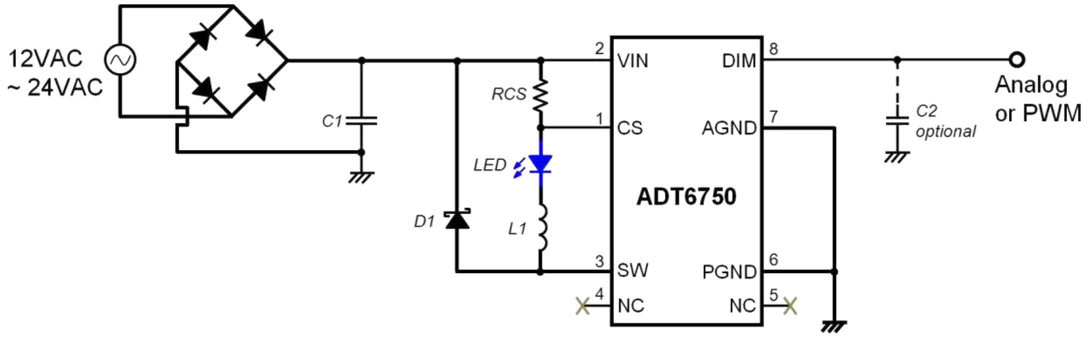
3. Keep the switching current path short and minimize the loop area, formed by SW and the input capacitors.

4. Route high-speed switching nodes (such as SW) away from sensitive analog areas (such as CS).

5. Ensure all feedback connections are short and direct. Place the RCS component as close as possible to the IC.

6. Exposed pad of device must be connected to ground with solder.

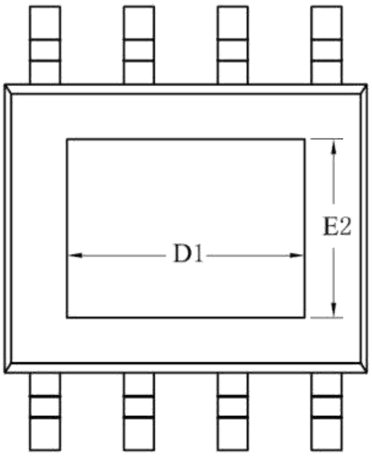
AC Power input application

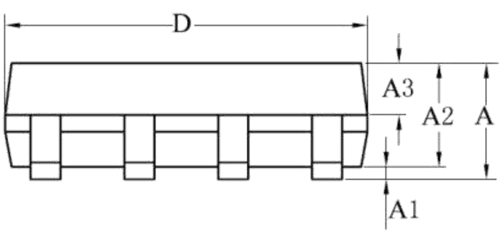


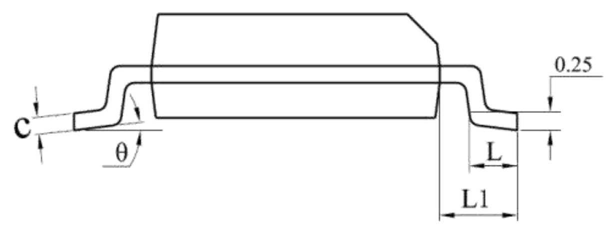
* This specifications are subject to be changed without notice

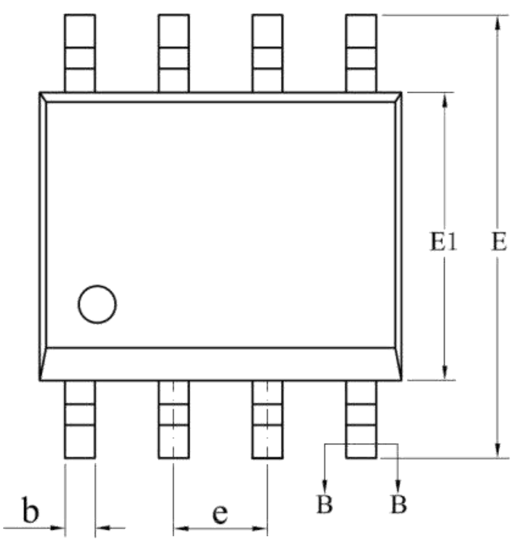
Package : ESOP8(with exposed pad), 4.9mm x 3.9mm body (units : mm)

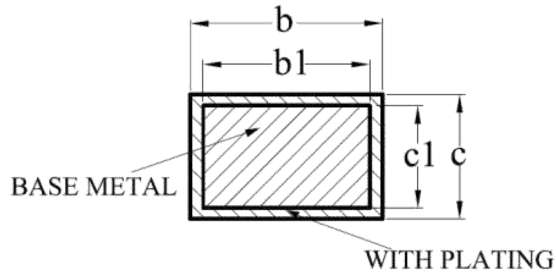
SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	__	__	1.77
A1	0.08	0.18	0.28
A2	1.20	1.40	1.60
A3	0.55	0.65	0.75
b	0.39	__	0.48
b1	0.38	0.41	0.43
c	0.21	__	0.26
c1	0.19	0.20	0.21
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
L	0.50	0.65	0.80
L1	1.05BSC		
θ	0	__	8°
D1	3.30REF		
E2	2.40REF		











SECTION B-B

* This specifications are subject to be changed without notice