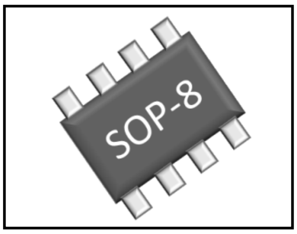
Data Sheet

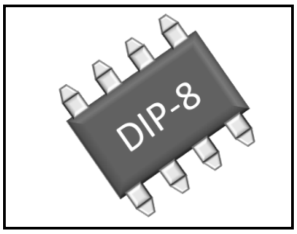
UR540X

SmartPower Enabled Non-isolated Power Switch For LED Lighting

Overview:

UR540X is a high performance Quasi Resonant mode non-isolated SMPS power switch optimized for AC/DC LED lighting. UR540X has an internal MOSFET to simplify circuit and PCB design in small power applications. SmartPower enabled UR540X allows customers to remove start and feedback resistors. By these patented technology, the circuit operated by UR540X has lower external component count and greater conversion efficiency than current products in market place. The device also has an internal compensating circuit for inductor parameter tolerance.



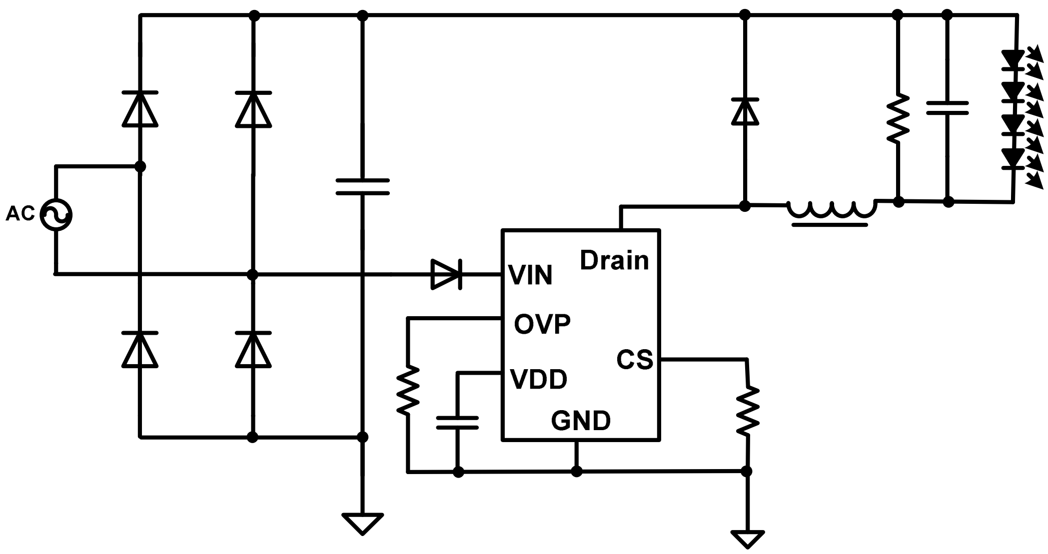


Features:

1. Universal input: 85V~265V
2. Internal MOSFET switch
3. Ultra high conversion efficiency up to 96.5%
4. Tight mass production current tolerance at ±3%
5. Low startup current
6. Quick startup within 100ms@4.7uf VDD Cap.
7. Inductor inductance tolerance compensation
8. Excellent line/load regulation
9. CS open circuit protection, inductor short protection
10. Open/Short circuit protection
11. Output over voltage protection
12. Constant temperature protection and over temperature latch off provides two levels of protection

Typical Application:

1. LED general lighting up to 25W



A typical simplified application diagram

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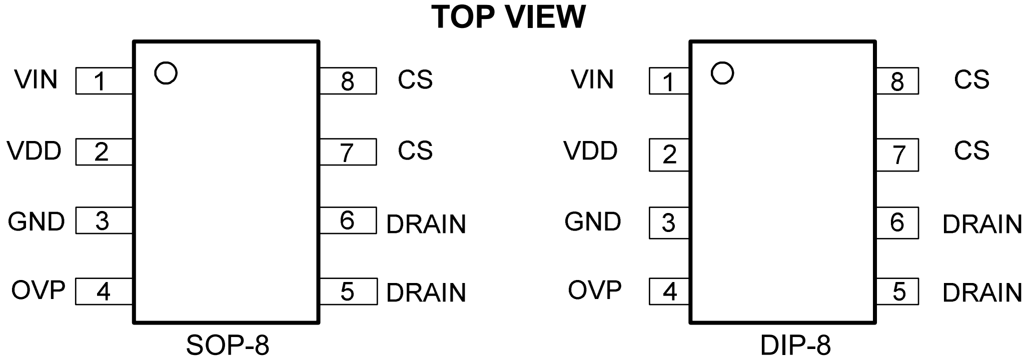
Pin Description:



Device	Pin Count	Package	Junction Temperature
UR5401T	8	SOP-8	-40°C - +150°C
UR5401D	8	DIP-8	-40°C - +150°C
UR5402T	8	SOP-8	-40°C - +150°C
UR5402D	8	DIP-8	-40°C - +150°C
UR5403T	8	SOP-8	-40°C - +150°C
UR5403D	8	DIP-8	-40°C - +150°C
UR5404T	8	SOP-8	-40°C - +150°C
UR5404D	8	DIP-8	-40°C - +150°C

Pin	Symbol	Description
1	VIN	HV Power input pin, connected to main source through a diode.
2	VDD	Power, this pin provides bias power for the IC during startup and steady state operation.
3	GND	Ground.
4	OVP	Output over voltage protection pin, programmed by a resistor, or defaulted by floating.
5,6	DRAIN	Power MOSFET drain.
7,8	CS	Current sense, used to set output current.

Block Diagram:

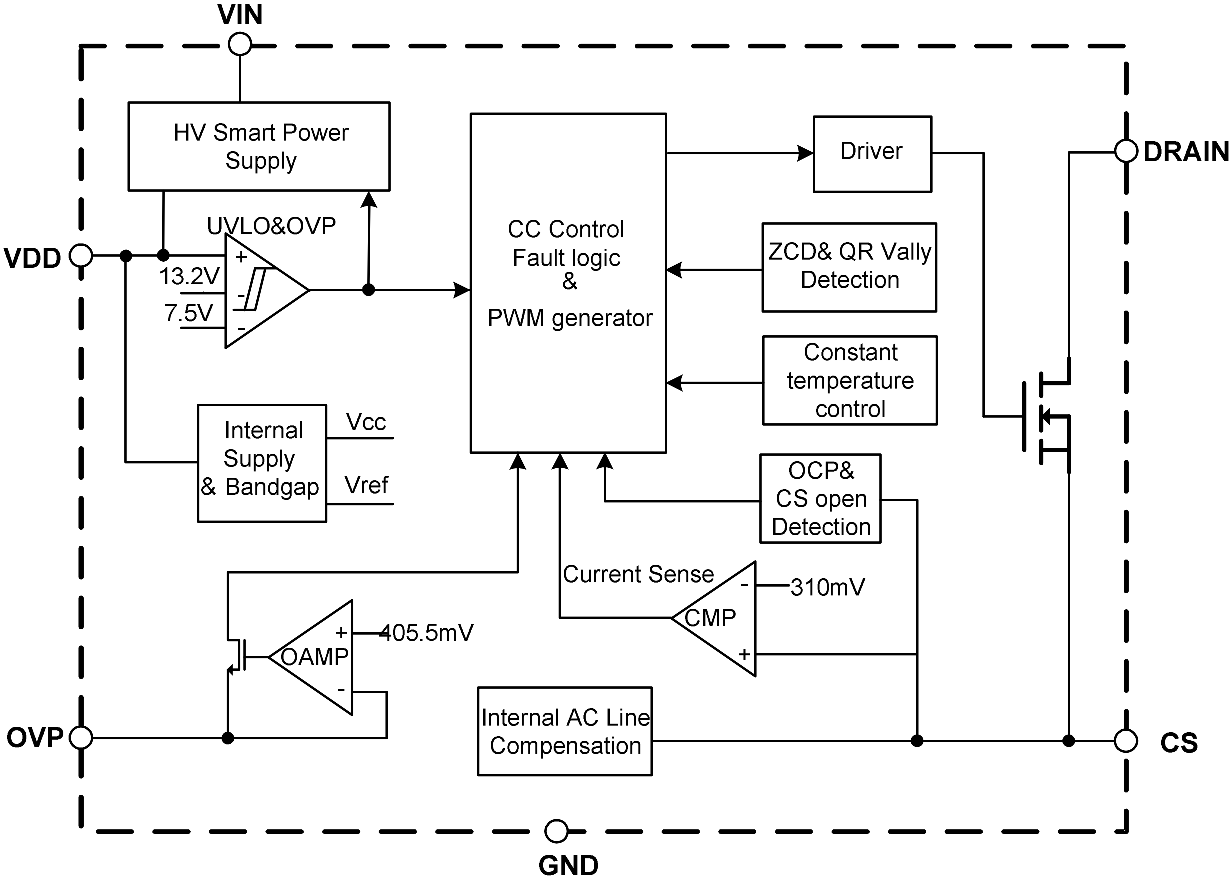


Fig.1 Block Diagram

Operation:

The UR540X is a floating buck converter with integrated 500V power N-FET for high-performance LED lighting. It has a proprietary high voltage smart LDO integrated which allows the AC input to charge up VDD when the input voltage is low to achieve higher efficiency. Also it works at quasi-resonant state to make a highest efficiency. Unique constant current control provides excellent line and load regulation. The rich protections can achieve a high safety and reliability in real application.

Smart Power Supply:

Initially, a fixed 2.2mA current will charges up VDD via AC line. When VDD reaches 13.2V, the internal PWM logic starts to output. Also the smart power supply circuit's control logic starts to work which will make sure that the VDD's energy is only provided by VIN when it is low.
The 700V HV startup method allows a very short startup time. For a 4.7uF VDD capacitor, the startup time will be around 70ms.
The Harbin F will shut down when VDD drops below 7.5V.

Quasi Resonant mode:

With a floating buck converter configuration, the UR540X turns off the internal power MOSFET with a peak current control. The peak current is sensed with a resistor R_{CS} and feeds back to CS pin. The peak current is regulated as:

$$I_{PK} = \frac{310(mV)}{R_{CS}(\Omega)}\ (mA)$$

When the Power MOSFET turns off, the energy stored in the inductor transfers to the output and turns on the freewheeling diode. At the moment of the freewheeling diode current goes to zero, the MOSFET's drain voltage (V_{SW}) drops from V_{LINE} to (V_{LINE}-V_{OUT}) and starts oscillation caused by the inductor and the parasitic caps. A proprietary circuit can detect the zero current point and the valley point of the oscillation. When the valley is detected, the UR540X will turn on the power MOSFET (See Fig.2).
As a result, there are virtually no MOSEFT turn-on losses and no freewheeling diode reverse recovery losses, ensuring high efficiency and low EMI noise.

Real current control:

The real-current control method allows the UR540X to control the output LED current using the peak inductor current information. The mean output LED current is as below:

$$I_{LED} = \frac{1}{2} * \frac{310(mV)}{R_{CS}(\Omega)}\ (mA)$$

A proprietary T_{QR} (the resonant time) compensation circuit will make the output current be free of T_{QR}'s affection. Additionally, the internal AC line compensation circuit helps to realize excellent line and load regulation.

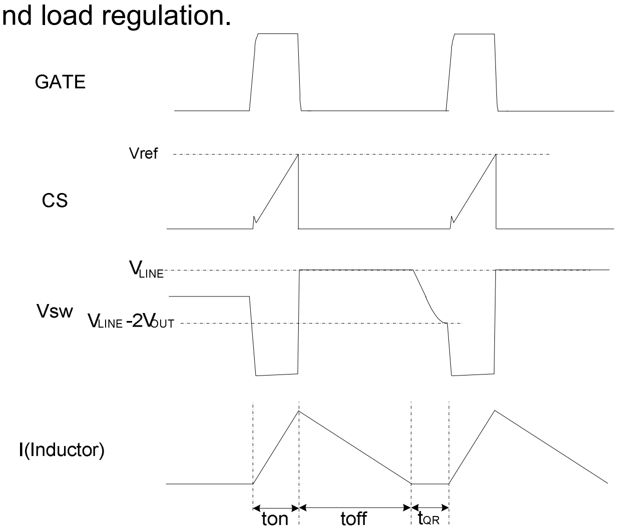


Fig.2 Quasi Resonant mode

VDD Under-Voltage Lockout:

When VDD drops below the UVLO threshold (7.5V) the IC stops switching. The operating current is low under this condition and the internal fixed 1.5mA startup current is turned on. The VDD will be charged up again by the 1.5mA current from AC line. Figure 3 shows the typical VDD under-voltage lockout waveform.

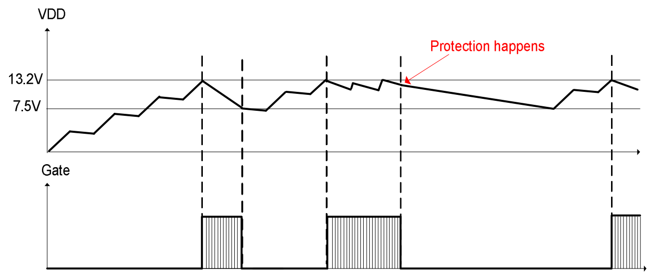


Fig.3 VDD Under-Voltage Lockout

Auto Starter:

The UR540X has an integrated auto starter. The starter times when the MOSFET is off. If the resonant valley detection circuit fails to send out another turn-on signal after 170us, the starter will automatically send out the turn-on signal to avoid unnecessary shutdown.

Leading-Edge Blanking:

At the power MOSFET is switched on, a turn-on spike occurs across the sensing resistor. To avoid fault trigger, an internal leading-edge blanking time is built in. Figure 4 shows the leading-edge blanking.

The LEB time of normal regulation CS detection is typically 400ns.

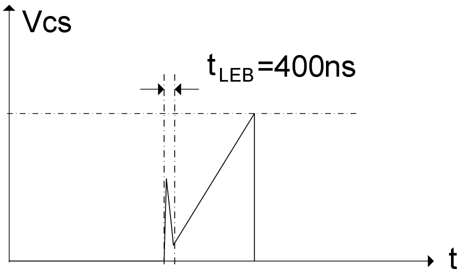


Fig.4 Leading-Edge Blanking

Output Over-Voltage Protection:

The output over-voltage threshold is programmed by an external resister at OVP pin. Since the converter is operating at QR mode. The output voltage and T_{OFF} has a relationship as below:

$$V_{OUT} = \frac{0.310}{R_{CS}} * \frac{Lm}{T_{OFF}} \ (V)$$

Lm is the inductance's value. So when the output goes high, T_{OFF} will goes low. Limit the minimum T_{OFF} can set the over-voltage protection function.
The external OVP resister will set the minimum T_{OFF_MIN} to compare with the real T_{OFF} time. While the T_{OFF_MIN} is triggered, the chip will latch off.
T_{OFF_MIN} is set by following equation:

$$T_{OFF\_MIN} = 150x10^{-12}xR_{OVP} \quad (S)$$

T_{QR} is a fixed time and in most of the case it is couple hundreds of nanoseconds which is negligible. So the
output over-voltage protection set point will be:

$$V_{OUT\_OVP} = \frac{0.310}{R_{CS}} \times \frac{Lm}{150*10^{-12}*R_{OVP}} \ (V)$$

A resistor must be connected to OVP pin. If OVP function is not needed, put a small value resistor (10Kohm) at OVP pin.

Output Short-Circuit Protection:

If an output short occurs, the swing of the resonant at SW will be very small. The valley point can't be detected. So the 170us auto-restart timer triggers the power MOSFET's turn-on signal which will force the switching frequency of the power converter drops to about 5KHz and the output current is limited to it nominal current.

Inductor Over-Current Protection:

The inductor over current protection prevents device damage caused by extremely excessive current, like inductor short. If the CS pin voltage rises to 606mV at gate turn on interval, the inductor over-current protection will be triggered and logic is latched off. The IC works at quiescent mode, the VDD voltage dropped below the UVLO which will make the IC shutdown and the system restarts again.
To avoid mis-trigger, the OCP's LEB time is relatively smaller than current regulation sensing LEB time, typically 270ns.

Over-Temperature Regulation and Latch off:

To prevent from any lethal thermal damage and extend the LEDs' life, the IC will reduce the output current when the IC's die temperature is higher than 150^{o}C. Such a temperature regulation will maintain a constant environment temperature at a closed lighting system.
For the case of the temperature regulation is losing control, the IC will latch off the regulation when the temperature is higher than 165^{o}C. Then VCC drops below UVLO and restart again.

Other Protections:

There are other protections to make sure system more reliable, such as CS open protection, maximum T_{ON} limitation.

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Absolute Maximum Ratings:

Parameters	Value	Unit
VDD, CS	-0.3 to +16.0	V
OVP	-0.3 to +6.0	V
ST	-0.3 to +600	V
Drain	-0.3 to +500	V
ESD Susceptibility (HBM, JESD22-A114-F)	2	KV
Store temperature Range	-55 to 150	^oC
Operating Junction Temperature	-40 to 125	^oC
θ_{JA}(junction to Ambient temperature) of SOP8	145	$^oC/W$
θ_{JA}(junction to Ambient temperature) of DIP8	65	$^oC/W$
Maximum Power Dissipation(SOP8)	0.5	W
Maximum Power Dissipation (DIP8)	1	W
Lead Temperature	260	^oC

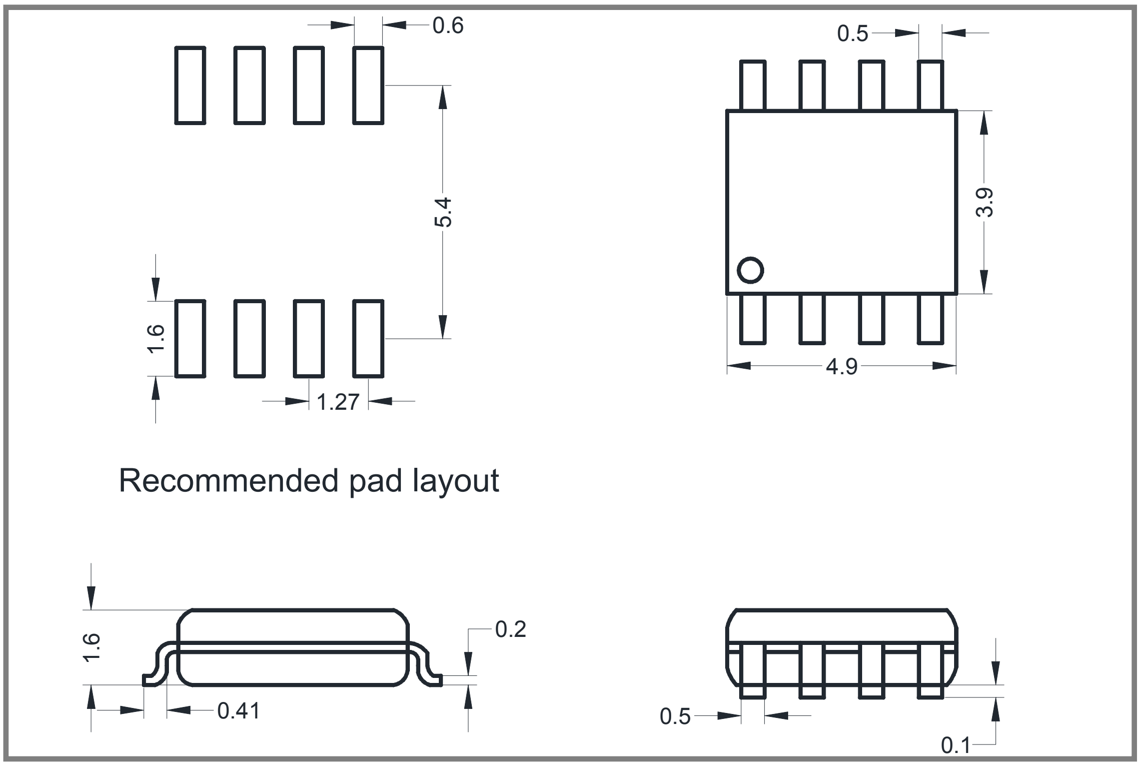
Electrical Characteristics:
T_A=+25^{o}C, unless otherwise noted.

Smart Power Supply Section						
V_{DD_TH}	Startup Voltage			13.2	13.9	V
V_{DD_UVLO}	Under-voltage Lockout Threshold		7.3	7.6		V
$I_{VIN\_STARTUP\_CHRG}$	VIN charge VDD startup current	VIN=100V, VDD=6V	1.8	2.2	3.0	mA
$I_{DD\_QUSIESCENT}$	Quiescent current after startup		180	210	350	uA
BV_{DSS_ST}	ST pin's breakdown voltage	VDD=14V, I_{ST}=100uA	600			V
Current Sense Section						
V_{CS_TH}	Current Sense Threshold		303	310	317	mV
V_{OCP}	Over Current Protection Threshold		560	608	650	mV
T_{LEB1}	Leading-Edge Blanking Time for normal switching			400		ns
T_{LEB2}	Leading Edge blanking Time for OCP			270		ns
T_{DELAY}	Delay to Output time			150		ns
Protection Section						
T_{ON_MAX}	Maximum On Time		28	47	55	us
V_{OVP}	OVP pin voltage	100kohm at OVP	389	405.5	421	mV
T_{OFF_MAX}	Maximum Off Time		100	145	180	us
$T_{REGULATION}$	Constant temperature regulation threshold			150		^oC
Power FET Section						
R_{DS_ON} (UR5401)	PowerFET's Rdson	VGS=10V			20	ohm
R_{DS_ON} (UR5402)	PowerFET's Rdson	VGS=10V			16	ohm
R_{DS_ON} (UR5403)	PowerFET's Rdson	VGS=10V			10	ohm
R_{DS_ON} (UR5404)	PowerFET's Rdson	VGS=10V			6	ohm
BV_{DSS}	PowerFET's Breakdown Voltage	V_{GS}=0V, I_{DS}=100uA	500			V
I_{DSS}	PowerFET's Leakage	V_{GS}=0V, V_{DS}=500V			10	uA

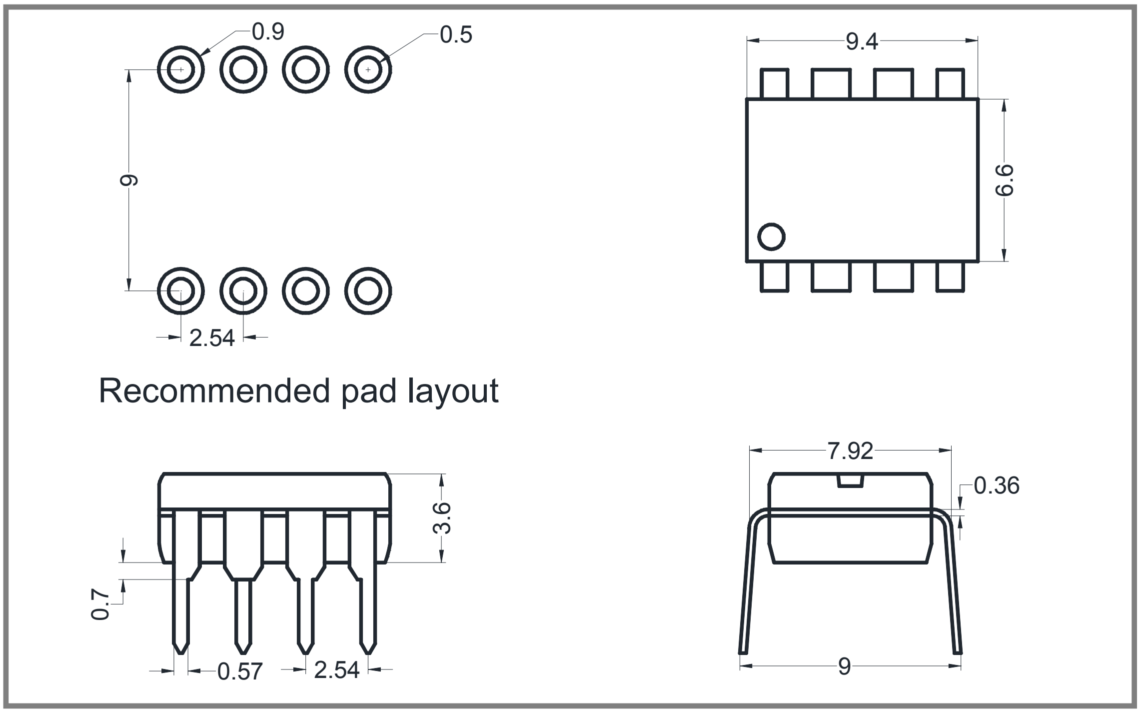
Notes:1. The upper and lower limit is guaranteed by IC test.

Physical Dimensions:

SOP8



DIP8



Notes:

All dimensions are in millimeters.

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Environment Protection and RoHS Compliant :

To protect our environment, the devices in SOP-8 are designed to be green. It is RoHS compatible for all 6 substances, free of Halogen, Bromine/BFR.

For the devices packaged in DIP-8, they are RoHS compatible.