LIS9452U

Ambient Acoustic and/or Luminous Intensity Controller and Non-isolated Buck LED Driver

Features

- Monolithic integration of ambient acoustic and luminous intensity sensing control and LED driving capability
- Patented CCM operation mode
- Output short circuit protection
- Over temperature adjustment
- Compact system-level solution with reduced external components
- No external output capacitor required
- Built-in leading edge blanking (LEB)
- Inductance compensation function
- Compatible with very wide supply output voltage range
- Cycle by cycle output current limiting
- Under voltage lockout
- Open circuit protection for the CS pin
- Optimized line and load regulation
- Built-in 550V Power MOSFET
- SOP-7 package

General Description

The LIS9452U is a unique non-isolated buck LED driver, which can be controlled by ambient acoustic and luminous intensity. External components required for practical applications are largely reduced with patented techniques. The LIS9452U works in continuous current mode (CCM), and therefore the ripple of the LEDs' load current is relatively low, even without external output bypassing capacitor. Compared to the discontinuous current mode (DCM), the inductor's peak current is smaller. That leads to less device loss and it is easy to achieve more than 95% overall efficiency. Furthermore, the LIS9452U adopts a patented output current regulation technique, which keeps the output current constant when the inductance and LED voltage varies, achieving excellent load regulation. In addition, an internal regulator has been integrated, and thus the LIS9452U is capable of working with high bus voltage, eliminating starting resistor and auxiliary winding.

The LIS9452U also implements various protection functions, including cycle-by-cycle current limiting, open-circuit protection for the CS pin, over temperature adjustment, and output short circuit protection, etc.

The LIS9452U can detect both ambient acoustic intensity and luminous intensity levels. When it is bright, the output LEDs are shut off. While in the dark, if the ambient acoustic intensity level is low, the output LEDs stays off as well. Once the acoustic intensity becomes higher than the specified threshold, the output LEDs will be lighted up for a certain time (around 20 seconds) and shut off afterwards. Therefore, the LIS9452U is suitable for illumination applications in corridors, toilets, gardens, and so on.

Furthermore, the LIS9452U can easily be adapted to be sensitive to ambient acoustic intensity or ambient luminous intensity only, respectively, with even fewer external components. Two typical application diagrams for the LIS9452U are shown in Figure 1 and Figure 2, respectively.

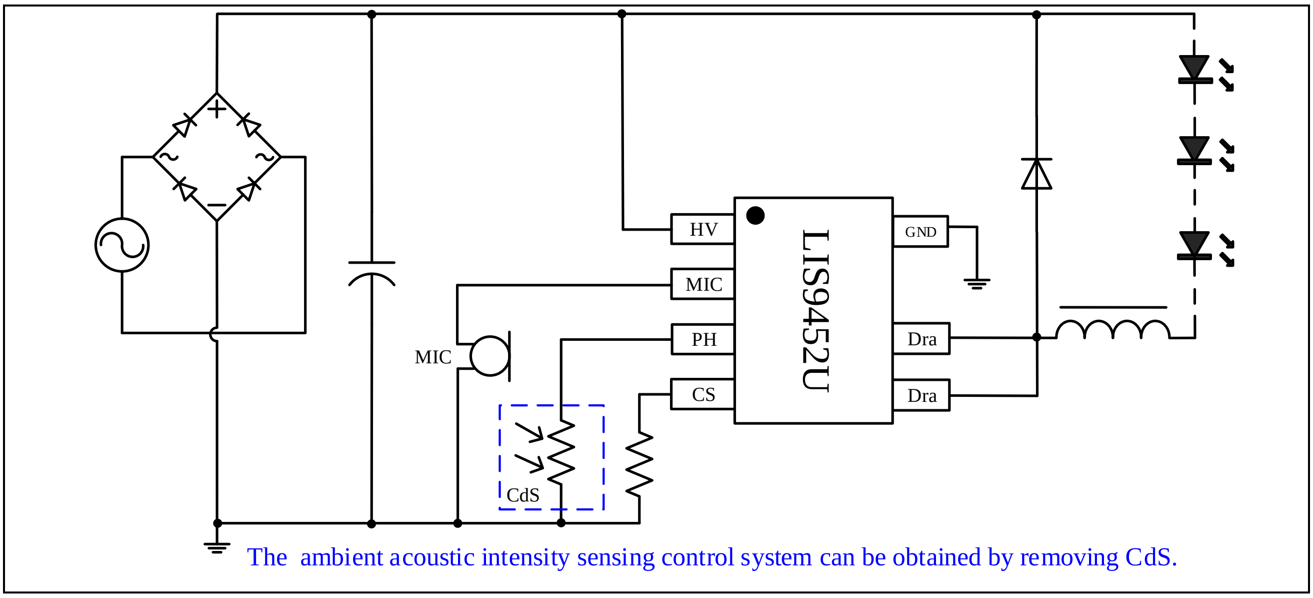


Figure1 Typical application diagram for the LIS9452U, sensitive to ambient acoustic and luminous intensity or to ambient acoustic intensity only (by removing the CdS photoresistor)

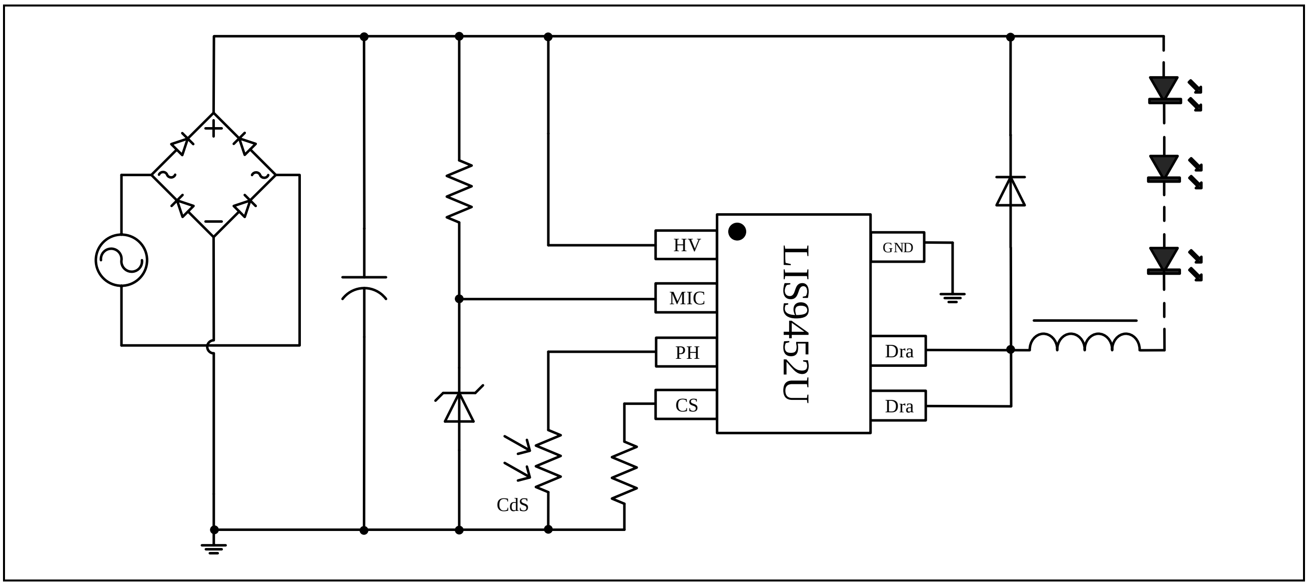


Figure2 Typical application diagram for the LIS9452U, sensitive to ambient luminous intensity only

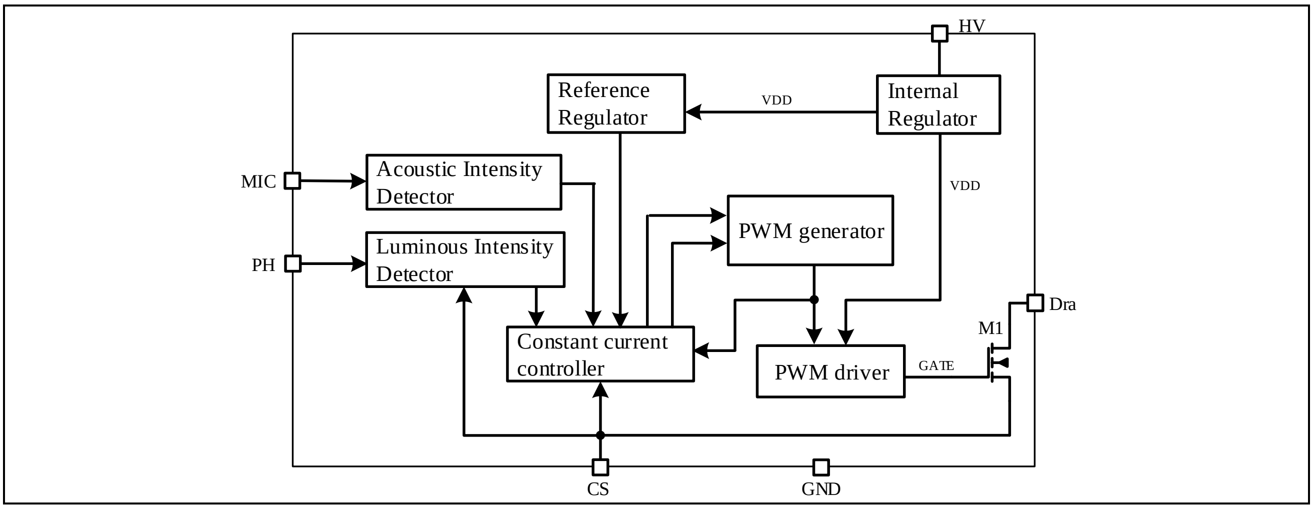
Application

- LED Bulb
- LED Landscape lamp
- LED Ceiling lamp
- Corridor illumination

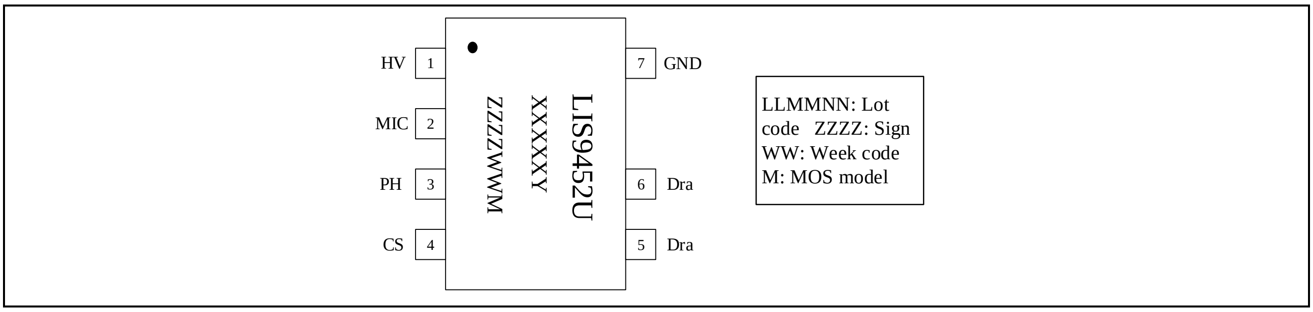
	Input voltage	Output voltage	Output current
Recommended power range	180V~264 Vac	<170 V	<120 mA
	85V~265 Vac	<80 V	<120 mA

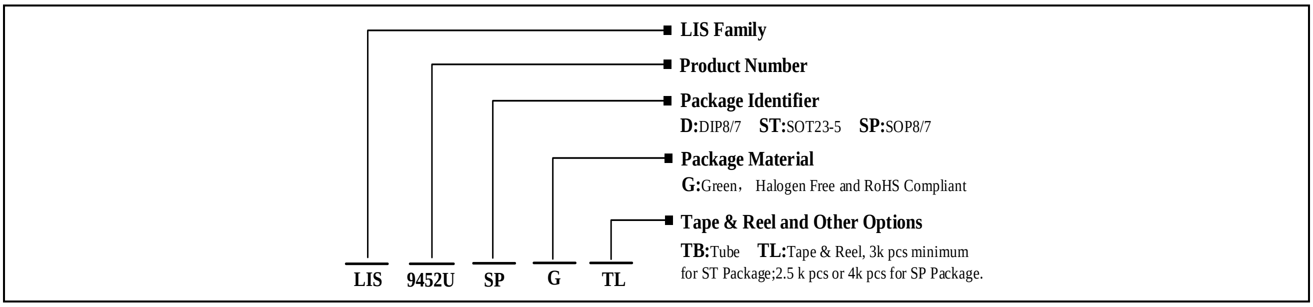
- Note: The recommended power range is valid only for applications at room temperature. The actual power may be reduced according to actual application environment.

Functional Block Diagram



PIN Information





Order serial number	Package types	Packaging tape
LIS9452U-SP-G-TL	SOP-7	Tape and Reel 2500 or 4000PCS

PIN Function Description

No.	Name	Input/ Output	Pin Function
1	HV	Input	High voltage power supply
2	MIC	Input	Ambient acoustic sensing input
3	PH	Input	Ambient luminous sensing input
4	CS	Input \ Output	Current sensing
5, 6	Dra	Input \ Output	Drain of the internal power MOSFET
7	GND	Input \ Output	Ground

Absolute Maximum Ratings

HV/Dra pin voltage to GND--- -0.3V~550V
Junction temperature. T_J--- -55℃~150℃
Operating ambient temperature. T_A--- -40℃~100℃
Min/max storage temperature range. Tstg --- -55℃~150℃
Lead temperature (lead-free packaging, welding, 10 seconds) ----------------------------------- 260℃
CS Pin voltage to GND -- -0.3V~7V

Electrical Parameters (TA=25 ℃ , unless otherwise stated , HV=40V)

Symbol	Parameters	Test conditions	Min.	Typ.	Max.	Unit
Power Supply						
I_{static}	Static current		-	110	150	μA
HV_{ON}	HV Starting voltage	Sweep HV voltage from low to high		10		V
HV_{OFF}	HV Under voltage protection	Sweep HV voltage from high to low		7		V
Frequency						
f_{MAX}	Maximum operating frequency			150		kHz
Δf	Frequency jittering range		-	±3	-	%
Sampling and Timings						
T_{LEB}	Leading edge blanking time		-	600	-	ns
V_{th_H}	The steady-state CS peak voltage		525	540	555	mV
V_{th_L}	The steady-state CS valley voltage		130	135	140	mV
T_{OFF_MIN}	Minimum turn off time			3		μs
T_{OFF_MAX}	Maximum turn off time			35		μs
T_{on_MIN}	Minimum turn on time			1		μs
T_{SS}	Soft start time		-	9	-	ms
Ambient Acoustic and Luminous Control						
T_{delay}	Delay time when the OUT pin gets asserted		18	20.5	23	s
$T_{start\ up}$	Self-check time at startup phase		70	80	90	ms
V_{H_MIC}	Threshold for the MIC pin		5.5		7	V
V_{open_MIC}	Floating voltage for the MIC pin		4.5		5	V
V_{H_PH}	High threshold for the PH pin		3.5		7	V
V_{L_PH}	Low threshold for the PH pin		0		1.5	V
V_{open_PH}	Floating voltage for the PH pin		6		7	V
I_{PH}	Pull up current for the PH pin		-	20	-	uA
Protect						

OTP	OTP trigger threshold		-	130	-	°C
OCP Delay	Output over current protection delay time			500		μs
Built-in MOS						
BV_{DSS}	Drain-Source breakdown voltage	I_D=250μA, Vgs=0V	550			V
I_{DSS}	Drain-Source leakage current	V_{DS}=550V, Vgs=0V			1	μA
$R_{DS(ON)}$	Drain-Source on resistor	I_D=0.5A, Vgs=10V		16		Ω
I_D	Drain-Source continuous current			0.8		A
T_r	Rising time			50		ns
T_f	Falling time			70		ns

Functional Description

Startup and Power Supply

The LIS9452U adopts a patented startup and power supplying technique, and hence the chip can be powered by a high voltage bus line directly through the HV pin. During startup, the inner VDD on the chip is first charged by the bus voltage through the Internal Regulator. Once the voltage at the HV pin reaches the threshold HV_{ON}, the chip starts and enters the self-test mode.

Under Voltage Lockout

An under voltage lockout (UVLO) hysteresis comparator has been integrated in the LIS9452U, and its hysteresis curve is shown in Figure 3. When the HV voltage rises above the turning on voltage (HV_{ON}), the chip starts and enters the self-test mode. Once the HV voltage falls below the UVLO voltage (HV_{OFF}), the chip is locked out and ceases to work.

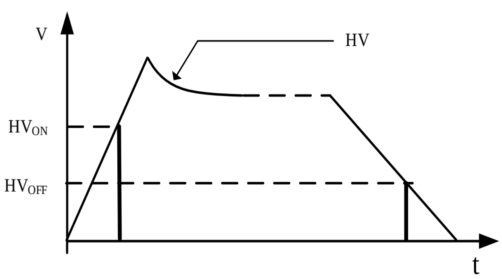


Figure 3 Hysteresis curve for the UVLO comparator

Soft Starting

The LIS9452U has an internal soft starting circuit that controls the ramp-up of the output voltage. During the ramp-up process, the operating frequency gradually increases from a minimum value to the required one determined by the output voltage and current within 9 ms. That avoids overshoot current and reduces stress imposed on the LEDs, and thus improving their lifetime. Moreover, during the soft starting process, the drain voltage overshoot of the internal power MOSFET is largely reduced, which improves the system's reliability as well.

Ambient Acoustic and Luminous Intensity Sensing Control

Once the LIS9452U is powered up, it remains in the self-test mode for about 80 ms, and the output LEDs are lighted up meantime. Afterwards, the LEDs are shut off, and the chip enters the standby mode. In the standby mode, the LIS9452U is capable of detecting the ambient acoustic intensity level by connecting a microphone to the MIC pin. It can also detect the ambient luminous intensity level by connecting a photosensitive element to the PH pin. If the voltage at the PH pin is lower than the low threshold (V_{L_PH}), the acoustic intensity detection is disabled. When the PH voltage is higher than the high threshold (V_{H_PH}), the acoustic intensity detection is enabled. Once the voltage at the MIC pin is higher than the microphone threshold (V_{H_MIC}), the output LEDs are lighted up for about 20 seconds. Afterwards, the LEDs are shut off and the chip enters the standby mode again.

Furthermore, if the MIC pin is pulled up externally (higher than VH_MIC), the LIS9452U is then only sensitive to ambient luminous intensity through the PH pin.

Leading Edge Blanking

The LIS9452U implements a leading edge blanking (LEB) function. Potential interference signals at the CS pin are blocked for 600 ns ahead of the moment when the internal power MOSFET is switched on. In this way, the power transistor will not be switched on/off accidently, thus guaranteeing a smooth operation of the system.

Output Current Regulation

The LIS9452U employs a patented output current regulation technique, which keeps the current flowing through LEDs constant with a large voltage variation of LED lamp strings. In addition, the output current is insensitive to inductance variation, and thus the tolerance requirement on the inductor is relaxed substantially.

Over Temperature Protection

An over temperature protection function has been realized in the LIS9452U, and it can gradually reduce the output current if the chip is overheated to a temperature around 130°C. Thereby, the overall reliability of the system is improved.

Open Circuit Protection for the CS Pin

The LIS9452U implements an open circuit protection function for the CS pin. If there is an open circuit between the CS and GND pins, the power MOSFET will be turned off and the chip will enter the auto-restart protection mode. If the fault is removed, the system will recover to normal operation.

Output Short Circuit Protection

The internal power MOSFET is protected by a short circuit protection function. If the output is short-circuited and such state lasts for about 500 μs, the internal power MOSFET will be turned off and the chip will enter the locked mode. In such mode, the chip's power consumption is very low and little heat is generated. When the output is no longer short-circuited, the chip can be recovered to normal operation by first decreasing the external bus voltage till the chip enters the UVLO state and then pulling it above HV_{ON} to power up the chip again.

Application Notes

CS Resistor

The LIS9452U integrates a non-isolated buck converter specifically designed for driving LEDs. The converter operates in a continuous current mode. The peak and valley currents flowing through the inductor are compared to an internal reference current per cycle, respectively. A patented current regulation technique has been employed to keep both the peak and valleys currents constant cycle-by-cycle. As a result, the overall LED current remains constant as well. After reaching the steady state,

The peak current flowing through the inductor is: $I_{PK}=V_{th\_H}/R_{CS}$

The valley current flowing through the inductor is: $I_{VL}=V_{th\_L}/R_{CS}$

The R_{CS} is the sampling resistor connecting to the CS pin.

The rated output current is: $I_{LED}=0.5*(I_{PK}+I_{VL}) = 0.5*(V_{th\_H}+V_{th\_L})/R_{CS}$

Inductor Design

When the output voltage reaches the steady state, during each cycle, the internal power MOSFET is first switched on and the inductor current increases gradually. When the inductor current reaches I_{PK}, the power MOSFET is turned off. The inductor gets demagnetized, and the inductor current decreases gradually. When the current reaches I_{VL}, the demagnetization process ends, and the power MOSFET is switched on again. The relationship between the inductance and demagnetization time can described by the equation below:

$$L = V_{OUT}*T_{DEM}/(I_{PK} - I_{VL}),$$

where L is the inductance, V_{OUT} is rated output voltage, and T_{DEM} is the corresponding demagnetization time. It is recommended to choose a demagnetization time around 6~10 µs. A value outside this range can lead to abnormal operation.

With the formulae above, L and I_{PK} can be obtained, and therefore a minimum number of turns of the inductor coil can be calculated as: $N > \frac{L*I_{PK}}{Bm*Ae}$, where Ae is the equivalent cross section area of the magnetic core; Bm is the allowed maximum magnetic flux density, the value is determined by magnetic core material.

Operating Frequency

The turn-on time of the internal power MOSFET per cycle can be calculated as: $T_{ON} = \frac{L*(I_{PK}-I_{VL})}{V_{IN}-V_{OUT}}$, where V_{IN} is the input DC voltage after rectification. While, the turn-off time can be expressed as: $T_{OFF} = \frac{L*(I_{PK}-I_{VL})}{V_{OUT}}$.

From the above two formulae, the operating frequency can be obtained as: $f = \frac{(V_{IN}-V_{OUT})*V_{OUT}}{L*V_{IN}*(I_{PK}-I_{VL})}$

If the parameters L, V_{OUT}, I_{PK}, I_{VL} are kept constant, the operating frequency decreases with the decreasing of V_{IN}. It is suggested to keep the minimum operating frequency (occurs at the lowest V_{IN}) above the highest audible frequency (around 22 kHz). On the other hand, it is recommended that the maximum operating frequency (occurs at the highest V_{IN}) should be less than 120 kHz to avoid excessive switching loss.

Ambient Acoustic and Luminous Intensity Sensing Control

Photosensitive resistor, photodiode, and photosensitive transistor can all be used as photosensitive elements, and conventional -52dB electret microphone can be used as acoustic intensity sensing element. For ambient acoustic and luminous intensity sensing control applications, users are free to place photosensitive devices anywhere. However, for Ambient luminous intensity sensing control applications, the photosensitive element should be blocked from direct light or other light sources to avoid false triggering. In addition, it is suggested to connect a 1 nF capacitor in parallel with the MIC and PH pins to ground to suppress switching noise, respectively.

Power Factor Correction

If a high power factor is required, a simple passive power factor correction circuit (valley filling circuit) could be applied. Such correction circuit consists of three diodes and two capacitors, and can improve the system's power factor to be more than 0.9. The power factor can be further increased if placing a 20 Ω resistor in series with the valley filling circuit.

If it is only needed to improve the power factor to be higher than 0.7, the input electrolytic capacitor can be replaced by a CBB capacitor to accomplish that. However, such replacement can worsen 50/60 Hz current ripple on the LED load and line regulation .

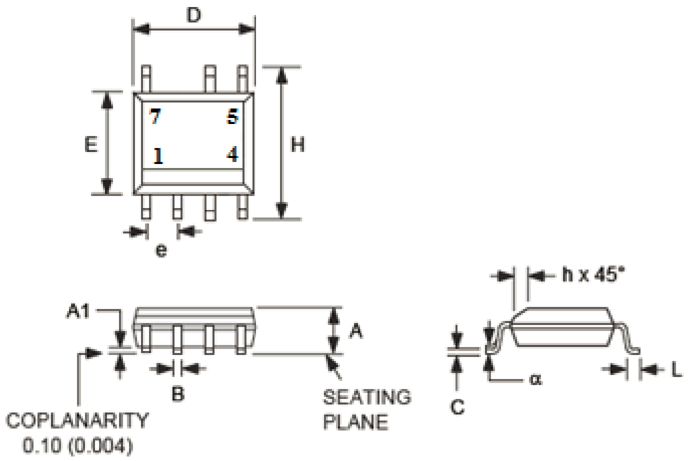
PCB Design

The charging and discharging loops for the inductor should be as small as possible.

The copper area attached to the two Dra pins (Pin5 and Pin6) should be as large as possible, in order to dissipate heat quickly.

Packaging Information

7 -Lead Small Outline (SOIC) Package



Symbol	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.060	0.068	1.52	1.73
A1	0.004	0.008	0.10	0.20
B	0.014	0.018	0.36	0.46
C	0.007	0.010	0.18	0.25
D	0.188	0.197	4.78	5.00
E	0.150	0.157	3.81	3.99
e	0.050 BSC		1.270 BSC	
H	0.230	0.244	5.84	6.20
h	0.010	0.016	0.25	0.41
L	0.023	0.029	0.58	0.74
α	0°	8°		

Compliant to JEDEC Standard MS12F

Controlling dimensions are in inches; millimeter dimensions are for reference only

This product is RoHS compliant and Halide free.

Soldering Temperature Resistance:

[a] Package is IPC/JEDEC Std 020D Moisture Sensitivity Level 1

[b] Package exceeds JEDEC Std No. 22-A111 for Solder Immersion Resistance; package can withstand 10 s immersion < 270°C

Dimension D does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm per end. Dimension E1 does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.25 mm per side.

The package top may be smaller than the package bottom. Dimensions D and E1 are determined at the outermost extremes of the plastic bocy exclusive of mold flash, tie bar burrs, gate burrs and interlead flash, but including any mismatch between the top and bottom of the plastic body.

Modification History

Version	Date	Status Description
V1.0	May. 2019	The Initial Version