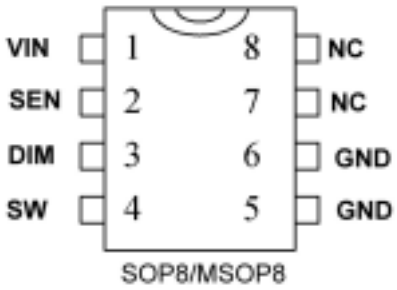
LED Driver with internal switch

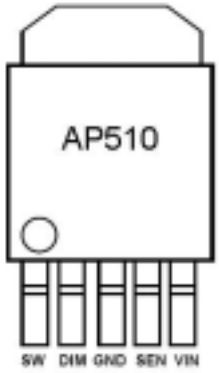
General Description

AP510 is a high efficiency , constant current , continuous mode inductive step-down converter,
designed for driving constant current to high power (single or multiple) LED with only 4 external components. AP510 operates from input supply between 6V and 36V and provides an externally adjustable output current of up to 1A.
The AP510 is specifically designed with PFM control to enhance the efficiency up to 95% .The Output current can be modify by an external resister , and can adjusted , by applying an external control signal to the DIM pin , The DIM pin will accept a PWM waveform.
Additionally , to ensure the system reliability , AP510 is built-in with over temperature protection , and LED open-circuit short-circuit protection to protect system from being damaged .



SOP8/MSOP8

SOT-236



TO-252

.Features

- 1A output current
- Wide input voltage range: 6V to 36V
- High efficiency (up to 95%)
- Internal NDMOS power switch
- Single pin on/off and brightness control using PWM
- Hysteretic PFM improves efficiency at light loads
- With Thermal/Soft start /LED open-short detect protection
- Only 4 External Components
- Up to 1Mhz switching frequency
- Typical 3% output current accuracy

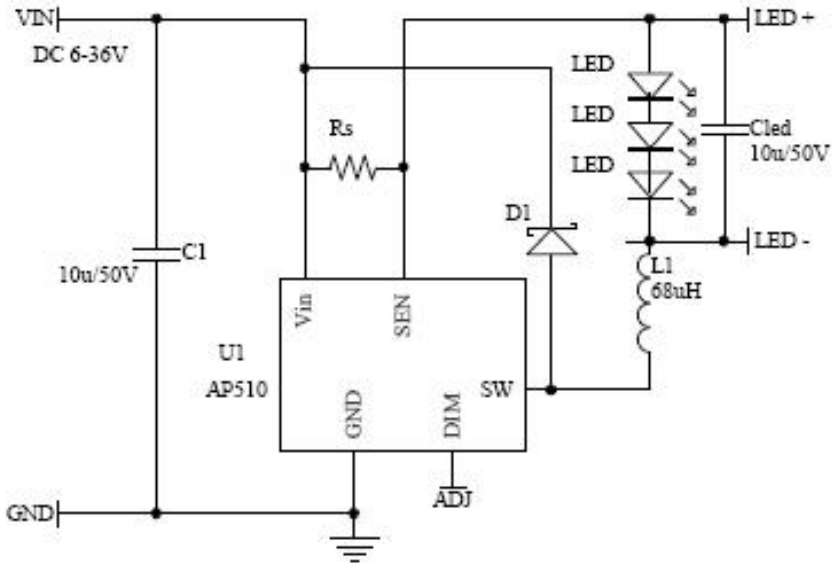
.Applications

- High power LED lighting
- Automotive LED lighting
- Low voltage industrial lighting
- LED back-up lighting
- Constant Current Source

.Pin Description

Pin Name	Pin Description
SW	Drain of NDMOS switch
GND	Ground pad
DIM	Dimming control pad
SEN	Connect resistor RS from this pin to VIN to define nominal average output current
VIN	Power pad

.Application circuit



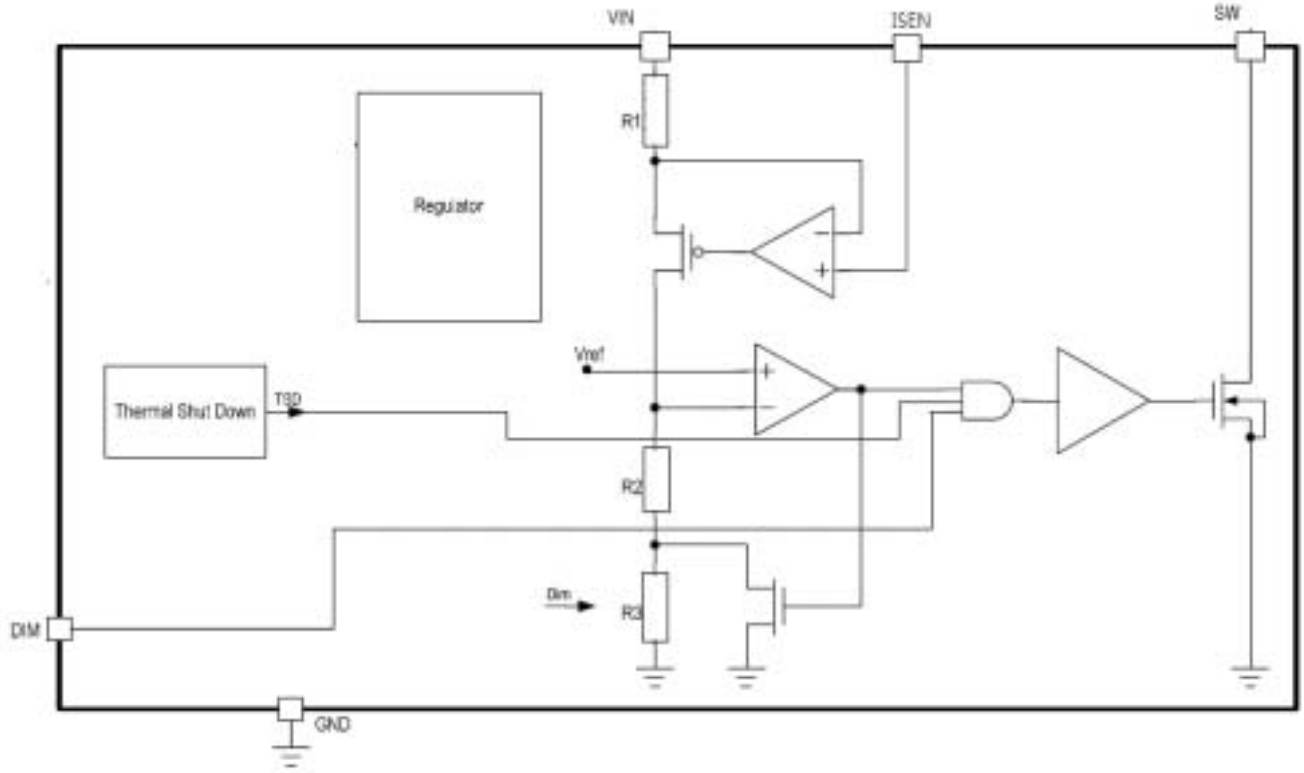
.Absolute maximum ratings

ITEM		SYMBOL	RATING	UNIT
Supply Voltage		VIN	0-36 (40V for 0.5 sec)	V
Output Current		IOUT	1.0	A
Sustaining Voltage at SW pin		VSW	-0.5~36 (40V for 0.5 sec)	V
Power Dissipation	SOP8	PD		W
	MSOP8			
	TO252			
	SOT23-6			
Thermal Resistance	SOP8	Rth(j-a)		℃/W
	MSOP8			
	TO252			
	SOT23-6			
Operating Temperature		Top	-40℃- +85℃	℃
Storage Temperature		Tsto	-55℃- +150℃	℃
Junction Temperature		Tj-MAX	150	℃

Electrical Characteristics (test Condition : Ta= 25 ℃, V_{IN}=12V)

Item	Symbol	Condition	min。	typ。	Max。	unit
Operating voltage	V_{IN}		6	-	36	V
Operating current	I_{IN}	V_{IN}= 9V~36V	-	1	2	mA
Output current	I_{OUT}		-	-	1	A
Output current Accuracy	$\Delta I_{OUT}/I_{OUT}$	150mA≦I_{OUT}≦1A		±3	±5	%
Efficiency		V_{IN}=12V, I_{OUT}=350mA,V_{out}=10.8V		95		%
SW Dropout voltage	ΔVsw	I_{OUT}=1A		0.5		V
Internal propagation delay	T_{PD}		100	200	300	NS
Input voltage	V_{IH}		3.5			V
	V_{IL}				0.5	V
Sense threshold hysteresis	$V_{SENSEHYS}$			±15	-	%
Mean current sense threshold voltage	V_{SENSE}		95	100	105	mV
Switch on resistance	$R_{DS(ON)}$	V_{IN}=12V, I_{OUT}=350mA, V_{out}=10.8V		0.5	1	Ω
Minimum switch 'ON' time	T_{ONmin}		100	350	450	ns
Minimum switch 'OFF' time	T_{OFFmin}		100	350	450	ns
Recommended duty cycle range oft switch	Dsw		0.2		0.8	
maximum operating frequency	$Freq_{MAX}$		40		1000	KHz
Thermal Shutdown Threshold	T_{SD}		145	160	175	℃
Thermal Shutdown Hystersis	T_{SD-HYS}			20		℃
Duty cycle range of PWM signal applied to DIM pin	$Duty_{DIM}$	PWM frequency = 1KHz	0.01		1	
Rise Time of Output current	Tr	V_{OUT}= 3.6V , I_{OUT}=350mA, f_{DIM}=1kHz , $Duty_{DIM}$=50%		20		ns
Fall Time of Output current	Tf	V_{OUT}= 3.6V , I_{OUT}=350mA, f_{DIM}=1kHz , $Duty_{DIM}$=50%		20		ns

.BLOCK diagram



.Application notes

.Setting nominal average output current with external resistor RS

The nominal average output current in the LED(s) is determined by the value of the external current sense resistor (RS) connected between VIN and Iout and is given by:

IOUTnom = 0.1/RS [for RS≧ 0.1Ω]
Nominal ripple current is ±15mV/RS

The table below gives values of nominal average output current for several preferred values of current setting resistor (RS) in the typical application circuit shown on page 1:

RS(Ω)	Nominal average output current (mA)
0.1	1000
0.13	760
0.15	667

.Dimming

A Pulse Width Modulated (PWM) signal with duty cycle DPWM can be applied to the DIM pin .,

TA logic low (below 0.5V) at DIM will disable the internal MOSFET and turn off .

. Open/short circuit LED protection

When any LED is open-circuit , the output current will be turned off .
When any LED is short-circuit , the output current will be limited to its preset value .

. Over Temperature protection

When the junction temperature over range . AP510 will turn off output Current .

.Minimum Input Voltage

The Minimum Input Voltage is the sum of the voltage drops on R_{SEN} , DCR of L1 , $Rds_{(ON)}$ of Internal MOS switch and the total forward voltage of LEDS V_{LED} .
$Vin=V_{RS}+V_{LED}+V_{L1}+V_{SW}$.

.Design Consideration :

.Switching Frequency

For better output current accuracy , the switching frequency should be determined by Minimum on/off time SW waveform .

$F_{SW}=(1-D)/T_{OFF,MIN}$, when the duty cycle is large than 0.5 (D = Vout / Vin)
or $F_{SW}=D/T_{ON,,MIN}$, when the duty cycle is smaller than 0.5

The switching frequency is related to efficiency (better at low frequency) , the size/cost Of components , and the amplitude of output ripple voltage and current (smaller at high frequency) . The slower switching frequency comes from the large value of inductor . In many applications , the Sensitivity of EMI limits the switching frequency . The switching frequency can be ranged from 40Khz To 1.0Mhz .

. LED Ripple Current

A LED constant current driver , is designed to control the current through the cascaded LED , instead of the voltage across it . Higher LED ripple current allows the use of smaller inductance , smaller output capacitance and even without an output capacitor . The advantages of higher LED ripple current are to minimize PCB size and reduce cost because of no output capacitor . Lower LED ripple current requires large induce and output capacitor . The advantages of lower LED ripple Current are to extend LED life time and to reduce heating of LED . The recommended ripple current is From 5 % to 20% of normal LED output current .

Capacitor selection

A low ESR capacitor should be used for input decoupling, as the ESR of this capacitor appears in series with the supply source impedance and lowers overall efficiency. This capacitor has to supply the relatively high peak current to the coil and smooth the current ripple on the input supply.
A minimum value of 4.7uF is acceptable if the input source is close to the device, but higher values will improve performance at lower input voltages, especially when the source impedance is high. The input capacitor should be placed as close as possible to the IC.
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 . A suitable Murata capacitor would be GRM42-2X7R475K-50.

Inductor selection

The inductance is determined by two factors : the switching frequency and the inductor ripple Current. The calculation of the inductance , L1 , can be described as

$$L1>(V_{IN}-V_{OUT}-V_{SEN}-(Rds_{(ON)}\times I_{OUT}))\times D/(f_{sw}\times \Delta I_L)$$

Higher values of inductance are recommended at higher supply voltages in order to minimize errors due to switching delays, which result in increased ripple and lower efficiency. Higher values of inductance also result in a smaller change in output current over the supply voltage range. (See graphs). The inductor should be mounted as close to the device as possible with low resistance connections to the SW and V_{IN} pins.

The chosen coil should have a saturation current higher than the peak output current and a continuous current rating above the required mean output current.

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.

Switch on time

$$Ton= L\Delta I/(V_{IN}-V_{LED} – I_{avg} (R_S + rL + Rsw))$$

$$T_{OFF}= L\Delta I/(V_{LED} + V_D + I_{avg} (R_S + rL))$$

Where

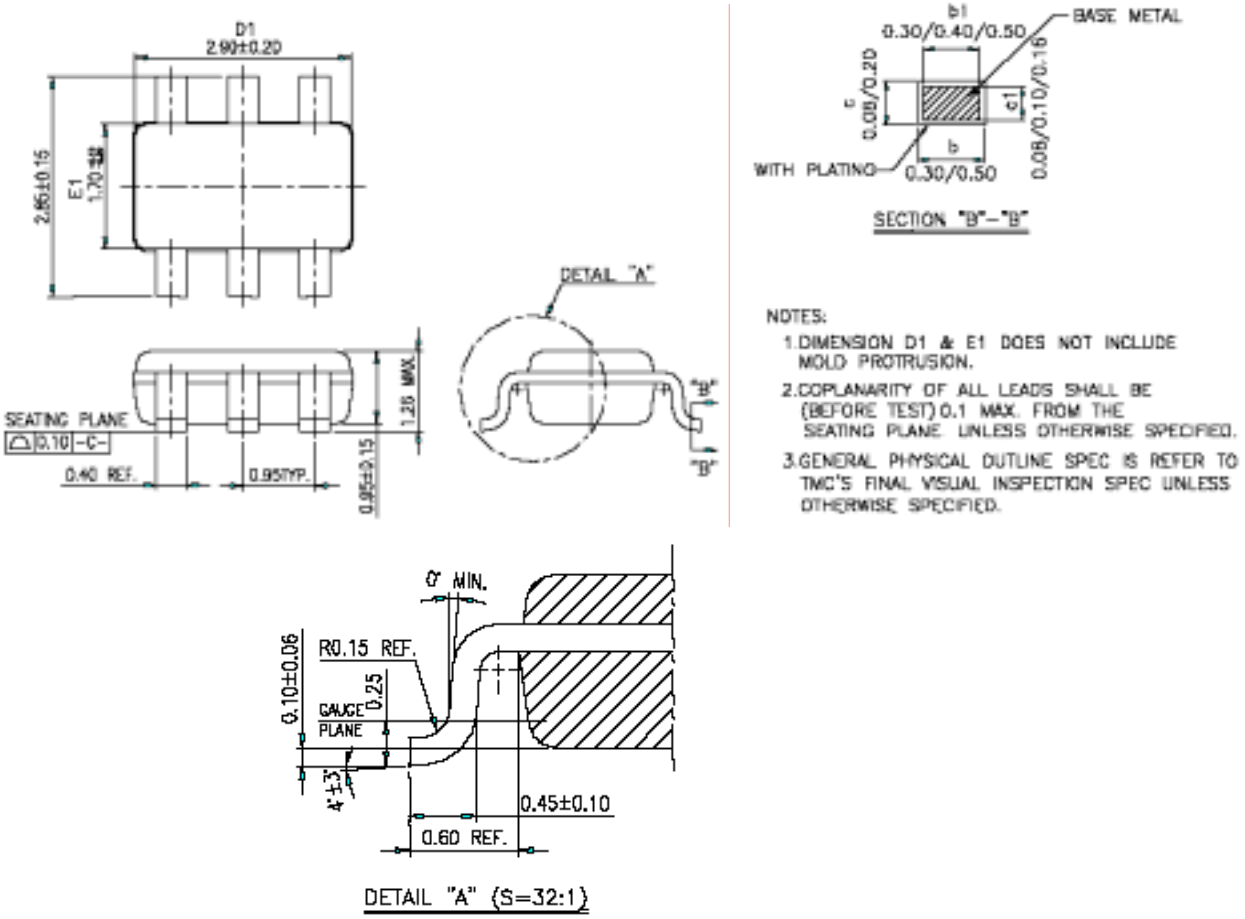
L is the coil inductance
rL is the coil resistance
R_S is the current sense resistance
Iavg is the required LED current
ΔI is the coil peak-peak ripple current {Internally set to 0.3 x Iavg}
V_{IN} is the supply voltage
V_{LED} is the total LED forward voltage
R_{SW} is the switch resistance
V_D is the diode forward voltage at the required load current

Diode selection :

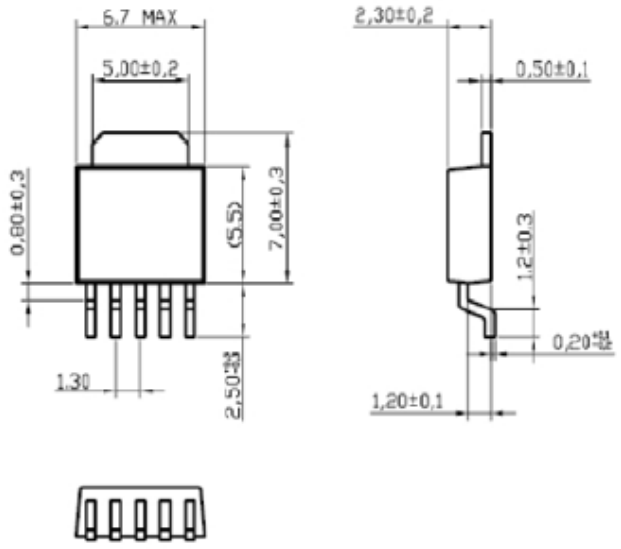
For maximum efficiency and performance, the rectifier (D1) should be a fast low capacitance Schottky diode with low reverse leakage at the maximum operating voltage and temperature. They also provide better efficiency than silicon diodes, due to a combination of lower forward voltage and reduced recovery time. It is important to select parts with a peak current rating above the peak coil current and a continuous current rating higher than the maximum output load current. It is very important to consider the reverse leakage of the diode when operating above 85°C. Excess leakage will increase the power dissipation in the device and if close to the load may create a thermal runaway condition. The higher forward voltage and overshoot due to reverse recovery time in silicon diodes will increase the peak voltage on the SW output. If a silicon diode is used, care should be taken to ensure that the total voltage appearing on the SW pin including supply ripple, does not exceed the specified maximum value.

. Package Information

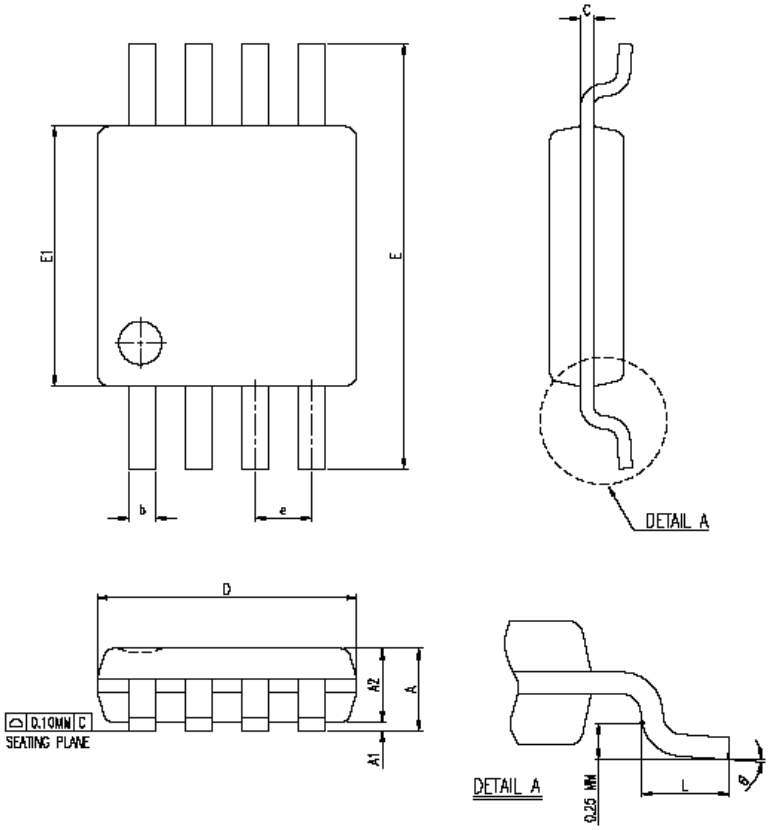
SOT23-6



TO252-5



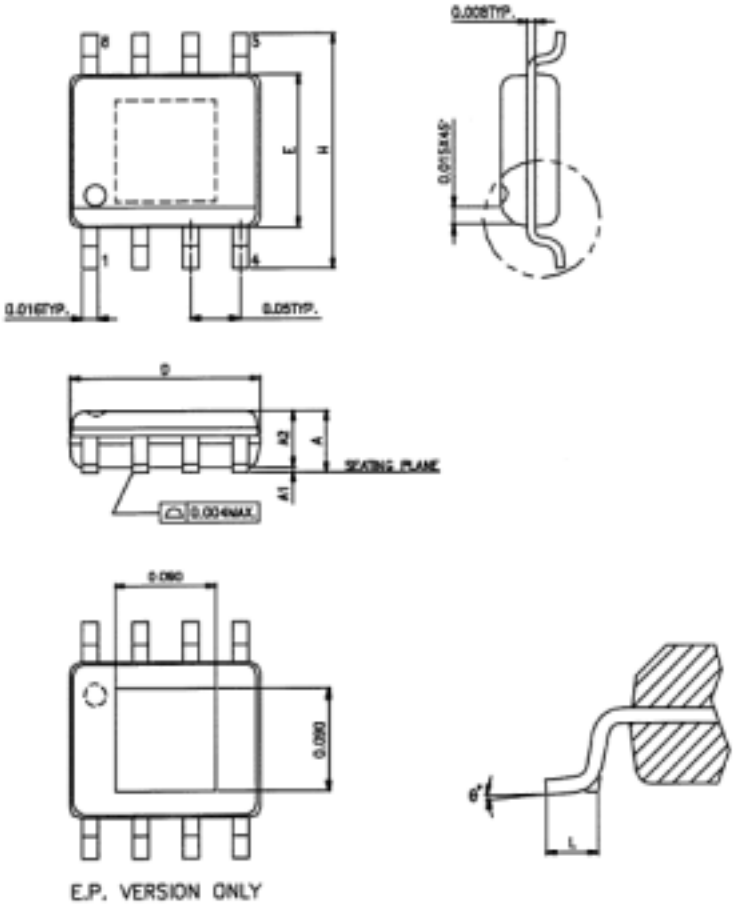
MSOP8



SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.81	1.02	1.10	0.032	0.040	0.043
A1	0.05		0.15	0.002		0.006
A2	0.76	0.86	0.95	0.030	0.034	0.037
b	0.28	0.30	0.38	0.011	0.012	0.015
C	0.13	0.15	0.23	0.005	0.006	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.75	4.90	5.05	0.187	0.193	0.199
E1	2.90	3.00	3.10	0.114	0.118	0.122
e	0.65 BASIC			0.026 BASIC		
L	0.40	0.55	0.70	0.016	0.022	0.028
θ	0°	3°	6°	0°	3°	6°
JEDEC						

*NOTES : DIMENSION " D " DOES NOT INCLUDE MOLD PROTRUSIONS OR GATE BURRS.
MOLD PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED 0.006 INCH (0.15 MM) PER SIDE .
DIMENSION " E1 " DOES NOT INCLUDE MOLD PROTRUSIONS
MOLD PROTRUSIONS SHALL NOT EXCEED 0.010 INCH (0.25 MM) PER SIDE .

SOP8



SYMBOLS	MIN.	MAX.
A	0.053	0.069
A1	0.004	0.010
A2	–	0.059
D	0.189	0.196
E	0.150	0.157
H	0.228	0.244
L	0.016	0.050
θ°	0	8

UNIT : INCH

NOTES:
1. JEDEC OUTLINE : MS-012 AA / E.P. VERSION : N/A
2. DIMENSIONS "D" DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.MOLD FLASH, PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED .15mm (.006in) PER SIDE.
3. DIMENSIONS "E" DOES NOT INCLUDE INTER-LEAD FLASH, OR PROTRUSIONS. INTER-LEAD FLASH AND PROTRUSIONS SHALL NOT EXCEED .25mm (.010in) PER SIDE.