DC-DC CONVERTER CONTROL CIRCUITS

- OUTPUT SWITCH FIXED VOLTAGE 14.5V
- 2% REFERENCE ACCURACY
- LOW QUIESCENT CURRENT: 15UA (TYP.)
- OPERATING FROM 18V TO 200V
- FREQUENCY OPERATION TO 80KHz (HM3135)
- ACTIVE CURRENT LIMITING

DESCRIPTION

The HM3135 series is a monolithic control circuit delivering the main functions for DC-DC voltage converting.

The device contains an internal temperature compensated reference, comparator, duty cycle controlled oscillator with an active current limit circuit, driver and high current output switch.

Output voltage is fixed 14.5V ,integrated two external resistors with a 2% reference accuracy.

Employing a minimum number of external components the HM3135 devices series is designed for Step-Down applications.

APPLICATIONS

l   **Electric-Vehicle, Electric-Bicycle Apliance**
l   **Industry Controls**
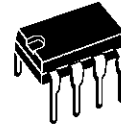
DIP-8

Product Summary

V_{IN}	18~ 200V
I_O	500mA
V_{OUT}	14.5V
Work Tem	-40 ~150 ℃

SOP-7

TYPICAL Application CIRCUIT
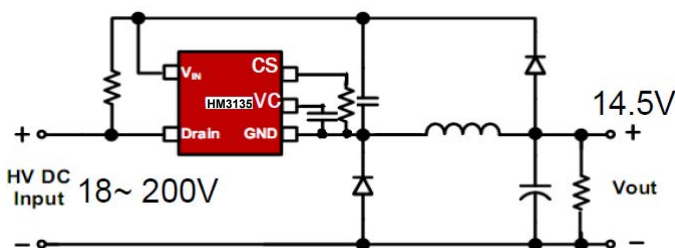
TYPICAL OUPUT CURRENT TABLE(1)		
Part Number	DCM (2)	CCM (3)
HM3135	300mA	500mA
HM3135P	400mA	600mA
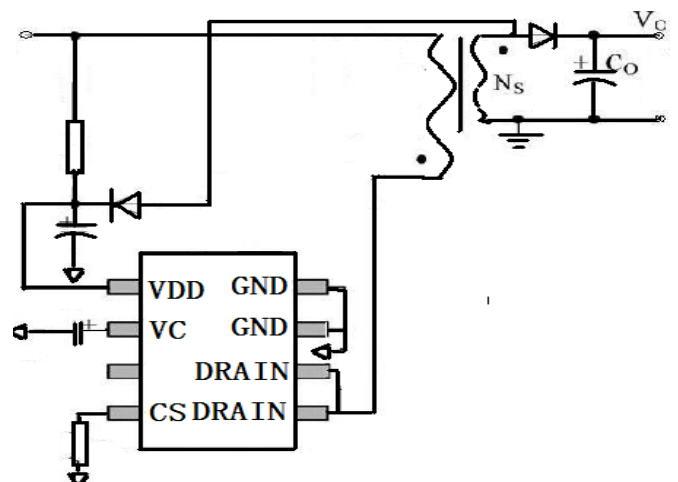
Pin Configuration
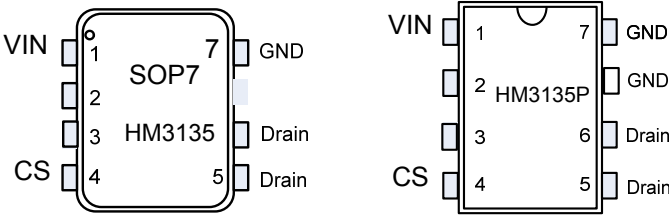
Block Diagram
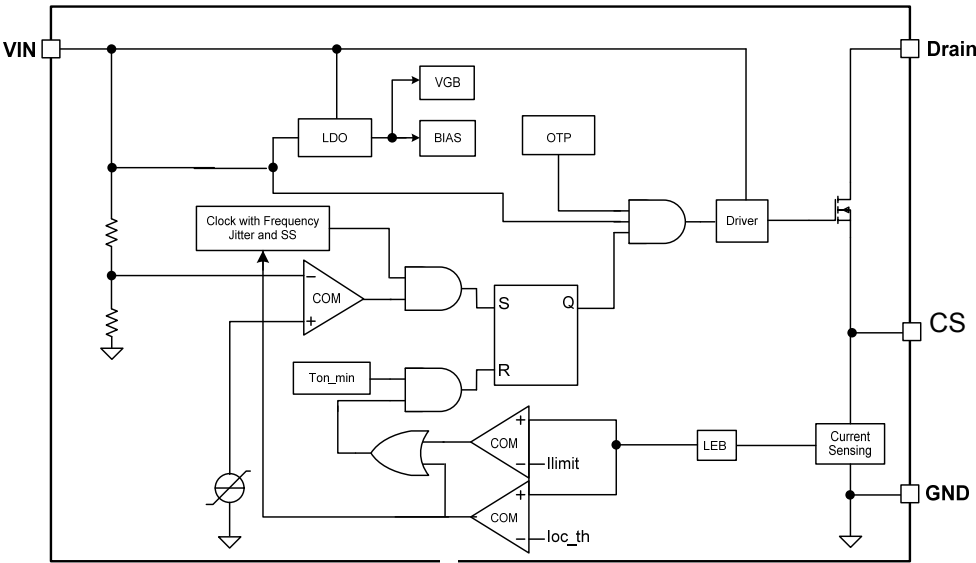
Pin Description

Pin Number	Pin Name	I/O	Description		
1	**VIN**	I	The VCC power supply for the HM3135 Family and the feedback for the circuit. For the normal operation, a capacitor with 4.7uF is recommended connected to this pin.		
5/6	**Drain**	I	The Power MOSFET Drain.	4	CS
7/8	**GND**	I/O	The ground reference for the IC		

Ordering Information

Part Number	Description
HM3135	SOP-Ⅰ, Halogen free in T&R, 2500Pcs/Reel
HM3135P	DIP-8, Halogen free, 50Pcs/Tube

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{dd}	Power Supply Voltage	26	V
V_{ir}	Comparator Input Voltage Range	-0.3 to 20	V
V_{dra}	Switch Drain Voltage	200	V
V_{sor}	Switch Source Voltage	200	V
V_{ds}	Switch Drain to source Voltage	200	V
V_{dg}	Driver Drain Voltage	200	V
I_{ds}	Driver Drain Current	300	mA
I_{SW}	Switch Current	0.5	A
P_{tot}	Power Dissipation at T_{amb} = 25 ^{o}C (for **DIP Package**)	1.25	W
	(for **SOIC Package**)	0.625	
T_{op}	Operating Ambient Temperature Range (for **AC SERIES**)		^{o}C
	(for **AB SERIES**)	- 40 to 1 4 5	
T_{stg}	Storage Temperature Range	- 40 to 150	^{o}C

Absolute Maximum Rating are those values beyond which damage to the device may occur.
Functional operation under these condition is not implied.

Recommended Operation Conditions (Note 2)

Parameter	Value	Unit
Supply Voltage, DRAIN	20 to 200	V
Operating Junction Temperature	-40 to 150	^{o}C

ELECTRICAL CHARACTERISTICS (Refer to the test circuits, V_{cc} = 60V, T = T_{LOW} to T_{HIGH}, unless otherwise specified, see note 2)

Control Function Section						
T_{LEB}	Current Sense Leading Edge Blanking Time	(Note 2)		200		ns
T_{on_min}	Minimum On Time	(Note 2)		300		ns
T_{on_max}	Maximum On Time		10	12	14	us
T_{ss}	Internal Soft Start Time	(Note 2)		5		ms
I_{limit}	Normal Peak Current Limit	HM3135	380	420	460	mA
		HM3135P	530	600	650	mA
I_{OC_th}	Over Current Protection Threshold	HM3135 Note 2		650		mA
		HM3135P(Note 2)		800		mA
F_{clk}	Internal Frequency Clock	HM3134	56	61	66	kHz
F_{clk}	Internal Frequency Clock	HM3135	70	80	95	kHz
BV_{DSS}	MOSFET Break Down Voltage		200			V
R_{ds_on}	Steady State Conduction Resistance	HM3135		1		Ohm
		HM3135P		1		Ohm
Over Temperature						
T_{SD}	Thermal Shut Down	(Note 2)		140		^{o}C
T_{RC}	Thermal Recovery	(Note 2)		130		^{o}C

Note1. Stresses listed as the above "Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note2. It's guaranteed by design and functionally tested during production manufacture.
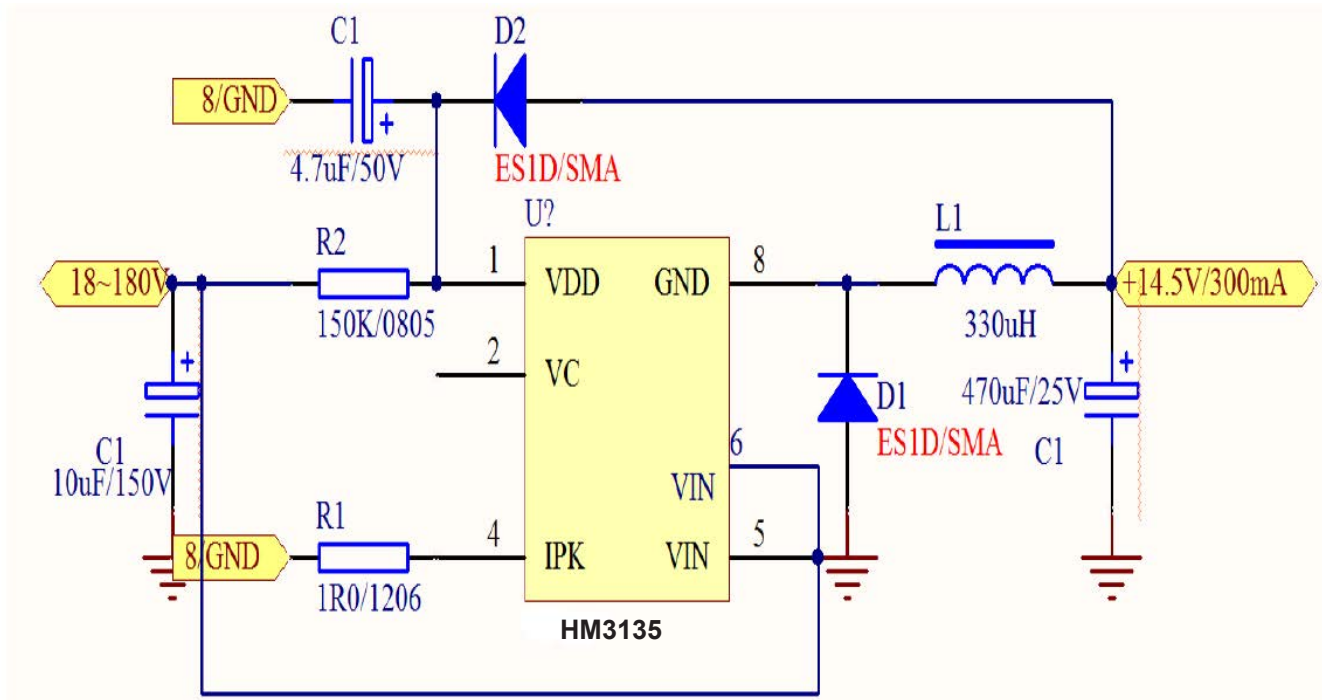
TYPICAL APPLICATION CIRCUIT

Step-Down Converter

(1).14.5V/300mA for18~180V

PERATION DESCRIPTION

I   Over Temperature Protection

When the IC temperature is over 140 $^{\circ}$C, the IC shuts down. Only when the IC temperature drops to 80 $^{\circ}$C, the IC restarts to work.

I   Light Load Mode Operation

To save more power loss in no load condition, HM3135 family adopts a light load mode operation. When the switching period is longer than 300us, the peak current limit will be decreased to 100mA. With this feature, ultra no load power loss consumed by the pre-load can be <5mW.

I   The Selection of the DC Output Stage

The output power rage determines the selection of the CS and LX design. For Pout<4W, it's recommended to use paraeter rectification; for Pout>4W, it's recommended to use dip8 paraeter rectification.

COMPONENTS SELECTION

I   Start-Up Resistor (R_{ST}) and Hold-up Capacitor (C_{VIN})

To keep proper start-up operation and meet the start-up time requirement, the value of the VIN capacitor C_{VIN} and start-up resistor R_{ST} need well designed.

Firstly make sure the current flowing through the RST is larger than the IC start-up current I_VIN_ST (3uA typically) and lower than the IC operation current I_VIN_op (800uA typically).

$$\frac{V_{in\_max}}{I_{\_VIN\_op}} < R_{ST} < \frac{V_{in\_min}}{I_{\_VIN\_ST}}$$

V_{in_min}: The minimum peak value of DC input voltage.

V_{in_max}: The maximum peak value of DC input voltage. For universal input, V_{in_max} is 180V.

Secondly the VIN capacitor is recommended to be selected by the following equation:

$$C_{VIN} < \frac{(\frac{V_{in\_min}}{R_{ST}} - I_{\_VIN\_ST}) \cdot T_{ST}}{V_{IN\_ON}}$$

For better line and load regulation, the value of C_{VIN} is recommended to be as small as possible. Typically 4.7uF is recommended. If the VIN capacitance is not big enough to cause the start-up failed; increase the value of C_{VIN} and decrease the RST, re-do the calculation of above equation until ideal start-up performance is got.

For better noise immunity, it's recommended that the VIN capacitor be placed as close as possible to the VIN Pin.

I   Freewheeling Diode (D_1)

Diode D1 should be an ultra-fast type. Slow diode is not acceptable, because the inductor is always working in continuous conduction mode during start-up period. Slow diode will cause high current spike which will falsely make the Power MOESFET turned off and prevent the output voltage reach regulation. Slow diode will also cause extra power loss and make the efficiency lower down. A 100V/1A diode with recovery time <50ns is recommended for Buck converter and 200V/A diode with recovery time <50ns is recommended for Buck/Boost converter, such as ES1D and ES2D.

I   Feedback Diode (D_F)

The information of the output voltage is sent the IC through the diode DF which can be a slow diode,

such as 1N400X series. To minimize the output voltage error, the forward voltage of D1 and D_F should match. At the same time, the power supply of the IC will be taken place by the output voltage through DF after the soft-start.

I   Inductor (L)

For Buck converter, the selection of L can be calculated by the following equation:

$$L = \frac{2 \cdot (V_{in\max} - V_{DS} - V_o) \cdot V_o \cdot I_o}{h \cdot [I_{\lim it}^2 - (2 \cdot I_o - I_{\lim it})^2] \cdot (V_{in\_min} - V_{DS}) \cdot f_{sw}} \quad \text{for CCM}$$

$$L = \frac{2 \cdot (V_{in\max} - V_{DS} - V_o) \cdot V_o \cdot I_o}{h \cdot I_{\lim it}^2 \cdot (V_{in\_min} - V_{DS}) \cdot f_{sw}} \quad \text{for DCM}$$

For Buck/Boost converter, the selection of L can be calculated by the following equation:

$$L = 2 \cdot \frac{P_o}{h \cdot [I_{\lim it}^2 - (2 \cdot I_o - I_{\lim it})^2] \cdot f_{sw}} \quad \text{for CCM}$$

$$L = 2 \cdot \frac{P_o}{h \cdot I_{\lim it}^2 \cdot f_{sw}} \quad \text{for DCM}$$

Where:

When $I_o > I_{limit}/2$, it's working in CCM operation mode; when $I_o < I_{limit}/2$, it's working in DCM operation mode.

V_{in_min}: The minimum DC input voltage after the rectified diode bridge. It's recommended to keep V_{in_min} higher than 70V always.

ɳ: The overall estimated efficiency, the typical value of 0.8 is recommended for DCM and 0.7 for CCM.

V_o: The averaged output voltage.

Io: The averaged output current.

V_F: The forward conduction voltage of the freewheeling diode D1.

V_{DS}: The MOSFET conduction voltage during it's turned on. The typical value of 5V is recommended

F_{sw}: The switching frequency and 80 kHz is recommended.

I_{limit}: The minimum peak inductor current limit. For HM3135, it's 380mA; for HM3135P it's 560mA.

Any standard off-the-shelf inductor that meets the design requirement can be selected. The value of the inductor L determines the averaged switching frequency according to the rule of power balance. Typically a 0.68mH-2.2mH inductor is recommended to be used with Isat>0.6A for HM3135 a nd Isat>0.8A for HM3135P.

I   Output Capacitor (C_{OUT})

The selection of output capacitor is determined by the requirement of the output voltage ripple. To make the output ripple small enough, a large value of C_{OUT} is needed. But large value of C_{OUT} will increase the cost and need longer time for soft-start. Typically a capacitor with 100uF/35V is recommended.

I   Pre-Load Resistor (R_L)

At no load condition, the switching frequency is determined by the value of C_{VIN} and the operation current of the IC not by the output voltage information. Combined with the value of the selection of inductor L1, there's a minimum input power for this circuit. To keep the regulation of the output voltage at no load condition, a minimum load current is needed. For 15V application, a resistor with value around of 30k ohm is recommended.

Table 1 shows the relationship between these circuit parameters and the key operation performance.
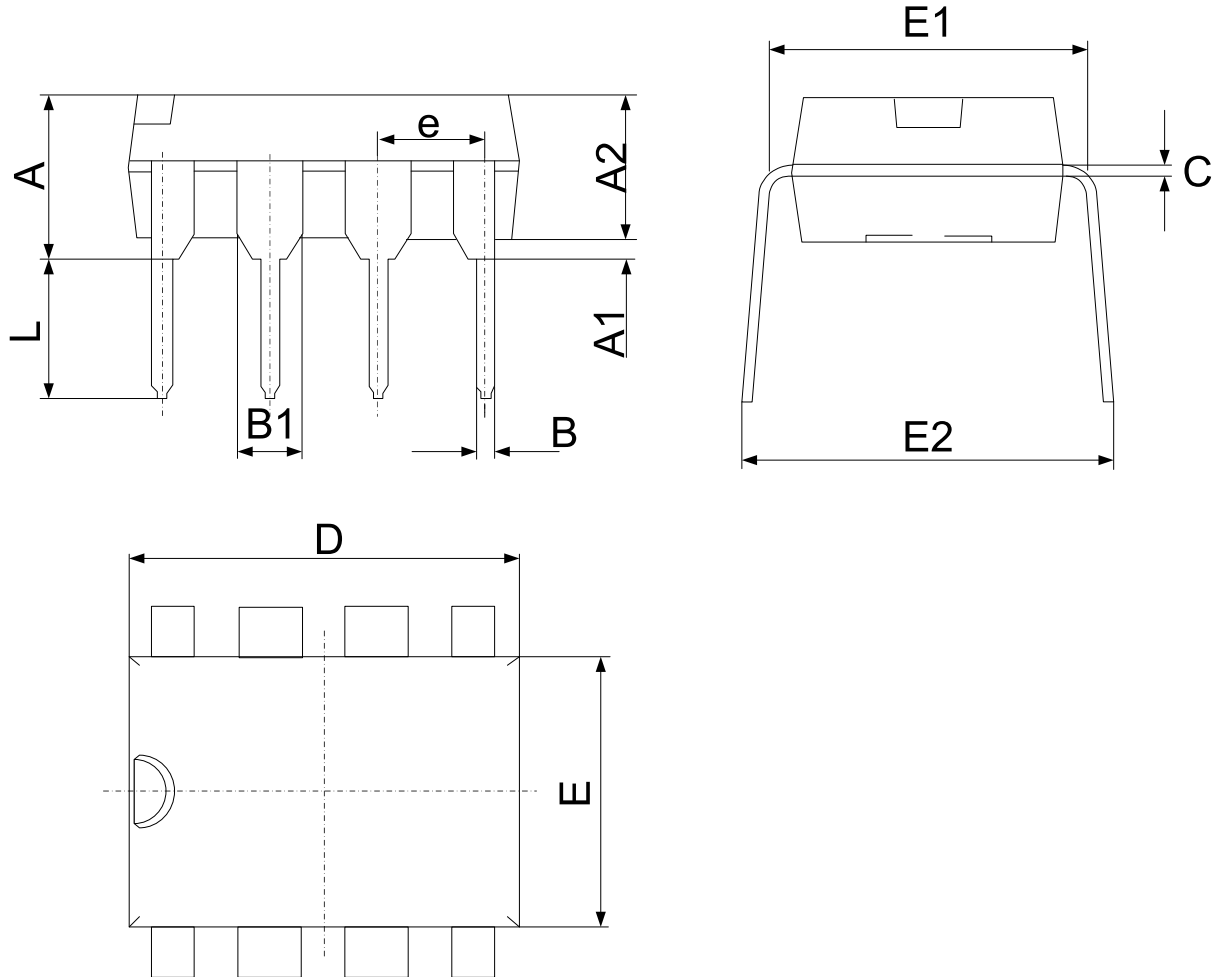
Table 1

	Start-up Time	Output Ripple	No Load
R_{ST} ↑	↑	→	↓
C_{VIN} ↑	↑	↑	↓
L ↑	↓	↑	↑
C_{OUT} ↑	↑	↓	→

Package Dimension

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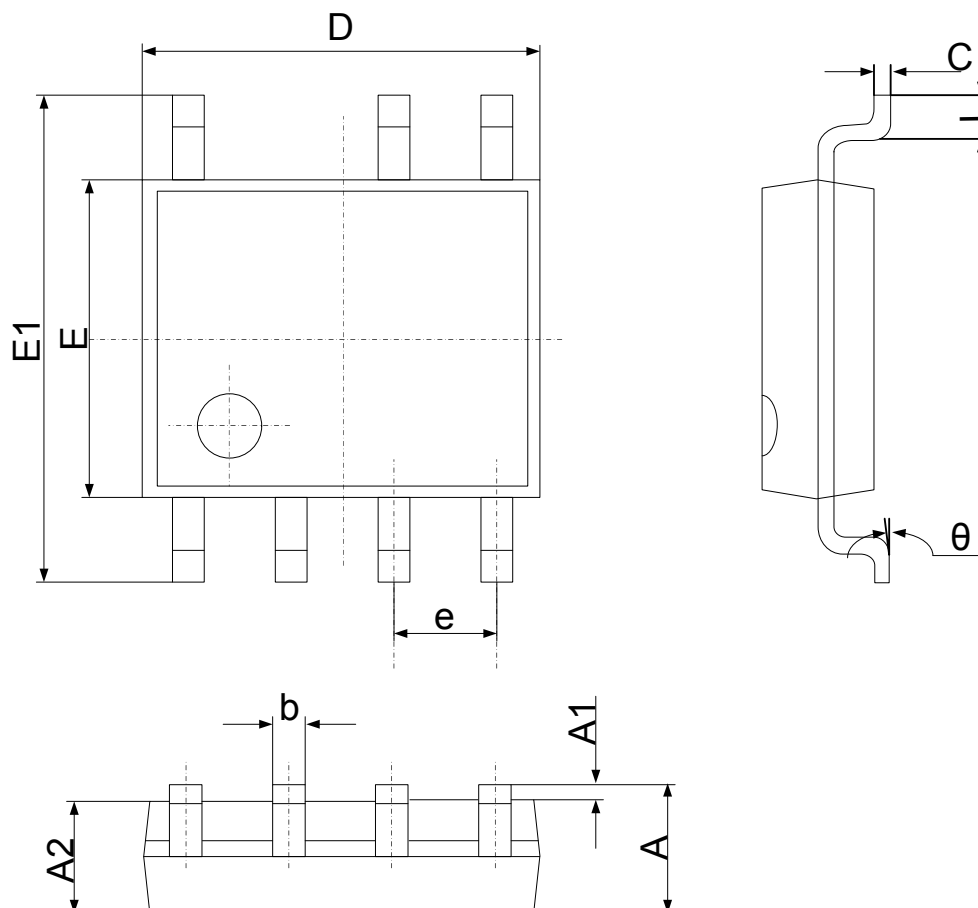
Symbol	Dimensions In Millimeters			Dimensions In Inches	
	Min	**Max**			**Min**
A	1.350	1.750	A		1.350
A1	0.100	0.250	A1		0.100
A2	1.350	1.550	A2		1.350
b	0.330	0.510	b		0.330
c	0.170	0.250	c		0.170
D	4.700	5.100	D		4.700
e	1.270（BSC）	0.050（BSC）	e		1.270（BSC）
E1	5.800	6.200	E1		5.800
E	3.800		4.000		
L	0.400	1.270	L		0.400
θ	0º	8º	θ		0º

DIP 8

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	4.310	0.035	0.047
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.142
B	0.380	0.570	0.015	0.022
B1	1.524(BSC)		0.060(BSC)	
C	0.204	0.360	0.008	0.014
D	9.000	9.400	0.354	0.370
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
e	2.540(BSC)		0.100(BSC)	
L	3.000	3.600	0.118	0.142
E2	8.400	9.000	0.331	0.354