High Precision Primary-side Feedback Constant Current Converter

■ Description

OCP8155 is a high precision constant current LED driver IC with an integrating 650V power MOSFET, designed for offline flyback constant current LED lighting within 18W output power, and suitable for universal input voltage from 85VAC to 265VAC.

IC adopts DIP-8L package. OCP8155 utilizes primary-side feedback technology to achieve excellent line regulation and load regulation without TL431, optical coupling and feedback circuit, greatly saving the system cost and size.

OCP8155 is provided with perfect protection functions. The chip detects the VCC pin for over-voltage detection, and once detecting an over-voltage signal, the chip enters a "Hiccups" mode to limit output power. Meanwhile the chip also includes LED open/short circuit protection, FB short circuit protection, under-voltage lockout and over-temperature protection functions to guarantee the entire system work safely and stably in harsh working environment.

■ Feature

- Internal 650V Power MOSFET
- Primary-side Feedback Technology,
  No Secondary-side Feedback Circuit Required
- No Loop Compensation
- ±3% Constant Current Accuracy
- 85VAC~265VAC Universal Input Voltage
- LED Open/Short Circuit Protection
- FB to GND Short Circuit Protection
- Over-temperature Protection
- Under-voltage Lockout Function
- CS Resistance Open Circuit Protection
- Operating Temperature Range：T_A=-40 ~ 85℃
- Available in DIP-8L Package

■ Application

- LED Fluorescent Lamp
- E27、Par Lamp、Down Light
- LED Bulb、Spot Light
- Other LED Lighting

■ Typical Application

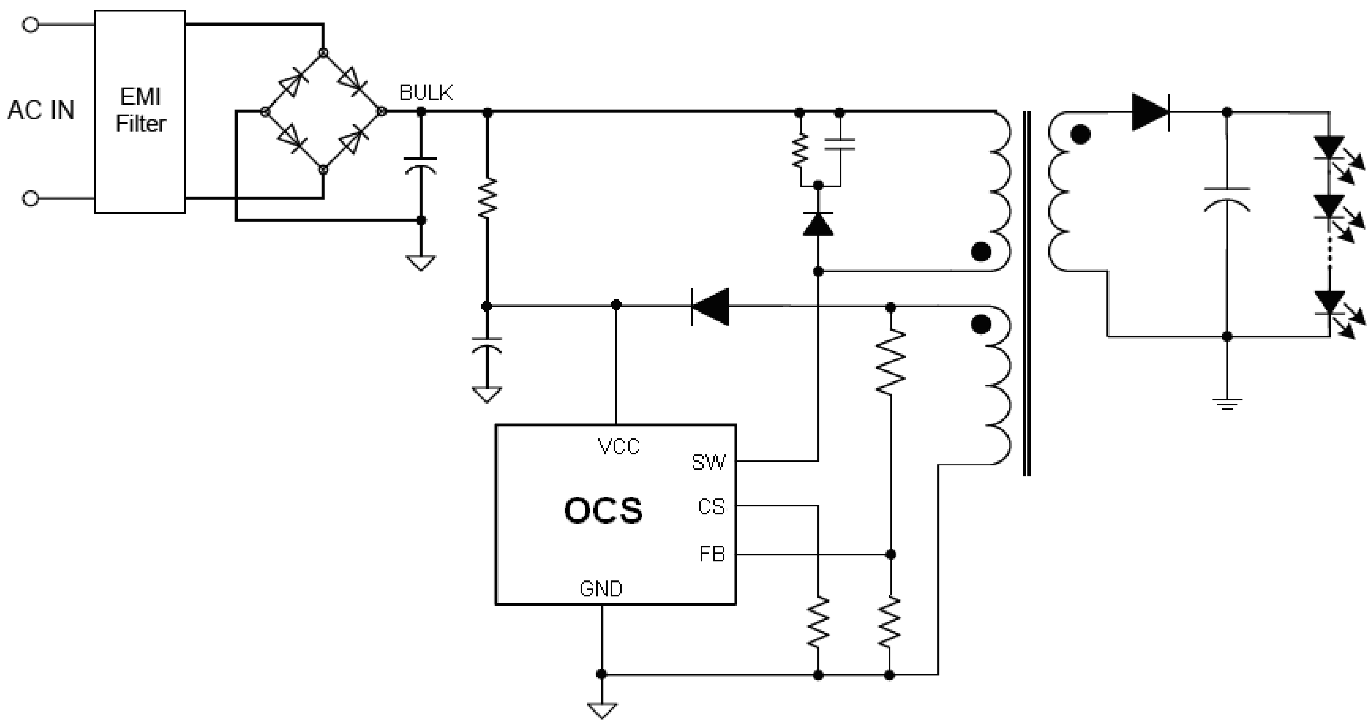
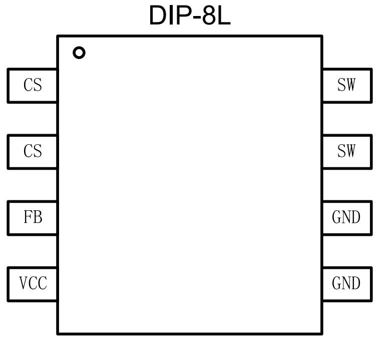


Figure 1, Typical Application for OCP8155

Pin Configuration



Pin Definition

Name	Pin No. DIP-8L	Description
CS	1	Primary-side Output Current Pin.
CS	2	Current Sense Input Pin.
FB	3	Connect the feedback dividing resistors and auxiliary winding to detect output voltage.
VCC	4	Power Supply Pin. Connect a bypass capacitance nearly.
GND	5	Signal Ground
GND	6	Signal Ground
SW	7	Switch Node
SW	8	Switch Node

Electrical Block Diagram

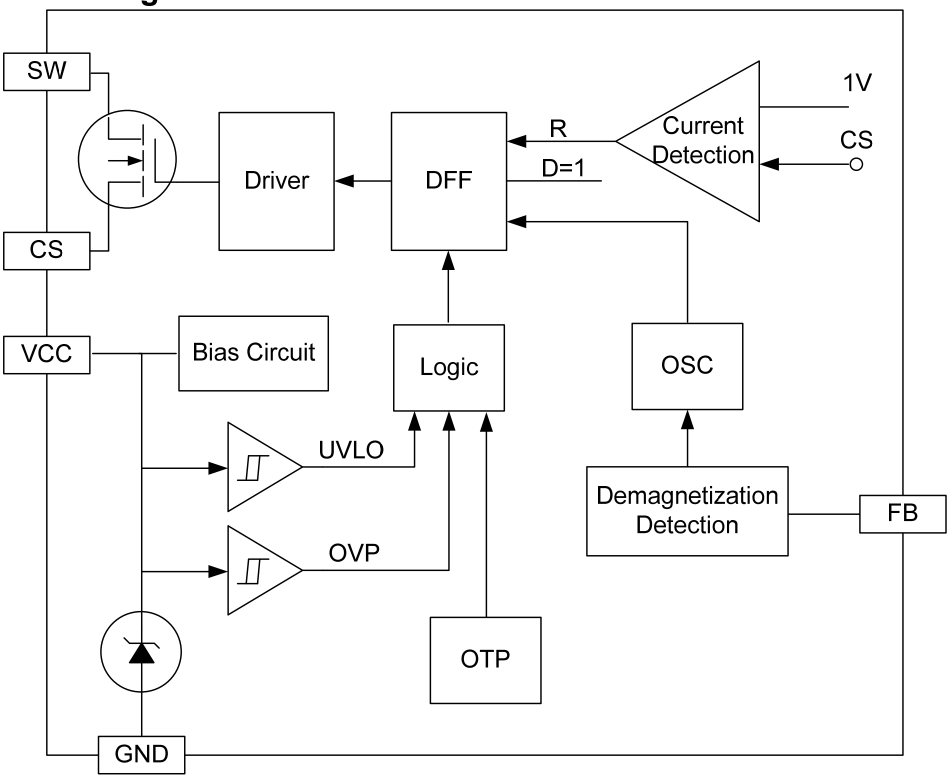


Figure 2, OCP8155 Internal Block Diagram

Absolute Maximum Ratings[1]

Symbol	Parameters		Range	Units
VCC	VCC pin input voltage		-0.3~25	V
SW	Switch node voltage		-0.3~650	V
CS	CS current sampling voltage		-0.3~7	V
FB	Feedback voltage		-0.3~7	V
θ_{JA}	Thermal resistance	DIP-8L	90	°C/W
P_{DMAX}[2]	Power dissipation		0.45	W
T_J	Operating junction temperature		−40 ~ 150	°C
T_{STO}	Storage temperature range		−55 ~ 150	°C

Note1: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device.

2:The maximum power dissipation decreases if temperature rises, it is decided by T_{JMAX}, θ_{JA}, and environment temperature (T_A). The maximum power dissipation is the lower one between $P_{DMAX} = (T_{JMAX} - T_A)/\ \theta_{JA}$ and the number listed in the maximum table.

Recommended Operation Conditions

Symbol	parameters		Range	Units
VCC	Power supply voltage		8.0~17.5	V
P_{OUTMAX}	Maximum output power	85~265VAC	18	W
		220VAC ±15%	21	
T_A	Operating environment temperature		−40 ~ 85	°C

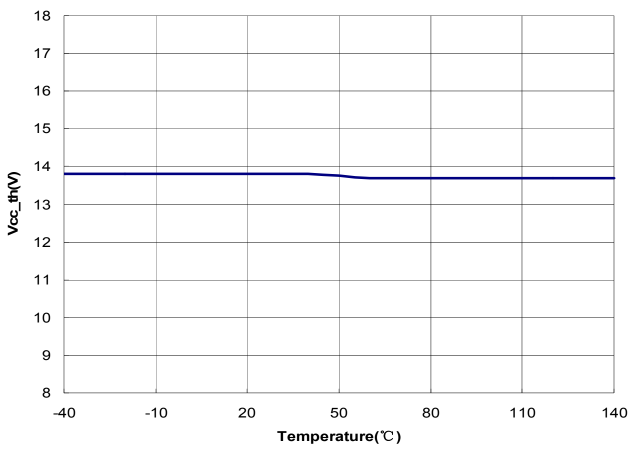
Electrical Parameters

(Test condition: Unless other specified, T_A=25℃, V_{CC}=12V)

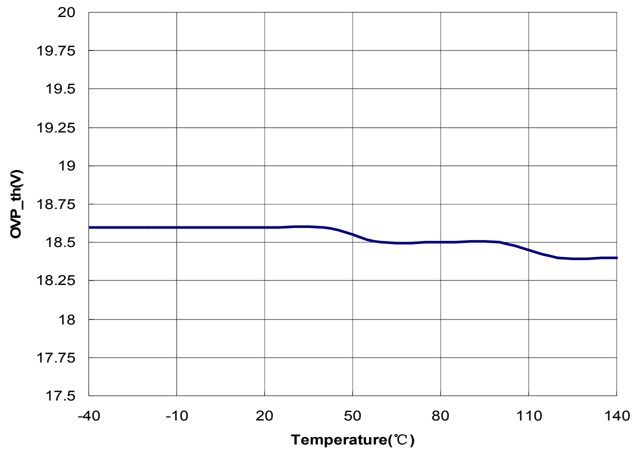
Symbol	Parameters	Conditions	Min	Typ	Max	Units
Supply Voltage Section						
V_{CC_TH}	VCC Turn On Voltage Threshold	V_{CC} Rising	12.0	14.0	16.0	V
V_{UVLO}	Under-voltage Lockout Threshold		6.4	7.2	8.0	V
V_{OVP}	VCC Over-voltage Protection Threshold		17.5	19	20.5	V
V_{CC_CLAMP}	VCC Clamp Voltage Threshold		21.0	23	25.0	V
Current Sense Section						
V_{CS_TH}	Current Sense Threshold		0.99	1.00	1.01	V
T_{ONMIN}	Minimum On Time		-	600	-	nS
Operating Current Section						
I_{ST}	VCC Start-up Current	V_{CC}=6.5V	-	32	60	uA
I_{OP}	Typical Operating Current	F_{OP}=40KHz	-	0.7	-	mA
Feedback section						
T_{DEMAG}_Min	Minimum demagnetization time		-	3	-	uS
V_{FB}	FB reference voltage		-	1	-	V
T_{OFFDLY}	Turn-off delay		-	136	-	nS
R_{LNC}	Bulk voltage compensation resistance		-	900	-	uV/uA
Maximum Duty Cycle						
D_{MAX}	System Maximum Duty Cycle		-	-	58	%
T	System Operating Cycle		-	3*Td	-	
F_{SHORT}	Short Circuit Operating Frequency		-	7.0	-	kHz
Over-temperature Protection Section						
T_{SD}	Thermal Shutdown Temperature		-	150	-	℃
T_{SD}_HYS	Over-temperature Protection Hysteresis		-	50	-	℃
Drive section						
$R_{DS(ON)}$	NMOS Drain-Source On-Resistance	V_{GS}=10V, I_D=1A	-	2.1	2.6	Ω
BV_{DSS}	Drain-Source Breakdown Voltage	V_{GS}=0V, I_D=250uA	650	-	-	V
I_{DSS}	Power MOSFET Drain leakage current	V_{DS}=520V, V_{GS}=0V	-	-	2	uA

Typical Parameter Characteristic

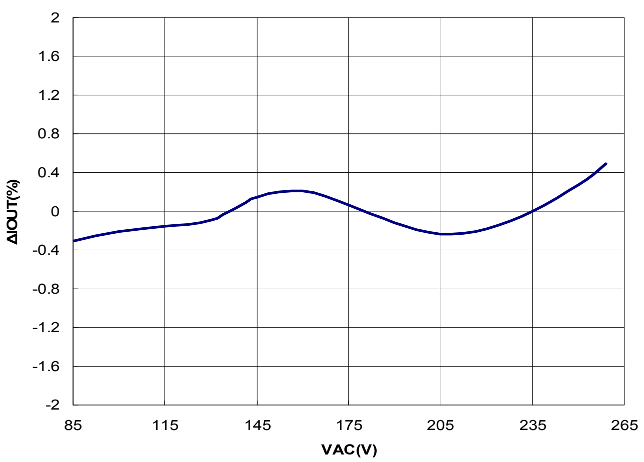
V_{CC_TH} vs. Temperature



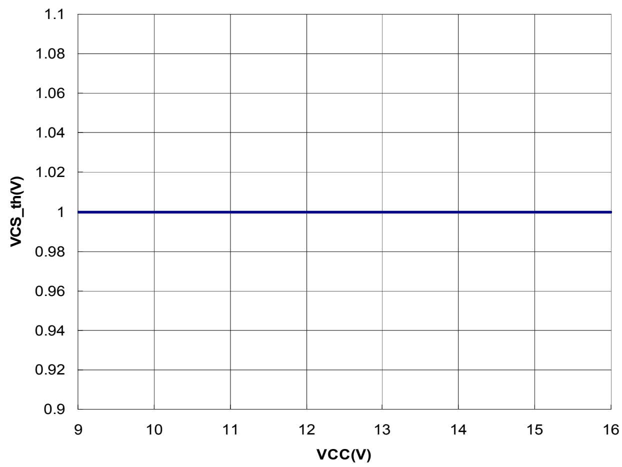
V_{OVP} vs. Temperature



Output Current vs. Input Voltage

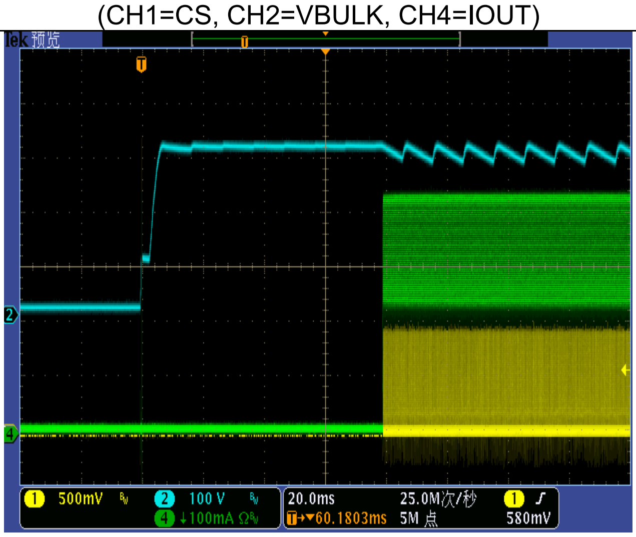


CS Threshold Voltage vs. VCC



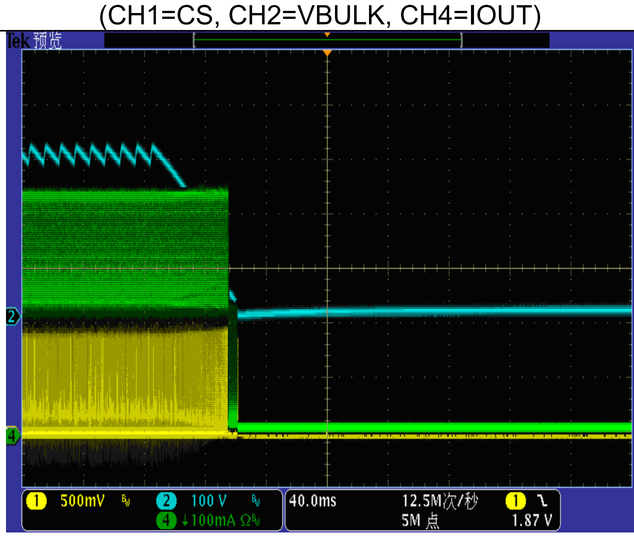
Electrical waveforms in the start-up state system

(CH1=CS, CH2=VBULK, CH4=IOUT)



Electrical waveforms in the power-off state system

(CH1=CS, CH2=VBULK, CH4=IOUT)



Application Information

OCP8155 is a high precision constant current LED driver IC designed for offline flyback , specially applying to constant current LED lighting within 18W output power. OCP8155 utilizes primary-side feedback technology to achieve excellent line regulation and load regulation without TL431, optical coupling and feedback circuit, greatly saving the system cost and size.

Start Up

OCP8155 only requires 32uA start-up current, than which VCC will rise as long as the current flowing through the start-up resistor R_{ST} is higher. The chip starts up when VCC goes up to 14V (Typical). At this time the operating current is usually higher than the current provided by the start-up resistor, which leads to VCC decrease. The start-up process will proceed successfully so long as the auxiliary winding can provide normal power supply to the chip before VCC deceases below under-voltage lockout threshold.

Turns Ratio Setting

Only when the chip operates in a current discontinuous conduction mode can it keep LED current constant. When designing the system, the chip operating in a current discontinuous conduction mode should be ensured. In another word, the designed maximum duty cycle must be less than the inherent maximum duty cycle (58%) in the chip. Turns Ratio is limited by two factors: the inherent maximum duty cycle and power MOSFET breakdown voltage.

First, turns ratio is considered according to the maximum duty cycle. Then duty cycle is calculated on the basis of continuous conduction mode:

$$D = \frac{V_{OR}}{V_{BULK} + V_{OR}} \quad (1)$$

According to formula (1), the maximum duty cycle working situation happens to the system when the V_{BULK} is lowest. Maximum V_{OR} which is limited by maximum duty cycle is gained when duty cycle is set to 58%.

Secondly, turns ratio is considered according to the power MOSFET breakdown voltage.

The Drain-Source breakdown voltage of the power MOSFET is:

$$V_{DS} = V_{BULK} + V_{RCD} = V_{BULK} + k * V_{OR} < V_{BK} \quad (2)$$

Where, V_{BK} is the Drain-Source breakdown voltage of the power MOSFET. The k coefficient affects the leakage inductance dissipation. Ultra-low value of k leads to large leakage inductance dissipation and low efficiency, while ultra-high value of k results in requiring high Drain-Source breakdown voltage of the power, so that k is usually set to 1.4~2.

According to formula (2), the power MOSFET endures the largest Drain-Source voltage when V_{BULK} is largest. Maximum V_{OR} which is limited by breakdown voltage is gained according to the Drain-Source breakdown voltage of the power MOSFET.

By considering these two aspects above, the lower V_{OR} is selected.

Then turns ratio of primary side and secondary side is calculated according to the following formula:

$$\frac{n_p}{n_s} = \frac{V_{OR}}{V_O} \quad (3)$$

According to the chip operating input voltage VCC and output voltage, the turns ratio of auxiliary-side and secondary-side is calculated by the following formula:

$$V_{CC} = \frac{n_a}{n_s} * V_O \quad (4)$$

Constant Current Control

IC compares CS pin voltage with internal 1V threshold voltage to set the primary-side peak current I_{pkp} of the transformer:

$$I_{pkp} = \frac{1}{R_{CS}} \quad (5)$$

The LED output current I_O is gained according to the following formula:

$$I_o = \frac{1}{6} * \frac{n_p}{n_s} * I_{pkp} \quad (6)$$

Where, I_{pkp} is the primary-side peak current of the transformer, n_p is the number of the primary-side turns of the transformer, and n_s is the number of the secondary-side turns of the transformer.

Components Parameters setting

The secondary inductance of the transformer is decided by operating frequency, output voltage and output current, according to the following formula:

$$L_s = \frac{V_O}{18 * I_O * F} \quad (7)$$

Where, F is the system operating frequency, usually set from 20kHz to 80kHz, and the center frequency is set from 40kHz to 48kHz to facilitate EMI testing.

Choose a suitable operating frequency according to actual condition, and then calculate the secondary inductance of the transformer on the basis of formula (7), and at last calculate the primary inductance and the auxiliary inductance of the transformer according to these turns ratios.

Current sampling resistor R_{CS} is chosen according to the formula (5)

The recommended range of R_{FB} resistor is 300~500kΩ.

Protection Functions

OCP8155 includes sorts of protections function, such as over-temperature protection, open circuit protection, short circuit protection and so on.

IC enters over-temperature protection when the temperature of IC goes up to 150℃, and stops exporting power until the temperature of IC decreases to 100℃.

When LED open circuit happens, gradually increasing output voltage will finally leads to the damage of output bypass capacitance. To protect this capacitance from damage, the chip detects the voltage on auxiliary winding node which reflects the output voltage. If the output voltage is ultra-high, the chip will power off and restart which happens over and over again, and the system will operate in this “hiccups” mode.

When LED short circuit happens, demagnetization process is very slow. In order to prevent the transformer charging too much, the chip operates at a lower frequency state in this case to ensure complete demagnetization of the transformer. After the elimination of short circuit condition, the output voltage returns to normal, the chip automatically enters normal operating mode.

PCB Layouts

The following guidelines should be followed in OCP8155 PCB layout:

(1) The bypass capacitor on VCC pin should be as close as possible to the VCC pin.

(2) The power ground path for current sense resistor should be as short as possible. The ground terminal of current sense resistor and other ground terminals should be separately connected to the ground terminal of BULK capacitance.

(3) The area of main current loop should be as small as possible in order to reduce EMI radiation.

(4) The dividing resistors connected to the FB pin should be as close as possible to FB pin.

■ Ordering Information

OCP8155XXX

Package Type:
N: DIP-8L

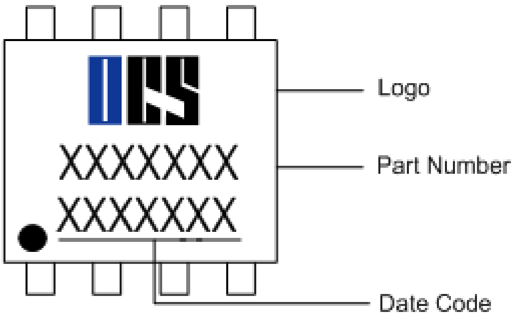
Packing:
Blank: Tube or Bulk

Temperature Range:
D: -40~85℃

Model Number	Maximum Output Power	Package	Packing Number	Temperature Range	Environmental Rating	Base Material
OCP8155ND	18W	DIP-8L	Bulk 50pcs/bulk	-40～85℃	Green	Cu

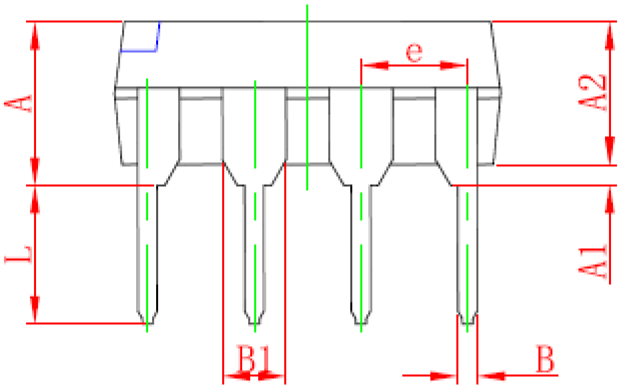
■ Marking Information

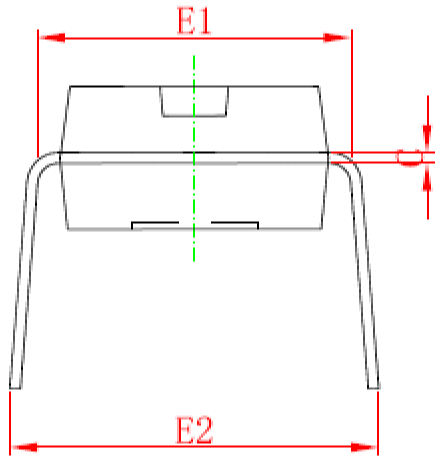
DIP-8L

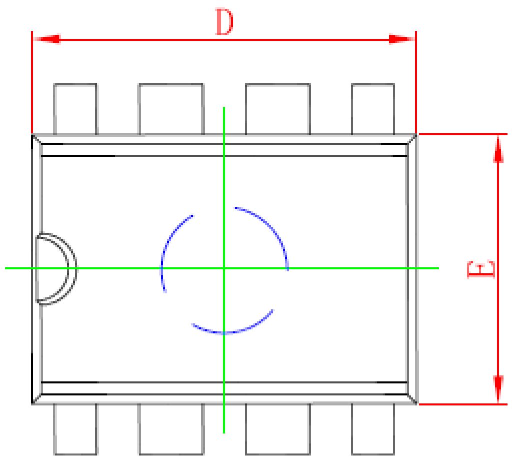


■ Package Information

DIP-8L







Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	3.710	4.310	0.146	0.170
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

■ Packing Information

Tube Packing:

(a) Packing Type: Tube packing
(b) Number of Each Tube: 50pcs/Tube