Over Current Protection IC With Shunt Regulator

Halogen Free

General Description

FP133 is a main rail current detection and over current protection IC. It includes a current shunt comparator and shutdown comparator with a precision shunt regulator like FP431.

The rail current detection gain can be adjusted with three external resistors. The regulator output CSO pin is connected to a shutdown comparator for driving a protection circuit like a photo-coupler to shutdown the primary side PWM IC when over current occurs.

The voltage shunt regulator has a 2.5V reference for switching power supply secondary output voltage feedback.

FP133 can be used for OCP and output voltage feedback function with few external parts. It is suitable for application in secondary main rail power supply of SPS or isolated fly-back DC-DC converter.

Features

- Independent Power Supply Voltage: 2.7 to 28V
- Wide Operating Temperature Range: -20℃~ +105℃
- Independent Shunt and Supply Voltage
- Low Input Offset Voltage
- Sense Gain Adjustable
- Built-in 1.25V Comparator for O.C.P
- Shunt Regulator Voltage: 2.5V (1.0%)
- Output Sink Current Capability up 50mA
- Package: SOP-8L

Typical Application Circuit

- SPS
- AC Adaptor
- Isolated Fly-back DC-DC Converter

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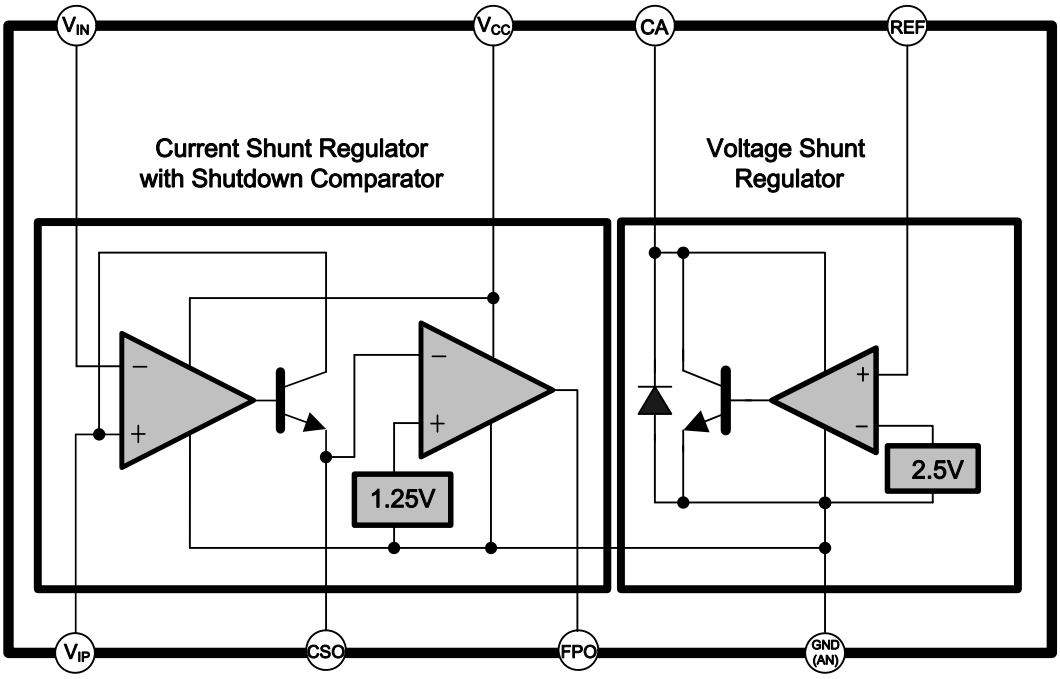
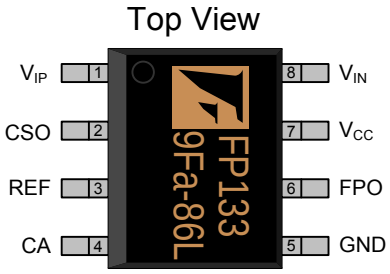
Function Block Diagram



Pin Descriptions

SOP-8L



Name	No.	I / O	Description
V_{IP}	1	I	Positive Input of Current Shunt OPA
CSO	2	O / I	Output of Current Shunt OPA to Inverting Input of Shutdown Comparator
REF	3	I	2.5V Reference
CA	4	I	Voltage Shunt Cathode Input
GND	5	P	IC Ground
FPO	6	O	Shutdown Comparator Output (O.C.)
V_{CC}	7	P	IC Power Supply
V_{IN}	8	I	Inverting Input of Current Shunt OPA

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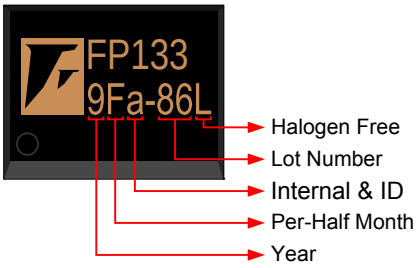
IC Date Code Identification

SOP-8L



Halogen Free: Halogen free product indicator

Lot Number: Wafer lot number's last two digits

For Example: 132386TB → 86

Internal ID: Internal Identification Code

Per-Half Month: Production period indicated in half month time unit

For Example: January → A (Front Half Month), B (Last Half Month)

February → C (Front Half Month), D (Last Half Month)

Year: Production year's last digit

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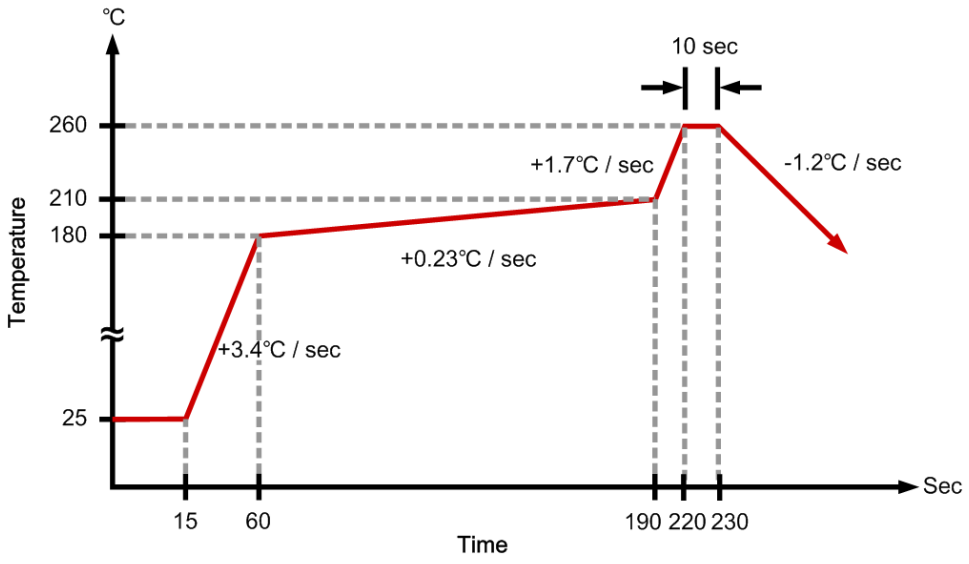
Ordering Information

Part Number	Operating Temperature	Package	MOQ	Description
FP133D-LF	-20°C ~ +105°C	SOP-8L	100EA	Tube
FP133DR-LF	-20°C ~ +105°C	SOP-8L	2500EA	Tape & Reel

Absolute Maximum Ratings

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power Supply Voltage	V_{CC}				30	V
Current Shunt Regulator Common Mode Inputs Voltage			-0.3		30	V
Current Shunt Regulator Differential Inputs Voltage		(V_{IP}-V_{IN})	-15		1.5	V
CSO Voltage			-0.3		V_{CC}	V
FPO Sink Current					25	mA
FPO Off Voltage					30	V
Cathode Voltage					30	V
Cathode Continuous Current			-50		50	mA
Reference Input Current			-0.05		1	mA
Maximum Junction Temperature	T_J				+150	°C
Storage Temperature Range	T_S		-55		+150	°C
Power Dissipation		T_A=25°C			570	mW
Lead Temperature		(soldering, 10 sec)			+260	°C

IR Re-flow Soldering Curve



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Recommended Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage	V_{cc}		2.7		28	V
Operating Temperature			-20		+105	°C

DC Electrical Characteristics

(V_{CC}=5V, T_A= -20°C~+105°C, V_{IP}=12V, R_{OUT}=125kΩ unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Current Shunt Comparator Section						
Full Scale Sense Voltage	V_{SENSE}	$V_{SENSE}=V_{IP}$ - V_{IN}		100	500	mV
Common-Mode Input Voltage	V_{CM}		2.7		28	V
Common-Mode Rejection	CMRR	V_{IP}=2.7V to 28V, V_{SENSE}=50mV	100	120		dB
Input Offset Voltage vs Temp	V_{OFFSET} (T_A)	T_{MIN} to T_{MAX}		4		µV / °C
Input Offset Voltage vs V_{CC}	V_{OFFSET} (V_{cc})	V_{IN}=2.7V to 28V, V_{SENSE}=50mV		2.5	10	µV / V
Input Bias Current	I_{BIAS}	V_{IP},V_{IN}		2		µA
Non-linearity Error	NLE	V_{SENSE}=10mV to 150mV			±1	%
Total Output Error	TOE	V_{SENSE}=100mV			±2	%
Output Impedance	R_{OUT}			1||5		GΩ||pF
Voltage Swing to V_{CC}	V_{SCC}			V_{CC}-0.8		V
Voltage Swing to V_{CM}	V_{SCM}			V_{CM}-0.5		V
Bandwidth	BW	R_{OUT}=125KΩ		32		kHz
Settling Time	T_S	5V Step, R_{OUT}=125KΩ		30		µS
Total Output-Current Noise	I_{NOISE}	BW=100KHz		3		nA
Shutdown Comparator Section						
Input Offset Voltage	V_{OFFSET}2			1.0	5.0	mV
Common-Mode Voltage (IN-)	V_{CM}		-0.3	-	V_{CC}-1.5	V
Voltage Gain	A_V		50	200		V/mV
Large Signal Response Time				300		nS
Response Time				1.3		µS
Output Sink Current	I_{SINK}	V_{CSO}>1.3V V_{FPO} = 1.0V		16		mA
Saturation Voltage	V_{SAT}	V_{CSO}>1.3V I_{FPO} =10mA			1	V
Output Leakage Current		V_{CSO}<1.0V V_{FPO} = 28V		0.1	1	µA
Reference Voltage (2%)	V_{REF}	T_A=25℃	1.238	1.25	1.263	V
		T_A=-25℃~105℃	1.225	1.25	1.275	V
Line Regulation		3V≦V_{CC}≦28V		2	15	mV

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Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Voltage Shunt Regulator Section						
Reference Voltage	V_{REF}	$V_{KA}=V_{REF}$, $I_{KA}=10mA$	2.475	2.5	2.525	V
V Reference vs. Temperature	V_{REF}	$V_{KA}=V_{REF}$, $I_{KA}=10mA$			30	mV
Line Regulation	ΔV_{REF} / ΔV_{KA}	$I_{KA}=10mA$, V_{KA} =10V~ V_{REF}		-1.4	-2.0	mV / V
		$I_{KA}=10mA$, V_{KA}=10V~ 28V		-1.0	-2.0	
Reference Current	I_{REF}	R1=10KΩ, R2=∞, $I_{KA}=10mA$		0.5	4	μA
I Reference vs. Temperature	ΔI_{REF}	R1=10KΩ, R2=∞, $I_{KA}=10mA$, T_A=Full rang		0.4	1.2	μA
Minimum Cathode Current for Regulation	$I_{KA\,(MIN)}$	$V_{KA}=V_{REF}$		0.1	0.5	mA
Dynamic Impedance	$\|Z_{KA}\|$	$V_{KA}=V_{REF}$, ΔI_{KA}=0.1mA~15mA Frequency < 1KHz		0.2	0.5	Ω
Total Device Section						
Output Off IC Current	I_{CC}	V_{CC}=28V		0.8		mA

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Function Description

Current Shunt Regulator

The figure below shows the FP133 current shunt block, load current (I_S) flowing from power supply and a dropout voltage (V_{IN}^+-V_{IN}^-) at the sense resistor (R_S).

Assume internal NPN transistor collector current is same as emitter current (I_O) and V_{IP} is very close to V_{IN}, the FP133 transfer function is:

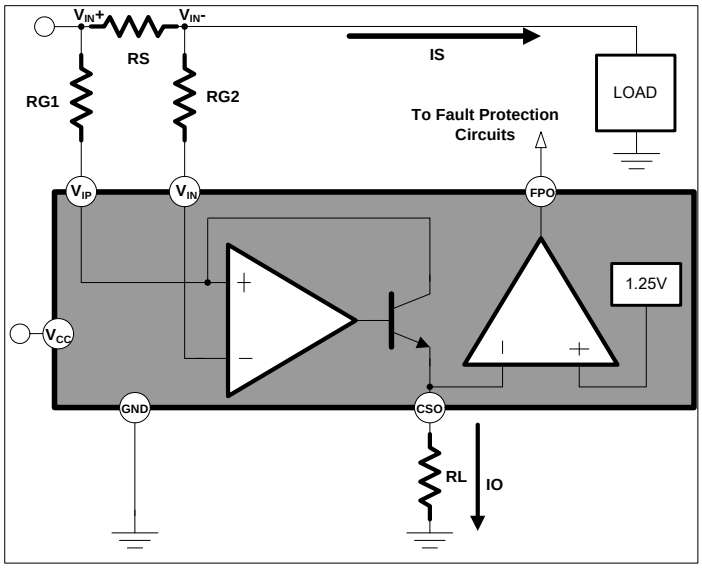
$$I_O = \frac{V_{IN}^+ - V_{IN}^-}{RG1} \quad \text{----- (1)}$$

In this figure, the (V_{IN}^+-V_{IN}^-), is equal to I_S x R_S and the current shunt output voltage (CSO) is equal to I_O x R_L. The final transfer function for rail current measurement in this application is:

$$V_{CSO} = G \times I_S \times R_S \quad \text{----- (2)}$$

$$G = R_L / RG1 \quad \text{----- (3)}$$

In FP133 internal circuits, the CSO output is connected to the shutdown comparator inverting input. When the voltage of CSO is higher than the internal reference voltage (1.25V), the FPO pin is switching from high to low state. This signal can be used for OCP protection control.



Note:

1. The minimum operating voltages of V_{CC}, V_{IP} and V_{IN} are 2.7V. If these supply voltages are lower than 2.7V, the transfer function at current shunt output (CSO) is no correct.
2. Do not force a V_{IN} voltage that is 15V higher than V_{IP}. This condition would generate a leakage current and an incorrect voltage at FP133 output.

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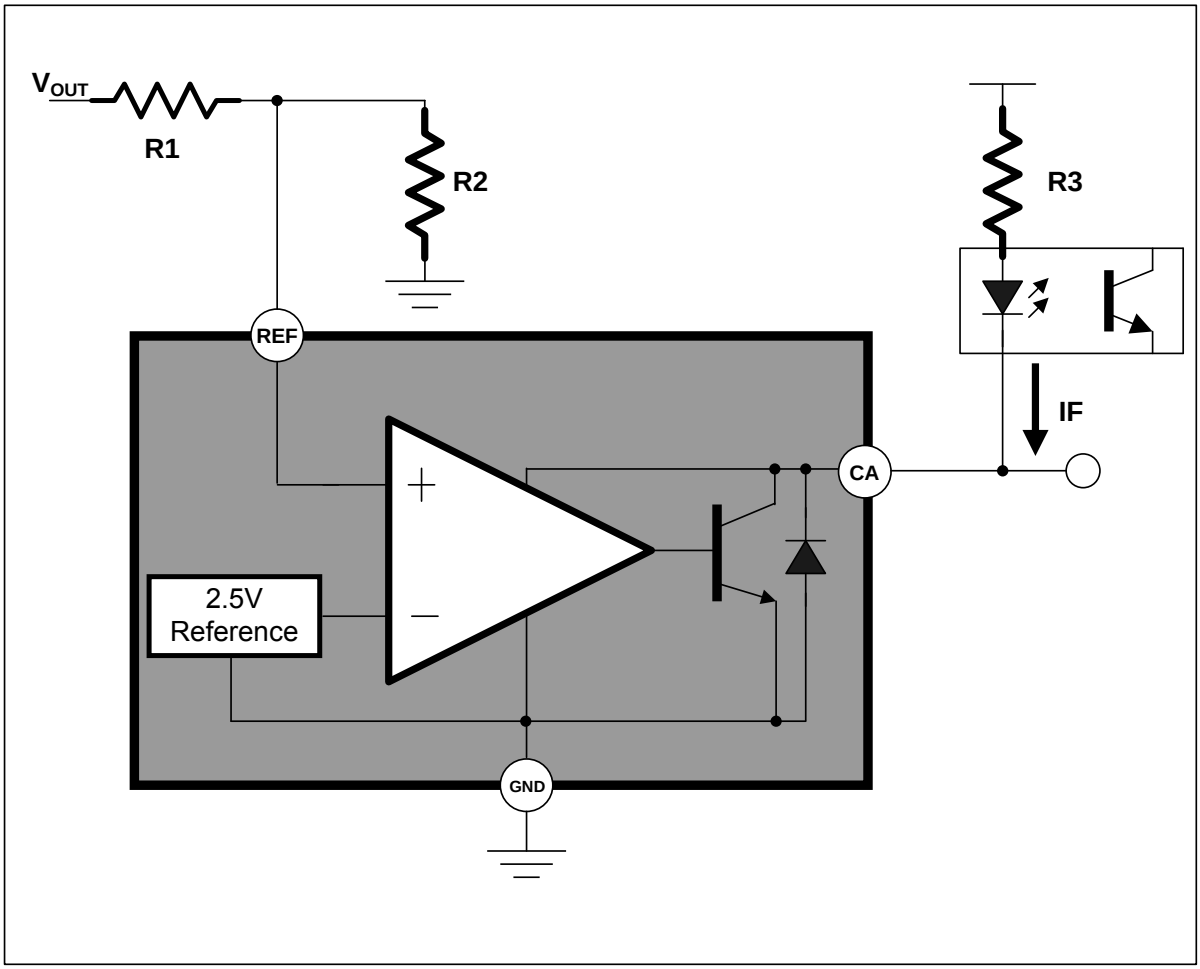
Voltage Shunt Regulator

The figure below shows the FP133 voltage shunt regulator. It includes an internal 2.5V voltage reference connecting to the comparator inverting input. The comparator's high cathode current sink ability is designed for photo-coupler driving.

The V_{OUT} equation is:

$$V_{OUT} = \left(1 + \frac{R1}{R2}\right) \times 2.5V \quad \text{---- (4)}$$



Note

1. Connect a compensation network between CA and REF pins to reduce high output voltage ringing during light loading or transient.
2. R3 is selectable for dynamic loading feedback.

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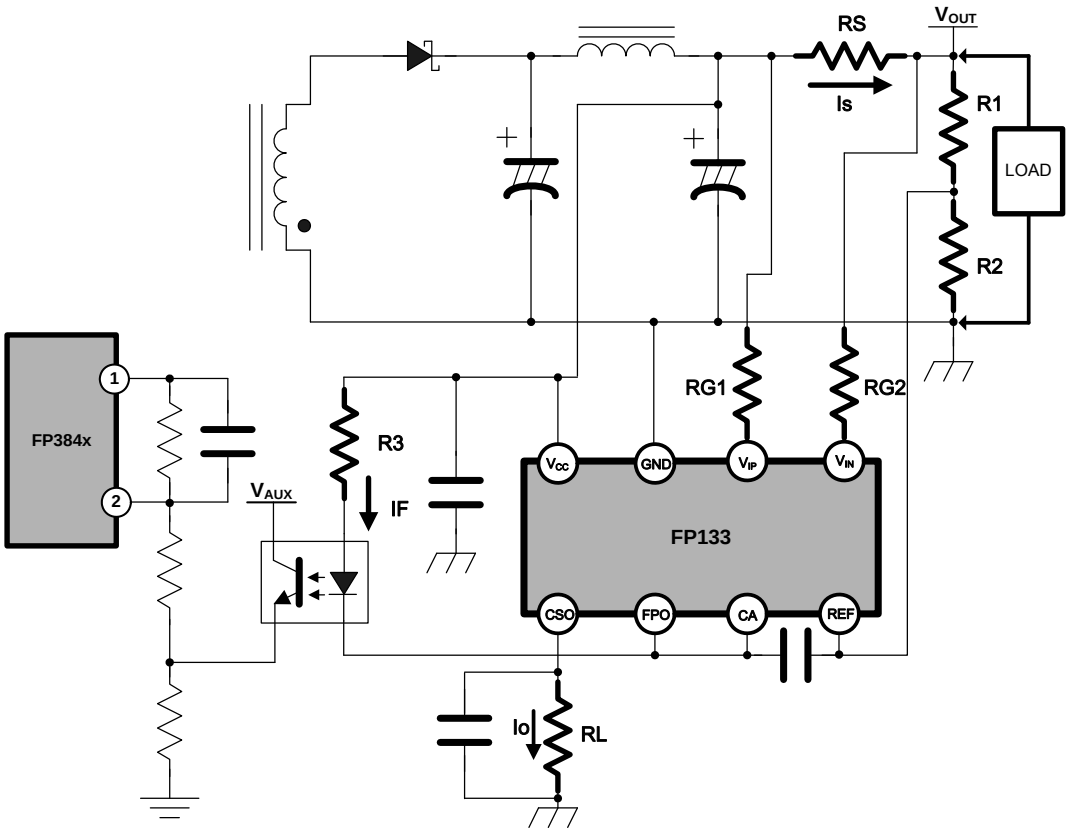

Adaptor secondary Voltage Feedback / Over Loading Protection circuit

The above circuit is a simple application for AC / DC adaptor over loading protection (OCP) function with output voltage feedback.

For example, when load current (I_S) increases, the FP133 CSO voltage would increase according to equation (2). Once the internal shutdown comparator's inverting input, which is connected to CSO pin, is higher than 1.25V reference, a sink current (I_{OUT}) will flow through the photo-coupler. The FP384x PWM IC will change the NMOS drive terminal to a minimum duty cycle current limitation for secondary side over current protection. The primary side auxiliary voltage can no longer maintain the FP384x power supply. The FP384x will be shutdown until AC line start-up voltage restart the PWM IC.

The FP133 voltage shunt regulator responses the output voltage change with R1 and R2. The feedback current will flow from photo-coupler to FP133 CA pin (pin4) and generates the feedback voltage signal to PWM IC FP384x.

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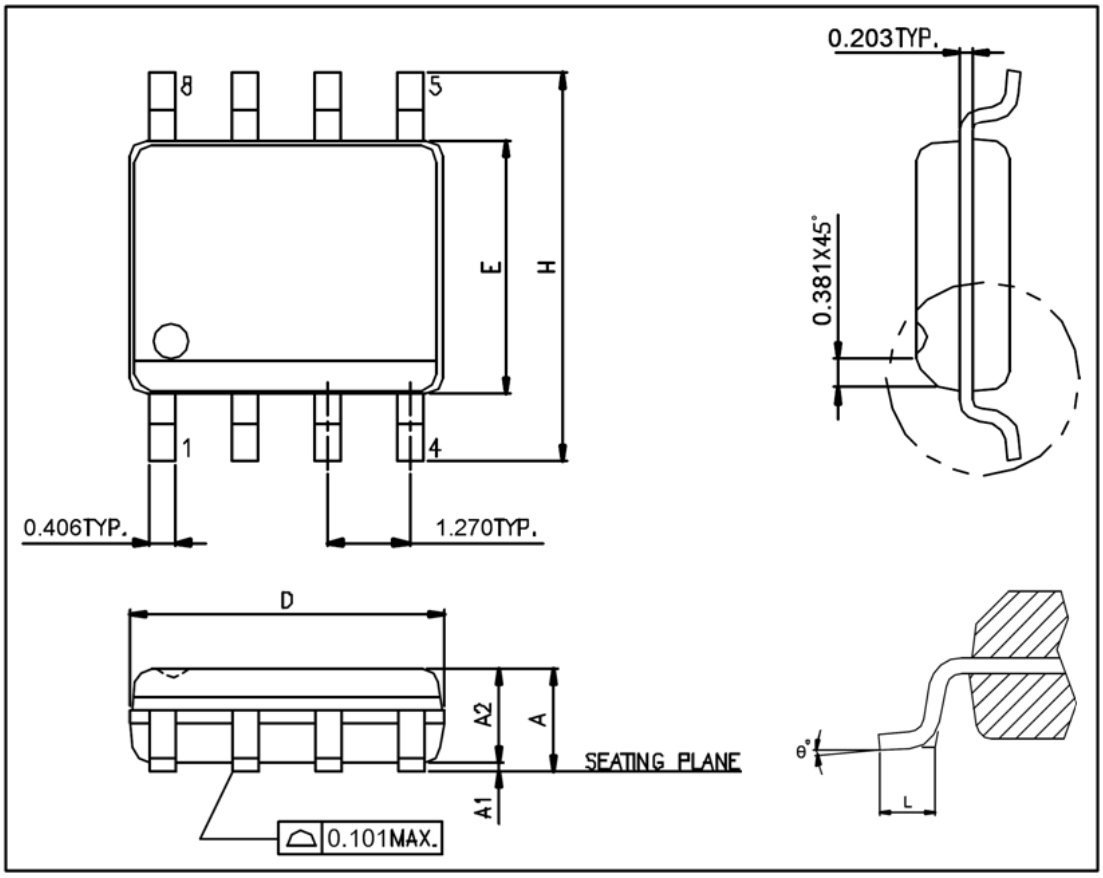
Package Outline

SOP-8L



UNIT: mm

Symbols	Min. (mm)	Max. (mm)
A	1.346	1.752
A1	0.101	0.254
A2	1.092	1.498
D	4.800	4.978
E	3.810	3.987
H	5.791	6.197
L	0.406	1.270
θ°	0°	8°

Note:

1. Package dimensions are in compliance with JEDEC Outline: MS-012 AA.
2. Dimension “D” does not include molding flash, protrusions or gate burrs.
3. Dimension “E” does not include inter-lead flash, or protrusions.

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