# 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.

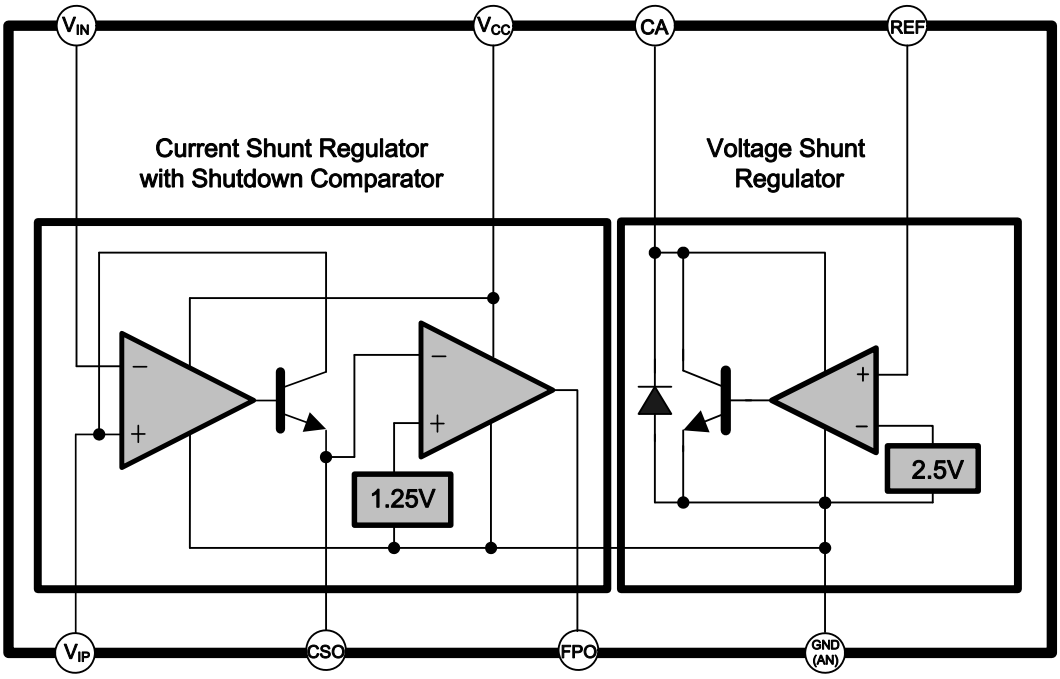
## Features

- 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

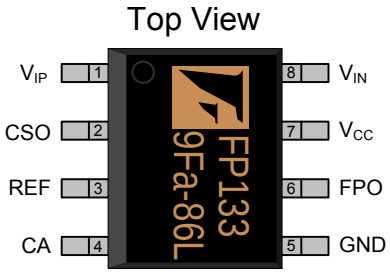
- SPS
- AC Adaptor
- Isolated Fly-back DC-DC Converter

## Function Block Diagram




## Pin Descriptions

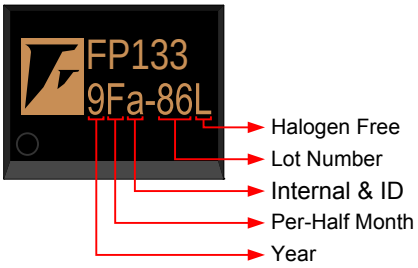
### SOP-8L




| 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 |

# 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

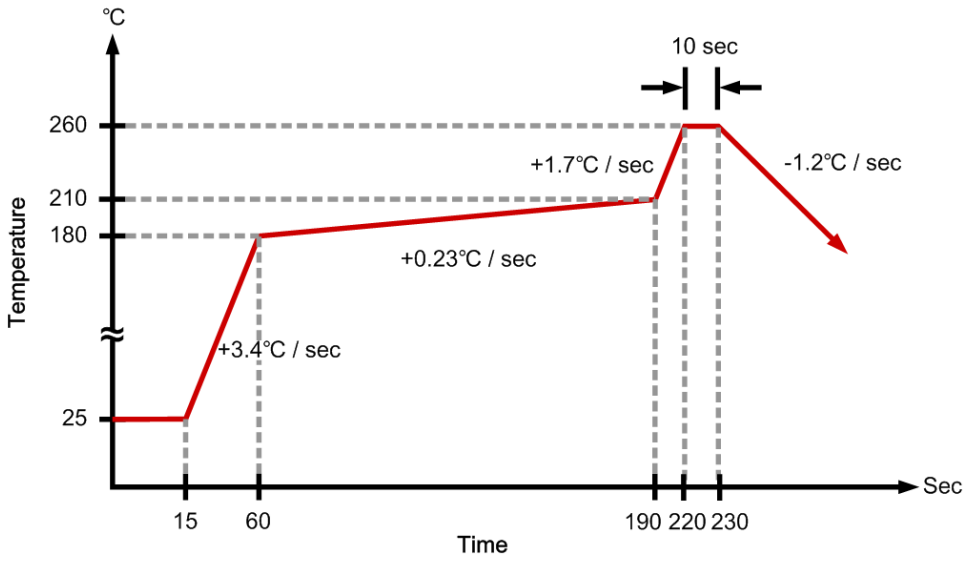
## Ordering Information

| 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



## 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 |

| 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 | $\Delta V_{REF}$ / $\Delta V_{KA}$ | $I_{KA}=10mA$, $V_{KA}$ =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 | $\Delta I_{REF}$ | 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 | $\|Z_{KA}\|$ | $V_{KA}=V_{REF}$, $\Delta I_{KA}$=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 |

# 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:

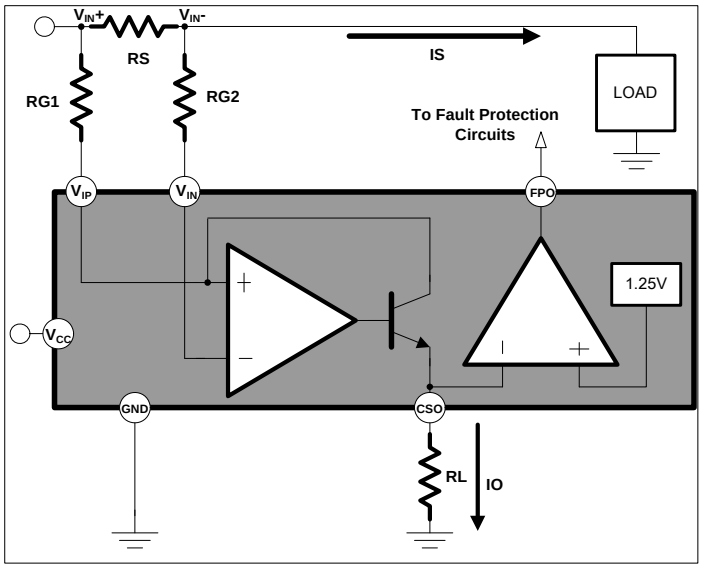
$$I_O = \frac{V_{IN}^+ - V_{IN}^-}{RG1} \quad \text{----- (1)}$$

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:**

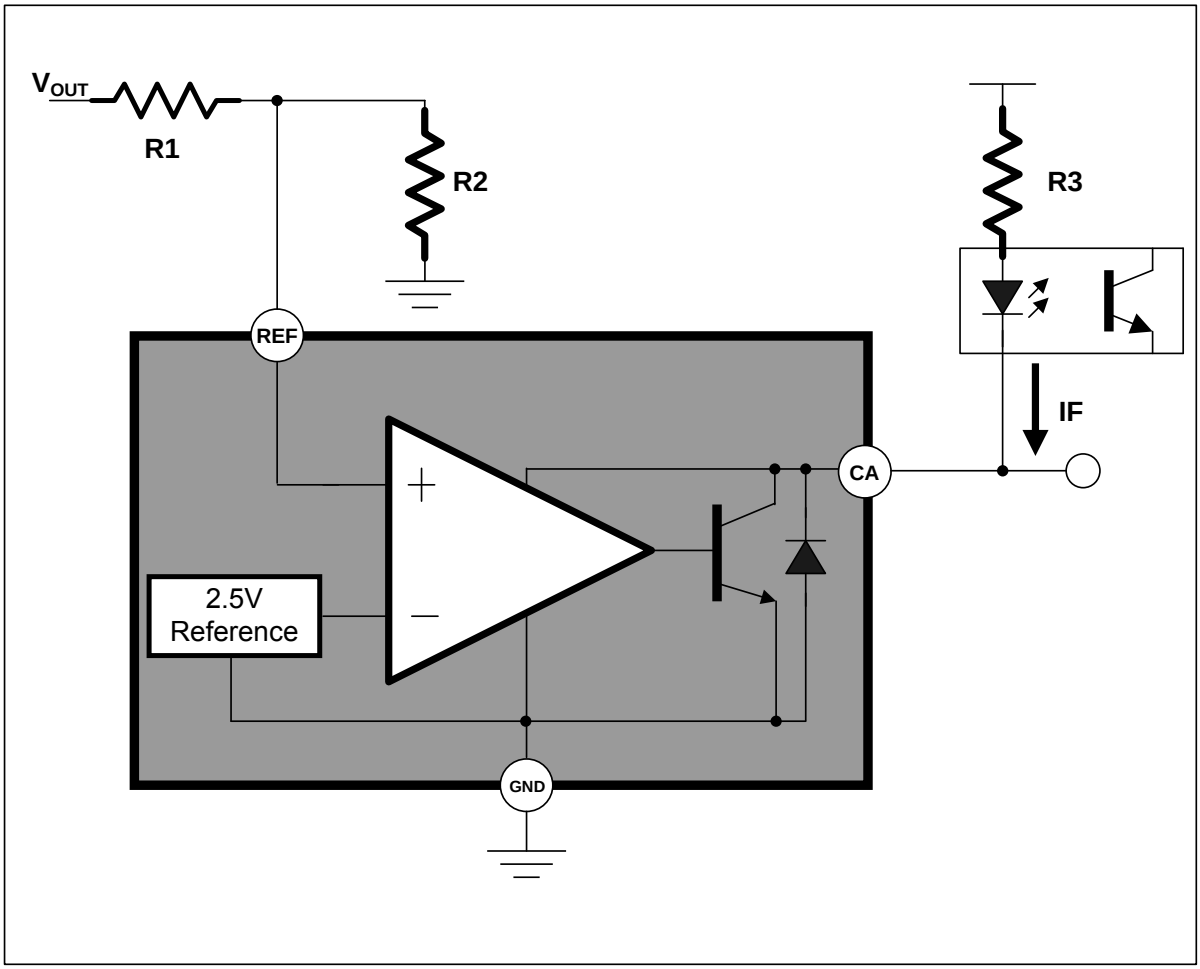
1. The minimum operating voltages of $V_{CC}$, $V_{IP}$ and $V_{IN}$ are 2.7V. If these supply voltages are lower than 2.7V, the transfer function at current shunt output (CSO) is no correct.
2. Do not force a $V_{IN}$ voltage that is 15V higher than $V_{IP}$. This condition would generate a leakage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

## 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.

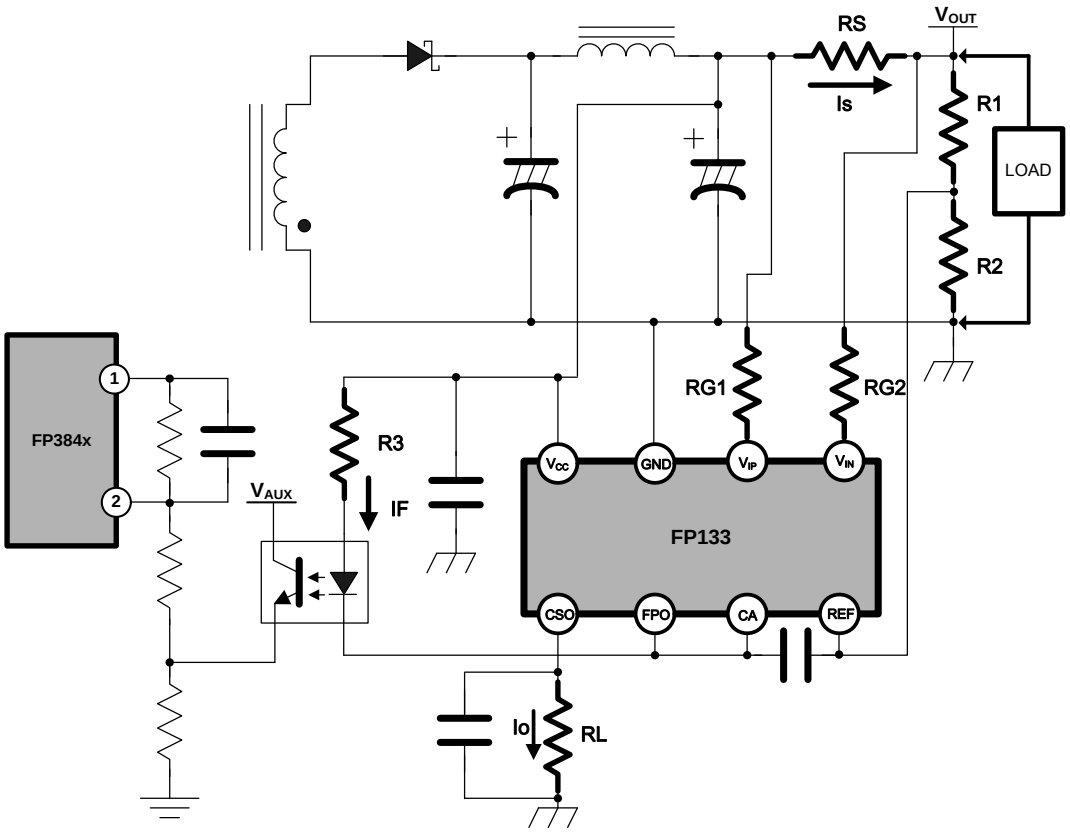
The $V_{OUT}$ equation is:

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




## 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.




Adaptor secondary Voltage Feedback / Over Loading Protection circuit

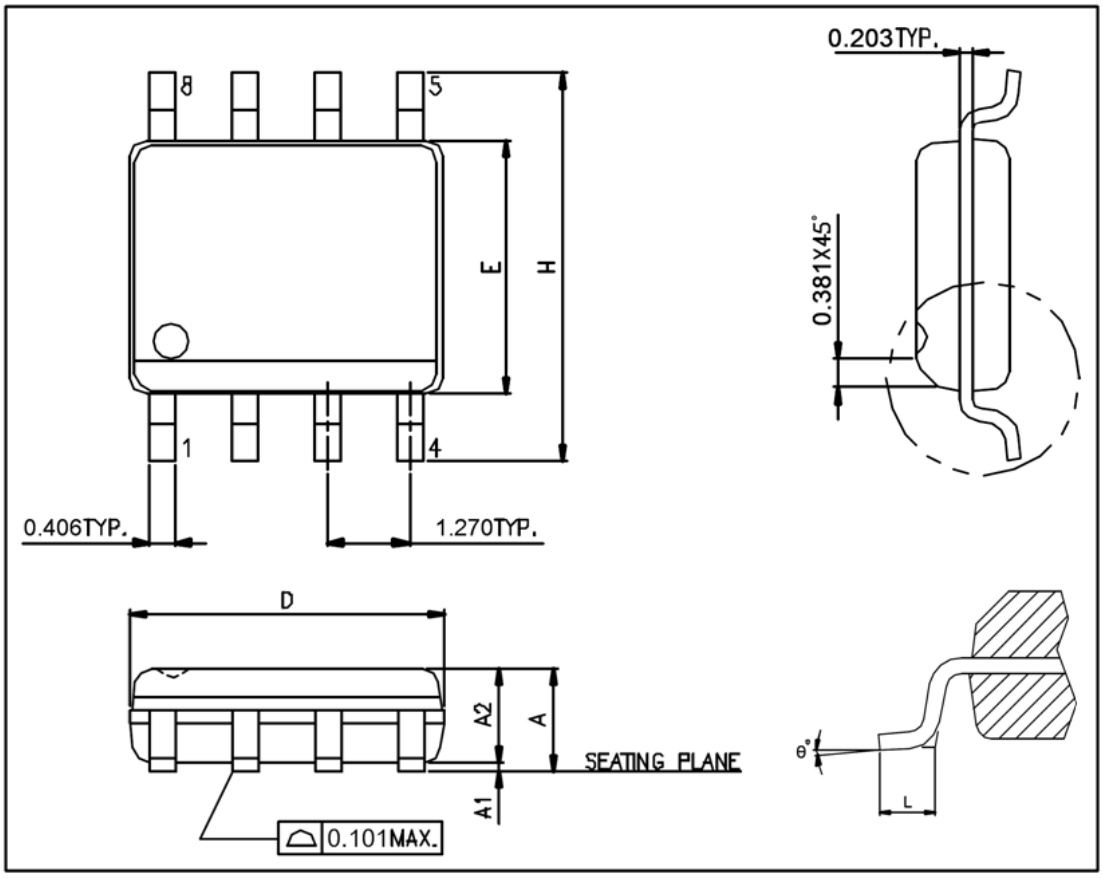
The above circuit is a simple application for AC / DC adaptor over loading protection (OCP) function with output voltage feedback.

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.

# 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.