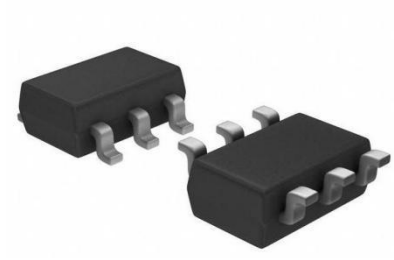
MORNSUN®

# SCM9301A Low-side Voltage Output Current Detection Amplifier

## Features

- Range of Operating Voltage: 6 to 30 VDC
- Set gain for external resistor: 10V/V, 20V/V, and 30V/V recommended
- Range of common-mode input voltage:
  When Rin/Ro=100Ω/1000Ω, $Vcm\_in_{20V/V} \in (0,0.9)V$
- Low temperature drift of gain
- Gain error as low as ±1%
- Input offset voltage is less than 1 mV
- Offset drift as low as 10 uV/℃
- Bandwidth above 1 MHz
- Range of Operating temperature: −40 to +125°C
- DC common mode rejection ratio up to 90 dB
- DC power supply rejection ratio up to 110 dB

## Package



Optional package for the product: SOT23-6, please see "Order Information" for details of silk screen printing.

## Application

- Low-side current detection
- Over current protection
- Power supply protection
- Circuit breaker

## Description

SCM9301A is a current detection amplifier chip, of which the gain can be set through the external I/O resistor, the recommended setting is 10-30 V/V, and the typical gain error over the range of temperature is as low as ±1%. Hence, this product is applicable for low-side current detection in a variety of ACDC and DCDC converters. The chip provides excellent common-mode rejection performance within the range of common-mode input, and the built-in LDO included, it is compatible with wide input range from 6 to 30V. SCM9301A perform one-way current measurement on shunt resistance, thus being suitable for various industrial applications. Within the temperature range from -40℃ to +125℃, the gain drift is as low as ±20 ppm/℃. The selection of different I/O impedance may affect the common-mode input range. Typically, when Rin/Ro=100Ω/1000Ω, the gain is 20 V/V, and the linear output is always available within the input common mode voltage range from 0 mV to 90 mV, the input offset voltage is typically 850 uV.

## Typical Application Circuit

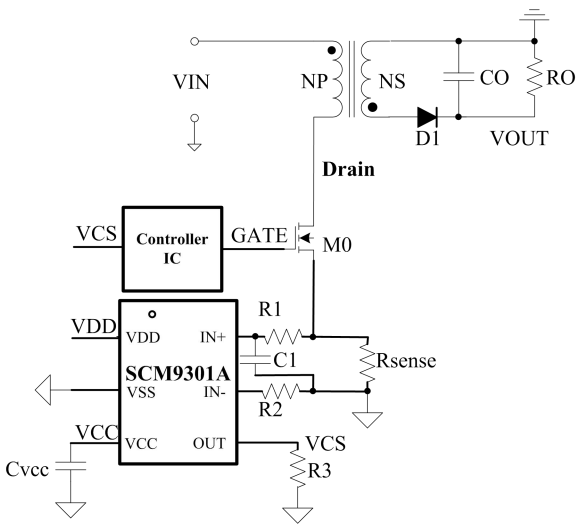



Fig. 1 Application Schematic diagram of SCM9301A applied in low-side detection of switching power supply

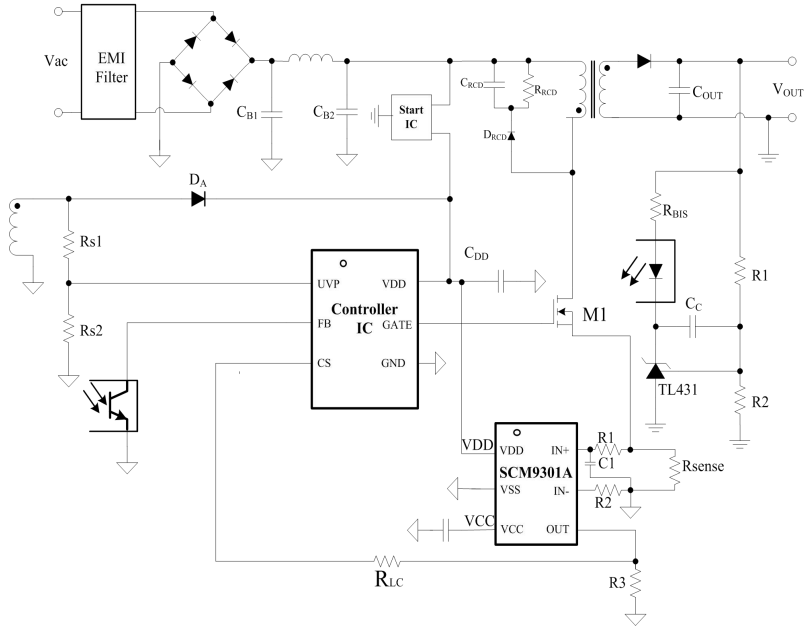



Fig. 2 Application schematic diagram of SCM9301A applied in ACDC switching power supply

## Contents



## Pin

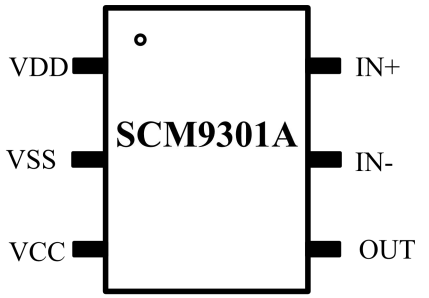



Fig. 3 SCM9301A package and pin diagram

## Inter Block Diagram

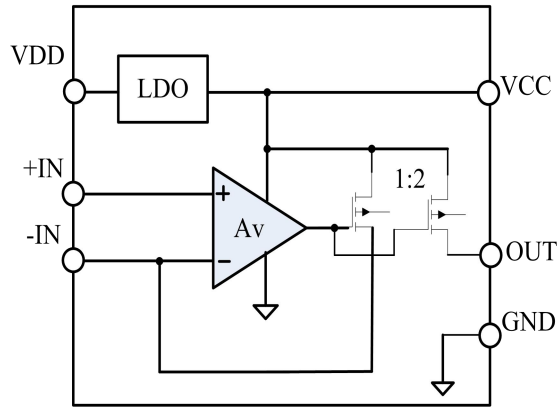



Fig. 4 Chip Internal block diagram of SCM9301A

## Pin Description

| No. | Name | I/O | Description |
|---|---|---|---|
| 1 | VDD | P | Chip power port |
| 2 | VSS | I | Chip ground port |
| 3 | VCC | I/O | External bypass capacitor , the internal low-voltage supply port |
| 4 | OUT | O | Current detection amplifier output pin |
| 5 | IN- | I | Inverting input pin of amplifier |
| 6 | IN+ | I | Non-inverting input pin of amplifier |

## Absolute Maximum Ratings

The following were collected in natural ventilation and normal operating temperature range (unless otherwise specified).

| Parameter | Symbols | Min | Max | Unit |
|---|---|---|---|---|
| Bias supply voltage | $V_{VDD}$ | 6 | 30 | V |
| VCC voltage | $V_{VCC}$ | -0.6 | 6 | V |
| Output voltage | $V_{OUT}$ | 0 | 5 | V |
| Maximum input voltage | Pressure between IN+ and IN- | | 0.3 | V |
| Storage temperature | $T_{STG}$ | -55 | 150 | ℃ |
| Operating junction temperature range | $T_J$ | -40 | 150 | |
| Soldering Temperature (Allowable reflow soldering temperature of chip within 10 seconds) | | | 260 | |
| Moisture Sensitivity Level | MSL | MSL1 | | |
| Electrostatic discharge (ESD) ratings | Human Body Model (HBM) | -4000 | 4000 | V |
| | Charging Device Model (CDM) | -1000 | 1000 | |

Note: If the stress values in the “Absolute Maximum Ratings” table are exceeded, it may cause permanent damage to the devices. Working under extreme rated conditions for a long time may affect the reliability of the device. All voltage values are based on the reference ground (GND).

## Recommended Operating Conditions

unless otherwise specified, the following parameters are tested at nomal temperature ($V_{VDD}$=8V,OUT with Cload=10pF)

| Corresponding parameters | | Min | Max | Unit |
|---|---|---|---|---|
| Bias supply voltage | $V_{VDD}$ | 6 | 30 | V |
| VCC bypass capacitance | $C_{VCC}$ | 1 | 10 | uF |
| Maximum operating frequency | $F_{sw}$ | 0.1 | 0.5 | MHz |
| Operating temperature | $T_J$ | -40 | 125 | ℃ |

## Electrical Characteristics

unless otherwise specified, the following parameters are tested at nomal temperature ($V_{VDD}$=8V,OUT with Cload=10pF)

| Symbols | Corresponding parameters | Test condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Chip power supply terminal (VDD pin) | | | | | | |
| VDD | Range of operating voltage | | 6 | | 30 | V |
| Ivdd | Statistic operating current | Vsense=0mV, Vcm_in=0V, $V_{VDD}$=8V, VCC suspended | 240 | 320 | 400 | uA |
| Ivdd_op | Operating current | Rin/Ro=100/1000Ω, Vsense=45mV, Vcm_in=0V $V_{VDD}$=8V, VCC suspended | 1.6 | 1.9 | 2.2 | mA |
| PSRR | Power supply rejection ratio | Range of common-mode input Throughout the range of temperature | | 120 | | dB |
| Input port (IN+, IN- pin) | | | | | | |
| Gain | Gain | Rin/Ro=1/10,Rin∈(40,100)Ω | | 20 | | V/V |
| AG | Accuracy | Throughout the range of common-mode input | | ±3 | | % |
| | Accuracy | Throughout the temperature range | | ±1 | ±5 | % |
| | Gain drift | | | 35 | 55 | ppm/℃ |
| Vos | Offset voltage | Throughout the range of common-mode input Throughout the range of temperature | | 0.5 | 2 | mV |
| Vos/T | Offset voltage drift | | | 10 | 15 | uV/℃ |
| Vcm_in | Common-mode input voltage range | Rin/Ro=100/1000Ω Amplification factor 20 V/V Vdm_in=45mV | 0 | | 0.9 | V |
| Vdm_in | Differential input voltage range | Rin/Ro=100/1000Ω Amplification factor 20 V/V Vcm_in,=0mV | | 100 | | mV |
| CMRR | Common-mode rejection ratio | Throughout the range of common-mode input Throughout the range of temperature | | 80 | | dB |
| Output port (OUT pin) | | | | | | |
| $V_{OUTmin}$ | Lower limit of output voltage range | | | 30 | | mV |
| $V_{OUTmax}$ | Upper limit of output voltage range | | 4 | 4.5 | | V |
| Dynamic response and others | | | | | | |
| BW_3dB | Small signal | | | 0.5 | 1 | MHz |
| SR | Slew rate | | | 13 | | V/uS |
| $T_{OP}$ | Temperature range | | -40 | | 125 | ℃ |

Note:VCC cannot be uesd as an external reference voltage.

## Typical Curves

The curves are determined for the 20V/V with Vdm_in=45mV and Vcm_in,=0V, unless otherwise specified.

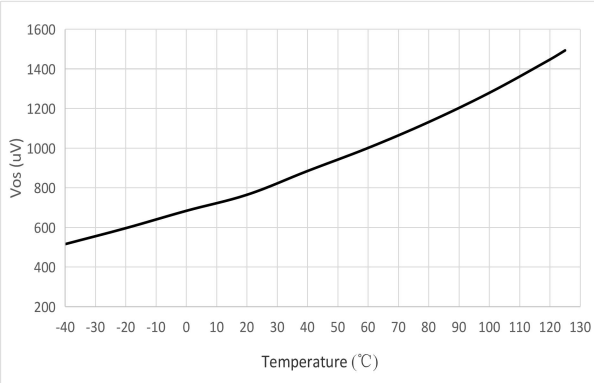



Fig. 5 Typical input offset VS Temperature Vdm/cm_in=0V

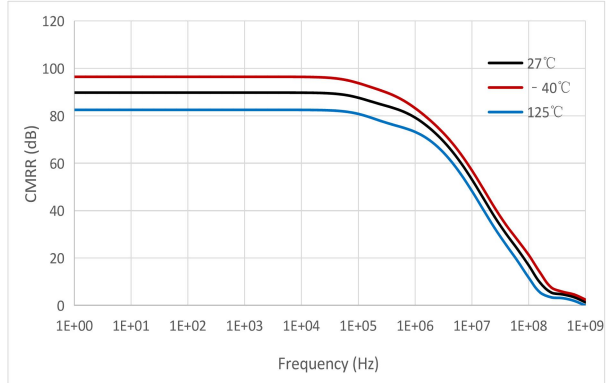



Fig. 6 Typical CMRR VS Frequency

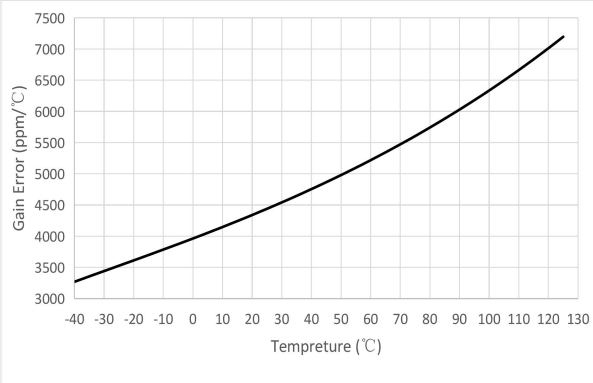



Fig. 7 Typical gain error VS Temperature

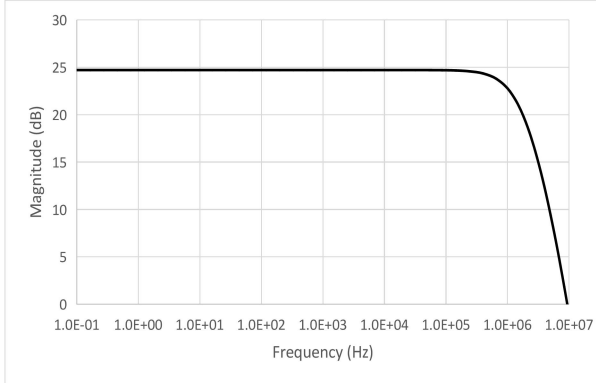



Fig. 8 Typical small signal bandwidth

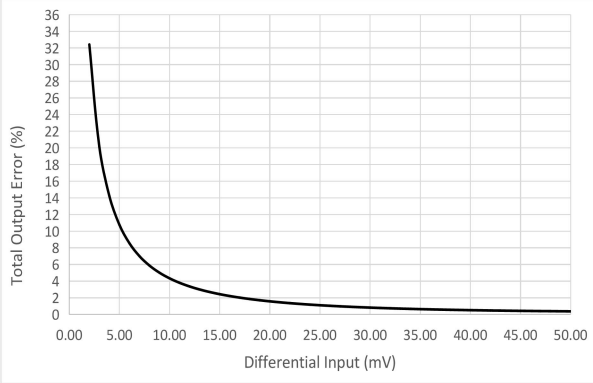



Fig. 9 Total output error VS Differential input voltage

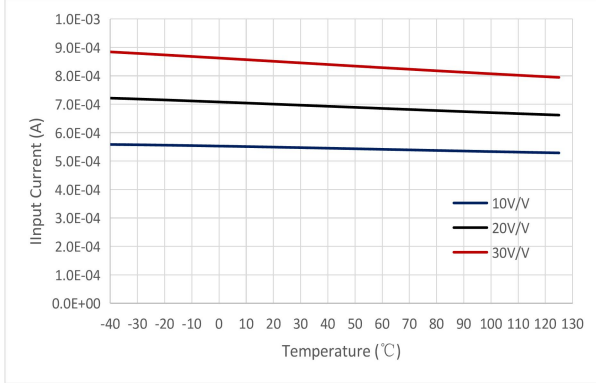



Fig. 10 VDD input current VS Temperature

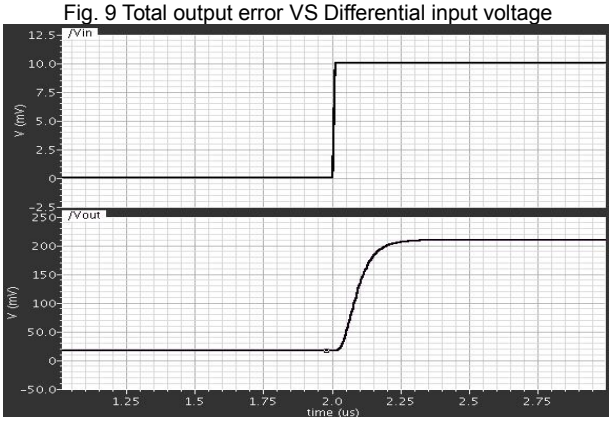



Fig. 11 Rise time (differential input = 10 mV)

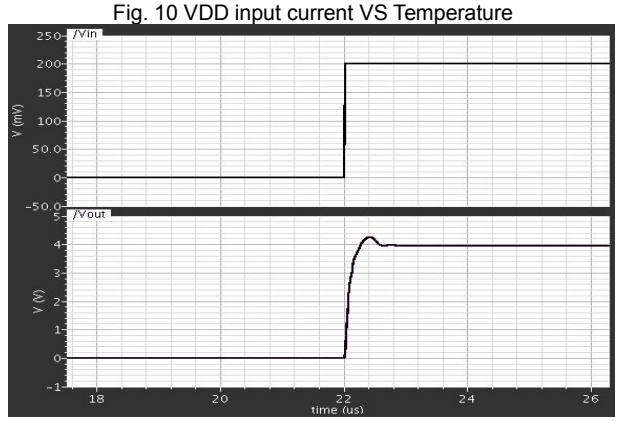



Fig. 12 Rise time (differential input = 200 mV)

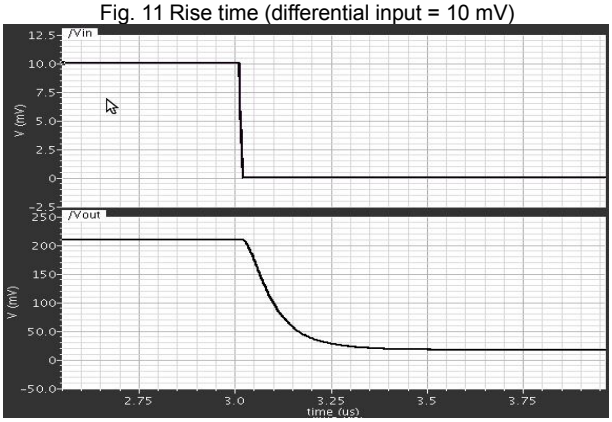



Fig. 13 Fall time (differential input = 10 mV)

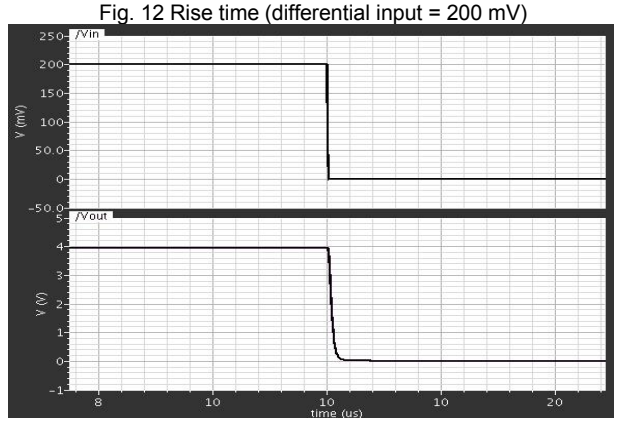



Fig. 14 Fall time (differential input = 200 mV)

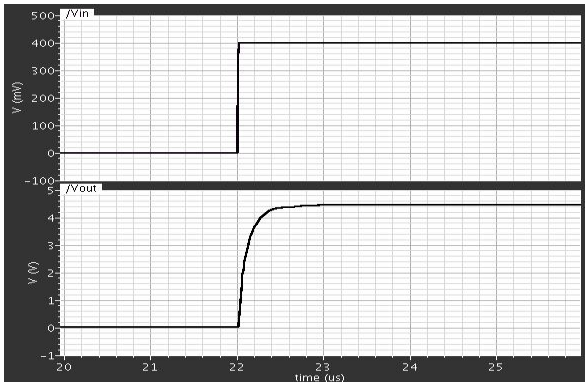



Fig. 15 Differential overload recovery time (rise)

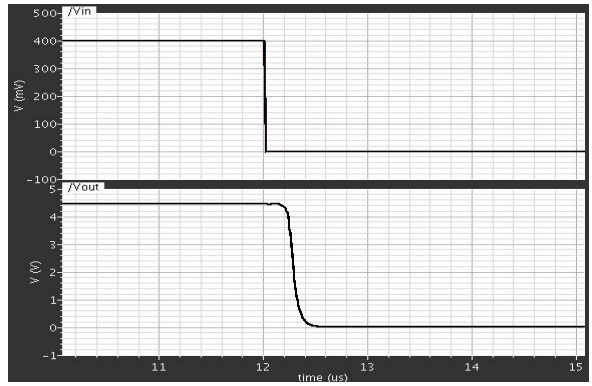



Fig. 16 Differential overload recovery time (fall)

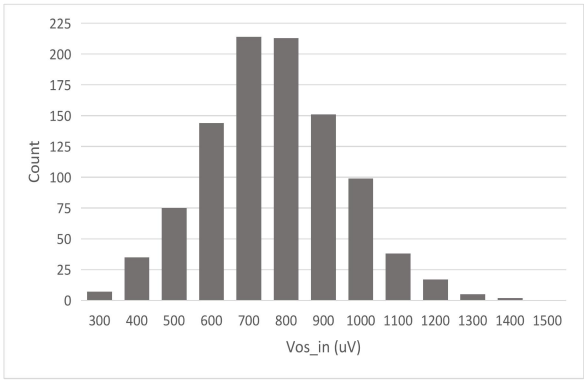



Fig. 17 Input offset voltage distribution

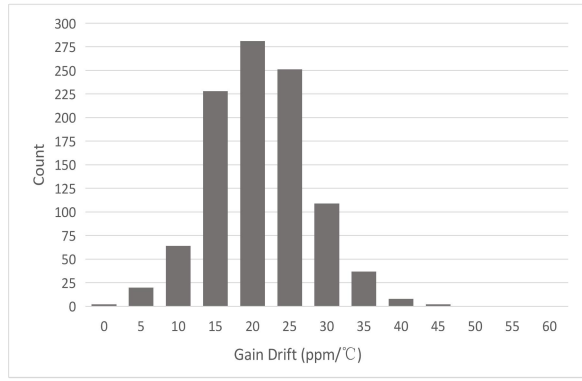



Fig. 18 Gain drift distribution

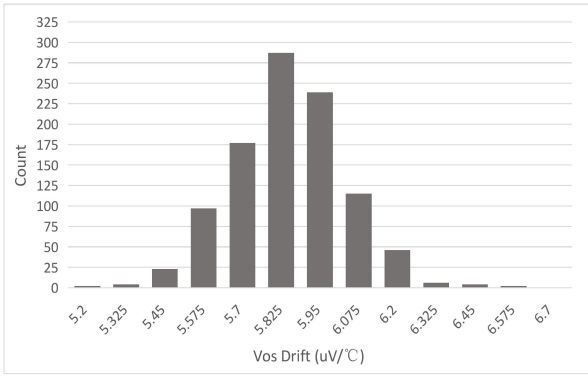



Fig. 19 Input offset drift distribution

## Chip Overview

SCM9301A is a current detection amplifier chip suitable for low-side current detection in a variety of ACDC and DCDC converters. It's principally designed to receive current on the main power loop , to obtain the detection voltage on the external detection resistor and to achieve non-destructive detection with adjustable peak current, different amplification factors are available within a certain range by adjusting the ratio of external resistance, the detection voltage is used as the differential input, and output as relatively high voltage value after being amplified by the current detection amplifier. This feedback to the control IC improves the signal-to-noise ratio of the detection signal under light load, thus enhancing the anti-interference capacity of detection. The following values are the typical values determined at normal temperature and atmospheric pressure with $V_{VDD}$=8V and Cload=10pF, unless otherwise specified.

## Operating Principle

In typical applications, SCM9301A amplifies the differential input voltage generated by the switching current passing through the resistor, suppresses the common-mode voltage and provides a buffer output with ground as reference for use in conjunction with the power controller IC. The figure below shows a simplified electrical schematic diagram of SCM9301A in application.

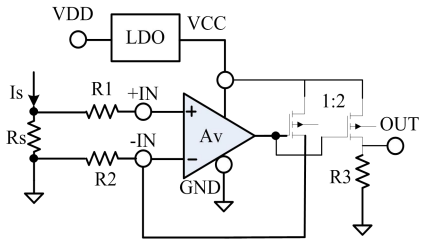



Fig. 20 Simplified schematic diagram

SCM9301A is configured as a differential amplifier. Transfer function:

$$Vout = k * \frac{R_3}{R_1} * (V_{IN+} - V_{IN-})$$

Resistors R3, R1 and R2 are external resistors recommended to be of the same type with the same accuracy, k represents the output current mirror ratio. In this version, k=2, corresponding to the total gain of SCM9301A from input to output is 20 V/V respectively. SCM9301A can accurately amplify the input differential signal, the main amplifier is designed in a symmetrical architecture, and the device offers excellent temperature stability, the typical offset drift is less than ±10uV/℃. Therefore, its accuracy and dynamic range are excellent.

## Input Connection

SCM9301A is specially designed for low-side detection. Its two input terminals are connected to the emitter of BJT tube via resistors R1 and R2, so the common-mode range of input is narrow, users are recommended to connect IN- to ground, for the voltage range of pin IN+, refer to the common-mode input voltage range and differential input voltage range recommended by the electrical parameters.

## Output Clamping

SCM9301A contains an LDO that allows the device to draw electricity directly from the high voltage rail, once the VDD voltage is higher than 6 V, the LDO output reaches the maximum value of 5.1 V, which is also the upper limit of the output voltage range of SCM9301A. Since the SCM9301A output terminal is usually connected to power control IC, the maximum output voltage range of 5.1 V ensure that the input terminal of control IC will not be damaged by excessive voltage.

## Output Linearity

Regardless of the input differential or common-mode voltage, the current detection amplifier must maintain the linearity of rated output. Even if the differential input voltage is extremely low, SCM9301A can maintain a high input-to-output linearity. Within the corresponding common-mode input range, SCM9301A can provide the correct output voltage as long as the input differential is at least 1 mV. This ability enables SCM9301A to achieve the suitable dynamic range, accuracy and flexibility in any application of current detection.

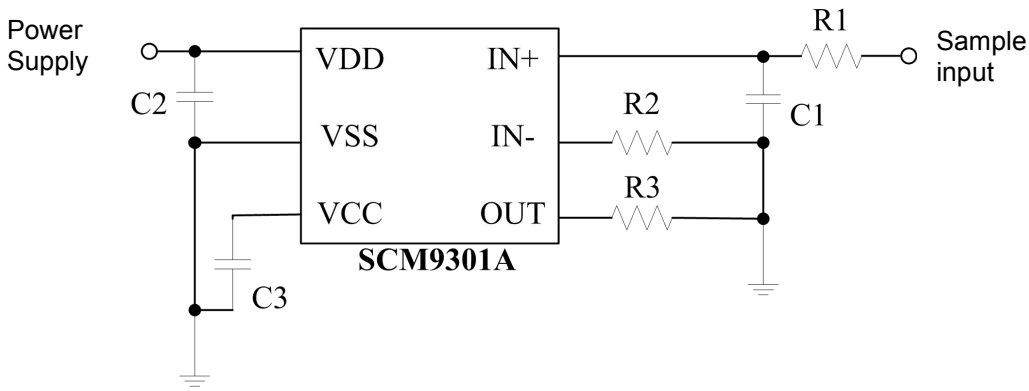
## Recommendations

1. Since the maximum output current of the SCM9301A linear amplification area is 2 mA, the resistor is selected to ensure R3*2mA≥Vcspk (as shown below), where Vcspk represents the maximum current sample voltage value feedback to the chip.

2. To achieve the best performance, one end of filter capacitor C1 is connected to IN+, while the other is connected to GND.

3. The static operating current of the chip is 1.7 mA, the general input voltage is about 15 V, and the power consumption is 25.5 mW. Therefore, the SCM9301A is not suitable for applications with harsh standby power consumption.

4. Adding C1 during operation of SCM9301A may increase the delay time, which is limited for high frequency applications. The specific delay data is related to the value of C1, the larger the value, the longer the delay time.



## Order Information

| Product model | Package | Pin count | Silk screen | Package |
|---|---|---|---|---|
| SCM9301ATA | SOT23-6 | 6 | 9301 YM | 3K/reel |

Product Model and Silk Screen Designation

SCM9301XYZ:

(1) SCM9301, product code.

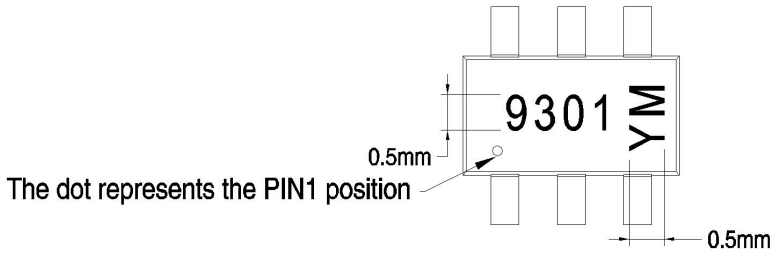
(2) X = A-Z, version code.

(3) Y = S, package code, T: SOT package.

(4) Z = C,I,A,M, temperature rating code, C: 0°C-70°C, I: -40°C-85°C, A: -40°C-125°C, M: -55°C-125°C.

(5) YM: Product traceability code, Y: Year of manufacture, M: Month of manufacture.

## Silk Screen Information



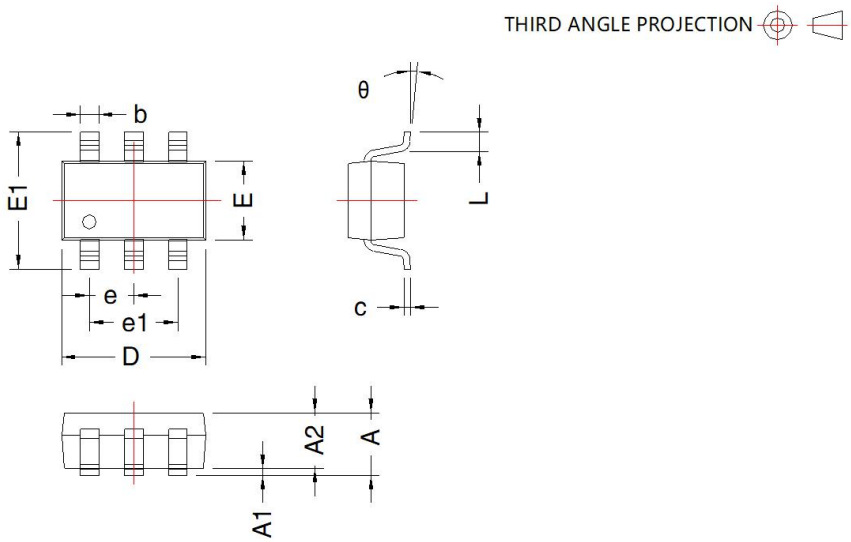

Note:

1、Typeface: Arial;

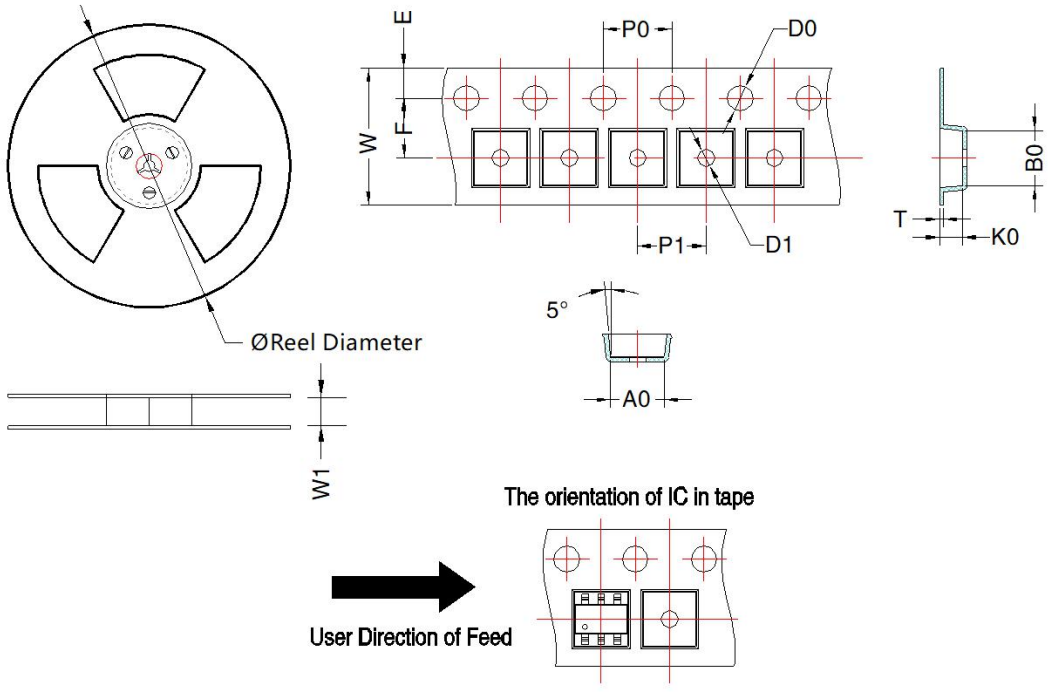
2、Character size:

Height: 0.5mm, Spacing: 0.1mm

## Package Information




| SOT23-6 | | | | |
|---|---|---|---|---|
| Mark | Dimension(mm) | | Dimension(inch) | |
| | Min | Max | Min | Max |
| A | 1.05 | 1.25 | 0.041 | 0.049 |
| A1 | 0 | 0.10 | 0 | 0.004 |
| A2 | 1.05 | 1.15 | 0.041 | 0.045 |
| D | 2.82 | 3.02 | 0.111 | 0.119 |
| E | 1.50 | 1.70 | 0.059 | 0.067 |
| E1 | 2.65 | 2.95 | 0.104 | 0.116 |
| L | 0.30 | 0.60 | 0.012 | 0.024 |
| b | 0.30 | 0.50 | 0.012 | 0.02 |
| e | 0.95 TYP | | 0.037 TYP | |
| e1 | 1.80 | 2.00 | 0.071 | 0.079 |
| c | 0.10 | 0.20 | 0.004 | 0.008 |
| θ | 0° | 8° | 0° | 8° |




| Device | Package Type | MPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | T (mm) | W (mm) | E (mm) | F (mm) | P1 (mm) | P0 (mm) | D0 (mm) | D1 (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SCM9301ATA | SOT23-6 | 3000 | 180.0 | 8.5 | 3.17 | 3.23 | 1.37 | 0.25 | 8.0 | 1.75 | 3.5 | 4 | 4 | 1.5 | 1.0 |

**Mornsun Guangzhou Science & Technology Co.,Ltd.**

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