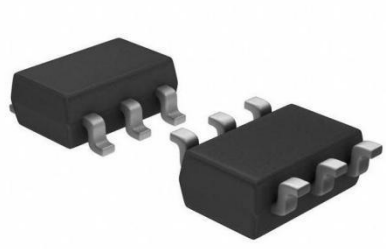
MORNSUN®

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

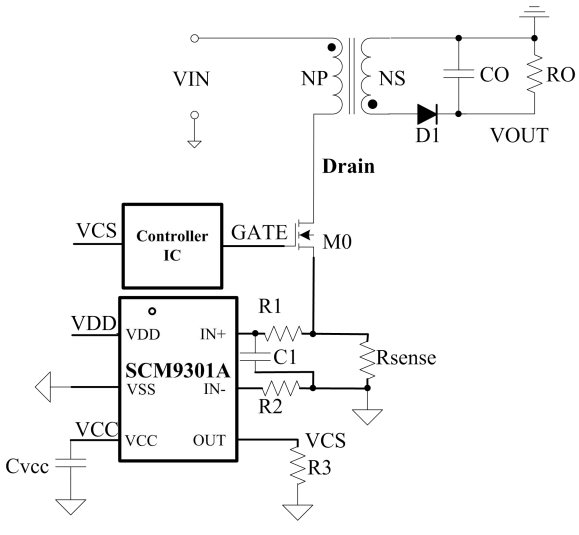


Fig. 1 Application Schematic diagram of SCM9301A applied in low-side detection of switching power supply

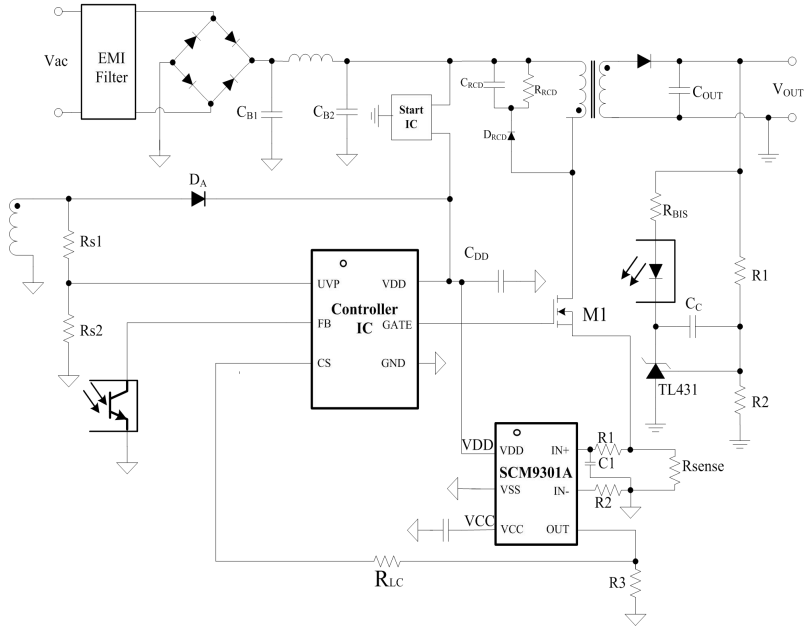


Fig. 2 Application schematic diagram of SCM9301A applied in ACDC switching power supply

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Pin

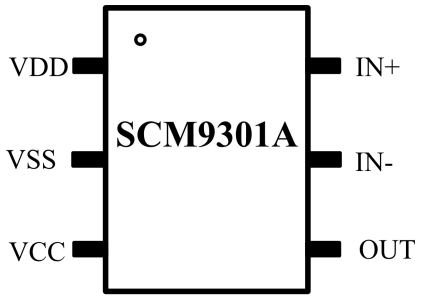

Fig. 3 SCM9301A package and pin diagram

Inter Block Diagram

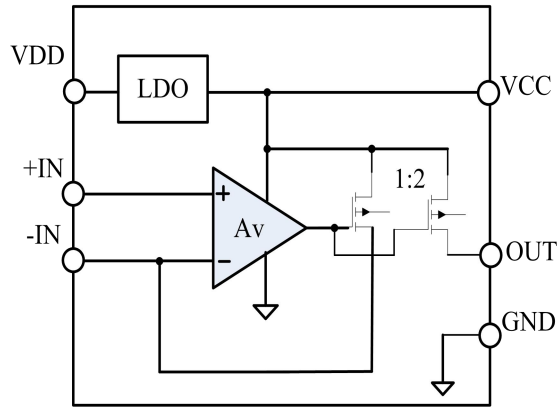

Fig. 4 Chip Internal block diagram of SCM9301A

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).

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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.

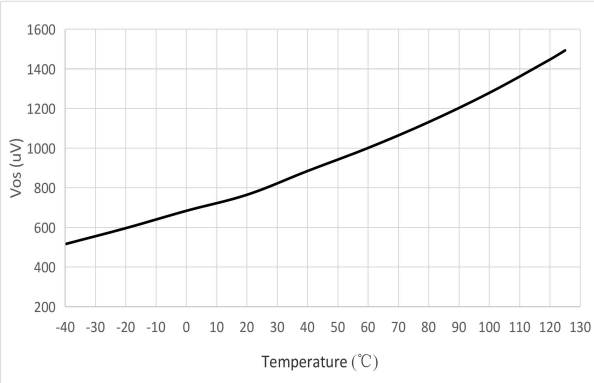

Fig. 5 Typical input offset VS Temperature Vdm/cm_in=0V

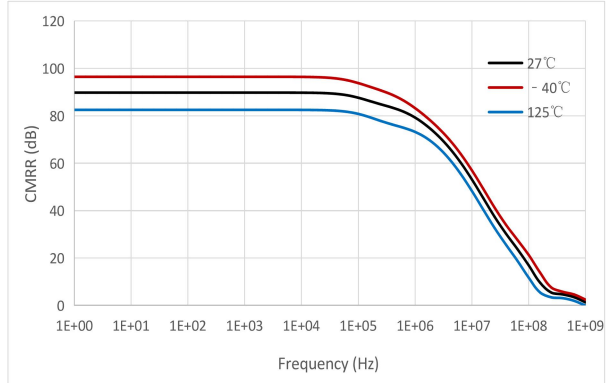

Fig. 6 Typical CMRR VS Frequency

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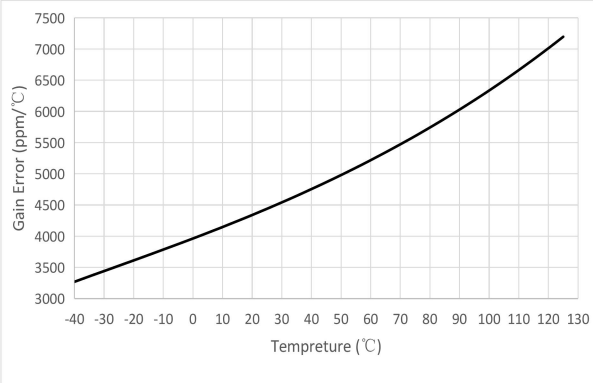

Fig. 7 Typical gain error VS Temperature

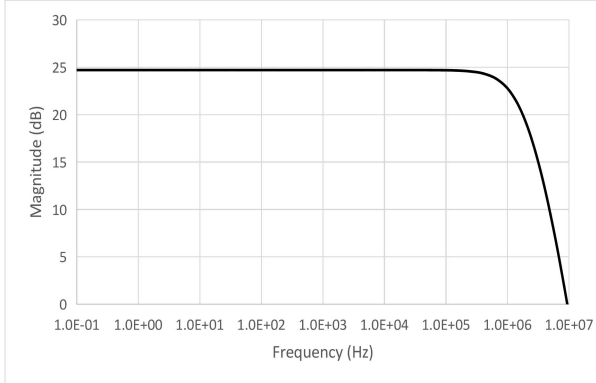

Fig. 8 Typical small signal bandwidth

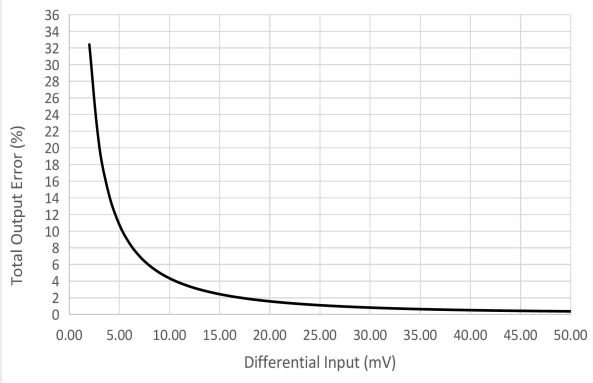

Fig. 9 Total output error VS Differential input voltage

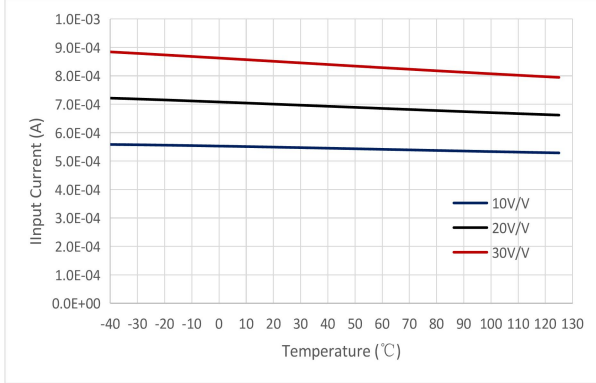

Fig. 10 VDD input current VS Temperature

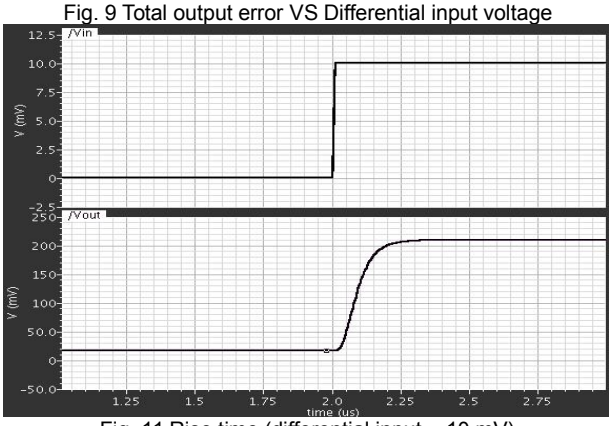

Fig. 11 Rise time (differential input = 10 mV)

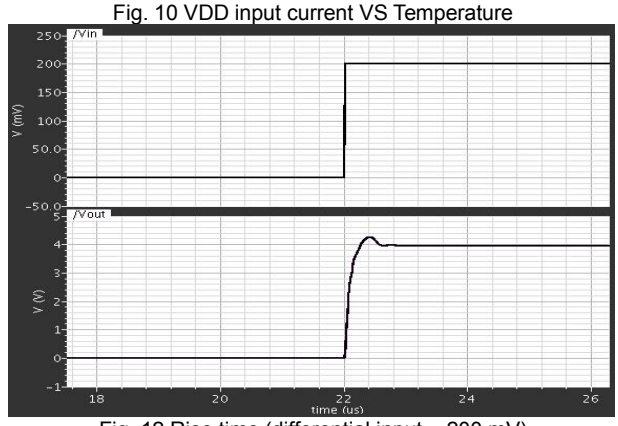

Fig. 12 Rise time (differential input = 200 mV)

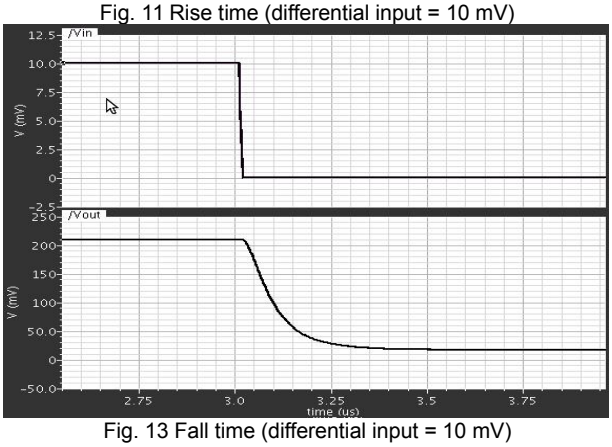

Fig. 13 Fall time (differential input = 10 mV)

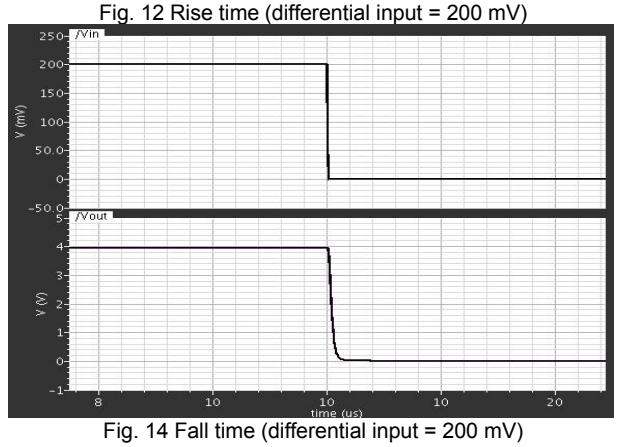

Fig. 14 Fall time (differential input = 200 mV)

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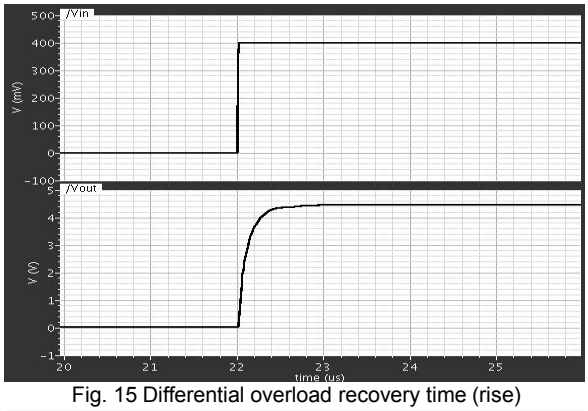

Fig. 15 Differential overload recovery time (rise)

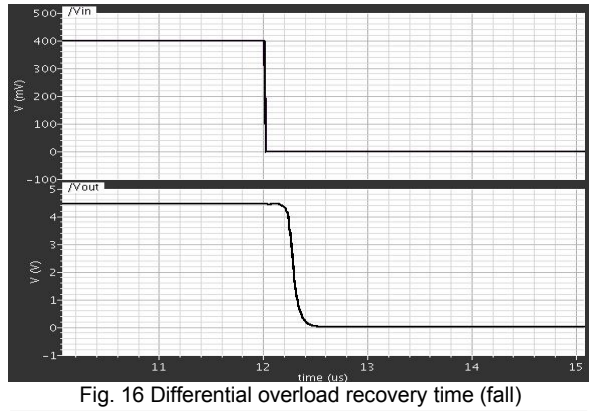

Fig. 16 Differential overload recovery time (fall)

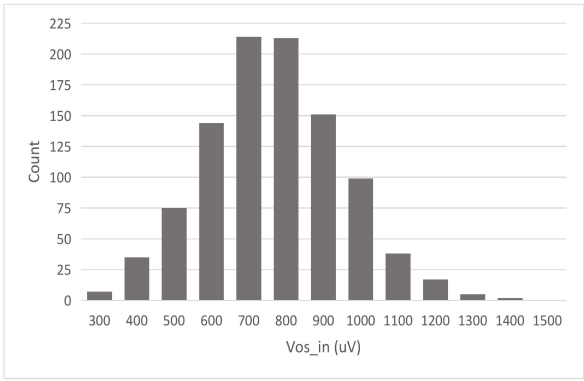

Fig. 17 Input offset voltage distribution

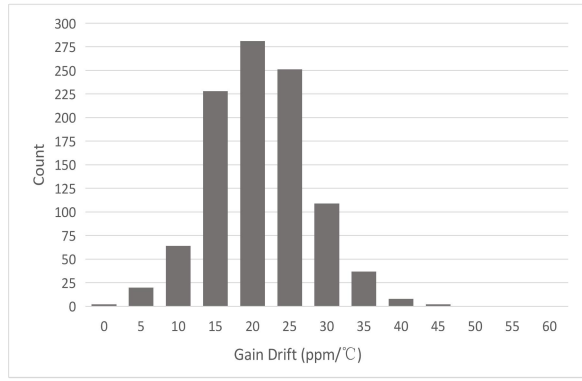

Fig. 18 Gain drift distribution

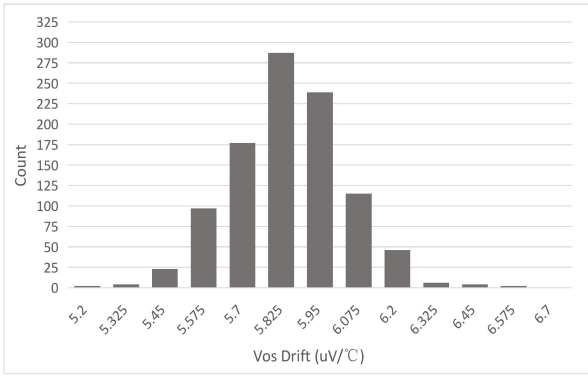

Fig. 19 Input offset drift distribution

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.

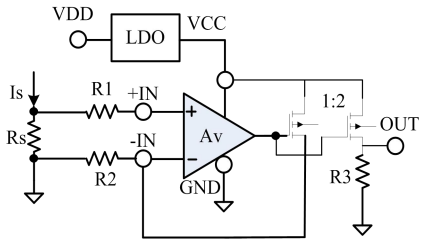

Fig. 20 Simplified schematic diagram

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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.

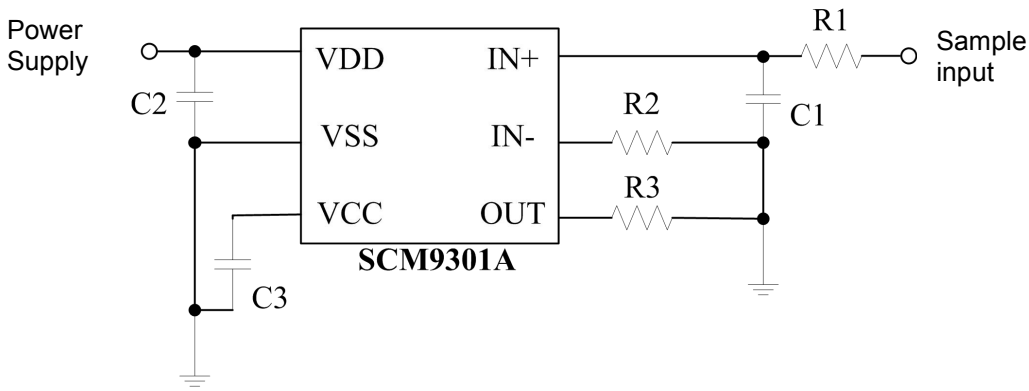
Recommendations

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.



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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.

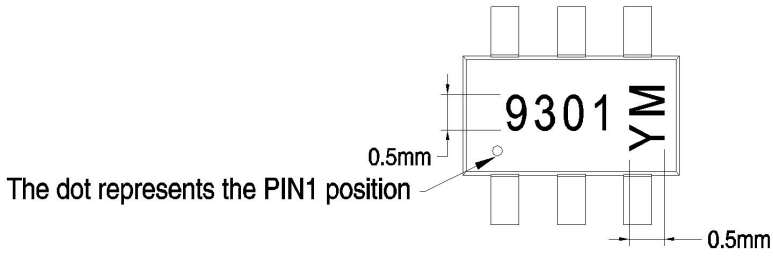
(2) X = A-Z, version code.

(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



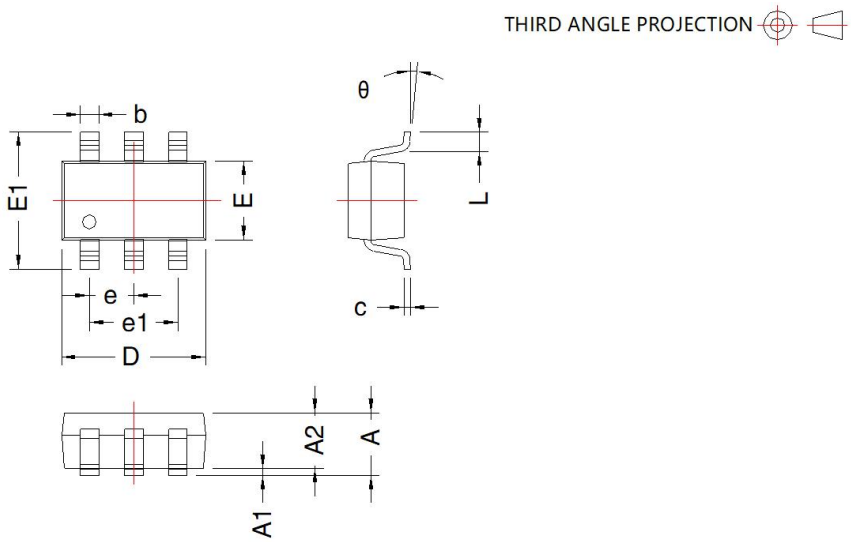
Note:

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°

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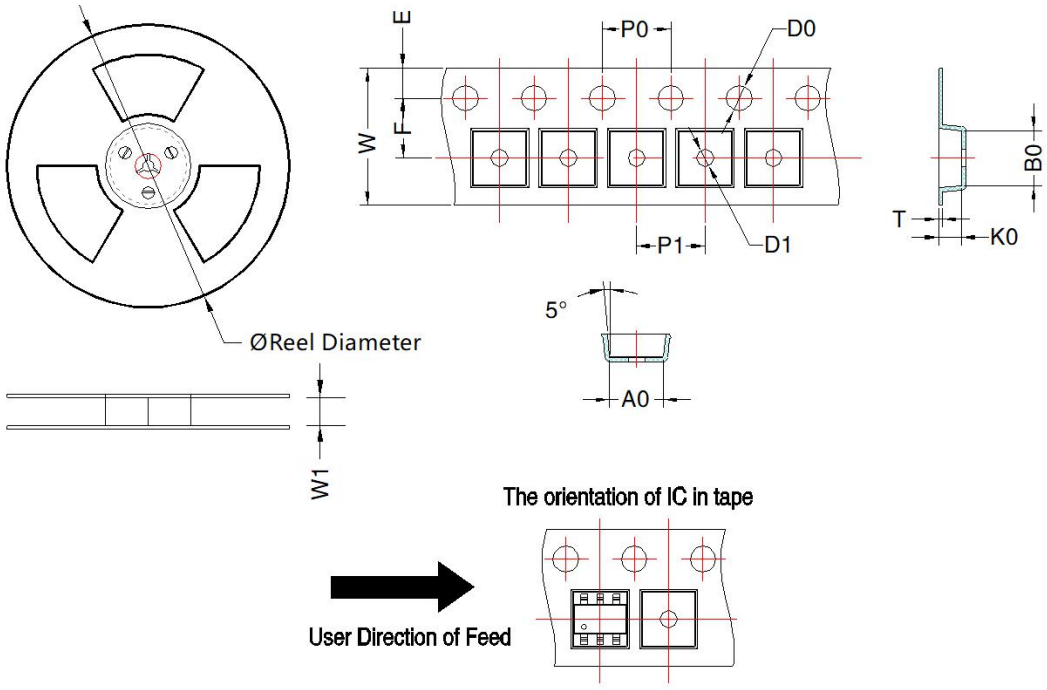

Device	Package Type	MPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	T (mm)	W (mm)	E (mm)	F (mm)	P1 (mm)	P0 (mm)	D0 (mm)	D1 (mm)
SCM9301ATA	SOT23-6	3000	180.0	8.5	3.17	3.23	1.37	0.25	8.0	1.75	3.5	4	4	1.5	1.0

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