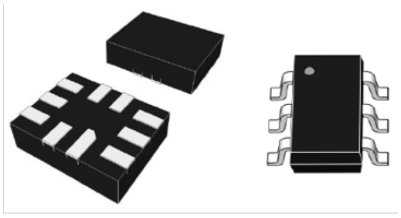
TSC210, TSC212, TSC213

Datasheet

High/low-side, bidirectional, zero-drift current sense amplifiers



Product status link
TSC210, TSC212, TSC213

Features

- Wide common mode voltage: -0.3 to 26 V
- Offset voltage: ±35 μV max. (TSC210)
- 2.7 to 26 V supply voltage
- Different gain available
- – TSC210 (200 V/V)
  – TSC212 (1000 V/V)
  – TSC213 (50 V/V)
- Gain error: ±1% max.
- Offset drift: 0.1 μV/°C max.
- Gain drift: 20 ppm/°C max.
- Quiescent current: 100 μA
- QFN10 (1.8x1.4) and SC70-6

Applications

- Telecom equipment
- Power management
- Notebook computers
- Industrial applications
- Battery chargers

Description

The TSC210, TSC212 and TSC213 is a series of zero-drift current sense amplifiers that can sense current via a shunt resistor over a wide range of common mode voltages from -0.3 to +26 V, whatever the supply voltage is. It is available in three different versions, each of them having a different gain. The TSC21x is designed with a specific zero-drift architecture, which can achieve high precision.

The TSC21x are current sense amplifiers that may be used in various functions such as precision current measurement, over current protection, current monitoring, feedback loops.

These devices fully operate over the broad supply voltage range of 2.7 to 26 V and over the industrial temperature range -40 to 125 °C.

1 Pin connections and description

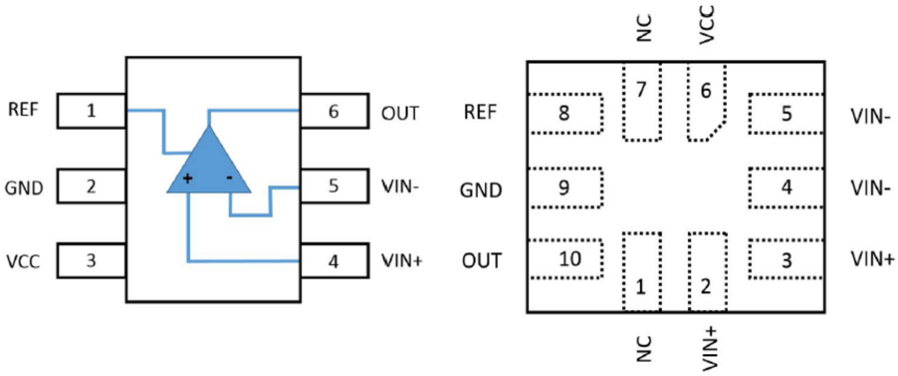


Figure 1. Pin connections (top view)

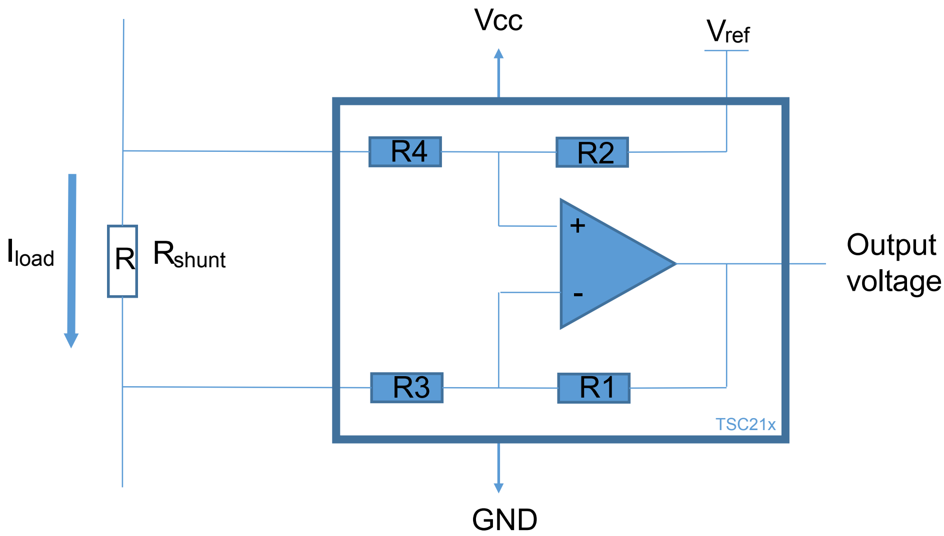
Table 1. Pin description

Name	SC70-6	QFN10	Description
REF	1	8	Reference voltage input
GND	2	9	Ground
Vcc	3	6	Power supply voltage
Vin+	4	2, 3	Connection to the external sense resistor
Vin-	5	4, 5	Connection to the external sense resistor
OUT	6	10	Output voltage
NC		1, 7	Not connected[1]

1. *Pins can be left floating or connected to VCC or GND.*

2 Block diagram

Figure 2. **Block diagram**



$$\text{Output voltage} = (R_{shunt} \times I_{load}) \times \text{Gain} + V_{ref}$$

Table 2. **Resistors and gain values**

Product	R1 and R2	R3 and R4	Gain
TSC210	1 MΩ	5 kΩ	200
TSC212	1 MΩ	1 kΩ	1000
TSC213	1 MΩ	20 kΩ	50

3 Absolute maxiumum ratings and operating conditions

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage(1)	26	V
V_{IN}	Differential voltage between input pins (In+, In-)	-26 to +26	V
	Common mode voltage on input pins	Gnd-0.3 to 26	
Ref	Reference input voltage	Gnd-0.3 to Vcc+0.3	V
I_{in}	Input current to any pin(2)	5	mA
V_{out}	Output voltage	Gnd-0.3 to Vcc+0.3	V
T_{Lead}	Lead temperature for 10 s(3)	260	°C
T_{stg}	Storage temperature	-65 to 150	°C
T_j	Junction temperature	150	°C
R_{th-ja}	Thermal resistance junction to ambient (4)(5) QFN10 SC70-6	124 232	°C/W
ESD	HBM: human body model(6)	3000	V
	CDM: charged device model (7)	1000	
	Latch-up immunity	200	mA

1. *All voltage values, except the differential voltage are with respect to the network ground terminal.*
2. *Input voltage can go beyond supply voltage but input current must be limited. Using a serial resistor with the input is highly recommended in that case.*
3. *Reflow at peak temperature of 260 °C. Time above 255 °C must not exceed 30 s.*
4. *Short-circuits can cause excessive heating and destructive dissipation.*
5. *R_{th} are typical values.*
6. *According to JEDEC standard JESD22-A114F.*
7. *According to ANSI/ESD STM5.3.1.*

Table 4. Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	2.7 to 26	V
V_{icm}	Common mode voltage on input pins	-0.3 to +26	V
T	Operating free-air temperature range	-40 to 125	°C

4 Electrical characteristics

Table 5. Electrical characteristics, T = 25 °C, V_{SENSE} = V_{IN+}- V_{IN-} (unless otherwise specified), TSC210, TSC213: V_{CC}= 5 V, V_{IN+}=12 V, V_{REF}= V_{CC}/2 (unless otherwise specified), TSC212: V_{CC} = 12 V, V_{IN+} = 12 V, V_{REF} = V_{CC}/2 (unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
Power supply						
V_{cc}	Supply voltage		2.7		26	V
I_{cc}	Quiescent current	V_{SENSE} = 0 mV		65	100	µA
		Tmin. < T < Tmax.			115	
Input						
V_O	Offset voltage (RTI) (1)					
	TSC210, TSC212	V_{SENSE} = 0 mV	-35		35	µV
	TSC213	V_{SENSE} = 0 mV	-100		100	
$\|\Delta V_O/\Delta_T\|$	Offset voltage variation (RTI) vs. temperature	V_{SENSE} = 0 mV, Tmin.< T < Tmax.		0.05	0.3	µV/°C
CMRR	Common mode rejection ratio					
	TSC210, TSC212	V_{IN}+= 0 to 26 V, V_{SENSE} = 0 mV, Tmin. < T < Tmax.	105	140		dB
	TSC213	V_{in}+= 0 to 26 V, V_{SENSE} = 0 mV, Tmin. < T < Tmax.	100	120		
PSRR	Power supply rejection ratio	V_{cc}= 2.7 to 26 V V_{IN}+=18 V, V_{SENSE} = 0 mV		0.1	10	µV/V
I_{IB}	Input bias current	V_{SENSE} = 0 mV	15	28	35	µA
I_{IO}	Input offset current	V_{SENSE} = 0 mV		0.02		
Output						
G	Gain	TSC210 TSC212 TSC213		200 1000 50		V/V
E_G	Gain error	V_{SENSE} = -5 to + 5 mV Tmin. < T < Tmax.		0.02	±1	%
T_G	Gain error vs. temperature	Tmin. < T < Tmax.		7	20	ppm/°C
NLE	Linearity error	V_{SENSE} = -5 to + 5 mV		0.01		%
C_L	Maximum capacitive load	No sustained oscillation		470		pF
V_{sw}+	Output swing close to V_{CC}	R_L=10 kΩ to Gnd Tmin. < T < Tmax.	V_{cc}-0.2	V_{cc}-0.05		V
V_{sw}-	Output swing close to Gnd	R_L=10 kΩ to Gnd Tmin. < T < Tmax.		5	30	mV

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
R_{Load}	Load regulation	I_{OUT}= -10 to +10 mA		0.5		Ω
Dynamic performance						
BW	Bandwidth	V_{CC} = 5 V, V_{icm} = 12 V, Cl = 100 pF				kHz
		TSC210		25		
		TSC212		6		
		TSC213		100		
SR	Slew rate	V_{CC} = 5 V, V_{icm} = 12 V, Cl = 100 pF				V/µs
		TSC210		0.2		
		TSC212		0.05		
		TSC213		0.85		
E_N	Noise (RTI)(1)	f = 1 kHz				nV/√Hz
		TSC210		40		
		TSC212		50		
		TSC213		38		

1. *RTI stands for “related to input”*

5 Typical characteristics

The TSC210 is used for typical characteristics, unless otherwise specified

Figure 3. Input offset voltage production distribution

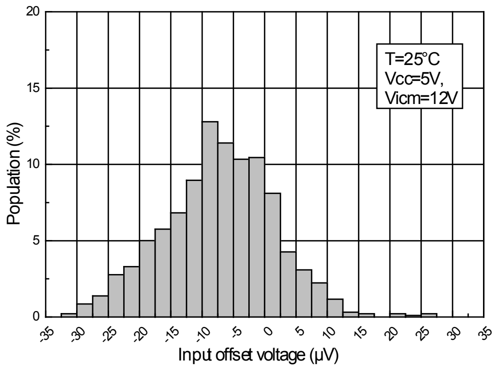


Figure 4. Input offset voltage vs temperature

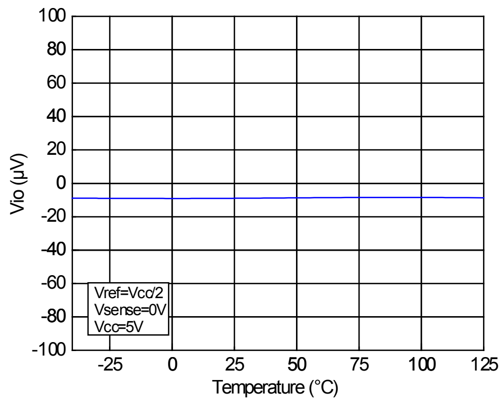


Figure 5. Common-mode rejection ratio production distribution

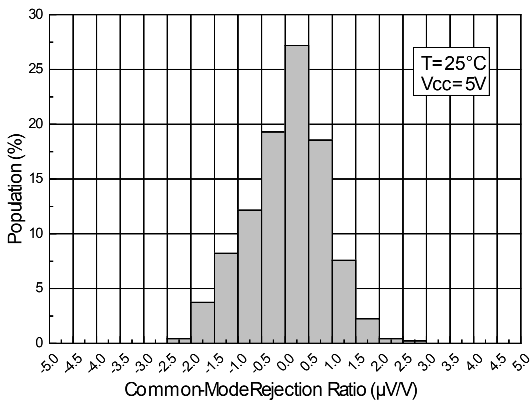


Figure 6. Common mode rejection ratio vs temperature

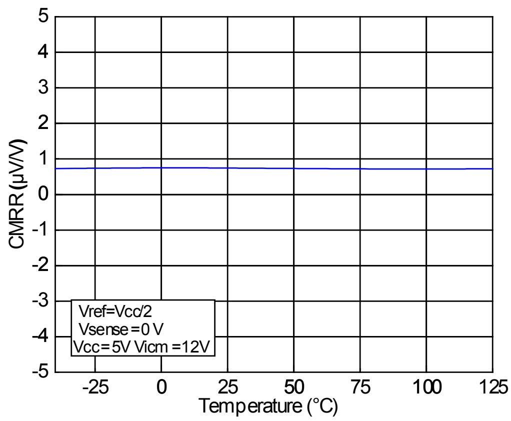


Figure 7. Gain vs frequency

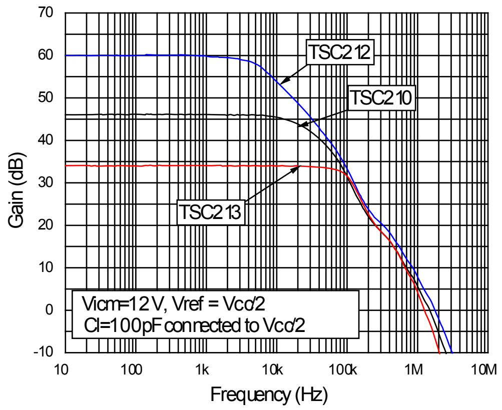


Figure 8. Power supply rejection ratio vs frequency

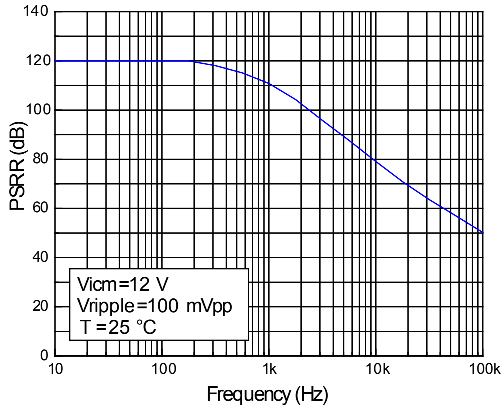


Figure 9. Common mode rejection ratio vs frequency

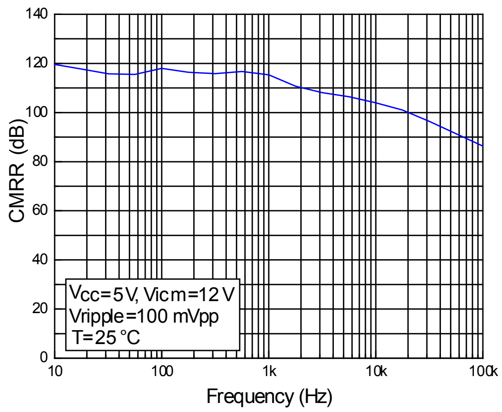


Figure 10. Positive output voltage swing vs output current V_{CC} = 2.7 V

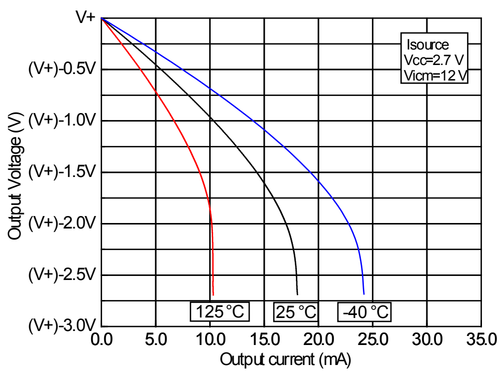


Figure 11. Negative output voltage swing vs output current V_{CC} = 2.7 V

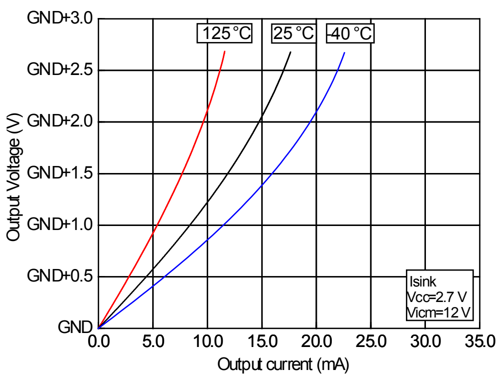


Figure 12. Positive output voltage swing vs output current V_{CC} = 5 V

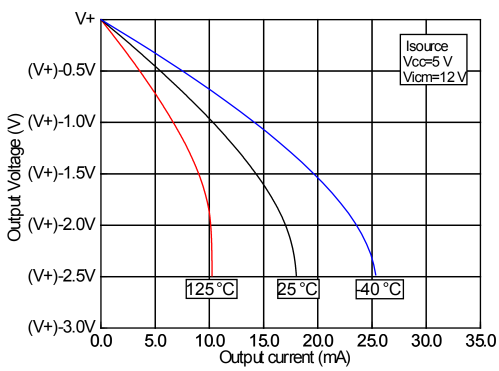


Figure 13. **Negative output voltage swing vs output current V_{CC} = 5 V**

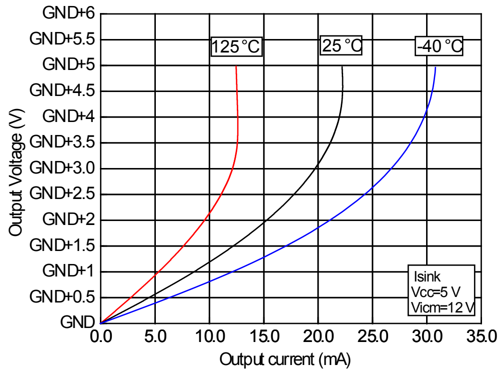


Figure 14. **Positive output voltage swing vs output current V_{CC} = 26 V**

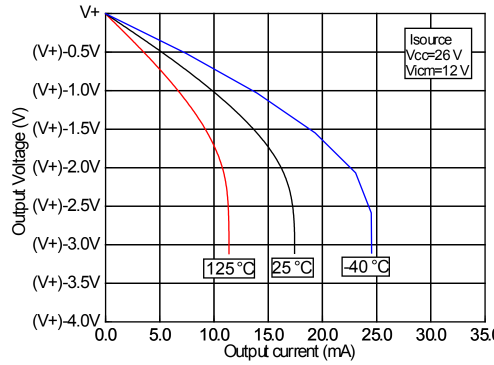


Figure 15. **Negative output voltage swing vs output current V_{CC} = 26 V**

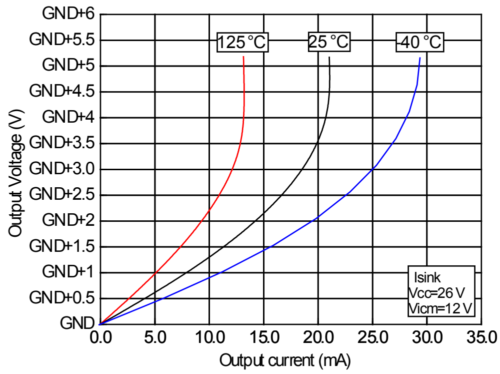


Figure 16. **Input bias current vs input common mode voltage with supply voltage = 5 V**

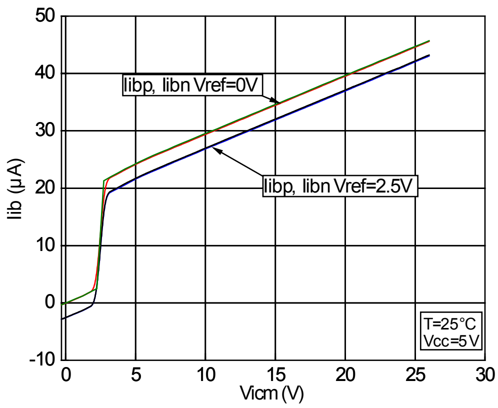


Figure 17. **Input bias current vs input common mode voltage with supply voltage = 0 V**

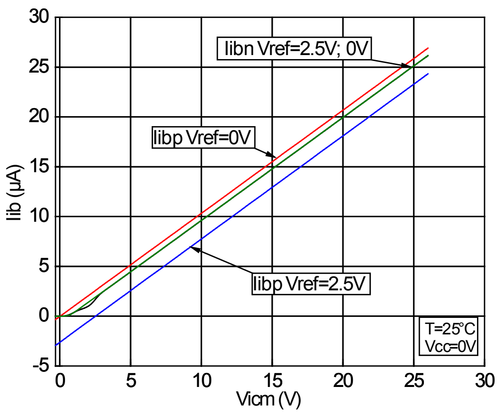
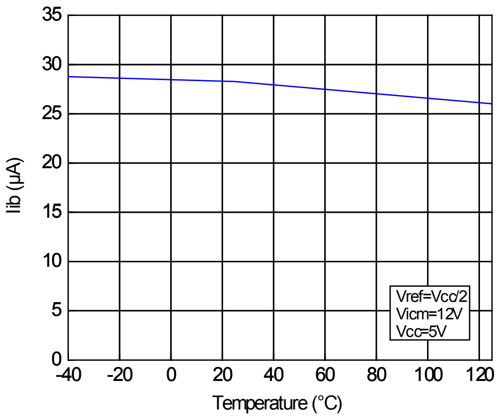


Figure 18. **Input bias current vs temperature**



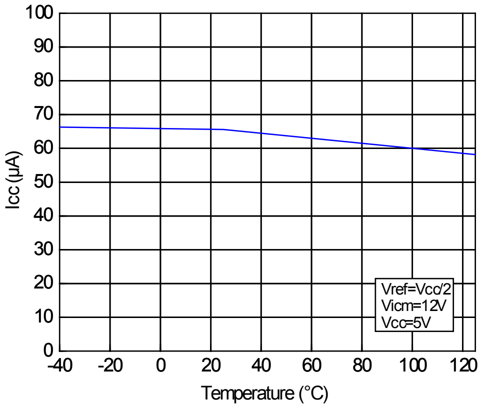


Figure 19. Quiescent current vs temperature

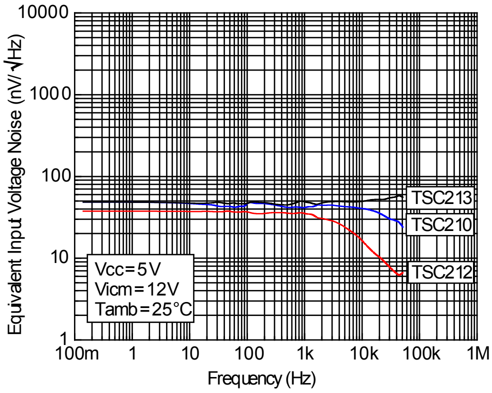


Figure 20. Input referred noise vs frequency

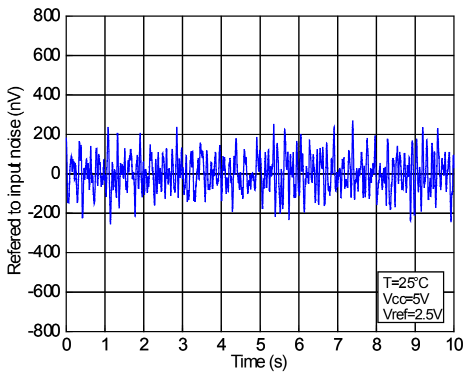


Figure 21. 0.1 Hz to 10 Hz voltage noise (referred to input)

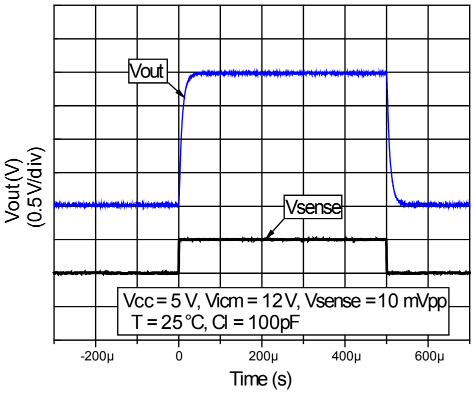


Figure 22. Step response (10-mVpp input step)

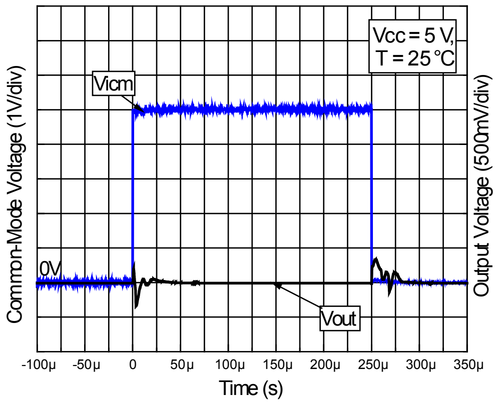


Figure 23. Common mode voltage transient response

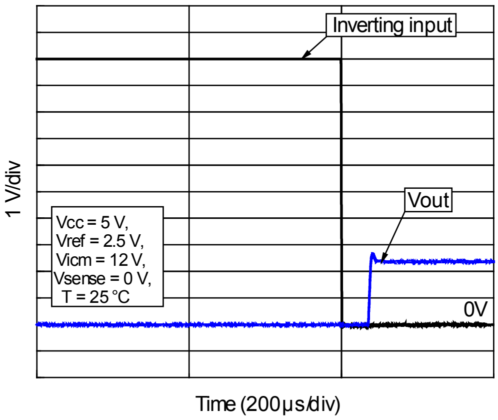


Figure 24. Inverting differential input overloaded

Figure 25. **Non inverting differential input overload**

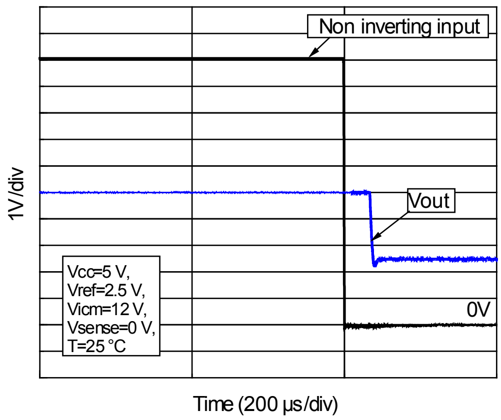


Figure 26. **Start-up response**

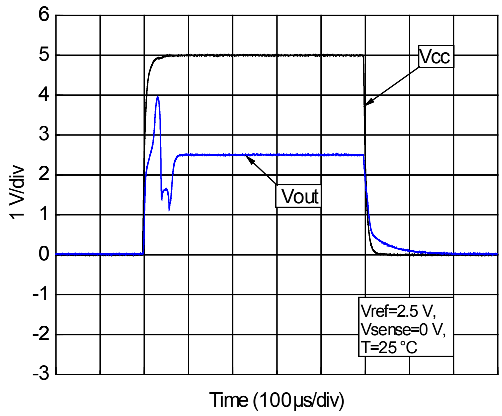
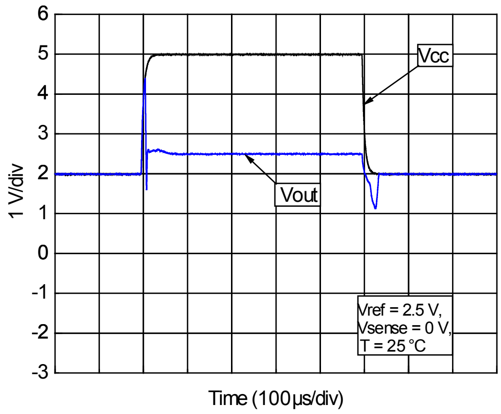


Figure 27. **Brownout recovery**



6 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

6.1 SC70-6 package information

Figure 28. SC70-6 package outline

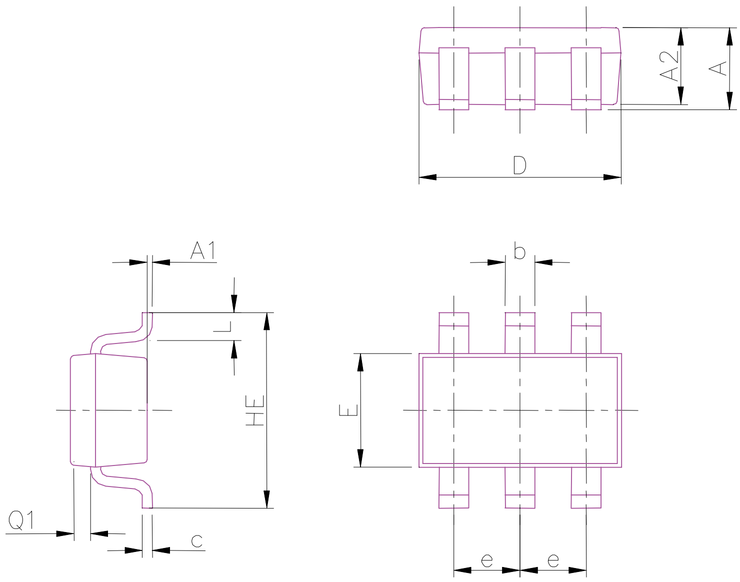


Table 6. SC70-6 mechanical data

Symbol	Milimeters			Inches(1)		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.80		1.10	0.037		0.041
A1	0		0.10	0.000		0.004
A2	0.80		1.00	0.035		0.039
b	0.15		0.30	0.008		0.010
c	0.10		0.18	0.004		0.004
D	1.80		2.20	0.078		0.086
E	1.15		1.35	0.050		0.052
e		0.65		0.025		0.026
HE	1.8		2.4	0.083		0.090
L	0.10		0.40	0.013		0.015
Q1	0.10		0.40	0.011		0.013

1. *Values in inches are converted from mm and rounded to 4 decimal digits.*

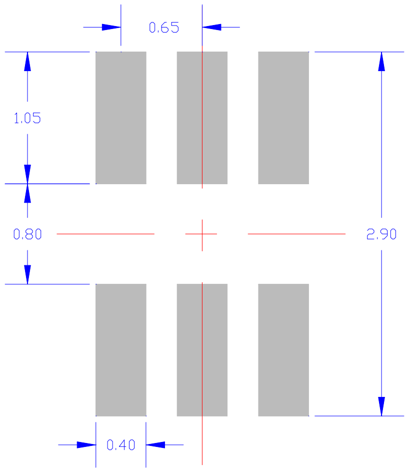


Figure 29. SC70-6 recommended footprint

6.2 QFN10 package information

Figure 30. QFN10 package outline

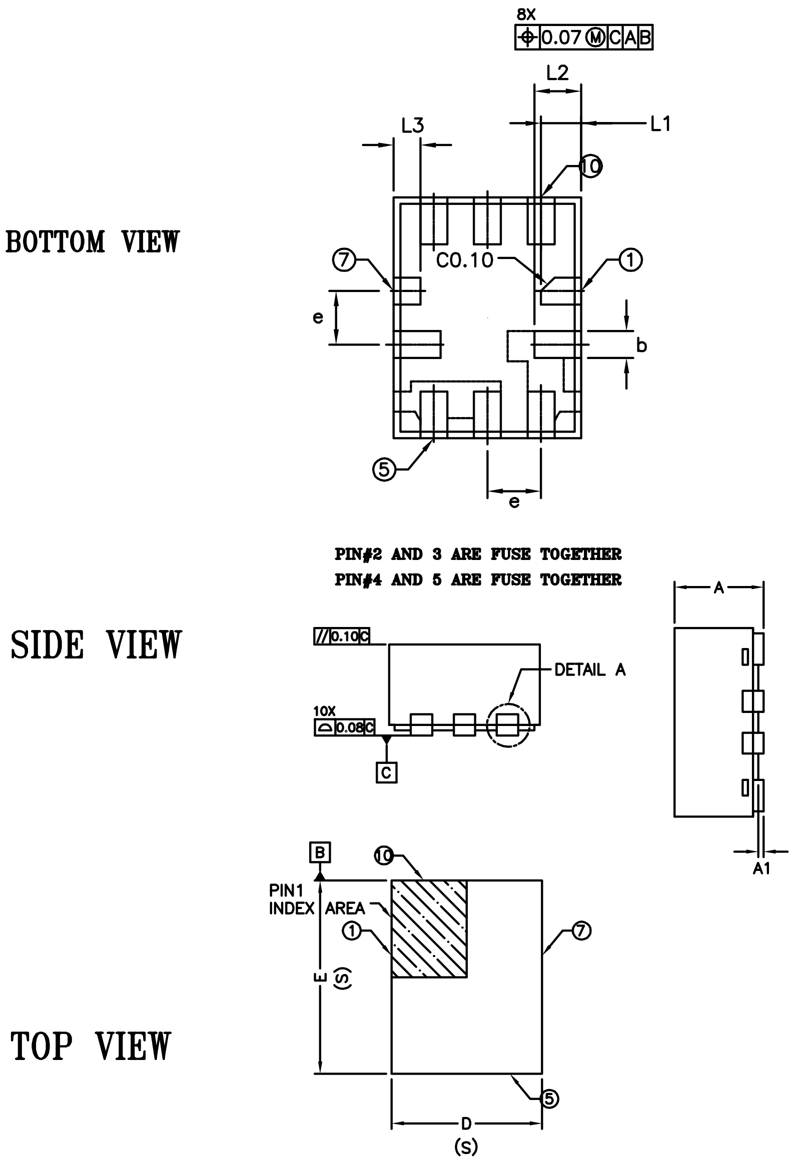


Figure 31. **QFN10 detail A package outline**

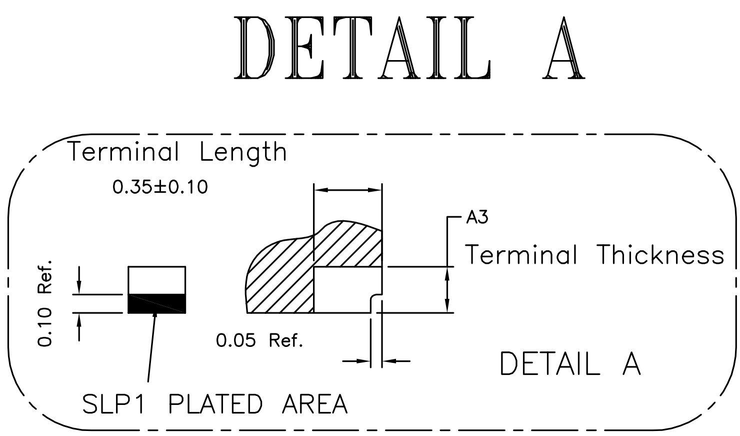


Table 7. **QFN10 mechanical data**

Symbol	mm		
	Min.	Typ.	Max.
A	0.70	0.75	0.80
A1	0.0		0.05
A3		0.203REF	
b	0.15	0.20	0.25
D	1.35	1.40	1.45
e		0.40 BSC	
E	1.75	1.80	1.85
L1	0.20	0.30	0.40
L2	0.25	0.35	0.45
L3	0.10	0.20	0.30

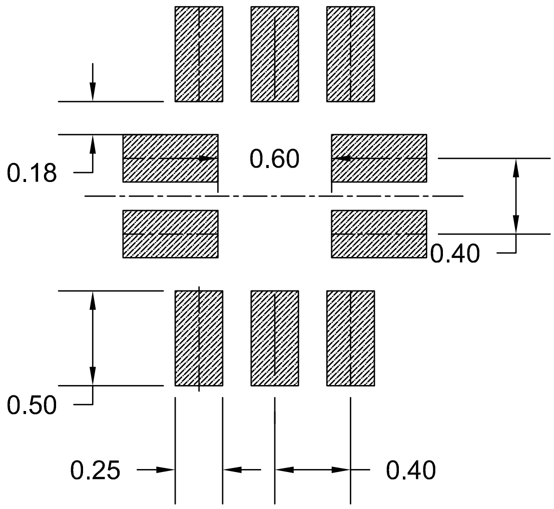


Figure 32. **QFN10 recommended footprint**

7 Ordering information

Table 8. **Ordering information**

Order code	Gain (V/V)	Package	Packing	Marking
TSC210ICT	200	SC70-6	Tape and reel	O10
TSC210IQT		QFN10		
TSC212ICT	1000	SC70-6		O12
TSC212IQT		QFN10		
TSC213ICT	50	SC70-6		O13
TSC213IQT		QFN10		

Revision history

Table 9. Document revision history

Date	Version	Changes
13-Feb-2020	1	Initial release.
27-Feb-2020	2	Update features in cover page and Section 4 Electrical characteristics.

Contents

List of tables

List of figures