

NCS210, NCS211, NCS212, NCS213, NCS214, NCS215

Current-Shunt Monitor, Voltage Output, Bi-Directional Zero-Drift

The NCS210, NCS211, NCS212, NCS213, NCS214, and NCS215 are voltage output current shunt monitors that can measure voltage across shunts at common-mode voltages from -0.3 V to 26 V , independent of supply voltage. Six fixed gains are available: 50 V/V , 75 V/V , 100 V/V , 200 V/V , 500 V/V , or 1000 V/V . The low offset of the zero-drift architecture enables current sensing with maximum drops across the shunt as low as 10 mV full-scale.

The devices can operate from a single $+2.7\text{ V}$ to $+26\text{ V}$ power supply, drawing a maximum of $100\text{ }\mu\text{A}$ of supply current. All versions are specified over the extended operating temperature range (-40°C to $+125^\circ\text{C}$). Available in SC-70 and thin UQFN space-saving packages.

Features

- Wide Common-Mode Input Range -0.3 V to 26 V
- Supply Voltage Range from 2.7 V to 26 V
- Low Offset Voltage $\pm 60\text{ }\mu\text{V}$ Max
- Low Offset Drift ($0.1\text{ }\mu\text{V}/^\circ\text{C}$)
- Low Gain Error (max 1%)
- Rail-to-rail Input and Output Capability
- Low Current Consumption (typ $65\text{ }\mu\text{A}$, $100\text{ }\mu\text{A}$ max)
- NCV Prefix for Automotive and Other Applications Requiring Unique Site Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

Typical Applications

- Current Sensing (High-Side/Low-Side)
- Automotive
- Telecom
- Sensors

This document contains information on some products that are still under development. ON Semiconductor reserves the right to change or discontinue these products without notice.



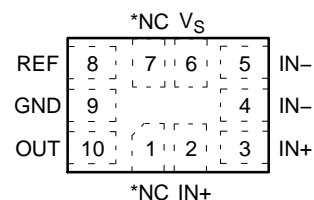
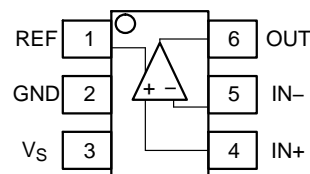
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SC70-6
SQ SUFFIX
CASE 419B

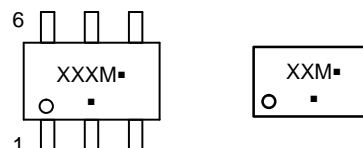

1 UQFN10
MU SUFFIX
CASE 488AT

PIN CONNECTIONS



*NC denotes no internal connection. These pins can be left floating or connected to any voltage between V_s and GND.

MARKING DIAGRAMS



XXX = Specific Device Code (See page 4)

M = Date Code

▪ = Pb-Free Package

(Note: Microdot may be in either location)

Product	Gain	R3-R4	R1-R2
NCS213	50	20 k Ω	1 M Ω
NCS215	75	13.3 k Ω	1 M Ω
NCS214	100	10 k Ω	1 M Ω
NCS210	200	5 k Ω	1 M Ω
NCS211	500	2 k Ω	1 M Ω
NCS212	1000	1 k Ω	1 M Ω

$$V_{\text{OUT}} = (I_{\text{LOAD}} \times R_{\text{SHUNT}}) \text{GAIN} + V_{\text{REF}}$$

ORDERING INFORMATION

See detailed ordering, marking and shipping information on page 4 of this data sheet.

NCS210, NCS211, NCS212, NCS213, NCS214, NCS215

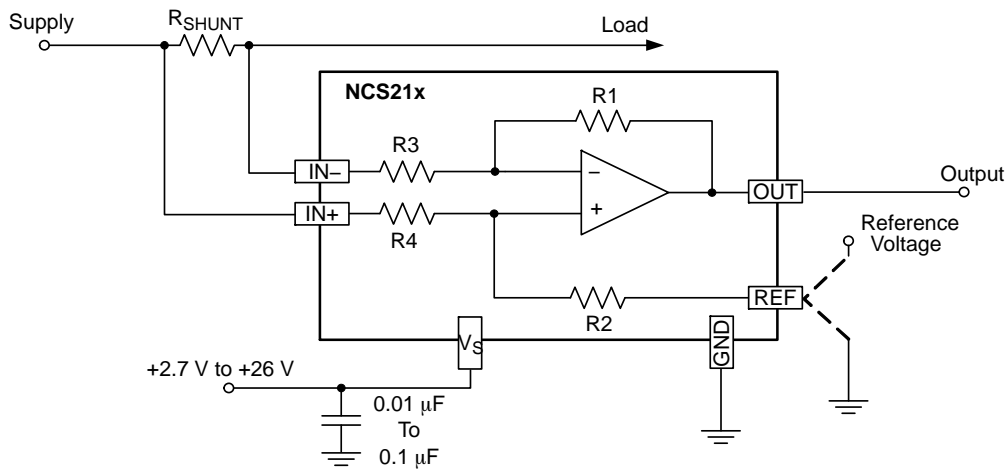


Figure 1. Application Schematic

Table 1. MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Supply Voltage (Note 1)		NCS21x NCV21x V_S	+26 +28	V
Analog Inputs	Differential ($V_{IN+} - V_{IN-}$)	V_{IN+}, V_{IN-}	-26 to +26	V
	Common-Mode (Note 2)		NCS21x NCV21x GND-0.3 to +26 GND-0.3 to +28	
REF Input		V_{REF}	GND-0.3 to (V_S) +0.3	V
Output (Note 2)		V_{OUT}	GND-0.3 to (V_S) +0.3	V
Input Current into Any Pin (Note 2)			5	mA
Maximum Junction Temperature		$T_{J(max)}$	+150	°C
Storage Temperature Range		TSTG	-65 to +150	°C
ESD Capability, Human Body Model (Note 3)		HBM	±3000	V
ESD Capability, Machine Model (Note 3)		MM	±100	V
Charged Device Model (Note 3)		CDM	±1000	V

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Refer to ELECTRICAL CHARACTERISTICS, RECOMMENDED OPERATING RANGES and/or APPLICATION INFORMATION for safe operating parameters.
2. Input voltage at any pin may exceed the voltage shown if current at that pin is limited to 5 mA.
3. This device series incorporates ESD protection and is tested by the following methods
 ESD Human Body Model tested per AEC-Q100-002 (EIA/JESD22-A114)
 ESD Machine Model tested per AEC-Q100-003 (EIA/JESD22-A115)
 ESD Charged Device Model tested per AEC-Q100-011.
 Latchup Current Maximum Rating: 50 mA per JEDEC standard: JESD78

Table 2. THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Characteristics, SC70 (Note 4) Thermal Resistance, Junction-to-Air (Note 5)	$R_{\theta JA}$	250	°C/W

4. Refer to ELECTRICAL CHARACTERISTICS, RECOMMENDED OPERATING RANGES and/or APPLICATION INFORMATION for safe operating parameters.
5. Values based on copper area of 645 mm² (or 1 in²) of 1 oz copper thickness and FR4 PCB substrate.

Table 3. RECOMMENDED OPERATING RANGES

Rating	Symbol	Min	Max	Unit
Supply Voltage	V_S	2.7	26	V
Ambient Temperature	T_A	-40	125	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

NCS210, NCS211, NCS212, NCS213, NCS214, NCS215

Table 4. ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, $T_A = -40^{\circ}\text{C}$ to 125°C , guaranteed by characterization and/or design.

At $T_A = +25^{\circ}\text{C}$, $V_{\text{SENSE}} = V_{\text{IN}+} - V_{\text{IN}-}$.

NCS210, NCS213, NCS214 and NCS215: $V_S = +5\text{ V}$, $V_{\text{IN}+} = 12\text{ V}$, and $V_{\text{REF}} = V_S/2$, unless otherwise noted.

NCS211 and NCS212: $V_S = +12\text{ V}$, $V_{\text{IN}+} = 12\text{ V}$, and $V_{\text{REF}} = V_S/2$, unless otherwise noted.

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
GAIN						
NCS210 NCS211 NCS212 NCS213 NCS214 NCS215		G		200 500 1000 50 100 75		V/V
Gain Error	$V_{\text{SENSE}} = -5\text{ mV to }5\text{ mV}$	G_e		± 0.2	± 1	%
	NCV210	G_e		± 0.2	± 1.5	%
Gain Error vs. Temperature	$T_A = -10^{\circ}\text{C to }125^{\circ}\text{C}$			7	14	ppm/ $^{\circ}\text{C}$
	NCV210			7	70	ppm/ $^{\circ}\text{C}$
Nonlinearity Error	$V_{\text{SENSE}} = -5\text{ mV to }5\text{ mV}$			± 0.01		%
Maximum Capacitive Load	No sustained oscillation			1		nF

VOLTAGE OFFSET

Offset Voltage (RTI Note 6)	NCS210, NCS211, NCS212, NCS214, NCS215	$V_{\text{SENSE}} = 0\text{ mV}$	V_{OS}		± 0.55	± 60	μV
	NCS213				± 5	± 100	μV
	NCV210				± 0.55	± 90	μV
Offset Drift			$\delta V/\delta T$		0.1	0.6	$\mu\text{V}/^{\circ}\text{C}$
	NCS213		$\delta V/\delta T$		0.5	1.5	$\mu\text{V}/^{\circ}\text{C}$
	NCV210		$\delta V/\delta T$		0.1	1.0	$\mu\text{V}/^{\circ}\text{C}$

INPUT

Input Bias Current		$V_{\text{SENSE}} = 0\text{ mV}$	I_{IB}			60	μA
Common-Mode Input Voltage Range			V_{CM}	-0.3		26	V
Common-Mode Rejection Ratio	NCS210, NCS211, NCS212, NCS214, NCS215	$V_S = 5\text{ V}$, $V_{\text{IN}+} = 2\text{ V to }+26\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$	CMRR	103	115		dB
		$V_S = 3.3\text{ V}$, $V_{\text{IN}+} = 3\text{ V to }+26\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$		103	115		dB
		$V_S = 3.3\text{ V}$, $V_{\text{IN}+} = 0\text{ V to }+26\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$ ($T_A = -10^{\circ}\text{C to }85^{\circ}\text{C}$)		103	120		dB
Common-Mode Rejection Ratio	NCS213	$V_S = 5\text{ V}$, $V_{\text{IN}+} = 2\text{ V to }+26\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$	CMRR	97	110		dB
		$V_S = 3.3\text{ V}$, $V_{\text{IN}+} = 3\text{ V to }+26\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$		97	110		dB
		$V_S = 3.3\text{ V}$, $V_{\text{IN}+} = 0\text{ V to }+26\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$ ($T_A = -10^{\circ}\text{C to }85^{\circ}\text{C}$)		97	115		dB
Common-Mode Rejection Ratio	NCV210	$V_S = 5\text{ V}$, $V_{\text{IN}+} = 2\text{ V to }+26\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$	CMRR	100	115		dB
		$V_S = 3.3\text{ V}$, $V_{\text{IN}+} = 3\text{ V to }+26\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$		100	115		dB

OUTPUT

Output Voltage Low	Referenced from GND $R_L = 10\text{ k}\Omega$ to Ground	V_{OL}		5	50	mV
Output Voltage High	Referenced from V_S $R_L = 10\text{ k}\Omega$ to Ground	V_{OH}		0.05	0.2	V

NCS210, NCS211, NCS212, NCS213, NCS214, NCS215

Table 4. ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, $T_A = -40^\circ\text{C}$ to 125°C , guaranteed by characterization and/or design.

At $T_A = +25^\circ\text{C}$, $V_{\text{SENSE}} = V_{\text{IN}+} - V_{\text{IN}-}$.

NCS210, NCS213, NCS214 and NCS215: $V_S = +5\text{ V}$, $V_{\text{IN}+} = 12\text{ V}$, and $V_{\text{REF}} = V_S/2$, unless otherwise noted.

NCS211 and NCS212: $V_S = +12\text{ V}$, $V_{\text{IN}+} = 12\text{ V}$, and $V_{\text{REF}} = V_S/2$, unless otherwise noted.

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
DYNAMIC PERFORMANCE						
Bandwidth ($f_{-3\text{dB}}$)	$C_{\text{LOAD}} = 10\text{ pF}$, NCS210 $C_{\text{LOAD}} = 10\text{ pF}$, NCS211 $C_{\text{LOAD}} = 10\text{ pF}$, NCS212 $C_{\text{LOAD}} = 10\text{ pF}$, NCS213 $C_{\text{LOAD}} = 10\text{ pF}$, NCS214 $C_{\text{LOAD}} = 10\text{ pF}$, NCS215	BW		40 25 10 100 60 50		kHz
Slew Rate		SR		0.4		V/ μs

NOISE

Spectral Density, 1 kHz (RTI Note 6)		e_n		35		nV/ $\sqrt{\text{Hz}}$
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POWER SUPPLY

Operating Voltage Range	$V_{\text{SENSE}} = 0\text{ mV}$	V_S	2.7		26	V
Quiescent Current	$V_{\text{SENSE}} = 0\text{ mV}$	I_{DD}		65	100	μA
Quiescent Current over Temperature	$V_{\text{SENSE}} = 0\text{ mV}$				115	μA
Power Supply Rejection Ratio	$V_S = +2.7\text{ V}$ to $+26\text{ V}$, $V_{\text{IN}+} = 18\text{ V}$, $V_{\text{SENSE}} = 0\text{ mV}$	PSRR		± 0.1	± 10	$\mu\text{V/V}$

6. RTI = referenced-to-input.

ORDERING INFORMATION

Device	Gain	Marking	Package	Shipping [†]
NCS210SQT2G	200	AAP	SC70-6 (Pb-Free)	3000 / Tape and Reel
NCS211SQT2G	500	AAM		
NCS212SQT2G (In Development)**	1000	AAN		
NCS213SQT2G (In Development)**	50	AAQ		
NCS214SQT2G (In Development)**	100	AAR		
NCS215SQT2G (In Development)**	75	AAT		
NCV210SQT2G *	200	VAP		
NCV211SQT2G * (In Development)**	500	VAM		
NCV212SQT2G * (In Development)**	1000	VAN		
NCV213SQT2G * (In Development)**	50	VAQ		
NCV214SQT2G * (In Development)**	100	VAR		
NCV215SQT2G * (In Development)**	75	VAT		
NCS210MUTAG (In Development)**	200	TBD	UQFN10 (Pb-Free)	3000 / Tape and Reel
NCS211MUTAG (In Development)**	500	TBD		
NCS212MUTAG (In Development)**	1000	TBD		
NCS213MUTAG (In Development)**	50	TBD		
NCS214MUTAG (In Development)**	100	TBD		
NCS215MUTAG (In Development)**	75	TBD		

[†]For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D

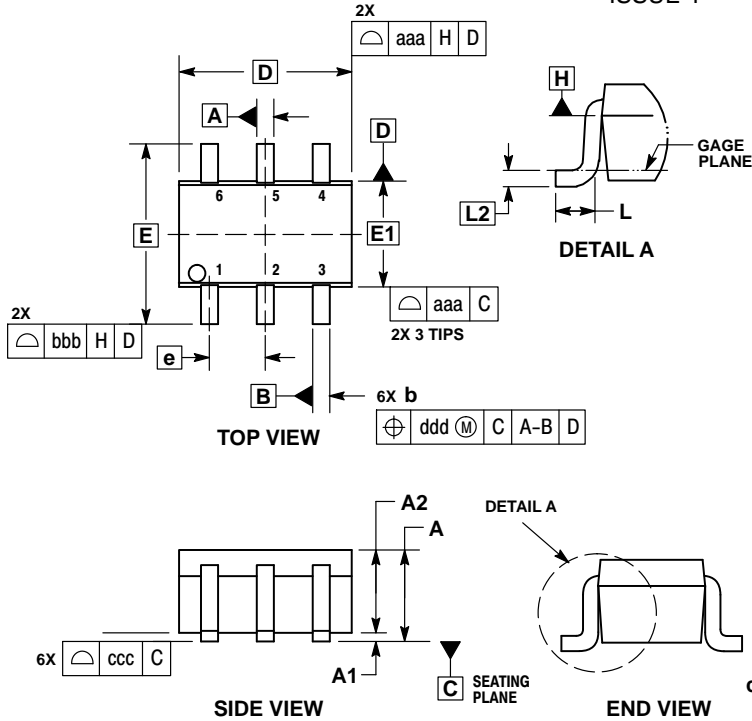
*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q100 Qualified and PPAP Capable.

** Contact local sales office for availability.

NCS210, NCS211, NCS212, NCS213, NCS214, NCS215

PACKAGE DIMENSIONS

SC-88/SC70-6/SOT-363
CASE 419B-02
ISSUE Y

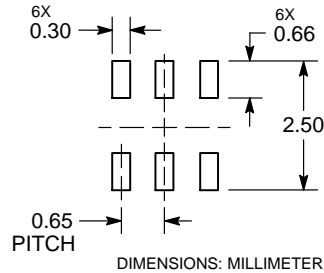


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.20 PER END.
4. DIMENSIONS D AND E1 AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY AND DATUM H.
5. DATUMS A AND B ARE DETERMINED AT DATUM H.
6. DIMENSIONS b AND c APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.08 AND 0.15 FROM THE TIP.
7. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 TOTAL IN EXCESS OF DIMENSION b AT MAXIMUM MATERIAL CONDITION. THE DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OF THE FOOT.

DIM	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	---	---	1.10	---	---	0.043
A1	0.00	---	0.10	0.000	---	0.004
A2	0.70	0.90	1.00	0.027	0.035	0.039
b	0.15	0.20	0.25	0.006	0.008	0.010
C	0.08	0.15	0.22	0.003	0.006	0.009
D	1.80	2.00	2.20	0.070	0.078	0.086
E	2.00	2.10	2.20	0.078	0.082	0.086
E1	1.15	1.25	1.35	0.045	0.049	0.053
e	0.65 BSC			0.026 BSC		
L	0.26	0.36	0.46	0.010	0.014	0.018
L2	0.15 BSC			0.006 BSC		
aaa	0.15			0.006		
bbb	0.30			0.012		
ccc	0.10			0.004		
ddd	0.10			0.004		

RECOMMENDED SOLDERING FOOTPRINT*

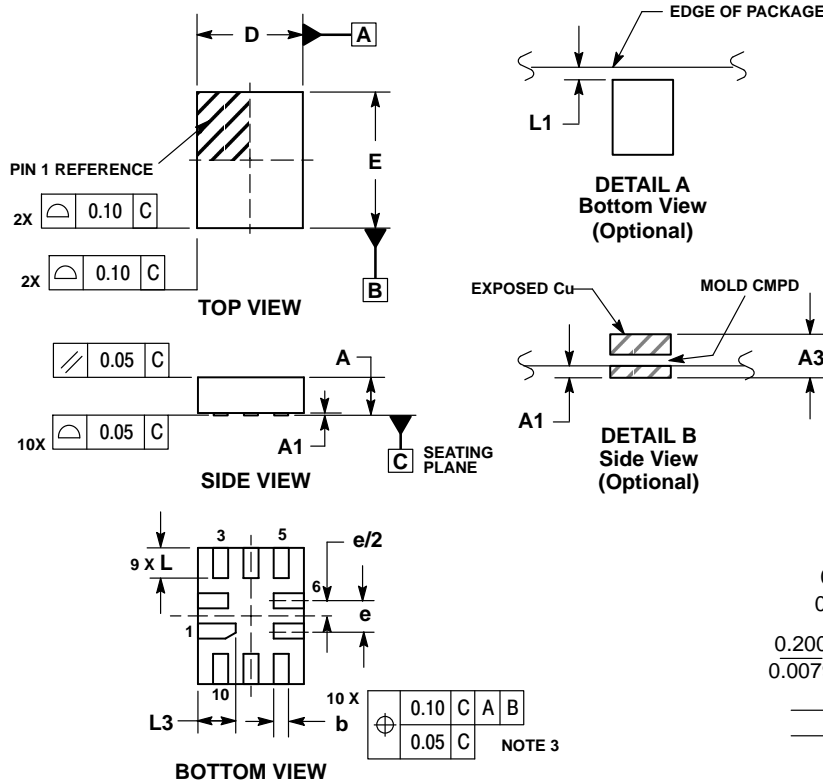


*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

NCS210, NCS211, NCS212, NCS213, NCS214, NCS215

PACKAGE DIMENSIONS

UQFN10 1.4x1.8, 0.4P CASE 488AT ISSUE A

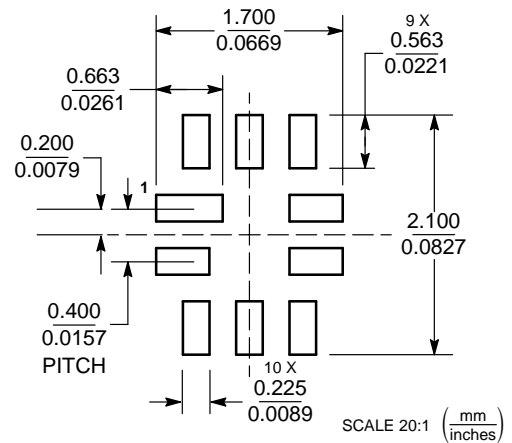


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.25 AND 0.30 MM FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

MILLIMETERS	
DIM	MIN MAX
A	0.45 0.60
A1	0.00 0.05
A3	0.127 REF
b	0.15 0.25
D	1.40 BSC
E	1.80 BSC
e	0.40 BSC
L	0.30 0.50
L1	0.00 0.15
L3	0.40 0.60

MOUNTING FOOTPRINT



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