NSE11409-Q1

90mΩ, 41V, Fully Protected Automotive Low-side Switch

Datasheet (EN) 0V4

Product Overview

NSE11409-Q1 is a 90mΩ low-side switch with 41V clamp voltage for automotive applications. It's designed for driving resistive or inductive loads with one side connected to the battery. Internal 41V clamp circuit protects device from surge energy when fast demagnetization at turn-off.

With internal output current limitation, the device is protected in overload condition. Built-in thermal shutdown protects the chip from over-temperature and short-circuit. A thermal swing mechanism is built to limit dissipated power to decelerate power accumulation. Thermal shutdown, with automatic restart, allows the devices to recover normal operation as soon as a fault condition disappears.

An internal diagnose function is built to indicate any faults when thermal shutdown and open-drain conditions through an open-drain status output pin. This device operates in ambient temperatures from –40°C to 125°C.

Key Features

- AEC-Q100 qualified
- Drain current: 8A
- 41V overvoltage clamp
- Thermal shutdown protection
- Thermal swing protection
- Fault diagnostic block
  - Thermal shutdown diagnosis
  - Open-drain diagnosis
- Very low standby current
- Very low electromagnetic susceptibility
- ESD protection

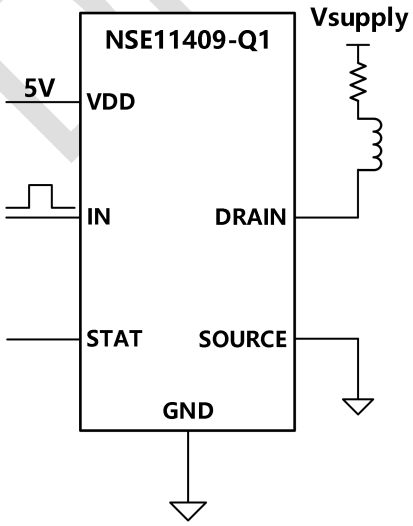
Applications

- Automotive Relays
- Solenoids
- Valves
- Lighting

Device Information

Part Number	*Package*	*Body Size*
NSE11409-Q1	SO-8	4.9mm x 3.9mm
	SOT223	6.48mm x 3.38mm

Typical Application



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1. Pin Configuration and Functions

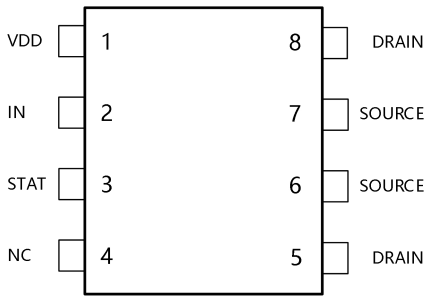


Table 1 SO-8 Pin Configuration and Description

PIN NO.	SYMBOL	FUNCTION
1	VDD	Power supply pin.
2	IN	CMOS compatible, voltage controlled input pin.
3	STAT	Open drain digital diagnostic pin.
4	NC	Not connect.
5, 8	DRAIN	PowerMOS drain.
6, 7	SOURCE	PowerMOS source.

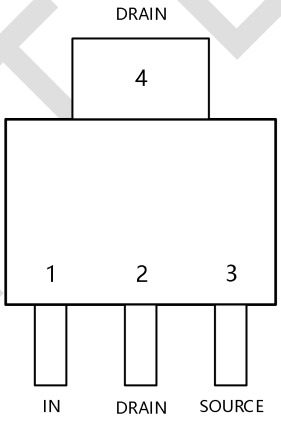


Table 2 SOT223 Pin Configuration and Description

PIN NO.	SYMBOL	FUNCTION
1	IN	CMOS compatible, voltage controlled input pin.
2, 4	DRAIN	PowerMOS drain.
3	SOURCE	PowerMOS source.

2. Absolute Maximum Ratings

Parameters	Symbol	Min	Typ	Max	Unit

Parameters	Symbol	Min	Typ	Max	Unit
Drain-to-Source Voltage	V_{DS}			Internally clamped	V
DC Drain Current	I_D			Thermal limited	A
Reverse DC drain current	$-I_D$			12.5	A
VDD Pin Current	I_{VDD}	-1		10	mA
INPUT Pin Current	I_{IN}	-1		10	mA
STATUS Pin Current	I_{STAT}	-1		10	mA
Junction Temperature	T_J	-40		150	°C
Storage Temperature	T_{stg}	-55		150	°C
Electrostatic discharge, Human-body model	HBM	-2000		2000	V
Electrostatic discharge, Charged-device model	CDM	-750		750	V

3. Thermal Information

Parameters	Symbol	SO-8	SOT223	Unit
IC Junction-to-ambient Thermal Resistance	θ_{JA}	99	145	°C/W

4. Specifications

4.1. Electrical Characteristics

(VDD = VIN= 4.5 V to 5.5 V, Tj=-40°C to 150°C. Unless otherwise noted.)

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Power MOSFET						
ON-state resistance	R_{ON}			90	mΩ	ID = 1.6 A; Tj = 25°C; VDD = VIN = 5 V
				180	mΩ	ID = 1.6 A; Tj = 150°C; VDD = VIN = 5 V
Drain-source clamp voltage	V_{CLAMP}	46	51	56	V	V_{IN} = 0V, I_D = 1.6 A
Drain-source clamp threshold voltage	V_{CLTH}	40			V	V_{IN} = 0V, I_D = 2 mA
OFF-state output current	I_{DSS}	0		3	µA	VIN = 0 V; VDS = 13 V; Tj = 25°C
		0		5	µA	VIN = 0 V; VDS = 13 V; Tj = 125°C
Bode diode forward voltage	V_{BD}		0.8		V	ID = 1.6 A; VIN = 0 V
VDD						
Operating supply voltage	V_S	3.5	5	5.5	V	

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Operating supply current	I_S		10	25	µA	OFF-state; Tj = 25°C; VIN = VDS = 0 V;
			25	65		ON-state; VIN = 5 V; VDS = 0 V
Supply clamp voltage	V_{SCL}	5.5		7	V	ISCL = 1 mA
			-0.7			ISCL = -1 mA
Logic Input						
Low-level input voltage	V_{IL}			0.9	V	
Low-level input current	I_{IL}	1			µA	VIN = 0.9V
High-level input voltage	V_{IH}	2.1			V	
High-level input current	I_{IH}			10	µA	VIN = 2.1V
Input hysteresis voltage	$V_{I(hyst)}$	0.13			V	
Input clamp voltage	V_{ICL}	5.5		7		IIN = 1 mA
			-0.7			IIN = -1 mA
Status indicator						
Status low output voltage	V_{STAT}			0.5	V	I_{STAT} = 1 mA
Status leakage current	I_{LSTAT}			10	µA	V_{STAT} = 5 V
Status pin input capacitance	C_{STAT}			100	pF	V_{STAT} = 5 V
Status clamp voltage	V_{STCT}	5.5		7	V	I_{STAT} = 1 mA
			-0.7			I_{STAT} = - 1 mA
Open load detection						
Open load OFF-state voltage detection threshold	V_{OI}	1.1	1.2	1.3	V	VIN = 0 V
Delay between INPUT falling edge and STATUS falling edge in open load condition	$t_{d(STAT)}$		425		µs	IOUT = 0 A
Switching characteristics (Vsupply = VIN = 3.5V to 5.5 V, See Figure 6 for Switching timing characteristics)						
Turn-on delay time	$t_{d(ON)}$		8		µs	RL = 8.2 Ω, VCC = 13 V
Turn-off delay time	$t_{d(OFF)}$		18		µs	RL = 8.2 Ω, VCC = 13 V
Rise time	t_r		10		µs	RL = 8.2 Ω, VCC = 13 V
Fall time	t_f		10		µs	RL = 8.2 Ω, VCC = 13 V
Switching energy losses at turn-on	W_{ON}		57		uJ	RL = 8.2 Ω, VCC = 13 V

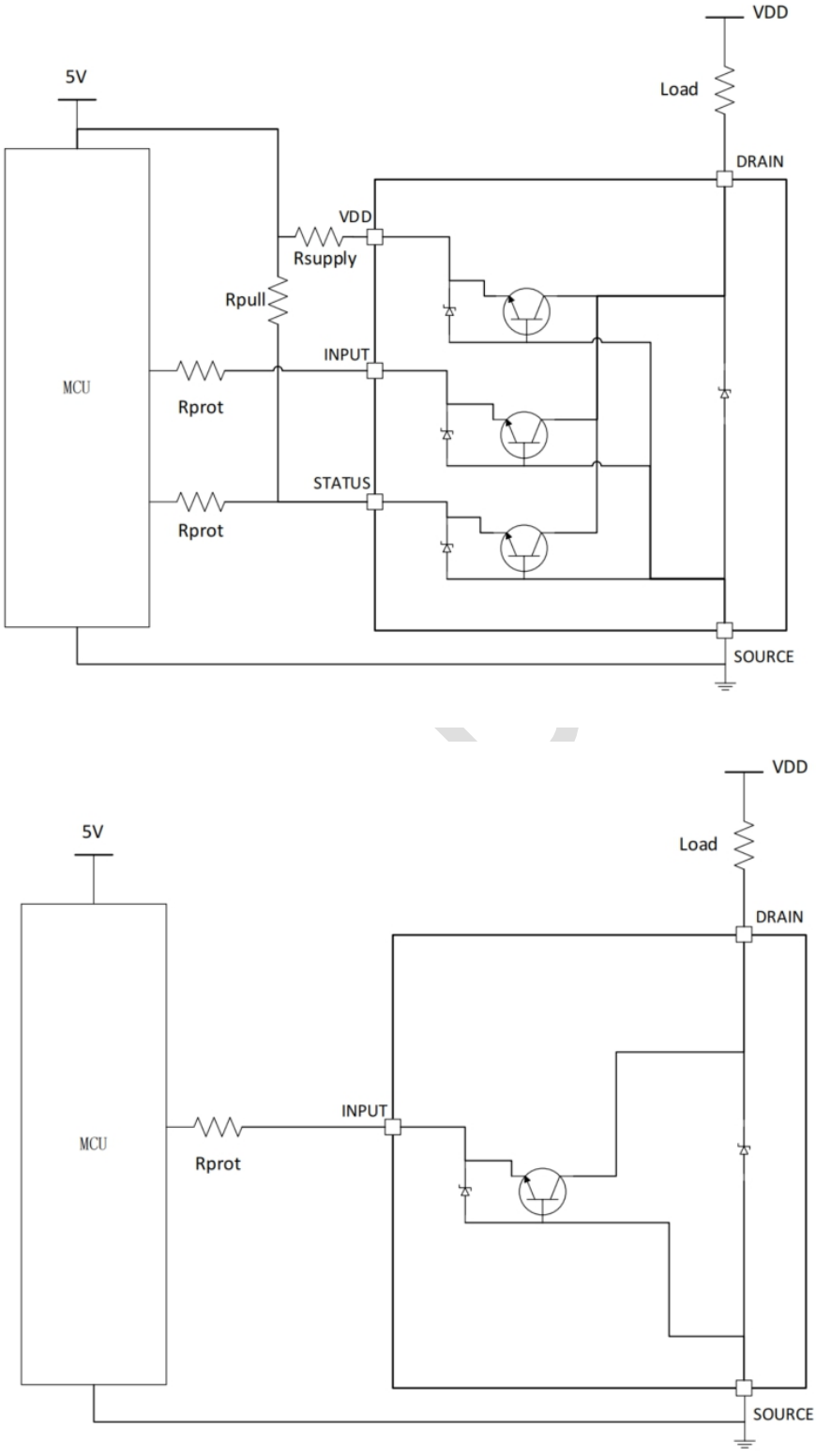
Parameters	Symbol	Min	Typ	Max	Unit	Comments
Switching energy losses at turn-off	W_{OFF}		55		uJ	RL = 8.2 Ω, VCC = 13 V
Protection and diagnostics						
DC short-circuit current	I_{limH}	5.5	8	10.5	A	VDS = 13 V, VS = VIN = 5V
Step response current limit	t_{dlimL}		44		µs	VDS = 13 V, VIN = 5V
Shutdown temperature	TTSD	150	175	200	℃	
Reset temperature	TR	T_{RS} + 1	T_{RS} + 5		℃	
Thermal reset of STATUS	TRS	135			℃	
Thermal hysteresis (TTSD - TR)	THYST		7		℃	

4.2. Typical Performance Characteristics

4.2.1. True table

Conditions	Input	Drain	Status
Normal operation	L	H	H
	H	L	H
Current limitation	L	H	H
	H	X	H
Over-temperature limitation	L	H	H
	H	H	L
VDD under-voltage	L	H	X
	H	H	X
Open-drain detection	L	L	L
	H	L	H

5. Application Information



5.1. MCU I/O protection

NSE11409 has Zener diodes inside for ESD protection and the intrinsic NPN parasitic bipolar, so that resistors for protection are necessary in series with the digital inputs to limit the current to protect MCU I/Os during transient and reverse battery conditions.

The value of resistors for protection can be calculated by the formula as shown below:

$$\frac{V_{ICL}}{I_{latchup}} \le R_{prot} \le \frac{V_{MCU\_OUT} - V_{IH}}{I_{IH\max}}$$

Where V_{ICL} is reverse clamp voltage of NSE11409, $I_{latchup}$ is the MCU I/O latch up current, V_{MCU_OUT} is the output voltage of MCU I/O, V_{IH} is the High-level input voltage of NSE11409, I_{IH} is the high level input current.
Let:
$I_{latchup}$ ≥ 20mA; V_{MCU_OUT} ≥4.5V, so 35Ω ≤ R_{prot} ≤ 100kΩ, the recommended value is 1kΩ. The supply resistor is the same.

5.2. The value of STATUS pull up resistor

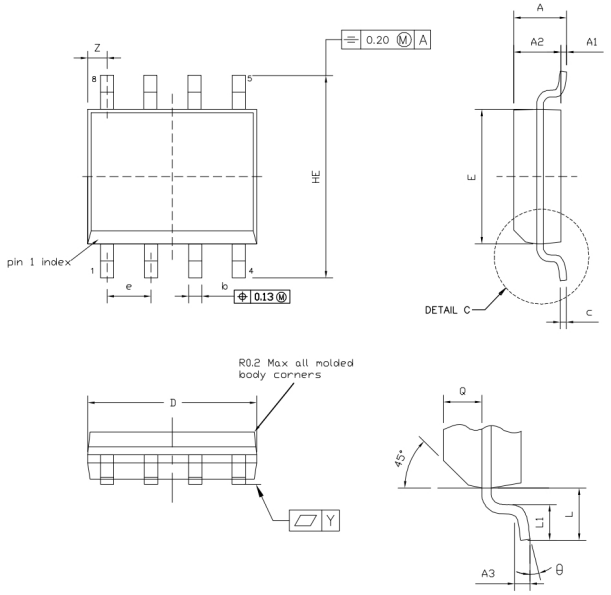
Because the STATUS pin is open drain output, a pull up resister is needed to fix the high voltage during normal operation. When the fault occurs, the voltage level of STATUS is pulled down by the internal MOSFET on. The value of pull up resistor can be calculated by the formula as shown below:

$$(\frac{V_{pull-up}}{V_{OL}} - 1) \bullet R_{on} < R_{pull-up} < \frac{V_{pull-up} - V_{OH}}{I_{leak}}$$

Where V_{pullup} is the minimum of pull-up supply, V_{OL} is the maximum of MCU logic low, R_{on} is the on resistance of the MOSFET of STATUS pin, V_{OH} is the minimum of MCU logic high, I_{leak} is the maximum leakage current of STATUS pin.
Let:
V_{pullup} = 4.5V;R_{on} = V_{STAT}/I_{STAT} = 500Ω, V_{OL} = 0.9V; V_{OH} = 2.1V; I_{leak} = 10uA, so 2kΩ ≤ R_{pullup} ≤ 240kΩ.

6. Package Information

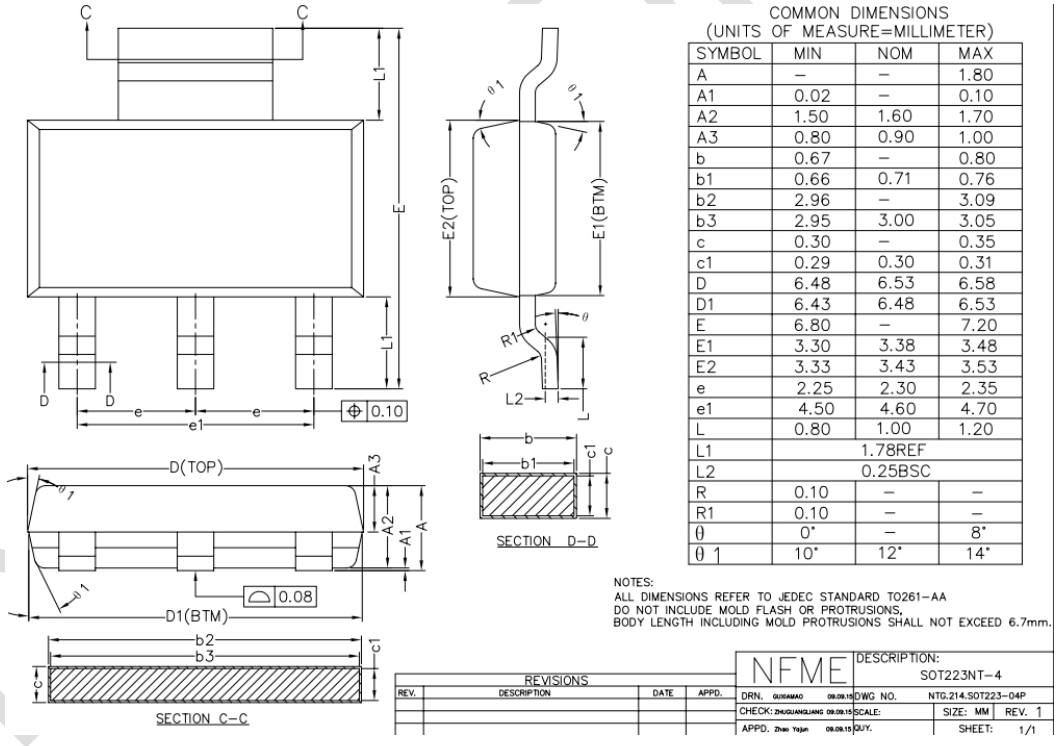
6.1. SO-8



* CONTROLLING DIMENSION : MM

SYMBOL	MILLIMETER		
	MIN.	NOM.	MAX.
A	---	---	1.75
A1	0.10	---	0.25
A2	1.25	1.35	1.45
b	0.33	0.38	0.49
c	0.19	0.20	0.25
D	4.80	4.90	5.00
E	3.80	3.90	4.00
Q	0.60	0.65	0.70
HE	5.80	6.00	6.20
e	1.27 BSC		
L	1.05 BSC		
L1	0.40	0.64	1.00
Y	---	0.10	---
Z	0.3	0.5	0.7
A3	0.25 BSC		
θ	0°	5°	8°

6.2. SOT223



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	–	–	1.80
A1	0.02	–	0.10
A2	1.50	1.60	1.70
A3	0.80	0.90	1.00
b	0.67	–	0.80
b1	0.66	0.71	0.76
b2	2.96	–	3.09
b3	2.95	3.00	3.05
c	0.30	–	0.35
c1	0.29	0.30	0.31
D	6.48	6.53	6.58
D1	6.43	6.48	6.53
E	6.80	–	7.20
E1	3.30	3.38	3.48
E2	3.33	3.43	3.53
e	2.25	2.30	2.35
e1	4.50	4.60	4.70
L	0.80	1.00	1.20
L1	1.78REF		
L2	0.25BSC		
R	0.10	–	–
R1	0.10	–	–
θ	0°	–	8°
θ 1	10°	12°	14°

NOTES:
ALL DIMENSIONS REFER TO JEDEC STANDARD TO261-AA
DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS,
BODY LENGTH INCLUDING MOLD PROTRUSIONS SHALL NOT EXCEED 6.7mm.

REVISIONS

REV.	DESCRIPTION	DATE	APPD.

NFME

DESCRIPTION: SOT223NT-4
DRN. GUIDAMAO 09.09.15 DWG NO. NTG.214.SOT223-04P
CHECK: ZHUGUANGJIANG 09.09.15 SCALE:
APPD. Zhao Yajun 09.09.15 QUY. SIZE: MM REV. 1
SHEET: 1/1

7. Revision history

Revision	Description	Date
0V1	Initial version	2021/08
0V2	Some updates and add true table	2021/09
0V3	Add application information	2021/12