NSD12416A-Q1

2CH, 160mΩ, 40V, Fully Protected Automotive Low-side Switch

Datasheet (EN) 1.2

Product Overview

NSD12416A-Q1 is a 160mΩ 2 channel low-side switch with 48V clamp voltage for automotive applications. It's designed for driving resistive or inductive loads with one side connected to the battery. Internal 48V 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 through an open-drain status output pin. This device operates in ambient temperatures from –40°C to 125°C.

Applications

- Automotive Relays
- Valves
- Solenoid drivers
- Lighting

Device Information

Part Number	Package	Body Size
NSD12416A-Q1SPR	SO-8	4.9mm x 3.9mm

Key Features

- AEC-Q100 (Grade 1) qualified for automotive application
- Drain current limitation: 2.5A
- 48V overvoltage clamp
- Thermal shutdown protection
- Thermal swing protection
- Fault diagnostic block
  - Thermal shutdown diagnosis
- Very low standby current
- Very low electromagnetic susceptibility
- ESD protection
- RoHS & REACH Compliance

Typical Application

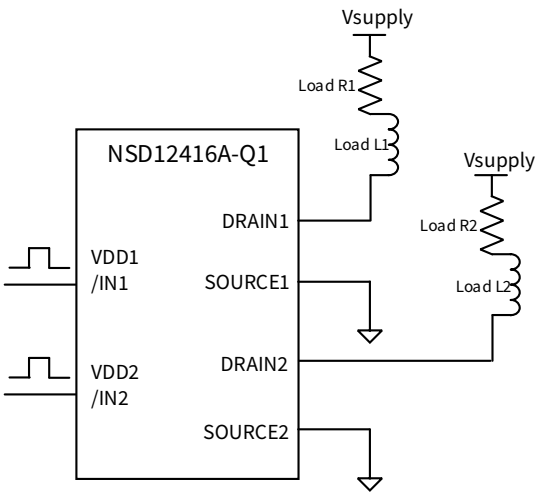

Figure 0.1 NSD12416A-Q1 Typical Application

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1. Pin Configuration and Functions

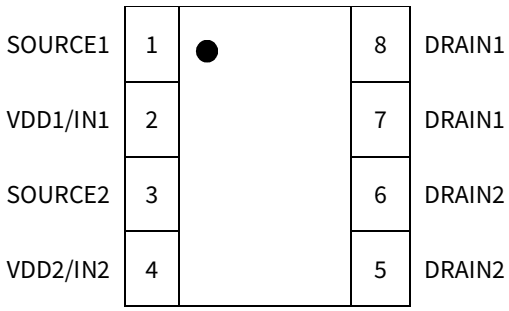


Figure 1.1 NSD12416A-Q1SPR Pinout

Table 1.1 NSD12416A-Q1SPR Pin Configuration and Description

PIN NO.	SYMBOL	FUNCTION
1,3	SOURCE1,2	PowerMOS source and ground reference for the control section
2,4	VDD1,2/IN1,2	Voltage controlled input pin with hysteresis, CMOS compatible. They control output switch state
8,7,6,5	DRAIN1,2	PowerMOS drain

2. Block diagram

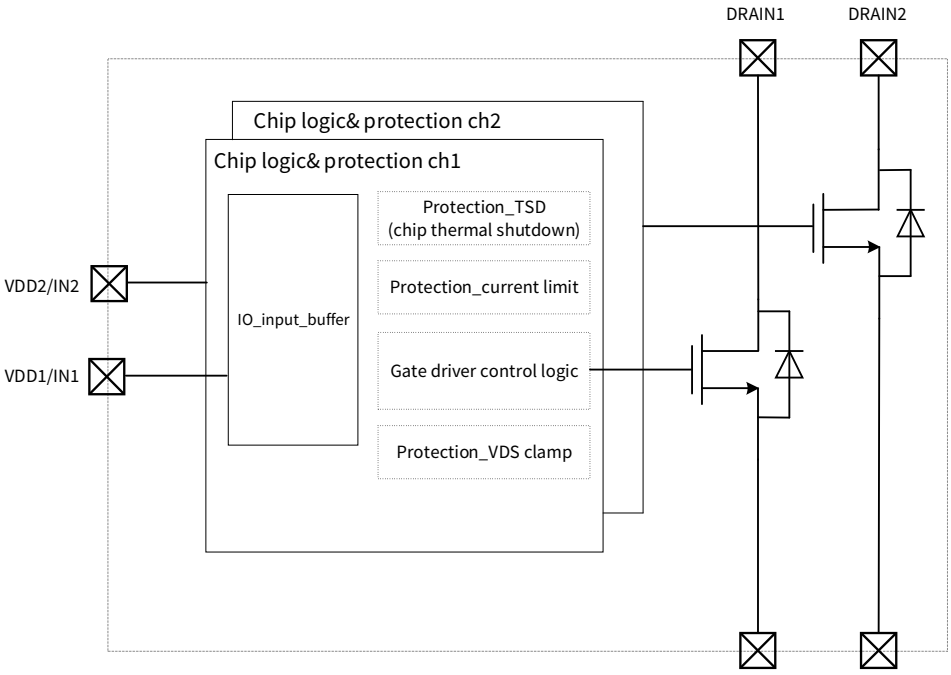


Figure 2.1 NSD12416A-Q1SPR Block diagram

3. Absolute Maximum Ratings

Parameters	Symbol	Min	Typ	Max	Unit
Drain-to-Source Voltage	V_{DS}			Internally clamped	V
DC Drain Current	I_D			Thermal limited	A
INPUT Pin Current	I_{IN}	-1		10	mA
Junction Temperature	T_J	-40		150	°C
Storage Temperature	T_{stg}	-55		150	°C
Single pulse avalanche energy (L = 12mH; T_J = 150 °C; R_L = 0Ω; I_{OUT} = I_{lim})	E_{AS}			40	mJ

4. ESD ratings

Parameters	Symbol	Value	Unit
V(ESD) Electrostatic discharge	Human-body model, per AEC-Q100-002-RevD， $V_{ESD-HBM}$	±2000	V
	Charged-device model, per AEC-Q100-011-RevB， $V_{ESD-CDM}$	±750	V

5. Thermal Information

Parameters	Symbol	SO-8	Unit
Junction-to-ambient Thermal Resistance	θ_{JA}	75.4	°C/W
Junction-to-top characterization parameter	ψ_{JT}	4	°C/W
Junction-to-case (top) thermal resistance	$\theta_{JC(top)}$	23.8	°C/W

The thermal data is based on the JEDEC standard high-K profile, JESD 51-7, four layers board.

6. Specifications

6.1. Electrical Characteristics

(V_{DD} = V_{IN}= 4.5 V to 5.5 V, T_J =-40°C to 150°C. Unless otherwise noted.)

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Power MOSFET						
ON-state resistance	R_{ON}		160		mΩ	I_D = 1 A; T_J = 25°C; V_{DD} = V_{IN} = 5 V
				320	mΩ	I_D = 1 A; T_J = 150°C; V_{DD} = V_{IN} = 5 V
Drain-source clamp voltage	V_{CLAMP}	46	48	56	V	V_{IN} = 0V, I_D = 1A
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	V_{IN} = 0 V; V_{DS} = 13 V; T_J = 25°C
		0		5	μA	V_{IN} = 0 V; V_{DS} = 13 V; T_J = 125°C
Body diode forward voltage	V_{BD}		0.8		V	I_D = 1A; V_{IN} = 0 V
Input section						
Supply current from input pin	I_{ISS}		30	65	μA	ON-state; V_{DD}=V_{IN} = 5 V; V_{DS} = 0 V
Input clamp voltage	V_{ICL}	5.5		8	V	I_{ICL} = 1 mA
			-0.7			I_{ICL} = -1 mA
Input threshold voltage	V_{INTH}	1		3.5	V	V_{DS} = V_{IN}; I_D = 1 mA
Switching characteristics						
Turn-on delay time	$t_{d\ (ON)}$		9		μs	R_L = 13 Ω, V_{CC} = 13 V
Turn-off delay time	$t_{d\ (OFF)}$		9		μs	R_L = 13 Ω, V_{CC} = 13 V
Rise time	t_r		9		μs	R_L = 13 Ω, V_{CC} = 13 V
Fall time	t_f		5		μs	R_L = 13 Ω, V_{CC} = 13 V
Switching energy losses at turn-on	W_{ON}		26		μJ	R_L = 13 Ω, V_{CC} = 13 V
Switching energy losses at turn-off	W_{OFF}		23		μJ	R_L = 13 Ω, V_{CC} = 13 V
Protection and diagnostics						
DC short-circuit current	I_{lim}	1.6	2.5	3	A	V_{DS} = 13 V, V_{DD} = V_{IN} = 5V
Shutdown temperature	T_{TSD}	150	175	200	°C	
Reset temperature	T_R	T_{RS} + 1	T_{RS} + 5		°C	
Thermal reset of STATUS	T_{RS}	135			°C	
Thermal hysteresis (T_{TSD} - T_R)	T_{HYST}		7		°C	
Dynamic temperature	ΔT_J		40		K	T_J = -40°C, V_{CC} = 13V
Dynamic temperature hysteresis	$\Delta T_{J\ (HYS)}$		15		K	

6.2. Switching characteristics

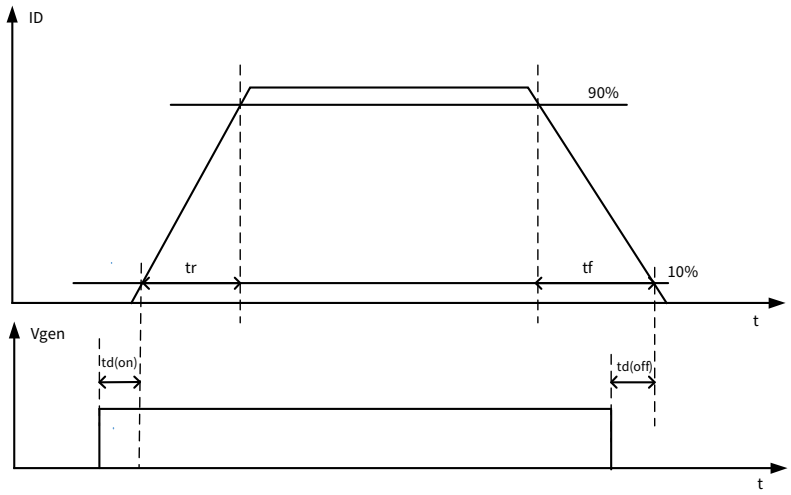


Figure 6.2 NSD12416A-Q1 Switching Characteristics

7. Protections

7.1. Current Limitation

NSD12416A-Q1 has current limitation to protect the silicon and bonding wire in case of overload or short circuit to battery.

7.2. Thermal shutdown and thermal swing

This device has both absolute and dynamic temperature protection. There are two thermal sensors on the controller and the MOSFET, the one on the MOSFET is the hottest and another one on the controller is the coldest. The absolute temperature protection is to shut down the MOSFET when the hottest junction temperature exceeds the T_{TSD}, and the dynamic temperature protection is also to shut down the MOSFET when the temperature difference between the hottest and the coldest exceeds ΔT_J.

8. MCU I/O protection

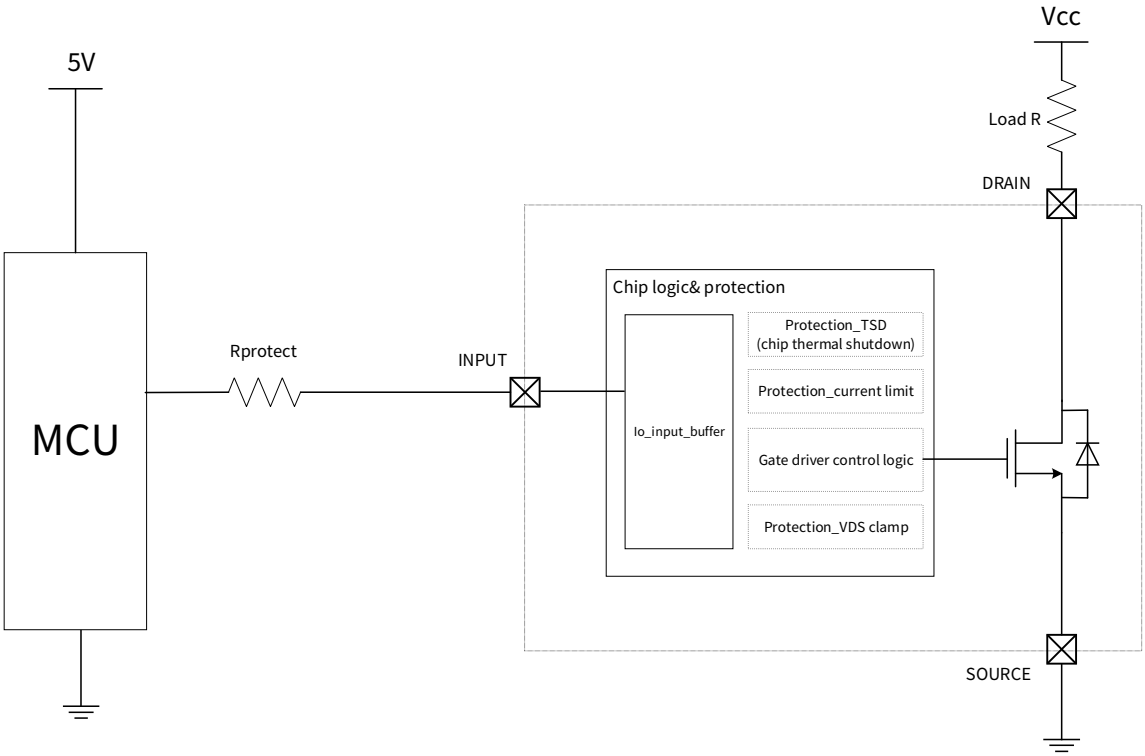


Figure 8.1 NSD12416A-Q1SPR application schematic

NSD12416A 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:

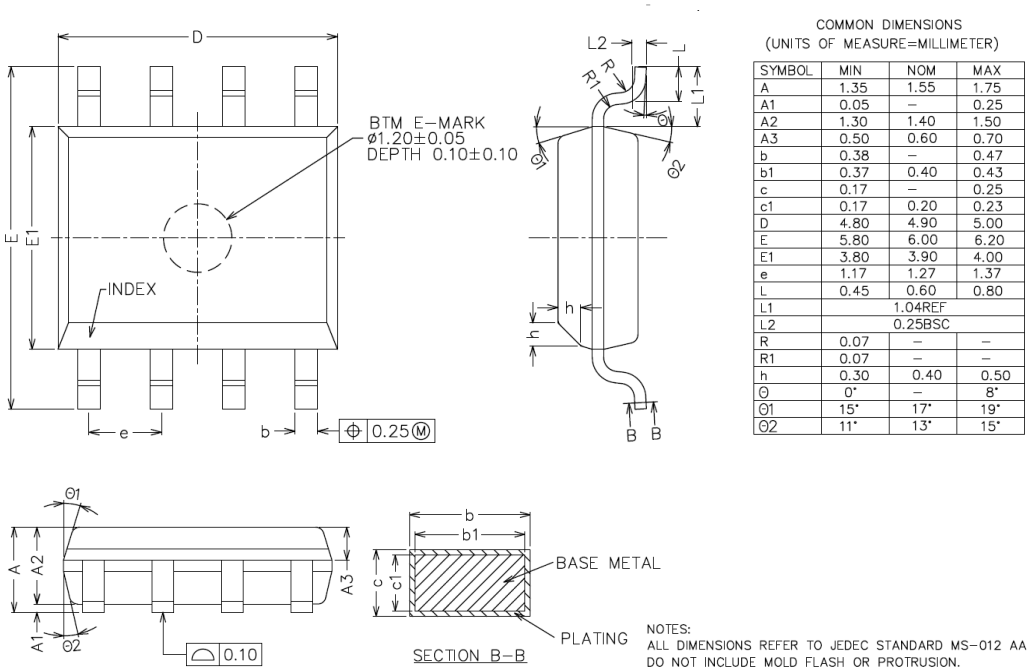
$$\frac{0.7}{I_{latchup}} \le R_{prot} \le \frac{V_{MCU\_OUT} - V_{IH}}{I_{IHmax}}$$

Where $I_{latchup}$ 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 NSD12416A, I_{IH} is the High-level input current.

Let: $I_{latchup} \ge 20mA$; $V_{MCU\_OUT} \ge 4.5V$, so $35\Omega \le R_{prot} \le 15k\Omega$, the recommended value is $1k\Omega$.

9. Package Information

9.1. SO-8 package information

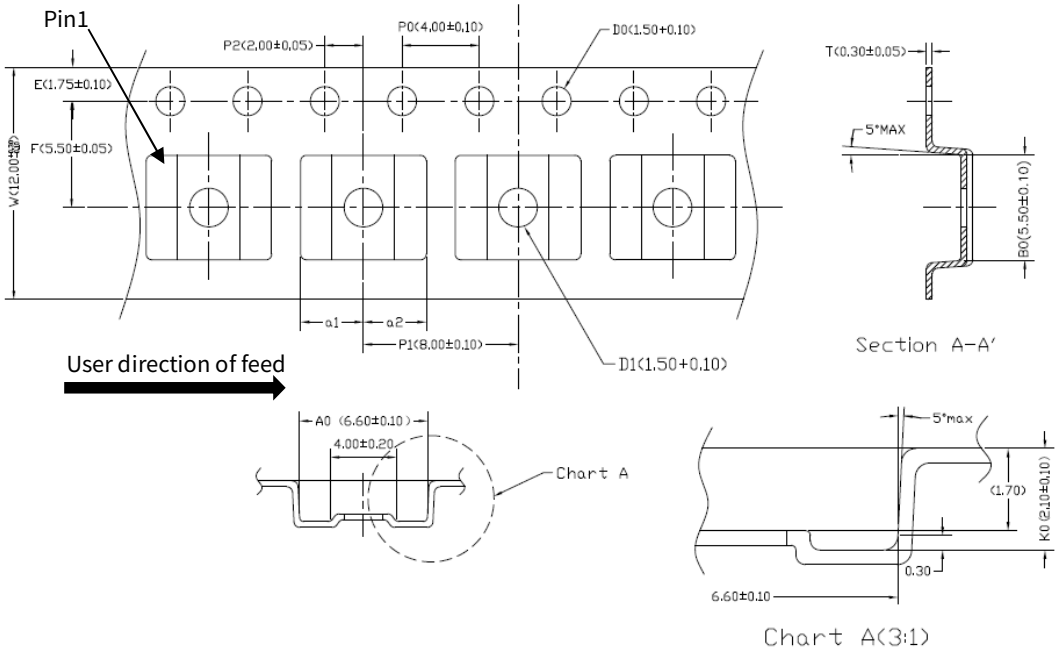


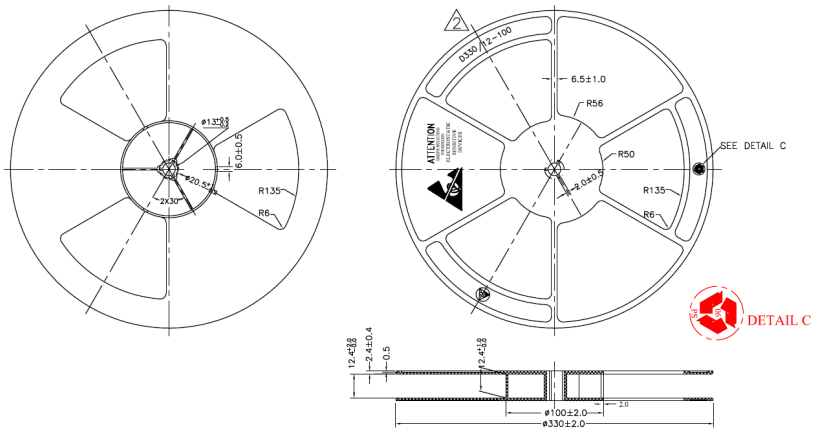
COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	1.35	1.55	1.75
A1	0.05	–	0.25
A2	1.30	1.40	1.50
A3	0.50	0.60	0.70
b	0.38	–	0.47
b1	0.37	0.40	0.43
c	0.17	–	0.25
c1	0.17	0.20	0.23
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.17	1.27	1.37
L	0.45	0.60	0.80
L1	1.04REF		
L2	0.25BSC		
R	0.07	–	–
R1	0.07	–	–
h	0.30	0.40	0.50
Θ	0°	–	8°
Θ1	15°	17°	19°
Θ2	11°	13°	15°

NOTES:
ALL DIMENSIONS REFER TO JEDEC STANDARD MS-012 AA
DO NOT INCLUDE MOLD FLASH OR PROTRUSION.

9.2. SO-8 packaging information





10. Ordering Information

Part Number	Package	MSL	SPQ
NSD12416A-Q1SPR	SO-8	3	2500
Note: All packages are ROHS compliant with peak reflow temperature of 260°C according to the JEDEC industry standard classifications and peak solder temperature.			

11. Revision History

Revision	Description	Date
1.0	Initial version	2024/2/1
1.1	Update key description	2024/3/26
1.2	Update format	2024/4/7

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