

## 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  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

## 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

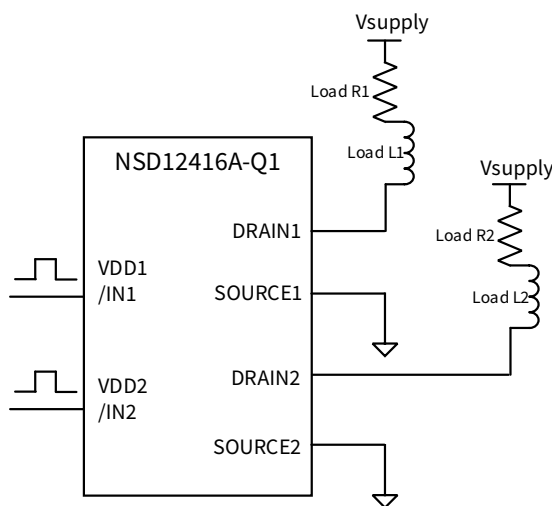


Figure 0.1 NSD12416A-Q1 Typical Application

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## 1. Pin Configuration and Functions

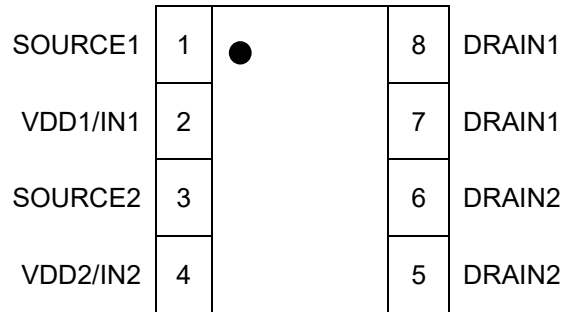


Figure 1.1 NSD12416A-Q1SPR Pinout

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

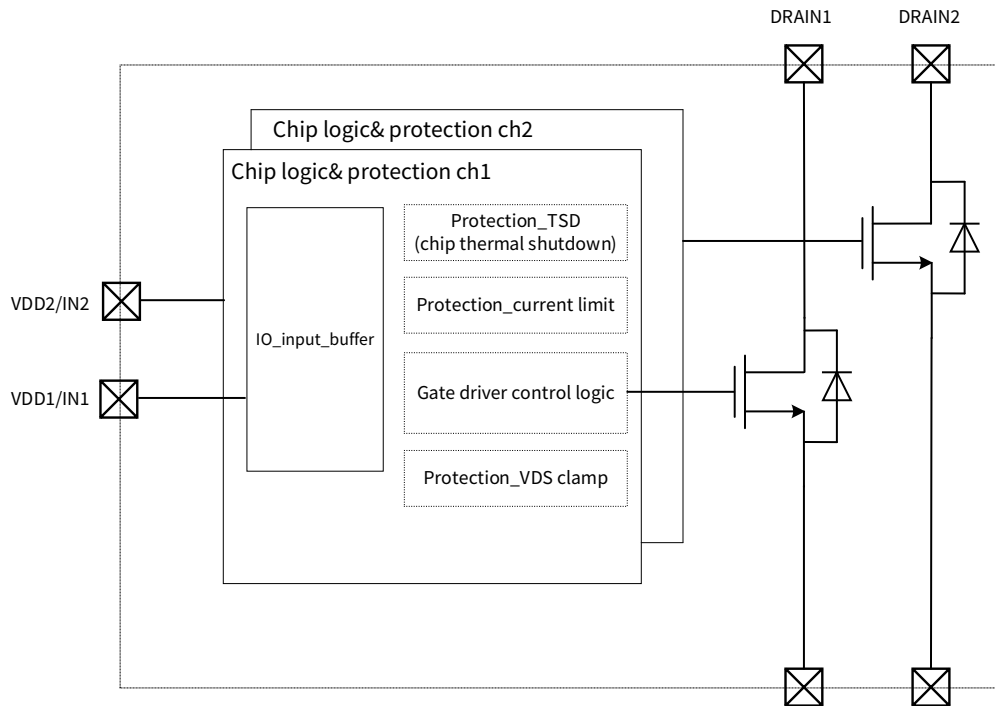


Figure 2.1 NSD12416A-Q1SPR Block diagram

### 3. Absolute Maximum Ratings

Parameters	Symbol	Min	Typ	Max	Unit
Drain-to-Source Voltage	$V_{DS}$			Internally clamped	V
Junction Temperature	$T_J$	-40		150	°C
Storage Temperature	$T_{stg}$	-55		150	°C
Single pulse avalanche energy (L = 12mH; $T_J = 150\text{ °C}$ ; $R_L = 0\Omega$ ; $I_{OUT} = I_{lim}$ )	$E_{AS}$			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	$\theta_{JA}$	75.4	°C/W
Junction-to-top characterization parameter	$\psi_{JT}$	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

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

Parameters	Symbol	Min	Typ	Max	Unit	Comments
<b>Power MOSFET</b>						
ON-state resistance	R <sub>ON</sub>		160		mΩ	I <sub>D</sub> = 1 A; T <sub>J</sub> = 25°C; V <sub>DD</sub> = V <sub>IN</sub> = 5 V
				320	mΩ	I <sub>D</sub> = 1 A; T <sub>J</sub> = 150°C; V <sub>DD</sub> = V <sub>IN</sub> = 5 V
Drain-source clamp voltage	V <sub>CLAMP</sub>	46	48	56	V	V <sub>IN</sub> = 0V, I <sub>D</sub> = 1A
Drain-source clamp threshold voltage	V <sub>CLTH</sub>	40			V	V <sub>IN</sub> = 0V, I <sub>D</sub> = 2 mA
OFF-state output current	I <sub>DSS</sub>	0		3	μA	V <sub>IN</sub> = 0 V; V <sub>DS</sub> = 13 V; T <sub>J</sub> = 25°C
		0		5	μA	V <sub>IN</sub> = 0 V; V <sub>DS</sub> = 13 V; T <sub>J</sub> = 125°C
Body diode forward voltage	V <sub>BD</sub>		0.8		V	I <sub>D</sub> = 1A; V <sub>IN</sub> = 0 V
<b>Input section</b>						
Supply current from input pin	I <sub>ISS</sub>		30	65	μA	ON-state; V <sub>DD</sub> =V <sub>IN</sub> = 5 V; V <sub>DS</sub> = 0 V
Input clamp voltage	V <sub>ICL</sub>	5.5		8	V	I <sub>ICL</sub> = 1 mA
			-0.7			I <sub>ICL</sub> = -1 mA
Input threshold voltage	V <sub>INTH</sub>	1		3.5	V	V <sub>DS</sub> = V <sub>IN</sub> ; I <sub>D</sub> = 1 mA
<b>Switching characteristics</b>						
Turn-on delay time	t <sub>d (ON)</sub>		9		μs	R <sub>L</sub> = 13 Ω, V <sub>CC</sub> = 13 V
Turn-off delay time	t <sub>d (OFF)</sub>		9		μs	R <sub>L</sub> = 13 Ω, V <sub>CC</sub> = 13 V
Rise time	t <sub>r</sub>		9		μs	R <sub>L</sub> = 13 Ω, V <sub>CC</sub> = 13 V
Fall time	t <sub>f</sub>		5		μs	R <sub>L</sub> = 13 Ω, V <sub>CC</sub> = 13 V
Switching energy losses at turn-on	W <sub>ON</sub>		26		μJ	R <sub>L</sub> = 13 Ω, V <sub>CC</sub> = 13 V
Switching energy losses at turn-off	W <sub>OFF</sub>		23		μJ	R <sub>L</sub> = 13 Ω, V <sub>CC</sub> = 13 V
<b>Protection and diagnostics</b>						
DC short-circuit current	I <sub>lim</sub>	1.6	2.5	3	A	V <sub>DS</sub> = 13 V, V <sub>DD</sub> = V <sub>IN</sub> = 5V
Shutdown temperature	T <sub>TSD</sub>	150	175	200	°C	
Reset temperature	T <sub>R</sub>	T <sub>RS</sub> + 1	T <sub>RS</sub> + 5		°C	
Thermal reset of STATUS	T <sub>RS</sub>	135			°C	
Thermal hysteresis (T <sub>TSD</sub> - T <sub>R</sub> )	T <sub>HYST</sub>		7		°C	
Dynamic temperature	ΔT <sub>J</sub>		40		K	T <sub>J</sub> = -40°C, V <sub>CC</sub> = 13V

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Dynamic temperature hysteresis	$\Delta T_J (HYS)$		15		K	

### 6.2. Switching characteristics

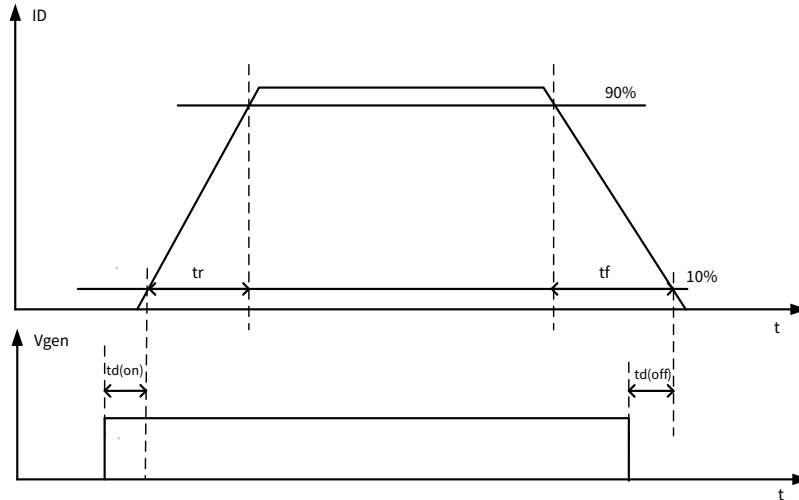


Figure 6.2 NSD12416A-Q1 Switching Characteristics

## 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  $\Delta T_J$ .

### 8. MCU I/O Protection

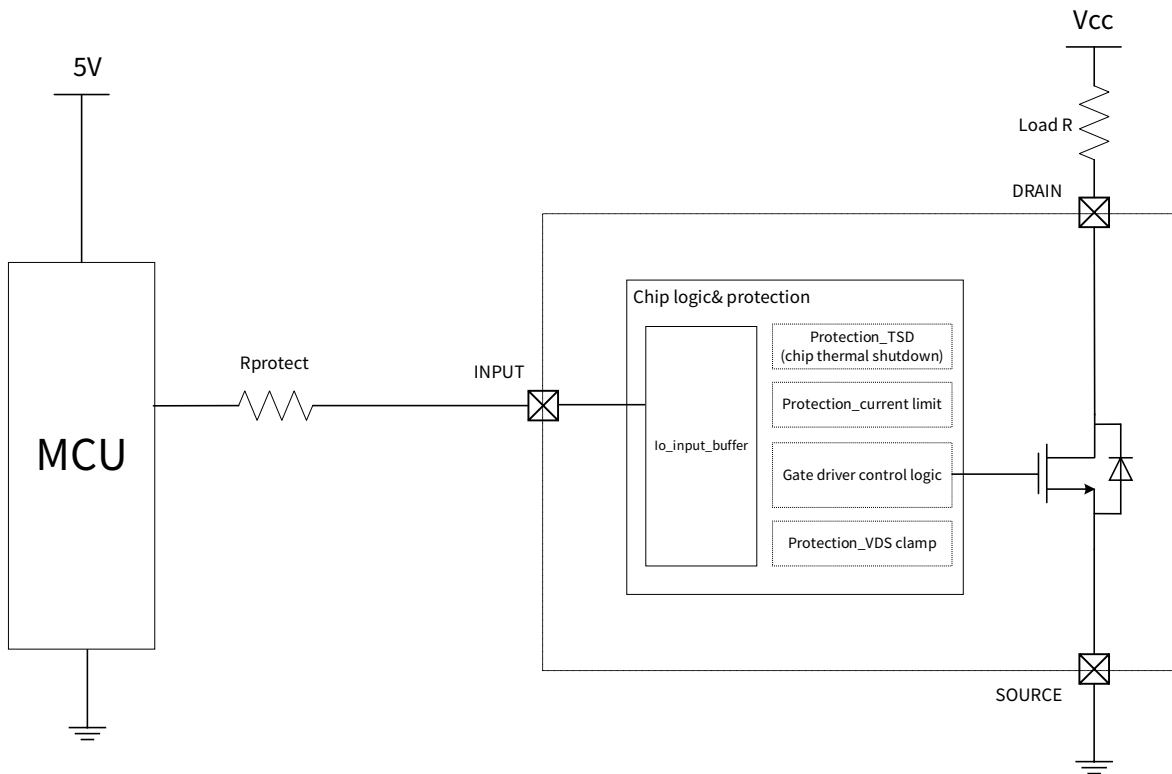


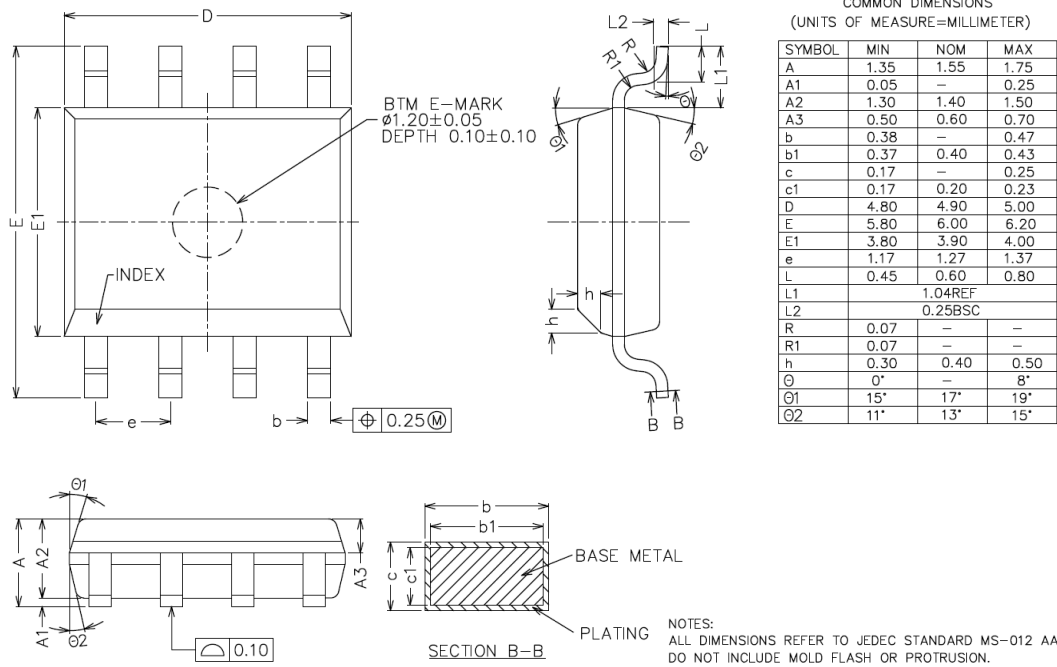
Figure 8.1 NSD12416A-Q1SPR application schematic

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.

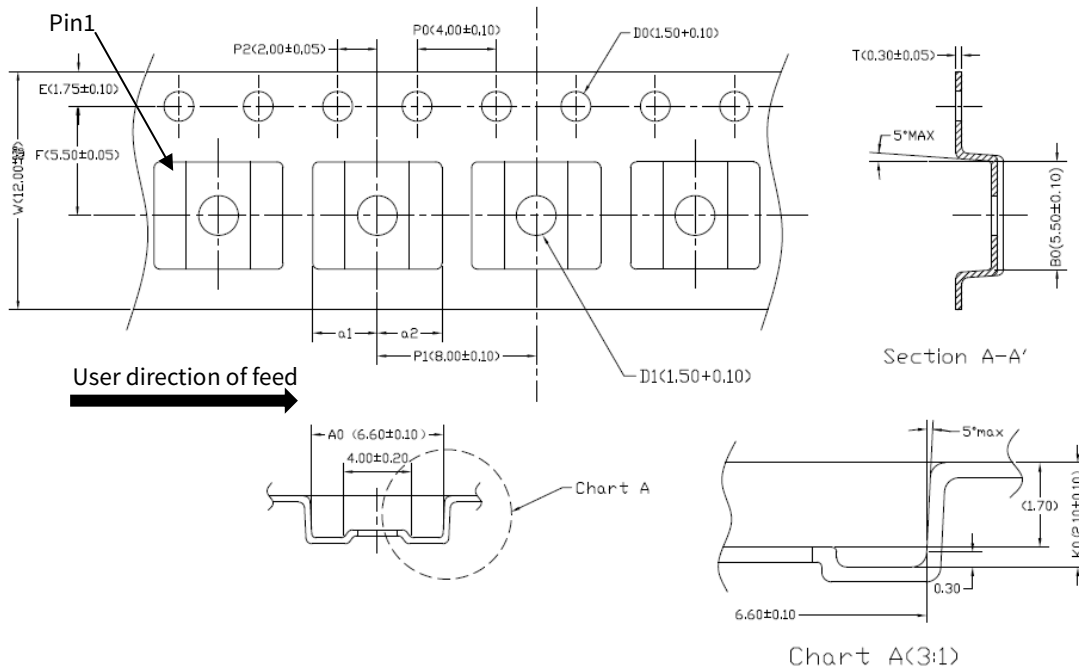
The value of resistors for protection  $R_{prot}$  is suggested 100ohm~1.5kohm.

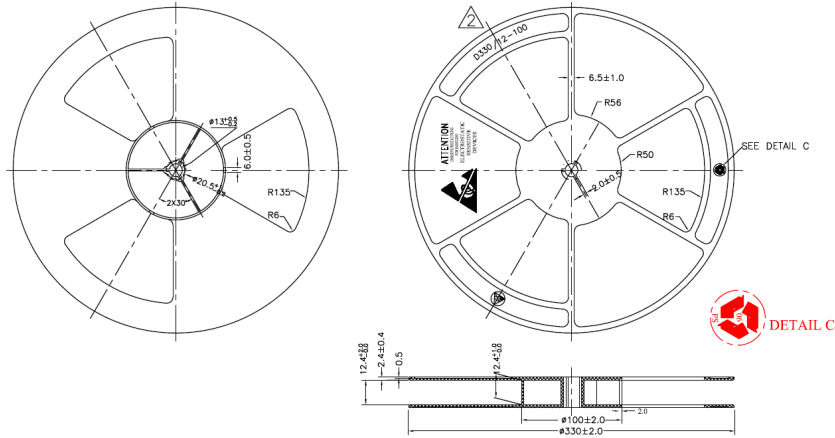
## 9. Package Information

### 9.1. SO-8 Package Information



### 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
1.3	Update the recommended value of resistors for MCU I/O protection	2025/5/16

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