NOVOSENSE

NSD11430-Q1
1CH, 300mΩ, 40V, Fully Protected Automotive Low-side Switch
Datasheet (EN) 1.1

Product Overview

NSD11430-Q1 is a 300mΩ 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 and short circuit to ground conditions 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

Normal MAX DC load current

Part Number	T_a	Load current(1)
NSD11430-Q1SPR	85°C	0.95A
	105°C	0.71A
NSD11430-Q1STBR	85°C	1.05A
	105°C	0.79A

(1) Based on the JEDEC standard high-K profile, JESD 51-7, four-layer board

Key Features

- AEC-Q100 Grade 1 Qualified
- Compatible with 3.3V MCU and 5V MCU
- Drain current limitation: 4.2A
- 48V over-voltage clamp
- Thermal shutdown protection
- Thermal swing protection
- Fault diagnostic block
  - Thermal shutdown diagnosis
  - Short circuit to ground diagnosis
- Very low standby current
- Very low electromagnetic susceptibility
- ESD protection
- RoHS & REACH Compliance

Device Information

Part Number	Package	Body Size
NSD11430-Q1SPR	SO-8	4.9mm x 3.9mm
NSD11430-Q1STBR	SOT223	6.48mm x 3.38mm

Typical Application

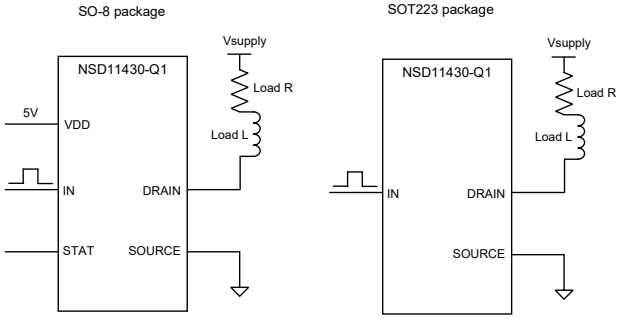

Figure 0.1 NSD11430-Q1 Typical Application

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1. Pin Configuration and Functions

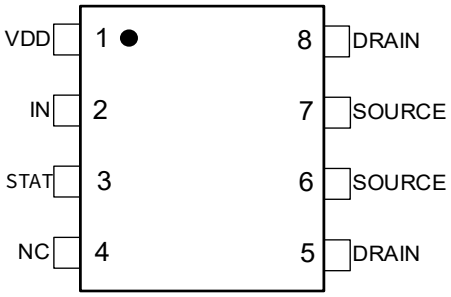


Figure 1.1 NSD11430-Q1SPR Pinout

Table 1.1 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 and ground reference for the control section

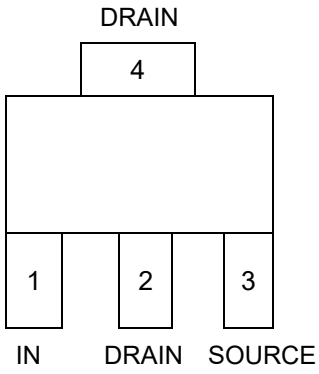


Figure 1.2 NSD11430-Q1STBR Pinout

Table 1.2 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. Block diagram

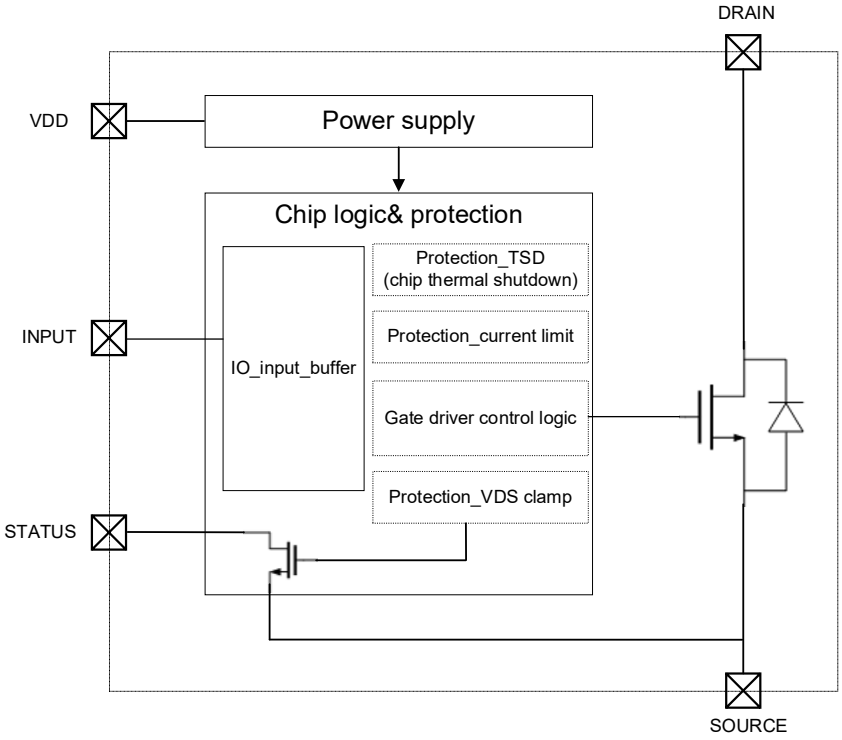


Figure 2.1 NSD11430-Q1SPR(SO-8) Block diagram

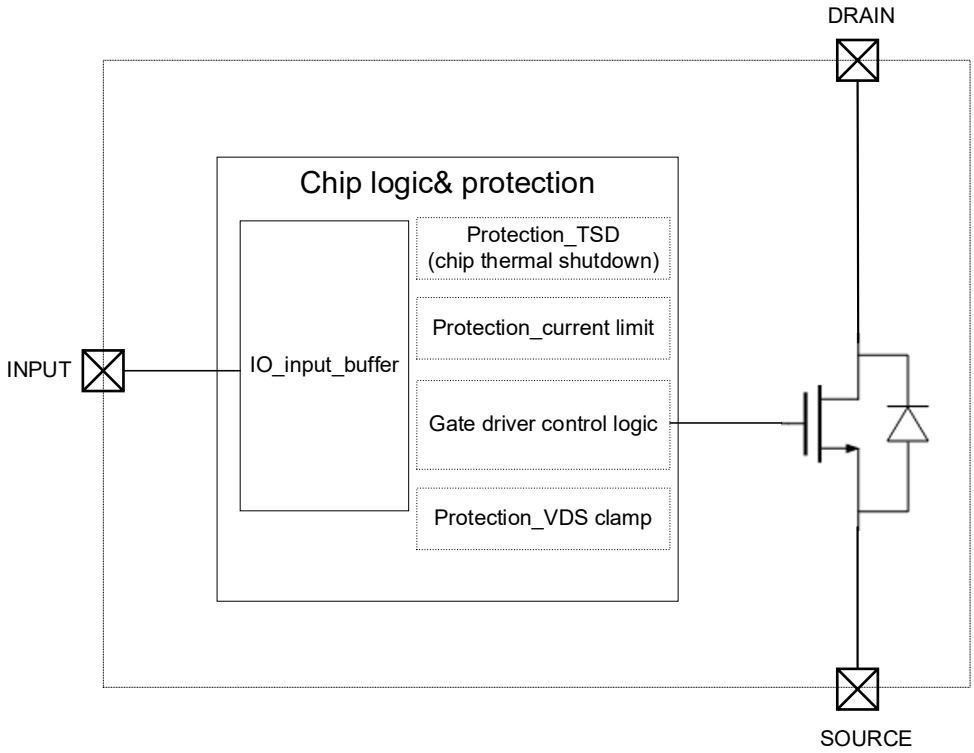


Figure 2.2 NSD11430- Q1STBR (SOT223) Block diagram

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
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 = 0; I_{OUT} = I_{lim})	E_{AS}			26	mJ

4. Power Dissipation for industrial PLC

Part number	Ta	P_D	UNIT
NSD11430-Q1SPR	25°C	1.21	W
	60°C	0.87	W
NSD11430-Q1STBR	25°C	1.47	W
	60°C	1.06	W

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

5. ESD Ratings

SYMBOL	PARAMETER	VALUE	UNIT
Electrostatic discharge	Human-body model, per AEC-Q100-002-RevD ， $V_{ESD-HBM}$	±4000	V
	Charged-device model, per AEC-Q100-011-RevB ， $V_{ESD-CDM}$	±750	V

6. Thermal Information

Parameters	Symbol	SO-8	SOT223	Unit
Junction-to-ambient Thermal Resistance	θ_{JA}	103	84.5	°C/W
Junction-to-top characterization parameter	ψ_{JT}	12	11	°C/W
Junction-to-case (top) thermal resistance	$\theta_{JC\ (top)}$	53	52	°C/W

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

7. Specifications

7.1. 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						
Operating supply voltage	V_S	3	5	5.5	V	
ON-state resistance	R_{ON}		300		mΩ	I_D = 0.8 A; T_J = 25°C; V_{DD} = 3.3V, V_{IN} = 5 V
			270		mΩ	I_D = 0.8 A; T_J = 25°C; V_{DD} = 5V, V_{IN} = 5 V
				600	mΩ	I_D = 0.8A; T_J = 150°C; V_{DD} = 3.3V, V_{IN} = 5 V
				540	mΩ	I_D = 0.8A; T_J = 150°C; V_{DD} = 5V, V_{IN} = 5 V
Drain-source clamp voltage	V_{CLAMP}	43	48	53	V	V_{IN} = 0V, I_D = 0.8 A
Drain-source clamp threshold voltage	V_{CLTH}	36			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 = 0.8A; V_{IN} = 0 V
VDD/Input section (SOT223 package only)						
Supply current from VDD/input pin	I_{ISS}		30	65	μA	ON-state: V_{DD} = V_{IN} = 5 V; V_{DS} = 0 V
VDD/input clamp voltage	V_{ICL}	5.5		8	V	I_S = 1 mA
			-0.7			I_S = -1 mA
VDD/input threshold voltage	V_{INTH}	1		3	V	V_{DS} = V_{IN}; I_D =1 mA
VDD (SO-8 package only)						
Operating supply current	I_S		10	25	μA	OFF-state; T_J = 25°C; V_{IN} = V_{DS} = 0 V;
			25	65	μA	ON-state; T_J = 25°C; V_{IN} = 5 V; V_{DS} = 0 V
Supply clamp voltage	V_{SCL}	5.5		8	V	I_{SCL} = 1 mA
			-0.7			I_{SCL} = -1 mA
Logic Input (SO-8 package only)						
Low-level input voltage	V_{IL}			0.9	V	V_{DD} = 5V,

Parameters	Symbol	Min	Typ	Max	Unit	Comments
				0.7	V	V_{DD} = 3.3V
Low-level input current	I_{IL}	1			μA	V_{IN} = 0.9V
High-level input voltage	V_{IH}	2.1			V	
High-level input current	I_{IH}			10	μA	V_{IN} = 2.1V
Input hysteresis voltage	$V_{I\ (hyst)}$	0.1			V	
Input clamp voltage	V_{ICL}	5.5		8	V	I_{IN} = 1 mA
			-0.7			I_{IN} = -1 mA
Status indicator (SO8 package only)						
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 (1)	C_{STAT}			100	pF	V_{STAT} = 5 V
Status clamp voltage	V_{STCL}	5.5		8	V	I_{STAT} = 1 mA
			-0.7			I_{STAT} = - 1 mA
Short circuit to ground detection (SO-8 package only)						
short circuit to ground OFF-state voltage detection threshold	V_{SCGTH}	1.1	1.2	1.4	V	V_{IN} = 0 V
Delay between INPUT falling edge and STATUS falling edge in short circuit to ground condition	$t_{d\ (STAT)}$		250		μs	I_D = 0 A
Switching characteristics						
Turn-on delay time	$t_{d\ (ON)}$		6		μs	R_L = 16 Ω, V_{CC} = 13 V
Turn-off delay time	$t_{d\ (OFF)}$		13		μs	R_L = 16Ω, V_{CC} = 13 V
Rise time	t_{rise}		3		μs	R_L = 16 Ω, V_{CC} = 13 V
Fall time	t_{fall}		8		μs	R_L = 16 Ω, V_{CC} = 13 V
Switching energy losses at turn-on	W_{ON}		6		μJ	R_L = 16Ω, V_{CC} = 13 V
Switching energy losses at turn-off	W_{OFF}		28		μJ	R_L = 16 Ω, V_{CC} = 13 V
Protection and diagnostics						
DC short-circuit current	I_{lim}	3	4.2	5.5	A	V_{DS} = 13 V, V_{DD} = V_{IN} = 5V
Shutdown temperature	T_{TSD}	150	175	200	°C	
Reset temperature (1)	T_R	T_{RS} + 1	T_{RS} + 5		°C	
Thermal reset of STATUS (1)	T_{RS}	135			°C	
Thermal hysteresis (T_{TSD} - T_R)	T_{HYST}		20		°C	

Parameters	Symbol	Min	Typ	Max	Unit	Comments
Dynamic temperature (1)	ΔT_J		40		K	T_J = -40°C, VCC = 13V
Dynamic temperature hysteresis (1)	$\Delta T_{J\ (HYS)}$		15		K	

(1) Not subject to production test, specified by design.

7.2. Typical Performance Curves (1)

（Unless otherwise specified，T_J =25°C，Vin=5V）

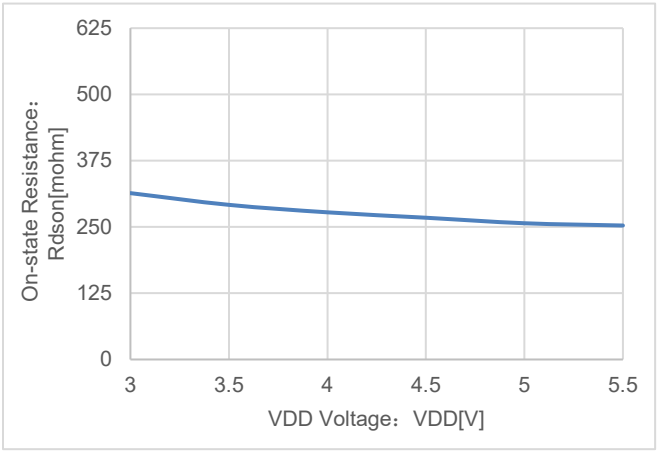


Figure 7.1 On-state Resistance vs VDD Voltage

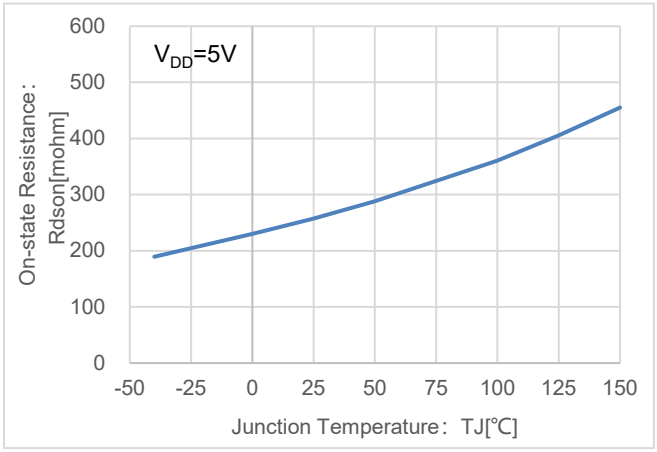


Figure 7.2 On-state Resistance vs Junction Temperature

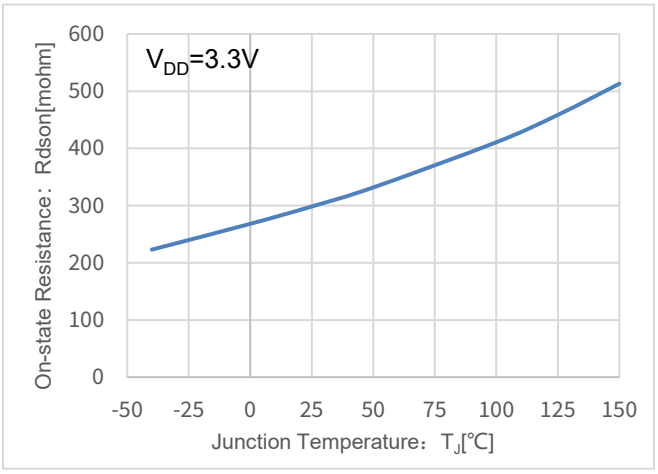


Figure 7.3 On-state Resistance vs Junction Temperature

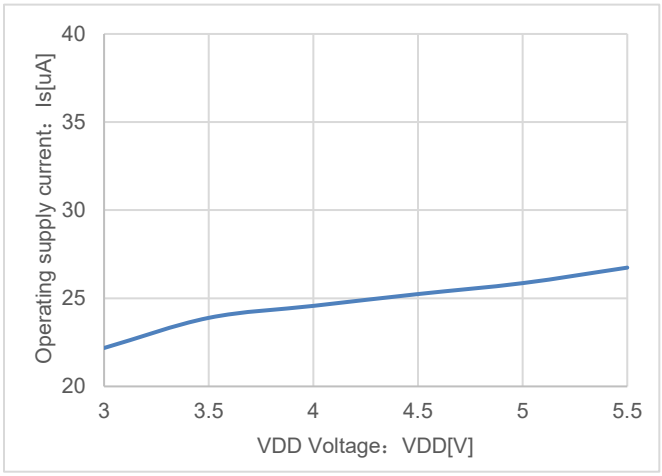


Figure 7.4 VDD Operating supply Current vs VDD Voltage

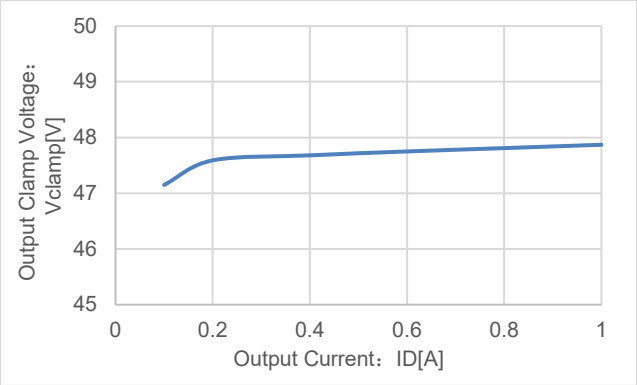


Figure 7.5 Output Clamp Voltage vs Output Current

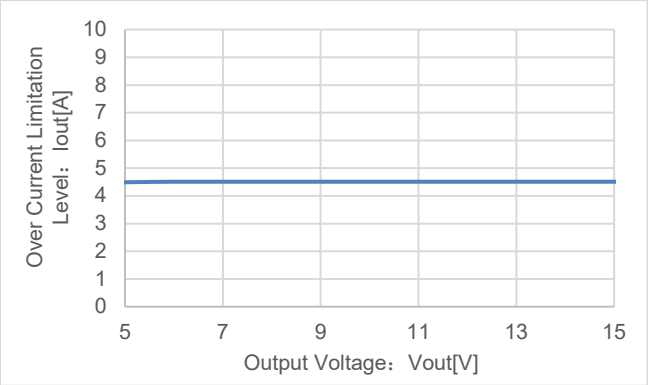


Figure 7.6 Over Current Limitation Level vs Output Voltage

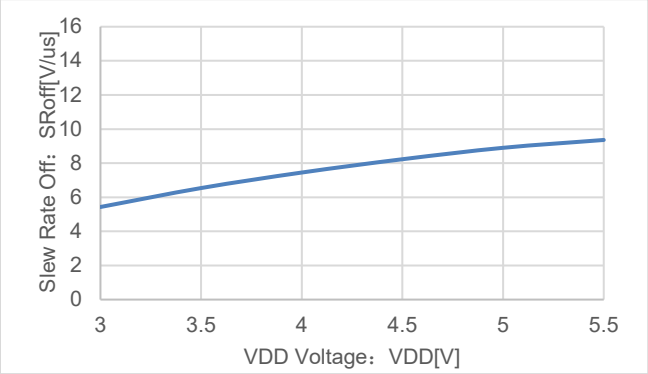


Figure 7.7 Slew Rate Off vs VDD Voltage

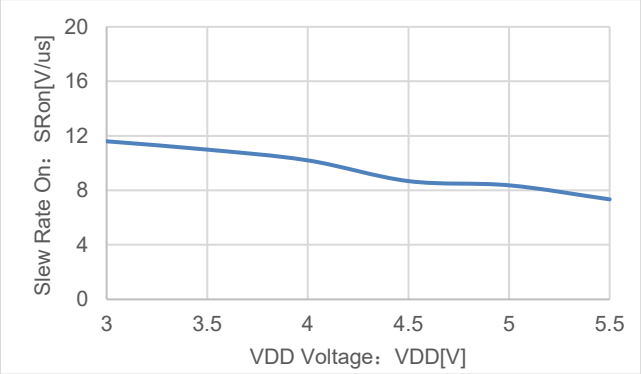


Figure 7.8 Slew Rate On vs VDD Voltage

(1) Not subject to production test, specified by design.

7.3. Typical Performance Characteristics

7.3.1.Truth 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
Short circuit to ground	L	L	L
	H	L	H

7.3.2.Switching characteristics

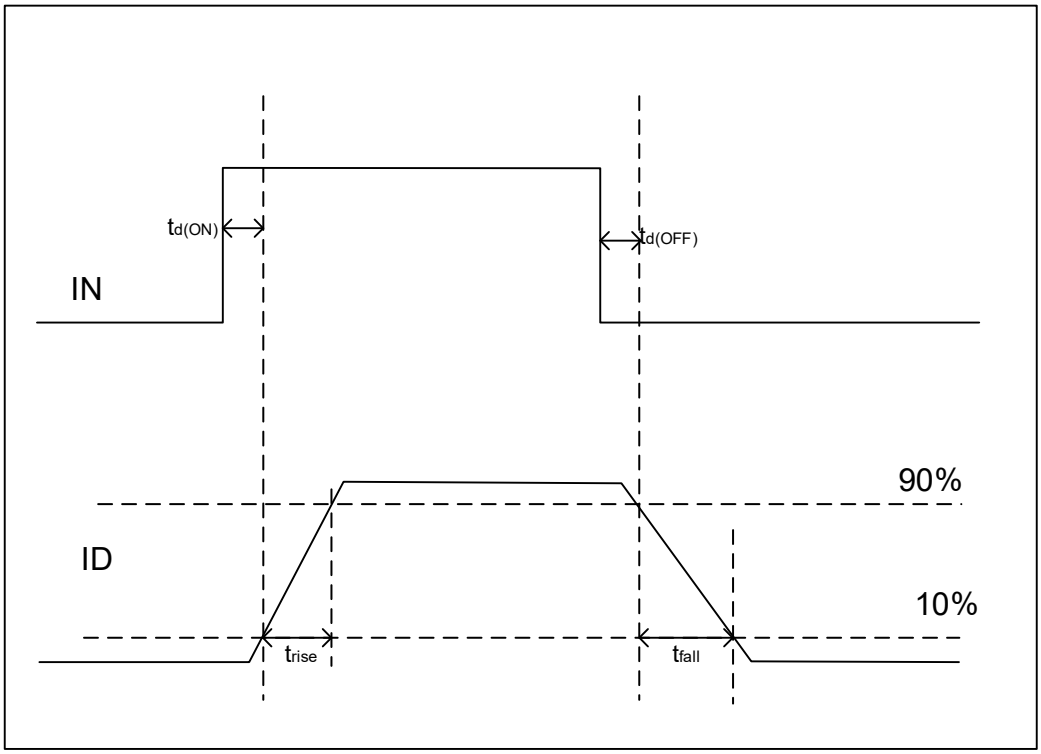


Figure 7.9 NSD11430-Q1 Switching Characteristics

8. Protections

8.1. Current Limitation

NSD11430-Q1 has current limitation to protect the silicon and bonding wire in case of overload or short circuit to battery.

8.2. 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.

9. Application information

9.1. Application Circuit

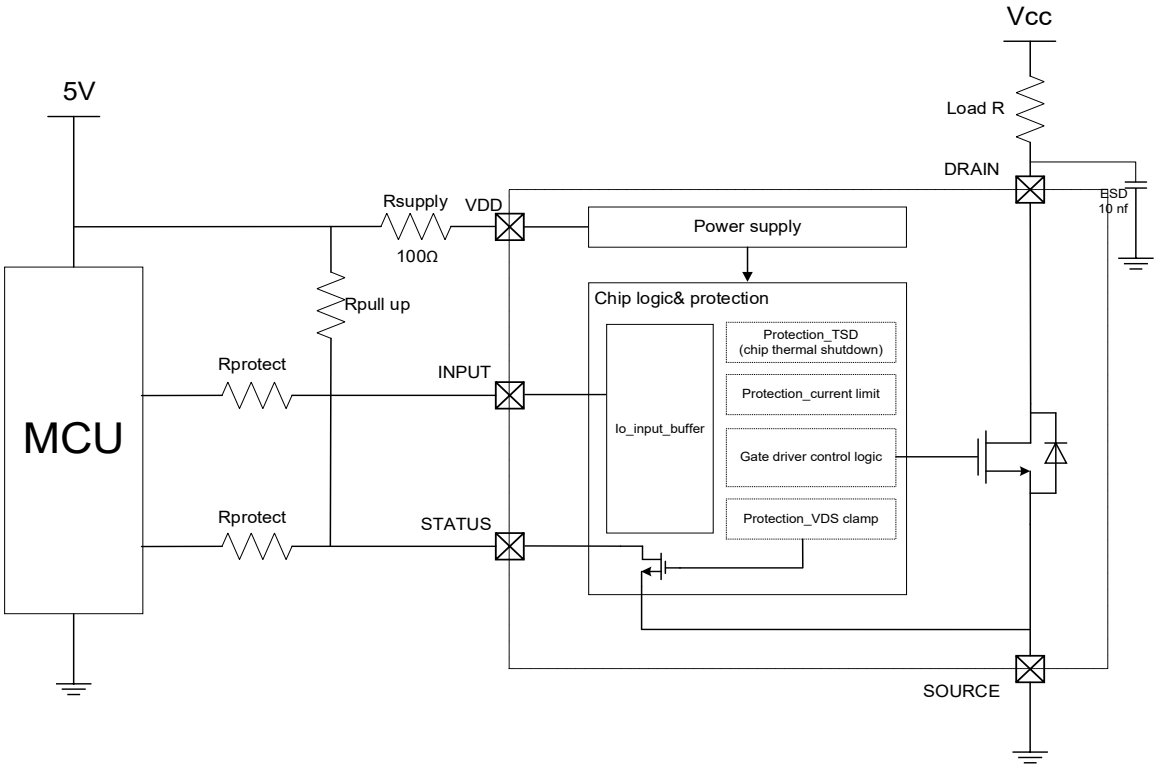


Figure 9.1 NSD11430-Q1SPR application schematic

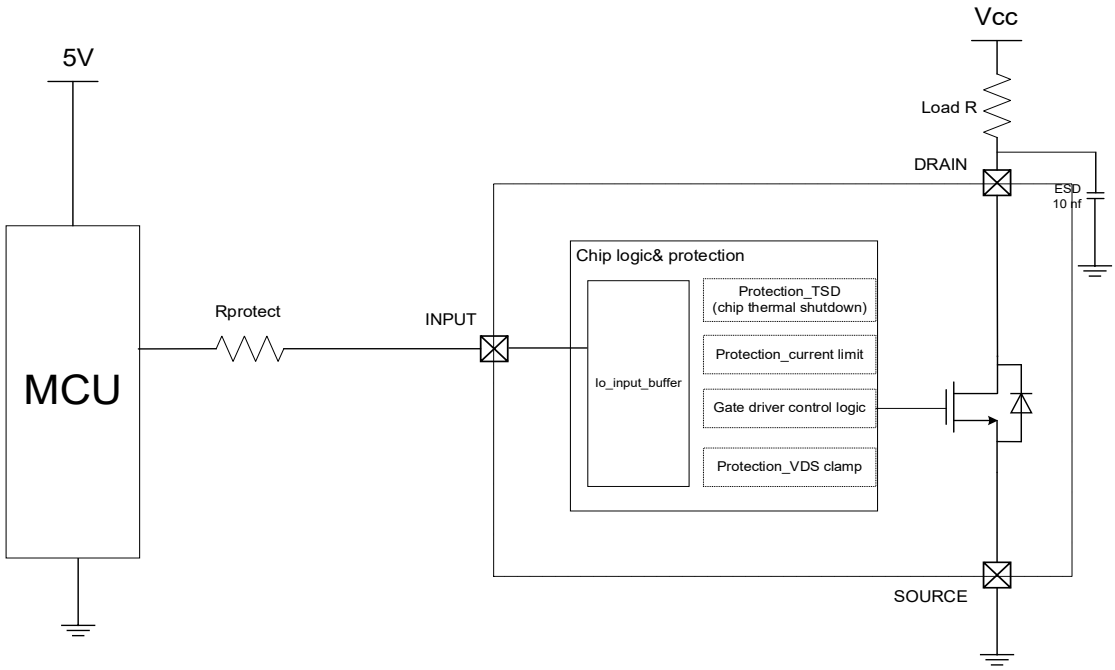


Figure 9.2 NSD11430-Q1STBR application schematic

9.2. MCU I/O protection

NSD11430 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.The supply resistor R_{supply} is the same.

9.3. The value of STATUS pulls 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} = 5V（5V MCU）; Ron = V_{STAT}/I_{STAT} = 500Ω, V_{OL} = 0.9V; V_{OH} = 2.1V; I_{leak} = 10uA, so 2.6kΩ ≤ R_{pullup} ≤ 240kΩ.
Let: V_{pullup} = 3.3V（3.3V MCU）; Ron = V_{STAT}/I_{STAT} = 500Ω, V_{OL} = 0.9V; V_{OH} = 2.1V; I_{leak} = 10uA, so 1.5kΩ ≤ R_{pullup} ≤ 90kΩ.
The recommended R_{pullup} value is 10kΩ.

9.4. Inductive load operation

If the load side of the chip is connected to a pure inductive load, at the moment the channel is switched off, the inductive load will generate a reverse electromotive force, then the chip's activate clamp circuit will clamp the voltage on the drain side at V_{CLAMP}. The current will slowly drop, and the energy generated during this period will be the E_{AS}.

The specific operation schematic is shown in Figure 9.3. E_{AS} is calculated as follows:

$$E_{AS}=\frac{1}{2}\cdot I_L^2\cdot L\cdot\frac{V_{\text{clamp}}}{V_{clamp}-V_{bat}}$$

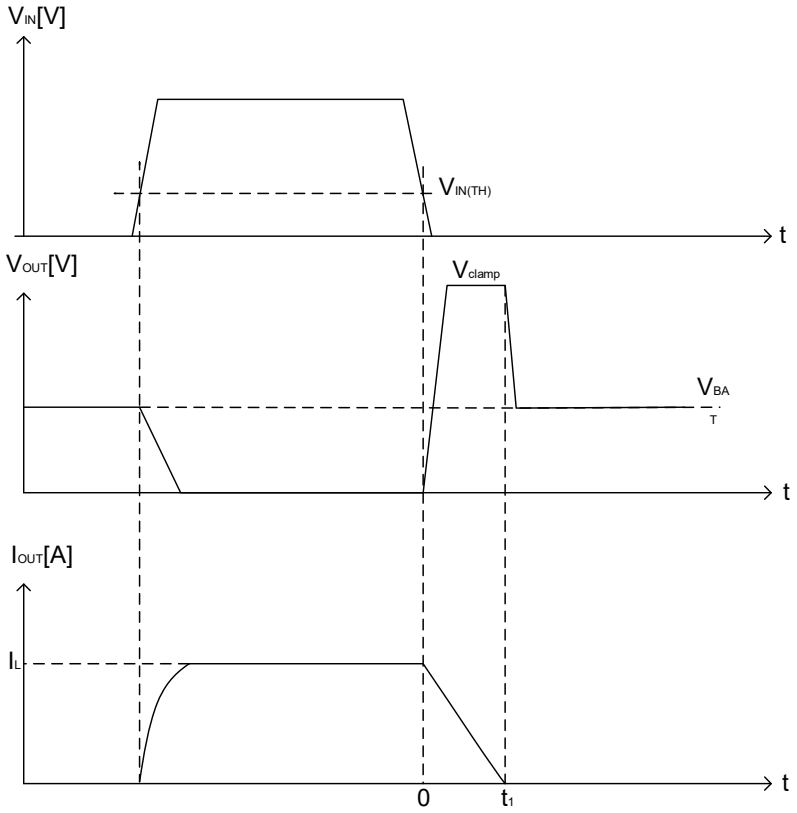
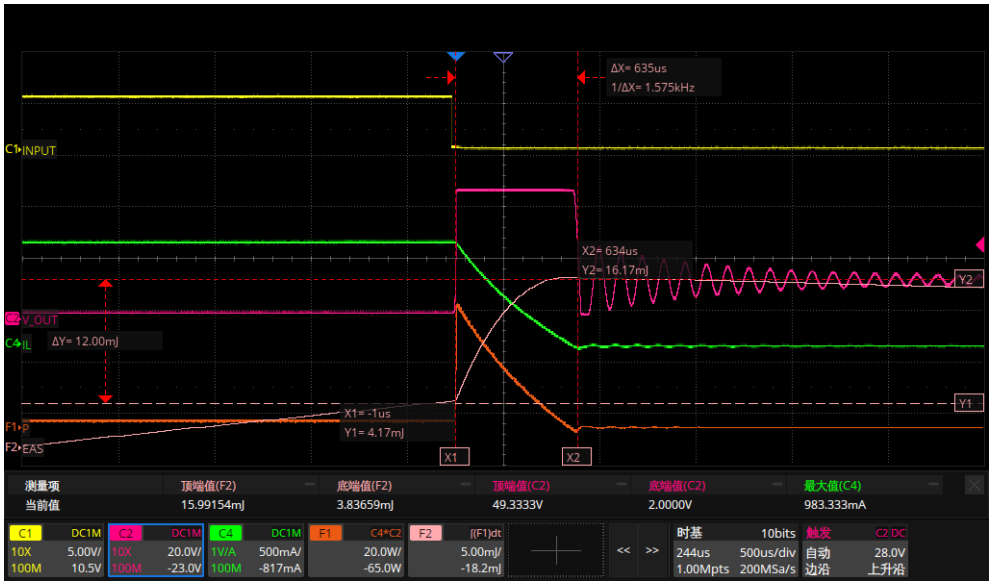


Figure 9.3 LSD Inductive load operation

In practical applications, the loads are not purely inductive and will contain resistance. So, the actual clamping energy calculation is shown in Figure 9.4.

$$E_{AS} = \int (V_{OUT} * I_L)dt = \int (C2 * C4)dt$$

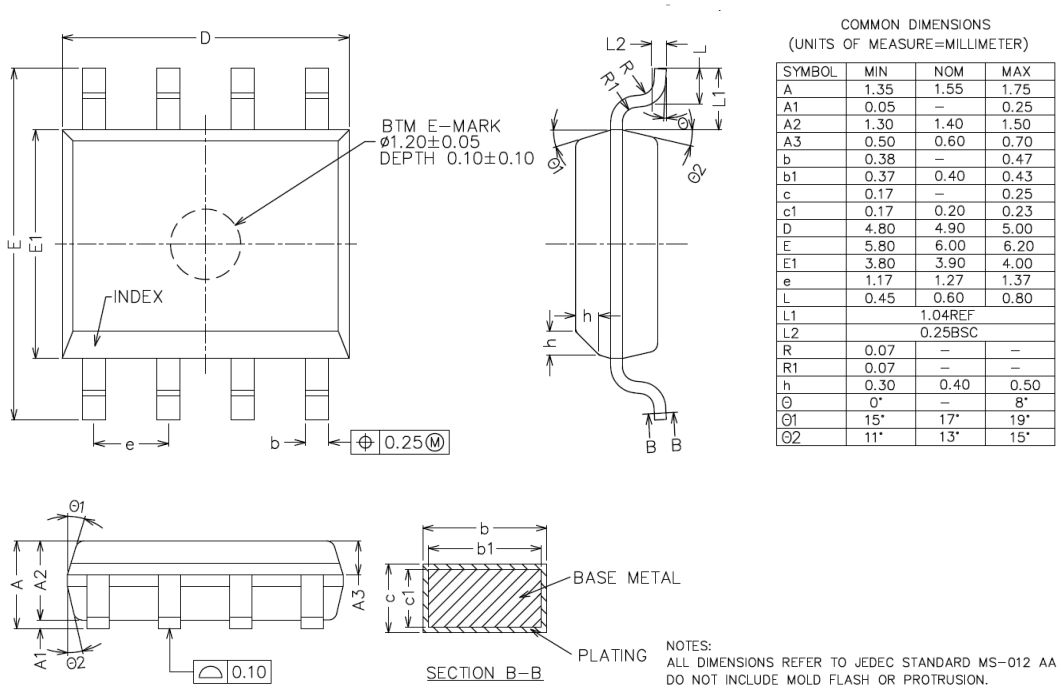


*where C1: INPUT C2: VOUT C4: IL F1: P=C2*C4 F2: EAS*

Figure 9.4 LSD Clamped energy actual test waveform

10. Package Information

10.1. SO-8 package information

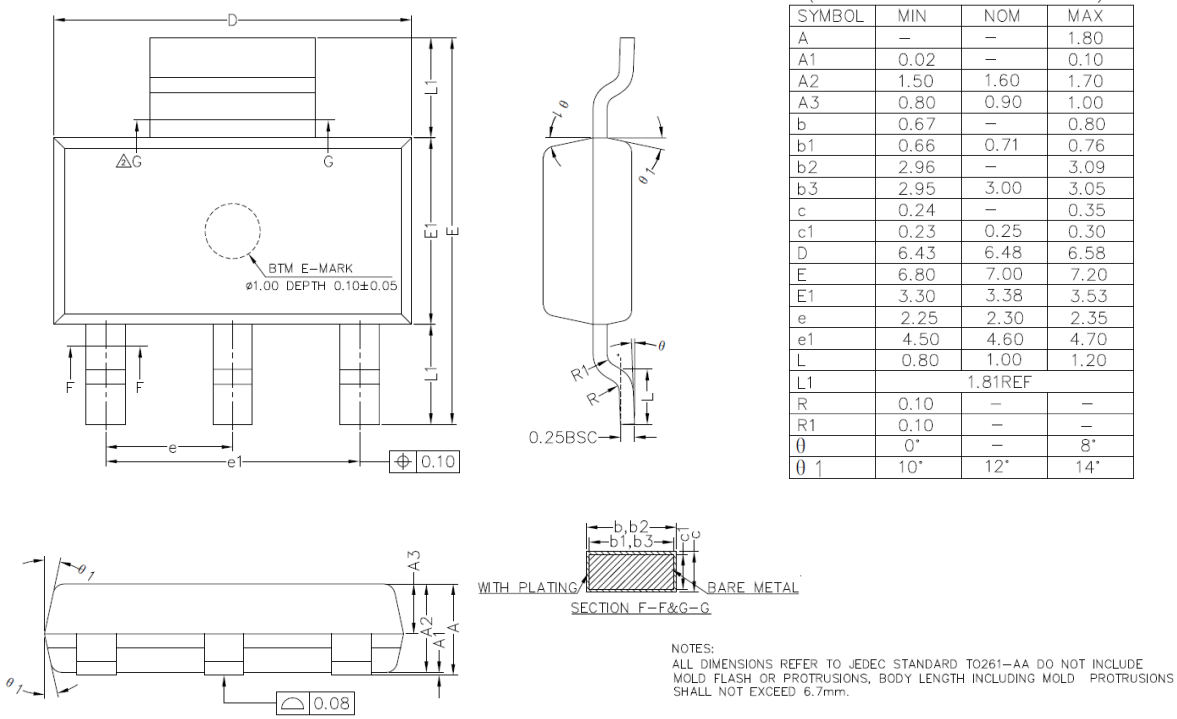


COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

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.

10.2. SOT223 package information



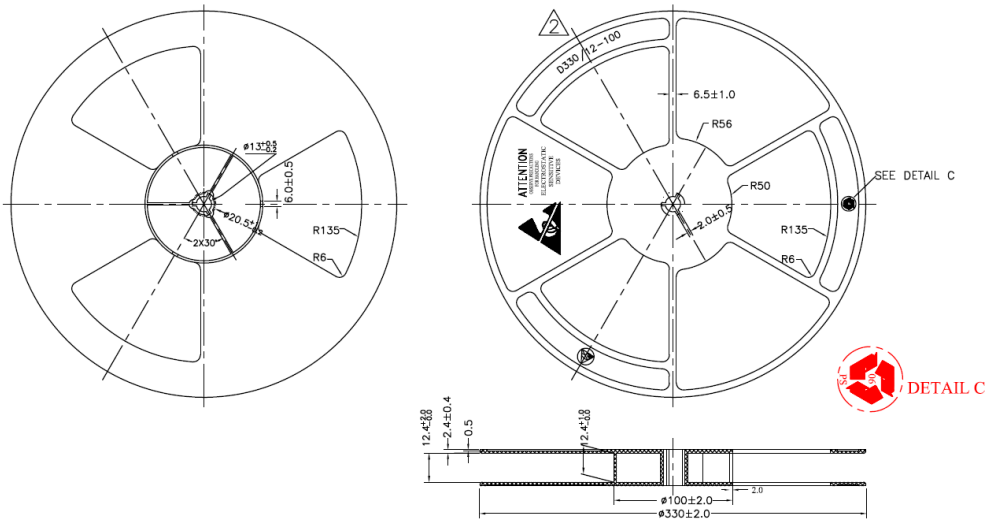
COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

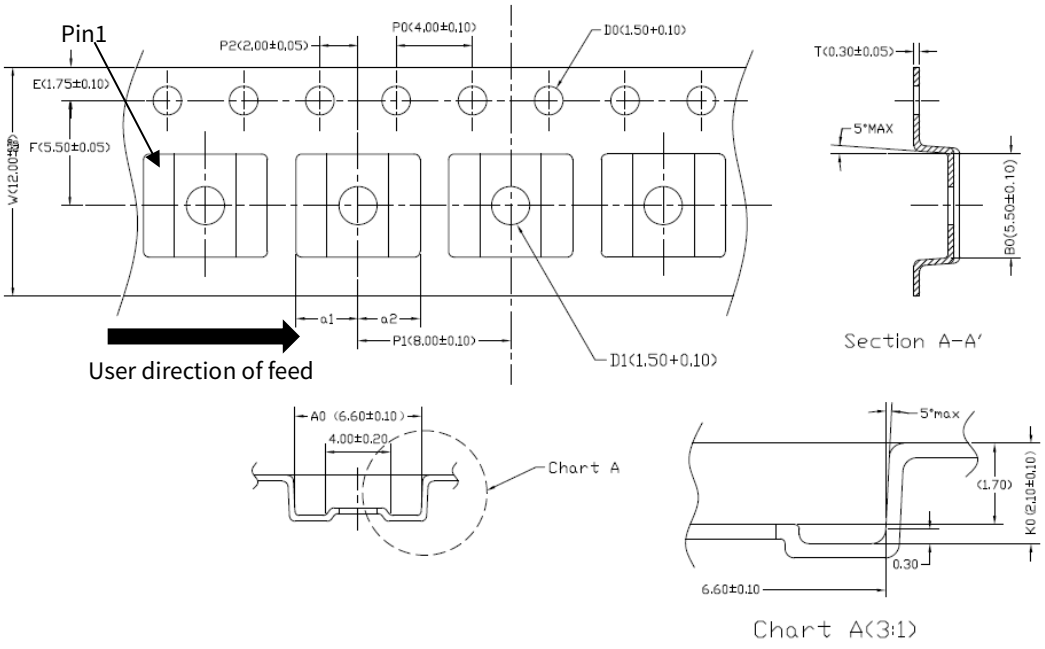
SYMBOL	MIN	NOM	MAX
A	–	–	1.80
A1	0.02	–	0.10
A2	1.50	1.60	1.70
A3	0.80	0.90	1.00
b	0.67	–	0.80
b1	0.66	0.71	0.76
b2	2.96	–	3.09
b3	2.95	3.00	3.05
c	0.24	–	0.35
c1	0.23	0.25	0.30
D	6.43	6.48	6.58
E	6.80	7.00	7.20
E1	3.30	3.38	3.53
e	2.25	2.30	2.35
e1	4.50	4.60	4.70
L	0.80	1.00	1.20
L1	1.81REF		
R	0.10	–	–
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.

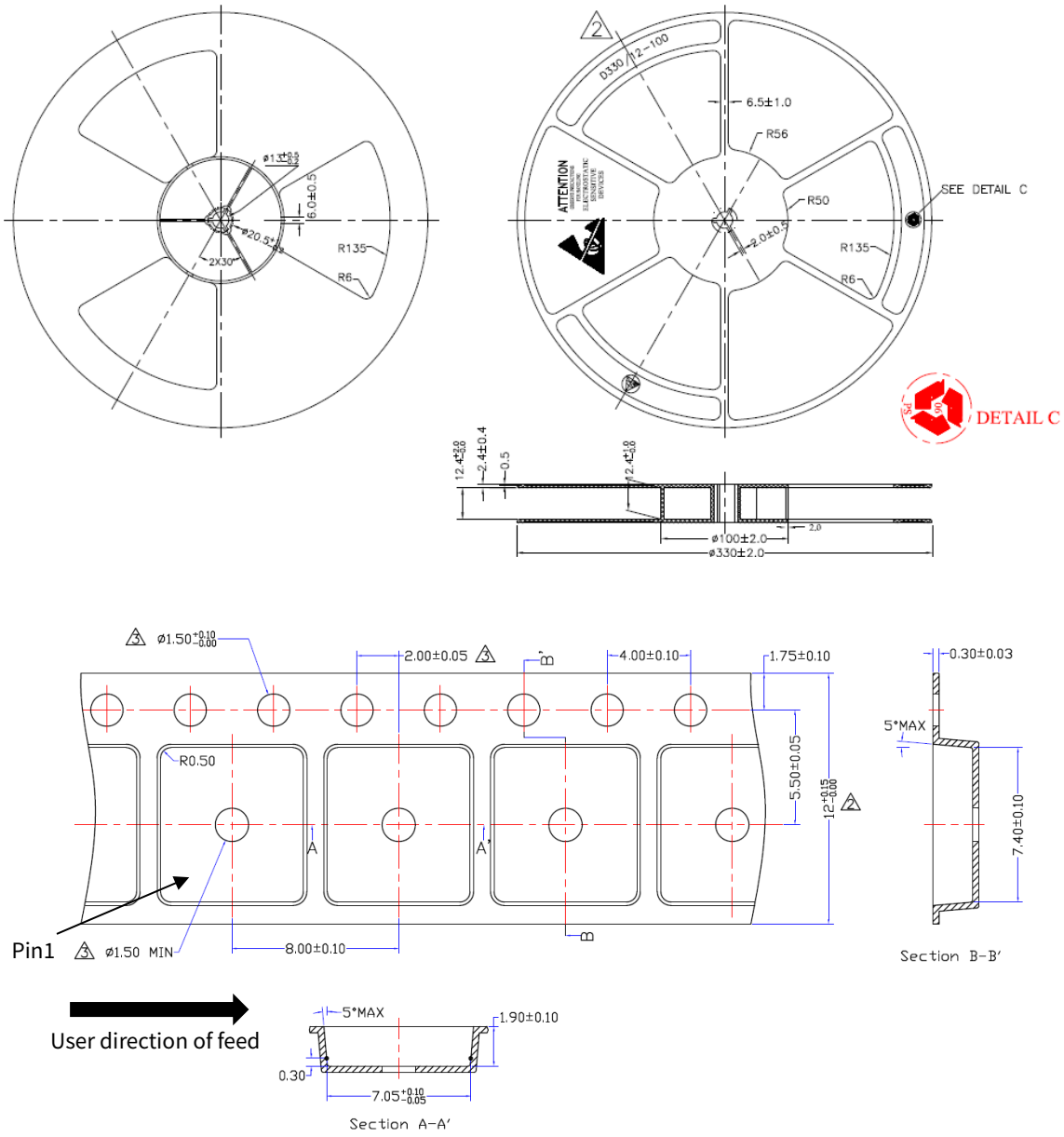
11. Packaging Information

11.1. SO-8 packaging information





11.2. SOT223 packaging information



12. Ordering Information

Part Number	Package	MSL	SPQ
NSD11430-Q1SPR	SO-8	3	2500
NSD11430-Q1STBR	SOT223	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.			

13. Revision History

Revision	Description	Date
1.0	Initial version	2024/11/20
1.1	Update power requirements for PLC applications	2025/4/1

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