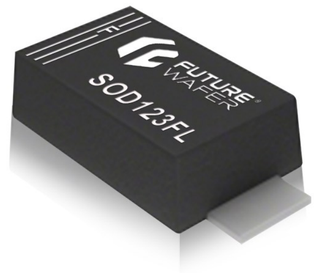
400-W , SOD123 Transient Voltage Suppression Diodes

1. Product profile

1-1.General description

The NVS4M Series has been designed to protect sensitive equipment against electro-static discharges according to IEC 61000-4-2, MIL STD 883 method 3015, and electrical over stress such as IEC 61000-4-4 and 5. They are generally for surges below 400 W 10/1000 µs. This technology makes it compatible with high-end equipment and SMPS where low leakage current and high junction temperature are required to provide reliability and stability over time. Their low clamping voltages provide a better safety margin to protect sensitive circuits with extended life time expectancy. packaged in SOD123FL, This minimizes PCB space consumption.



SOD123-FL

3D Models

1-2. Features

- Bi/Uni-directional configurations
- Plastic package has underwriters
- Glass passivated chip junction
- 400 Watts peak pulse power (t_p = 10/1000uS)
- Halogen free and Rohs compliant
- Fast response time: typically less than 1.0ps from 0 volts to $V_{(BR)}$ for Uni-directional and 5.0ns For Bi-directional types
- High temperature soldering guaranteed: 250°C/10 seconds at terminals

1-3. Applications

NVS4M Devices are ideal for the protection of I/O interfaces, V_{CC} bus and other vulnerable circuit used in cellular phones, portable devices, business machines, power supplies and other consumer applications.

1-4. IEC Compatibility

- ESD / Transient protection according to:
  - IEC61000-4-2(ESD) : ±30KV(Contact) / ±30KV(Air)
  - IEC61000-4-5(Surge) : 400W (10/10000us)

1-5. Mechanical characteristics

- Molded SOD123-FL package
- Packing : tape and reel
- Flammability rating UL 94V-0
- Halogen free
- Moisture sensitivity levels (MSL): Level 1
- UL Listed: E538773

UL CERTIFIED SAFETY US E538773 · RoHS2 COMPLIANT · HALOGEN FREE · LEVEL 1 · LEAD FREE

2. Maximum ratings

Parameter	Symbol	Test condition	Min.	Typ.	Max.	Units
Peak pulse power	P_{PP}	10/1000 us,	-	-	400	W
		8/20 us,	-	-	2400	
Instantaneous forward voltage	V_F	100A For Uni-direction only	-	-	3.5	V
Peak forward surge current	I_{FSM}	8.3mS signal half sine wave Uni-directional only	-	-	40	A
Total power dissipation	P_{tot}	T_{amb} <= 25 °C	-	-	1	W
Electrostatic discharge	$V_{ESD\ (Contact)}$	IEC61000-4-2 ；	-30	-	+30	KV
	$V_{ESD\ (Air)}$	R = 330Ω,C = 150pF				
Junction temperature	T_j		-	-	+150	°C
Ambient temperature	T_{amb}		-55	-	+150	
Storage temperature	T_{STG}		-65	-	+150	

Table 1. Electrical characteristics

3. Electrical Characteristics

Part number		Reverse stand-off voltage	Breakdown voltage		Test current	Reverse leakage	Max. clamp voltage	Peak pulse current	Marking	
		VRWM	VBR @ I T		I T	IR @ VRWM	VC @ IPP	I PP (10/1000us)		
			Min	Max						
Uni	Bi	V	V	V	mA	µA	V	A	Uni	Bi
400W Surface Mount Transient Voltage Suppressors NVS4M Series										
NVS4M5.0A	NVS4M5.0CA	5.0	6.40	7.07	10.0	200.0	9.2	43.48	A1	FA1
NVS4M6.0A	NVS4M6.0CA	6.0	6.67	7.37	10.0	200.0	10.3	38.83	A2	FA2
NVS4M6.5A	NVS4M6.5CA	6.5	7.22	7.98	10.0	100.0	11.2	35.71	A3	FA3
NVS4M8.5A	NVS4M8.5CA	8.5	9.44	10.40	1.0	20.0	14.4	27.78	A4	FA4
NVS4M10A	NVS4M10CA	10.0	11.1	12.3	1.0	10.0	17.0	23.53	A5	FA5
NVS4M12A	NVS4M12CA	12.0	13.3	14.7	1.0	1.0	19.9	20.10	A6	FA6
NVS4M13A	NVS4M13CA	13.0	14.4	15.9	1.0	1.0	21.5	18.60	A7	FA7
NVS4M15A	NVS4M15CA	15.0	16.7	18.5	1.0	1.0	24.4	16.39	A8	FA8
NVS4M18A	NVS4M18CA	18.0	20.0	22.1	1.0	1.0	29.2	13.70	A9	FA9
NVS4M20A	NVS4M20CA	20.0	22.2	24.5	1.0	1.0	32.4	12.35	AA/CV	FAA
NVS4M24A	NVS4M24CA	24.0	26.7	29.5	1.0	1.0	38.9	10.28	AB/SZ	FAB
NVS4M26A	NVS4M26CA	26.0	28.9	31.9	1.0	1.0	42.1	9.50	AC/DE	FAC
NVS4M28A	NVS4M28CA	28.0	31.1	34.4	1.0	1.0	45.4	8.81	AD/DG	FAD
NVS4M30A	NVS4M30CA	30.0	33.3	36.8	1.0	1.0	48.4	8.26	CK	FCK
NVS4M33A	NVS4M33CA	33.0	36.7	40.6	1.0	1.0	53.3	7.50	AE/DM	FAE
NVS4M36A	NVS4M36CA	36.0	40.0	44.2	1.0	1.0	58.1	6.88	AF/DP	FAF
NVS4M40A	NVS4M40CA	40.0	44.4	49.1	1.0	1.0	64.5	6.20	AL	FAL
NVS4M43A	NVS4M43CA	43.0	47.8	52.8	1.0	1.0	69.4	5.76	AS	FAS
NVS4M45A	NVS4M45CA	45.0	50.0	55.3	1.0	1.0	72.7	5.50	AR	FAR
NVS4M48A	NVS4M48CA	48.0	53.3	58.9	1.0	1.0	77.4	5.17	AG/DX	FAG
NVS4M51A	NVS4M51CA	51.0	56.7	62.7	1.0	1.0	82.4	4.85	AH/DG	FAH
NVS4M58A	NVS4M58CA	58.0	64.4	71.2	1.0	1.0	93.6	4.27	AI/EG	FAI
NVS4M60A	NVS4M60CA	60.0	66.7	73.7	1.0	1.0	96.8	4.13	FRK	FZK
NVS4M64A	NVS4M64CA	64.0	71.1	78.6	1.0	1.0	103.0	3.88	FRM	FZM
NVS4M70A	NVS4M70CA	70.0	77.8	86.0	1.0	1.0	113.0	3.54	FRP	FZP
NVS4M75A	NVS4M75CA	75.0	83.3	92.1	1.0	1.0	121.0	3.31	FRF	FZR
NVS4M78A	NVS4M78CA	78.0	86.7	95.8	1.0	1.0	126.0	3.17	FRT	FZT
NVS4M85A	NVS4M85CA	85.0	94.4	104.0	1.0	1.0	137.0	2.92	FRV	FZV
NVS4M90A	NVS4M90CA	90.0	100.0	111.0	1.0	1.0	146.0	2.74	FRX	FZX
NVS4M100A	NVS4M100CA	100.0	111.0	123.0	1.0	1.0	162.0	2.47	FRZ	FZZ
NVS4M110A	NVS4M110CA	110.0	122.0	135.0	1.0	1.0	177.0	2.26	FSE	FVE
NVS4M120A	NVS4M120CA	120.0	133.0	147.0	1.0	1.0	193.0	2.07	FSG	FVG
NVS4M130A	NVS4M130CA	130.0	144.0	159.0	1.0	1.0	209.0	1.91	FSK	FVK
NVS4M150A	NVS4M150CA	150.0	167.0	185.0	1.0	1.0	243.0	1.65	FSM	FVM
NVS4M160A	NVS4M160CA	160.0	178.0	197.0	1.0	1.0	259.0	1.54	FSP	FVP
NVS4M170A	NVS4M170CA	170.0	189.0	209.0	1.0	1.0	275.0	1.45	FSR	FVR
NVS4M180A	NVS4M180CA	180.0	200.0	220.0	1.0	1.0	292.0	1.37	FST	FVT
NVS4M190A	NVS4M190CA	190.0	211.0	232.0	1.0	1.0	324.0	1.23	FSV	FVV

Table 2. Electrical characteristics

4. Terminology

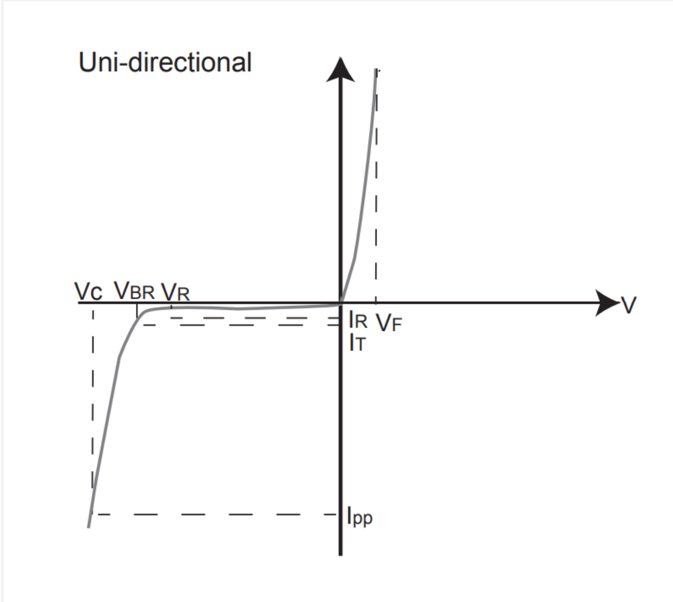
4.1 Basic Characteristics

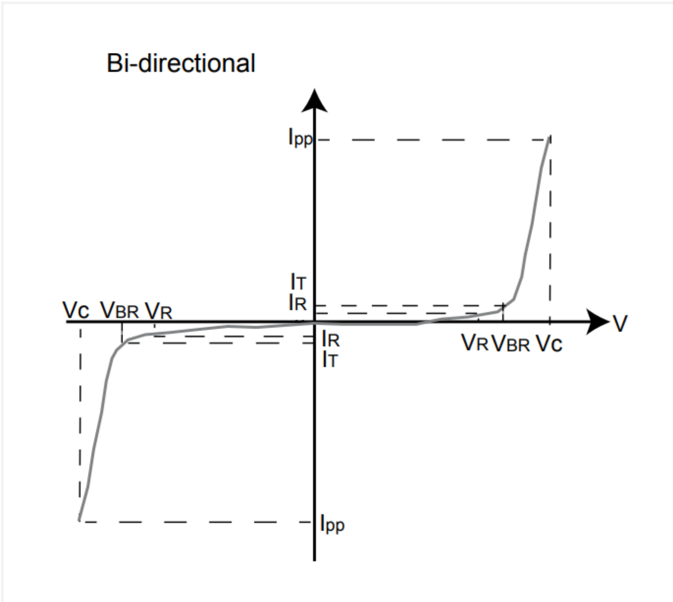
TVS diode, under the specified reverse application conditions, when subjected to a high-energy transient overvoltage pulse, due to it has a very fast response time (sub-nanosecond) and a very high surge absorption ability, its working impedance can be immediately reduced to a very low on value, allowing large currents to pass, and clamping the voltage to a predetermined level, thereby effectively protecting precision components in electronic circuits from damage. TVS can withstand instantaneous pulse power up to kilowatts, and its clamp response time is only 1ps (10-12S). The forward surge current allowed by TVS can reach 50 ~ 200A under the conditions of T_A = 250°C and T = 10ms.

TVS diodes work similarly to common Zener diodes. If the breakdown voltage is higher than the mark, the TVS diode will conduct. Compared with the Zener diode, the TVS diode has a higher current conduction capability. When the two poles of a TVS diode are subjected to reverse transient high-energy shocks, the high impedance between the two poles of the TVS diode becomes low at a speed of the order of 10 -12S, while absorbing surge power of up to several kilowatts. The clamped voltage between the two poles is at a safe value, which effectively protects precision components in electronic circuits from being damaged by surge pulses.

When the reverse voltage of the two poles of the TVS is greater than the maximum reverse voltage, it starts to conduct reversely; after the reverse voltage is greater than the breakdown voltage, it begins to be broken down, while the current starts to change suddenly; when the reverse voltage is greater than the maximum clamping voltage, the tube is in an avalanche breakdown state. At this time, the current flowing through the tube increases sharply, and the voltage difference across the tube does not change much (the voltage is clamped).

Under specified reverse application conditions, the TVS diode will provide a low-impedance path, and the instantaneous current flowing to the protected component will be shunted to the TVS diode through a large current method, while the voltage across the protected component will be limited to the clamping voltage of TVS. When the overvoltage condition disappears, the TVS diode returns to a high impedance state.





Parameter	Symbol
Reverse working voltage	V_{RWM}
Reverse leakage current	I_R
Reverse breakdown voltage	V_{BR}
Test current	I_T
Clamping voltage	V_C
Maximum peak pulse current	I_{PP}
Forward voltage	V_F

Table 3. V-I curve

4. Terminology

4-2 Main Parameters

1) Breakdown voltage $V_{(BR)}$

In the region where the device breaks down, the voltage across the device is measured at the specified test current $I_{(BR)}$, which is called the breakdown voltage. In this area, the TVS diode becomes a low impedance path.

2) Maximum reverse pulse peak current I_{PP}

In reverse operation, I_{PP} refers to the maximum pulse peak current allowed by the device under specified pulse conditions. The product of I_{PP} and the maximum clamping voltage V_C (max) is the maximum value of the transient pulse power.

The TVS should be properly selected during use, so that the rated transient pulse power P_{PK} is greater than the maximum transient surge power that may occur in the protected device or wires.

When the instantaneous pulse peak current appears, the TVS is broken down and its breakdown voltage value rises to the maximum clamping voltage value. As the pulse current decreases exponentially, the clamping voltage also decreases and returns to the original state. Therefore, TVS diode can suppress the impact of possible pulse power to effectively protect the electronic circuits.

The test waveform of the TVS peak current uses a standard wave (exponential waveform), which is determined by T_R / T_P.

Peak current rise time T_R: The time from when the current reaches 0.9 I_{PP} from 0.1 I_{PP}.

Half-peak current time T_P: The time after the current passes through the maximum peak from zero and then drops to 0.5 I_{PP}.

The T_R / T_P values of typical test waveforms are listed below:

A. EMP wave: 10ns / 1000ns

B. Lightning wave: 8μs / 20μs

C. Standard wave: 10μs / 1000μs

3) Maximum reverse working voltage V_{RWM}

When the device operates in reverse, the voltage across the device is called the maximum reverse operating voltage V_{RWM} under the specified I_R, usually V_{RWM} = (0.8 ~ 0.9) $V_{(BR)}$. At this voltage, the power consumption of the device is small. When used, V_{RWM} should not be lower than the normal working voltage of the protected device or circuits.

4) Maximum clamping current V_C(max)

The maximum voltage value across the device under the peak pulse current I_{PP} is called the maximum clamping voltage. When used, V_C (max) should not be higher than the maximum allowable safe voltage of the protected device. And the ratio of the maximum clamping voltage to the breakdown voltage is called the clamping coefficient.

Clamping coefficient = V_C(max) / $V_{(BR)}$, the general clamping coefficient is about 1.3.

5) Reverse pulse peak power P_{PK}

The P_{PK} of TVS depends on the pulse peak current I_{PP} and the maximum clamping voltage V_C (max). In addition, it is also related to the pulse waveform, pulse time and ambient temperature.

When the pulse time Tp is constant, $P_{PK} = K1 \cdot K2 \cdot V_C (max) \cdot I_{PP}$

(K1 is the power coefficient, and K2 is the temperature coefficient of the power) . The typical pulse duration tp is 1ms. When the pulse time tp applied to the transient voltage suppression diode is shorter than the standard pulse time, its peak pulse power will increase as tp is shortened. TVS reverse pulse peak power P_{PK} is related to the pulse waveform subjected to surge, expressed by the power coefficient K1: $E=\int i(t) \cdot V(t)dt$. i (t) is the pulse current waveform, and V (t) is the clamping voltage waveform.

This rated energy value is not reproducible to TVS in a very short time. However, in practical applications, surges often occur repeatedly. In this case, even if the single pulse energy is much smaller than the pulse energy that the TVS device can withstand, if repeat, these single pulse energy will accumulated, in some cases, it will exceed the pulse energy that the TVS device can withstand. Therefore, the circuit design must carefully consider and select the TVS device, so that the accumulation of pulse energy repeatedly applied within the specified interval does not exceed the pulse energy rating of the TVS device.

6) Capacitance C_J

The capacitance of TVS is determined by the area of the silicon sheet and the bias voltage. In the case of zero bias, the capacitance value decreases with the increase of the bias voltage. The value of the capacitance will affect the response time of the TVS device.

7) Leakage current I_R

When the maximum reverse working voltage is applied to the TVS, the TVS tube has a leakage current IR. When the TVS is used in a high impedance circuit, the leakage current is an important parameter. In practice, especially in automotive electronics, this parameter affects static current.

5. Rating and characteristics curve

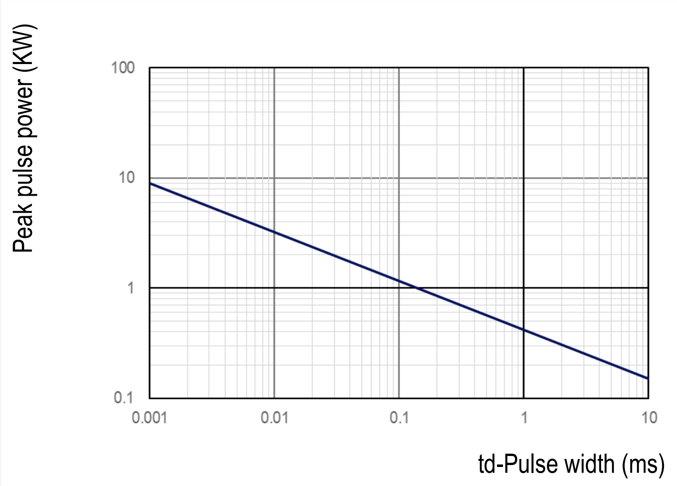


Figure 1. Non-repetitive peak pulse power vs. pulse time

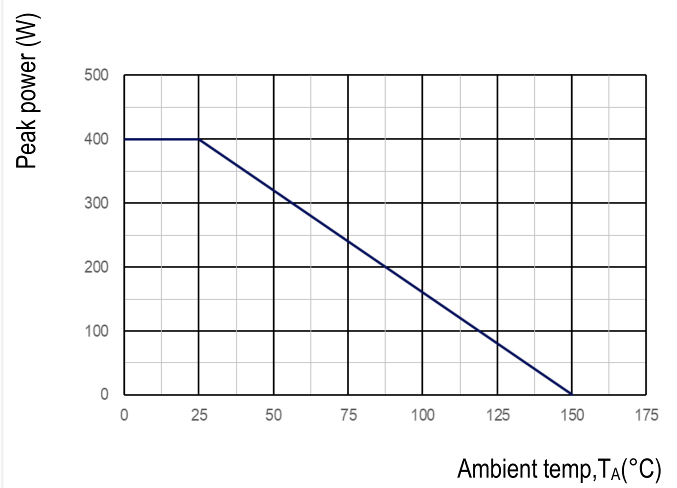


Figure 2. Power derating curve

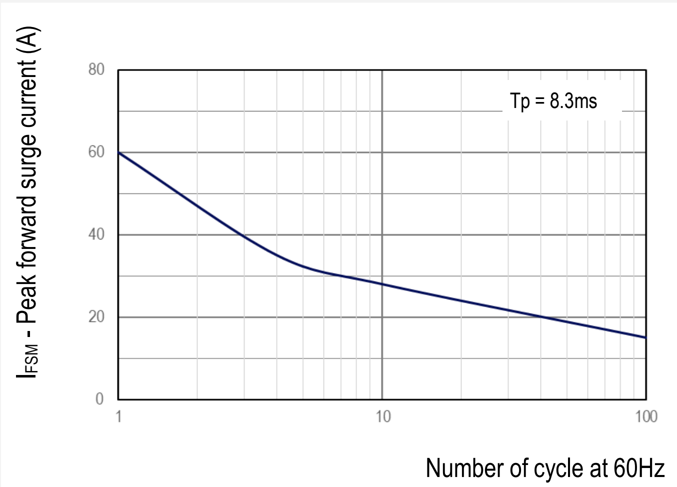


Figure 3. Maximum non-repetitive peak forward surge current uni-directional only

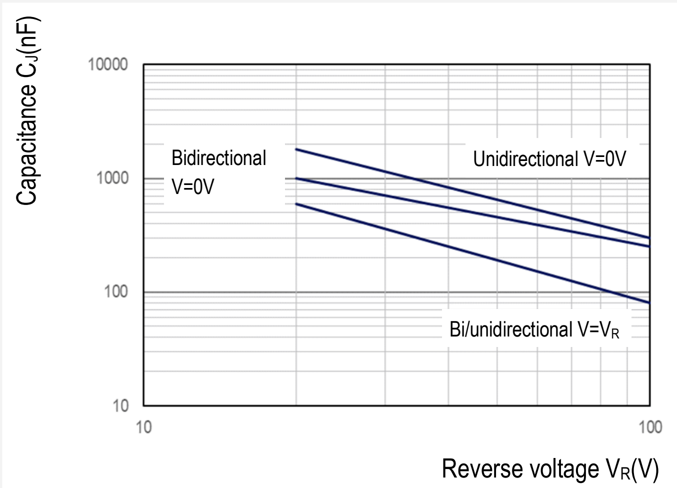


Figure 4. Normalized capacitance vs. reverse voltage

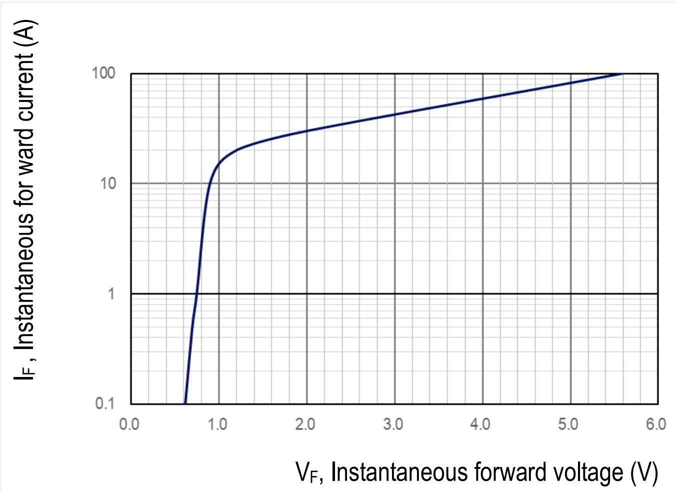


Figure 5. Typical instantaneous forward characteristics

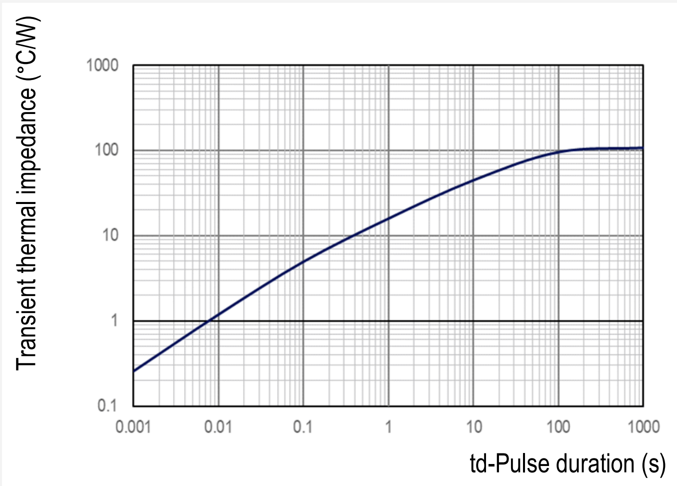


Figure 6. Typical transient thermal impedance

6. Application examples

6.1 Lighting protection

In thunderstorm-prone areas, lightning-induced voltage often breaks down some of the integrated circuits in a computer network. The reason is that cables are damaged due to transient high voltage caused by lightning induction, by installing tvs diodes in the microcomputer, it is useful to reduce damages and commercial loss. And the result shows that it is very practical, and it can improve the reliability of the whole machine application.

TVS also have many other applications, for example, for VMOS high power transistors, the tvs diodes between the gate and the source and the machine can prevent gate breakdown and improve the reliability of the VMOS power tube application.

6.2 Transistor protection

Various transient voltages can cause damage to the EB junction or CE junction of the transistor. Especially when the collector of the transistor has an inductive load (coil, transformer, motor), a high-voltage back-EMF can be generated, which often causes the transistor to be damaged. It is necessary to use a tvs diode as a protector.

6.3 Electric relay protection

Relay contacts often use large currents to switch on and off high-current inductive loads such as motors, and the inductor has a high back electromotive force when switching, and has a large amount of energy. What's more, the contacts are burned or broken to produce an arc, and the surge current generated by the arc is very large. To protect the contacts by suppressing the occurrence of arcs to protect the relays, adding a tvs diode is more effective. In the past, a capacitor or a capacitor series resistor, a diode or a diode series resistor and other suppression methods were used.

6.4 Silicon control protection

The thyristor may has wrong trigger and cause malfunction. The control electrode current cannot be too large and the voltage cannot be too high, in order to do it, TVS can be used for protection.

6.5 Integrated circuit (IC) protection

As integrated circuits become more integrated, their withstand voltages are getting lower and lower, and they are easily damaged by transient voltages. Protective measures must be taken, for example, adding TVS diode in the circuit, the CMOS circuit has a protection network at its input and output ends.

6.6 Integrated Op Amp protection

Integrated op amps are very sensitive to external electrical stress. In the process of using op amps, if having excessive voltage or current due to operating errors or abnormal working conditions, especially surges and electrostatic pulses, it is easy to damage the op amp. In the integrating circuit, if the capacitor is charged and discharged to a high potential, and then the power supply voltage is cut off, a transient voltage will be generated at the input terminal, and a large discharge current will occur, resulting in damage to the operational amplifier. At this time, tvs protection method adopted at the input terminal of op amp to avoid device damage. If the capacitance value is large (such as greater than 0.1μF), the protecting effect will be very significant.

6.7 Microcomputer system protection

In a typical microcomputer system, various interference or transient voltages entering through the power line, input line, and output line may cause the microcomputer to malfunction and fail, especially from the switching power supply. The on-off motor near the microcomputer, voltage surges and transients of AC power, electrostatic discharges, etc. may cause the system to fail, and in severe cases may damage the device. Connecting the TVS diode to the input and output lines of the power supply of the microcomputer can prevent the transient voltage from entering the "microcomputer" bus, strengthen the microcomputer's resistance to external interference, ensure the normal operation, and improve its reliability.

6.8 DC Regulated power supply protection

A DC regulated power supply with a transistor that expands the current output, adding a TVS diode to its regulated output can protect the equipment, and can also absorb peak voltage from the collector to the emitter in the circuit to protect the transistor. In a word, adding a tvs diode at the output end of each voltage stabilization source can greatly improve the reliability of the whole operation.

6.9 Suppression of electromagnetic pulse interference

A nuclear explosion will cause a strong electromagnetic pulse, which causes induced voltage in the wire. If the induced voltage exceeds the breakdown voltage of the device, it may cause the breakdown of the component, especially for long-term transmission, it is more easily to cause high voltage.TVS diodes are connected in parallel to the signal and power lines, which can absorb the induced voltage caused by electromagnetic pulses, ensure the reliability of the system, and avoid radiation damage to components.

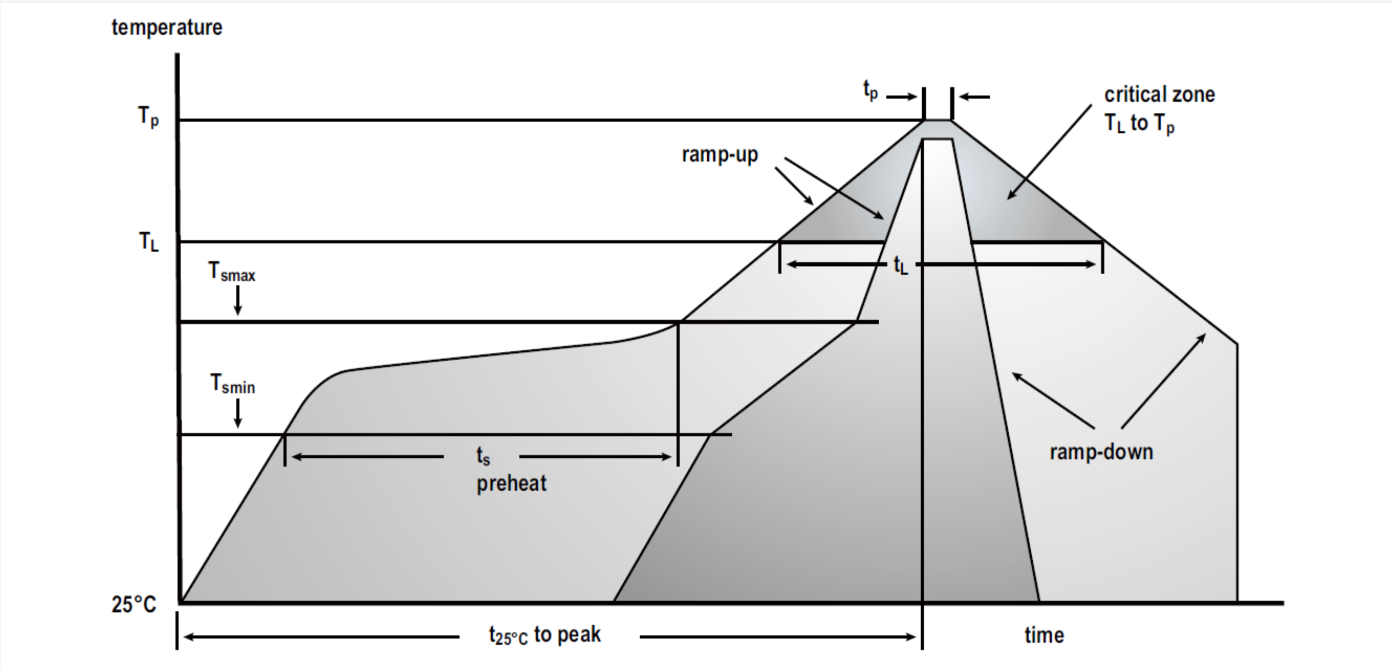
7. Recommended reflow soldering profile

7-1. Limiting value

The below temperature profile for moisture sensitivity characterization is based on the IPC/JEDEC joint industry standard: J-STD-020D-01.

Profile Feature	SnPb eutectic assembly	Pb-free assembly
Average ramp-up rate (Tsmax to Tp)	3˚C/s maximum	3˚C/s maximum
Preheat Temperature minimum (Tsmin) Temperature maximum (Tsmax) Time (tsmin to tsmax)	 100˚C 150˚C 60 s to 120 s	 150˚C 200˚C 60 s to 180 s
Time maintained above Temperature (TL) Time (tL)	 183˚C 60 s to 150 s	 217˚C 60 s to 150 s
Peak/classificationtemperature(T)	235˚C	260˚C
Number of allowed reflow cycles	3	3
Time within 5˚C of actual peak temperature (tp)	10 s to 30 s	20 s to 40 s
Ramp-down rate	6˚C/s maximum	6˚C/s maximum
Time 25˚C to peak temperature	6 minutes maximum	8 minutes maximum

7-2. Reflow soldering profile



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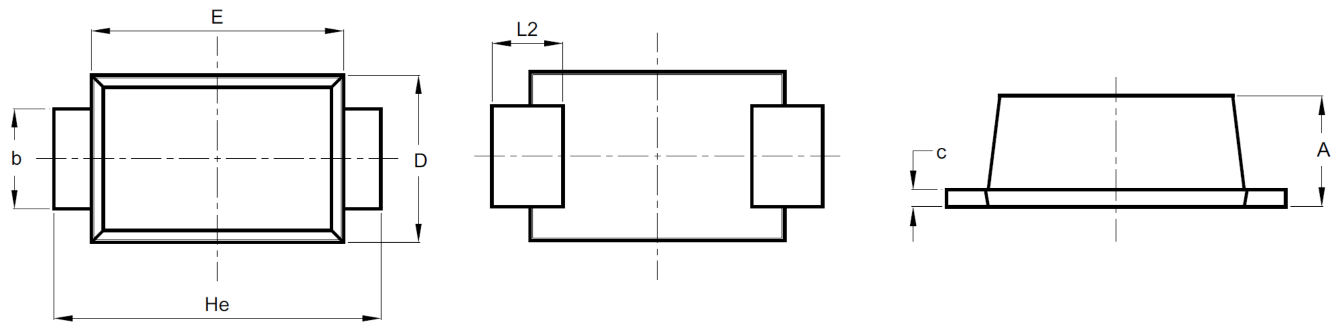
8. Package information

8-1. Dimension

Plastic surface-mounted package ; 2 Leads



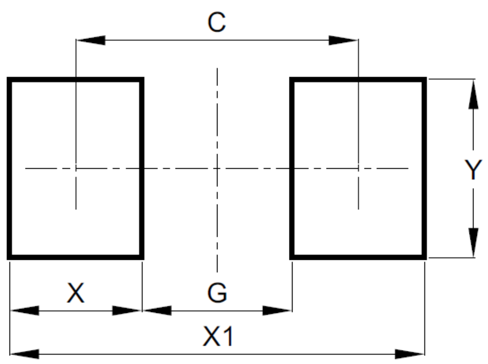
Dimension in mm

Dim	A	b	c	D	E	He	L2
Min	0.81	0.80	0.05	1.70	2.60	3.30	0.35
Typ	-	-	-	1.80	2.70	3.50	-
Max	1.15	1.05	0.30	1.90	2.80	3.70	0.85

Table 4. Package summary

8-2. PCB Pad layout recommendation

Reflow soldering footprint for SOD123-FL



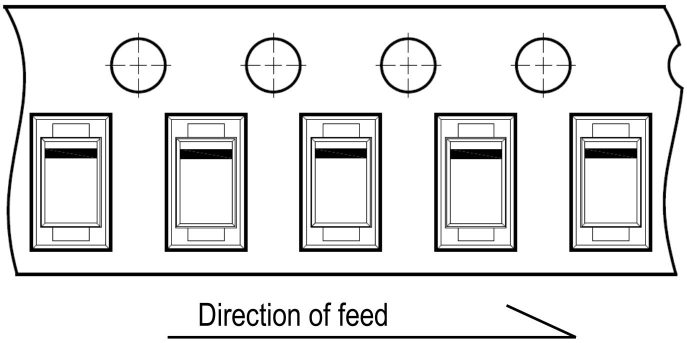
Dimension in mm

Dim	C	G	X	X1	Y
Value	2.86	1.52	1.34	4.20	1.80

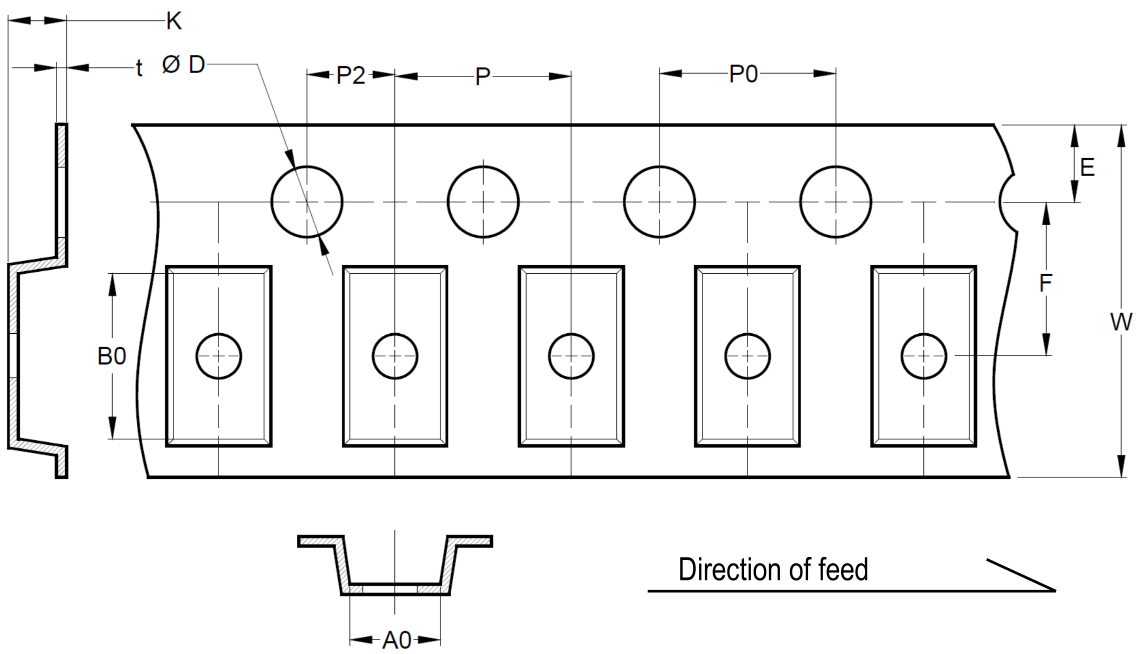
Table 5. layout summary

9. Packing

9-1. Taping and reel specification

Taping width	Tape orientation
8 mm	

9-2. Embossed carrier tape specification



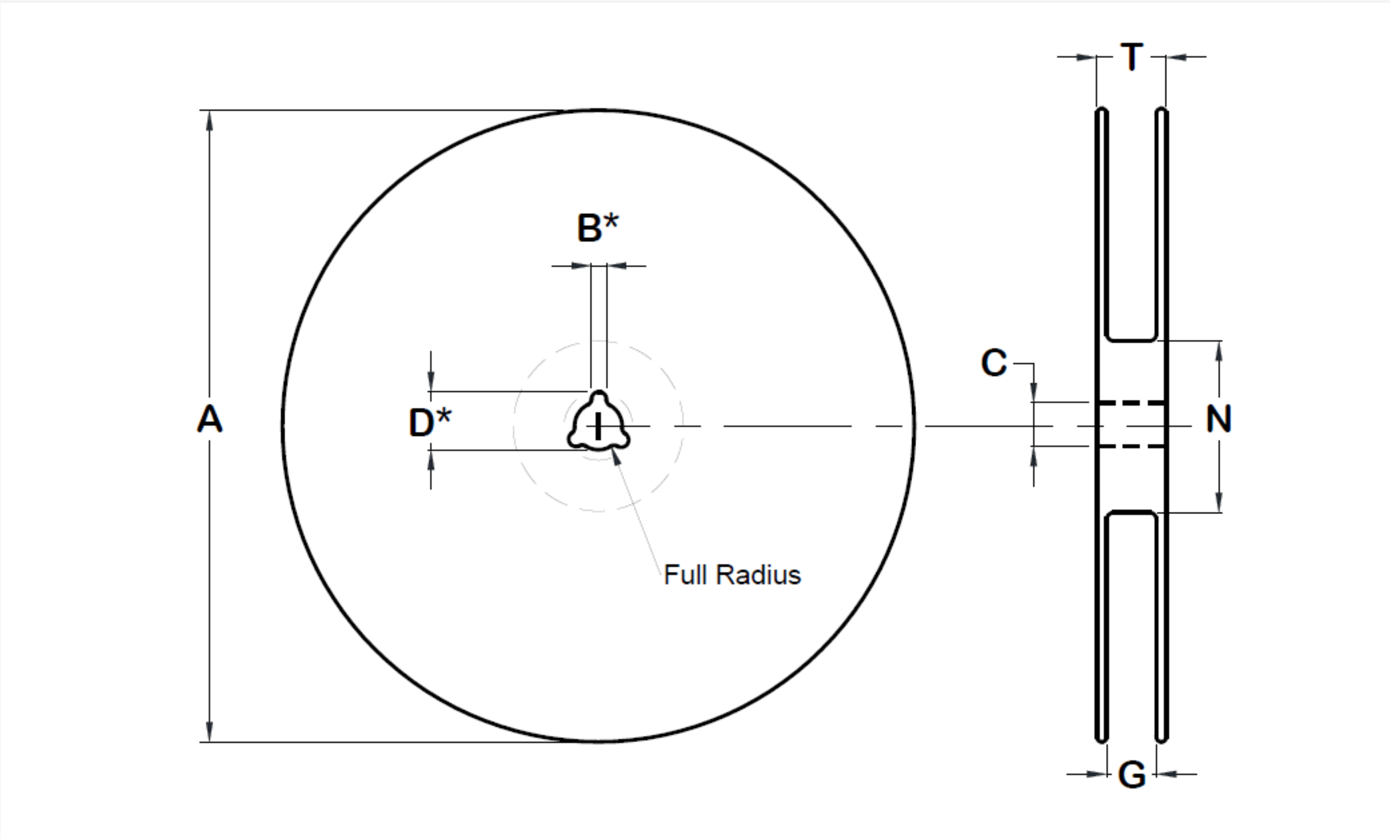
Unit : mm

Dimension	W	D	D1	E	F	K	P	P0	P2	t
Value	8 mm	1.5 +0.1/-0.0	1.4 mm	1.75 ±0.10	7.5 ±0.10	3.7 Max.	8.0 ±0.10	4.0 ±0.10	2.0 ±0.10	0.4 Max.
A0 / B0 / K0	Determined by component size. The clearance between the component and the cavity must comply to the rotational and lateral movement requirement provided in figures in the “maximum component movement in tape pocket” section.									

Table 6. Carrier tape summary

10. Surface mount reel specification

10-1. Reel specification

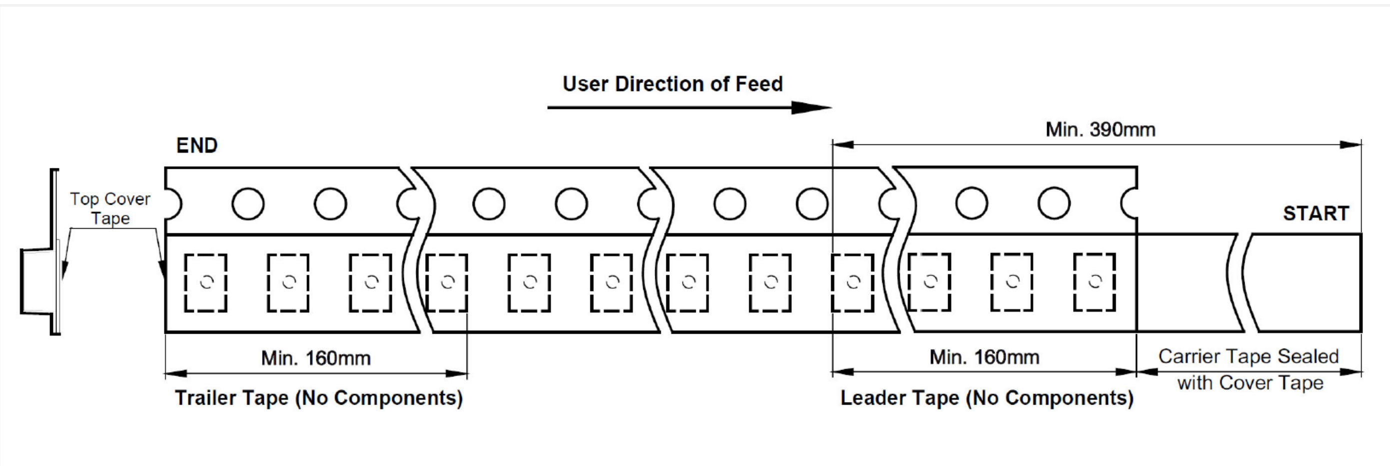


Unit : mm

Dimension	Tape Width	Reel Size	A	B	C	D	N	G	T
Value	8 mm	7”	178 ±2	2.0 +0.5-0	13 +0.5-0.2	20.5 ±0.2	55 ±5	8.4 +1.5/ -0.0	14.4

Table 7. Reel information

10-2. Tape leader and trailer specification



11. Ordering Information

Part number	Package name	Description	Packing
NVS4M Series	SOD-123FL	Plastic surface-mounted package; 2 Leads	3,000 Pcs / 7” Tape and Reel

Table 8. Ordering Information

12. Marking information

Part number	Marking code
NVS4M Series	Series marking

Table 9. Marking codes

13. Pinning information

13-1. Uni-directional

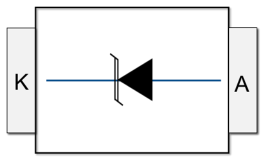
Pin	Symbol	Description	Simplified outline	Graphic symbol
1	K	Cathode		
2	A	Anode		

Table 10. Uni-Directional Pinning

13-2. Bi-directional

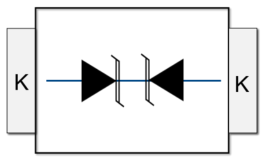
Pin	Symbol	Description	Simplified outline	Graphic symbol
1	K	Cathode		
2	K	Cathode		

Table 11. Bi-directional pinning

14. Legal information

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14. Revision history

Version	Document ID	Release date	Change notice	Basis
A	F117492	01-DEC-2017	New create	Market
B		01-JUN-2019	Update company information	System
C		23-SEP-2019	Update version	System
2.0		11-APR-2021	Update version	System
4.0		28-JAN-2023	Update version	System
5.0		06-JAN-2024	UL Listed	Engineer

Table 12. Revision history

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