瞬态抑制二极管 TVS Diodes

Transient Voltage Suppression Diodes

SMAJ Series

概述 Description

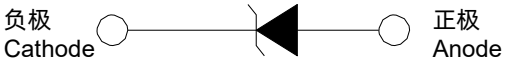
瞬态抑制二极管 (TVS) 是一种电路保护元件，它可以削弱或过滤瞬突增的态电压(过压)，在浪涌到来瞬间几纳秒时间内发生雪崩击穿，将浪涌电流引至接地端，并将电压箝位在安全范围内，从而实现了高效能的电压保护。

Transient Voltage Suppressor (TVS) is a circuit protection component that either attenuates (reduces) or filters a transient voltage spike (overvoltage), TVS diodes provide critical protection by going into avalanche breakdown within no more than a few nanoseconds after a strike, clamping the transient voltage, and routing its current to the ground.

应用 Applications

- 通信设备 Communication Equipment
- 安防 Security & Protection
- 工控设备 Industrial Control Equipment
- 电源 Power Supply
- 汽车电子 Automotive Electronics
- 新能源设备 New Energy
- 防雷保护 Lightning Protection

功能图 Functional Diagram



单向 Uni-Directional

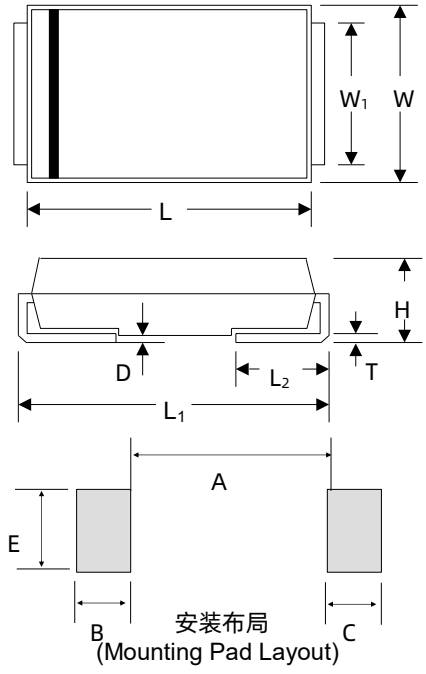
双向 Bi-Directional

特性 Features

- 低浪涌电阻
- 优异的箝位性能
- 小型化紧凑封装，内部结构去应力设计
- 12 V以上电压规格对应漏电典型值低于1.0 μA
- 重复率0.01% 的10/1000 μS 波形对应峰值脉冲功率400 W
- 表贴应用，节约空间
- 典型的故障模式为电压或电流超过额定而导致的短路
- IEC 61000-4-2 ESD 30 kV(空气)，30 kV(接触)
- 数据线EFT保护符合IEC 61000-4-4
- 快速响应时间
- 玻璃钝化保护或平面芯片(< 10 V)
- 回流焊高温保证:260 °C/30 s
- 温度系数典型值0.1%
- 密封材料阻燃等级V-0
- 湿度敏感等级符合MSL 等级1
- 引脚镀锡
- 无卤素，符合RoHS要求
- 无铅E3：二级互连引线无铅，端子镀锡(Sn) (IPC/JEDEC J-STD-609A.01)

- Low incremental surge resistance
- Excellent clamping capability
- Low profile package with built-in strain relief
- Typical I_R less than 1.0 μA above 12 V
- 400 W peak pulse power capability with a 10/1000 μS Waveform, repetition rate (duty cycle): 0.01%
- For surface mounted applications to optimize board space
- Typical failure mode is short from over-specified voltage or current
- IEC 61000-4-2 ESD 30 kV (Air), 30 kV (Contact)
- EFT protection of data lines in accordance with IEC 61000-4-4
- Very fast response time
- Glass passivated chip junction or Planar chip (< 10 V)
- High temperature to reflow soldering guaranteed: 260 °C/30sec
- V_{BR} @ T_J= V_{BR}@25 °C x (1+αT x (T_J - 25)) (αT:Temperature Coefficient, typical value is 0.1%)
- Plastic package is flammability rated V-0 per Underwriters Laboratories
- Meet MSL level1, per J-STD-020
- Matte tin lead–free plated
- Halogen free and RoHS compliant
- Pb-free E3 means 2nd level interconnect is Pb-free and the terminal finish material is tin(Sn) (IPC/JEDEC J-STD-609A.01)

封装尺寸 Package Outline Dimensions (DO-214AC)



符号 Symbol	公制(毫米) Millimeters		英制(英寸) Inches	
	Min.	Max.	Min.	Max.
L	3.99	4.60	0.157	0.181
W	2.30	2.79	0.095	0.110
W_1	1.25	1.65	0.049	0.065
H	1.90	2.44	0.075	0.096
T	0.152	0.305	0.006	0.012
L_1	4.80	5.28	0.189	0.208
L_2	0.78	1.52	0.030	0.060
D	-	0.203	-	0.008
A	-	2.30	-	0.090
B	2.10	-	0.082	-
C	2.10	-	0.082	-
E	1.80	-	0.070	-

TVS

额定参数与特性 Maximum Ratings and Characteristics

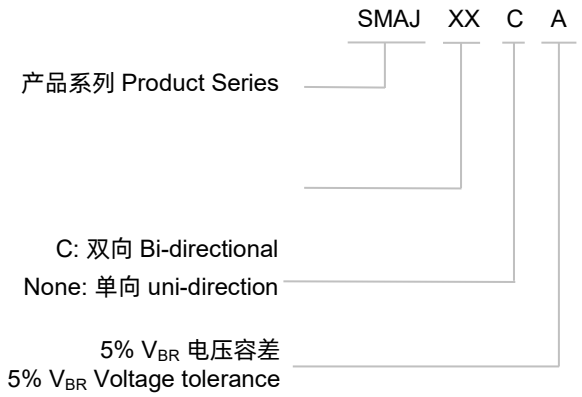
(除另有注释，默认T_A=25 ℃ Ratings at 25 °C ambient temperature unless otherwise specified.)

参数 Parameter	符号 Symbol	值 Value	单位 Unit
10/1000 μS 脉冲波形(1)(2)(图4)下，峰值脉冲功率 (1)(2)(图2)-单芯片器件 Peak Power Dissipation（Fig.2)- with a 10/1000 μS waveform(1)(2)(Fig.4)-Single Die Parts	P_{PPM}	400	W
10/1000 μS 脉冲波形(1)(2)(图4)下，峰值脉冲功耗(图2)-双芯片器件(5) Peak Power Dissipation (Fig2) with a 10/1000 μS waveform(1)(2)(Fig.4)-Stacked Die Parts(5)	P_{PPM}	600	W
峰值功耗 ,无限散热，T_L=50 °C Peak Power Dissipation on Infinite Heat Sink at T_L=50 °C	P_D	3.3	W
正向脉冲电流峰值(3),额定负载叠加8.3 ms 单半正弦波测得(JEDEC方法) Peak Forward Surge Current,8.3ms single half sinewave superimposed on rated load (JEDEC Method)(3)	I_{FSM}	60	A
正向瞬态峰值电压 @ I_F=25 A，仅适用于单向产品 (4) Maximum Instantaneous Forward Voltage at 25 A for Unidirectional Only(4)	V_F	3.5/5.0	V
工作温度范围 Operating Temperature Range	T_J	-65 to 150	°C
存储温度范围 Storage Temperature Range	T_{STG}	-65 to 175	°C
热阻(结至引线) Typical Thermal Resistance Junction to Lead	$R_{\theta JL}$	30	°C/W
热阻(结至环境) Typical Thermal Resistance Junction to Ambient	$R_{\theta JA}$	120	°C/W

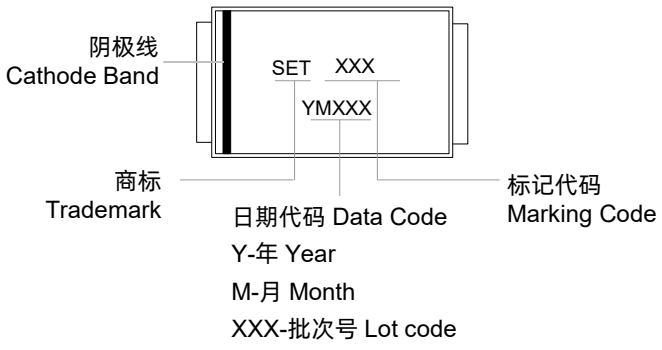
注释 Notes

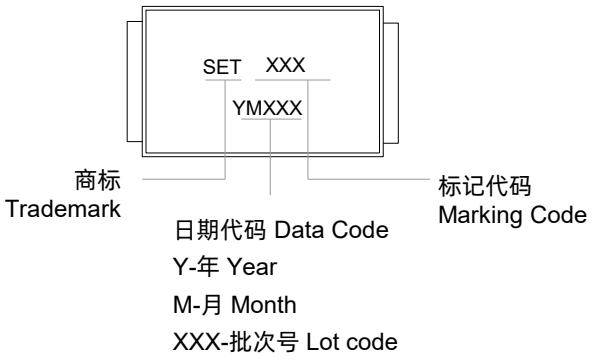
1. 参照图4非重复性脉冲电流波形，初始结温25 °C 以图3所示曲线降额（环境温度T_A=25 ℃ ）。
   Non-repetitive current pulse, per Fig. 4 and derated above T_J (initial)=25°C per Fig. 3.
2. 测试安装于5.0 mm^2 焊盘。
   Mounted on 5.0 mm^2 land areas.
3. 叠加波形为8.3 ms单个半周期正弦波或等幅方波，最长周期4次/min。
   Measured of 8.3 ms single half sine-wave or equivalent square wave, duty cycle=4 pulses per minute maximum.
4. V_F < 3.5 V为单芯片产品，V_F < 5.0 V为双芯片产品。
   V_F < 3.5 V for single die parts and V_F< 5.0 V for stacked-die parts.
5. 双芯片产品的详细信息，请参阅电气特性中以*标示的部件编号。
   For stacked die component details, please refer to models marked with * in electrical characteristics table.

型号规则 Part Numbering System



标记 Marking





TVS

术语 Glossary

项目 Item	描述 Description
V_C	**箝位电压 Clamping Voltage** TVS在低差阻区域内的电压，用于限制设备两端的电压。 Voltage across TVS in a region of low differential resistance that serves to limit the voltage across the device terminals.
V_R	**反向关断电压 Reverse Stand-off Voltage** TVS 在没有导通状态下最高电压。 Maximum voltage that can be applied to the TVS without operation. 注：也用V_{WM}（最高直流工作电压）表示，也称为截止电压(V_{so})。 NOTE : It is also shown as V_{WM} (maximum working voltage (maximum d.c. voltage)) and known as rated stand-off voltage (V_{so}).
I_R	**反向漏电流 Reverse Leakage Current** 量测V_R的电流。 Current measured at V_R. 注：也用I_D 待机电流表示。 NOTE : Also shown as I_D for stand-by current.
V_{BR}	**击穿电压 Breakdown Voltage** 在击穿区以指定电流I_T (测试电流)通过TVS的电压。 Voltage across TVS at a specified current I_T (test current) in the breakdown region.
I_{PPM}	**额定随机重复峰值脉冲电流 Rated Random Recurring Peak Impulse Current** 施加在设备上的随机重复峰值脉冲电流的最大额定值。 Maximum-rated value of random recurring peak impulse current that may be applied to a device.
$P_{M(AV)}$	**额定平均功率 Rated Average Power Dissipation** 所有电源(包括瞬态电流和待机电流)在短时间内平均产生的最大额定功耗。 Maximum-rated value of power dissipation resulting from all sources, including transients and standby current, averaged over a short period of time.
P_{PPM}	**额定随机重复峰值脉冲功率 Rated Random Recurring Peak Impulse Power Dissipation** 额定随机重复峰值脉冲电流(I_{PPM}) 和规定的最大箝位电压(V_C)乘积的最大额定值。 Maximum-rated value of the product of rated random recurring peak impulse current (I_{PPM}) multiplies by specified maximum clamping voltage (V_C).
C_J	**电容 Capacitance** 在规定的频率和电压下所测量的TVS电容。 Capacitance across the TVS measured at a specified frequencyx and voltage.

—(GB-T 18802.321 / IEC 61643-321 / JESD210A)

TVS

项目 Item	描述 Description
V_{FS}	**正向浪涌峰值电压 Peak Forward Surge Voltage** 在指定的正向浪涌电流(I_{FS})和持续时间下，通过TVS的峰值电压。 Peak voltage across TVS for a specified forward surge current (I_{FS}) and time duration. 注：也用V_F 表示。 NOTE : Also shown as V_F.
I_{FS}	**正向浪涌电流 Forward Surge Current** 在正向导通区域通过TVS的脉冲电流。 Pulsed current through TVS in the forward conducting region. 注：也用I_F表示。 NOTE : Also shown as I_F.
$\alpha_{V(BR)}$	**击穿电压温度系数 Temperature Coefficient of Breakdown Voltage** 击穿电压的变化与温度变化的比值。 The change of breakdown voltage divided by the change of temperature.
I_{PP}	**峰值脉冲电流 Peak pulse Current** 施加在TVS上的峰值脉冲电流，以确定箝位电压V_C 的特定波形。 Peak pulse current value applied across the TVS to determine the clamping voltage V_C for a specified wave shape.
I_T	**脉冲直流测试电流 Pulsed D.C. Test Current** 测量击穿电压V_{BR}的试测试电流。该电流值由制造商确定，通常以脉冲持续时间小于40 ms的毫安级电流给出。 Test current for measurement of the breakdown voltage V_{BR}. This is defined by the manufacturer and usually given in milliamperes with a pulse duration of less than 40 ms. 注：也用I_{BR}表示。 NOTE : Also shown as I_{BR}.

—(GB-T 18802.321 / IEC 61643-321 / JESD210A)

TVS

电气特性（除另有注释，默认T_A=25 ℃）
Electrical Characteristics (T_A=25 °C unless otherwise noted)Table 1

型号 Part Number		标记代码 Device Marking Code		击穿电压 Breakdown Voltage $V_{BR}@I_T$		测试电流 Test Current I_T	反向关断电压 Reverse Stand-off Voltage V_R	最大反向漏电流 Max. Reverse Leakage $I_R@V_R$	最大峰值脉冲电流 Max. Peak Pulse Current I_{PP}	最大箝位电压 Max. Clamping Voltage $V_C@I_{PP}$
				Min	Max					
Uni	Bi	Uni	Bi	(V)		(mA)	(V)	(μA)	(A)	(V)
SMAJ5.0A	SMAJ5.0CA	AE	WE	6.4	7	10	5	800	43.5	9.2
SMAJ6.0A	SMAJ6.0CA	AG	WG	6.67	7.37	10	6	800	38.8	10.3
SMAJ6.5A	SMAJ6.5CA	AK	WK	7.22	7.98	10	6.5	500	35.7	11.2
SMAJ7.0A	SMAJ7.0CA	AM	WM	7.78	8.6	10	7	200	33.3	12
SMAJ7.5A	SMAJ7.5CA	AP	WP	8.33	9.21	1	7.5	100	31	12.9
SMAJ8.0A	SMAJ8.0CA	AR	WR	8.89	9.83	1	8	50	29.4	13.6
SMAJ8.5A	SMAJ8.5CA	AT	WT	9.44	10.4	1	8.5	20	27.8	14.4
SMAJ9.0A	SMAJ9.0CA	AV	WV	10	11.1	1	9	10	26	15.4
SMAJ10A	SMAJ10CA	AX	WX	11.1	12.3	1	10	5	23.5	17
SMAJ11A	SMAJ11CA	AZ	WZ	12.2	13.5	1	11	1	22	18.2
SMAJ12A	SMAJ12CA	BE	XE	13.3	14.7	1	12	1	20.1	19.9
SMAJ13A	SMAJ13CA	BG	XG	14.4	15.9	1	13	1	18.6	21.5
SMAJ14A	SMAJ14CA	BK	XK	15.6	17.2	1	14	1	17.2	23.2
SMAJ15A	SMAJ15CA	BM	XM	16.7	18.5	1	15	1	16.4	24.4
SMAJ16A	SMAJ16CA	BP	XP	17.8	19.7	1	16	1	15.4	26
SMAJ17A	SMAJ17CA	BR	XR	18.9	20.9	1	17	1	14.5	27.6
SMAJ18A	SMAJ18CA	BT	XT	20	22.1	1	18	1	13.7	29.2
SMAJ20A	SMAJ20CA	BV	XV	22.2	24.5	1	20	1	12.3	32.4
SMAJ22A	SMAJ22CA	BX	XX	24.4	26.9	1	22	1	11.3	35.5
SMAJ24A	SMAJ24CA	BZ	XZ	26.7	29.5	1	24	1	10.3	38.9
SMAJ26A	SMAJ26CA	CE	YE	28.9	31.9	1	26	1	9.5	42.1
SMAJ28A	SMAJ28CA	CG	YG	31.1	34.4	1	28	1	8.8	45.4
SMAJ30A	SMAJ30CA	CK	YK	33.3	36.8	1	30	1	8.3	48.4
SMAJ33A	SMAJ33CA	CM	YM	36.7	40.6	1	33	1	7.5	53.3
SMAJ36A	SMAJ36CA	CP	YP	40	44.2	1	36	1	6.9	58.1
SMAJ40A	SMAJ40CA	CR	YR	44.4	49.1	1	40	1	6.2	64.5
SMAJ43A	SMAJ43CA	CT	YT	47.8	52.8	1	43	1	5.8	69.4
SMAJ45A	SMAJ45CA	CV	YV	50	55.3	1	45	1	5.5	72.7
SMAJ48A	SMAJ48CA	CX	YX	53.3	58.9	1	48	1	5.2	77.4

TVS

瞬态抑制二极管 TVS Diodes

Transient Voltage Suppression Diodes

SMAJ Series

型号 Part Number		标记代码 Device Marking Code		击穿电压 Breakdown Voltage $V_{BR}@I_T$		测试电流 Test Current I_T	反向关断电压 Reverse Stand-off Voltage V_R	最大反向漏电流 Max. Reverse Leakage $I_R@V_R$	最大峰值脉冲电流 Max. Peak Pulse Current I_{PP}	最大箝位电压 Max. Clamping Voltage $V_C@I_{PP}$
				Min	Max					
Uni	Bi	Uni	Bi	(V)		(mA)	(V)	(μA)	(A)	(V)
SMAJ51A	SMAJ51CA	CZ	YZ	56.7	62.7	1	51	1	4.9	82.4
SMAJ54A	SMAJ54CA	RE	ZE	60	66.3	1	54	1	4.6	87.1
SMAJ58A	SMAJ58CA	RG	ZG	64.4	71.2	1	58	1	4.3	93.6
SMAJ60A	SMAJ60CA	RK	ZK	66.7	73.7	1	60	1	4.1	96.8
SMAJ64A	SMAJ64CA	RM	ZM	71.1	78.6	1	64	1	3.9	103
SMAJ70A	SMAJ70CA	RP	ZP	77.8	86	1	70	1	3.5	113
SMAJ75A	SMAJ75CA	RR	ZR	83.3	92.1	1	75	1	3.3	121
SMAJ78A	SMAJ78CA	RT	ZT	86.7	95.8	1	78	1	3.2	126
SMAJ85A	SMAJ85CA	RV	ZV	94.4	104	1	85	1	2.9	137
SMAJ90A	SMAJ90CA	RX	ZX	100	111	1	90	1	2.7	146
SMAJ100A	SMAJ100CA	RZ	ZZ	111	123	1	100	1	2.5	162
SMAJ110A	SMAJ110CA	SE	VE	122	135	1	110	1	2.3	177
SMAJ120A	SMAJ120CA	SG	VG	133	147	1	120	1	2.1	193
SMAJ130A	SMAJ130CA	SK	VK	144	159	1	130	1	1.9	209
SMAJ150A	SMAJ150CA	SM	VM	167	185	1	150	1	1.6	243
SMAJ160A	SMAJ160CA	SP	VP	178	197	1	160	1	1.5	259
SMAJ170A	SMAJ170CA	SR	VR	189	209	1	170	1	1.5	275
SMAJ180A	SMAJ180CA	ST	VT	201	222	1	180	1	1.4	292
SMAJ188A	SMAJ188CA	SB	VB	209	231	1	188	1	1.4	304
SMAJ200A	SMAJ200CA	SV	VV	224	247	1	200	1	1.2	324
SMAJ220A	-	SX	-	246	272	1	220	1	1.1	356
-	SMAJ220CA*	-	VX	246	272	1	220	1	1.1	356
SMAJ250A	-	SZ	-	279	309	1	250	1	1.0	405
-	SMAJ250CA*	-	VZ	279	309	1	250	1	1.0	405
SMAJ300A*	SMAJ300CA*	TE	UE	335	371	1	300	1	0.8	486
SMAJ350A*	SMAJ350CA*	TG	UG	391	432	1	350	1	0.7	567
SMAJ400A*	SMAJ400CA*	TK	UK	447	494	1	400	1	0.6	648
SMAJ440A*	SMAJ440CA*	TM	UM	492	543	1	440	1	0.6	713

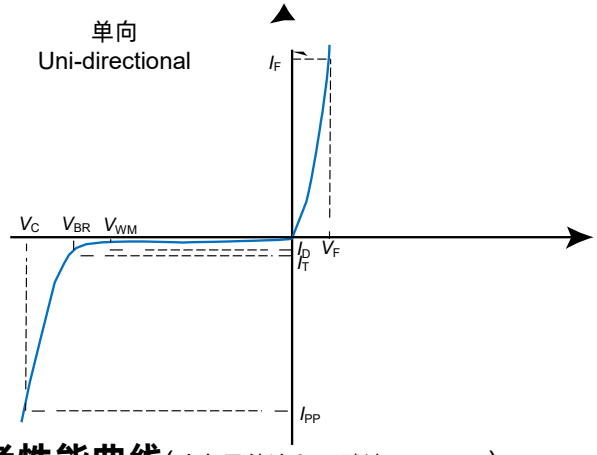
注释 Notes:

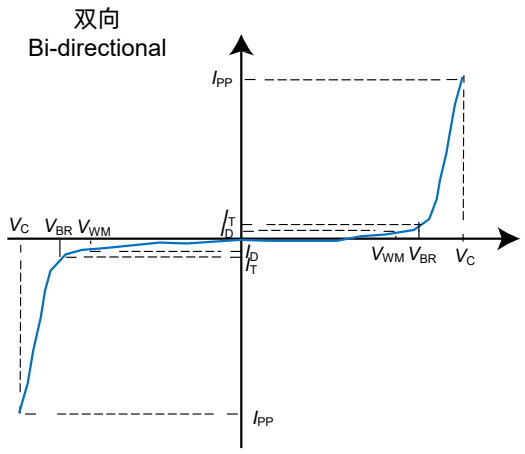
1.对于V_R为10 V及更低的双向产品，I_R值需乘以两倍。
For bidirectional type having V_R of 10 volts and less, the I_R should be doubled.

2.对于没有A的产品，V_{BR}范围为±10%且V_C也比有A的产品高5%，当前不推荐没有A的产品用于新设计，带A的产品推荐优先选用。
For parts without A in the PN, the V_{BR} tolerance is ± 10% and V_C is 5% higher than parts with A. The parts without A are currently available, but not recommended for new designs. The parts with A are preferred.

3.双芯片产品的详细信息，请参阅电气特性中以*标示的部件编号 。
For stacked die component details, please refer to models marked with * in electrical characteristics table.

伏安特性曲线 I-V Curve Characteristics





参考性能曲线(除有另外注释，默认T_A=25 ℃)

Performance Curve for Reference(T_A=25 °C unless otherwise noted)

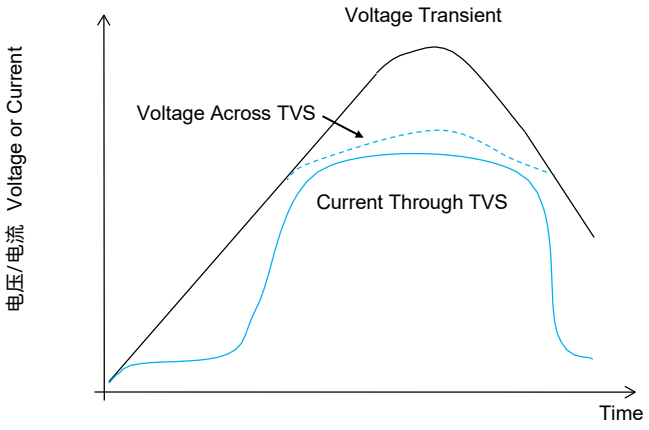


FIGURE 1 TVS瞬态箝位波形
TVS Transients Clamping Waveform

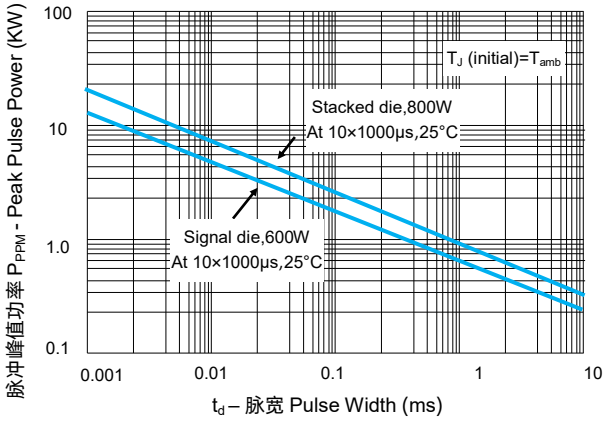


FIGURE 2 峰值脉冲功率额定曲线
Peak Pulse Power Rating Curve

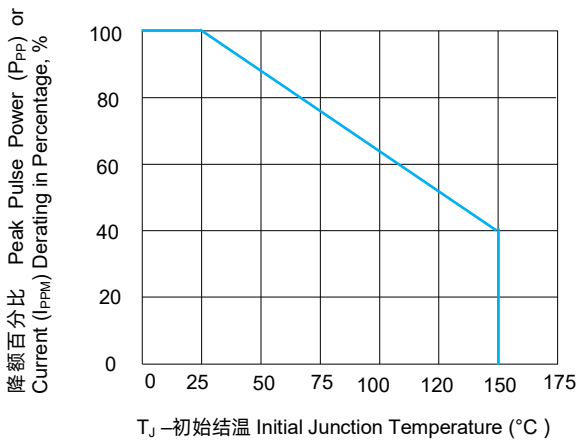


FIGURE 3 峰值脉冲功率降额曲线
Peak Pulse Power Derating Curve

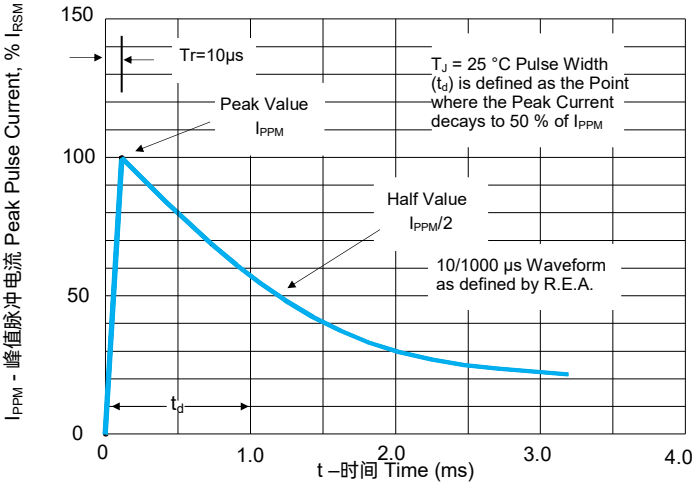


FIGURE 4 脉冲波形 Pulse Waveform

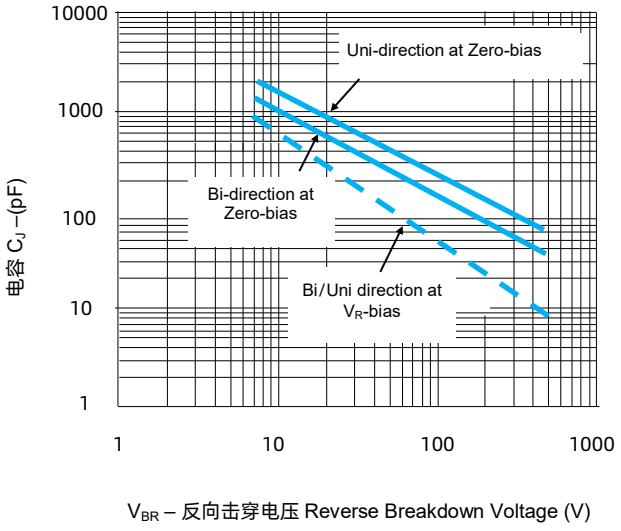


FIGURE 5 典型结电容 Typical Junction Capacitance

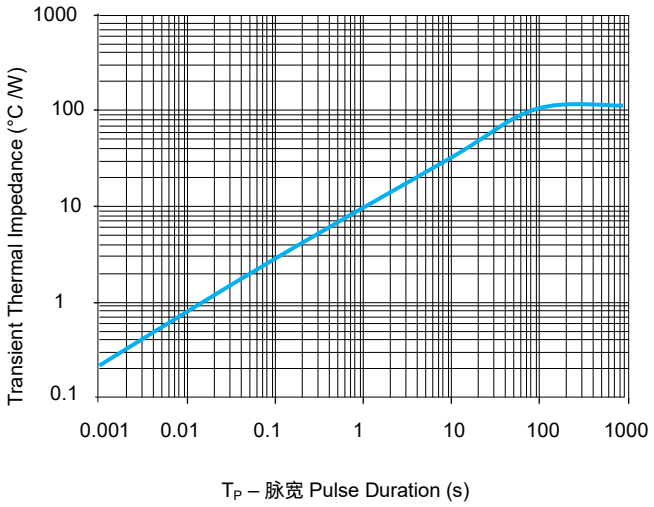


FIGURE 6 典型瞬态热阻 Typical Transient Thermal Impedance

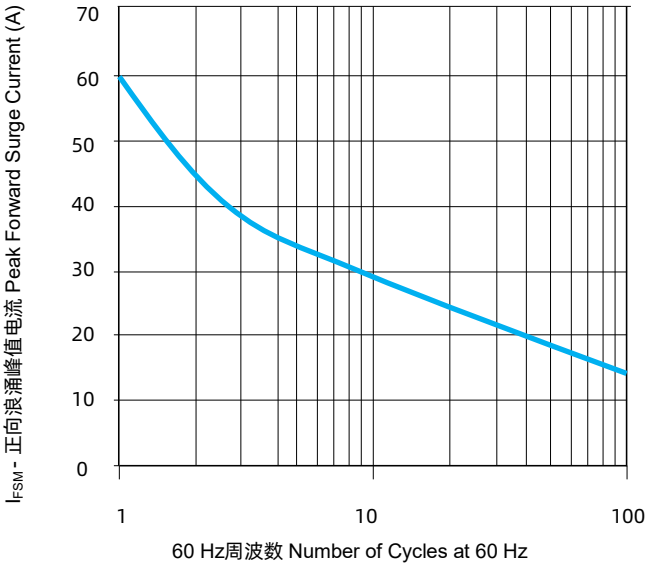


FIGURE 7 最大非重复正向浪涌电流(单向型)
Maximum Non-Repetitive Forward Surge Current
Uni-Directional only

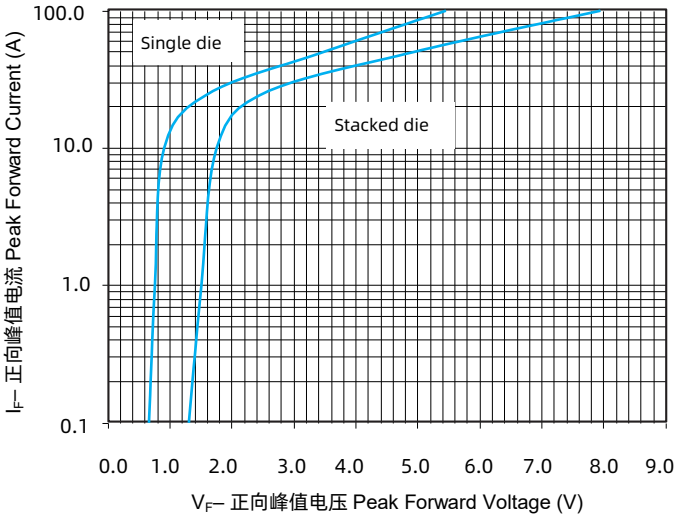


FIGURE 8 峰值正向电压及电流(典型值)
Peak Forward Drop vs Peak Forward Current (Typical Values)

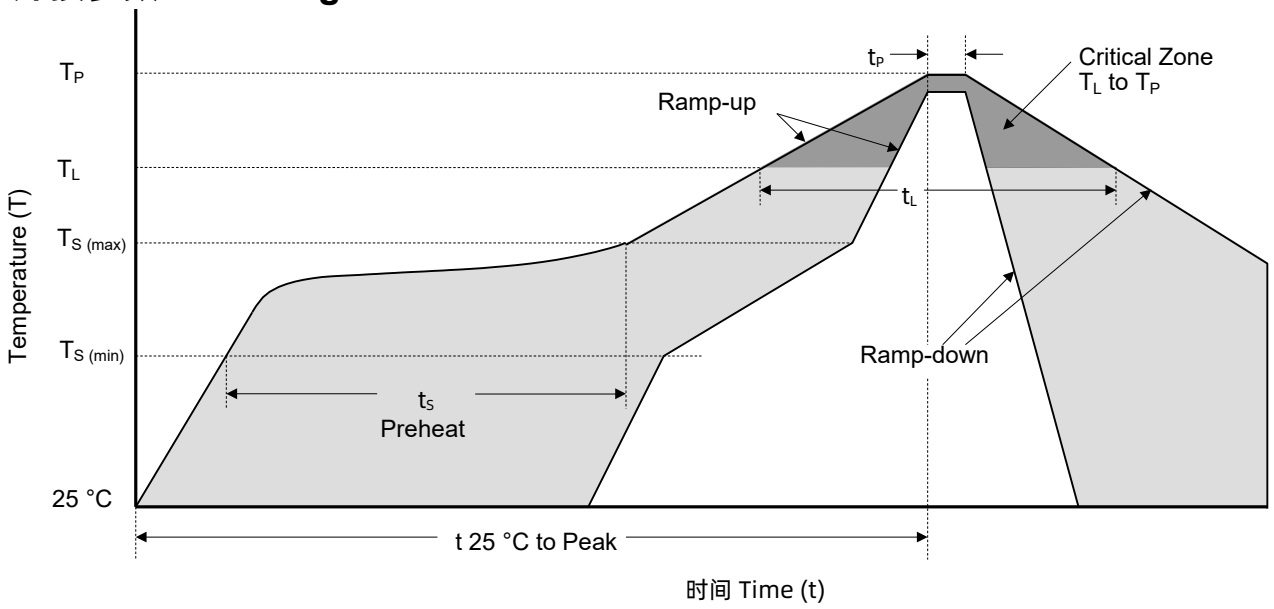
环境特性 Environmental Specifications

高温存储 High Temp. Storage	JESD22-A103
高温反偏 HTRB	JESD22-A108
温度循环 Temperature Cycling	JESD22-A104
湿度敏感性等级 MSL	JESDEC-J-STD-020, Level 1
高温高湿反偏 H3TRB	JESD22-A101
耐焊接热 RSH	JESD22-A111

物理特性 Physical Specifications

重量 Weight	0.002 ounce,0.061 grams
封装 Case	JESD22DO214AC. Molded plastic body over glass passivated junction
极性 Polarity	Color band denotes positive end (cathode) except Bidirectional
端子 Terminal	Matte Tin-plated leads, Solderability per JESD22-B102

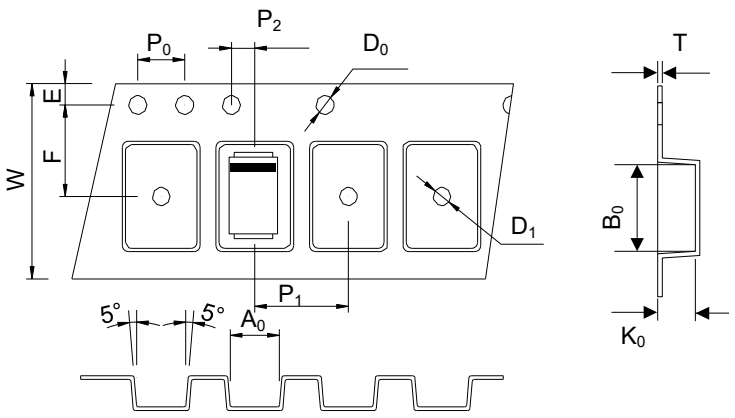
焊接参数 Soldering Parameters

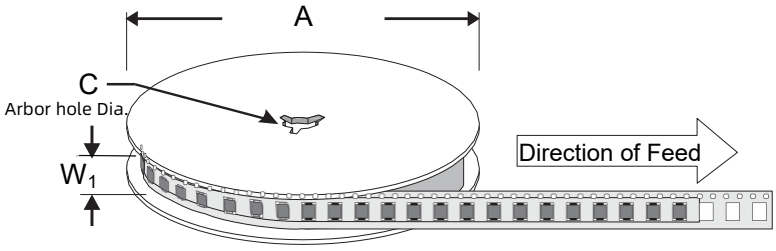


回流焊条件 Reflowing Condition

回流焊接参数 Reflow Soldering Parameters		无铅组装 Lead-Free Assembly
预热 Pre-heat	最低温($T_{S\ (min)}$) Temperature Min ($T_{S\ (min)}$)	150 °C
	最高温($T_{S\ (max)}$) Temperature Max ($T_{S\ (max)}$)	200 °C
	升温时长(t_s) Time (min to max) (t_s)	60 ~ 120 seconds
平均升温速率(液相温度(T_L)至峰值温度(T_P)) Average Ramp-up Rate (Liquidus Temp (T_L) to Peak Temp (T_P))		3 °C / second max.
T_S (max) 到T_L升温速率 T_S (max) to T_L Ramp-up Rate		3 °C / second max.
回流 Reflow	温度 Temperature (T_L) (Liquidus)	217 °C
	时长 Time (min to max) (t_L)	60 ~ 150 seconds
峰值温度 Peak Temperature (T_P)		$260^{+0/-5}$ °C
实际峰值温度 (t_P) 5 °C 以内的时间 Time of within 5 °C of Actual Peak Temperature (t_P)		20 ~ 40 seconds
降温速率 Ramp-down Rate		6 °C / second max.
25 °C 至峰值温度时长 Time from 25 °C to Peak Temperature		8 Minutes max.
极限温度 Do Not Exceed		260 °C

包装信息 Packaging Information

编带 Tape	符号 Symbol	尺寸 Dimension (mm)
	W	12.00±+0.30/-0.10
	P_0	4.00±0.10
	P_1	8.00±0.10
	P_2	2.00±0.05
	D_0	1.55±0.05
	D_1	1.55±0.05
	E	1.75±0.10
	F	5.50±0.05
	A_0	2.79±0.10
	B_0	5.33±0.10
	K_0	2.36±0.10
	T	0.30±0.05

卷盘尺寸 Reel Size	13寸卷盘 13” Reel	
	A	330 mm
	C	13.2 mm
	W_1	12.5 mm

型号 Part Number	封装 Package	卷盘数量 QTY (Reel)	包装选项 Packaging Option	包装规格 Packaging Specification
SMAJ×××	DO-214AC	5000 PCS	Tape & Reel – 12 mm tape/13” reel	EIA STD RS-481

注意
ATTENTION

使用方法 Usage

1. 请在规定的温度范围内使用TVS。
   TVS must be operated in the specified ambient temp.
2. 请勿使用强极性溶剂清洗TVS以免破坏封装层。
   Do not clean the TVS with strong polar solvent such as ketone, esters, benzene and halogenated hydrocarbon, to avoid damaging the encapsulating layer.
3. 请勿对TVS施加剧烈的振动，冲击或压力，以避免元件开裂。
   Please do not apply severe vibration, shock or pressure to TVS, to avoid element cracking.

更换 Replacement

1. 若TVS出现可视化损伤，请将其更换。
   If TVS is visually damaged, please replace it.
2. TVS为非修理型产品，安全起见，请更换同等规格的TVS。
   TVS is a non-repairable product. For safety sake, please use equivalent TVS for replacement.

存储 Storage

1. 存储温度范围。
   Storage Temp. Range: (-55 to 150) °C.
2. 请勿将TVS存放于高温高湿或腐蚀性气体环境中，已避免影响引脚的焊接性能，请于收货后一年内进行使用 。
   Do not store the TVS at the high temp., high humidity or corrosive gas environment, to avoid influencing the solder-ability of the lead wires. The product shall be used up within 1 year after receiving the goods.

环境条件 Environmental Conditions

1. 请勿暴露于室外阳光直射环境。
   TVS should not be exposed to the open air, nor direct sunshine.
2. 请避免雨水，水汽等高温高湿环境。
   TVS should avoid rain, water vapor or other condition of high temp. and high humidity.
3. 请避免沙尘，盐雾等有害环境。
   TVS should avoid sand dust, salt mist, or other harmful gases.

TVS最大典型结电容 Max. Typical Capacitance of TVS

高频线路应用中请参照规格书中所给出的典型电容曲线。
The typical capacitance of TVS is listed in the specifications. Designers may refer to it when designing TVS in high frequency circuit.

安装机械应力 Installation Mechanical Stress

1. 安装TVS时请避免敲击，防止物理损伤。
   Do not knock TVS when installing, to avoid mechanical damage.
2. 请不要对 TVS 施加剧烈的振动、冲击或压力，以免表面树脂或元件破裂。
   Please do not apply severe vibration, shock or pressure to TVS, to avoid surface resin or element cracking.

TVS