11. Assurance of Repetitive Avalanche Capability of Schottky Barrier Diodes

【1】Meaning of SBD Avalanche Capability

SBDs are used in switching power supplies, DC−DC converters and other equipment as devices as high−speed switching rectifiers. These devices are essential for achieving reductions in size and weight. However, since the surge voltage applied to the SBD tends to increase as operating frequency becomes higher, the SBDs that are selected for use in today's applications have higher capabilities. Therefore, Shindengen has recently realized and provided a product warranty for repetitive avalanche capability of SBDs for the first time in the world by ensuring breakdown capability against temperature and surge stress over a long period of time, implementing reliability testing, and performing 100**%** avalanche testing on our production line.

Using a test circuit like that shown in Fig.32 or Fig.33, an arbitrary peak surge reverse power (P_{RSM}) is applied to confirm the absence of abnormalities before and after testing. When no abnormalities are detected, the power supply voltage is increased and P_{RSM} is applied again. During this process, the SBD exhibits avalanche and V_R is clamped, remaining nearly constant. Moreover, when the power supply voltage is further increased and P_{RSM} is applied, only I_{RP} increases ultimately resulting in breakdown. The P_{RSM} immediately prior to the SBD breaking down at this time is referred to P_{RSM} capability or avalanche capability.

In addition, in the case of assuming the manner of use of SBD in actual devices, it is necessary to guarantee repetitive P_{RSM} capability. This repetitive P_{RSM} is abbreviated as P_{RRSM}.

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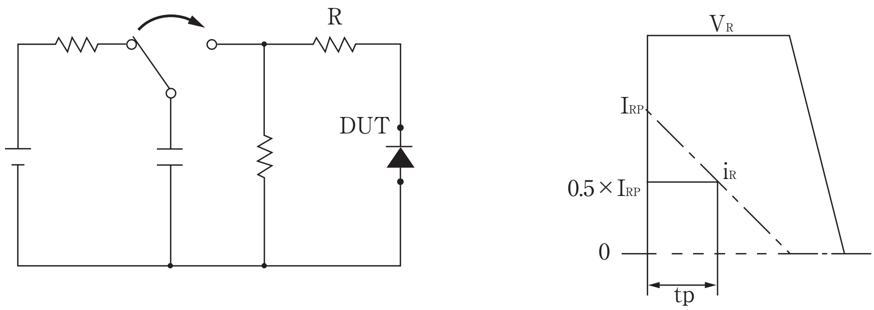
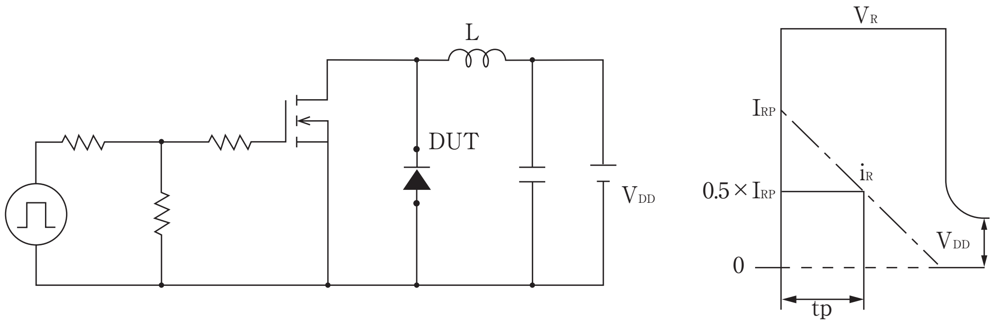


a. Circuit diagram $P_{RSM}=V_R \times I_{RP}$

$E=tp \times V_R \times I_{RP}$

b. Weveform

《**Fig.32 Method A**》



a. Circuit diagram $P_{RSM}=V_R \times I_{RP}$

$E=1/2 \times L \times I^2$

b. Weveform

《**Fig.33 Method B**》

【2】Warranty Example

Verification of whether or not an application like that shown in Fig.34 is within the range of the warranty is shown below.

The P_{RRSM} rating of S30SC4M is as follows from the rating tables：

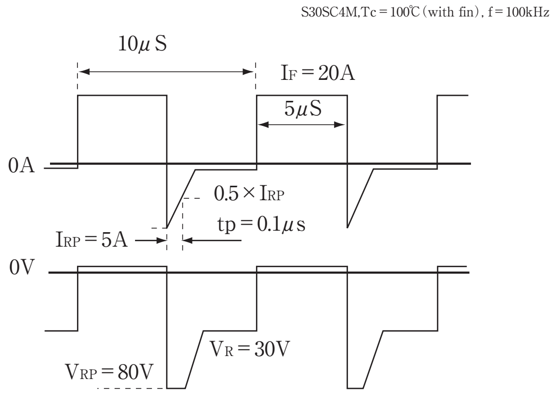
1000W（Tj=25℃ ,tp=10μ s）……………………………………………(1)

In this case，P_{RRSM} is as follows：

$P_{RRSM}=V_{RP}\cdot I_{RP}$

=80×5=400W（Tc=100℃ ,tp=0.1μs） ………………………(2)

When the temperature and pulse width conditions at this time are made to be uniform：The application is within the warranty if (1)>(2).



《**Fig. 34　Operating Waveform Example**》

《**Table 1　P_{RRSM} Ratings（Conditions : Tj=25℃　tp=10μs, repeating）**》

Type No.	P_{RRSM}〔W〕	Type No.	P_{RRSM}〔W〕	Type No.	P_{RRSM}〔W〕
D1NS4	60	D10SC6M(R)	330	D2FS4	330
D1NS6	60	D10SC9M	330	D2FS6	330
D2S4M	160	D15SCA4M	330	D3FS4A	330
D2S6M	160	S15SC4M	330	DE3S4M	330
S2S6M	160	S20SC4M	660	DE3S6M	330
D3S4M	330	S20SC9M	660	DE5S4M	330
D3S6M	330	S25SC6M	660	DE5S6M	330
D4SC6M	330	D25SC6MR	660	DE5SC3ML	330
S5S4M	330	S30SC4M	1000	DE5SC4M	330
D5S4M	330	D30SC4M	1000	DE5SC6M	330
D5S6M	330	S60SC3ML	1000	DF10SC4M	330
D5S9M	330	S60SC4M	1000	DF15SC4M	330
D5SC4M(R)	330	S60SC6M	1000	DF20SC4M	330
S10SC4M	330	D1FS4	160	DF25SC6M	660
D10SC4M	330	D1FS4A	160	DF30SC3ML	1000
		D1FS6	60	DF30SC4M	1000

(1) Determine Tj.

(a)From the forward power dissipation curve (catalog data):

P_F=11W (I_F=10A, D=0.5)

(b)From the reverse power dissipation curve (catalog data):

P_R=12W (V_R=30V, D=0.5)

(c)Reverse surge power dissipation P_{RS} is determined from the operating waveform:

$P_{RS}=V_{RP}\cdot I_{RP}\cdot tp\cdot f$

$=80\times5\times0.1\times10^{-6}\times100\times10^{3}=4W$

(d)Determine the average power dissipation Pa.

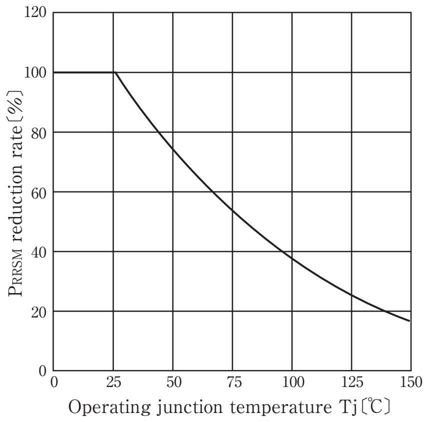
$Pa=P_F+P_R+P_{RS}$

$=11+12+4=27W$

(e)Estimate the operating junction temperature Tj:

$Tj=Pa\cdot\theta jc+Tc$ (when equipped with a fin)

$=27\times1+100=127$℃



《**Fig. 35　PRRSM-Tj**》

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(2) Derate rated value (1) from PRRSM－Tj of Fig.35 since Tj has been determined.

$P_{RRSM}'=1000\times0.25=250W\cdots$ (1)′

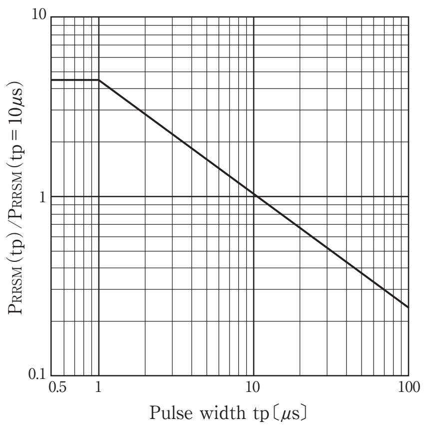
(3) Derate rated value (1)' from PRRSM－tp of Fig.36.

$P_{RRSM}''=P_{RRSM}'\cdot P_{RRSM}(tp)/P_{RRSM}(10\mu s)$

$=250\times4.4=1100W\cdots$ (1)″

From the above:

This application can be used since (1)″=1100W ＞ (2)=400W.



《**Fig. 36　PRRSM-tp**》

【3】Thermal Runaway

Thermal runaway refers to the phenomenon in which diode loss increases due to a temperature rise around the diode, which in turn causes an additional temperature rise, thereby resulting in a vicious cycle that eventually leads to thermal breakdown. The worst conditions occur when the diode is used in environment in which the ambient temperature itself exceeds the maximum operating junction temperature $T_j(max)$. Since the allowable loss is already zero, the device ends up breaking down when used at this temperature.

In cases of unavoidably using at high temperatures, a design is required that prevents the device temperature from exceeding the maximum operating junction temperature $T_j(max)$, such as by providing a large heat sink fin or by treating the surface of the heat sink with a substance having good radiation efficiency.

【4】Electrostatic Breakdown

Devices have predetermined maximum ratings. In the case of diodes, adequate reliability measures are taken provided the voltage is within the range of the V_{RM} maximum rating.

However, breakdown may occur prior or during circuit mounting or during operation. This is considered to be the result an overvoltage in excess of the maximum rating being applied to the device causing breakdown due to static electricity charged by a human body or assembled machinery during handling or operation.

Static electricity may range from several kV to several tens of kV. When this voltage passes through the device eleclrodes and discharges, there may be deterioration or breakdown of the device. Adequate caution must be taken with respect to handling and protective circuits.

When taking measures against static electricity, workers must either use anti-electrostatic gloves or wear electrostatic rings.

In addition, since devices may be affected by external factors even after mounting, protective measures must be taken into consideration such as the insertion of protective circuits and so forth.