Diode

Renesas Diode Symbols and Their Definitions

Renesas uses many symbols drawn from the maximum ratings and electrical characteristics tables for the convenience of users and circuit designers who need to know the performance of particular kinds of product. The specific meanings of these symbols are given in more specialist technical literature, but for convenience of readers of diode data sheet, the meanings have been simplified.

1. General Principles Relating to the Symbols

Capital letters used for the symbol and suffix indicate DC characteristics. AC and small signal characteristics are denoted by lower case letters.

Note that although permissible power (Pd) is not a DC characteristic, it does contain a capital letter in part.

The use of suffixes is described below. There are some exceptions and conventional usages which depart from the principles.

Table 1 Example of a Symbol Display

Symbol	First Item	Definition
T	opr	The first item provides a supplementary explanation of the symbol.
R	th	
P	d	
I	$_F$	The first item indicates the direction of transmission.
V	$_R$	

The first item is classified in the following two ways.

a. To provide a supplementary explanation of the contents indicated by the symbol. (In this case, the first item sometimes has three letters or more).
b. To indicate the direction of transmission.
   F: Forward transmission
   R: Reverse transmission

2. Symbols for Maximum Ratings

With semiconductor products, the maximum ratings are usually defined in terms of the “absolute maximum ratings”. The strictest care must be taken to assure that the values given in the maximum ratings table for each type are never exceeded, even for an instant. Even momentary excess of these maximum ratings can lead to immediate deterioration or destruction of the device concerned. Even if the device operates for a while after the excess, it must be assumed that the operation life has been shortened considerably.

In designing electronic circuits with semiconductor devices, the first step to circuit design is to make sure that their maximum ratings are never exceeded, no matter what electrical fluctuations due to external conditions may occur.

For example, even though the current and voltage applied to a particular diode may be within the maximum ratings, the power consumption is given by the product of current and voltage and must be within the range of permissible dissipation for the particular type. Furthermore, this permissible dissipation will decrease as the service temperature is rises, and the service range will be reduced accordingly.

The following table gives brief definitions of the various items of maximum ratings prescribed for the different devices covered by diode data sheet.

Table 2 Diode Maximum Ratings

Term	Symbol	Definition
Repetitive peak reverse voltage	V_{RRM}	Maximum allowable instantaneous value of reverse voltage repeatedly applicable.
Non-repetitive peak reverse surge voltage	V_{RSM}	Maximum allowable instantaneous value of reverse surge voltage without repetition.
Peak reverse voltage	V_{RM} [$V_{R(peak)}$]	Maximum allowable instantaneous value of reverse voltage that can be applied.
Reverse voltage	V_R	Maximum allowable value of reverse voltage.
Repetitive peak forward current	I_{FRM}	Maximum allowable instantaneous value of forward current repeatedly applicable.
Non-repetitive peak forward surge current	I_{FSM} [$I_{F(peak)}$]	Maximum allowable surge value of forward current without repetition.
Peak forward current	I_{FM} [$I_{F(peak)}$]	Maximum allowable instantaneous value of forward current.
Forward current	I_F	Maximum allowable value of forward current.
Average rectified current	I_O	Maximum allowable continuous average current in the forward direction under specified conditions.
Thermal resistance	Rth Rth(j-a), [Rth(j-c)]	Under thermally steady state while the device is energized, the value of the temperature difference between the junction and ambient air or between the junction and case per unit power dissipation at the junction.
Power dissipation	Pd	Maximum value of power dissipation repeatedly consumable in diode under specified conditions.
Junction temperature	Tj	Temperature at the junction which is determined as the basis of the rating and indicated by the allowable range of temperature in device operation.
Storage temperature	Tstg	Range of allowable temperature for storage of the device.
Operating ambient temperature	Topr	Limit value of the ambient temperature at which operation is possible under the prescribed heating conditions.
Lead temperature	Tl	Upper limit value of lead temperature.

3. Symbol of Electrical Characteristics

Table 3 Electrical Characteristics of Switching Diodes

Term	Symbol	Definition
Reverse voltage	V_R	Voltage value when the specified reverse current (I_R) is flowing.
Forward voltage	V_F	Voltage value when the specified forward current (I_F) is flowing.
Reverse current	I_R	Current value when the specified reverse voltage (V_R) is applied.
Forward current	I_F	Current value when the specified forward voltage (V_F) is applied.
Capacitance	C	Terminal capacitance when the specified reverse voltage (V_R) and frequency (f) are applied.
Rectifier efficiency	η	Under specified conditions, the ratio of DC output power voltage (revealed in load after rectification) to AC input power voltage.
Forward resistance	r_f	Resistance value when specified forward current and frequency are applied.
Forward temperature coefficient	$\Delta V_F / \Delta Ta$	Ratio of forward voltage change to ambient temperature change.
Reverse recovery time	t_{rr}	Time taken for the reverse current (I_R) to reach the specified level (Irr) when the reverse voltage (V_R) is applied while the device is conducting in the forward direction. When without a rule of (Irr), assumed with 0.1 I_R.

Table 4 Electrical Characteristics of Switching Diodes

Term	Symbol	Definition
Zener voltage	V_Z	Voltage value when the specified reverse current (I_Z) is flowing.
Zener current	I_Z	Standard current for measuring Zener voltage.
Dynamic resistance	Z_Z, r_d, Z_{ZT}, Z_{Zk}	Ratio of small change in Zener voltage to small change in Zener current.
Temperature coefficient	γ_Z	Ratio of Zener voltage change to ambient temperature change.

Table 5 Electrical Characteristics of Variable Capacitance Diodes

Term	Symbol	Definition
Matching error	$\Delta C/C$	Percentage of capacitance variation among group of devices under specified conditions. $\Delta C/C = (Cmax - Cmin) \div Cmin \times 100\%$
Capacitance ratio	n	Ratio of capacitance with specified differences in voltage.
Series resistance	r_s	Series resistance value when specified reverse voltage and frequency are applied.
Performance index	Q	High frequency characteristics performance indicated by series resistance capacitance value when specified reverse voltage and frequency are applied. $Q = 1/(2\pi f \cdot r_S \cdot C)$

4. Indicator of Units and Mathematical Power

Units for maximum ratings and characteristics are as follows.

a. Unit indicators method *[1]

Types of Quantity	Symbol	Unit Abbreviations	Reading
Current	I, i	A	ampere
Voltage	V, v	V	volt
Power	P	W	watt
Resistance	R, r	Ω	ohm
Static capacitance	C	F	farad
Inductance	L	H	henry
Admittance	y	S	siemens
Conductance	g	S	siemens
Susceptance	b	S	siemens
Gain, attenuation	—	dB	decibel
Time	t	s	second
Frequency	f	Hz	hertz
Angle	(ϕ)	°	degrees
Temperature	T	°C	degrees
Length	(l)	m	meter
Efficiency	η	%	percent

Note: 1. All of the units shown here are to be applied to the power product of 10^0. When indicating the power product in connection with time t (s) or frequency f (Hz), the following indicators should be used: t (μs), f (kHz), etc.

b. Unit indicators method *[1]

Power	Abbreviation	Prefix
10^9	G	giga
10^6	M	mega
10^3	k	kilo
10^0	—	—
10^{-3}	m	milli
10^{-6}	μ	micro
10^{-9}	n	nano
10^{-12}	p	pico
10^{-15}	f	femto

Note: 1. Currently, the powers 10^9 to 10^{-15} are used for semiconductor devices. However, it does not follow that all of the powers are used for different quantities; 10^{-3} (m) and 10^{-9} (n) are not customarily used for static capacitance.

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