

JEDEC STANDARD

Silicon Rectifier Diodes

JESD282B.01

(Minor Revisions of JESD282-B, April 2000)

NOVEMBER 2002

JEDEC SOLID STATE TECHNOLOGY ASSOCIATION



NOTICE

JEDEC standards and publications contain material that has been prepared, reviewed, and approved through the JEDEC Board of Directors level and subsequently reviewed and approved by the EIA General Counsel.

JEDEC standards and publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for use by those other than JEDEC members, whether the standard is to be used either domestically or internationally.

JEDEC standards and publications are adopted without regard to whether or not their adoption may involve patents or articles, materials, or processes. By such action JEDEC does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the JEDEC standards or publications.

The information included in JEDEC standards and publications represents a sound approach to product specification and application, principally from the solid state device manufacturer viewpoint. Within the JEDEC organization there are procedures whereby an JEDEC standard or publication may be further processed and ultimately become an ANSI/EIA standard.

No claims to be in conformance with this standard may be made unless all requirements stated in the standard are met.

Inquiries, comments, and suggestions relative to the content of this JEDEC standard or publication should be addressed to JEDEC at the address below, or call (703) 907-7559 or www.jedec.org

Published by
©JEDEC Solid State Technology Association 2002
2500 Wilson Boulevard
Arlington, VA 22201-3834

This document may be downloaded free of charge; however JEDEC retains the copyright on this material. By downloading this file the individual agrees not to charge for or resell the resulting material.

PRICE: Please refer to the current
Catalog of JEDEC Engineering Standards and Publications or call Global Engineering
Documents, USA and Canada 1-800-854-7179, International (303) 397-7956

Printed in the U.S.A.
All rights reserved

PLEASE!

DON'T VIOLATE
THE
LAW!

This document is copyrighted by JEDEC and may not be
reproduced without permission.

Organizations may obtain permission to reproduce a limited number of copies
through entering into a license agreement. For information, contact:

JEDEC Solid State Technology Association
2500 Wilson Boulevard
Arlington, Virginia 22201-3834
or call (703) 907-7559

SILICON RECTIFIER DIODES

CONTENTS

	Page
SECTION 1: RECTIFIER DIODE DEFINITIONS AND LETTER SYMBOLS	
1.1 Physical structure nomenclature	1
1.2 Semiconductor rectifier diode characteristics and rating terms	2
1.3 Terms used in describing rectifier diode circuits	5
1.4 General letter symbols	7
1.4.1 Temperature symbols	7
1.4.2 Thermal resistance and impedance symbols	7
1.4.3 Transient and electrical symbols	7
1.5 Letter symbols subscripts	8
SECTION 2: REGISTRATION	
2.1 Introduction	17
2.2 Purpose and intent	17
2.3 Brief outline of registration procedures	18
2.4 Detailed procedures and rules governing registration of type designations without letter suffix	18
2.4.1 Application	18
2.4.2 Assignment	20
2.4.3 Release (public announcement)	21
2.4.4 Correction notice and re-registration	21
2.5 Detailed procedures and rules governing registration of type designations with letter suffix	23
2.6 Appeal of the Type Administrator's decisions	24
2.7 Description of registration format	25
2.8 Use of JEDEC registered data	25
2.9 Test and rating methods applied to JEDEC data	26
SECTION 3: USE OF RECTIFIER DIODE REGISTRATION FORMATS	
3.1 Introduction	27
3.2 General description	28
3.3 Mechanical data	28
3.4 Maximum data	29
3.4.1 Temperature	29
3.4.2 Electrical ratings	30
3.5 Electrical characteristics	33
3.5.1 Reverse blocking current	33
3.5.2 Forward voltage	33
3.5.3 Reverse recovery	33
3.6 Thermal characteristics	34
SECTION 4: RATING ESTABLISHMENT AND VERIFICATION TESTS	
4.1 Introduction and reference table	35
4.2 Electrical tests	36
4.2.1 Repetitive ratings tests	36
4.2.2 Nonrepetitive rating tests	43

SILICON RECTIFIER DIODES**CONTENTS (continued)**

	Page
4.3 Non-electrical tests	59
4.3.1 Storage life test	59
4.3.2 Lead or terminal temperature test	58
4.4 Post test measurements	60
 SECTION 5: CHARACTERISTICS TESTS	
5.1 Introduction and reference table	61
5.1.1 Automatic Test Equipment (ATE)	62
5.2 General guidelines	62
5.3 Types of electrical tests	63
5.3.1 Alternating current or dynamic tests	63
5.3.2 Continuous current or static tests	63
5.3.3 Pulse tests	63
5.4 Thermal considerations	64
5.4.1 Thermal equilibrium	64
5.4.2 Thermal monitoring	64
5.4.3 Thermal management	64
5.5 Instrumentation	65
5.5.1 Analog instruments	65
5.5.2 Digital voltmeters	66
5.5.3 Power supplies	66
5.5.4 Pulse generators	66
5.5.5 Oscilloscopes	68
5.5.6 Temperature measuring instruments	59
5.6 Electrical characteristics tests	70
5.6.1 Peak reverse current, I_{RM}	71
5.6.2 DC reverse current, I_R	72
5.6.3 Average reverse current, $I_{R(AV)}$	73
5.6.4 Peak forward voltage, V_{FM}	77
5.6.5 DC forward voltage, V_F	80
5.6.6 Average forward voltage, $V_{F(AV)}$	81
5.6.7 Reverse breakdown voltage, $V_{(BR)}$	82
5.6.8 Forward switching characteristics	86
5.6.9 Reverse recovery characteristics	90
5.6.10 Total capacitance, C_t	106
5.7 Thermal characteristics tests	107
5.7.1 Terminology	108
5.7.2 General test description	109
5.7.3 Heat dissipator requirements	112
5.7.4 Determining reference temperature	113
5.7.5 Thermal resistance test methods	114
5.7.6 Transient thermal impedance test methods	123
5.7.7 Effective thermal resistance of bridge rectifier assemblies	131

SILICON RECTIFIER DIODES**CONTENTS (continued)**

	Page
SECTION 6: USER'S GUIDE	
6.1 Introduction	139
6.2 Diode safety considerations	139
6.3 Voltage considerations	139
6.3.1 Repetitive peak reverse voltage	139
6.3.2 Non-repetitive peak reverse voltage	140
6.3.3 Overvoltages	140
6.3.4 Series operation	141
6.4 Current considerations	142
6.4.1 Maximum operating junction temperature	142
6.4.2 Junction heat generation	143
6.4.3 Thermal resistance	143
6.4.4 Steady-state current ratings	145
6.4.5 Overload current ratings	146
6.4.6 Parallel operation	147
6.5 Switching characteristics	148
6.5.1 Forward recovery and turn-on-time	148
6.5.2 Reverse recovery	149
6.6 Fundamental rectifier circuits	150
6.7 Cooling considerations	156
6.7.1 General mounting considerations	156
6.7.2 Installation of stud-mounted semiconductor devices	159
6.7.3 Installation of disk-type semiconductor devices	159
6.7.4 Installation of lead-mounted semiconductor devices	160
6.7.5 Installation of press-fit semiconductor devices	161
6.7.6 Installation of button-type semiconductor devices	162
6.8 Temperature measurements	163
6.8.1 General	163
6.8.2 Diode junction temperature	163
6.8.3 Case temperature	165
6.8.4 Mounting surface temperature	165
6.8.5 Lead temperature	167
6.8.6 Free-air convection measurements of assemblies	167
6.8.7 Forced-air convection measurements of assemblies	168
6.9 Diode Failure modes	169
6.9.1 General	169
6.9.2 Catastrophic failure	170
6.9.3 Degradation failure	170
6.10 Simple measurement in troubleshooting	170
6.11 Surface mounting	171
SECTION 7: DIFFERENCES BETWEEN JESD282B.01 AND JESD282-B	172

SILICON RECTIFIER DIODES**CONTENTS (continued)**

	Page
Figures	
1.1 Cross section of a semiconductor rectifier diode	10
1.2 Typical semiconductor rectifier diode packages	10
1.3 Sketches of typical semiconductor rectifier stacks	11
1.4 Graphical symbol of a rectifier diode and of a rectifier circuit element	11
1.5 Example of rectifier circuit elements in a circuit diagram	11
1.6 Examples of rectifier circuit elements	12
1.7 Reverse voltage waveforms	12
1.8 Current waveforms during rectifier diodes reverse recovery	13
1.9 Illustration of symbols for reverse and forward voltage and current and junction temperature excursion resulting from the developed power	14
1.10 Reverse Recovery Softness Factor (RRSF)	15
4.1 Diode operating life test circuit and waveforms	37
4.2 Working peak reverse voltage life test	38
4.3 DC reverse voltage life test	39
4.4 Diode thermal fatigue life test circuit and waveforms	41
4.5 Diode repetitive peak reverse voltage test circuit and waveforms	42
4.6 Reverse energy test circuit for Schottky Rectifiers - Test Method No. 1	45
4.7 Reverse energy test circuit for Schottky Rectifiers - Test Method No. 2	45
4.8 Diode surge current and non-repetitive peak reverse voltage test circuit and waveforms	47
4.9 Diode surge current and non-repetitive peak reverse voltage without average forward current test circuits and waveforms	49
4.10 Non-repetitive peak reverse voltage test circuit	51
4.11 Basic test circuit for surge (non-repetitive), 1.5 millisecond duration	52
4.12 Non-repetitive reverse power test circuit	55
4.13 Destructive current test circuit	56
4.14 Rectangular pulse power test waveform and circuit	58
5.1 Pulse generation circuit and waveform	67
5.2 Peak reverse current test circuit	72
5.3 DC reverse current test circuit	73
5.4 Average reverse current test circuit, without forward current	74
5.5 Average reverse current test circuit with forward current	76
5.6 60 Hz peak forward voltage test circuit	77
5.7 Peak forward voltage pulse test circuit	79
5.8 Detailed peak forward voltage pulse test circuit	79
5.9 Minimum reverse breakdown voltage test circuit	82
5.10 Variable amplitude ac source for reverse breakdown voltage test	83
5.11 Maximum reverse breakdown voltage test circuit	85
5.12 Forward switching characteristics test circuit	87
5.13 Forward switching characteristic waveforms	88
5.14 Test circuit for reverse recovery condition A	92
5.15 Response pulse waveforms for condition A	93

SILICON RECTIFIER DIODES**CONTENTS (continued)**

	Page
5.16 Test circuit for reverse recovery condition B	95
5.17 Suggested board layout for low L_1/R_4 for condition B	96
5.18 DUT current waveform (condition B)	97
5.19 Circuit for measuring reverse recovery characteristics (condition C)	98
5.20 Test current waveforms for various types of rectifier diodes under test in the circuit for measuring reverse recovery characteristics (for condition C)	100
5.21 t_{rr} test circuit for condition D	103
5.22 Suggested board layout for low L_1/R_4 for condition D	104
5.23 Generalized reverse recovery waveforms for condition D	106
5.24 Capacitance test circuit	107
5.25 Typical transient thermal impedance characteristics	111
5.26 Current and voltage waveforms during thermal resistance test	115
5.27 Illustration of forward voltage waveform extrapolation	116
5.28 Thermal resistance test circuit (high current devices)	118
5.29 Thermal resistance test circuit (low current devices)	121
5.30 Current and voltage waveforms for heating pulse transient thermal impedance test	125
5.31 Current and voltage waveforms for transient thermal impedance test	127
5.32 Rectifier diode calibration curve	128
5.33 Basic test circuit for transient thermal impedance test method	130
5.34 Single-phase bridge	133
5.35 Three-phase bridge	134
5.36 Criteria to adjust V_{AC}	136
6.1 Test current waveforms for various types of rectifier diodes under test in the circuit for measuring reverse recovery characteristics	150
6.2a Fundamental rectifier circuits - resistive load	152
6.2b Fundamental rectifier circuits - resistive load	153
6.3a Fundamental rectifier circuits - inductive load	154
6.3b Fundamental rectifier circuits - inductive load	155
6.4 Surface flatness	157
6.5 Typical on-state current and corresponding junction and case temperature in a half-wave ac circuit	164
6.6 Free-air convection measurement	168
6.7 Forced convection measurement	169
Tables	
1-1 Letter symbols for rectifier specifications	9
4-1 Reference table of ratings and test methods	35
5-1a Reference table of characteristics, symbol, and test methods	61
5-1b Reference table of thermal characteristics, symbol, and test methods	61
5-2 Temperature measuring instruments	70
5-3 Reverse recovery condition B	94
5-4 Reverse recovery condition D	101
5-5 Example for recording data	131

SECTION 1: RECTIFIER DIODE DEFINITIONS AND LETTER SYMBOLS

1.1 Physical structure nomenclature

anode: The p-type region from which the forward current flows within a semiconductor diode.

NOTE In Schottky diodes, usually the barrier metal replaces the p-type semiconductor region and the remaining semiconductor region is n-type; however, some Schottky diodes have been made with the barrier metal replacing the n-type semiconductor region, in which case the remaining semiconductor region is p-type.

anode terminal (A, a): The terminal connected to the p-type region of the p-n junction or, when two or more p-n junctions are connected in series with the same polarity, to the extreme p-type region.

NOTE See note to “anode”.

cathode: The n-type region to which the forward current flows within a semiconductor diode.

NOTE See note to “anode”.

cathode terminal (K, k): The terminal connected to the n-type region of the p-n junction or, when two or more p-n junctions are connected in series with the same polarity, to the extreme n-type region.

NOTE See note to “anode”.

electrode (of a semiconductor device): An element that performs one or more functions of emitting or collecting electrons or holes, or of controlling their movements by an electric field.

junction (in a semiconductor device) (general term): A transition region between semiconductor regions of different electrical properties, or a physical region between a semiconductor region and a region of a different type; it is characterized by a potential barrier that impedes the movement of charge carriers from the region of higher concentration to the region with lower concentration.

rectifier stack: An integral assembly of two or more rectifier diodes, including its associated housing, and any integral mounting and cooling attachments. (See Figure 1.3.)

rectifying junction: A junction in a semiconductor device that exhibits asymmetrical conductance.

semiconductor device (general term): A device whose essential characteristics are due to the flow of charge carriers within a semiconductor material.

NOTE The definition includes devices whose essential characteristics are only in part due to the flow of charge carriers in a semiconductor but that are considered as semiconductor devices for the purposes of specification.

1.1 Physical structure nomenclature (cont'd)

semiconductor rectifier diode: A semiconductor diode intended to be used for current and voltage rectification. (See Figures 1.1 and 1.2. For graphical symbol, see Figure 1.4.)

NOTE 1 The term “semiconductor rectifier diode” includes the associated housing and any integral mounting and cooling attachments.

NOTE 2 The term “rectifier cell” is sometimes used as a synonym for “rectifier diode” when the diode is an element of a rectifier stack.

terminal: An externally available point of connection.

1.2 Semiconductor rectifier diode characteristic and rating terms

average current: The value of a periodic current averaged over a full cycle unless otherwise specified.

average rectified output current (50 Hz or 60 Hz sinewave input, 180° conduction angle) (I_O): The output current averaged over a full cycle from a rectifier with a 50 Hz or 60 Hz sinewave input and a 180° conduction angle.

average voltage: The value of a periodic voltage averaged over a full cycle unless otherwise specified.

blocking: A term describing the state of a semiconductor device or junction that imposes high resistance to the passage of current.

breakdown: The phenomenon, occurring in a reverse-biased semiconductor junction, whose initiation is observed as a transition from a region of high small-signal resistance to a region of substantially lower small-signal resistance for an increasing magnitude of reverse current.

breakdown current: A current in the breakdown region.

breakdown region: The portion of the voltage-current characteristic beyond the initiation of breakdown for an increasing magnitude of reverse current.

breakdown voltage (For symbol see Table 1-1): The voltage measured at a specified current in a breakdown region.

fall time charge (Q_{rrf}): That part of the recovered charge that is recovered from the diode during the reverse recovery fall time.

NOTE The time intervals t_{rrf} and t_{rrr} are defined so that their sum is equal to the reverse recovery time t_{rr} , whereas the recovered charge Q_{rr} is defined for an integration time t_i . As a consequence, the sum of the partial charges Q_{rrf} and Q_{rrr} will differ from Q_{rr} unless t_{rr} equals t_i .

1.2 Semiconductor rectifier diode characteristic and rating terms (cont'd)

forward current (in a semiconductor diode) (For symbol see Table 1-1): The current flowing from the external circuit into the anode terminal.

forward direction: The direction of a (positive) forward current

forward power dissipation (For symbol see Table 1-1): The power dissipation resulting from forward current.

forward recovery time (t_{fr}): The time interval between the instant when the forward voltage rises through a specified first value, usually 10% of its final value, and the instant when it falls from its peak value, V_{FRM} , to a specified low second value, V_{FR} , upon the application of a step current following a zero-voltage or a specified reverse-voltage condition.

forward voltage (across a semiconductor diode) (For symbol see Table 1-1): A positive anode-cathode voltage.

nonrepetitive peak reverse voltage (V_{RSM}): The peak reverse voltage including all nonrepetitive transient voltages but excluding all repetitive voltages. (See Figure 1.7.)

overload forward current ($I_{FM(OV)}$): A current whose continuous application would cause the maximum-rated virtual junction temperature to be exceeded, but that is limited in duration such that this temperature is not exceeded.

NOTE Devices may be subjected to overload currents as frequently as called for by the application while being subjected to normal operating voltages. (Ref. IEC 747-2.)

peak forward current (I_{FM}): The peak instantaneous value of the forward current.

peak reverse current (I_{RM}): The peak instantaneous value of the reverse current.

peak reverse voltage (V_{RM}): The peak instantaneous value of the reverse voltage.

recovered charge (Q_{rr}): The total amount of charge recovered from a diode, including the capacitive component of charge, when the diode is switched from a specified conductive condition to 1) a specified nonconductive condition, or 2) an unspecified nonconductive condition with the measurement ending after a specified integration time, t_i , with other circuit conditions as specified.

repetitive peak forward current (I_{FRM}): The peak forward current including all repetitive transient currents but excluding all nonrepetitive transient currents.

repetitive peak reverse current (I_{RRM}): The peak reverse current including all repetitive transient currents but excluding all nonrepetitive transient currents.

repetitive peak reverse voltage (V_{RRM}): The peak reverse voltage including all repetitive transient voltages but excluding all nonrepetitive transient voltages. (See Figure 1.7.)

1.2 Semiconductor rectifier diode characteristic and rating terms (cont'd)

reverse current (in a semiconductor diode) (For symbol see Table 1-1): The current flowing from the external circuit into the cathode terminal

reverse direction: The direction of a (positive) reverse current.

reverse power dissipation (For symbol see Table 1-1): The power dissipation resulting from reverse current.

reverse recovery current (For symbol see Table 1-1): The transient reverse current associated with a change from forward current to a reverse condition. (See 5.6.9.)

reverse recovery current fall time (t_{rrf} , t_b): The portion of the reverse recovery time interval after the reverse recovery current has reached its maximum (peak) value. (See Figure 1.8.)

reverse recovery current rise time (t_{rrr} , t_a): The portion of the reverse recovery time interval prior to the instant when the reverse recovery current reaches its maximum (peak) value. (See Figure 1.8.)

reverse recovery softness factor (RRSF): The absolute value of the ratio of (1) di_{RR}/dt (the rate of rise of the reverse recovery current) when the current is passing through zero at the beginning of the reverse recovery time, to (2) di_{RF}/dt (the maximum value of the rate of fall of the reverse recovery current) after the current has passed through its peak value, I_{RM} . (See Figure 1.10.)

NOTE The ratio of reverse recovery current fall time (t_b) to the reverse recovery current rise time (t_a) has been called “recovery softness factor” (RSF); however, RRSF is a more useful measure of the diode softness characteristic.

reverse recovery time (t_{rr}): The time interval between the instant when the current passes through zero when changing from the forward direction to the reverse direction and, after reverse current reaches its peak value $I_{RM(REC)}$, the instant when

- 1) the reverse current first intersects the zero-current axis as shown in Figure 1.8(a), or
- 2) the extrapolated reverse current reaches zero, as shown in Figure 1.8(b), or
- 3) the reverse current reaches a specified low value $i_{R(REC)}$, as shown in Figure 1.8(c).

NOTE In 2), the extrapolation is carried out with respect to specified points “A” and “B”, as shown in generalized form in Figure 1.8(b). Point “A” may be specified at other than $I_{RM(REC)}$.

reverse voltage (across a semiconductor diode) (For symbol see Table 1-1): A positive cathode-anode voltage.

rise time charge (Q_{rrr}): That part of the recovered charge that is recovered from the diode during the reverse recovery rise time.

NOTE See note to “fall time charge”.

1.2 Semiconductor rectifier diode characteristic and rating terms (cont'd)

stored charge (Q_s): The total amount of charge recovered from a diode minus the capacitive component of charge when the diode is switched from a specified conductive condition to a specified nonconductive condition with other circuit conditions specified.

surge peak forward current (I_{FSM}): The peak forward current including all nonrepetitive transient currents but excluding all repetitive transient currents.

thermal resistance (R_{th} , R_q): The temperature difference between two specified points or regions divided by the power dissipation under conditions of thermal equilibrium.

total power dissipation (For symbol see Table 1-1): The sum of the forward and reverse power dissipations.

transient thermal impedance (Z_{th} , Z_q): The change in temperature difference between two specified points or regions that occurs during a time interval divided by the step-function change in power dissipation that occurred at the beginning of the interval and caused the change in temperature difference.

virtual junction temperature (T_j): A temperature representing the temperature of the junction calculated on the basis of a simplified model of the thermal and electrical behavior of the semiconductor diode.

working peak reverse voltage (V_{RWM}): The peak reverse voltage excluding all transient voltages. (See Figure 1.7.)

1.3 Terms used in describing rectifier diode circuits

blocking period (of a rectifier circuit element): The part of an alternating-voltage cycle during which the current flows in the reverse direction.

NOTE The blocking period is not necessarily the same as the reverse period because of the effect of circuit parameters and semiconductor rectifier diode characteristics.

bridge rectifier circuit: See “double-way rectifier circuit”.

commutation: The transfer of unidirectional current between rectifier circuit elements that conduct in succession.

conducting [conduction] period (of a rectifier circuit element): The part of an alternating-voltage cycle during which the current flows in the forward direction.

NOTE The forward period is not necessarily the same as the conducting period because of circuit parameters and semiconductor rectifier diode characteristics.

1.3 Terms used in describing rectifier diode circuits (cont'd)

double-way rectifier circuit: A circuit in which the current flows in both directions from each terminal of the alternating-voltage circuit to the rectifier circuit elements connected to each terminal.

NOTE The terms “single-way” and “double-way” provide a means for describing the effect of the rectifier circuit on current in the transformer windings connected to rectifier circuits. Most rectifier circuits may be classified into these two general types. Many double-way circuits are also referred to as bridge circuits. Both single-way and double-way circuits are illustrated in Figures 6.2 and 6.3. The 1-1-1-H, 2-1-1-C, 3-1-1-Y, 6-1-1-Y, and 6-1-1-S types are examples of single-way circuits. The 4-1-1-B and 6-1-1-B types are examples of double-way circuits.

form factor (of a waveform): The ratio of the root-mean-square value of the wave to the average value.

forward period (of a rectifier circuit element): The part of an alternating-voltage cycle during which forward voltage appears across the rectifier circuit element.

full-wave rectifier circuit: A circuit that changes single-phase alternating current into pulsating unidirectional current utilizing both halves of each cycle.

half-wave rectifier circuit: A circuit that changes single-phase alternating current into pulsating unidirectional current utilizing only one half of each cycle.

harmonic content (of a nonsinusoidal periodic wave): The order and magnitude of the harmonic components.

(percent) ripple voltage or current: The ratio, in percent, of the effective (root-mean-square) value of the ripple voltage or current to the average value of a pulsating unidirectional voltage or current, respectively.

rectifier circuit element: One or more semiconductor rectifier diodes or rectifier stacks connected in series, in parallel, or both, to operate as a unit that is bounded by two circuit terminals and conducts current substantially in only one direction.

NOTE Graphical symbols for rectifier circuit elements are shown in Figures 1.4, 1.5, and 1.6.

reverse period (of a rectifier circuit element): The parts of an alternating-voltage cycle during which reverse voltage appears across the rectifier circuit element.

ripple voltage or current: The alternating component whose instantaneous values are the difference between the average and instantaneous values of a pulsating unidirectional voltage or current, respectively.

single-way rectifier circuit: A circuit in which the current flows in only one direction from each terminal of the alternating-voltage circuit to the rectifier circuit element connected to each terminal.

NOTE See note under “double way rectifier circuit”.

1.4 General letter symbols

1.4.1 Temperature symbols

ambient temperature	T_A
case temperature	T_C
storage temperature	T_{stg}
virtual junction temperature	T_J^*

* T_{VJ} may be substituted for T_J

1.4.2 Thermal resistance and impedance symbols

thermal resistance	$R_{th}^\dagger$
thermal resistance, case-to-ambient	$R_{thCA}^\dagger$
thermal resistance, junction-to-ambient	$R_{thJA}^\dagger$
thermal resistance, junction-to-case	$R_{thJC}^\dagger$
thermal resistance, junction-to-lead	$R_{thJL}^\dagger$
thermal resistance, junction-to-mounting	$R_{thJM}^\dagger$

$^\dagger R_\theta$ may be substituted for R_{th} , and similarly $Z_{\theta(t)}$ may be substituted for $Z_{th(t)}$, etc.

transient thermal impedance	$Z_{th}^\dagger$
transient thermal impedance, junction-to-ambient	$Z_{thJA}^\dagger$
transient thermal impedance, junction-to-case	$Z_{thJC}^\dagger$
transient thermal impedance, junction-to-lead	$Z_{thJL}^\dagger$
transient thermal impedance, junction-to-mounting	$Z_{thJM}^\dagger$

$^\dagger R_\theta$ may be substituted for R_{th} , and similarly $Z_{\theta(t)}$ may be substituted for $Z_{th(t)}$, etc.

1.4.3 Transient and electrical symbols

fall time	t_f
forward recovery time	t_{fr}
junction capacitance	C_j
pulse duration	t_p
recovered charge	Q_{rr}
stored charge	Q_s
reverse recovery time	t_{rr}

1.4 General letter symbols (cont'd)**1.4.3 Transient and electrical symbols (cont'd)**

rise time	t_r
reverse recovery current rise time	t_{rr} , t_a
reverse recovery current fall time	t_{rrf} , t_b
reverse recovery softness factor	RRSF

1.5 Letter symbols subscripts

The following letters are used as qualifying subscripts in rectifier diode voltage, current, and power letter symbols to denote specific descriptive terms. The use of some of them is illustrated in Table 1-1 and Figure 1.9.

A, a	anode
(AV)	average value
(BR)	breakdown
K, k	cathode
F, f	forward
M, m	maximum peak value
S	nonrepetitive or surge
(OV)	overload
r	reverse or as a second subscript, recovery
R	reverse or as a second subscript, repetitive
(REC)	recovery
(RMS)	total rms value
W	working

1.5 Letter symbols subscripts (cont'd)

Table 1-1 — Letter symbols for rectifier specifications

Table P-1 Letter Symbols for Rectifier Specifications						
	Total rms value	RMS value of alternating component	DC value with no alternating component	DC value with alternating component	Instantaneous total value	Maximum (peak) total value
Forward current	$I_{F(RMS)}$	I_f	I_F	$I_{F(AV)}$	i_F	I_{FM}
Forward current, overload						$I_{FM(OV)}$
Forward current, repetitive peak						I_{FRM}
Forward current, surge (nonrepetitive) peak						I_{FSM}
Rectified output current, average,180° conduction angle, 50 or 60 Hz, sinewave input	$I_{R(RMS)}$	I_r	I_R	I_O	i_R	
Reverse current				$I_{R(AV)}$		I_{RM}
Reverse current, repetitive peak						I_{RRM}
Reverse recovery current						$I_{RM(REC)}$
Forward power dissipation			P_F	$P_{F(AV)}$	P_F	P_{FM}
Peak power dissipation with surge current						P_{FSM}
Reverse power dissipation			P_R	$P_{R(AV)}$		P_{RM}
Total power dissipation			P_T	$P_{T(AV)}$		P_{TM}
Breakdown voltage	$V_{F(RMS)}$	V_f	$V_{(BR)}$		$v_{(BR)}$	
Forward voltage			V_F			$V_{F(AV)}$
Forward surge voltage	$V_{R(RMS)}$	V_r	V_R	$V_{R(AV)}$	v_R	V_{FSM}
Reverse voltage						V_{RM}
Reverse voltage, working peak						V_{RWM}
Reverse voltage, repetitive peak						V_{RRM}
Reverse voltage, nonrepetive peak						V_{RSM}
Peak junction temperature with repetitive forward current flowing						T_{JRM}
Peak junction temperature with surge forward current flowing						T_{JSM}

1.5 Letter symbols subscripts (cont'd)

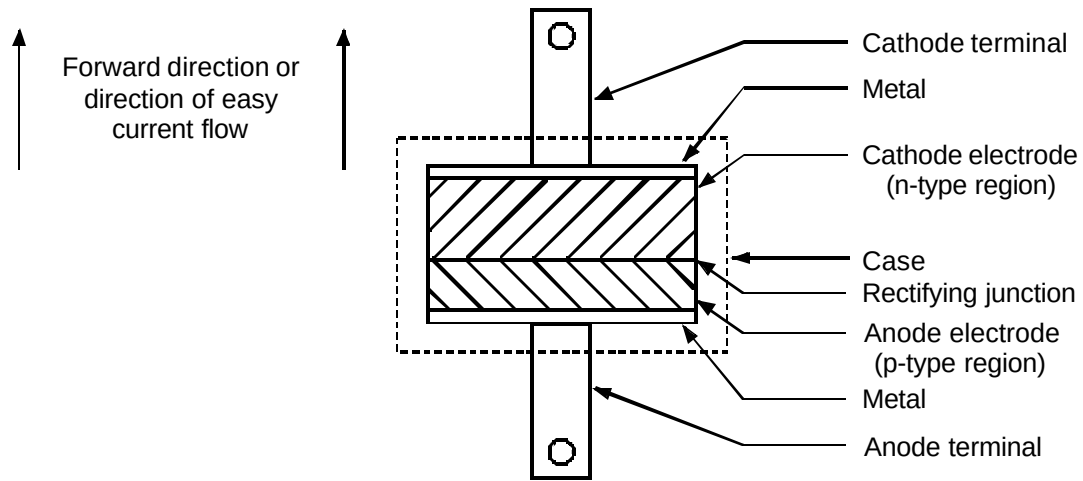


Figure 1.1 — Cross section of a semiconductor rectifier diode

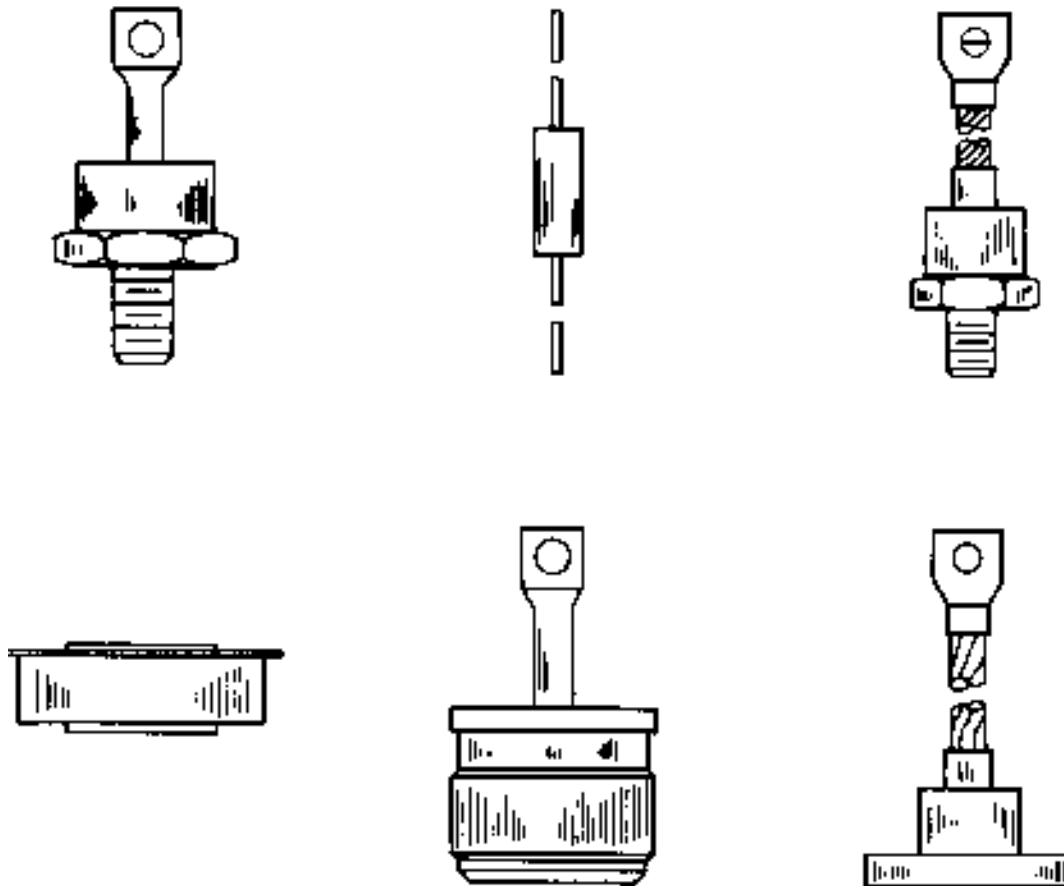


Figure 1.2 — Typical semiconductor rectifier diode packages

1.5 Letter symbols subscripts (cont'd)

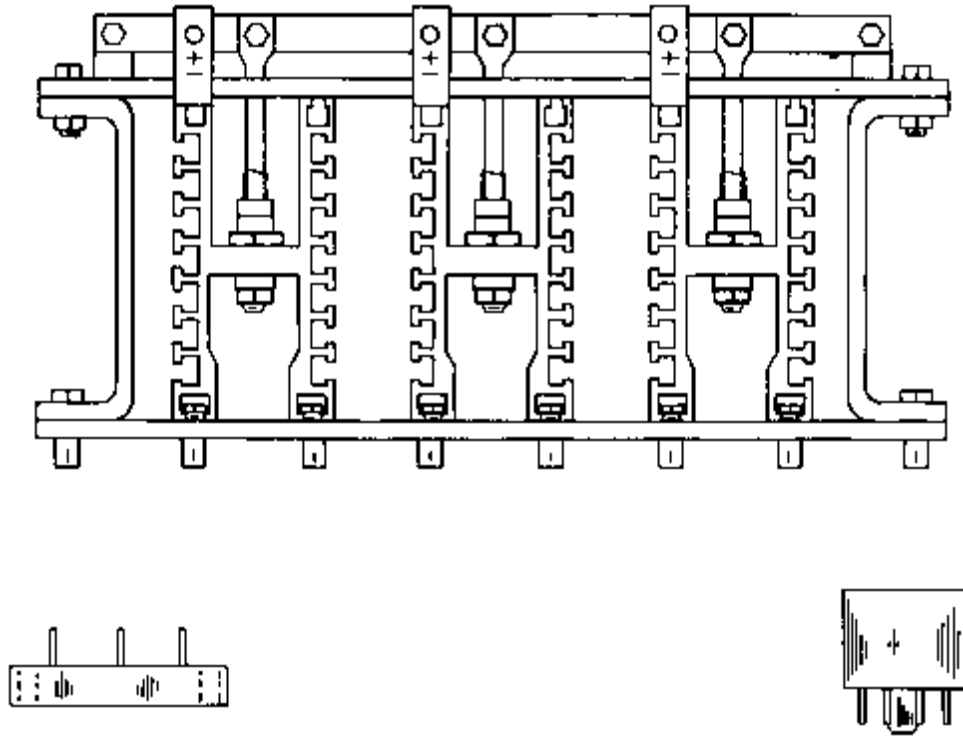


Figure 1.3 — Sketches of typical semiconductor rectifier stacks

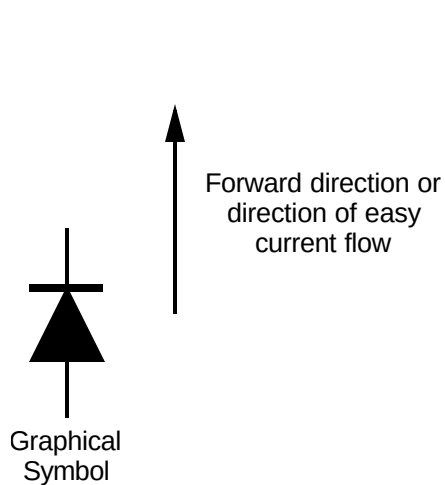


Figure 1.4 — Graphical symbol of a rectifier diode and of a rectifier circuit element

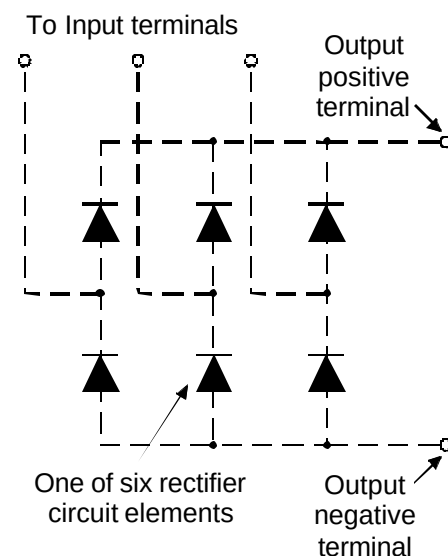


Figure 1.5 — Example of rectifier circuit elements in a circuit diagram

1.5 Letter symbols subscripts (cont'd)

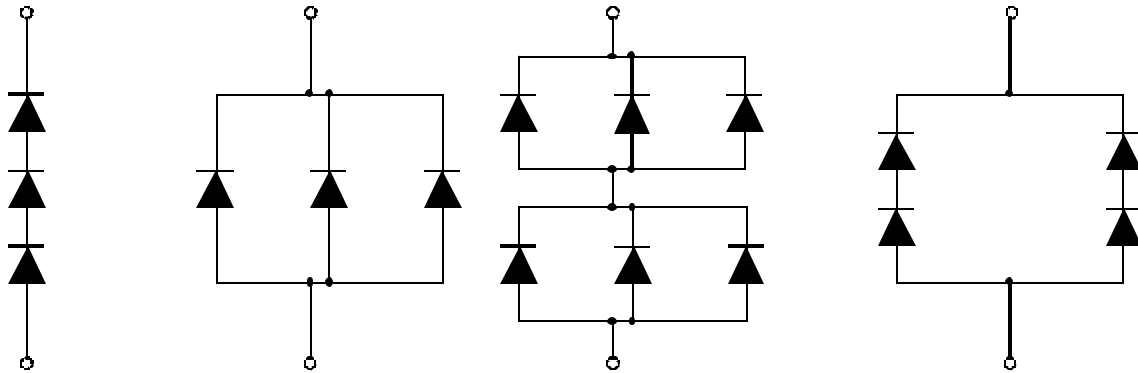


Figure 1.6 — Examples of rectifier circuit elements

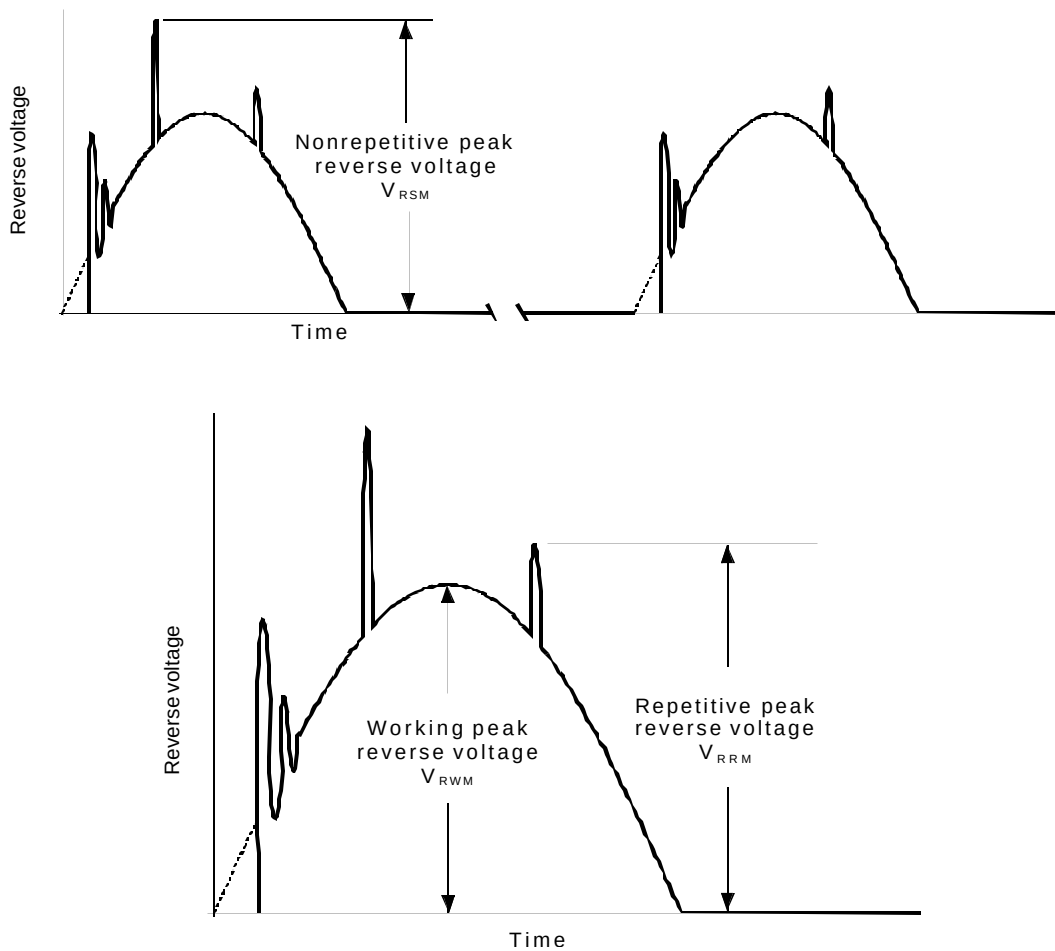


Figure 1.7 — Reverse voltage waveforms

1.5 Letter symbols subscripts (cont'd)

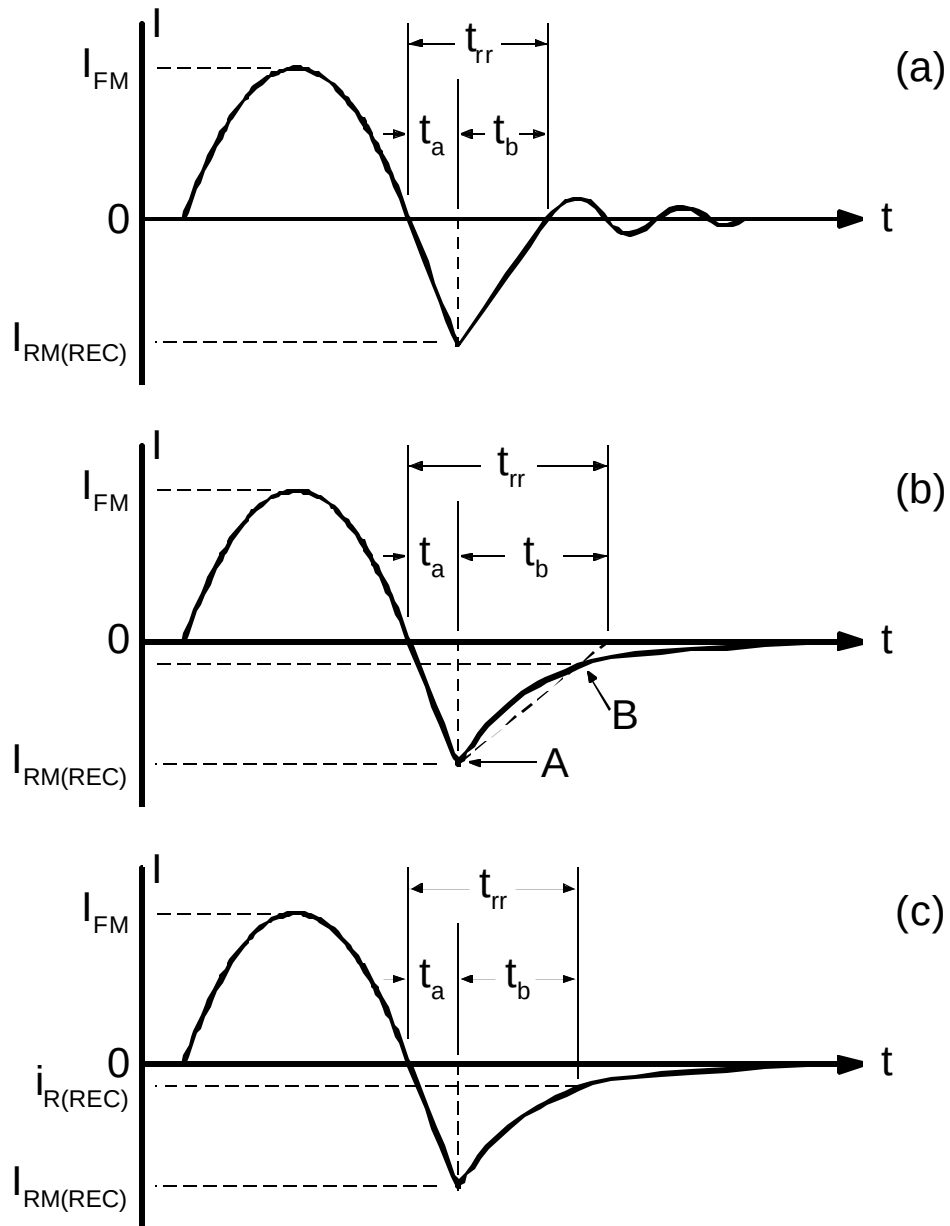
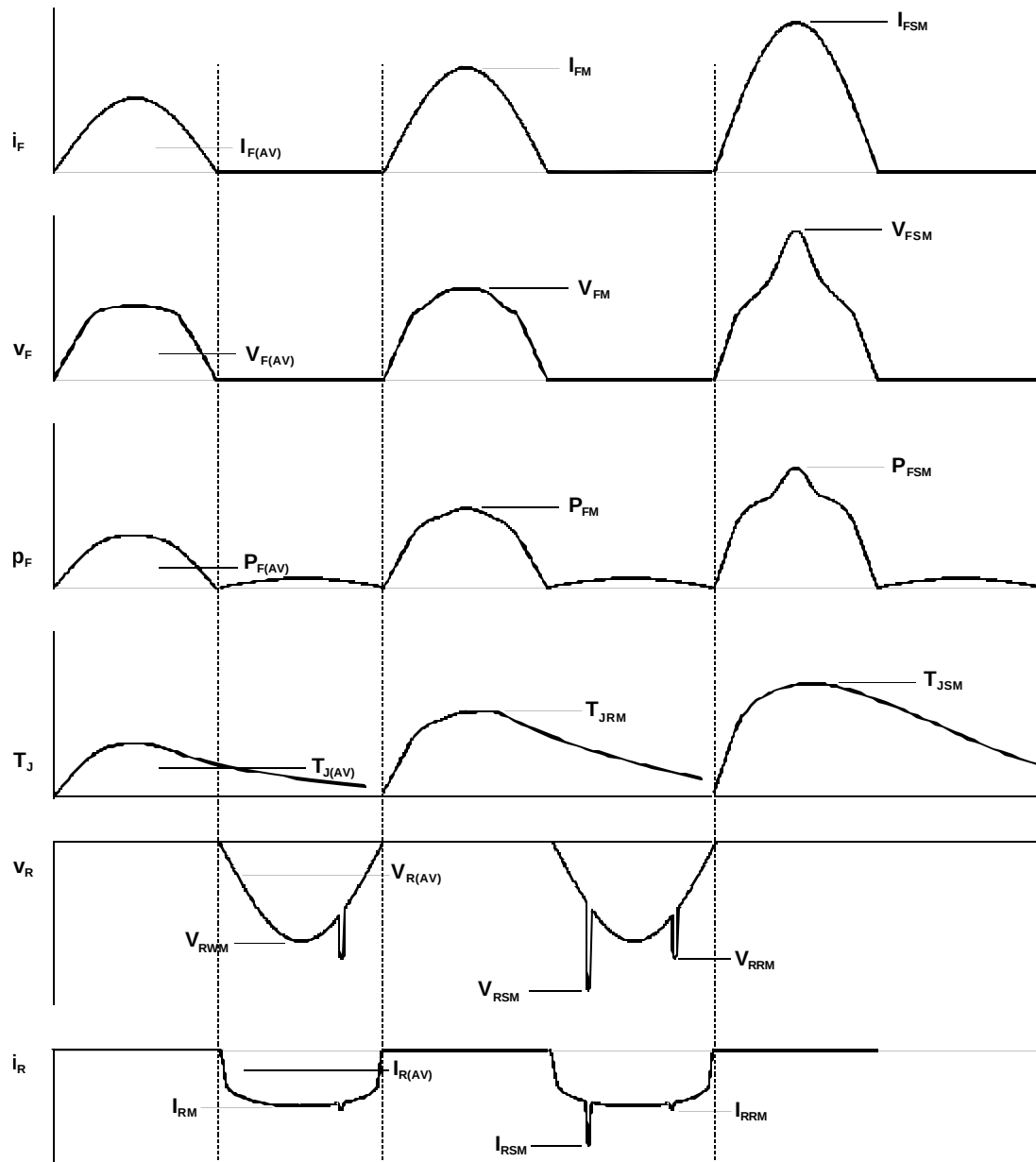


Figure 1.8 — Current waveforms during rectifier diode reverse recovery

1.5 Letter symbols subscripts (cont'd)



NOTE 1 Instantaneous values, such as i_F , v_F , etc. indicate a value on the waveform at a desired point in time.

NOTE 2 I_o is the average rectified current of sinusoidal waveform. For other waveforms the average rectified current is designated as $I_{F(AV)}$.

NOTE 3 In the figure above vertical dashed lines are used to show concurrence of the other waveforms with the end of, and beginning of, i_F .

Figure 1.9 — Illustration of symbols for reverse and forward voltage and current and junction temperature excursion resulting from the developed power

1.5 Letter symbols subscripts (cont'd)

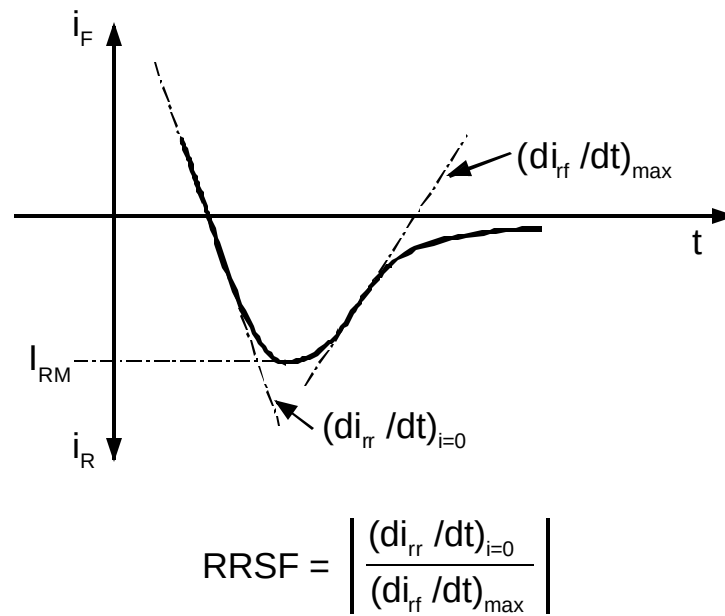


Figure 1.10 — RRSF Reverse Recovery Softness Factor

SECTION 2: REGISTRATION

2.1 Introduction

This chapter describes the established procedures that are followed in the registration of semiconductor devices and the assignment of type designations. These procedures are discussed from the standpoint of both administration by JEDEC and compliance by the device manufacturer. Technical standards concerning registration are not included but are discussed in Section 3.

Registration consists of the assignment of type designations to solid state devices in accordance with established rules, recording the assignment and defining data, and the full dissemination of the information to the electronics industry.

Registration procedures and rules are established by JEDEC, which is a sector of EIA (Electronic Industries Alliance). In any event, JEDEC neither assumes liability for, nor endorses the use of any products which bear its authorized registration number. JEDEC has as its primary objective the development of Recommended Standards and Registration Formats in the field of solid state devices. An effective registration procedure is considered basic to the achievement of this objective.

The material in this section on type assignments is taken from JEDEC Publication No. 15D (February, 1981). However, the latest revision of this publication has overriding authority where any conflict may occur with the material contained herein.

The term “type designation” used here refers to the number assigned to a solid state device in accordance with EIA Recommended Standard EIA-370-B “Designation System for Discrete Semiconductor Devices” (February 1982; Reaffirmed November 1995). The term “type designation” may be applied to the original number assigned (without suffix) or to a number with a suffix letter. All procedures described here apply equally well to both the basic type designation and to the suffix letter designation unless otherwise stated (see 2.2.4 and 2.2.5).

2.2 Purpose and intent

The purpose of the type designation and registration system is to facilitate the purchase and distribution of solid state devices by nontechnical individuals. The registration procedures are designed to ensure that devices registered with JEDEC differ from each other significantly in performance characteristics or physical dimensions.

The following is a partial list of the many ways in which the JEDEC registration system is useful to many segments of the electronics industry.

- 1) A single number replaces the multiple house numbers that would be used where there are two or more manufacturers of a particular device. This advantage is of particular value to the larger consumer such as the Government, because it means in most cases the procurement and supply of a single item, instead of multiple items.
- 2) The existence of a nationality recognized designation encourages other manufacturers to make similar devices, thereby increasing and promoting competition.

2.2 Purpose and intent (cont'd)

- 3) Requires types registered under the JEDEC system to differ from each other in a significant degree in terms of performance characteristics or physical dimensions.
- 4) Allows types registered under the JEDEC system to be more easily compared because the defining characteristics of the specification must be based upon standard test conditions and registered according to standard formats.
- 5) The publication of registration information through trade channels makes it easier for consumers to obtain second sources of supply.
- 6) The specifications of registered devices carrying the authorized designations cannot be changed at will by the first or any subsequent manufacturer, thus promoting standardization and interchangeability.
- 7) In many cases it provides a means for nontechnical personnel of user stock procurement and maintenance operations to obtain equivalent replacement parts.
- 8) It provides a permanent record for future procurement in those cases where the original manufacturer(s) no longer exist or make the type.
- 9) It provides a parts identification system which is of benefit to the distributor and user of electronic parts.
- 10) The JEDEC system permits reduction in the required number of parts in inventory.

It is the intent of the type designation and registration system to permit the assignment of discrete semiconductor device type designations not only to single solid state devices but also to combinations of solid state devices such as more than one diode element, or diode elements and transistor or thyristor elements, within the same primary envelope. In each case, EIA Standard EIA-370-B, "Designation System for Discrete Semiconductor Devices" governs.

2.3 Brief outline of registration procedures

Application: The manufacturer furnishes to the Type Administrator defining data for a device in accordance with the applicable registration format and requests assignment of a type designation. (See 3.1.)

Assignment: The Type Administrator assigns a type designation and notifies the manufacturer of the assignment.

Release (Public Announcement): Within one hundred and twenty (120) days after the date of assignment, the Type Administrator announces the registration of the type by distributing the data to the manufacturers and users of solid state devices.

Correction Notice and Registration: Once data on a type has been released, it is possible to change the defining data for that type only by either of two methods: a correction notice or a reregistration. In those cases where an error has been discovered in the data submitted, a correction notice may be filed only by the original sponsor to the Type Administrator within sixty (60) days after release. On the other hand, any device manufacturer may, at any time, propose a reregistration to change the registered values for a device.

2.3 Brief outline of registration procedures (cont'd)

In order for the change to be adopted, however, there must be no opposition to the proposal from any other manufacturer of the device.

2.4 Detailed procedures and rules governing registration of type designation without letter suffix

2.4.1 Application

Any manufacturer of solid state devices, whether or not a member of JEDEC or EIA may request a type registration from the Type Administrator for a device the manufacturer is developing or manufacturing. Foreign manufacturers may also request type registrations. All applicants for type registrations will be charged a fee for the service.

The requirement that final registration data be made available to the Type Administrator in order to obtain a type registration makes it necessary for the manufacturer to defer his application until the device is about to be marketed.

A request for registration must be made in writing by the manufacturer of the device. It must be accompanied by sufficient defining data to show that the device differs from any existing device for which a number has been assigned by the Type Administrator. The data must be submitted to Technology Association in accordance with the applicable formats developed by JEDEC Solid State. See 2.7, 2.8, and 2.9 for rules pertinent to development and use of formats. If an appropriate format does not exist, the information submitted must meet the minimum requirements set by the Type Administrator. In any case, the Type Administrator shall be the sole authority for determining the adequacy of data submitted. Any appeal of the Type Administrator's determination shall be made in writing within thirty (30) days, in accordance with the procedures set out in 2.6.

For rectifier diodes, the Type Administrator will insist that a new type number, not a suffix letter, be used, if a new device differs from an older registered device in any of the following respects:

- 1) Any change in forward current rating, except surge current.
- 2) Any change in reverse voltage rating.
- 3) Any change in maximum storage or operating temperature rating.
- 4) A new rating or characteristic not required of the older device and for which industry agreement for reregistration of the older device could not be reached.
- 5) A major change exceeding the greatest change permitted for suffix designations in one or more of the characteristics listed.
- 6) New outline dimensions.

2.4 Detailed procedures and rules governing registration of type designation without letter suffix (cont'd)

2.4.1 Application (cont'd)

The data submitted shall be a typed original (or equivalent quality) on unfolded 8-1/2" by 11" plain white bond paper (no letterhead). Specific instructions for data submissions appear with each registration format. The data shall be mailed with suitable protection against creasing or bending. If the material is not received in condition suitable for reproduction, the Type Administrator reserves the right to return it to the sponsor, notwithstanding delay and further costs to the sponsor.

Should the Type Administrator receive more than one application for a particular device, he shall assign the designation for the type to the manufacturer having the earliest time of receipt at the office of the Type Administrator. A manufacturer wishing to establish early receipt may make use of a telegram that furnishes adequate information for assignment. The telegram must be followed within fourteen (14) days by a letter supplying the information in the standard form; otherwise the application will be canceled and the applicant so notified.

Any manufacturer filing subsequently to the first application will be furnished full information on the assignment, and the first manufacturer shall be informed of the disclosure.

2.4.2 Assignment

Upon receipt of the application for a type registration, the Type Administrator will make a search of existing type registrations to determine whether the applicant's device has sufficiently distinct characteristics to warrant the assignment of a new type designation. In determining discreteness or distinctness, the Type Administrator shall take into account major differences such as, but not limited to, different maximum ratings, new tests, different limits from those that have been applied to existing devices, physical changes, and any other characteristics that differ significantly from already registered devices.

If additional data are deemed necessary by the Type Administrator to justify an assignment of a type number, he shall so inform the applicant. If the additional information is not given to the Type Administrator within fourteen (14) days, the applicant shall be notified that the application has been rejected and given reasons therefor.

In case the submitted data closely corresponds with that of a device already assigned a designation by the Type Administrator, the Type Administrator shall reject the application in writing, giving the reasons therefor and supplying the type designation that is considered applicable. Any appeal of the Type Administrator's determination shall be made in writing within thirty (30) days in accordance with the procedures set out in 2.6.

Correction or changes in the data may be submitted by the original applicant in the period prior to release. Changes are permissible only to the extent that the device characterization is not changed sufficiently to warrant a change in its type designation status. All changes or corrections must be authorized by the Type Administrator prior to their publication in association with a JEDEC type number and must have prior coordination with the other applicants to whom the designations may have been disclosed under the provisions of 2.4.1.

2.4 Detailed procedures and rules governing registration of type designation without letter suffix (cont'd)

2.4.2 Assignment (cont'd)

In making type designation assignments, the Type Administrator shall follow current JEDEC Standards, and the technical formats and guidance rules supplied by JEDEC Solid State Technology Association. When all of this information is insufficient to cover a specific case, the Type Administrator may delay the application pending a decision from the appropriate JEDEC Committee. (In any case of rectifier diodes the Committee would be JC-22.) The Type Administrator shall notify the applicant of the delay and the reason therefor.

2.4.3 Release (public announcement)

The Type Administrator shall release the registration data to the public as soon as he has been authorized to do so by the manufacturer, who in turn does so when he is ready to market the device. If earlier authorization is not received, the Type Administrator shall automatically release the data one hundred and twenty (120) days after date of assignment. A delay may be requested for legitimate causes.

In those cases where a manufacturer publicly discloses data on an authorized type designation before he has requested the Type Administrator to release the data, the Type Administrator shall automatically release the data without waiting for the one hundred and twenty (120) day period to end. The Type Administrator will take such action only in those cases when he has been given conclusive evidence that disclosure has been made by the manufacturer. For purposes of this section, the term "disclosure" is meant to include the disclosure of an unreleased but authorized type designation and its data or use through advertising, general distribution of data sheets, inclusion in price lists, sampling, or other marketing steps. Disclosure as part of a government contract for the development of a device is not considered to be disclosure within the meaning of this section.

In the case where an invitation-for-bid has been issued in connection with a government contract for a solid state type that has not been released, the Type Administrator shall use a procedure for affecting registration other than the one described in the preceding paragraph. The recipient of the invitation-for-bid shall supply details concerning the invitation and its sources. The Type Administrator will then contact the sponsor of the unreleased type designation, informing him of circumstances which require the immediate release of data on the type.

The registration data is distributed by the Type Administrator to all known manufacturers of solid state devices, as well as to subscription lists of equipment designers, users and other nonmanufacturers of solid state devices.

2.4.4 Correction notice and reregistration

After a type designation has been completely registered, one of the ways in which it is possible to change the defining data is by means of a correction notice. This can be filed only by the original sponsor or the Type Administrator and must be in the hands of the Type Administrator within sixty (60) days after the release date. Corrections to registered data after sixty (60) days from date of release must be made through the reregistration procedure.

The correction notice process may be used when it is found that the registered data contains obvious incompatibilities, typographical errors, or ambiguities. The correction notice will be circulated to the same mailing list of those persons receiving the registration information and it will clearly refer to the particular release involved.

2.4 Detailed procedures and rules governing registration of type designation without letter suffix (cont'd)

2.4.4 Correction notice and reregistration (cont'd)

A correction notice does not become effective until sixty (60) days after its release. During this period any manufacturer may object to the notice if he can show that the change is not truly an obvious error, incompatibility, or ambiguity. A single valid objection, if it cannot be reconciled by the Type Administrator with the proponent, will cause the correction notice to be canceled.

The second way in which the defining data for a registered type may be changed is by means of reregistration. Reregistration may be proposed only by a manufacturer or the appropriate JEDEC Committee (JC-22 in the case of rectifier diodes). In submitting data, the manufacturer should use the most current approved format. If absolutely necessary, he may use the format which was in effect at the time of registration of the device being reregistered.

A reregistration proposal should be limited to those changes or additions which do not affect unilateral interchangeability with the original version. Any proposed reregistration, which in the opinion of the Type Administrator will effect unilateral interchangeability shall be rejected by the Type Administrator. Examples of changes which affect unilateral interchangeability are relaxed package dimensions, relaxed electrical ratings or characteristics, etc. For dimensions and characteristics, increase of maximum limit or reduction of a minimum limit constitutes a relaxation. For ratings (which imply device capability), reduction of an upper limit or increase of a lower limit constitutes a relaxation. Manufacturers who believe unilateral interchangeability will not be affected have the prerogative of appealing the Type Administrator's decision as provided in 2.6.

Approved reregistration requests will be processed as follows: The Type Administrator shall distribute the reregistration proposal to the device manufacturers on the mailing list to receive copies of all semiconductor registrations. The reregistration release will instruct manufacturers having valid objections to the proposal to submit their comments in writing (oral comments are not acceptable) to the Type Administrator, so that he may receive them within sixty (60) days from the date of release.

If no written adverse comments to a reregistration proposal are received within the sixty (60) day period, the reregistration proposal becomes effective, superseding the original registration, and the industry shall be so notified by the Type Administrator.

In the event that adverse comments on the proposed reregistration are received and:

- 1) If there is a possibility that the objections may be resolved, the Type Administrator shall issue a "HOLD IN ABEYANCE" notice at the end of the sixty (60) day period.
- 2) If attempts at reconciliation fail, the reregistration shall be canceled and a cancellation notice sent to all recipients of the previous information.
- 3) If the reconciliation results in a compromise, the previous proposal shall be canceled and the new proposal shall be submitted for a sixty day approval by the industry.
- 4) If the reconciliation results in the objectors, rescinding their negative comments, the Type Administrator shall issue a notice that the reregistration proposal has been accepted.

2.4 Detailed procedures and rules governing registration of type designation without letter suffix (cont'd)

2.4.4 Correction notice and reregistration (cont'd)

In those cases where the Type Administrator has rejected comments because he considers them to be not valid, he shall notify the objector of his action and inform the objector that he has thirty (30) days in which to file an appeal with the JEDEC office who, in turn, will notify the Type Administrator that an appeal has been filed. If no appeal is made within the specified period, the Type Administrator will proceed in accordance with the previous paragraphs.

2.5 Detailed procedures and rules governing registration of type designations with letter suffix

All of the preceding rules are applicable to the assignment of a type designation which contains a suffix letter, except as amended in the following paragraphs.

The applicability of a suffix assignment, as opposed to a new designation, is outlined in EIA Standard EIA-370-B. In general, a suffix designation can be applied to an improved version of an existing type if the improved version is unilaterally interchangeable with the prototype and all prior suffix versions.

Exceptions exist for letters R and M. The letter R is used to indicate a reverse-polarity diode in an asymmetrical package which is mechanically and electrically identical to a forward-polarity device. When the package has a mounting base (stud, flange or case mounting) which is used as one electrical connection, the definition for polarity of a rectifier diode is as follows:

In forward-polarity devices, the mounting base shall be the cathode terminal, and in reverse-polarity devices, it shall be the anode terminal.

For the use of suffix letter M refer to EIA Recommended Standard EIA-370-B.

For rectifier diodes suffixes may be issued when there is a significant change in one or more of the characteristics or ratings listed in the table below. The change must be such that the new device is unilaterally interchangeable with the older one having the same basic number, so that the new type, which has been given the letter suffix, may be used to replace the original type device. Only changes which result in device improvement within the range shown in the table below will be allowed. If a proposed rating is between the original rating and the nearer limit of the specified range, the change is deemed not significant enough to warrant either a suffix letter or a new type number. If the proposed rating lies beyond the further limit, a new type number is required.

If the device outline is identical to that of an existing type or differs to such a slight extent that the new type may be physically substituted for the existing type, a suffix letter may be considered. If the new outline differs significantly, such as would be the case if it had a different registration (DO) number, a new type number is required, even if electrical ratings and characteristics are the same.

2.5 Detailed procedures and rules governing registration of type designations with letter suffix (cont'd)

Parameter	Allowed range for use of letter suffix
Forward Voltage (V_{FM})	$0.8 - 0.9 \times V_{FM} \text{ (reg)}^*$
Reverse Current (I_{RM})	$0.05 - 0.20 \times I_{RM} \text{ (reg)}^*$
Surge (Nonrepetitive) Peak Forward Current (I_{FSM})	$1.50 - 3.50 \times I_{FSM} \text{ (reg)}^*$
Reverse Recovery Time (t_{rr})	$0.10 - 0.50 \times t_{rr} \text{ (reg)}^*$
* $I_{RM} \text{ (reg)}$ etc. represents the registered value of the particular parameter in the original type device.	

The request and the accompanying information will not be treated as confidential information but will be circulated for approval to the recipients of solid state device registration releases in the same manner as a registration proposal (see 2.4.4).

In submitting the data, the manufacturer should use the current format. If necessary, he may use the format which was used for registration of the last suffix letter version (or the designation without suffix letter if no letter has been previously assigned).

If adverse comments on the assignment of the suffix letter are received by the Type Administrator within the sixty (60) day period, he shall refer the entire matter to the cognizant JEDEC Committee for guidance.

When the JEDEC Committee votes on recommendations to be submitted to the Type Administrator, members whose companies are directly involved in the dispute shall be excluded from voting. The Type Administrator, preferably, or his designated alternate shall be present at the meeting when the JEDEC Committee discusses the matter he has referred to them.

The Type Administrator shall make the decision on the registration of the suffix letter designation after considering the Committee's recommendations.

The Type Administrator shall inform the cognizant JEDEC Committee and the parties involved of his decision.

If no adverse comments are received within thirty (30) days, then the notice of the assignment becomes effective. If adverse comments are received, then a status notice (Hold-in-Abeyance) can be issued until all avenues of appeal are exhausted or the case dropped.

2.6 Appeal of the Type Administrator's decision

Decisions of the Type Administrator are subject to appeal to the JEDEC Board of Directors and to an Ad Hoc Arbitration Panel as provided in JEDEC Publication No. 15D. For details the reader is referred to this Publication.

2.7 Description of the registration format

A format is intended to provide a uniform method for presentation of the definition and performance of a JEDEC registered device. The Type Administrator uses the completed format to assure the uniqueness of the device for type assignment purposes. The registrant manufacturer uses the format to completely define a device to the degree which the formulating Committee and JEDEC Board of Directors believe is necessary to assure device interchangeability. Other potential manufacturers use the completed format and registration data to facilitate and assure device interchangeability. Solid state device users employ the completed registration data to select, compare, and define devices to achieve intended circuit performance. The format provides for a common language of understanding between supplier and user.

Each format provides for specific values of mechanical and electrical parameters in two categories. One is for mandatory parameters, and the Type Administrator shall not accept a proposal registration unless every such parameter is provided.

The other is for additional parameters which the formulating Committee believes desirable for the further definition of a device intended for a normal application. Additional data not listed in a format are permissible if the registrant manufacturer believes it is necessary to further define the device and to assure interchangeability.

The Type Administrator must receive a properly completed registration format (see 2.3) in order to issue a JEDEC type number assignment. In the event an appropriate format has not been prepared by the JEDEC Committees, the Type Administrator, with advice from JEDEC Board of Directors or a Committee Chairman, will determine what shall constitute an interim substitute format.

A completed format characterizes a device by listing or referencing all mechanical outline dimensions and terminal identifications, all essential electrical performance data and maximum ratings, all necessary test methods, and all appropriate parameter symbols which are believed necessary to assure device interchangeability. Each JEDEC product Committee originates formats for every device category over which it has been assigned responsibility. Each format is approved for circulation and use by the JEDEC Board of Directors. JEDEC Committees have the responsibility for maintaining and upgrading the technical content of formats such that they reflect the advancement of the technology of both design and manufacture. Mechanical and electrical parameters are to be listed as minimum, maximum, or rated values required to assure device interchangeability.

2.8 Use of JEDEC registered data

The solid state device manufacturer should use the JEDEC data for a registered device as the basis for his commercial data. Since the JEDEC registration data is industry property, each manufacturer who desires to produce and market that device must comply in every respect with the registered data. Commercial data describing that device must identify by asterisks all parameters which appear on the JEDEC registration. If a manufacturer believes it desirable, he may list additional defining data, such as performance curves or quality items, provided such additions do not affect interchangeability.

JEDEC type designations should be used in the form in which they are assigned. In data presentation and in device marking, the JEDEC designation should be kept separate and distinct and not made part of other identifying numbers, if such other numbers are present.

2.8 Use of JEDEC registered data (cont'd)

Alternations in a JEDEC number should not be made for any purpose such as to indicate special selection, to modify characteristics, or to indicate interchangeability.

Specific examples of past practices which are considered to be in conflict with this policy are illustrated but not limited to the following:

Slash Branding:	JEDEC No./JEDEC No. JEDEC No./House No.
Unauthorized Suffixes:	1N9000Z 1N9000-2 1N9000-TO-9 1N9000/TO-9

JEDEC reserves all rights to the use of its symbols and designations. The Armed Services make use of JEDEC designations and have been permitted to modify these designations by means of prefixes to indicate conformance with military specifications.

2.9 Test and rating methods applied to JEDEC data

Defining data on a format must be supported by sufficient references or included information, to assure an understanding of the test methods used in the measurement and interpretation of data and ratings. It is the responsibility of the formulating JEDEC Committee and the Board of Directors to define as many of the following test methods, conditions and other information, as is appropriate for the device or format under consideration:

- 1) Standard circuits for the measurement of electrical characteristics.
- 2) Standard circuits for life testing of semiconductor devices.
- 3) Standard mechanical tests (shock, vibration, etc.).
- 4) Standard fixtures and gauges.
- 5) Standard time duration of test when applicable (hours, cycles, pulses, etc.).

There should be no question as to the intention behind, or interpretation of, any parameter or test listed on a format.

SECTION 3: USE OF RECTIFIER DIODE REGISTRATION FORMATS

3.1 Introduction

This section provides the guidelines for filling in the Rectifier Diode Registration Information required in registration formats.

On a given format, every item preceded by an “M” is a mandatory item and must be completely filled in, since it represents an essential rating or characteristic required to ensure device interchangeability in broad, general rectifier diode applications. The data requested in other items are optional and should be filled in as appropriate to ensure interchangeability in those special applications in which the device is intended to serve. In any event, the data supplied should adequately define the device in terms of interchangeability in the intended application and should distinguish it from existing registered devices. (See 2.4 and 2.5).

If additional data are necessary to ensure interchangeability, the data should be submitted as part of the registration. When data are submitted for which no blanks appear in the registration format, care must be taken to completely describe the conditions under which the specified performance characteristics or ratings are to be met. All data submitted for registration, whether mandatory, optional, or supplemental to the format, become a part of the formal registration.

When preparing a registration data format for submission, delete all italicized notes, all unused items and all “M’s”. Renumber the items in proper sequence wherever necessary to avoid gaps in the item numbers used.

Existing JEDEC standards for measurement methods (refer to Sections 4 and 5), preferred voltage, current and temperature values (given in 3.4.1 and 3.4.2) and definitions and letter symbols (refer to Section 1) are to be used, as applicable.

All JEDEC registered data must appear on the device manufacturer's commercial data sheets and be identified as JEDEC registration data by means of asterisks. Additional data, including performance curves, may be included in commercial data sheets provided interchangeability is not affected.

For the purpose of achieving standardization, specific registration formats are available to fit particular types of rectifier diodes. These formats are subject to change as new semiconductor developments or circuit applications become practicable. At present, the following formats are available:

<u>NUMBER</u>	<u>DESCRIPTION</u>
JC-22, RDF-21	Lead Mounted Silicon Rectifier Diodes
JC-22, RDF-22	Stud- or Base-Mounted Silicon Rectifier Diodes
JC-22, RDF-23	Stud- or Base-Mounted Silicon Controlled Avalanche Rectifier Diodes or Transient Suppressor Rectifier Diodes
JC-22, RDF-24	Enclosed Silicon Rectifier Circuit Assemblies
JC-22, RDF-25	Unencapsulated Semiconductor Rectifier Diode Elements
JC-22, RDF-26	Diode, Stud- or Base-Mounted Rectifier Diodes having Significant Reverse loss.

3.1 Introduction (cont'd)

The registrant is urged to contact the Type Administrator at EIA Headquarters to be abreast of the latest developments.

In the following paragraphs an explanation of the requirements of various parts of the formats is given.

3.2 General description (Registration Format Section I)

This section of the format establishes the broad descriptive classifications pertaining to the device to be registered. For instance, the semiconductor material used, the type of mounting (lead, base, stud) and the basic electrical configuration (diode assembly, etc.) are to be given here; also the major areas of usage and similar facts.

3.3 Mechanical data (Registration Format Section II)

The outline dimensions of the device are to be given in this section. If possible, an outline drawing registered with JEDEC should be used. Registered outlines are found in the latest edition of JEDEC Publication No. 95 "JEDEC Registered and Standard Outlines for Semiconductor Devices". (They are assigned numbers beginning with "DO" when they are two-terminal housings.)

If such a registered outline is not applicable, an outline drawing must be furnished on a separate page attached to the format. The drawing must be prepared so as to conform with the latest edition of EIA Standard RS-308A, "JEDEC Type Registration for Semiconductor Devices, Preparation of Outline Drawings".

The electrical function of each terminal of the device is also to be given. If the case is also an electrical terminal, its electrical function shall be given. Otherwise, a note is to be included stating "all leads insulated from case". Any terminal not performing an electrical function is to be designated "NC".

When it is required to color code rectifier diode terminals or leads, the following is recommended in the interest of standardization: Anode - Black, Cathode - Red.

For smaller rectifier diodes, a banding of the body at the cathode end is acceptable. The recommended color of the band is red but other colors are acceptable.

For assemblies, the following color code is recommended in the interest of standardization.

<u>Terminals</u>	<u>Color</u>
AC	Yellow
Positive or Cathode	Red
Negative or Anode	Black

Any special precautions necessary for the proper handling of the device are to be given. Likewise, any restrictions as to mounting positions which may be required in order to ensure proper operation of the device should be given here. The case or lead temperature point shall also be defined.

3.4 Maximum ratings (Registration Format Section III)

Maximum thermal and electrical ratings assigned to the device are to be given in this section. Maximum ratings are those which, if exceeded, may cause permanent damage, or introduce latent failure mechanisms within the device.

3.4.1 Temperature

A temperature reference point (lead or case) must be specified. For a hex base stud-mounted device, the temperature reference point shall be specified as the center of the flat surface of any one of the hex faces. For lead mounted devices, the temperature reference point is generally 3/8 inch (9.5 mm) from the body of the device or its tabulation(s). For a disc type device it shall be a point on the cylindrical surface of a designated mounting pole.

Reference point temperatures in degrees Celsius (centigrade) are to be selected, when possible, from the table below and inserted in blanks corresponding to the symbols T_1 through T_{11} as required. A logical sequence covering the temperatures used in the formats follows:

Preferred Temperature Values - Degrees Celsius

-65*	40	115
-55*	55*	125
-40	65	150
-25*	70*	175
-10	85*	200
0	90	250
	100*	

* Recommended for use in new documents.

If it is necessary to register values other than those given above, they should be multiples of five degrees Celsius.

Several key temperatures are specified on the formats. The following list is all-inclusive; not all temperatures are required on all formats. All temperatures defined herein must be in increments of 5 °C.

T_1 is the minimum operating temperature and must be equal to or lower than 0 °C.

T_2 is the minimum operating temperature with no derating and must be equal to or lower than 25 °C.

T_3 is the maximum operating temperature with no current derating when V_R equals its rated value.

T_3 is related to T_5 according to the table below.

3.4 Maximum ratings (Registration Format Section III) (cont'd)

3.4.1 Temperature (cont'd)

T_4 is the temperature of a breakpoint in the maximum average forward current versus temperature relationship, which can be used to segment the derating curve, and must be greater than T_3 and also less than T_5 .

T_5 is the maximum operating temperature at which point the power dissipation is derated to zero.

T_6 is the minimum storage temperature and must be equal to or less than T_1 .

T_7 is the maximum storage temperature and must be equal to or greater than T_5 .

T_8 is the peak repetitive instantaneous junction temperature under forward current overload and must be equal to or greater than T_5 .

T_9 is the maximum operating temperature, with the maximum dc reverse voltage rating applied, and must be equal to or lie between T_3 and T_5 .

T_{10} is the maximum operating temperature, with the maximum working peak reverse voltage rating applied, and must lie between T_5 and T_9 .

T_{11} is the maximum lead or terminal temperature for soldering purposes.

TEMPERATURE RELATIONSHIPS		
Maximum Operating Reference Point Temperature, T_5 (°C)	Corresponding Range of Max. Reference Point Temperature in Full Load, (T_3) (°C)	Corresponding Preferred Maximum Reference Point Temperature at Full Load, (T_3) (°C)
100	40 - 70	55
125	50 - 100	70
150	70 - 125	100
175	85 - 150	125
200	100 - 175	150

Once the values of T_1 , etc., have been established in the section on Operating Temperatures, the same values shall be used whenever symbols T_1 , etc. appear in the registration format. The actual numerical values shall be shown in parentheses following each letter symbol.

3.4.2 Electrical ratings

The electrical ratings to be given include the maximum reverse voltage rating and the maximum forward current rating that can be continuously handled by the device over the specified operating temperature range.

3.4 Maximum ratings (Registration Format Section III) (cont'd)

3.4.2 Electrical ratings (cont'd)

For these ratings the discrete rectifier diode is operated in a single-phase, half-wave circuit with a 60 Hz sinusoidal voltage source and a resistive load. These ratings are to be applicable over a frequency range of at least 50 Hz to 400 Hz.

In the interest of standardization, it is recommended that only rectifier diodes possessing the voltage and current ratings in the following table be registered:

Preferred Voltage Ratings (V)			Preferred Average* Current Ratings at T_3 (°C)				
25	100	1000	0.10	1.0	10	100	1000
50	200	1200	0.25	2.5	15	150	1200
	400	1500	0.60	6.0	25	250	1500
	600	2000			40	400	2000
	800	2500			60	600	
		3000				800	
*Full cycle average half-sine wave forward current, 50 Hz to 400 Hz.							
NOTE If it is necessary to register values other than those given above, use values from the list of ANSI (rounded) 10 numbers which are: 1.0, 1.2, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0 and 8.0 times any integral power of 10.							

3.4.2.1 Voltage ratings

Reverse voltage may be derated in the temperature range T_1 to T_2 . This derating information is to be registered as additional information. As no blanks are provided for such derating information, it should be included in a manner consistent with the other parts of the registration, and given an appropriate paragraph number.

Where it is desired to use a single registration format to register more than one device in a series and the devices have different voltage ratings, the information required to establish the voltage ratings may be given in the form of a note at the end of the format; reference shall be made to this note in appropriate blanks in the format. This note may consist of a table giving the various voltages which apply to the different devices in the series.

Several reverse voltage ratings are required (often two or more of these have the same value):

V_{RWM} : Maximum peak value of the 60 Hz half-sine wave reverse voltage that can be withstood on a repetitive basis over the operating temperature range of T_2 to T_{10} .

V_{RRM} : Maximum peak value of 100 Fs pulses at a 60 Hz rate that can be withstood on a repetitive basis over the operating temperature range of T_2 to T_{10} .

3.4.2 Electrical ratings (cont'd)

3.4.2.1 Voltage ratings (cont'd)

V_{RSM} : Maximum peak value of nonrepetitive 60 Hz half-wave reverse voltage pulses that can be withstood over the operating temperature of T_2 to T_{10} (for avalanche devices, an energy limit is required).

V_R : Maximum dc reverse voltage that can be withstood on a repetitive basis over the operating temperature range of T_2 to T_9 .

3.4.2.2 Current ratings

The current rating of a rectifier diode(s) is to be registered as an average value (averaged over a full cycle of 60 Hz sinusoidal input voltage) as this is of more significance than an rms value with respect to the major applications of rectifier diodes. Spaces are given to register the current rating over the normal (no derating) temperature range T_2 to T_3 and also for stud and base mounted devices at a value (temperature T_4) which is above the normal temperature range. By definition, the current rating at T_5 or T_{10} is zero so a complete current rating curve is to be registered.

This curve may be approximated with three straight line segments. The current at T_4 should be approximately 1/3, 1/2, or 2/3 of the rated current over the normal operating temperature range. For lead mounted devices, the current rating curve may be approximated with two straight line segments. (T_4 therefore is not required.)

The numbers registered may be rounded to whole numbers and to ± 5 °C. Current ratings for rectifier diodes are based on 60 Hz sinusoidal waveforms into resistive loads and a conduction angle of $180^\circ \pm 5^\circ$; however, the ratings are to apply from 50 Hz to 400 Hz. Additional information for establishing current ratings is found in Section 6.

The surge current rating is the peak value of a specified half-sinewave of current. This surge may be repeated after thermal equilibrium has been re-established with the device operating at its repetitive current rating. The device is to be capable of withstanding a minimum of 100 such surges without failure. For the 60 Hz half-sinewave surge rating, the current surge is to be preceded by and followed by the normal operating conditions consisting of maximum rated 60 Hz half-sinewave current, device reference point temperature equal to T_3 and rated repetitive 60 Hz, peak reverse blocking voltage, if applicable. In addition, the half cycle of reverse blocking voltage following the half-sinewave surge current is to be the registered nonrepetitive 60 Hz peak reverse blocking voltage, if such exists. Otherwise, rated working peak reverse voltage shall be applied.

3.5 Electrical characteristics (Registration Format Section IV)

3.5.1 Reverse blocking current

The reverse current characteristic generally can be registered as either $I_{R(AV)}$ or I_{RRM} ; the latter is preferred. When registering $I_{R(AV)}$, the device shall be operated at its current and voltage ratings $I_{F(AV)}$ and V_{RRM} , and at T_3 . When registering I_{RRM} , the device shall be operated at its voltage rating, V_{RRM} , at T_5 . The dc reverse current, I_R , is registered at its dc reverse voltage rating V_R , and at T_9 . For transient suppressor and controlled avalanche diodes, the minimum and maximum breakdown voltages are to be registered. In addition, the reverse currents at which these voltages are measured are to be specified in each case.

In the section under reverse blocking current, where more than one device is being registered on a single format and the reverse current(s) is (are) not the same for all the devices being registered, the current value(s) may be given in the same note which lists the voltage ratings; reference shall be made to this note in the appropriate blank.

3.5.2 Forward voltage

The peak forward voltage, V_{FM} , can be registered at either maximum continuous rated load conditions or at the peak value of rated full load half-sinewave current ($I_{R(AV)}$) using a short pulse at $T_C = 25^\circ\text{C}$. The latter method is preferred because of the ease of measurement. In order to avoid significant heating of the junction during the test for forward voltage, the width of the current pulse used to make the measurement shall not exceed 2 milliseconds and the repetition rate of the pulses shall be low enough to impose a duty cycle of no more than 2%.

3.5.3 Reverse recovery

The nature of the reverse recovery characteristics of a rectifier diode affects interchangeability with other rectifier diodes in some applications. Therefore, recovery characteristics are to be registered as follows:

When method C or D is specified (see 5.6.9), the maximum recovery time, t_{rr} , of the rectifier diode is to be registered in two parts, i.e., t_{rr1} and t_{rrf} . The first part, t_{rr1} , is measured from the instant of current reversal to the instant current reaches its peak reverse value, and t_{rrf} is measured from this peak value to the specified point given in Section 5 of this document. Maximum peak recovery current, $I_{RM(REC)}$, is also to be registered.

Rectifier diodes can possess different degrees of recovery characteristics. After peak recovery current, the current may immediately, or a short time later, decrease very abruptly (abrupt recovery) or it may decrease slowly and smoothly to its steady-state reverse blocking value (soft recovery); refer to Figures 1.10 and 5.20.

Recovered charge Q_{rr} is to be registered and is defined as the area under the reverse current vs. time curve. The starting point is the instant of current reversal and the ending point is when the reverse current first crosses the zero axis after it has passed through $I_{RM(REC)}$ or where a straight line extrapolation of the reverse current after $I_{RM(REC)}$ crosses the zero axis. Another definition for the end of the reverse recover period is when some specified reverse current point, $I_{R(REC)}$, is reached.

Test conditions for registered recovery characteristic values are also registered. Fixed conditions, unless otherwise specified are $T_C = 25^\circ\text{C}$, test repetition rate equals 60 pulses per second, and di/dt is equal to $25\text{A}/\mu\text{s}$. The peak forward current, I_{FM} , is to be registered and must be greater than or equal to three times the rated average dc forward current I_o . Its pulse duration, t_p , shall also be registered.

3.6 Thermal characteristics (Registration Format Section V)

The maximum steady-state thermal resistance between the junction and the temperature reference point specified in the beginning of the format is to be registered. When required, the maximum transient thermal impedance characteristics shall be supplied in tabular form or as a curve.

Also to be registered is the maximum allowable thermal resistance between the temperature reference point and the ambient in order to prevent thermal runaway when registered voltage is applied over the registered operating temperature range (forward current, $I_{F(AV)}$, being zero).

SECTION 4: RATING ESTABLISHMENT AND VERIFICATION TESTS

4.1 Introduction and reference table of ratings and test

This section describes standard test methods to be used in establishing and verifying the maximum ratings for rectifier diodes given in the JC-22 series of registration formats for rectifier diodes.

NOTE The word “diode(s)” will be used throughout Section 4 to indicate rectifier diodes. The term “rating” is a value that establishes either limiting condition (maxima or minima) for the diode. It is determined for specified values of environmental and operating conditions and may be stated in any suitable terms. Operation beyond a rating may result in device degradation or damage, temporary or permanent, immediate or latent.

The following table cross references maximum ratings, the test method(s) used to establish each rating, and the number of the section of Section 4 that describes the test method.

Table 4-1 — Reference table of ratings and test methods

Maximum Rating	Title	Reference No.
Operating Temperature	Repetitive Rating Tests	4.2.1
Storage Temperature	Storage Life Test	4.3.1
Lead or Terminal Temperature for Soldering	Lead or Terminal Temperature Test	4.3.2
Working Peak Reverse Voltage, Half Sine Wave	Steady State Operating Life Test Working Peak Reverse Voltage Life Test	4.2.1.1 or 4.2.1.2
Nonrepetitive Peak Reverse Voltage, Half Sine Wave	60 Hz Sinewave Surge Current and Nonrepetitive Peak Reverse Voltage Test	4.2.2.2, 4.2.2.3, or 4.2.2.4
DC Reverse Voltage	DC Reverse Voltage Life Test	4.2.1.3
Repetitive Peak Reverse Voltage	Repetitive Peak Reverse Voltage Test	4.2.1.5
Average Forward Current, Half Sine Wave	Steady State Operating Life Test	4.2.1.1
Surge (Nonrepetitive) Forward Current (60 Hz 1/2 Sinewave)	60 Hz Sinewave Surge Current Test and Nonrepetitive Peak Reverse Voltage Test with Average Forward Current	4.2.2.2
Surge (Nonrepetitive) Forward Current (60 Hz 1/2 Sinewave)	60 Hz Sinewave Surge Current Test and Nonrepetitive Peak Reverse Voltage Test without Average Forward Current	4.2.2.3
Surge (Nonrepetitive) Forward Current, 1.5 Millisecond Duration	Surge (Nonrepetitive) Forward Current, 1.5 Millisecond Duration, Test	4.2.2.5
Thermal Fatigue	Thermal Fatigue Life Test	4.2.1.4
Surge (Nonrepetitive) Reverse Power, 40 Microseconds Duration	Triangular Pulse Nonrepetitive Reverse Power Test	4.2.2.6
Surge (Nonrepetitive) Reverse Power	Rectangular Pulse Nonrepetitive Power Test	4.2.2.8
Reverse (Nonrepetitive) Surges for Schottky Barrier Diodes	Nonrepetitive Reverse Energy, Power and Current Rating Test for Schottky Barrier Diodes	4.2.2.1
Peak Destructive Current and Fault Clearing Time	Destructive Current (Rupture) Rating Test for Disc Type and Stud- and Base-Mounted Rectifier Diodes	4.2.2.7

4.1 Introduction and reference table of ratings and test (cont'd)

NOTE 1 Operating Temperature Ratings cannot be established except in conjunction with other ratings. Operating Temperature Ratings are established by performing the tests in Section 4.2.1 Repetitive Ratings Tests, which are applicable to the device type.

NOTE 2 These tests are presented for information and use where applicable. It is not to be inferred that all diode(s) are required to meet all of the above tests.

NOTE 3 50 Hz may be substituted for 60 Hz where required.

4.2 Electrical tests

4.2.1 Repetitive ratings tests

4.2.1.1 Steady-state operating life test for diodes

A. Introduction

This test method is used to establish the maximum temperature, maximum voltage, and maximum current ratings for diodes.

B. Operating conditions

- 1) Power sources shall be 60 Hz sinusoidal waveform sources.
- 2) The test device shall be made to conduct rated average current registered at T_3 .
- 3) The conduction angle of the test current shall be 150° to 180° .
- 4) The test temperature shall be T_3 .
- 5) Rated half sine wave working peak reverse voltage shall be applied during alternate non-conducting half cycles starting no later than 5° after conduction has ceased.
- 6) The conduction angle of the reverse voltage waveform shall be $175^\circ \pm 5^\circ$.
- 7) A suggestion test circuit is shown in Figure 4.1.

C. The duration of the life test shall be 1,000 hours.

D. Post test measurements

All of the characteristics given in Section 4.4 that are indicated as being applicable to the device type shall be measured to establish the rating.

4.2.1 Repetitive ratings tests (cont'd)

4.2.1.1 Steady-state operating life test for diodes (cont'd)

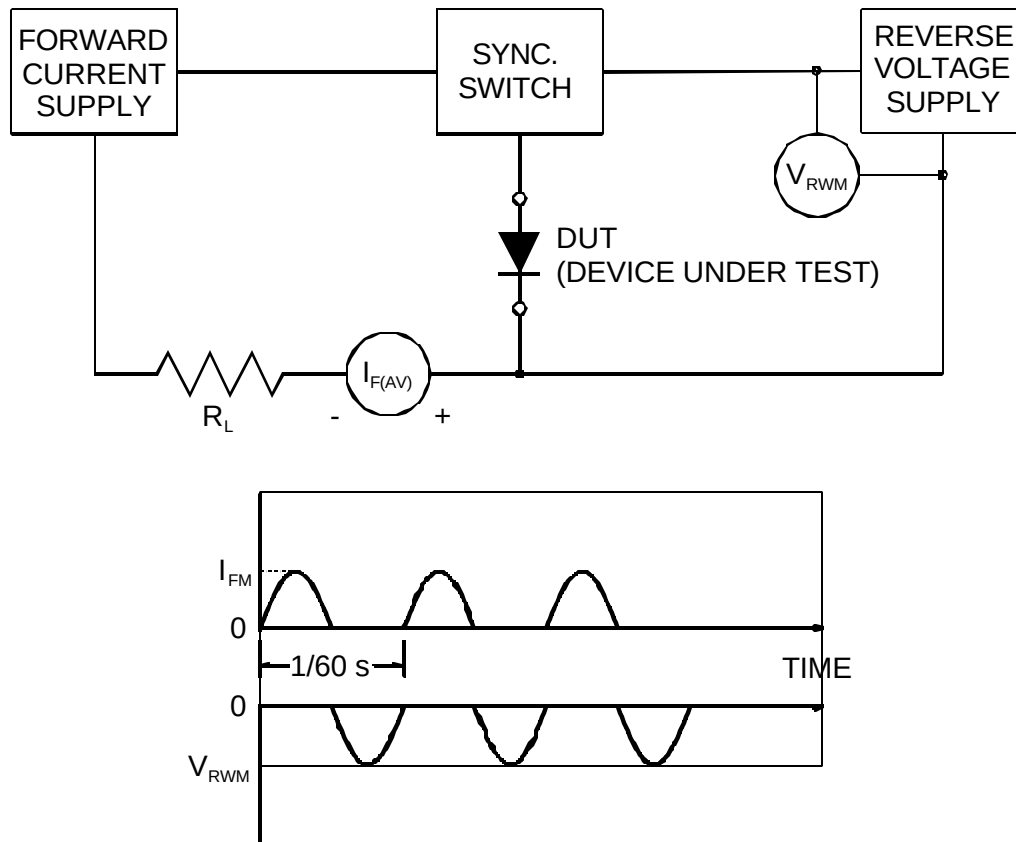


Figure 4.1 — Diode operating life test circuit and waveforms

4.2.1 Repetitive ratings tests (cont'd)

4.2.1.2 Working peak reverse voltage life test

A. Introduction

This test method is used to establish the half-sinewave working peak reverse voltage rating for a diode.

B. Operating conditions

- 1) The power source shall be a 60 Hz sinusoidal waveform source.
- 2) The test temperature shall be T_5 .
- 3) The test voltage shall be rated half-sinewave working peak reverse voltage.
- 4) Maximum thermal resistance from case to ambient shall be specified. (This requirement is to ensure thermal stability.)
- 5) A suggested test circuit is shown in Figure 4.2.

C. The duration of the life test shall be 1,000 hours.

D. Post test measurements

All of the characteristics given in Section 4.4 that are indicated as being applicable to the device type shall be measured to establish the rating.

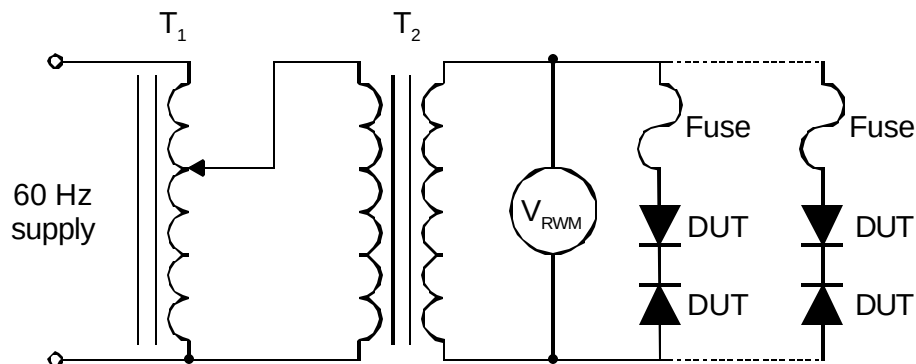


Figure 4.2 — Working peak reverse voltage life test

4.2.1 Repetitive ratings tests (cont'd)

4.2.1.3 DC reverse voltage life test

A. Introduction

This test method is used to establish the reverse voltage rating for a diode.

B. Operating conditions

- 1) The power source shall be dc with 1% maximum ripple.
- 2) The test temperature shall be T_5 .
- 3) The test voltage shall be the rated dc value.
- 4) Maximum thermal resistance from case to ambient shall be specified. (This requirement is to ensure thermal stability.)
- 5) A suggested test circuit is shown in Figure 4.3.

C. The duration of the life test shall be 1,000 hours.

D. Post test measurements

All of the characteristics given in Section 4.4 that are indicated as being applicable to the device type shall be measured to establish the rating.

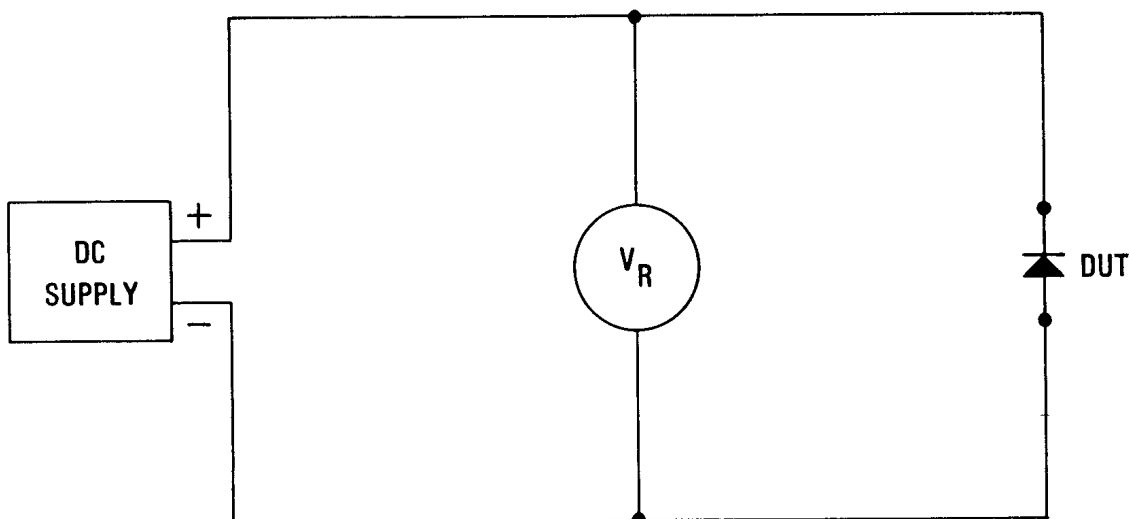


Figure 4.3 — DC reverse voltage life test

4.2.1 Repetitive ratings tests (cont'd)

4.2.1.4 Thermal fatigue life test

A. Introduction

This is a reference test method used to establish the ability of a diode to withstand the thermal cycling produced by alternately applying and removing forward current. Significant reverse voltages are not involved in the test, except as required by the ac heating current source operating into a very low resistance load. This test method applies to diodes whose temperature reference point is on the device case.

B. Operating conditions (See Figure 4.4)

- 1) The heating current source shall be a 60 Hz sinusoidal ac supply.
- 2) The heating current conduction angle shall be 150° to 180°.
- 3) The heating current magnitude shall be that value registered at temperature T_3 .
- 4) The case temperature reached at the end of the heating period shall be T_3 plus 10 °C, minus 0 °C.
- 5) The case temperature reached after the cooling period shall be 30 °C $\pm$ 10 °C.
- 6) The change in case temperature produced by the conditions specified in 4 and 5 must be 50 °C minimum. If this cannot be achieved using the heating current case temperature specified in 3, the current may be reduced (but not less than 50% of the registered value) so that the case temperature can be raised. Consult manufacturer's current rating curves.
- 7) The heating period shall be long enough to allow the case temperature to reach the value specified in paragraph 4 above.
- 8) The cooling period shall be long enough to allow the case temperature to reach the value specified in paragraph 5 above.
- 9) The total time for one heating-cooling cycle shall be a maximum of 10 minutes. (See Figure 4.4).
- 10) A suggested circuit for testing many devices at a time is shown in Figure 4.4. To obtain case temperature excursions within tolerance, the power dissipation and thermal resistance of the test devices may be matched or the thermal resistance of the heat dissipaters may be made adjustable.

C. Test duration

The duration of the test is to be specified as a number of complete thermal cycles.

D. Post test measurements

All of the characteristics given in section 4.4 that are indicated as being applicable to the device type in addition to thermal resistance shall be measured to establish the rating.