# IEEE Standard Letter Symbols for Semiconductor Devices

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# 1. ELECTRICAL QUANTITIES

#### 1.1 Quantity Symbols

1.1.1 Instantaneous values of current, voltage, and power, that vary with time, are represented by the lowercase letter of the proper symbol.

Examples: i, v, p

1.1.2 Maximum (peak), average (direct-current), and root-mean-square values of current, voltage, and power are represented by the upper-case letter of the appropriate symbol.

Examples: I, V, P

#### 1.2 Subscripts for Quantity Symbols

1.2.1 Direct-current values and instantaneous total values are indicated by upper-case subscripts.

Examples:  $i_{\rm C}$ ,  $I_{\rm C}$ ,  $v_{\rm EB}$ ,  $V_{\rm EB}$ ,  $p_{\rm C}$ ,  $P_{\rm C}$ 

1.2.2 Alternating-component values are indicated by lower-case subscripts.

Examples:  $i_{e}$ ,  $I_{e}$ ,  $v_{eb}$ ,  $V_{eb}$ ,  $p_{e}$ ,  $P_{e}$ 

1.2.3 To distinguish between maximum (peak), average, and root-mean-square values, maximum values are represented by the addition of a subscript M or m, and average by (AV).

Note: Where this distinction is not necessary, the additional subscript may be omitted.

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# Examples: $i_{cm}$ , $I_{cm}$ , $I_{CM}$ , $i_{C(AV)}$

1.2.4 Symbols to be used as subscripts. (For example, see Fig. 1 and Basic Symbols Chart 1.2.5.)

E. e = emitter terminal B, b = base terminal C, c = collector terminal J, j = terminal, general A, a = anode terminal K, k cathode terminal ~ G. g gate terminal ~ X, x = circuit node M, m = maximum value Min,  $\min = \min$  value (AV)= average value

1.2.5 A final subscript may be used to identify the termination of the port other than the one to which the quantity is referred:

- O = Open-circuit termination
- S = Short-circuit termination
- $\mathbf{X} = \mathbf{General termination}$

R = Resistive termination

V = Bias-Voltage termination.



Fig. 1-Illustration of proper symbol usage.

This subscript should be upper case if the other subscripts are upper case, and lower case if the other subscripts are are lower case.

Example:  $I_{CBO}$ ,  $I_{CES}$ ,  $V_{(BR)CER}$ 

1.2.6 Basic Symbols Chart (Table I)

TABLE	I
SYMBOL	s

		<i>i</i> , <i>v</i> , <i>p</i>	<i>I, V, P</i>
SUBSCRIPTS	e b c j a k g	Instantaneous Value of Alternating Component	Root-Mean-Square Value of Alternating Component With additional subscript m, Maximum (peak) Value of Alternating Component
	E B C J A K G	Instantaneous Total Value	Direct-current Value With additional subscript <i>M</i> , Maximum (Peak) Total Value With additional subscript (AV) Direct-current Value with Alternating Component

1.2.7 Examples of application of basic symbols chart.

- $I_{\rm E}$  = emitter direct-current (no alternating component)
- *I<sub>e</sub>* = root-mean-square value of alternating component of emitter current
- $i_{e}$  = instantaneous value of alternating compoent of emitter current

 $i_{\rm E}$  = instantaneous total value of emitter current

- $I_{E(AV)}$  = average of emitter current with alternating component
- $I_{\rm em}$  = maximum (peak) value of the alternating component of emitter current
- $I_{\rm EM}$  = maximum total (peak) value of the emitter current

# 1.3 The Subscript Sequence Conforms to the Mathematical Convention for Writing Determinants from a Set of Fundamental Kirchhoff's Equations

1.3.1 The first subscript designates the terminal at which the current is measured, or where the terminal potential is measured with respect to the reference terminal, or circuit node, designated by the second subscript. (Conventional current flow into the terminal from the external circuit is positive.) When the reference terminal or circuit node is understood, the second subscript may be omitted where its use is not required to preserve the meaning of the symbol.

1.3.2 Supply voltage may be indicated by repeating the terminal subscript. The reference terminal may then be designated by the third subscript.

Examples:  $V_{\text{EE}}$ ,  $V_{\text{CC}}$ ,  $V_{\text{BB}}$ ,  $V_{\text{EEB}}$ ,  $V_{\text{CCB}}$ ,  $V_{\text{BBC}}$ ,  $V_{\text{KK}}$ 1.3.3 In devices having more than one terminal of the same type, the terminal subscripts are modified by adding a number following the subscript and on the same line.

Example:  $V_{B1-B2}$ 

In multiple-unit devices, the terminal subscripts are modified by a number preceding the subscript.

# Example: V<sub>1B-2B</sub>

1.3.4 When necessary to distinguish between components of current or voltage, the symbols may be used as shown in Fig. 1. The illustration shows a case where a small alternating component is developed in the collector circuit of a transistor.

# 2. Electrical Parameters

## 2.1 Parameter Symbols

2.1.1 Value of four-pole matrix parameters, or other resistances, impedances, admittances, etc., inherent in the device, may be represented by the lower-case symbol with the proper subscripts.

Examples: h<sub>11b</sub>, z<sub>21b</sub>, y<sub>21b</sub>, h<sub>11B</sub>, h<sub>21e</sub>

2.1.2 The four-pole matrix parameters of external circuits and of circuits in which the device forms only a part shall be represented by upper-case symbols with appropriate subscripts.

Examples: H<sub>11</sub>, Z<sub>22</sub>, Y<sub>21</sub>, Y<sub>12</sub>

#### 2.2 Subscript for Parameter Symbols

2.2.1 Static<sup>1</sup> values of parameters are indicated by the upper-case subscript.

Examples: h<sub>11B</sub>, Z<sub>21B</sub>, y<sub>22C</sub>

2.2.2 Small-signal values of parameters are indicated by the lower-case subscript.

Examples: h<sub>11b</sub>, z<sub>21b</sub>, y<sub>22c</sub>

2.2.3 The first subscript or subscript pair, in matrix notation, identifies the element of the four-pole matrix.

11	or i	=	input
22	or o	R	output

- 21 or f = forward transfer
- 12 or r = reverse transfer

Examples:  $V_1 = h_{11}I_1 + h_{12}V_2$   $V_i = h_iI_i + h_rV_o$  $I_2 = h_{21}I_1 + h_{22}V_2$   $I_o = h_fI_i + h_oV_o$ 

- Note 1) Voltage and current symbols in matrix notations are designated with a single-digit subscript 1 = input and subscript 2 = output.
- Note 2) The quantities and parameters in these equations may be complex.

2.2.4 The subscript following the numeric pair identifies the circuit configuration. When the common terminal is understood, it may be omitted.

<sup>1</sup> The static value is the slope of the line from the origin to the operating point on the appropriate characteristic curve, *i.e.*, the quotient of the appropriate electrical quantities at the operating point.

August

- e = emitter terminal, common
- b = base terminal, common
- c = collector terminal, common
- j = general terminal, common
- a = anode terminal, common
- k = cathode terminal, common
- g = gate terminal, common

Examples: (common-base transistor)

$$I_{1} = y_{11b}V_{1b} + y_{12b}V_{2b} \qquad I_{i} = y_{ib}V_{ib} + y_{rb}V_{ob}$$
$$I_{2} = y_{21b}V_{1b} + y_{22b}V_{2b} \qquad I_{o} = y_{fb}V_{ib} + y_{ob}V_{ob}$$

2.2.5 The subscript "o" or "s" following the subscript identifying circuit configuration for a two-port parameter identifies the termination of the port opposite from the one to which the parameter is referred:

- o = opposite port open-circuited
- s = opposite port short-circuited.

This subscript should be upper case if the other subscripts are upper case and should be lower case if the other subscripts are lower case.

Example:  $C_{11bs}$ ,  $C_{oeo}$ 

## 3. LETTER SYMBOLS IN ALPHABETICAL ORDER

The following list has been compiled according to the conventions set forth in Sections 1 and 2 of this Standard. In many of the symbols that follow only the direct-current versions are listed, *e.g.*,  $I_{CBO}$ . Other symbols are easily generated by application of the rules of Sections 1 and 2.

 $C_{11s}$ ,  $C_{11bs}$ ,  $C_{11cs}$ ,  $C_{11es}$ ,  $C_{ibs}$ ,  $C_{ies}$ ,  $C_{ies}$ —The capacitance measured across the input terminals with the output terminals short-circuited to alternating current.

Note: The use of the upper-case symbol is an exception to the rules set forth in Section 2.1.1.

 $C_{22o}$ ,  $C_{22bo}$ ,  $C_{22co}$ ,  $C_{22co}$ ,  $C_{obo}$ ,  $C_{oco}$ ,  $C_{oco}$ —The capacitance measured across the output terminals with the input opencircuited to alternating current.

Note: The use of the upper-case symbol is an exception to the rules set forth in Section 2.1.1.

 $f_{h21b}$ ,  $f_{h21e}$ ,  $f_{h21e}$ —The lowest frequency at which the magnitude of the parameter indicated by the subscript is 0.707 of its low-frequency value.

*Note:* The use of the symbol  $f_{\alpha}$  is not recommended.

 $f_{max}$ —The maximum frequency of oscillation of the device.

 $f_1$ —The frequency at which the modulus of the commonemitter small-signal short-circuit forward current transfer ratio,  $|h_{21e}|$ , has decreased to unity.

 $f_{\rm T}$ —The product of the modulus of the common-emitter small-signal short-circuit forward current transfer ratio,  $|{\rm h}_{21e}|$ , multiplied by the frequency of measurement when this latter is sufficiently high so that the modulus of  ${\rm h}_{21e}$  is decreasing with a slope approximately 6 decibels per octave. *Note:* This is the frequency at which the modulus of  $h_{21e}$  is extrapolated to unity.

 $h_{21B}$ ,  $h_{21E}$ ,  $h_{21C}$ ,  $h_{FB}$ ,  $h_{FE}$ ,  $h_{FC}$ —The static value of the short-circuit forward current transfer ratio.

Note: Use of the symbols  $\alpha_{FB}$ ,  $\alpha_{FC}$ ,  $\alpha_{FE}$  is not recommended.

 $h_{21b}$ ,  $h_{21e}$ ,  $h_{21e}$ ,  $h_{fb}$ ,  $h_{fe}$ ,  $h_{fe}$ --The small-signal short-circuit forward current transfer ratio.

Note: Use of the symbols  $\alpha_{fb}$ ,  $\alpha_{fc}$ ,  $\alpha_{fc}$  is not recommended.

 $h_{11B}$ ,  $h_{11E}$ ,  $h_{11C}$ ,  $h_{IB}$ ,  $h_{IE}$ ,  $h_{IC}$ —The static value of the short-circuit input resistance.

 $h_{11b}$ ,  $h_{11e}$ ,  $h_{11e}$ ,  $h_{ib}$ ,  $h_{ie}$ ,  $h_{ie}$ —The small-signal value of the short-circuit input impedance.

 $h_{22B}$ ,  $h_{22E}$ ,  $h_{22C}$ ,  $h_{OB}$ ,  $h_{OE}$ ,  $h_{OC}$ —The static value of the open-circuit output conductance.

 $h_{22b}$ ,  $h_{22e}$ ,  $h_{22e}$ ,  $h_{ob}$ ,  $h_{oe}$ ,  $h_{oe}$ —The small-signal value of the open-circuit output admittance.

 $h_{12B}$ ,  $h_{12E}$ ,  $h_{12C}$ ,  $h_{RB}$ ,  $h_{RE}$ ,  $h_{RC}$ —The static value of the open-circuit reverse voltage transfer ratio.

 $h_{12b}, h_{12e}, h_{12e}, h_{rb}, h_{re}, h_{re}$ —The small-signal value of the open-circuit reverse voltage transfer ratio.

 $\operatorname{Re}(h_{11b})$ ,  $\operatorname{Re}(h_{21b})$ ,  $\operatorname{Re}(h_{22b})$ —Real part of the small-signal value of the parameter within the parenthesis.

Im $(h_{11b})$ , Im $(h_{21b})$ , Im $(h_{22b})$ —-Imaginary part of the small-signal value of the parameter within the parenthesis.

 $I_{\rm FO}$ ,  $I_{\rm RO}$ —The current through the collector junction in a PNPN-type switch when the switch is in the forward (reverse) blocking state and the gate terminal, if any, is open-circuited.

 $I_{AGO}$ ,  $I_{GAO}$ ,  $I_{GKO}$ ,  $I_{CBO}$ ,  $I_{CBO}$ ,  $I_{CEO}$ ,  $I_{EBO}$ ,  $I_{ECO}$ ,  $I_{BEO}$ ,  $I_{BCO}$ —The current into the terminal indicated by the first subscript when it is biased in the reverse direction with respect to the reference terminal and the other terminal is open-circuited.

 $I_{\rm FS}$ ,  $I_{\rm RS}$ —The current through the collector junction in a PNPN-type switch when it is in the forward (reverse) blocking state and the gate terminal is short-circuited to the terminal of the adjacent region.

 $I_{AGS}$ ,  $I_{GKSG}$ ,  $I_{KGS}$ ,  $I_{GASG}$ ,  $I_{CBS}$ ,  $I_{CES}$ ,  $I_{EBS}$ ,  $I_{ECS}$ ,  $I_{BES}$ ,  $I_{BCS}$ —The current into the terminal indicated by the first subscript when it is biased in the reverse direction with respect to the reference terminal and the other terminal is short-circuited to the terminal indicated by the subscript following the subscript S.

Note: When the last subscript is omitted, the other terminal is short-circuited to the reference terminal.

 $I_{FX}$ ,  $I_{RX}$ —The current through the collector junction in a PNPN-type switch when the switch is in the forward (reverse) blocking state and the gate terminal is returned to the terminal of the adjacent region through a stated impedance and/or bias voltage. Note: When the return is through a resistance, the subscript "X" should be replaced by the subscript "R." When the return is through a stated bias voltage, the subscript "X" should be replaced by the subscript "V."

 $I_{AGX}$ ,  $I_{GKXG}$ ,  $I_{KGX}$ ,  $I_{GAXG}$ ,  $I_{CBX}$ ,  $I_{CEX}$ ,  $I_{EDX}$ ,  $I_{ECX}$ ,  $I_{BEX}$ ,  $I_{BCX}$ —The current into the terminal indicated by the first subscript when it is biased in the reverse direction with respect to the reference terminal and the other terminal is returned to the terminal indicated by the subscript following the subscript "X" through a stated impedance and/or bias voltage.

Note: When the last subscript is omitted, the other terminal is returned to the reference terminal. When the return is through a resistance, the subscript "X" should be replaced by the subscript "R." When the return is through a stated bias voltage, the subscript "X" should be replaced by the subscript "V."

 $I_{(BR)}$ —The current through a diode at breakdown voltage.

 $I_{(BR)FO}$ ,  $I_{(BR)RO}$ —The current through the collector junction in a PNPN-type switch at forward breakover (reverse breakdown) voltage when the gate terminal, if any, is open-circuited.

 $I_{(BR)AGO}$ ,  $I_{(BR)GAO}$ ,  $I_{(BR)GKO}$ ,  $I_{(BR)KGO}$ ,  $I_{(BR)CEO}$ ,  $I_{(BR)CEO}$ ,  $I_{(BR)EBO}$ ,  $I_{(BR)ECO}$ ,  $I_{(BR)BEO}$ ,  $I_{(BR)BCO}$ . The current into the terminal indicated by the first subscript when it is biased at the breakdown (breakover) voltage with respect to the reference terminal and the other terminal is open-circuited.

 $I_{(BR)FS}$ ,  $I_{(BR)RS}$ —The current through the collector junction in a PNPN type switch at forward breakover (reverse breakdown) voltage when the gate terminal is short-circuited to the terminal of the adjacent region.

 $I_{(BR)AGS}$ ,  $I_{(BR)GKSG}$ ,  $I_{(BR)KGS}$ ,  $I_{(BR)GASG}$ ,  $I_{(BR)CBS}$ ,  $I_{(BR)CES}$ ,  $I_{(BR)EBS}$ ,  $I_{(BR)ECS}$ ,  $I_{(BR)BES}$ ,  $I_{(BR)BCS}$ —The current into the terminal indicated by the first subscript when it is biased at the breakdown voltage with respect to the reference terminal and the other terminal is shortcircuited to the terminal indicated by the subscript following the subscript S.

Note: When the last subscript is omitted, the other terminal is short-circuited to the reference terminal.

 $I_{(BR)FX}$ ,  $I_{(BR)RX}$ —The current through the collector junction in a PNPN-type switch at forward breakover (reverse breakdown) voltage when the gate terminal is returned to the terminal of the adjacent region through a stated impedance and/or bias voltage.

Note: When the return is through a resistance, the subscript "X" should be replaced by the subscript "R." When the return is through a stated bias voltage, the subscript "X" should be replaced by the subscript "V."  $I_{(BR)AGX}$ ,  $I_{(BR)GKXG}$ ,  $I_{(BR)KGX}$ ,  $I_{(BR)GAXG}$ ,  $I_{(BR)CBX}$ ,  $I_{(BR)CEX}$ ,  $I_{(BR)EBX}$ ,  $I_{(BR)ECX}$ ,  $I_{(BR)BEX}$ ,  $I_{(BR)BCX}$ . The current into the terminal indicated by the first subscript when it is biased at the breakdown voltage with respect to the reference terminal and the other terminal is returned to the terminal indicated by the subscript following the subscript "X" through a stated impedance and/or bias voltage.

Note: When the last subscript is omitted, the other terminal is returned to the reference terminal. When the return is through a resistance, the subscript "X" should be replaced by the subscript "R." When the return is through a stated bias voltage, the subscript "X" should be replaced by the subscript "V."

 $I_{\rm F}$ —The forward current of a diode or the current through the collector junction of a PNPN-type switch when the switch is in the on state.

- Note: If necessary to specify terminal currents in a PNPN-type switch when the switch is in the on state, the symbols  $I_{AF}$ ,  $I_{KF}$  shall be used.
- $I_{GF}$ —The forward gate current in a PNPN-type switch.
- $I_{GQ}$ —The gate turn-off current in a PNPN-type switch.
- $I_{\rm GR}$ —The reverse gate current in a PNPN-type switch.
- $I_{GT}$ —The gate trigger current in a PNPN-type switch.

 $I_{\rm H}$  —The holding current in a PNPN-type switch.

*Note:* If necessary to state gate conditions, the appropriate additional subscript shall be used.

 $I_{\rm R}$ —Reverse current of a diode.

M—The multiplication factor which is equal to the ratio of the total current through a reverse biased junction to the minority carrier current arriving at the junction.

 $r_{\text{CEsat}}$ ,  $r_{\text{BEsat}}$ ,  $r_{\text{CBsat}}$ ,  $r_{\text{AGsat}}$ ,  $r_{\text{AKsat}}$ ,  $r_{\text{KGsat}}$ —The saturation resistance is the resistance between the terminal indicated by the first subscript and the reference terminal for the saturation conditions stated.

- $T_{\rm A}$ —Ambient temperature
- $T_{\rm c}$ —Case temperature
- $T_{J}$ —Junction temperature

 $t_d$ —The delay time is the time interval between the application of an input pulse and the time when the resulting minority carrier generated output pulse attains 10 per cent of its maximum amplitude.

 $t_{\rm f}$ —The fall time, which is the time interval (following the storage time) during which the output pulse decays to 10 per cent of the constant value that existed during the storage interval.

 $t_{\rm fr}$ —The forward recovery time of a semiconductor device.

 $t_r$ —The rise time, which is the time interval during which the output pulse increases from 10 per cent to 90 per cent of its maximum amplitude.

 $t_{\rm rr}$ —The reverse recovery time of a semiconductor device.

 $t_s$ —The storage time, which is the time interval between the application of a turnoff pulse and the time when the resulting output pulse decays to 90 per cent of its amplitude.

 $V_{\rm FO}$ ,  $V_{\rm RO}$ —The voltage between the anode and cathode terminals of a PNPN-type switch for a given current through the collector junction when the switch is in the forward (reverse) blocking state and the gate terminal, if any, is open-circuited.

 $V_{\rm FS}$ ,  $V_{\rm RS}$ —The voltage between the anode and cathode terminals of a PNPN-type switch for a given current through the collector junction when the switch is in the forward (reverse) blocking state and the gate terminal is short-circuited to the terminal of the adjacent region.

 $V_{\rm Fx}$ ,  $V_{\rm Rx}$ —The voltage between the anode and cathode terminals of a PNPN-type switch for a given current through the collector junction when the switch is in the forward (reverse) blocking state and the gate terminal is returned to the terminal of the adjacent region through a stated impedance and/or bias voltage.

Note: When the return is through a resistance, the subscript "X" should be replaced by the subscript "R." When the return is through a stated bias voltage, the subscript "X" should be replaced by the subscript "V."

 $V_{(BR)}$ —The breakdown voltage of a diode.

 $V_{(BR)FO}$ ,  $V_{(BR)RO}$ —The forward breakover (reverse breakdown) voltage in a PNPN-type switch between the anode and cathode terminals when the gate terminal, if any, is open-circuited.

 $V_{(BR)AGO}$ ,  $V_{(BR)GAO}$ ,  $V_{(BR)GKO}$ ,  $V_{(BR)KGO}$ ,  $V_{(BR)CBO}$ ,  $V_{(BR)CEO}$ ,  $V_{(BR)EEO}$ ,  $V_{(BR)ECO}$ ,  $V_{(BR)BEO}$ ,  $V_{(BR)BCO}$ —The breakdown (breakover) voltage between the terminals indicated by the subscripts when the terminal indicated by the first subscript is biased in the reverse direction with respect to the reference terminal and the other terminal is open-circuited.

*Note:* The abbreviation BV is in common use for this quantity.

 $V_{(BR)FS}$ ,  $V_{(BR)RS}$ —The forward breakover (reverse breakdown) voltage in a PNPN-type switch between the anode and cathode terminals when the gate terminal is short-circuited to the terminal of the adjacent region.

 $V_{(BR)AGS}$ ,  $V_{(BR)GKSG}$ ,  $V_{(BR)KGS}$ ,  $V_{(BR)GASG}$ ,  $V_{(BR)CBS}$ ,  $V_{(BR)CES}$ ,  $V_{(BR)EBS}$ ,  $V_{(BR)ECS}$ ,  $V_{(BR)BES}$ ,  $V_{(BR)BCS}$ —The breakdown (breakover) voltage between the terminals indicated by the subscripts when the terminal indicated by the first subscript is biased in the reverse direction with respect to the reference terminal and the other terminal is short-circuited to the terminal indicated by the subscript following the subscript S.

- Note 1) When the last subscript is omitted, the other terminal is short-circuited to the reference terminal.
- Note 2) The abbreviation BV is in common use for this quantity.

 $V_{(BR)FX}$ ,  $V_{(BR)RX}$ —The forward breakover (reverse breakdown) voltage in a PNPN-type switch between the anode and cathode terminals when the gate terminal is returned to the terminal of the adjacent region through a stated impedance and/or bias voltage.

Note: When the return is through a resistance, the subscript "X" should be replaced by the subscript "R." When the return is through a stated bias voltage, the subscript "X" should be replaced by the subscript "V."

 $V_{(BR)AGX}$ ,  $V_{(BE)GKXG}$ ,  $V_{(BR)KGX}$ ,  $V_{(BR)GAXG}$ ,  $V_{(BE)CEX}$ ,  $V_{(BR)CEX}$ ,  $V_{(BR)EEX}$ ,  $V_{(BR)ECX}$ ,  $V_{(BR)BEX}$ ,  $V_{(BR)BCX}$ —The breakdown (breakover) voltage between the terminals indicated by the subscripts when the terminal indicated by the first subscript is biased in the reverse direction with respect to the reference terminal and the other terminal is returned to the terminal indicated by the subscript following the subscript "X" through a stated impedance and/or bias voltage.

- Note 1) When the last subscript is omitted, the other terminal is returned to the reference terminal.
- Note 2) The abbreviation BV is in common use for this quantity.
- Note 3) When the return is through a resistance, the subscript "X" should be replaced by the subscript "R." When the return is through a stated bias voltage, the subscript "X" should be replaced by the subscript "V."

 $V_{\text{CB}(f1)}, V_{\text{CE}(f1)}, V_{\text{EB}(f1)}, V_{\text{EC}(f1)}, V_{\text{BC}(f1)}, V_{\text{BC}(f1)}$ —The direct-current open-circuit voltage (floating potential) between the terminal indicated by the first subscript and the reference terminal when the other terminal is biased in the reverse direction with respect to the reference terminal.

 $V_{\text{CEsat}}$ —The direct-current voltage between the collector and the emitter terminals for stated saturation conditions.

 $V_{\rm F}$ —Forward voltage of a diode or the anode-to-cathode voltage of a PNPN-type switch when the switch is in the on state.

 $V_{GF}$ —The forward gate voltage in a PNPN-type switch.

 $V_{\rm GR}$ —The reverse gate voltage in a PNPN-type switch.

 $V_{GT}$ —The gate trigger voltage in a PNPN-type switch.

 $V_{\rm GQ}$ —The gate turn-off voltage in a PNPN-type switch.

 $V_{\rm R}$  —Reverse voltage of a diode.

 $V_{(\rm RT)}$ —The reach-through voltage (sometimes referred to as "punch-through" voltage) is that value of reverse voltage at which the space charge region of the collectorbase junction extends to the space-charge region of the emitter-base junction.

# Acknowledgment

The Institute wishes to acknowledge its indebtedness to those who have so freely given of their time and knowledge and have conducted experimental work on which many of the IEEE publications are based.

This publication was prepared jointly by Task Group 28.4.12 of the Semiconductor Devices Subcommittee of the IRE Solid-State Devices Committee, the IRE Symbols Committee, and the Rectifier Device Working Group of the Component Subcommittee of the AIEE Semiconductor Rectifiers Committee.

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