TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS FOR DISCRETE NON-MICROWAVE SEMICONDUCTOR DEVICES

ESCC Basic Specification No. 2135000

Issue 2	March 2014

Document Custodian: European Space Agency – see https://escies.org

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DCR No.	CHANGE DESCRIPTION
838	Specification upissued to incorporate editorial changes per DCR.

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1 SCOPE

This specification forms part of ESCC Basic Specification No. 21300, Terms, Definitions, Abbreviations, Symbols and Units, and covers discrete non-microwave semiconductor devices.

2 TERMS, DEFINITIONS AND ABBREVIATIONS

2.1 DIODES

2.1.1 Low Power Switching Diodes

Voltages	
Forward Continuous (Direct) Voltage (V_F)	Forward voltage is the voltage drop which results from the flow of forward current through the semiconductor diode.
Instantaneous Total Forward Voltage (V_F)	
Average Forward Voltage ($V_{F(AV)}$)	
Reverse Continuous (Direct) Voltage (V_R)	Reverse voltage is the voltage drop which results from the flow of reverse current through the semiconductor diode.
Instantaneous Total Reverse Voltage (V_R)	
Peak Reverse Voltage (V_{RM})	
Surge Reverse Voltage (V_{RSM})	
Breakdown Voltage ($V_{(BR)}$)	The breakdown voltage is the voltage measured at a specified current in the breakdown region.

Currents	
Forward Continuous (Direct) Current (I_F)	Forward current is the current flowing through the diode in the direction of lower resistance to the flow of steady direct current.
Instantaneous Forward Current (i_F)	
Peak Forward Current (F_M)	
Surge Forward Current (I_{FSM})	The surge current is the maximum current pulse which can be carried by the semiconductor or diode for the length of time, repetition frequency and waveform specified.
Average Output Rectified Current (I_O)	
Reverse Continuous (Direct) Current (I_R)	The reverse current is the current flowing through the diode in the direction of higher resistance to steady direct current when a specified reverse voltage is applied.
Instantaneous Reverse Current (i_R)	

Currents (Continued)
Peak Reverse Current (I_{RM})

Power
Surge Non-repetitive Power (I_{PSM})

Switching Parameters	
Forward Recovery Time (t_{frcc})	The forward recovery time is the time required for the current or voltage to reach a specified condition after instantaneous switching from 0 or a specified reverse voltage to a specified forward biased condition.
Reverse Recovery Time (t_{rr})	The reverse recovery time is the time required for the current or voltage to reach a specified condition after instantaneous switching from a specified forward current to a specified reverse biased condition.
Reverse Recovery Current (i_{rr})	
Recovered Charge (Stored Charge) (Q_s)	

Sundry Quantities
Differential Resistance (r)
Damping Coefficient (δ or d)
Damping Resistance (r_δ or r_d)
Efficiency (η)
Rectification Efficiency (η_r)

2.1.2 Tunnel Diodes

Currents	
Peak Point Current (I_p)	
Valley Point Current (I_v)	Valley current is the current measured at the positive voltage at which the current has reached a minimum value from which it will increase if the voltage is increased further.
Peak-to-Valley Point Current Ratio (I_p/I_v)	
Reverse Continuous (Direct) Current (I_R)	

Voltages	
Peak Point Voltage (V_P)	Peak point voltage is the voltage at which peak point current occurs.
Valley Point Voltage (V_V)	Valley voltage is the voltage at which valley current occurs.
Projected Peak Point Voltage (V_{pp})	
Reverse Continuous (Direct) Voltage (V_R)	

2.1.3 Rectifier Diodes

Voltages	
Continuous (Direct) Forward Voltage (V_f)	Forward voltage is the voltage drop which results from the flow of forward current through the semiconductor diode.
Crest (Peak) Forward Voltage (V_{FM})	
Average Forward Voltage ($V_{F(AV)}$)	With I_O specified.
Continuous (Direct) Reverse Voltage (V_R)	
Crest (Peak) Working Reverse Voltage (V_{RWM})	
Repetitive Peak Reverse Voltage (V_{RRM})	Maximum recurrent reverse voltage.
Non-repetitive Peak Reverse Voltage (V_{RSM})	Peak transient reverse voltage.
Breakdown Voltage ($V_{(BR)}$)	
Threshold Voltage (V_{TO})	

Currents	
Continuous (Direct) Forward Current (I_F)	
Repetitive Peak Forward Current (I_{FRM})	
Overload Forward Current ($I_{(OV)}$)	
Surge (Non-repetitive) Forward Current (I_{FSM})	The surge current is the maximum current pulse which can be carried by the semiconductor diode for the length of time, repetition frequency and waveform specified.
Average Output Rectified Current (I_O)	
Continuous (Direct) Reverse Current (I_R)	
Average Reverse Current ($I_{R(AV)}$)	With I_O specified.

Sundry Quantities
Slope Resistance (r_T)

2.1.4 Voltage Reference

Voltage Regulator Diode Current near Breakdown Knee (I_K)
Voltage Regulator Diode Current (I_Z)
Voltage Regulator Impedance near Breakdown Knee (Z_K)

2.2 THYRISTORS

Principal Voltages - Anode-Cathode Voltages	
Continuous (Direct) Off-state Voltage (V_D)	The off-state is the condition of the device corresponding to the portion of the anode-cathode voltage current characteristic for forward currents less than the forward break-over current.
Peak Off-state Voltage (V_{DM})	
Crest (Peak) Working Off-state Voltage (V_{DWM})	
Repetitive Peak Off-state Voltage (V_{DRM})	
Non-repetitive Peak Off-state Voltage (V_{DSM})	
Break-over Continuous (Direct) Voltage ($V_{(BO)}$)	The forward break-over voltage is the maximum positive voltage from anode to cathode for which the small signal is 0 for a specified gate current.
Continuous (Direct) On-state Voltage (V_T)	
Minimum On-state Voltage (V_{TMIN})	
On-state Threshold Voltage ($V_{T(TO)}$)	
Continuous (Direct) Reverse Voltage (V_R))	
Crest (Peak) Working Reverse Voltage (V_{RWM})	The working peak reverse voltage is the maximum instantaneous value of the reverse voltage, excluding all repetitive and non-repetitive transient voltages which occur across the device.
Repetitive Peak Reverse Voltage (V_{RRM})	The repetitive peak reverse voltage is the maximum instantaneous value of the reverse voltage, including all repetitive transient voltages, but excluding all non-repetitive transient voltages which occur across the device.
Non-repetitive Peak Reverse Voltage (V_{RSM})	The non-repetitive peak reverse voltage is the maximum instantaneous value of the reverse voltage, including all non-repetitive transient voltages, but excluding all repetitive transient voltages which occur across the device.

Principal Voltages - Anode-Cathode Voltages (Continued)	
Reverse Breakdown Voltage ($V_{(BR)}$)	The reverse breakdown voltage is the value of negative value from anode to cathode at which a transition commences from a region of high small signal resistance to a region of substantially lower small signal resistance between the anode and the cathode

Principal Currents - Anode-Cathode Currents	
Continuous (Direct) Off-state Current (I_D)	
Continuous (Direct) Break-over Current ($I_{(BO)}$)	The forward break-over current is the current through the device at forward break-over voltage.
Continuous (Direct) Holding Current (I_H)	The holding current is the minimum current through the anode required to maintain the device in the on-state for specified gate conditions and load.
Continuous (Direct) On-state Current (I_T)	The on-state is the condition of the device corresponding to the low impedance low voltage portion of the anode to cathode voltage current characteristic for positive anode to cathode voltage.
Overload On-state Current ($I_{(OV)}$)	
Repetitive Peak On-state Current (I_{TRM})	
Surge (Non-repetitive) On-state Current (I_{TSM})	
Continuous (Direct) Reverse Blocking Current (I_R)	
Repetitive Peak Reverse Current (I_{RRM})	

Gate Voltages (The gate voltage is the voltage between the gate and the terminal of the adjacent region)	
Forward Gate Continuous (Direct) Voltage (V_{FG})	
Peak Forward Gate Voltage (V_{FGM})	
Reverse Gate Continuous (Direct) Voltage (V_{RG})	
Peak Reverse Gate Voltage (V_{RGM})	
Gate Trigger Continuous (Direct) Voltage (V_{GT})	The gate trigger voltage is the voltage between the gate and the terminal of the adjacent region required to produce the gate trigger current.
Minimum Gate Trigger Voltage (V_{GTMIN})	
Gate Non-trigger Continuous (Direct) Voltage (V_{GD})	
Gate Turn-off Continuous (Direct) Voltage (V_{GQ})	The gate turn-off voltage is the voltage between the gate and the terminal of the adjacent region required to produce the gate turn-off current.

Gate Currents (The gate current is the current through the gate).	
Forward Gate Continuous (Direct) Current (I_{FG})	
Peak Forward Gate Current (I_{FGM})	
Reverse Gate Continuous (Direct) Current (I_{RG})	
Gate Trigger Continuous (Direct) Current (I_{GT})	The gate trigger current is the minimum gate current required to cause switching from the off-state to the on-state for a stated anode to cathode voltage.
Gate Non-trigger Continuous (Direct) Current (I_{GD})	
Gate Turn-off Continuous (Direct) Current (I_{GQ})	The gate turn-off current is the minimum gate current required to cause switching from the on-state to the off-state for a stated anode current in the on-state.

Time Quantities	
Gate-controlled Turn-on Time (t_{gt})	
Gate-controlled Turn-off Time (t_{gq})	
Circuit-commutated Recovery Time (t_q)	Circuit-commutated turn-off time.

Sundry Quantities
On-state Slope Resistance (rT)

2.3 TRANSISTORS

Voltages	
Collector-Base (DC) Voltage (V_{CB})	
Collector-Emitter (DC) Voltage (V_{CE})	
Emitter-Base (DC) Voltage (V_{EB})	
Base-Emitter (DC) Voltage (V_{BE})	
Collector-Base (DC) Voltage (V_{CBO})	With $I_E = 0$; I_C specified.
Emitter-Base (DC) Voltage (V_{EBO})	With $I_C = 0$; I_E specified.
Collector-Emitter (DC) Voltage (V_{CEO})	With $I_B = 0$; I_C specified.
Collector-Emitter (DC) Voltage (V_{CER})	With $R_{BE} = R$; I_C specified.
Collector-Emitter (DC) Voltage (V_{CES})	With $V_{BE} = 0$; I_C specified.
Collector-Emitter (DC) Voltage (V_{CEX})	With $V_{BE} = X$ specified (reverse biased Emitter-Base); I_C specified.

Voltages (Continued)	
Floating Voltage, Emitter-Base (V_{EBfi})	With $I_E = 0$; V_{CB} specified. A floating potential is the DC voltage between an open-circuited terminal and the reference point when a DC voltage is applied to the other terminals as specified.
Punch-through (Penetration) Voltage (V_{pt})	
Saturation Voltage, Collector-Emitter (V_{CEsat})	With I_B specified; I_C specified. The saturation voltage is the DC voltage between the measurement electrode and the reference electrode for specified saturation conditions.
Saturation Voltage, Base-Emitter (V_{BEsat})	With I_B specified; I_C specified.

Breakdown Voltages (Open Circuit) (The abbreviation BV is in common use for these quantities) (Breakdown voltage is the voltage measured at a specified current in the breakdown region)	
Breakdown Voltage, Collector-Base ($V_{(BR)CBO}$)	With $I_E = 0$; I_C specified.
Breakdown Voltage, Emitter-Base ($V_{(BR)EBO}$)	With $I_C = 0$; I_C specified.
Breakdown Voltage, Collector-Emitter ($V_{(BR)CEO}$)	With $I_B = 0$; I_C specified.

Breakdown Voltages (Specified Circuit) (The abbreviation BV is in common use for these quantities) (Breakdown voltage is the voltage measured at a specified current in the breakdown region)	
Breakdown Voltage, Collector-Emitter ($V_{(BR)CER}$)	With $R_{BE} = R$; I_C specified.
Breakdown Voltage, Collector-Emitter ($V_{(BR)CEX}$)	With $R_{BE} = X$; I_C specified.

Breakdown Voltage (Short Circuit) (The abbreviation BV is in common use for this quantity) (Breakdown voltage is the voltage measured at a specified current in the breakdown region)	
Breakdown Voltage, Collector-Emitter ($V_{(BR)CES}$)	With $V_{BE} = 0$; I_C specified.

Currents
Base (DC) Current (I_B)
Collector (DC) Current (I_C)

Currents (Continued)	
Emitter (DC) current (I_E)	
Collector Cut-off Current (I_{CBO})	With $I_E = 0$; V_{CB} specified.
Collector Cut-off Current (I_{CEO})	With $I_B = 0$; V_{CE} specified.
Emitter Cut-off Current (I_{EBO})	With $I_C = 0$; V_{EB} specified.
Collector Cut-off Current (I_{CER})	With $R_{BE} = R$; V_{CE} specified.
Collector Cut-off Current (I_{CES})	With $V_{BE} = 0$; V_{CE} specified.
Collector Cut-off Current (I_{CEX})	With $V_{BE} = X$; V_{CE} specified.
Base Cut-off Current (I_{BEX})	With $V_{BE} = X$; V_{CE} specified.

Powers	
Collector Power Dissipation (P_C)	With T_{amb} or T_{case} specified.
Total Input Power (DC or average) to all Electrodes (P_{tot})	With T_{amb} or T_{case} specified.

Electrical Parameters - Static Parameters (Specified for bias conditions)	
Static Value of the Forward Current Transfer Ratio:	Static forward current transfer ratio is the ratio of the DC output current to the DC input current under specified test conditions.
In Common Emitter Configuration (h_{21E} or h_{FE})	$h_{21E} = \frac{IC}{IB} = \frac{IE}{IB}$ -1 with V_{CE} = constant.

Electrical Parameters - Small Signal Parameters (Specified for bias and frequency conditions)	
Small signal value of the Open-Circuit Reverse Voltage Transfer Ratio:	Small signal open-circuit reverse voltage transfer ratio is the ratio of the AC input voltage to the AC output voltage, with 0 AC input current.
In Common Emitter configuration (h_{12e} or h_{re})	$h_{12e} = \frac{Vbe}{Vce}$ with I_b = constant.
In Common Base configuration (h_{12b} or h_{rb})	$h_{12b} = \frac{Veb}{Vcb}$ with I_e = constant.

Electrical Parameters - Small Signal Parameters (Specified for bias and frequency conditions) (Continued)	
Small signal value of the Short-Circuit Forward Current Transfer Ratio:	Small signal short-circuit forward current transfer ratio is the ratio of the AC output current to the AC input current, with 0 AC output voltage.
In Common Emitter configuration (h_{21e} or h_{fe})	$h_{21e} = \frac{Ic}{Ib}$ with V_{ce} = constant.
In Common Base configuration (h_{21b} or h_{fb})	$h_{21b} = \frac{Ic}{Ie}$ with V_{cb} = constant.
Small signal value of the Open-Circuit Output Admittance:	Small signal open-circuit output admittance is the ratio of the AC output current to the AC voltage applied to the output terminals, with 0 AC input current.
In Common Emitter configuration (h_{22e} or h_{oe})	$h_{22e} = \frac{Ic}{Vce}$ with I_b = constant.
In Common Base configuration (h_{22b} or h_{ob})	$h_{22b} = \frac{Ic}{Vcb}$ with I_e = constant.

Electrical Parameters - Capacitance	
Input Capacitance:	Output short circuited to AC.
In Common Emitter configuration (C11es or Cies)	$h11e = Re\ (h11e) + \frac{1}{i\omega C11es}$
In Common Base configuration (C11bs or Cibs)	$h11b = Re\ (h11b) + \frac{1}{i\omega C11bs}$
Output Capacitance:	Input open circuited to AC.
In Common Base configuration (C22bo or Cobo)	$h22b = Re\ (h22b) + i\omega C22bo$
Output Capacitance:	Input short circuited to AC.
In Common Emitter configuration (C22es or Coes)	$y22e = Re\ (y22e) + i\omega C22es$
In Common Base configuration (C22bs or Cobs)	$y22b = Re\ (y22b) + i\omega C22bs$

Electrical Parameters - Frequency Parameters
Cut-off Frequency:
In Common Emitter configuration (fh21e or fhfe)
In Common Base configuration (fh21b or fhfb)
In Common Collector configuration (fh21c or fhfc)

Electrical Parameters - Frequency Parameters (Continued)	
Frequency of Unity Current Transfer Ratio (f_i)	fT = f × h21e = 1
Transistor Frequency (f_T)	fT = f × h21e (h21e is measured in a region where the roll-off is 6dB/octave).
Maximum Frequency of Oscillation (f_{max})	The maximum frequency of oscillation is the highest frequency at which a transistor will oscillate under specified conditions. **NOTES:** This also approximates the frequency at which maximum available power gain has decreased to unity.

Electrical Parameters - Switching Parameters	
Pulse Average Time	Symbol under consideration. The average pulse time of a pulse is the time duration from a point on the leading edge which is 50% of the maximum amplitude to a point on the trailing edge which is 50% of the maximum amplitude.
Pulse Time (t_p)	The pulse time of a pulse is the time interval from the point on the leading edge which is 90% of the maximum amplitude to a point on the trailing edge which is 90% of the maximum amplitude.
Duty Cycle	Symbol under consideration.
Delay Time (t_d)	The delay time of a pulse is the time interval from a point at which the leading edge of the input pulse has risen to 10% of its maximum amplitude to a point at which the leading edge of the output pulse has risen to 10% of its maximum amplitude.
Rise Time (t_r)	The rise time of a pulse is that time duration during which the amplitude of its leading edge is increasing from 10% to 90% of the maximum amplitude.
Carrier Storage Time (t_s)	The storage time of a pulse is the time interval from a point 10% down from the maximum amplitude on the trailing edge of the input pulse to a point 10% down from the maximum amplitude on the trailing edge of the output pulse.
Fall Time (t_f)	The fall time of a pulse is that time duration during which the amplitude of its leading edge is decreasing from 90% to 10% of the maximum amplitude.
Turn-on Time (t_d+t_r)	Under consideration.
Turn-off Time (t_s+t_f)	Under consideration.
Emitter Depletion Layer Capacitance (C_{Te})	
Collector Depletion Layer Capacitance (C_{Tc})	

Electrical Parameters - Switching Parameters (Continued)
Collector Time Coefficient (τC)
Rise Time Coefficient (τR)
Fall Time Coefficient (τF)
Stored Charge (Q_S)
Transient Current Ratio in Saturation (h21 E_{sat} or h_{FEsat})
Collector Emitter Saturation Resistance: Small Signal Value (r_{cesat}); Static Value (r_{CEsat})

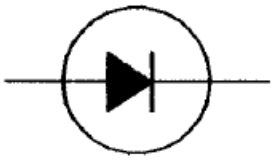
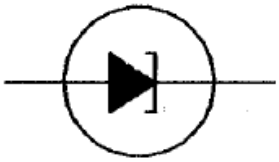
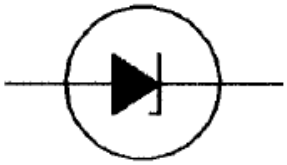
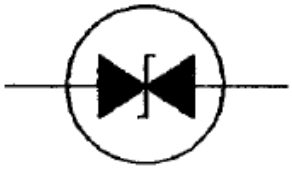
Electrical Parameters - Sundry Quantities	
Noise (N, n)	At a selected input frequency, the noise figure is the ratio of the total noise power per unit bandwidth (at a corresponding output frequency) delivered to the output termination, to the portion thereof contributed at the input frequency by the input termination, whose noise temperature is standard (293+5°K) at all frequencies.
Noise Current (I_n)	
Noise Voltage (V_n)	
Noise Power (P_n)	
Effective Noise Bandwidth (B)	
Amplification	Symbol under consideration.
Current Amplification	Symbol under consideration.
Voltage Amplification	Symbol under consideration.

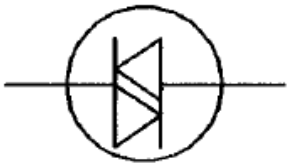
Electrical Parameters - Gain (G)	
Power Gain: For small signals For large signals	The large signal power gain is the ratio of the AC output power to the AC input power under specified large signal conditions. It is usually expressed in decibels (dB).
Insertion Power Gain	Symbol under consideration.
Transducer Power Gain	Symbol under consideration.
Available Power Gain	Symbol under consideration.
Maximum Power Gain	Symbol under consideration.
Efficiency (η)	
Collector Efficiency (ηc)	

Electrical Parameters - External Circuit Parameters
Emitter (DC) Voltage Supply (V_{EE})
Base (DC) Voltage Supply (V_{BB})
Collector (DC) Voltage Supply (V_{CC})
External Emitter Resistance (R_E)
External Base Resistance (R_B)
External Collector Resistance (R_C)
External Resistance connecting Base to Emitter (R_{BE})
Generator Resistance (R_G)
Load Resistance (R_L)
Load Capacitance (C_L)

3 GRAPHIC SYMBOLS

3.1 DIODES

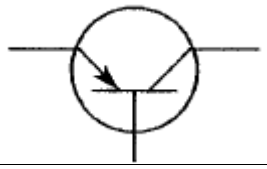
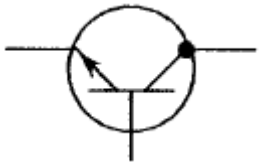
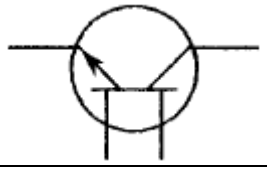
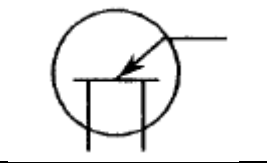
SYMBOL	DESCRIPTION
	P/N Diode
	Semiconductor rectifier diode
	Tunnel Diode
	Breakdown diode, uni-directional
	Breakdown diode bi-directional

SYMBOL	DESCRIPTION
	Bi-directional diode (transistor)

3.2 THYRISTORS

SYMBOL	DESCRIPTION
	Triode thyristor (general symbol)
	Reverse blocking triode thyristor, N-gate
	Reverse blocking triode thyristor, P-gate

3.3 TRANSISTORS

SYMBOL	DESCRIPTION
	PNP Transistor
	NPN Transistor with collector connected to the envelope
	Uni-junction transistor with P-type base
	Uni-junction transistor with N-type base

3.4 FIELD-EFFECT TRANSISTORS

SYMBOL	DESCRIPTION
	Junction field-effect transistor with N-type channel
	Junction field-effect transistor with P-type channel