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FOR SPACE STANDARDIZATION

Space product assurance

End-of-life parameter drifts - EEE components

ECSS Secretariat
ESA-ESTEC
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Noordwijk, The Netherlands

Foreword

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Therefore, a Technical Memorandum is not considered by ECSS as suitable for direct use in Invitation To Tender (ITT) or business agreements for space systems development.

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Change log

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Introduction

This Technical Memorandum gathers end–of–life drifts in EEE component parameters suitable for worst case circuit analyses, when the current information is sufficient.

This Technical Memorandum gathers all data agreed by the Working Group during preparation of this document.

1 Scope and limitations

This Technical Memorandum is suitable for all parties involved at all levels in the realization of space segment hardware and its interfaces.

The objective of this Technical Memorandum is to provide data about end-of-life parameter drifts and their use for equipment performance assessment up to the equipment end-of-life. To this end, the following are supplied:

- Estimation of end-of-life drifts due to ageing;
- Methodology guidelines and recommendations.

The reported ageing drifts in Clause 6 should not be confused with the endurance test drift limits allowed in the relevant ESCC specifications (table 4 or 6). The drift values reported here are based on effective life test results and extrapolated for operating temperature maxima respecting derating rules.

The selected data is derived from limited test samples, representative of the knowledge presently available as analysed by the ECSS WG.

End of life is one of the contributor of the Worst Case Circuit Analysis, others being Temperature, tolerance and radiation.

2 Normative references

Bibliography and Reference documents in annex at end of document.

3
Terms, definitions and abbreviated terms

3.1 Terms from other standards

For the purposes of this document, the terms and definitions from ECSS-S-ST-00-01 apply.

3.2 Terms specific to the present document

3.2.1 ambient temperature

temperature surrounding a component

3.2.2 case temperature

temperature on a component package surface

3.2.3 hot spot temperature

highest measured or predicted temperature within any component

3.2.4 junction temperature

temperature reached by a semiconductor within its active area during operation

3.2.5 operating conditions

parameter stress and environment (temperature, vibration, shock and radiation) in which components are expected to operate

3.2.6 performance

operation of a component or an equipment with respect to specified criteria

3.3 Abbreviated terms

For the purpose of this document, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	Meaning
AC	alternating current
A/D	analogue to digital
AWG	American wire gauge
C	capacitance
DC	direct current
EMC	electro-magnetic compatibility
EPPL	European preferred parts list
EOL	end-of-life
ESCC	European Space Component Coordination
ESR	equivalent series resistance
f	frequency
FET	field effect transistor
GaAs	gallium arsenide
GEO	geostationary orbit
HBT	hetero-junction bipolar transistor
ISO	International Organization for Standardization
LED	light emitting diode
LEO	low Earth orbit
MEO	medium Earth orbit
MOS	metal on silicon
MIL (spec)	specification of the US Department of Defense
NASA	National Aeronautics and Space Administration
P	power
RadHard	radiation hardened
Ri	insulation resistance
SEBO	single event burn-out
SEGR	single event gate rupture
Si	silicon
SOA	safe operating area
T_j	junction temperature
T_{op}	operating temperature
V_{CE}	collector-emitter voltage

4 User responsibility

The user of this Technical Memorandum should verify that the ordered assurance level of procured components is compatible with the intended application.

5 End-of-life parameter drift

5.1 General

A worst-case circuit performance analysis is performed to assess the performance of an equipment at the end of its planned life.

The present Technical Memorandum provides the time and temperature drift laws and the parameter drifts data when available at time of document drafting.

The laws and drifts are only provided in this document when they are validated.

a. Temperature law is validated when drift data is available at least at three T°.

b. Time law is validated only when drift measurements are available at several time intervals (more than two).

The designers should apply one of the following data sources:

a. the present Technical Memorandum,

b. or the drift after life test as defined in the procurement specification,

c. or the drift from a representative set of life test data.

The applicability of the proposed life test data should be justified.

Data published by the manufacturer in the data sheet or application notes should be applied by order of precedence, on a case by case basis.

ECSS-Q-HB-30-01 provides extrapolation rules in the hypothesis that the time law is linear and the T° acceleration follows the Arrhenius law:

a. For extrapolation to design life time one should refer to ECSS-Q-HB-30-01.

b. For interpolation to design temperature one should refer to ECSS-Q-HB-30-01.

When a deviation to the present Technical Memorandum is encountered and approved on the basis of the drift from a representative set of life test data, an ECSS Change Request form (available from the ECSS Website).

The following additional text should appear in the Change Request:

> "It is proposed to take into account the present deviation for further issue of the ECSS-Q-TM-30-12"

5.2 Methodology

Drifts should be derived from test.

Key Test conditions parameters are:

- Junction Test Temperature
- Test Duration
- Sample statistics

Test conditions and duration should cover mission conditions and duration according to time law and acceleration laws.

Apply Arrhenius to extrapolate to lower operating junction temperature.

Apply referenced Ea or, preferably derive Activation energy Ea from test at two temperatures.

Time extrapolation law from test to mission durations should be validated. It should be based on three intermediate measurements, unless the pessimistic linear extrapolation is used.

When provided in percentage, the drift value provided in this Technical Memorandum was derived from the initial measured value or from the minimum or maximum specified as applicable.

In the application, this value should be applied in a WCCA on either the minimum or maximum limit specification, according to the drifts table.

5.3 Applicability

The parameter degradation figures provided in this Technical Memorandum are suitable for all components procured in accordance with approved space specifications (ESCC, NASA, MIL, National Space Agencies, customer or manufacturer).

This Technical Memorandum is also suitable for other components that have undergone rigorous selection testing in accordance with ECSS-Q-ST-60.

5.4 Elements contributing to parameter drift

This Technical memorandum only deals with the ageing (end-of-life factors).

- Component ageing and drifts (end-of-life factors)

  The ageing of a component is a continuous process of physico-chemical change. In most cases, the rate of change is an exponential function of temperature. The figures provided in this Technical Memorandum take into account the most common degradation mechanisms.

5.5 Other Elements contributing to parameter drift

In general, parameter drift comprises the following, unless otherwise specified.

- Initial tolerance

  Parameter tolerance defined in the procurement specification.

- Temperature effects

  The junction or case temperature which affects the component's initial performance and contributes to the ageing mechanism.

- Voltage or current effects

  The parameter degradation resulting from the applied voltage or current should be considered.

- Radiation effects

  Semiconductors are susceptible to degradation due to radiation. A great disparity of behaviour can appear under the influence of radiation which can be caused by:

  — mission orbit and duration,

  — radiation types (such as protons, electrons and heavy ions),

  — component technology, manufacturer, diffusion lot.

  Identical components from different manufacturers can have a different radiation sensitivity.

- Component mounting

  The mounting on a printed circuit board or substrate of surface mount components induces a stress that can have an influence on the component performance. Components sensitive to mounting processes are identified, but the expected change is not quantified as this is considered to be part of the evaluation of the device.

- Mission duration

  Most parameter drifts are a function of time. The end-of-life parameter drift figures are valid for missions of up to 18 years provided the components are derated in accordance with ECSS-Q-ST-30-11 Standard.

6
End-of-life drift figures

6.1 General

This Clause provides

1. The drift laws and activation energies
2. The end-of-life parameter drift figures
3. A data integrity assessment.

Abbreviations used in the tables are explained in Clause 3.

Annex A contains a complete listing of the family and group codes for parts that are referred to in this Technical Memorandum.

The following format was used to collect and provide the data source references and statistics in order to raise the integrity level of this TM document.

Table 6-1: Table format for collection of data source reference

Clause		
Family-Code		
Data source	Note (1)	
Reference		
Duration		
Test flow	Note (2)	
Thermal parameter	Note (3)	
Temperature		
Electrical Load Parameter	Note (4)	
Load figure	Note (5)	
# Manufacturers		
# Lots		p
# Parts/ Lot		N
Mission life coverage	Note (6)	
Confidence level indicator	Note (7)	1/Square root of pN

(1) Data Source	Select between User industry, Parts Manufacturer , ESCC or Other	
(2) Test flow	Select between ESCC Table #, Life tests, burn-in, Other.	
(3) Thermal parameter	Select between Tc for passives or Tj for actives or unknown	
(4) Electrical Test Parameter	Select between Voltage for Capa or Power for Resistors, or Other as applicable	
(5) Load figure	Select between Voltage xVr for Capa or %Pn for Resistors, or Other as applicable	
(6) Mission Life coverage	Maximum Life Duration derived from test data for derated junction or case temperature	
(7) Confidence level indicator	Qualitative ranking based on square root of total Nber of parts	
	Low	Class 1_0.4: 1 to 6 parts
	Fair	Class 0.4_0.2: 7 to 25 parts
	Good	Class 0.2_0.1: 26 to 100 parts
	High	Class 0.1_0: more then 100 parts

The Bibliography and reference documents, at the end of this document, contains a complete list of reference documents and data sources.

6.2 Capacitors: ceramic – family-group code: 01-01 and 01-02

6.2.1 Drift laws

a. Time law: unknown, linear one was used.

b. Temperature law: Arrhenius law with Activation Energy: Ea=0,34 eV

6.2.2 End-of-life drifts Type I and Type II:

Capacitance ΔC/C	55 °C	85 °C	110 °C
Type I			
10 years	±0,10 %	±0,28 %	± 0,57 %
18 Years	±0,18 %	±0,50 %	± 1,02 %
Type II			
10 years	±0,19 %	±0,53 %	± 1,14 %
18 Years	±0,34 %	±0,96 %	± 2,05 %
Insulation ΔR/R	55 °C	85 °C	110 °C
Type I and Type II			
10 years	-50 %		
18 Years			
Derived from test data at 125 °C, 3000 h , 2xUr			

6.2.3 Data source and statistics

Integrity assessment	Mission life coverage	18 Years at 110 °C
	Confidence level indicator	Type I : Good
		Type II: Good

6.3 Capacitors: solid tantalum – family-group code: 01-03

6.3.1 Drift laws

a. Time law: unknown, linear one was used.

b. Temperature law: Arrhenius law with Activation Energy: Ea=0,19 eV

6.3.2 End-of-life drifts

Capacitance ΔC/C	55 °C	85 °C	110 °C
10 years	±0,63 %	±1,11 %	± 1.67 %
18 Years	±1,14 %	±2 %	± 3 %
Leakage Current	55 °C	85 °C	110 °C
10 years	Maximum specified limit.		
18 Years			
Derived from test data at 125 °C, 2000 h, 0.66xUr			

6.3.3 Data source and statistics

Integrity assessment	Mission life coverage	18 Years at 110 °C
	Confidence level indicator	High

6.4 Capacitors: non-solid tantalum – family-group code: 01-04

6.4.1 Drift laws

a. Time law: unknown, linear one was used.

b. Temperature law: Arrhenius law with Activation Energy: Ea= 0,43 eV

6.4.2 End-of-life drifts

Capacitance ΔC/C	55 °C	85 °C	110 °C
10 years	±4 %	±15 %	± 37 %
18 Years	±4 %	±15 %	± 39 %
Leakage Current	55 °C	85 °C	110 °C
10 years	Maximum specified limit.		
18 Years			
Derived from test data at 125 °C, 2000 hrs, Ur			

6.4.3 Data source and statistics

Integrity assessment	Mission life coverage	18 Years at 110 °C
	Confidence level indicator	Good

6.5 Capacitors: film – family-group code: 01-05

6.5.1 Drift laws

a. Time law: unknown, linear one was used.

b. Temperature law: Arrhenius law with Activation Energy: Ea= 0,22 eV

6.5.2 End-of-life drifts

6.5.2.1 For Polycarbonate

Capacitance ΔC/C	55 °C	85 °C	100 °C
10 years	±0,7 %	±1,35 %	±1,8 %
18 Years	±0,78 %	±1,50 %	± 2 %
Insulation ΔR/R	55 °C	85 °C	100 °C
10 years	-50 %		
18 Years			
For information: derived from RAC data at 100 °C.			

6.5.2.2 For Polyethylene (PET PM90, PM94, …)

Capacitance ΔC/C	55 °C	85 °C	100 °C
10 years	±1,9 %	±3,7 %	±5 %
18 Years	±2 %	±3,8 %	± 5 %
Insulation ΔR/R	55 °C	85 °C	100 °C
10 years	-50 %		
18 Years			
Derived from test data at 100 °C, 1.25xUr, 2000hrs for 80% load ratio			

6.5.3 Data source and statistics

Integrity assessment	Mission life coverage	Polycarbonate: unknown
		Polyethylene: 18 Years at 100 °C
	Confidence level indicator	Polycarbonate: unknown
		Polyethylene: High

6.6 Capacitors: glass and porcelain – family-group code: 01-06

6.6.1 Drift laws

a. Time law: unknown, linear one was used.

b. Temperature law: Arrhenius law with Activation Energy: Ea= 0,37 eV

6.6.2 End-of-life drifts

Capacitance ΔC/C	55 °C	85 °C	110 °C
10 years	± 0,02 %	± 0,06 %	±0,13 %
18 Years	± 0,04 %	± 0,10 %	±0,24 %
Derived from test data at 125 °C, 2xUr, 1000hrs for 60% load ratio..			

6.6.3 Data source and statistics

Integrity assessment	Mission life coverage	18 Years at 110 °C
	Confidence level indicator	Fair

6.7 Capacitors: mica – family-group code: 01-07

6.7.1 Drift laws

a. Time law

b. Temperature law: Arrhenius law with Activation Energy: Ea= 0,37 eV

6.7.2 End-of-life drifts

Capacitance ΔC/C	55 °C	85 °C	110 °C
10 years	± 0,10 %	± 0,15 %	±0,33 %
18 Years	± 0,18 %	± 0,27 %	±0,6 %
For information: derived from RAC data			

6.7.3 Data source and statistics

Integrity assessment	Mission life coverage	Unknown
	Confidence level indicator	Unknown

6.8 Capacitors: feedthrough – family-group code: 01-10

See Clause 6.2 Ceramic capacitors.

6.9 Capacitors: semiconductor technology (MOS type) – family-group code: 01-11

6.9.1 Drift laws

No data available.

6.9.2 End-of-life drifts

No data available.

6.9.3 Data source and statistics

No data available.

6.10 Capacitors: miscellaneous (variable capacitors) – family-group code: 01-99

6.10.1 Drift laws

a. Time law: not applicable

b. Temperature law : no thermal activation

c. Activation Energy: not applicable

6.10.2 End-of-life drifts

Stays within specification limit.

6.10.3 Data source and statistics

No data available.

6.11 Connectors – family-group code: 02-01, 02-02, 02-03, 02-07 and 02-09

6.11.1 Drift laws

No drift should be considered.

6.11.2 End-of-life drifts

No drift should be considered.

6.11.3 Data source and statistics

No data available.

6.12 Connectors RF – family-group code: 02-05

6.12.1 Drift laws

No drift should be considered.

6.12.2 End-of-life drifts

No drift should be considered.

6.12.3 Data source and statistics

No data available.

6.13 Piezo-electric devices: crystal resonator – family-group code: 03-01

6.13.1 Drift laws

No drift law considered.

6.13.2 End-of-life drifts

Parameters	**Drifts**	**Special conditions**
Crystals		
Δf/f	Ageing specified in the detail specification.	Unless otherwise specified, ageing includes the expected total drift (including life-time, vibration, shock, drive level). Ageing should be added to the frequency tolerance at T_0 and to the frequency variation over the operating temperature range.
Hybrid oscillators		
Parameters applicable for the Logic Family components inside the hybride.		The variation applicable to the logic family inside the hybrid should be added to ageing.

6.13.3 Data source and statistics

No data available.

6.14 Diodes – family-group code: 04-01, 04-02, 04-03, 04-04, 04-06, 04-08, 04-10 to 04-13, and 04-14

6.14.1 Drift laws

a. Time law: unknown, linear one was used

b. Temperature law: Arrhenius with Activation Energy: Ea= 1,1 eV

6.14.2 End-of-life drifts

6.14.2.1 Signal

No data available.

6.14.2.2 Switching

No data available.

Forward Voltage	55 °C	85 °C	110 °C	
10 years				
18 Years				

Reverse Current	55 °C	85 °C	110 °C	
10 years				
18 Years				

6.14.2.3 Rectifier

Forward Voltage	55 °C	85 °C	110 °C
5 years			+1.4 %
10 years			
18 Years		+0.45%	
Reverse Current	55 °C	85 °C	110 °C
5 years			+ 13%
10 years			
18 Years		+ 4.4%	
Derived from Test data 2000 hrs, Tj=150°C			

6.14.2.4 Schottky

No data available.

6.14.2.5 Zener, non compensated reference

No data available.

6.14.2.6 Zener, compensated reference

Zener Voltage	55 °C	85 °C	110 °C
10 years	0 %	- 0,2 %	
18 Years			
Reverse Current	55 °C	85 °C	110 °C
10 years	+0,4 %	+30 %	
18 Years			
Dynamic Impedance	55 °C	85 °C	110 °C
10 years	-0,1 % / +0 %	-2.9 % / + 1.2 %	
18 Years			
Derived from test data: at Ta= 100 °C, 3000 h, with Ea= 1.1 eV			

6.14.3 Data source and statistics

6.14.3.1 Signal

No data available.

6.14.3.2 Switching

No data available.

6.14.3.3 Rectifier

N	Mission life coverage	18 Years at 85 °C
	Confidence level indicator	Fair

6.14.3.4 Schottky

No data available.

6.14.3.5 Zener , non compensated reference

No data available.

6.14.3.6 Zener , compensated reference

Integrity assessment	Mission life coverage	18 Years at 55 °C
	Confidence level indicator	Good

6.15 Diodes: RF/microwave – family-group code: 04-05, 04-11 to 04-13, 04-15, 04-16 and 04-17

6.15.1 Drift laws

a. Time law:

b. Temperature law:

c. Activation Energy:

6.15.2 End-of-life drifts for RF diode

6.15.2.1 Step recovery, varactor

No data available.

6.15.2.2 Schottky barrier

No data available.

6.15.3 Data source and statistics

6.15.3.1 Step Recovery, Varactor

No data available.

6.15.3.2 Schottky barrier

No data available.

6.16 Feedthrough filters – family-group code: 05-01

6.16.1 Drift laws

No data available.

6.16.2 End-of-life drifts

Parameters	**Drifts**
Attenuation	-2 dB in addition to the initial tolerance.
DRi/Ri	-50 %
Information note. Attenuation: to be checked, in the meantime, drift is as proposed by ECSS-Q60 11A Insulation resistance: should be similar to Ceramic capacitor	

6.16.3 Data source and statistics

No data available.

6.17 Fuses: Cermet (metal film on ceramic) – family-group code: 06-01

6.17.1 Drift laws

No data available.

6.17.2 End-of-life drifts

No drift should be considered.

6.17.3 Data source and statistics

No data available.

6.18 Inductors and transformers – family-group code: 07-01 - 07-03

6.18.1 Drift laws

No data available.

6.18.2 End-of-life drifts

No drift should be considered.

6.18.3 Data source and statistics

No data available.

6.19 Integrated circuits: logic – family-group code: 08-10, 08-20, 08-21, 08-29 to 08-42, and 08-80

6.19.1 Drift laws

No data available.

6.19.2 End-of-life drifts

No drift should be considered.

6.19.3 Data source and statistics

No data available.

6.20 Integrated circuits: non-volatile memories – family-group code: 08-22, 08-23 and 08-24

6.20.1 Drift laws

No data available.

6.20.2 End-of-life drifts

No drift should be considered.

6.20.3 Data source and statistics

No data available.

6.21 Integrated circuits: linear – family-group code: 08-50 to 08-60 and 08-69

6.21.1 Drift laws

a. Time law

b. Temperature law Arrhenius

c. Activation Energy: Ea= 0,8 eV

6.21.2 End-of-Life drifts

6.21.2.1 Relevant parameters for linear ICs

Family code	Part type	Parameter	Code	Units
Op Amp		Input Offset Voltage	V(IO)	% of max limit
		Input Bias Current	I(B)	% of max limit
		Input Offset Current	I(OS)	% of max limit
		Large signal Voltage Gain	A(VO)	% of min limit
		Gain BandWidth product	GBW	% of min limit
		Common Mode Rejection Ratio	CMRR	% of min limit
		Power Supply Rejection Ratio	PSRR	% of min limit
		Supply Current	ICC	% of max limit
Comparator		Input Offset Voltage	V(IO)	% of max limit
		Input Bias Current	I(B)	% of max limit
		Input Offset Current	I(OS)	% of max limit
		Large signal Voltage Gain	A(VO)	% of min limit
		Supply Current	ICC	% of max limit
Regulator		Output Voltage		
		Reference Voltage		
		Line Regulation		
		Load Regulation		
		Input Offset Voltage	V(IO)	% of max limit
		Input Bias Current	I(B)	% of max limit

Family code	Part type	Parameter	Code	Units
		Input Offset Current	I(OS)	% of max limit
		Large signal Voltage Gain	A(VO)	% of min limit
		gain band Width product	GBW	% of min limit
		Supply Current	ICC	% of max limit
		Overvoltage Protection Threshold	OVPTH	
		Undervoltage protection Threshold	UVPTH	
		Overcurrent protection threshold	OIPTH	
PWM		Output Voltage		
		Reference Voltage		
		Line Regulation		
		Load Regulation		
		Input Offset Voltage	V(IO)	% of max limit
		Input Bias Current	I(B)	% of max limit
		Input Offset Current	I(OS)	% of max limit
		Large signal Voltage Gain	A(VO)	% of min limit
		gain band Width product	GBW	% of min limit
		Supply Current	ICC	% of max limit
		Overvoltage Protection Threshold	OVPTH	
		Undervoltage protection Threshold	UVPTH	
		Overcurrent protection threshold	OIPTH	
		Duty Cycle Max		
		Duty Cycle Min		
		Undervoltage protection hysterisis		
		Under voltage protection High		
		Under voltage protection Low		
Voltage Reference		Reference Voltage		
		Line Regulation		
		Load Regulation		
D/A converters		Full Scale current	IFS	mA
		Zero Scale current	IZS	micro A
		Supply Current	ICC	% of max limit

Family code	Part type	Parameter	Code	Units
A/D converters				
Analog Switch				
Analog Multiplexer				
Note 1: only DC relevant parameters are provided				
Note 2: AC parameters definitions may also be useful				

6.21.2.2 Operational Amplifiers

Input bias Current (% of maximum limit)	55 °C	85 °C	110 °C	
10 years	Covered by test data available			
18 Years	Covered by test data available			

The drifts values derived from Test referenced in RD3 show large dispersions from type to type.

The typical Test conditions reported at Ta=125 °C, 1000h, do not allow to cover the full Temperature-Duration spectrum.

With the assumption of Ea= 0,8 eV only the 55 °C, 18 years area is covered.

6.21.3 Data source and statistics

Integrity assessment	Mission life coverage	18 Years at 55 °C
	Confidence level indicator	Unknown

6.22 Integrated circuits: linear converters – family-group code: 08-61 and 08-62

6.22.1 Drift laws

No data available.

6.22.2 End-of-life drifts

No data available.

6.22.3 Data source and statistics

No data available.

6.23 Integrated circuits: MMICs – family-group code: 08-95

6.23.1 Drift Laws

To be defined.

To be organized depending on the RF functionality of the circuits.

6.23.2 End-of-life drifts

To be defined.

To be organized depending on the RF functionality of the circuits.

6.23.3 Data source and statistics

To be defined.

To be organized depending on the RF functionality of the circuits.

6.24 Integrated circuits: miscellaneous – family-group code: 08-99

6.24.1 Drift laws

Refer to relevant Integrated Circuit sections.

6.24.2 End-of-life drifts

Refer to relevant Integrated Circuit sections.

6.24.3 Data source and statistics

Refer to relevant Integrated Circuit sections.

6.25 Relays and switches – family-group code: 09-01, 09-02 and 16-01

6.25.1 Drift laws

Time law: not applicable.

Acceleration factor: operations number threshold.

6.25.2 End-of-life drifts

Parameters	**Drifts**
Contact resistance	Maximum limit (if N < 1 000 operations). Maximum limit × 2 (if N > 1 000 operations).
For thermal switches only: • Operating temperature (T_f) • Reset temperature (T_r)	 Initial tolerance + 1 ºC Initial tolerance + 1 ºC

6.25.3 Data source and statistics

Not applicable.

6.26 Resistors – family-group code: 10-01 to 10-11

6.26.1 Drift laws – Generic to Resistors

Drift figures are presented in table format at Tcase + 50 %Pn.

As a preferable alternative, drifts should be reported in tables as a function of Hot Spot Temperatures 55 °C, 85 °C and 125 °C. This is on stand-by at time of production of this Technical memorandum.

All data, except for clause 6.26.2.6 Chip High Precision, is compiled manufacturer data for which confidence level could not be assessed.

a. Time law: Cubic root of time law apply to all Metal and Film Resistors.

b. Temperature law: Arrhenius with activation Energy Ea specified type by type.

6.26.2 End-of-life drifts

6.26.2.1 Metal film (RNC except RNC90)

Time law: cubic root of time

Temperature law: Arrhenius, Ea= 0,28 eV

Drifts at Tcase + 50 %Pn	55 °C	85 °C	125 °C
10 years	0,19	0,44 %	1,1 %
18 years	0,23	0,52 %	1,3 %
Derived from compiled manufacturer Test data 8000 h at 125 °C, 100 % Pn , Drift 0,5 % Data published by the manufacturer in the data sheet or application notes should be applied by order of precedence, on a case by case basis.			

6.26.2.2 Metal film (RLR)

Time law: cubic root of time

Temperature law: Arrhenius, Ea= 0,28 eV

Drifts at Tcase + 50 %Pn	55 °C	85 °C	125 °C
10 years	0,39	0,88 %	2,2 %
18 years	0,47	1,04 %	2,7 %
Drifts derived from Test 8000 h 125 °C, 100 % Pn, Drift 1 %			

6.26.2.3 Foil (RNC90)

Time law: linear

A linear law is proposed for RNC90 for 0,3W, 125 °C.

Drift = 0,006t + 76,6

Temperature law: Arrhenius,Ea=0,18 eV

Drifts at Tcase + 50 %Pn	55 °C	85 °C	125 °C
10 years	0,02 %	0,06 %	0,08 %
18 years	0,02 %	0,04 %	0,11 %
Or ΔR/R= 50 E-6 whichever is higher.			
Drifts derived from Test 1000 h, 115 °C, 100 % Pn, Drift 50 E-6			

6.26.2.4 Wire-wound power resistors (Type RWR, RER)

Parameters	**Drifts**		
	5 years	**10 years**	**18 years**
DR/R - wire-wound power: types RWR, RER	0,8 %	1,2 %	1,5 %

6.26.2.5 Chip Thin Film Resistor (Type RM), network Resistor;

Time law: cubic root of time

Temperature law: Arrhenius, Ea= 0,28 eV

Drifts at Tcase + 50 %Pn	55 °C	85 °C	125 °C
10 years	0,19	0,44 %	1,1 %
18 years	0,23	0,52 %	1,3 %
Drifts derived from Test 8000 h 125 °C, 100 % Pn, Drift 0,5 %			

6.26.2.6 Chip, Thin Film, high precision resistors (type UMA and PHR)

Time law: cubic root of time

Temperature law: Arrhenius, Ea= 0,28 eV

Drifts at Tcase + 50 %Pn	55 °C	85 °C	
10 years	0,04 %	0,09 %	
18 years	0,05 %	0,11 %	
Note 1: this data is superseded by the data provided in the detailed specification Note 2: EoL data does not account for the soldering process drift. Note 3: or ΔR/R = 100 E-6 for NiCr Thin Film Chip whichever is higher. Note 4: derived from Test 8000 h, 85 °C, P=70mW, Drift 0,1 %			

6.26.2.7 Networks

Apply same drift values as the discrete counterparts.

6.26.2.8 Heaters

Parameters	**Drifts**		
	5 years	**10 years**	**18 years**
Heaters DR/R	±0,6 %	±0,8 %	±1 %

6.26.3 Data source and statistics

6.26.3.1 Metal film (RNC except RNC90)

No data available.

6.26.3.2 Metal film (RLR)

No data available.

6.26.3.3 Foil (RNC90)

No data available.

6.26.3.4 Wire-wound power resistors (Type RWR, RER)

No data available.

6.26.3.5 Chip Thin Film Resistor (Type RM), network Resistor;

No data available.

6.26.3.6 Chip, Thin Film, high precision resistors (type UMA and PHR)

Integrity assessment	Mission life coverage	18 Years at 85 °C
	Confidence level indicator	High

6.26.3.7 Networks

No data available.

6.26.3.8 Heaters

No data available.

6.27 Thermistors – family-group code: 11-01 to 11-03

6.27.1 Drift laws

No data available.

6.27.2 End-of-life drifts

Parameters	**Drifts**		
	Technology	**Temperature**	
		0-100 °C	**Other Temperature**
Resistance PTC thermistor	Platinium Wire wound	Initial tolerance	Add ±0,5 % to the initial tolerance
	Platinium Thin Film	No data available	No data available
	Ceramic	No data available	No data available
NTC thermistor	Manufacturer data: Beta therm		

6.27.3 Data source and statistics

No data available.

6.28 Transistors: bipolar – family-group code: 12-01 to 12-04 and 12-09

6.28.1 Drift laws

a. Time law: linear, quadratic law to be checked

b. Temperature law : Arrhenius, with activation Energy Ea= 0,7 eV

6.28.2 End-of-life drifts

Vce : (%)	55 °C	85 °C	110 °C	
10 years	0,05 %	0,38 %	1,66 %	
18 Years	0,09 %	0,68 %	+3 %	

Vbe : (%)	55 °C	85 °C	110 °C	
10 years	0,02	0,13 %	0,56 %	
18 Years	0,03 %	0,23 %	+1 %	

Icbo : (%)	55 °C	85 °C	110 °C	
10 years	+0,4 %	+9,8 %	+100 %	
18 Years	+0,7 %	+18 %	+180 %	

Icbx : ( )	55 °C	85 °C	110 °C	
10 years				
18 Years				

Icbx : ( )

To be studied

Gain :	55 °C	85 °C	110 °C	
10 years				
18 Years	-0,13 %	-1,5 %	-7 %	

BVceo, BVces, BVceo : (% of specified minimum value)	55 °C	85 °C	110 °C	
10 years	No drift values are proposed for Breakdown Voltages which are treated in terms of derating			
18 Years				
Data derived from Life Test 3000 h at Tj stress 200 °C Equivalent to 19 years at Tj=110 °C				

6.28.3 Data source and statistics

Integrity assessment	Mission life coverage	18 years at 110°C
	Confidence level indicator	Good

6.29 Transistors: FET – family-group code: 12-05 and 12-06

6.29.1 Drift laws

No data available.

6.29.2 End-of-life drifts

- VGS(th) : ± TBD %
- Igss : Within maximum specified value
- Idss : Within maximum specified value
- On-state resistance : Within maximum specified value

6.29.3 Data source and statistics

No data available.

6.30 Transistors: RF: bipolar – family-group code: 12-10, 12-11, 12-13

6.30.1 Drift Laws

No data available.

6.30.2 End-of-life drifts

No data available.

6.30.3 Data source and statistics

No data available.

6.31 Transistors: RF: FET – family-group code: 12-12, 12-14, 12-15(FET), 12-16(FET)

6.31.1 Drift laws

For GaAs

Time law: Square root

Temperature law : Arrhenius

Activation Energy: Ea= 1.1 eV for Low level on Gain and Consumption.

Activation Energy: Ea= 1 eV for Power>1W on Consumption

6.31.2 End-of-life drifts

6.31.2.1 Si FETs

Parameters	**Drifts**
Pinch off voltage (Vp)	±10 %
Gate leakage current (I_{GS})	5 × worst case operational value
Drain current for V_{GS} = 0 (I_{DSS})	Normally "ON": ±20 % Normally "OFF": 5 × initial value
Drain current for V_{GS} threshold ($I_{DS\ @}$ Vth)	Normally "ON": 5 × initial value Normally "OFF": ±20 %
Transconductance (g_m)	±25 %
Gain	
Output Power	
Data kept from former ECSS-Q60-11A for information only.	

6.31.2.2 Low level GaAs FETs

Relevant parameters:

Gain (dB per transistor stage)

Consumption (%)

6.31.2.3 Power GaAs FETs (Pout <1W)

Relevant parameters:

Output Power (dB per transistor stage)

Consumption (%)

Preliminary data.

6.31.3 Data source and statistics

6.31.3.1 Si FETs

No data available.

6.31.3.2 Low level GaAs FETs

Integrity assessment	Mission life coverage	18 years, 115°C
	Confidence level indicator	Fair

6.31.3.3 Power GaAs FETs (Pout <1W)

Integrity assessment	Mission life coverage	18 years, 115°C
	Confidence level indicator	Fair

6.32 Wires and cables – family-group code: 13-01 to 13 03

6.32.1 Drift laws

No generic data available.

6.32.2 End-of-life drifts

No generic data available.

6.32.3 Data source and statistics

Generic.

6.33 Opto-electronics – family-group code: 18-01 to 18-05

6.33.1 Drift laws

No data available.

6.33.2 End-of-life drifts

Relevant parameters.

Parameters	Drifts
Light emitting diodes Light output power	
Opto-coupler Ageing coefficient for current transfer ratio	
Photo-transistor Collector leakage current (I_{ceo})	

6.33.3 Data source and statistics

No data available.

6.34 RF passive components: family-group-code: 30-01, 30-07, 30-09, 30-10 and 30-99

6.34.1 Drift laws

No data available.

6.34.2 End-of-life drifts

To be defined.

6.34.3 Data source and statistics

No data available.

6.35 Fibre optic components: fibre and cable: family-group-code: 27-01

6.35.1 Drift laws

No data available.

6.35.2 End-of-life drifts

To be defined.

6.35.3 Data source and statistics

No data available.

6.36 Hybrids

6.36.1 Drift laws

No data available.

6.36.2 End-of-life drifts

To be defined.

6.36.3 Data source and statistics

No data available.

Annex A (informative) Family and group codes

This annex contains an extract from the European preferred parts list (EPPL) and it lists all the parts referred to in this Technical Memorandum providing their family and group codes.

Family code	Group code	Family	Group
01	01	Capacitors	Ceramic
01	02	Capacitors	Ceramic Chip
01	03	Capacitors	Tantalum solid
01	04	Capacitors	Tantalum non-solid
01	05	Capacitors	Plastic metallized
01	06	Capacitors	Glass
01	07	Capacitors	Mica
01	09	Capacitors	Aluminium solid
01	10	Capacitors	Feedthrough
01	11	Capacitors	Semiconductor
02	01	Connectors	Circular
02	02	Connectors	Rectangular
02	03	Connectors	Printed circuit board
02	07	Connectors	Microminiature
02	09	Connectors	Rack and panel
03	01	Piezo-electric devices	Crystal resonator
04	01	Diodes	Switching
04	02	Diodes	Rectifier
04	03	Diodes	Voltage regulator
04	04	Diodes	Voltage reference/zener
04	05	Diodes	RF/microwave Schottky - Si

04	06	Diodes	Pin
04	08	Diodes	Transient suppression
04	10	Diodes	High voltage rectifier
04	11	Diodes	Microwave varactor - GaAs
04	12	Diodes	Step recovery
04	13	Diodes	Microwave varactor - Si
04	14	Diodes	Current regulator
04	15	Diodes	Microwave Schottky - GaAs
04	16	Diodes	RF/microwave - PIN
04	17	Diodes	Microwave GUNN - GaAs
05	01	Filters	Feedthrough
06	01	Fuses	All
07	01	Inductors	RF coil
07	02	Inductors	Cores
07	03	Inductors	Chip
08	10	Microcircuits	Microprocessors/microcontrollers/ peripherals
08	20	Microcircuits	Memory SRAM
08	21	Microcircuits	Memory DRAM
08	22	Microcircuits	Memory PROM
08	23	Microcircuits	Memory EPROM
08	24	Microcircuits	Memory EEPROM
08	29	Microcircuits	Memory others
08	30	Microcircuits	Programmable logic
08	40	Microcircuits	ASIC technologies digital
08	41	Microcircuits	ASIC technologies linear
08	42	Microcircuits	ASIC technologies mixed analogue/digital
08	50	Microcircuits	Linear operational amplifier
08	51	Microcircuits	Linear sample and hold amplifier
08	52	Microcircuits	Linear voltage regulator
08	53	Microcircuits	Linear voltage comparator
08	54	Microcircuits	Linear switching regulator
08	55	Microcircuits	Linear line driver
08	56	Microcircuits	Linear line receiver

08	57	Microcircuits	Linear timer
08	58	Microcircuits	Linear multiplier
08	59	Microcircuits	Linear switches
08	60	Microcircuits	Linear multiplexer/demultiplexer
08	61	Microcircuits	Linear analog to digital converter
08	62	Microcircuits	Linear digital to analogue converter
08	69	Microcircuits	Linear other functions
08	80	Microcircuits	Logic families
08	99	Microcircuits	Miscellaneous
09	01	Relays	Non-latching
09	02	Relays	Latching
10	01	Resistors	Metal oxide
10	02	Resistors	Wire-wound precision - including surface mount
10	03	Resistors	Wire-wound chassis mounted
10	04	Resistors	Variable trimmers
10	05	Resistors	Composition
10	07	Resistors	Shunt
10	08	Resistors	Metal film
10	09	Resistors	Chip - all
10	10	Resistors	Network - all
10	11	Resistors	Heaters, flexible
11	01	Thermistors	Temperature compensating
11	02	Thermistors	Temperature measuring
11	03	Thermistors	Temperature sensor
12	01	Transistors	Low power, NPN - < 2 W
12	02	Transistors	Low power, PNP - < 2 W
12	03	Transistors	High power, NPN - > 2 W
12	04	Transistors	High power, PNP - > 2 W
12	05	Transistors	FET N channel
12	06	Transistors	FET P channel
12	09	Transistors	Switching
12	10	Transistors	RF/microwave NPN low power/low noise
12	11	Transistors	RF/microwave PNP low power/low noise

12	12	Transistors	RF/microwave FET N-channel/P-channel
12	13	Transistors	RF/microwave bipolar power
12	14	Transistors	RF/microwave FET power - Si
12	15	Transistors	Microwave power - GaAs
12	16	Transistors	Microwave low noise - GaAs
13	01	Wires and cables	Low frequency
13	02	Wires and cables	Coaxial
13	03	Wires and cables	Fibre optic
16	01	Switches	Standard DC/AC power toggle

Family code	Group code	Family	Group
18	01	Opto electronics	Optocoupler
18	02	Opto electronics	LED
18	03	Opto electronics	Phototransistor
18	04	Opto electronics	Photo diode/sensor
18	05	Opto electronics	Laser diode
27	01	Fibreoptic components	Fibre/cable
30	01	RF passive devices	Coaxial couplers
30	07	RF passive devices	Isolator/circulator
30	09	RF passive devices	Coaxial power dividers
30	10	RF passive devices	Coaxial attenuators/loads
30	99	RF passive devices	Miscellaneous

Bibliography and reference documents

EEE manufacturer

- RD7 Vishay VSD-TN0005-0407

Agency

- RD3 Reports as per ESTEC Contract 13474/99/NL/MV
- RD4 RAC « Reliable application of Capacitor », RAC parts selection, application and control series, 1996.
- RD5 JPL reliability analyses handbook , D-5703
- RD6 CNES RO- CNE-RS-9065, WCA-DB, Ed1 -Rev0, December 1995

Industry

- RD2 : Thales Alenia Space Company standard instruction and data base for dependability analysis. Ref.: 100141982F-EN-issue 2 (13 May 2007). Also proposed as common Astrium/Alcatel data base in meeting MOM/ECSS-Q-60-11/WG/OO1 , 18-19 march 04

ECSS

- ECSS-Q-ST-30 Space product assurance - Dependability
- ECSS-Q-HB-30-01 Space product assurance - Worst Case Circuit Analysis
- ECSS Q-ST-30-11 Space product assurance - Derating - EEE Component
- ECSS-E-ST-10-12 Space engineering - Method for calculation of radiation dose and margin policy
- gil1 : Space Product Assurance : Derating and end-of-life parameter drifts - Electrical, electronic and electromechanical components Ref.: ECSS-Q-60-11A (7 September 2004)

Data source collection

- EoL_Data statistics_CNES_Diodes and Bipolar.zip, 30 July 2009
- Data source and Statistics for ECSS TM-30-12_RF FET_tas.xls, 05 October 2009
- Data source and Statistics for ECSS TM-30-12_Capa_ast.xls