NOTICE OF CHANGE

**NOT MEASUREMENT SENSITIVE**

MIL-HDBK-217F
NOTICE 1
10 JULY 1992

# MILITARY HANDBOOK
# RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT

To all holders of MIL-HDBK-217F

1. The following pages of MIL-HDBK-217F have been revised and supersede the pages listed.

| New Page(s) | Date | Superseded Page(s) | Date |
|---|---|---|---|
| vii | | vii | 2 December 1991 |
| 5-3 | | 5-3 | 2 December 1991 |
| 5-4 | | 5-4 | 2 December 1991 |
| 5-7 | | 5-7 | 2 December 1991 |
| 5-8 | 2 December 1991 | 5-8 | Reprinted without change |
| 5-9 | | 5-9 | 2 December 1991 |
| 5-10 | 2 December 1991 | 5-10 | Reprinted without change |
| 5-11 | 2 December 1991 | 5-11 | Reprinted without change |
| 5-12 | | 5-12 | 2 December 1991 |
| 5-13 | | 5-13 | 2 December 1991 |
| 5-14 | 2 December 1991 | 5-14 | Reprinted without change |
| 5-19 | | 5-19 | 2 December 1991 |
| 5-20 | 2 December 1991 | 5-20 | Reprinted without change |
| 6-15 | | 6-15 | 2 December 1991 |
| 6-16 | 2 December 1991 | 6-16 | Reprinted without change |
| 7-1 | 2 December 1991 | 7-1 | Reprinted without change |
| 7-2 | | 7-2 | 2 December 1991 |
| 12-3 | | 12-3 | 2 December 1991 |
| 12-4 | 2 December 1991 | 12-4 | Reprinted without change |
| A-1 | 2 December 1991 | A-1 | Reprinted without change |
| A-2 | | A-2 | 2 December 1991 |
| A-3 | | A-3 | 2 December 1991 |
| A-4 | 2 December 1991 | A-4 | Reprinted without change |
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| A-10 | 2 December 1991 | A-10 | Reprinted without change |
| A-11 | 2 December 1991 | A-11 | Reprinted without change |
| A-12 | | A-12 | 2 December 1991 |
| A-13 | | A-13 | 2 December 1991 |
| A-14 | | A-14 | 2 December 1991 |
| A-15 | 2 December 1991 | A-15 | Reprinted without change |
| A-16 | | A-16 | 2 December 1991 |

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AREA-RELI

2. Retain the pages of this notice and insert before the Table of Contents.

3. Holders of MIL-HDBK-217F will verify that page changes and additions indicated have been entered. The notice pages will be retained as a check sheet. The issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the military handbook is revised or canceled.

Custodians:
Army - CR
Navy - EC
Air Force - 17

Preparing Activity:
Air Force - 17

Project No. RELI-0068

Review Activities:
Army - MI, AV, ER
Navy - SH, AS, OS
Air Force - 11, 13, 14, 15, 18, 19, 99

User Activities:
Army - AT, ME, GL
Navy - CG, MC, YD, TD
Air Force - 85

## FOREWORD

MIL-HDBK-217F, Notice 1 is issued to correct minor typographical errors in the basic F Revision. MIL-HDBK-217F (base document) provides the following changes based upon recently completed studies (see Ref. 30 and 32 listed in Appendix C):

1. New failure rate prediction models are provided for the following nine major classes of microcircuits:

   - Monolithic Bipolar Digital and Linear Gate/Logic Array Devices
   - Monolithic MOS Digital and Linear Gate/Logic Array Devices
   - Monolithic Bipolar and MOS Digital Microprocessor Devices (Including Controllers)
   - Monolithic Bipolar and MOS Memory Devices
   - Monolithic GaAs Digital Devices
   - Monolithic GaAs MMIC Devices
   - Hybrid Microcircuits
   - Magnetic Bubble Memories
   - Surface Acoustic Wave Devices

This revision provides new prediction models for bipolar and MOS microcircuits with gate counts up to 60,000, linear microcircuits with up to 3000 transistors, bipolar and MOS digital microprocessor and co-processors up to 32 bits, memory devices with up to 1 million bits, GaAs monolithic microwave integrated circuits (MMICs) with up to 1,000 active elements, and GaAs digital ICs with up to 10,000 transistors. The $C_1$ factors have been extensively revised to reflect new technology devices with improved reliability, and the activation energies representing the temperature sensitivity of the dice ($\pi_T$) have been changed for MOS devices and for memories. The $C_2$ factor remains unchanged from the previous Handbook version, but includes pin grid arrays and surface mount packages using the same model as hermetic, solder-sealed dual in-line packages. New values have been included for the quality factor ($\pi_Q$), the learning factor ($\pi_L$), and the environmental factor ($\pi_E$). The model for hybrid microcircuits has been revised to be simpler to use, to delete the temperature dependence of the seal and interconnect failure rate contributions, and to provide a method of calculating chip junction temperatures.

2. A new model for Very High Speed Integrated Circuits (VHSIC/VHSIC Like) and Very Large Scale Integration (VLSI) devices (gate counts above 60,000).
3. The reformatting of the entire handbook to make it easier to use.
4. A reduction in the number of environmental factors ($\pi_E$) from 27 to 14.
5. A revised failure rate model for Network Resistors.
6. Revised models for TWTs and Klystrons based on data supplied by the Electronic Industries Association Microwave Tube Division.

## 5.1 MICROCIRCUITS, GATE/LOGIC ARRAYS AND MICROPROCESSORS

**DESCRIPTION**

1. Bipolar Devices, Digital and Linear Gate/Logic Arrays
2. MOS Devices, Digital and Linear Gate/Logic Arrays
3. Field Programmable Logic Array (PLA) and Programmable Array Logic (PAL)
4. Microprocessors

$$\lambda_p = (C_1\pi_T + C_2\pi_E)\,\pi_Q\pi_L \text{ Failures}/10^6 \text{ Hours}$$

Bipolar Digital and Linear Gate/Logic Array Die Complexity Failure Rate - $C_1$

| Digital | | Linear | | PLA/PAL | |
|---|---|---|---|---|---|
| No. Gates | $C_1$ | No. Transistors | $C_1$ | No. Gates | $C_1$ |
| 1 to 100 | .0025 | 1 to 100 | .010 | Up to 200 | .010 |
| 101 to 1,000 | .0050 | 101 to 300 | .020 | 201 to 1,000 | .021 |
| 1,001 to 3,000 | .010 | 301 to 1,000 | .040 | 1,001 to 5,000 | .042 |
| 3,001 to 10,000 | .020 | 1,001 to 10,000 | .060 | | |
| 10,001 to 30,000 | .040 | | | | |
| 30,001 to 60,000 | .080 | | | | |

MOS Digital and Linear Gate/Logic Array Die Complexity Failure Rate - $C_1$*

| Digital | | Linear | | PLA/PAL | |
|---|---|---|---|---|---|
| No. Gates | $C_1$ | No. Transistors | $C_1$ | No. Gates | $C_1$ |
| 1 to 100 | .010 | 1 to 100 | .010 | Up to 500 | .00085 |
| 101 to 1,000 | .020 | 101 to 300 | .020 | 501 to 2,000 | .0017 |
| 1,001 to 3,000 | .040 | 301 to 1,000 | .040 | 2,001 to 5,000 | .0034 |
| 3,001 to 10,000 | .080 | 1,001 to 10,000 | .060 | 5,001 to 20,000 | .0068 |
| 10,001 to 30,000 | .16 | | | | |
| 30,001 to 60,000 | .29 | | | | |

*NOTE: For CMOS gate counts above 60,000 use the VHSIC/VHSIC-Like model in Section 5.3

Microprocessor
Die Complexity Failure Rate - $C_1$

| No. Bits | Bipolar $C_1$ | MOS $C_1$ |
|---|---|---|
| Up to 8 | .060 | .14 |
| Up to 16 | .12 | .28 |
| Up to 32 | .24 | .56 |

All Other Model Parameters

| Parameter | Refer to |
|---|---|
| $\pi_T$ | Section 5.8 |
| $C_2$ | Section 5.9 |
| $\pi_E, \pi_Q, \pi_L$ | Section 5.10 |

## 5.2 MICROCIRCUITS, MEMORIES

**DESCRIPTION**
1. Read Only Memories (ROM)
2. Programmable Read Only Memories (PROM)
3. Ultraviolet Eraseable PROMs (UVEPROM)
4. "Flash," MNOS and Floating Gate Electrically Eraseable PROMs (EEPROM). Includes both floating gate tunnel oxide (FLOTOX) and textured polysilicon type EEPROMs
5. Static Random Access Memories (SRAM)
6. Dynamic Random Access Memories (DRAM)

$$\lambda_p = (C_1 \pi_T + C_2 \pi_E + \lambda_{cyc}) \pi_Q \pi_L \text{ Failures}/10^6 \text{ Hours}$$

Die Complexity Failure Rate - $C_1$

| Memory Size, B (Bits) | MOS | | | | Bipolar | |
|---|---|---|---|---|---|---|
| | ROM | PROM, UVEPROM, EEPROM, EAPROM | DRAM | SRAM (MOS & BiCMOS) | ROM, PROM | SRAM |
| Up to 16K | .00065 | .00085 | .0013 | .0078 | .0094 | .0052 |
| $16K < B \le 64K$ | .0013 | .0017 | .0025 | .016 | .019 | .011 |
| $64K < B \le 256K$ | .0026 | .0034 | .0050 | .031 | .038 | .021 |
| $256K < B \le 1M$ | .0052 | .0068 | .010 | .062 | .075 | .042 |

$A_1$ Factor for $\lambda_{cyc}$ Calculation

| Total No. of Programming Cycles Over EEPROM Life, C | Flotox[1] | Textured-Poly[2] |
|---|---|---|
| Up to 100 | .00070 | .0097 |
| $100 < C \le 200$ | .0014 | .014 |
| $200 < C \le 500$ | .0034 | .023 |
| $500 < C \le 1K$ | .0068 | .033 |
| $1K < C \le 3K$ | .020 | .061 |
| $3K < C \le 7K$ | .049 | .14 |
| $7K < C \le 15K$ | .10 | .30 |
| $15K < C \le 20K$ | .14 | .30 |
| $20K < C \le 30K$ | .20 | .30 |
| $30K < C \le 100K$ | .68 | .30 |
| $100K < C \le 200K$ | 1.3 | .30 |
| $200K < C \le 400K$ | 2.7 | .30 |
| $400K < C \le 500K$ | 3.4 | .30 |

1. $A_1 = 6.817 \times 10^{-6}$ (C)
2. No underlying equation for Textured-Poly.

$A_2$ Factor for $\lambda_{cyc}$ Calculation

| Total No. of Programming Cycles Over EEPROM Life, C | Textured-Poly $A_2$ |
|---|---|
| Up to 300K | 0 |
| $300K < C \le 400K$ | 1.1 |
| $400K < C \le 500K$ | 2.3 |

All Other Model Parameters

| Parameter | Refer to |
|---|---|
| $\pi_T$ | Section 5.8 |
| $C_2$ | Section 5.9 |
| $\pi_E, \pi_Q, \pi_L$ | Section 5.10 |
| $\lambda_{cyc}$ (EEPROMS only) | Page 5-5 |
| $\lambda_{cyc} = 0$ For all other devices | |

## 5.3 MICROCIRCUITS, VHSIC/VHSIC-LIKE AND VLSI CMOS

**DESCRIPTION**
CMOS greater than 60,000 gates

$$\lambda_p = \lambda_{BD}\pi_{MFG}\pi_T\pi_{CD} + \lambda_{BP}\pi_E\pi_Q\pi_{PT} + \lambda_{EOS} \text{ Failures}/10^6 \text{ Hours}$$

Die Base Failure Rate - $\lambda_{BD}$

| Part Type | $\lambda_{BD}$ |
|---|---|
| Logic and Custom | 0.16 |
| Gate Array and Memory | 0.24 |

All Other Model Parameters

| Parameter | Refer to |
|---|---|
| $\pi_T$ | Section 5.8 |
| $\pi_E$, $\pi_Q$ | Section 5.10 |

Manufacturing Process Correction Factor - $\pi_{MFG}$

| Manufacturing Process | $\pi_{MFG}$ |
|---|---|
| QML or QPL | .55 |
| Non QML or Non QPL | 2.0 |

Package Type Correction Factor - $\pi_{PT}$

| Package Type | $\pi_{PT}$ Hermetic | $\pi_{PT}$ Nonhermetic |
|---|---|---|
| DIP | 1.0 | 1.3 |
| Pin Grid Array | 2.2 | 2.9 |
| Chip Carrier (Surface Mount Technology) | 4.7 | 6.1 |

Die Complexity Correction Factor - $\pi_{CD}$

| Feature Size (Microns) | Die Area (cm²) A ≤ .4 | .4 < A ≤ .7 | .7 < A ≤ 1.0 | 1.0 < A ≤ 2.0 | 2.0 < A ≤ 3.0 |
|---|---|---|---|---|---|
| .80 | 8.0 | 14 | 19 | 38 | 58 |
| 1.00 | 5.2 | 8.9 | 13 | 25 | 37 |
| 1.25 | 3.5 | 5.8 | 8.2 | 16 | 24 |

$$\pi_{CD} = \left(\left(\frac{A}{.21}\right)\left(\frac{2}{X_s}\right)^2(.64)\right) + .36$$

A = Total Scribed Chip Die Area in $cm^2$  $X_s$ = Feature Size (microns)

Die Area Conversion: $cm^2 = MIL^2 \div 155,000$

Package Base Failure Rate - $\lambda_{BP}$

| Number of Pins | $\lambda_{BP}$ |
|---|---|
| 24 | .0026 |
| 28 | .0027 |
| 40 | .0029 |
| 44 | .0030 |
| 48 | .0030 |
| 52 | .0031 |
| 64 | .0033 |
| 84 | .0036 |
| 120 | .0043 |
| 124 | .0043 |
| 144 | .0047 |
| 220 | .0060 |

$$\lambda_{BP} = .0022 + ((1.72 \times 10^{-5})(NP))$$

NP = Number of Package Pins

Electrical Overstress Failure Rate - $\lambda_{EOS}$

| $V_{TH}$ (ESD Susceptibility (Volts))* | $\lambda_{EOS}$ |
|---|---|
| 0 - 1000 | .065 |
| > 1000 - 2000 | .053 |
| > 2000 - 4000 | .044 |
| > 4000 - 16000 | .029 |
| > 16000 | .0027 |

$$\lambda_{EOS} = (-\ln(1 - .00057\exp(-.0002\,V_{TH})))/.00876$$

$V_{TH}$ = ESD Susceptibility (volts)

* Voltage ranges which will cause the part to fail. If unknown, use 0 - 1000 volts.

## 5.4 MICROCIRCUITS, GaAs MMIC AND DIGITAL DEVICES

**DESCRIPTION**
Gallium Arsenide Microwave Monolithic Integrated Circuit (GaAs MMIC) and GaAs Digital Integrated Circuits using MESFET Transistors and Gold Based Metallization

$$\lambda_p = [\, C_1 \pi_T \pi_A + C_2 \pi_E \,] \pi_L \pi_Q \text{ Failures}/10^6 \text{ Hours}$$

MMIC: Die Complexity Failure Rates - $C_1$

| Complexity (No. of Elements) | $C_1$ |
|---|---|
| 1 to 100 | 4.5 |
| 101 to 1000 | 7.2 |

1. $C_1$ accounts for the following active elements: transistors, diodes.

Digital: Die Complexity Failure Rates - $C_1$

| Complexity (No. of Elements) | $C_1$ |
|---|---|
| 1 to 1000 | 25 |
| 1,001 to 10,000 | 51 |

1. $C_1$ accounts for the following active elements: transistors, diodes.

Device Application Factor - $\pi_A$

| Application | $\pi_A$ |
|---|---|
| MMIC Devices | |
| Low Noise & Low Power (≤ 100 mW) | 1.0 |
| Driver & High Power (> 100 mW) | 3.0 |
| Unknown | 3.0 |
| Digital Devices | |
| All Digital Applications | 1.0 |

All Other Model Parameters

| Parameter | Refer to |
|---|---|
| $\pi_T$ | Section 5.8 |
| $C_2$ | Section 5.9 |
| $\pi_E$, $\pi_L$, $\pi_Q$ | Section 5.10 |

## DESCRIPTION
Hybrid Microcircuits

$$\lambda_p = [\,\Sigma\, N_c\, \lambda_c\,]\,(1 + .2\,\pi_E)\,\pi_F\,\pi_Q\,\pi_L \quad \text{Failures}/10^6 \text{ Hours}$$

$N_c$ = Number of Each Particular Component
$\lambda_c$ = Failure Rate of Each Particular Component

The general procedure for developing an overall hybrid failure rate is to calculate an individual failure rate for each component type used in the hybrid and then sum them. This summation is then modified to account for the overall hybrid function ($\pi_F$), screening level ($\pi_Q$), and maturity ($\pi_L$). The hybrid package failure rate is a function of the active component failure modified by the environmental factor (i.e., (1 + .2 $\pi_E$) ). Only the component types listed in the following table are considered to contribute significantly to the overall failure rate of most hybrids. All other component types (e.g., resistors, inductors, etc.) are considered to contribute insignificantly to the overall hybrid failure rate, and are assumed to have a failure rate of zero. This simplification is valid for most hybrids; however, if the hybrid consists of mostly passive components then a failure rate should be calculated for these devices. If factoring in other component types, assume $\pi_Q$ = 1, $\pi_E$ =1 and $T_A$ = Hybrid Case Temperature for these calculations.

Determination of $\lambda_c$

| Determine $\lambda_c$ for These Component Types | Handbook Section | Make These Assumptions When Determining $\lambda_c$ |
|---|---|---|
| Microcircuits | 5 | $C_2$ = 0, $\pi_Q$ = 1, $\pi_L$ = 1, $T_J$ as Determined from Section 5.12, $\lambda_{BP}$ = 0 (for VHSIC), $\pi_E$ = 1 (for SAW). |
| Discrete Semiconductors | 6 | $\pi_Q$ = 1, $T_J$ as Determined from Section 6.14, $\pi_E$ = 1. |
| Capacitors | 10 | $\pi_Q$ = 1, $T_A$ = Hybrid Case Temperature, $\pi_E$ = 1. |

NOTE: If maximum rated stress for a die is unknown, assume the same as for a discretely package die of the same type. If the same die has several ratings based on the discrete packaged type, assume the lowest rating. Power rating used should be based on case temperature for discrete semiconductors.

Circuit Function Factor - $\pi_F$

| Circuit Type | $\pi_F$ |
|---|---|
| Digital | 1.0 |
| Video, 10 MHz < f < 1 GHz | 1.2 |
| Microwave, f > 1 GHz | 2.6 |
| Linear, f < 10 MHz | 5.8 |
| Power | 21 |

All Other Hybrid Model Parameters

| | |
|---|---|
| $\pi_L$, $\pi_Q$, $\pi_E$ | Refer to Section 5.10 |

## 5.6 MICROCIRCUITS, SAW DEVICES

**DESCRIPTION**
Surface Acoustic Wave Devices

$$\lambda_p = 2.1\, \pi_Q\, \pi_E \text{ Failures}/10^6 \text{ Hours}$$

Quality Factor - $\pi_Q$

| Screening Level | $\pi_Q$ |
|---|---|
| 10 Temperature Cycles (-55°C to +125°C) with end point electrical tests at temperature extremes. | .10 |
| None beyond best commerical practices. | 1.0 |

Environmental Factor - $\pi_E$

| Environment | $\pi_E$ |
|---|---|
| $G_B$ | .5 |
| $G_F$ | 2.0 |
| $G_M$ | 4.0 |
| $N_S$ | 4.0 |
| $N_U$ | 6.0 |
| $A_{IC}$ | 4.0 |
| $A_{IF}$ | 5.0 |
| $A_{UC}$ | 5.0 |
| $A_{UF}$ | 8.0 |
| $A_{RW}$ | 8.0 |
| $S_F$ | .50 |
| $M_F$ | 5.0 |
| $M_L$ | 12 |
| $C_L$ | 220 |

## 5.7 MICROCIRCUITS, MAGNETIC BUBBLE MEMORIES

The magnetic bubble memory device in its present form is a non-hermetic assembly consisting of the following two major structural segments:

1. A basic bubble chip or die consisting of memory or a storage area (e.g., an array of minor loops), and required control and detection elements (e.g., generators, various gates and detectors).
2. A magnetic structure to provide controlled magnetic fields consisting of permanent magnets, coils, and a housing.

These two structural segments of the device are interconnected by a mechanical substrate and lead frame. The interconnect substrate in the present technology is normally a printed circuit board. It should be noted that this model does not include external support microelectronic devices required for magnetic bubble memory operation. The model is based on Reference 33. The general form of the failure rate model is:

$$\lambda_p = \lambda_1 + \lambda_2 \text{ Failures}/10^6 \text{ Hours}$$

where:

$\lambda_1$ = Failure Rate of the Control and Detection Structure

$$\lambda_1 = \pi_Q [N_C C_{11} \pi_{T1} \pi_W + (N_C C_{21} + C_2)\pi_E] \pi_D \pi_L$$

$\lambda_2$ = Failure Rate of the Memory Storage Area

$$\lambda_2 = \pi_Q N_C (C_{12} \pi_{T2} + C_{22} \pi_E) \pi_L$$

**Chips Per Package - $N_C$**

| | | |
|---|---|---|
| $N_C$ | = | Number of Bubble Chips per Packaged Device |

**Temperature Factor – $\pi_T$**

$$\pi_T = (.1) \exp\left[\frac{-Ea}{8.63 \times 10^{-5}} \left(\frac{1}{T_J + 273} - \frac{1}{298}\right)\right]$$

Use:

| | | |
|---|---|---|
| $E_a$ | = | .8 to Calculate $\pi_{T1}$ |
| $E_a$ | = | .55 to Calculate $\pi_{T2}$ |
| $T_J$ | = | Junction Temperature (°C), $25 \le T_J \le 175$ |
| $T_J$ | = | $T_{CASE}$ + 10°C |

**Device Complexity Failure Rates for Control and Detection Structure - $C_{11}$ and $C_{21}$**

| | | |
|---|---|---|
| $C_{11}$ | = | $.00095(N_1)^{.40}$ |
| $C_{21}$ | = | $.0001(N_1)^{.226}$ |
| $N_1$ | = | Number of Dissipative Elements on a Chip (gates, detectors, generators, etc.), $N_1 \le 1000$ |

## 5.7 MICROCIRCUIT, MAGNETIC BUBBLE MEMORIES

Write Duty Cycle Factor - $\pi_W$

$$\pi_W = \frac{10D}{(R/W)^{.3}}$$

$\pi_W = 1$ for $D \le .03$ or $R/W \ge 2154$

$$D = \frac{\text{Avg. Device Data Rate}}{\text{Mfg. Max. Rated Data Rate}} \le 1$$

R/W = No. of Reads per Write

NOTE:
For seed-bubble generators, divide $\pi_W$ by 4, or use 1, whichever is greater.

Duty Cycle Factor - $\pi_D$

$$\pi_D = .9D + .1$$

$$D = \frac{\text{Avg. Device Data Rate}}{\text{Mfg. Max. Rated Data Rate}} \le 1$$

Device Complexity Failure Rates for Memory Storage Structure - $C_{12}$ and $C_{22}$

$$C_{12} = .00007(N_2)^{.3}$$

$$C_{22} = .00001(N_2)^{.3}$$

$N_2$ = Number of Bits, $N_2 \le 9 \times 10^6$

All Other Model Parameters

| Parameter | Section |
|---|---|
| $C_2$ | 5.9 |
| $\pi_E$, $\pi_Q$, $\pi_L$ | 5.10 |

Temperature Factor For All Microcircuits - $\pi_T$

| | TTL, STTL, ASTTL, CML, HTTL, FTTL, DTL, ECL | BiCMOS, LSTTL, LTTL, ALSTTL | IIL, ISL | Digital MOS, VHSIC CMOS | Linear (Bipolar & MOS) | Memories (Bipolar & MOS), MNOS | GaAs MMIC | GaAs Digital |
|---|---|---|---|---|---|---|---|---|
| Ea(eV) → $T_J$ (°C) | .4 | .5 | .6 | .35 | .65 | .6 | 1.5 | 1.4 |
| 25 | .10 | .10 | .10 | .10 | .10 | .10 | 3.20E-09 | 1.00E-08 |
| 30 | .13 | .14 | .15 | .13 | .15 | .15 | 8.40E-09 | 2.50E-08 |
| 35 | .17 | .19 | .21 | .16 | .23 | .21 | 2.10E-08 | 5.90E-08 |
| 40 | .21 | .25 | .31 | .19 | .34 | .31 | 5.20E-08 | 1.40E-07 |
| 45 | .27 | .34 | .43 | .24 | .49 | .43 | 1.30E-07 | 3.10E-07 |
| 50 | .33 | .45 | .61 | .29 | .71 | .61 | 2.90E-07 | 6.80E-07 |
| 55 | .42 | .59 | .85 | .35 | 1.0 | .85 | 6.70E-07 | 1.50E-06 |
| 60 | .51 | .77 | 1.2 | .42 | 1.4 | 1.2 | 1.50E-06 | 3.10E-06 |
| 65 | .63 | 1.0 | 1.6 | .50 | 2.0 | 1.6 | 3.20E-06 | 6.40E-06 |
| 70 | .77 | 1.3 | 2.1 | .60 | 2.8 | 2.1 | 6.80E-06 | 1.30E-05 |
| 75 | .94 | 1.6 | 2.9 | .71 | 3.8 | 2.9 | 1.40E-05 | 2.50E-05 |
| 80 | 1.1 | 2.1 | 3.8 | .84 | 5.2 | 3.8 | 2.90E-05 | 4.90E-05 |
| 85 | 1.4 | 2.6 | 5.0 | .98 | 7.0 | 5.0 | 5.70E-05 | 9.40E-05 |
| 90 | 1.6 | 3.3 | 6.6 | 1.1 | 9.3 | 6.6 | 1.10E-04 | 1.70E-04 |
| 95 | 1.9 | 4.1 | 8.5 | 1.3 | 12 | 8.5 | 2.10E-04 | 3.20E-04 |
| 100 | 2.3 | 5.0 | 11 | 1.5 | 16 | 11 | 4.00E-04 | 5.80E-04 |
| 105 | 2.7 | 6.2 | 14 | 1.8 | 21 | 14 | 7.50E-04 | 1.00E-03 |
| 110 | 3.2 | 7.5 | 18 | 2.1 | 28 | 18 | 1.40E-03 | 1.80E-03 |
| 115 | 3.7 | 9.2 | 23 | 2.4 | 35 | 23 | 2.40E-03 | 3.10E-03 |
| 120 | 4.3 | 11 | 28 | 2.7 | 45 | 28 | 4.30E-03 | 5.30E-03 |
| 125 | 5 | 13 | 35 | 3.1 | 58 | 35 | 7.50E-03 | 9.00E-03 |
| 130 | 5.8 | 16 | 44 | 3.5 | 73 | 44 | 1.30E-02 | 1.50E-02 |
| 135 | 6.7 | 19 | 54 | 3.9 | 92 | 54 | 2.20E-02 | 2.40E-02 |
| 140 | 7.7 | 23 | 67 | 4.4 | 120 | 67 | 3.70E-02 | 3.90E-02 |
| 145 | 8.8 | 27 | 82 | 5.0 | 140 | 82 | 6.10E-02 | 6.30E-02 |
| 150 | 10 | 32 | 100 | 5.6 | 180 | 100 | 1.00E-01 | 1.00E-01 |
| 155 | 11 | 37 | 120 | 6.3 | 220 | 120 | 1.60E-01 | 1.60E-01 |
| 160 | 13 | 43 | 150 | 7.0 | 270 | 150 | 2.60E-01 | 2.40E-01 |
| 165 | 15 | 50 | 180 | 7.8 | 330 | 180 | 4.10E-01 | 3.70E-01 |
| 170 | 16 | 58 | 210 | 8.7 | 400 | 210 | 6.40E-01 | 5.70E-01 |
| 175 | 18 | 68 | 250 | 9.6 | 480 | 250 | 9.90E-01 | 8.50E-01 |

$$\pi_T = .1 \exp\left(\frac{-Ea}{8.617 \times 10^{-5}}\left(\frac{1}{T_J + 273} - \frac{1}{298}\right)\right)$$ Silicon Devices

$$\pi_T = .1 \exp\left(\frac{-Ea}{8.617 \times 10^{-5}}\left(\frac{1}{T_J + 273} - \frac{1}{423}\right)\right)$$ GaAs Devices

$E_a$ = Effective Activation Energy (eV) (Shown Above)

$T_J$ = Worse Case Junction Temperature (Silicon Devices) or Average Active Device Channel Temperature (GaAs Devices). See Section 5.11 (or Section 5.12 for Hybrids) for $T_J$ Determination.

NOTES:

1. $T_J = T_C + P\theta_{JC}$
   - $T_C$ = Case Temperature (°C)
   - $P$ = Device Power Dissipation (W)
   - $\theta_{JC}$ = Junction to Case Thermal Resistance (°C/W)

   $\theta_{JC}$ should be obtained from the device manufacturer, MIL-M-38510, or from the default values shown in Section 5.11 for the closest equivalent device.

2. Use Digital MOS column for HC, HCT, AC, ACT, C and FCT technologies.
3. Table entries should be considered valid only up to the rated temperature of the component under consideration.

## 5.9 MICROCIRCUITS, $C_2$ TABLE FOR ALL

Package Failure Rate for all Microcircuits - $C_2$

| | Package Type | | | | |
|---|---|---|---|---|---|
| Number of Functional Pins, $N_p$ | Hermetic: DIPs w/Solder or Weld Seal, Pin Grid Array (PGA)[1], SMT (Leaded and Nonleaded) | DIPs with Glass Seal[2] | Flatpacks with Axial Leads on 50 Mil Centers[3] | Cans[4] | Nonhermetic: DIPs, PGA, SMT (Leaded and Nonleaded)[5] |
| 3 | .00092 | .00047 | .00022 | .00027 | .0012 |
| 4 | .0013 | .00073 | .00037 | .00049 | .0016 |
| 6 | .0019 | .0013 | .00078 | .0011 | .0025 |
| 8 | .0026 | .0021 | .0013 | .0020 | .0034 |
| 10 | .0034 | .0029 | .0020 | .0031 | .0043 |
| 12 | .0041 | .0038 | .0028 | .0044 | .0053 |
| 14 | .0048 | .0048 | .0037 | .0060 | .0062 |
| 16 | .0056 | .0059 | .0047 | .0079 | .0072 |
| 18 | .0064 | .0071 | .0058 | | .0082 |
| 22 | .0079 | .0096 | .0083 | | .010 |
| 24 | .0087 | .011 | .0098 | | .011 |
| 28 | .010 | .014 | | | .013 |
| 36 | .013 | .020 | | | .017 |
| 40 | .015 | .024 | | | .019 |
| 64 | .025 | .048 | | | .032 |
| 80 | .032 | | | | .041 |
| 128 | .053 | | | | .068 |
| 180 | .076 | | | | .098 |
| 224 | .097 | | | | .12 |

1. $C_2 = 2.8 \times 10^{-4} (N_p)^{1.08}$

2. $C_2 = 9.0 \times 10^{-5} (N_p)^{1.51}$

3. $C_2 = 3.0 \times 10^{-5} (N_p)^{1.82}$

4. $C_2 = 3.0 \times 10^{-5} (N_p)^{2.01}$

5. $C_2 = 3.6 \times 10^{-4} (N_p)^{1.08}$

NOTES:

1. SMT: Surface Mount Technology
2. DIP: Dual In-Line Package
3. If DIP Seal type is unknown, assume glass
4. The package failure rate ($C_2$) accounts for failures associated only with the package itself. Failures associated with mounting the package to a circuit board are accounted for in Section 16, Interconnection Assemblies.

## 5.12 MICROCIRCUITS, $T_J$ DETERMINATION, (FOR HYBRIDS)

Typical Hybrid Characteristics

| Material | Typical Usage | Typical Thickness, $L_i$ (in.) | Feature From Figure 5-1 | Thermal Conductivity, $K_i$ $\left(\frac{W/in^2}{°C/in}\right)$ | $\left(\frac{1}{K_i}\right)(L_i)$ $(in^2\ °C/W)$ |
|---|---|---|---|---|---|
| Silicon | Chip Device | 0.010 | A | 2.20 | .0045 |
| GaAs | Chip Device | 0.0070 | A | .76 | .0092 |
| Au Eutectic | Chip Attach | 0.0001 | B | 6.9 | .000014 |
| Solder | Chip/Substrate Attach | 0.0030 | B/E | 1.3 | .0023 |
| Epoxy (Dielectric) | Chip/Substrate Attach | 0.0035 | B/E | .0060 | .58 |
| Epoxy (Conductive) | Chip Attach | 0.0035 | B | .15 | .023 |
| Thick Film Dielectric | Glass Insulating Layer | 0.0030 | C | .66 | .0045 |
| Alumina | Substrate, MHP | 0.025 | D | .64 | .039 |
| Beryllium Oxide | Substrate, PHP | 0.025 | D | 6.6 | .0038 |
| Kovar | Case, MHP | 0.020 | F | .42 | .048 |
| Aluminum | Case, MHP | 0.020 | F | 4.6 | .0043 |
| Copper | Case, PHP | 0.020 | F | 9.9 | .0020 |

NOTE: MHP: Multichip Hybrid Package, PHP: Power Hybrid Package (Pwr: ≥ 2W, Typically)

$$\theta_{JC} = \frac{\sum_{i=1}^{n} \left(\frac{1}{K_i}\right)(L_i)}{A}$$

n = Number of Material Layers

$K_i$ = Thermal Conductivity of $i^{th}$ Material $\left(\frac{W/in^2}{°C/in}\right)$ (User Provided or From Table)

$L_i$ = Thickness of $i^{th}$ Material (in) (User Provided or From Table)

A = Die Area ($in^2$). If Die Area cannot be readily determined, estimate as follows:
$A = [\ .00278\ (\text{No. of Die Active Wire Terminals}) + .0417]^2$

Estimate $T_J$ as Follows:

$$T_J = T_C + (\theta_{JC})\ (P_D)$$

$T_C$ = Hybrid Case Temperature (°C). If unknown, use the $T_C$ Default Table shown in Section 5.11.

$\theta_{JC}$ = Junction-to-Case Thermal Resistance (°C/W) (As determined above)

$P_D$ = Die Power Dissipation (W)

## 5.13 MICROCIRCUITS, EXAMPLES

### Example 1: CMOS Digital Gate Array

Given: A CMOS digital timing chip (4046) in an airborne inhabited cargo application, case temperature 48°C, 75mW power dissipation. The device is procured with normal manufacturer's screening consisting of temperature cycling, constant acceleration, electrical testing, seal test and external visual inspection, in the sequence given. The component manufacturer also performs a B-level burn-in followed by electrical testing. All screens and tests are performed to the applicable MIL-STD-883 screening method. The package is a 24 pin ceramic DIP with a glass seal. The device has been manufactured for several years and has 1000 transistors.

$$\lambda_p = (C_1\pi_T + C_2\pi_E)\,\pi_Q\pi_L$$ Section 5.1

$C_1$ = .020 — 1000 Transistors = 250 Gates, MOS $C_1$ Table, Digital Column

$\pi_T$ = .29 — Determine $T_J$ from Section 5.11
$T_J$ = 48°C + (28°C/W)(.075W) = 50°C
Determine $\pi_T$ from Section 5.8, Digital MOS Column.

$C_2$ = .011 — Section 5.9

$\pi_E$ = 4.0 — Section 5.10

$\pi_Q$ = 3.1 — Section 5.10

| | |
|---|---|
| Group 1 Tests | 50 Points |
| Group 3 Tests (B-level) | 30 Points |
| TOTAL | 80 Points |

$$\pi_Q = 2 + \frac{87}{80} = 3.1$$

$\pi_L$ = 1 — Section 5.10

$$\lambda_p = [\,(.020)(.29) + (.011)(4)\,]\,(3.1)(1) = .15 \text{ Failure}/10^6 \text{ Hours}$$

### Example 2: EEPROM

Given: A 128K Flotox EEPROM that is expected to have a $T_J$ of 80°C and experience 10,000 read/write cycles over the life of the system. The part is procured to all requirements of Paragraph 1.2.1, MIL-STD-883, Class B screening level requirements and has been in production for three years. It is packaged in a 28 pin DIP with a glass seal and will be used in an airborne uninhabited cargo application.

$$\pi_p = (C_1\,\pi_T + C_2\,\pi_E + \lambda_{cyc})\,\pi_Q\,\pi_L$$ Section 5.2

$C_1$ = .0034 — Section 5.2

$\pi_T$ = 3.8 — Section 5.8

$C_2$ = .014 — Section 5.9

Matching Network Factor - $\pi_M$

| Matching | $\pi_M$ |
|---|---|
| Input and Output | 1.0 |
| Input Only | 2.0 |
| None | 4.0 |

Quality Factor - $\pi_Q$

| Quality | $\pi_Q$ |
|---|---|
| JANTXV | .50 |
| JANTX | 1.0 |
| JAN | 2.0 |
| Lower | 5.0 |

Environment Factor - $\pi_E$

| Environment | $\pi_E$ |
|---|---|
| $G_B$ | 1.0 |
| $G_F$ | 2.0 |
| $G_M$ | 5.0 |
| $N_S$ | 4.0 |
| $N_U$ | 11 |
| $A_{IC}$ | 4.0 |
| $A_{IF}$ | 5.0 |
| $A_{UC}$ | 7.0 |
| $A_{UF}$ | 12 |
| $A_{RW}$ | 16 |
| $S_F$ | .50 |
| $M_F$ | 9.0 |
| $M_L$ | 24 |
| $C_L$ | 250 |

## 6.9 TRANSISTORS, HIGH FREQUENCY, SI FET

**SPECIFICATION**
MIL-S-19500

**DESCRIPTION**
Si FETs (Avg. Power < 300 mW, Freq. > 400 MHz)

$$\lambda_p = \lambda_b \pi_T \pi_Q \pi_E \quad \text{Failures}/10^6 \text{ Hours}$$

Base Failure Rate - $\lambda_b$

| Transistor Type | $\lambda_b$ |
|---|---|
| MOSFET | .060 |
| JFET | .023 |

Temperature Factor - $\pi_T$

| $T_J$ (°C) | $\pi_T$ | $T_J$ (°C) | $\pi_T$ |
|---|---|---|---|
| 25 | 1.0 | 105 | 3.9 |
| 30 | 1.1 | 110 | 4.2 |
| 35 | 1.2 | 115 | 4.5 |
| 40 | 1.4 | 120 | 4.8 |
| 45 | 1.5 | 125 | 5.1 |
| 50 | 1.6 | 130 | 5.4 |
| 55 | 1.8 | 135 | 5.7 |
| 60 | 2.0 | 140 | 6.0 |
| 65 | 2.1 | 145 | 6.4 |
| 70 | 2.3 | 150 | 6.7 |
| 75 | 2.5 | 155 | 7.1 |
| 80 | 2.7 | 160 | 7.5 |
| 85 | 3.0 | 165 | 7.9 |
| 90 | 3.2 | 170 | 8.3 |
| 95 | 3.4 | 175 | 8.7 |
| 100 | 3.7 | | |

$$\pi_T = \exp\left(-1925\left(\frac{1}{T_J + 273} - \frac{1}{298}\right)\right)$$

$T_J$ = Junction Temperature (°C)

Quality Factor - $\pi_Q$

| Quality | $\pi_Q$ |
|---|---|
| JANTXV | .50 |
| JANTX | 1.0 |
| JAN | 2.0 |
| Lower | 5.0 |

Environment Factor - $\pi_E$

| Environment | $\pi_E$ |
|---|---|
| $G_B$ | 1.0 |
| $G_F$ | 2.0 |
| $G_M$ | 5.0 |
| $N_S$ | 4.0 |
| $N_U$ | 11 |
| $A_{IC}$ | 4.0 |
| $A_{IF}$ | 5.0 |
| $A_{UC}$ | 7.0 |
| $A_{UF}$ | 12 |
| $A_{RW}$ | 16 |
| $S_F$ | .50 |
| $M_F$ | 9.0 |
| $M_L$ | 24 |
| $C_L$ | 250 |

## 7.1 TUBES, ALL TYPES EXCEPT TWT AND MAGNETRON

**DESCRIPTION**
All Types Except Traveling Wave Tubes and Magnetrons. Includes Receivers, CRT, Thyratron, Crossed Field Amplifier, Pulsed Gridded, Transmitting, Vidicons, Twystron, Pulsed Klystron, CW Klystron

$$\lambda_p = \lambda_b \pi_L \pi_E \text{ Failures}/10^6 \text{ Hours}$$

Base Failure Rate - $\lambda_b$
**(Includes Both Random and Wearout Failures)**

| Tube Type | $\lambda_b$ |
|---|---|
| Receiver | |
| Triode, Tetrode, Pentode | 5.0 |
| Power Rectifier | 10 |
| CRT | 9.6 |
| Thyratron | 50 |
| Crossed Field Amplifier | |
| QK681 | 260 |
| SFD261 | 150 |
| Pulsed Gridded | |
| 2041 | 140 |
| 6952 | 390 |
| 7835 | 140 |
| Transmitting | |
| Triode, Peak Pwr. ≤ 200 KW, Avg. Pwr. ≤ 2KW, Freq. ≤ 200 MHz | 75 |
| Tetrode & Pentode, Peak Pwr. ≤ 200 KW, Avg. Power ≤ 2KW, Freq. ≤ 200 KW | 100 |
| If any of the above limits exceeded | 250 |
| Vidicon | |
| Antimony Trisulfide ($Sb_2S_3$) Photoconductive Material | 51 |
| Silicon Diode Array Photoconductive Material | 48 |
| Twystron | |
| VA144 | 850 |
| VA145E | 450 |
| VA145H | 490 |
| VA913A | 230 |
| Klystron, Pulsed* | |
| 4KMP10000LF | 43 |
| 8568 | 230 |
| L3035 | 66 |
| L3250 | 69 |
| L3403 | 93 |
| SAC42A | 100 |
| VA842 | 18 |
| Z5010A | 150 |
| ZM3038A | 190 |

* If the pulsed Klystron of interest is not listed above, use the Alternate Pulsed Klystron $\lambda_b$ Table on the following page.

| Tube Type | $\lambda_b$ |
|---|---|
| Klystron, Low Power, (e.g. Local Oscillator) | 30 |
| Klystron, Continuous Wave* | |
| 3K3000LQ | 9.0 |
| 3K50000LF | 54 |
| 3K210000LQ | 150 |
| 3KM300LA | 64 |
| 3KM3000LA | 19 |
| 3KM50000PA | 110 |
| 3KM50000PA1 | 120 |
| 3KM50000PA2 | 150 |
| 4K3CC | 610 |
| 4K3SK | 29 |
| 4K50000LQ | 30 |
| 4KM50LB | 28 |
| 4KM50LC | 15 |
| 4KM50SJ | 38 |
| 4KM50SK | 37 |
| 4KM3000LR | 140 |
| 4KM50000LQ | 79 |
| 4KM50000LR | 57 |
| 4KM170000LA | 15 |
| 8824 | 130 |
| 8825 | 120 |
| 8826 | 280 |
| VA800E | 70 |
| VA853 | 220 |
| VA856B | 65 |
| VA888E | 230 |

* If the CW Klystron of interest is not listed above, use the Alternate CW Klystron $\lambda_b$ Table on the following page.

## 7.1 TUBES, ALL TYPES EXCEPT TWT AND MAGNETRON

Alternate* Base Failure Rate for Pulsed Klystrons - $\lambda_b$

| P(MW) | F(GHz) .2 | .4 | .6 | .8 | 1.0 | 2.0 | 4.0 | 6.0 |
|---|---|---|---|---|---|---|---|---|
| .01 | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |
| .30 | 16 | 16 | 17 | 17 | 17 | 18 | 20 | 21 |
| .80 | 16 | 17 | 17 | 18 | 18 | 21 | 25 | 30 |
| 1.0 | 17 | 17 | 18 | 18 | 19 | 22 | 28 | 34 |
| 3.0 | 18 | 20 | 21 | 23 | 25 | 34 | 51 | |
| 5.0 | 19 | 22 | 25 | 28 | 31 | 45 | 75 | |
| 8.0 | 21 | 25 | 30 | 35 | 40 | 63 | 110 | |
| 10 | 22 | 28 | 34 | 40 | 45 | 75 | | |
| 25 | 31 | 45 | 60 | 75 | 90 | 160 | | |

$\lambda_b$ = 2.94 (F)(P) + 16

F = Operating Frequency in GHz, $0.2 \le F \le 6$

P = Peak Output Power in MW, $.01 \le P \le 25$ and $P \le 490\ F^{-2.95}$

*See previous page for other Klystron Base Failure Rates.

Alternate* Base Failure Rate for CW Klystrons - $\lambda_b$

| P(KW) | F(MHz) 300 | 500 | 800 | 1000 | 2000 | 4000 | 6000 | 8000 |
|---|---|---|---|---|---|---|---|---|
| 0.1 | 30 | 31 | 33 | 34 | 38 | 47 | 57 | 66 |
| 1.0 | 31 | 32 | 33 | 34 | 39 | 48 | 57 | 66 |
| 3.0 | 32 | 33 | 34 | 35 | 40 | 49 | 58 | |
| 5.0 | 33 | 34 | 35 | 36 | 41 | 50 | | |
| 8.0 | 34 | 35 | 37 | 38 | 42 | | | |
| 10 | 35 | 36 | 38 | 39 | 43 | | | |
| 30 | 45 | 46 | 48 | 49 | | | | |
| 50 | 55 | 56 | 58 | 59 | | | | |
| 80 | 70 | 71 | 73 | | | | | |
| 100 | 80 | 81 | | | | | | |

$\lambda_b$ = 0.5P + .0046F + 29

P = Average Output Power in KW, $0.1 \le P \le 100$ and $P \le 8.0(10)^6(F)^{-1.7}$

F = Operating Frequency in MHz, $300 \le F \le 8000$

*See previous page for other Klystron Base Failure Rates.

Learning Factor - $\pi_L$

| T (years) | $\pi_L$ |
|---|---|
| ≤ 1 | 10 |
| 2 | 2.3 |
| ≥ 3 | 1.0 |

$\pi_L$ = $10(T)^{-2.1}$, $1 \le T \le 3$
= 10, $T \le 1$
= 1, $T \ge 3$

T = Number of Years since Introduction to Field Use

Environment Factor - $\pi_E$

| Environment | $\pi_E$ |
|---|---|
| $G_B$ | .50 |
| $G_F$ | 1.0 |
| $G_M$ | 14 |
| $N_S$ | 8.0 |
| $N_U$ | 24 |
| $A_{IC}$ | 5.0 |
| $A_{IF}$ | 8.0 |
| $A_{UC}$ | 6.0 |
| $A_{UF}$ | 12 |
| $A_{RW}$ | 40 |
| $S_F$ | .20 |
| $M_F$ | 22 |
| $M_L$ | 57 |
| $C_L$ | 1000 |

## 12.2 ROTATING DEVICES, SYNCHROS AND RESOLVERS

**DESCRIPTION**
Rotating Synchros and Resolvers

$$\lambda_p = \lambda_b \pi_S \pi_N \pi_E \text{ Failures}/10^6 \text{ Hours}$$

**NOTE:** Synchros and resolvers are predominately used in service requiring only slow and infrequent motion. Mechanical wearout problems are infrequent so that the electrical failure mode dominates, and no mechanical mode failure rate is required in the model above.

Base Failure Rate - $\lambda_b$

| $T_F$ (°C) | $\lambda_b$ | $T_F$ (°C) | $\lambda_b$ |
|---|---|---|---|
| 30 | .0083 | 85 | .032 |
| 35 | .0088 | 90 | .041 |
| 40 | .0095 | 95 | .052 |
| 45 | .010 | 100 | .069 |
| 50 | .011 | 105 | .094 |
| 55 | .013 | 110 | .13 |
| 60 | .014 | 115 | .19 |
| 65 | .016 | 120 | .29 |
| 70 | .019 | 125 | .45 |
| 75 | .022 | 130 | .74 |
| 80 | .027 | 135 | 1.3 |

$$\lambda_b = .00535 \exp\left(\frac{T_F + 273}{334}\right)^{8.5}$$

$T_F$ = Frame Temperature (°C)

If Frame Temperature is Unknown Assume
$T_F$ = 40 °C + Ambient Temperature

Size Factor - $\pi_S$

| DEVICE TYPE | $\pi_S$ Size 8 or Smaller | Size 10-16 | Size 18 or Larger |
|---|---|---|---|
| Synchro | 2 | 1.5 | 1 |
| Resolver | 3 | 2.25 | 1.5 |

Number of Brushes Factor - $\pi_N$

| Number of Brushes | $\pi_N$ |
|---|---|
| 2 | 1.4 |
| 3 | 2.5 |
| 4 | 3.2 |

Environment Factor - $\pi_E$

| Environment | $\pi_E$ |
|---|---|
| $G_B$ | 1.0 |
| $G_F$ | 2.0 |
| $G_M$ | 12 |
| $N_S$ | 7.0 |
| $N_U$ | 18 |
| $A_{IC}$ | 4.0 |
| $A_{IF}$ | 6.0 |
| $A_{UC}$ | 16 |
| $A_{UF}$ | 25 |
| $A_{RW}$ | 26 |
| $S_F$ | .50 |
| $M_F$ | 14 |
| $M_L$ | 36 |
| $C_L$ | 680 |

## 12.3 ROTATING DEVICES, ELAPSED TIME METERS

**DESCRIPTION**
Elapsed Time Meters

$$\lambda_p = \lambda_b \pi_T \pi_E \text{ Failures}/10^6 \text{ Hours}$$

Base Failure Rate - $\lambda_b$

| Type | $\lambda_b$ |
|---|---|
| A.C. | 20 |
| Inverter Driven | 30 |
| Commutator D.C. | 80 |

Temperature Stress Factor - $\pi_T$

| Operating T (°C)/Rated T (°C) | $\pi_T$ |
|---|---|
| 0 to .5 | .5 |
| .6 | .6 |
| .8 | .8 |
| 1.0 | 1.0 |

Environment Factor - $\pi_E$

| Environment | $\pi_E$ |
|---|---|
| $G_B$ | 1.0 |
| $G_F$ | 2.0 |
| $G_M$ | 12 |
| $N_S$ | 7.0 |
| $N_U$ | 18 |
| $A_{IC}$ | 5.0 |
| $A_{IF}$ | 8.0 |
| $A_{UC}$ | 16 |
| $A_{UF}$ | 25 |
| $A_{RW}$ | 26 |
| $S_F$ | .50 |
| $M_F$ | 14 |
| $M_L$ | 38 |
| $C_L$ | N/A |

**Parts Count Reliability Prediction** - This prediction method is applicable during bid proposal and early design phases when insufficient information is available to use the part stress analysis models shown in the main body of this Handbook. The information needed to apply the method is (1) generic part types (including complexity for microcircuits) and quantities, (2) part quality levels, and (3) equipment environment. The equipment failure rate is obtained by looking up a generic failure rate in one of the following tables, multiplying it by a quality factor, and then summing it with failure rates obtained for other components in the equipment. The general mathematical expression for equipment failure rate with this method is:

$$\lambda_{EQUIP} = \sum_{i=1}^{i=n} N_i (\lambda_g \pi_Q)_i \qquad \text{Equation 1}$$

for a given equipment environment where:

$\lambda_{EQUIP}$ = Total equipment failure rate (Failures/$10^6$ Hours)

$\lambda_g$ = Generic failure rate for the $i^{th}$ generic part (Failures/$10^6$ Hours)

$\pi_Q$ = Quality factor for the $i^{th}$ generic part

$N_i$ = Quantity of $i^{th}$ generic part

n = Number of different generic part categories in the equipment

Equation 1 applies if the entire equipment is being used in one environment. If the equipment comprises several units operating in different environments (such as avionics systems with units in airborne inhabited ($A_I$) and uninhabited ($A_U$) environments), then Equation 1 should be applied to the portions of the equipment in each environment. These "environment-equipment" failure rates should be added to determine total equipment failure rate. Environmental symbols are defined in Section 3.

The quality factors to be used with each part type are shown with the applicable $\lambda_g$ tables and are not necessarily the same values that are used in the Part Stress Analysis. Microcircuits have an additional multiplying factor, $\pi_L$, which accounts for the maturity of the manufacturing process. For devices in production two years or more, no modification is needed. For those in production less than two years, $\lambda_g$ should be multiplied by the appropriate $\pi_L$ factor (See page A-4).

It should be noted that no generic failure rates are shown for hybrid microcircuits. Each hybrid is a fairly unique device. Since none of these devices have been standardized, their complexity cannot be determined from their name or function. Identically or similarly named hybrids can have a wide range of complexity that thwarts categorization for purposes of this prediction method. If hybrids are anticipated for a design, their use and construction should be thoroughly investigated on an individual basis with application of the prediction model in Section 5.

The failure rates shown in this Appendix were calculated by assigning model default values to the failure rate models of Section 5 through 23. The specific default values used for the model parameters are shown with the $\lambda_g$ Tables for microcircuits. Default parameters for all other part classes are summarized in the tables starting on Page A-12. For parts with characteristics which differ significantly from the assumed defaults, or parts used in large quantities, the underlying models in the main body of this Handbook can be used.

Generic Failure Rate, $\lambda_g$ (Failures/$10^6$ Hours) for Microcircuits. See Page A-4 for $\pi_Q$ Values
(Defaults: $\pi_T$ Based on Ea Shown, Solder or Weld Seal DIPs/PGAs (No. Pins as Shown Below), $\pi_L$ = 1 (Device in Production ≥ 2 Yr.))

| Section # | Part Type | Environ. → $T_J$(°C) → | $G_B$ 50 | $G_F$ 60 | $G_M$ 65 | $N_S$ 60 | $N_u$ 65 | $A_{IC}$ 75 | $A_{IF}$ 75 | $A_{UC}$ 90 | $A_{UF}$ 90 | $A_{RW}$ 75 | $S_F$ 50 | $M_F$ 65 | $M_L$ 75 | $C_L$ 80 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Bipolar Technology** | | | | | | | | | | | | | | | |
| 5.1 | Gate/Logic Arrays, Digital (Ea = .4) | | | | | | | | | | | | | | | |
| | 1 - 100 Gates | (16 Pin DIP) | .0036 | .012 | .024 | .024 | .035 | .025 | .030 | .032 | .049 | .047 | .0036 | .030 | .069 | 1.2 |
| | 101 - 1000 Gates | (24 Pin DIP) | .0060 | .020 | .038 | .037 | .055 | .039 | .048 | .051 | .077 | .074 | .0060 | .046 | .11 | 1.9 |
| | 1001 to 3000 Gates | (40 Pin DIP) | .011 | .035 | .066 | .065 | .097 | .070 | .085 | .091 | .14 | .13 | .011 | .082 | .19 | 3.3 |
| | 3001 to 10,000 Gates | (128 Pin PGA) | .033 | .12 | .22 | .22 | .33 | .23 | .28 | .30 | .46 | .44 | .033 | .28 | .65 | 12 |
| | 10,000 to 30,000 Gates | (180 Pin PGA) | .052 | .17 | .33 | .33 | .48 | .34 | .42 | .45 | .68 | .65 | .052 | .41 | .95 | 17 |
| | 30,000 to 60,000 Gates | (224 Pin PGA) | .075 | .23 | .44 | .43 | .63 | .46 | .56 | .61 | .90 | .85 | .075 | .53 | 1.2 | 21 |
| 5.1 | Gate/Logic Arrays, Linear (Ea = .65) | | | | | | | | | | | | | | | |
| | 1 - 100 Transistors | (14 Pin DIP) | .0095 | .024 | .039 | .034 | .049 | .057 | .062 | .12 | .13 | .076 | .0095 | .044 | .096 | 1.1 |
| | 101 - 300 Transistors | (18 Pin DIP) | .017 | .041 | .065 | .054 | .078 | .10 | .11 | .22 | .24 | .13 | .017 | .072 | .15 | 1.4 |
| | 301 - 1000 Transistors | (24 Pin DIP) | .033 | .074 | .11 | .092 | .13 | .19 | .19 | .41 | .44 | .22 | .033 | .12 | .26 | 2.0 |
| | 1001 - 10,000 Transistors | (40 Pin DIP) | .050 | .12 | .18 | .15 | .21 | .29 | .30 | .63 | .67 | .35 | .050 | .19 | .41 | 3.4 |
| 5.1 | Programmable Logic Arrays (Ea = .4) | | | | | | | | | | | | | | | |
| | Up to 200 Gates | (16 Pin DIP) | .0061 | .016 | .029 | .027 | .040 | .032 | .037 | .044 | .061 | .054 | .0061 | .034 | .076 | 1.2 |
| | 201 to 1000 Gates | (24 Pin DIP) | .011 | .028 | .048 | .045 | .065 | .054 | .063 | .077 | .10 | .089 | .011 | .057 | .12 | 1.9 |
| | 1001 to 5000 Gates | (40 Pin DIP) | .022 | .052 | .087 | .082 | .12 | .099 | .11 | .14 | .19 | .16 | .022 | .10 | .22 | 3.3 |
| | **MOS Technology** | | | | | | | | | | | | | | | |
| 5.1 | Gate/Logic Arrays, Digital (Ea = .35) | | | | | | | | | | | | | | | |
| | 1 to 100 Gates | (16 Pin DIP) | .0057 | .015 | .027 | .027 | .039 | .029 | .035 | .039 | .056 | .052 | .0057 | .033 | .074 | 1.2 |
| | 101 to 1000 Gates | (24 Pin DIP) | .010 | .026 | .045 | .043 | .062 | .049 | .057 | .066 | .092 | .083 | .010 | .053 | .12 | 1.9 |
| | 1001 to 3000 Gates | (40 Pin DIP) | .019 | .047 | .080 | .077 | .11 | .088 | .10 | .12 | .17 | .15 | .019 | .095 | .21 | 3.3 |
| | 3001 to 10,000 Gates | (128 Pin PGA) | .049 | .14 | .25 | .24 | .36 | .27 | .32 | .36 | .51 | .48 | .049 | .30 | .69 | 12 |
| | 10,001 to 30,000 Gates | (180 Pin PGA) | .084 | .22 | .39 | .37 | .54 | .42 | .49 | .56 | .79 | .72 | .084 | .46 | 1.0 | 17 |
| | 30,000 to 60,000 Gates | (224 Pin PGA) | .13 | .31 | .53 | .51 | .73 | .59 | .69 | .82 | 1.1 | .98 | .13 | .63 | 1.4 | 21 |
| 5.1 | Gate/Logic Arrays, Linear (Ea = .65) | | | | | | | | | | | | | | | |
| | 1 to 100 Transistors | (14 Pin DIP) | .0095 | .024 | .039 | .034 | .049 | .057 | .062 | .12 | .13 | .076 | .0095 | .044 | .096 | 1.1 |
| | 101 to 300 Transistors | (18 Pin DIP) | .017 | .041 | .065 | .054 | .078 | .10 | .11 | .22 | .24 | .13 | .017 | .072 | .15 | 1.4 |
| | 301 to 1,000 Transistors | (24 Pin DIP) | .033 | .074 | .11 | .092 | .13 | .19 | .19 | .41 | .44 | .22 | .033 | .12 | .26 | 2.0 |
| | 1001 to 10,000 Transistors | (40 Pin DIP) | .05 | .12 | .18 | .15 | .21 | .29 | .30 | .63 | .67 | .35 | .05 | .19 | .41 | 3.4 |
| 5.1 | Floating Gate Programmable Logic Array, MOS (Ea = .35) | | | | | | | | | | | | | | | |
| | Up to 16K Gates | (24 Pin DIP) | .0046 | .018 | .035 | .035 | .052 | .035 | .044 | .044 | .070 | .070 | .0046 | .044 | .10 | 1.9 |
| | 16K to 64K Gates | (28 Pin DIP) | .0056 | .021 | .042 | .042 | .062 | .042 | .052 | .053 | .084 | .083 | .0056 | .052 | .12 | 2.3 |
| | 64K to 256K Gates | (28 Pin DIP) | .0061 | .022 | .043 | .042 | .063 | .043 | .054 | .055 | .086 | .084 | .0061 | .053 | .13 | 2.3 |
| | 256K to 1M Gates | (40 Pin DIP) | .0095 | .033 | .064 | .063 | .094 | .065 | .080 | .083 | .13 | .13 | .0095 | .079 | .19 | 3.3 |
| 5.1 | Microprocessors, Bipolar (Ea = .4) | | | | | | | | | | | | | | | |
| | Up to 8 Bits | (40 Pin DIP) | .028 | .061 | .098 | .091 | .13 | .12 | .13 | .17 | .22 | .18 | .028 | .11 | .24 | 3.3 |
| | Up to 16 Bits | (64 Pin PGA) | .052 | .11 | .18 | .16 | .23 | .21 | .24 | .32 | .39 | .31 | .052 | .20 | .41 | 5.6 |
| | Up to 32 Bits | (128 Pin PGA) | .11 | .23 | .36 | .33 | .47 | .44 | .49 | .65 | .81 | .65 | .11 | .42 | .86 | 12 |
| 5.1 | Microprocessors, MOS (Ea = .35) | | | | | | | | | | | | | | | |
| | Up to 8 Bits | (40 Pin DIP) | .048 | .089 | .13 | .12 | .16 | .16 | .17 | .24 | .28 | .22 | .048 | .15 | .28 | 3.4 |
| | Up to 16 Bits | (64 Pin PGA) | .093 | .17 | .24 | .22 | .29 | .30 | .32 | .45 | .52 | .40 | .093 | .27 | .50 | 5.6 |
| | Up to 32 Bits | (128 Pin PGA) | .19 | .34 | .49 | .45 | .60 | .61 | .66 | .90 | 1.1 | .82 | .19 | .54 | 1.0 | 12 |

**Generic Failure Rate, $\lambda_g$ (Failures/$10^6$ Hours) for Microcircuits. See Page A-4 for $\pi_Q$ Values**
**(Defaults: $\pi_T$ Based on Ea Shown, Solder or Weld Seal DIPs/PGAs (No. Pins as Shown Below), $\pi_L$ = 1 (Device in Production ≥ 2 Yr.))**

| Section # | Part Type | Environ. → / $T_J$(°C) → | $G_B$ 50 | $G_F$ 60 | $G_M$ 65 | $N_S$ 60 | $N_U$ 65 | $A_{IC}$ 75 | $A_{IF}$ 75 | $A_{UC}$ 90 | $A_{UF}$ 90 | $A_{RW}$ 75 | $S_F$ 50 | $M_F$ 65 | $M_L$ 75 | $C_L$ 60 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.2 | MOS Technology | | | | | | | | | | | | | | | |
| | Memories, ROM (Ea = .6) | | | | | | | | | | | | | | | |
| | Up to 16K | (24 Pin DIP) | .0047 | .018 | .036 | .035 | .053 | .037 | .045 | .048 | .074 | .071 | .0047 | .044 | .11 | 1.9 |
| | 16K to 64K | (28 Pin DIP) | .0059 | .022 | .043 | .042 | .063 | .045 | .055 | .060 | .090 | .086 | .0059 | .053 | .13 | 2.3 |
| | 64K to 256K | (28 Pin DIP) | .0067 | .023 | .045 | .044 | .066 | .048 | .059 | .068 | .099 | .089 | .0067 | .055 | .13 | 2.3 |
| | 256K to 1 MB | (40 Pin DIP) | .011 | .036 | .068 | .066 | .098 | .075 | .090 | .11 | .15 | .14 | .011 | .083 | .20 | 3.3 |
| 5.2 | Memories, PROM, UVEPROM, EEPROM, EAPROM (Ea = .6) (NOTE: $\lambda_{cyc}$ = 0 Assumed for EEPROM) | | | | | | | | | | | | | | | |
| | Up to 16K | (24 Pin DIP) | .0049 | .018 | .036 | .036 | .053 | .037 | .046 | .049 | .075 | .072 | .0048 | .045 | .11 | 1.9 |
| | 16K to 64K | (28 Pin DIP) | .0061 | .022 | .044 | .043 | .064 | .046 | .056 | .062 | .093 | .087 | .0062 | .054 | .13 | 2.3 |
| | 64K to 256K | (28 Pin DIP) | .0072 | .024 | .046 | .045 | .067 | .051 | .061 | .073 | .10 | .092 | .0072 | .057 | .13 | 2.3 |
| | 256K to 1 MB | (40 Pin DIP) | .012 | .038 | .071 | .068 | .10 | .080 | .095 | .12 | .16 | .14 | .012 | .086 | .20 | 3.3 |
| 5.2 | Memories, DRAM (Ea = .6) | | | | | | | | | | | | | | | |
| | Up to 16K | (18 Pin DIP) | .0040 | .014 | .027 | .027 | .040 | .029 | .035 | .040 | .059 | .055 | .0040 | .034 | .080 | 1.4 |
| | 16K to 64K | (22 Pin DIP) | .0055 | .019 | .036 | .034 | .051 | .039 | .047 | .056 | .079 | .070 | .0055 | .043 | .10 | 1.7 |
| | 64K to 256K | (24 Pin DIP) | .0074 | .023 | .043 | .040 | .060 | .049 | .058 | .076 | .10 | .084 | .0074 | .051 | .12 | 1.9 |
| | 256K to 1 MB | (28 Pin DIP) | .011 | .032 | .057 | .053 | .077 | .070 | .080 | .12 | .15 | .11 | .011 | .067 | .15 | 2.3 |
| 5.2 | Memories, SRAM, (MOS & BiMOS) (Ea = .6) | | | | | | | | | | | | | | | |
| | Up to 16K | (18 Pin DIP) | .0079 | .022 | .038 | .034 | .050 | .048 | .054 | .083 | .10 | .073 | .0079 | .044 | .098 | 1.4 |
| | 16K to 64K | (22 Pin DIP) | .014 | .034 | .057 | .050 | .073 | .077 | .085 | .14 | .17 | .11 | .014 | .065 | .14 | 1.8 |
| | 64K to 256K | (24 Pin DIP) | .023 | .053 | .084 | .071 | .10 | .12 | .13 | .25 | .27 | .16 | .023 | .092 | .19 | 1.9 |
| | 256K to 1 MB | (28 Pin DIP) | .043 | .092 | .14 | .11 | .16 | .22 | .23 | .46 | .49 | .26 | .043 | .15 | .30 | 2.3 |
| 5.2 | Bipolar Technology | | | | | | | | | | | | | | | |
| | Memories, ROM, PROM (Ea = .6) | | | | | | | | | | | | | | | |
| | Up to 16K | (24 Pin DIP) | .010 | .028 | .050 | .048 | .067 | .062 | .070 | .10 | .13 | .098 | .010 | .058 | .13 | 1.9 |
| | 16K to 64K | (28 Pin DIP) | .017 | .043 | .071 | .063 | .091 | .095 | .11 | .18 | .21 | .14 | .017 | .081 | .18 | 2.3 |
| | 64K to 256K | (28 Pin DIP) | .028 | .065 | .10 | .085 | .12 | .15 | .16 | .30 | .33 | .19 | .028 | .11 | .23 | 2.3 |
| | 256K to 1 MB | (40 Pin DIP) | .053 | .12 | .18 | .15 | .21 | .27 | .29 | .56 | .61 | .33 | .053 | .19 | .39 | 3.4 |
| 5.2 | Memories, SRAM (Ea = .6) | | | | | | | | | | | | | | | |
| | Up to 16K | (24 Pin DIP) | .0075 | .023 | .043 | .041 | .060 | .050 | .058 | .077 | .10 | .084 | .0075 | .052 | .12 | 1.9 |
| | 16K to 64K | (28 Pin DIP) | .012 | .033 | .058 | .054 | .079 | .072 | .083 | .12 | .15 | .11 | .012 | .069 | .15 | 2.3 |
| | 64K to 256K | (28 Pin DIP) | .018 | .045 | .074 | .065 | .095 | .10 | .11 | .19 | .22 | .14 | .018 | .084 | .18 | 2.3 |
| | 256K to 1 MB | (40 Pin DIP) | .033 | .079 | .13 | .11 | .16 | .18 | .20 | .35 | .39 | .24 | .033 | .14 | .30 | 3.4 |
| 5.3 | VHSIC Microcircuits, CMOS | Refer to Section 5.3, VHSIC CMOS | | | | | | | | | | | | | | |
| 5.4 | GaAs MMIC (Ea = 1.5) | | | | | | | | | | | | | | | |
| | 1 to 100 Elements | (8 Pin DIP) | .0013 | .0052 | .010 | .010 | .016 | .011 | .013 | .015 | .022 | .021 | .0013 | .013 | .031 | .57 |
| | 101 to 1000 Active Elements (Default: Driver and High Power (> 100 mW)) | (16 Pin DIP) | .0028 | .011 | .022 | .022 | .034 | .023 | .028 | .030 | .047 | .045 | .0028 | .028 | .068 | 1.2 |
| | GaAs Digital (Ea = 1.4) | | | | | | | | | | | | | | | |
| 5.4 | 1 to 1000 Active Elements | (36 Pin DIP) | .0066 | .026 | .052 | .052 | .078 | .054 | .067 | .078 | .12 | .11 | .0066 | .065 | .16 | 2.9 |
| | 1001 to 10,000 Active Elements | (64 Pin PGA) | .013 | .050 | .10 | .10 | .15 | .10 | .13 | .15 | .23 | .20 | .013 | .13 | .30 | 5.5 |

**Quality Factors - $\pi_Q$**

| Description | $\pi_Q$ |
|---|---|
| **Class S Categories:**<br>1. Procured in full accordance with MIL-M-38510, Class S requirements.<br>2. Procured in full accordance with MIL-I-38535 and Appendix B thereto (Class U).<br>3. Hybrids: (Procured to Class S requirements (Quality Level K) of MIL-H-38534. | .25 |
| **Class B Categories:**<br>1. Procured in full accordance with MIL-M-38510, Class B requirements.<br>2. Procured in full accordance with MIL-I-38535, (Class Q).<br>3. Hybrids: Procured to Class B requirements (Quality Level H) of MIL-H-38534. | 1.0 |
| **Class B-1 Category:**<br>Fully compliant with all requirements of paragraph 1.2.1 of MIL-STD-883 and procured to a MIL drawing, DESC drawing or other government approved documentation. (Does not include hybrids). For hybrids use custom screening section below. | 2.0 |

**Learning Factor - $\pi_L$**

| Years in Production, Y | $\pi_L$ |
|---|---|
| ≤ .1 | 2.0 |
| .5 | 1.8 |
| 1.0 | 1.5 |
| 1.5 | 1.2 |
| ≥ 2.0 | 1.0 |

$\pi_L = .01 \exp(5.35 - .35Y)$

Y = Years generic device type has been in production

**Quality Factors (cont'd): $\pi_Q$ Calculation for Custom Screening Programs**

| Group | MIL-STD-883 Screen/Test (Note 3) | Point Valuation |
|---|---|---|
| 1* | TM 1010 (Temperature Cycle, Cond B Minimum) and TM 2001 (Constant Acceleration, Cond B Minimum) and TM 5004 (or 5008 for Hybrids) (Final Electricals @ Temp Extremes) and TM 1014 (Seal Test, Cond A, B, or C) and TM 2009 (External Visual) | 50 |
| 2* | TM 1010 (Temperature Cycle, Cond B Minimum) or TM 2001 (Constant Acceleration, Cond B Minimum)<br>TM 5004 (or 5008 for Hybrids) (Final Electricals @ Temp Extremes) and TM 1014 (Seal Test, Cond A, B, or C) and TM 2009 (External Visual) | 37 |
| 3 | Pre-Burn in Electricals<br>TM 1015 (Burn-in B-Level/S-Level) and TM 5004 (or 5008 for Hybrids) (Post Burn-in Electricals @ Temp Extremes) | 30 (B Level)<br>36 (S Level) |
| 4* | TM 2020 Pind (Particle Impact Noise Detection) | 11 |
| 5 | TM 5004 (or 5008 for Hybrids) (Final Electricals @ Temperature Extremes) | 11 (Note 1) |
| 6 | TM 2010/17 (Internal Visual) | 7 |
| 7* | TM 1014 (Seal Test, Cond A, B, or C) | 7 (Note 2) |
| 8 | TM 2012 (Radiography) | 7 |
| 9 | TM 2009 (External Visual) | 7 (Note 2) |
| 10 | TM 5007/5013 (GaAs) (Wafer Acceptance) | 1 |
| 11 | TM 2023 (Non-Destructive Bond Pull) | 1 |

$$\pi_Q = 2 + \frac{87}{\Sigma \text{ Point Valuations}}$$

*NOT APPROPRIATE FOR PLASTIC PARTS

NOTES:
1. Point valuation only assigned if used independent of Groups 1, 2 or 3.
2. Point valuation only assigned if used independent of Groups 1 or 2.
3. Sequencing of tests within groups 1, 2 and 3 must be followed.
4. TM refers to the MIL-STD-883 Test Method.
5. Nonhermetic parts should be used only in controlled environments (i.e., $G_B$ and other temperature/humidity controlled environments).

EXAMPLES:
1. Mfg. performs Group 1 test and Class B burn-in: $\pi_Q = 2 + \frac{87}{50+30} = 3.1$
2. Mfg. performs internal visual test, seal test and final electrical test: $\pi_Q = 2 + \frac{87}{7+7+11} = 5.5$

| Other Commercial or Unknown Screening Levels | $\pi_Q = 10$ |
|---|---|

Generic Failure Rate - $\lambda_g$ (Failures/$10^6$ Hours) for Discrete Semiconductors

| Section # | Part Type | Env.→ $G_B$ | $G_F$ | $G_M$ | $N_S$ | $N_U$ | $A_{IC}$ | $A_{IF}$ | $A_{UC}$ | $A_{UF}$ | $A_{RW}$ | $S_F$ | $M_F$ | $M_L$ | $C_L$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $T_J$ (°C) → 50 | 60 | 65 | 60 | 65 | 75 | 75 | 90 | 90 | 75 | 50 | 65 | 75 | 60 |
| | DIODES | | | | | | | | | | | | | | |
| 6.1 | General Purpose Analog | .0036 | .028 | .049 | .043 | .10 | .092 | .21 | .20 | .44 | .17 | .0018 | .076 | .23 | 1.5 |
| 6.1 | Switching | .00094 | .0075 | .013 | .011 | .027 | .024 | .054 | .054 | .12 | .045 | .00047 | .020 | .060 | .40 |
| 6.1 | Fast Recovery Pwr. Rectifier | .065 | .52 | .89 | .78 | 1.9 | 1.7 | 3.7 | 3.7 | 8.0 | 3.1 | .032 | 1.4 | 4.1 | 28 |
| 6.1 | Power Rectifier/ Schottky Pwr. | .0028 | .022 | .039 | .034 | .082 | .073 | .16 | .16 | .35 | .13 | .0014 | .060 | .18 | 1.2 |
| 6.1 | Transient Suppressor/Varistor | .0029 | .023 | .040 | .035 | .084 | .075 | .17 | .17 | .36 | .14 | .0015 | .062 | .18 | 1.2 |
| 6.1 | Voltage Ref/Reg. (Avalanche and Zener) | .0033 | .024 | .039 | .035 | .082 | .066 | .15 | .13 | .27 | .12 | .0016 | .060 | .16 | 1.3 |
| 6.1 | Current Regulator | .0056 | .040 | .066 | .060 | .14 | .11 | .25 | .22 | .46 | .21 | .0028 | .10 | .28 | 2.1 |
| 6.2 | Si Impatt (f ≤ 35 GHz) | .86 | 2.8 | 8.9 | 5.6 | 20 | 11 | 14 | 36 | 62 | 44 | .43 | 16 | 67 | 350 |
| 6.2 | Gunn/Bulk Effect | .31 | .76 | 2.1 | 1.5 | 4.6 | 2.0 | 2.5 | 4.5 | 7.6 | 7.9 | .16 | 3.7 | 12 | 94 |
| 6.2 | Tunnel and Back | .004 | .0096 | .027 | .019 | .058 | .025 | .032 | .057 | .097 | .10 | .002 | .048 | .15 | 1.2 |
| 6.2 | PIN | .028 | .068 | .19 | .14 | .41 | .18 | .22 | .40 | .69 | .71 | .014 | .34 | 1.1 | 8.5 |
| 6.2 | Schottky Barrier and Point Contact (200 MHz ≤ f ≤ 35 GHz) | .047 | .11 | .31 | .23 | .68 | .30 | .37 | .67 | 1.1 | 1.2 | .023 | .56 | 1.8 | 14 |
| 6.2 | Varactor | .0043 | .010 | .029 | .021 | .063 | .028 | .034 | .062 | .11 | .11 | .0022 | .052 | .17 | 1.3 |
| 6.10 | Thyristor/SCR | .0025 | .020 | .034 | .030 | .072 | .064 | .14 | .14 | .31 | .12 | .0012 | .053 | .16 | 1.1 |
| | TRANSISTORS | | | | | | | | | | | | | | |
| 6.3 | NPN/PNP (f < 200 MHz) | .00015 | .0011 | .0017 | .0017 | .0037 | .0030 | .0067 | .0080 | .013 | .0056 | .000073 | .0027 | .0074 | .056 |
| 6.3 | Power NPN/PNP (f < 200 MHz) | .0057 | .042 | .069 | .063 | .15 | .12 | .26 | .23 | .50 | .22 | .0029 | .11 | .29 | 2.2 |
| 6.4 | Si FET (f ≤ 400 MHz) | .014 | .099 | .16 | .15 | .34 | .28 | .62 | .53 | 1.1 | .51 | .0069 | .25 | .68 | 5.3 |
| 6.9 | Si FET (f > 400 MHz) | .099 | .24 | .64 | .47 | 1.4 | .61 | .76 | 1.3 | 2.3 | 2.4 | .049 | 1.2 | 3.6 | 30 |
| 6.8 | GaAs FET (P < 100 mW) | .17 | .51 | 1.5 | 1.0 | 3.4 | 1.8 | 2.3 | 5.4 | 9.2 | 7.2 | .083 | 2.8 | 11 | 63 |
| 6.8 | GaAs FET (P ≥ 100 mW) | .42 | 1.3 | 3.9 | 2.5 | 8.5 | 4.5 | 5.6 | 13 | 23 | 18 | .21 | 6.9 | 27 | 160 |
| 6.5 | Unijunction | .016 | .12 | .20 | .18 | .42 | .36 | .80 | .74 | 1.6 | .66 | .0079 | .31 | .88 | 6.4 |
| 6.6 | RF, Low Noise (f > 200 MHz, P < 1W) | .094 | .23 | .63 | .46 | 1.4 | .60 | .75 | 1.3 | 2.3 | 2.4 | .047 | 1.1 | 3.6 | 28 |
| 6.7 | RF, Power (P ≥ 1W) | .045 | .091 | .23 | .18 | .50 | .18 | .23 | .32 | .55 | .73 | .023 | .41 | 1.1 | 11 |

**Generic Failure Rate - $\lambda_g$ (Failures/$10^6$ Hours) for Discrete Semiconductors (cont'd)**

| Section # | Part Type | Env.→ $T_J$(°C)→ | $G_B$ 50 | $G_F$ 60 | $G_M$ 65 | $N_S$ 60 | $N_U$ 65 | $A_{IC}$ 75 | $A_{IF}$ 75 | $A_{UC}$ 90 | $A_{UF}$ 90 | $A_{RW}$ 75 | $S_F$ 50 | $M_F$ 65 | $M_L$ 75 | $C_L$ 60 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OPTO-ELECTRONICS | | | | | | | | | | | | | | | |
| 6.11 | Photodetector | | .011 | .029 | .13 | .074 | .20 | .084 | .13 | .17 | .23 | .36 | .0057 | .15 | .51 | 6.6 |
| 6.11 | Opto-Isolator | | .027 | .070 | .31 | .17 | .47 | .20 | .30 | .42 | .56 | .85 | .013 | .35 | 1.2 | 16 |
| 6.11 | Emitter | | .00047 | .0012 | .0056 | .0031 | .0084 | .0035 | .0053 | .0074 | .0098 | .015 | .00024 | .0063 | .021 | .28 |
| 6.12 | Alphanumeric Display | | .0062 | .016 | .073 | .040 | .11 | .046 | .069 | .096 | .13 | .20 | .0031 | 082 | .28 | 3.6 |
| 6.13 | Laser Diode, GaAs/Al GaAs | | 5.1 | 16 | 78 | 39 | 120 | 58 | 86 | 86 | 110 | 240 | 2.6 | 87 | 350 | 3600 |
| 6.13 | Laser Diode, In GaAs/In GaAsP | | 9.0 | 28 | 135 | 69 | 200 | 100 | 150 | 150 | 200 | 400 | 4.5 | 150 | 600 | 6200 |
| 7 | TUBES | See Section 7 (Includes Receivers, CRTs, Cross Field Amplifiers, Klystrons, TWTs, Magnetrons) | | | | | | | | | | | | | | |
| 8 | LASERS | See Section 8 | | | | | | | | | | | | | | |

**Discrete Semiconductor Quality Factors - $\pi_Q$**

| Section Number | Part Types | JANTXV | JANTX | JAN | Lower | Plastic |
|---|---|---|---|---|---|---|
| 6.1, 6.3, 6.4, 6.5, 6.10, 6.11, 6.12 | Non-RF Devices/ Opto-Electronics* | .70 | 1.0 | 2.4 | 5.5 | 8.0 |
| 6.2 | High Freq Diodes | .50 | 1.0 | 5.0 | 25 | 50 |
| 6.2 | Schottky Diodes | .50 | 1.0 | 1.8 | 2.5 | ---- |
| 6.6, 6.7, 6.8, 6.9 | RF Transistors | .50 | 1.0 | 2.0 | 5.0 | ---- |
| 6.13 | *Laser Diodes | $\pi_Q$ = 1.0 Hermetic Package<br>= 1.0 Nonhermetic with Facet Coating<br>= 3.3 Nonhermetic without Facet Coating | | | | |

Generic Failure Rate, $\lambda_g$ (Failure/$10^6$ Hours) For Resistors

| Section # | Part Type | Style | MIL-R- | Env. → $G_B$ / $T_A$ (°C) → 30 | $G_F$ 40 | $G_M$ 45 | $N_S$ 40 | $N_U$ 45 | $A_{IC}$ 55 | $A_{IF}$ 55 | $A_{UC}$ 70 | $A_{UF}$ 70 | $A_{RW}$ 55 | $S_F$ 30 | $M_F$ 45 | $M_L$ 55 | $C_L$ 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9.1 | Composition | RCR | 39008 | .00050 | .0022 | .0071 | .0037 | .012 | .0052 | .0065 | .016 | .025 | .025 | .00025 | .0098 | .035 | .36 |
| 9.1 | Composition | RC | 11 | .00050 | .0022 | .0071 | .0037 | .012 | .0052 | .0065 | .016 | .025 | .025 | .00025 | .0098 | .035 | .36 |
| 9.2 | Film, Insulated | RLR | 39017 | .0012 | .0027 | .011 | .0054 | .020 | .0063 | .013 | .018 | .033 | .030 | .00025 | .014 | .044 | .69 |
| 9.2 | Film, Insulated | RL | 22684 | .0012 | .0027 | .011 | .0054 | .020 | .0063 | .013 | .018 | .033 | .030 | .00025 | .014 | .044 | .69 |
| 9.2 | Film, RN (R, C or N) | RNR | 55182 | .0014 | .0031 | .013 | .0061 | .023 | .0072 | .014 | .021 | .038 | .034 | .00028 | .016 | .050 | .78 |
| 9.2 | Film | RN | 10509 | .0014 | .0031 | .013 | .0061 | .023 | .0072 | .014 | .021 | .038 | .034 | .00028 | .016 | .050 | .78 |
| 9.3 | Film, Power | RD | 11804 | .012 | .025 | .13 | .062 | .21 | .078 | .10 | .19 | .24 | .32 | .0060 | .18 | .47 | 8.2 |
| 9.4 | Film, Network | RZ | 83401 | .0023 | .0066 | .031 | .013 | .055 | .022 | .043 | .077 | .15 | .10 | .0011 | .055 | .15 | 1.7 |
| 9.5 | Wirewound, Accurate | RBR | 39005 | .0085 | .018 | .10 | .045 | .16 | .15 | .17 | .30 | .38 | .26 | .0068 | .13 | .37 | 5.4 |
| 9.5 | Wirewound, Accurate | RB | 93 | .0085 | .018 | .10 | .045 | .16 | .15 | .17 | .30 | .38 | .26 | .0068 | .13 | .37 | 5.4 |
| 9.6 | Wirewound, Power | RWR | 39007 | .014 | .031 | .16 | .077 | .26 | .073 | .15 | .19 | .39 | .42 | .0042 | .21 | .62 | 9.4 |
| 9.6 | Wirewound, Power | RW | 26 | .013 | .028 | .15 | .070 | .24 | .066 | .13 | .18 | .35 | .38 | .0038 | .19 | .56 | 8.6 |
| 9.7 | Wirewound, Power, Chassis Mounted | RER | 39009 | .0080 | .018 | .096 | .045 | .15 | .044 | .088 | .12 | .24 | .25 | .0040 | .13 | .37 | 5.5 |
| 9.7 | Wirewound, Power, Chassis Mounted | RE | 18546 | .0080 | .018 | .096 | .045 | .15 | .044 | .088 | .12 | .24 | .25 | .0040 | .13 | .37 | 5.5 |
| 9.8 | Thermistor | RTH | 23648 | .065 | .32 | 1.4 | .71 | 1.6 | .71 | 1.9 | 1.0 | 2.7 | 2.4 | .032 | 1.3 | 3.4 | 62 |
| 9.9 | Wirewound, Variable | RTR | 39015 | .026 | .056 | .36 | .17 | .59 | .17 | .27 | .36 | .60 | 1.1 | .013 | .53 | 1.6 | 25 |
| 9.9 | Wirewound, Variable | RT | 27208 | .026 | .056 | .36 | .17 | .59 | .17 | .27 | .36 | .60 | 1.1 | .013 | .53 | 1.6 | 25 |
| 9.10 | Wirewound, Variable, Precision | RR | 12934 | .36 | .80 | 7.7 | 3.2 | 13 | 3.9 | 5.8 | 7.8 | 11 | 26 | .18 | 12 | 37 | 560 |
| 9.11 | Wirewound, Variable, Semiprecision | RA | 19 | .15 | .35 | 3.1 | 1.2 | 5.4 | 1.9 | 2.8 | * | * | 9.0 | .075 | * | * | * |
| 9.11 | Wirewound, Variable, Semiprecision | RK | 39002 | .15 | .35 | 3.1 | 1.2 | 5.4 | 1.9 | 2.8 | * | * | 9.0 | .075 | * | * | * |
| 9.12 | Wirewound, Variable, Power | RP | 22 | .15 | .51 | 2.9 | 1.2 | 5.0 | 1.6 | 2.4 | * | * | 7.6 | .076 | * | * | * |
| 9.13 | Nonwirewound, Variable | RJR | 39035 | .033 | .10 | .50 | .21 | .87 | .19 | .27 | .52 | .79 | 1.5 | .017 | .79 | 2.2 | 35 |
| 9.13 | Nonwirewound, Variable | RJ | 22097 | .033 | .10 | .50 | .21 | .87 | .19 | .27 | .52 | .79 | 1.5 | .017 | .79 | 2.2 | 35 |
| 9.14 | Composition, Variable | RV | 94 | .050 | .11 | 1.1 | .45 | 1.7 | 2.8 | 4.6 | 4.6 | 7.5 | 3.3 | .025 | 1.5 | 4.7 | 67 |
| 9.15 | Nonwirewound, Variable Precision | RQ | 39023 | .043 | .15 | .75 | .35 | 1.3 | .39 | .78 | 1.8 | 2.8 | 2.5 | .021 | 1.2 | 3.7 | 49 |
| 9.15 | Film, Variable | RVC | 23285 | .048 | .16 | .76 | .36 | 1.3 | .36 | .72 | 1.4 | 2.2 | 2.3 | .024 | 1.2 | 3.4 | 52 |

NOTE: 1) * Not Normally used in this Environment
2) $T_A$ = Default Component Ambient Temperature (°C)

| Quality | Established Reliability Styles S | R | P | M | MIL-SPEC | Lower |
|---|---|---|---|---|---|---|
| $\pi_Q$ | .030 | .10 | .30 | 1.0 | 3.0 | 10 |

Generic Failure Rate, $\lambda_g$ (Failures/$10^6$ Hours) for Capacitors

| Section # | Part Type or Dielectric | Style | MIL-C- | Env.→ $G_B$ $T_A$(°C)→30 | $G_F$ 40 | $G_M$ 45 | $N_S$ 40 | $N_U$ 45 | $A_{IC}$ 55 | $A_{IF}$ 55 | $A_{UC}$ 70 | $A_{UF}$ 70 | $A_{RW}$ 55 | $S_F$ 30 | $M_F$ 45 | $M_L$ 55 | $C_L$ 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10.1 | Paper, By-Pass | CP | 25 | .0036 | .0072 | .033 | .018 | .055 | .023 | .03 | .070 | .13 | .083 | .0018 | .044 | .12 | 2.1 |
| 10.1 | Paper, By-Pass | CA | 12889 | .0039 | .0087 | .042 | .022 | .070 | .035 | .047 | .19 | .35 | .13 | .002 | .056 | .19 | 2.5 |
| 10.2 | Paper/Plastic, Feed-through | CZR | 11693 | .0047 | .0096 | .044 | .034 | .073 | .030 | .040 | .094 | .15 | .11 | .0024 | .058 | .16 | 2.7 |
| 10.3 | Paper/Plastic Film | CPV | 14157 | .0021 | .0042 | .017 | .010 | .030 | .0088 | .013 | .026 | .048 | .044 | .0010 | .023 | .063 | 1.1 |
| 10.3 | Paper/Plastic Film | CQR | 19978 | .0021 | .0042 | .017 | .010 | .030 | .0088 | .013 | .026 | .048 | .044 | .0010 | .023 | .063 | 1.1 |
| 10.4 | Metallized Paper/Plastic | CHR | 39022 | .0029 | .0058 | .023 | .014 | .041 | .012 | .018 | .037 | .066 | .060 | .0014 | .032 | .088 | 1.5 |
| 10.4 | Metallized Plastic/Plastic | CH | 18312 | .0029 | .0058 | .023 | .014 | .041 | .012 | .018 | .037 | .066 | .060 | .0014 | .032 | .088 | 1.5 |
| 10.5 | Metallized Paper/Plastic | CFR | 55514 | .0041 | .0083 | .042 | .021 | .067 | .026 | .048 | .086 | .14 | .10 | .0020 | .054 | .15 | 2.5 |
| 10.6 | Metallized Plastic | CRH | 83421 | .0023 | .0092 | .019 | .012 | .033 | .0096 | .014 | .034 | .053 | .048 | .0011 | .026 | .07 | 1.2 |
| 10.7 | MICA (Dipped or Molded) | CMR | 39001 | .0005 | .0015 | .0091 | .0044 | .014 | .0068 | .0095 | .054 | .069 | .031 | .00025 | .012 | .046 | .45 |
| 10.7 | MICA (Dipped) | CM | 5 | .0005 | .0015 | .0091 | .0044 | .014 | .0068 | .0095 | .054 | .069 | .031 | .00025 | .012 | .046 | .45 |
| 10.8 | MICA (Button) | CB | 10950 | .018 | .037 | .19 | .094 | .31 | .10 | .14 | .47 | .60 | .46 | .0091 | .25 | .68 | 11 |
| 10.9 | Glass | CYR | 23269 | .00032 | .00096 | .0059 | .0029 | .0094 | .0044 | .0062 | .035 | .045 | .020 | .00016 | .0076 | .030 | .29 |
| 10.9 | Glass | CY | 11272 | .00032 | .00096 | .0059 | .0029 | .0094 | .0044 | .0062 | .035 | .045 | .020 | .00016 | .0076 | .030 | .29 |
| 10.10 | Ceramic (Gen. Purpose) | CK | 11015 | .0036 | .0074 | .034 | .019 | .056 | .015 | .015 | .032 | .048 | .077 | .0014 | .049 | .13 | 2.3 |
| 10.10 | Ceramic (Gen. Purpose) | CKR | 39014 | .0036 | .0074 | .034 | .019 | .056 | .015 | .015 | .032 | .048 | .077 | .0014 | .049 | .13 | 2.3 |
| 10.11 | Ceramic (Temp. Comp.) | CCR | 20 | .00078 | .0022 | .013 | .0056 | .023 | .0077 | .015 | .053 | .12 | .046 | .00039 | .017 | .065 | .68 |
| 10.11 | Ceramic Chip | CDR | 55681 | .00078 | .0022 | .013 | .0056 | .023 | .0077 | .015 | .053 | .12 | .046 | .00039 | .017 | .065 | .68 |
| 10.12 | Tantalum, Solid | CSR | 39003 | .0018 | .0039 | .016 | .0097 | .028 | .0091 | .011 | .034 | .057 | .055 | .00072 | .022 | .066 | 1.0 |
| 10.13 | Tantalum, Non-Solid | CLR | 39006 | .0061 | .013 | .069 | .039 | .11 | .031 | .061 | .13 | .29 | .18 | .0030 | .089 | .26 | 4.0 |
| 10.13 | Tantalum, Non-Solid | CL | 3965 | .0061 | .013 | .069 | .039 | .11 | .031 | .061 | .13 | .29 | .18 | .0030 | .089 | .26 | 4.0 |
| 10.14 | Aluminum Oxide | CUR | 39018 | .024 | .061 | .42 | .18 | .59 | .46 | .55 | 2.1 | 2.6 | 1.2 | .012 | .49 | 1.7 | 21 |
| 10.15 | Aluminum Dry | CE | 62 | .029 | .081 | .58 | .24 | .83 | .73 | .88 | 4.3 | 5.4 | 2.0 | .015 | .68 | 2.8 | 28 |
| 10.16 | Variable, Ceramic | CV | 81 | .08 | .27 | 1.2 | .71 | 2.3 | .69 | 1.1 | 6.2 | 12 | 4.1 | .032 | 1.9 | 5.9 | 85 |
| 10.17 | Variable, Piston | PC | 14409 | .033 | .13 | .62 | .31 | .93 | .21 | .28 | 2.2 | 3.3 | 2.2 | .016 | .93 | 3.2 | 37 |
| 10.18 | Variable, Air Trimmer | CT | 92 | .080 | .33 | 1.6 | .87 | 3.0 | 1.0 | 1.7 | 9.9 | 19 | 6.1 | .040 | 2.5 | 8.9 | 100 |
| 10.19 | Variable, Vacuum | CG | 23183 | 0.4 | 1.3 | 6.7 | 3.6 | 13 | 5.7 | 10 | 58 | 90 | 23 | .20 | * | * | * |

NOTE: 1) * Not Normally used in this Environment
2) $T_A$ = Default Component Ambient Temperature (°C)

| Quality | Established Reliability Styles S | R | P | M | L | MIL-SPEC | Lower |
|---|---|---|---|---|---|---|---|
| $\pi_Q$ | .030 | .10 | .30 | 1.0 | 3.0 | 3.0 | 10 |

**Generic Failure Rate, $\lambda_g$ (Failures/$10^6$ Hours) for Inductive and Electromechanical Parts**

| Section # | Part Type | MIL- | Env.→ $G_B$ | $G_F$ | $G_M$ | $N_S$ | $N_U$ | $A_{IC}$ | $A_{IF}$ | $A_{UC}$ | $A_{UF}$ | $A_{RW}$ | $S_F$ | $M_F$ | $M_L$ | $C_L$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $T_A$ (°C)→ 30 | 40 | 45 | 40 | 45 | 55 | 55 | 70 | 70 | 55 | 30 | 45 | 55 | 40 |
| | **INDUCTIVE DEVICES** | | | | | | | | | | | | | | | |
| 11.1 | Low Power Pulse XFMR | T-21038 | .0035 | .023 | .049 | .019 | .065 | .027 | .037 | .041 | .052 | .11 | .0018 | .053 | .16 | 2.3 |
| 11.1 | Audio XFMR | T-27 | .0071 | .046 | .097 | .038 | .13 | .055 | .073 | .081 | .10 | .22 | .0035 | .11 | .31 | 4.7 |
| 11.1 | High Pwr. Pulse and Pwr. XFMR, Filter | T-27 | .023 | .16 | .34 | .13 | .45 | .21 | .27 | .35 | .45 | .82 | .011 | .37 | 1.2 | 16 |
| 11.1 | RF XFMR | T-55631 | .028 | .18 | .39 | .15 | .52 | .22 | .29 | .33 | .42 | .88 | .014 | .42 | 1.2 | 19 |
| 11.2 | RF Coils, Fixed or Molded | C-15305 C-39010 | .0017 | .0073 | .023 | .0091 | .031 | .011 | .015 | .016 | .022 | .052 | .00083 | .025 | .073 | 1.1 |
| 11.2 | RF Coils, Variable | C-15305 | .0033 | .015 | .046 | .018 | .061 | .022 | .03 | .033 | .044 | .10 | .0017 | .05 | .15 | 2.2 |
| | **ROTATING DEVICES** | | | | | | | | | | | | | | | |
| 12.1 | Motors | | 1.6 | 2.4 | 3.3 | 2.4 | 3.3 | 7.1 | 7.1 | 31 | 31 | 7.1 | 1.6 | * | * | * |
| 12.2 | Synchros | | .07 | .20 | 1.5 | .70 | 2.2 | .78 | 1.2 | 7.9 | 12 | 5.1 | .035 | 1.7 | 7.1 | 68 |
| 12.2 | Resolvers | | .11 | .30 | 2.2 | 1.0 | 3.3 | 1.2 | 1.8 | 12 | 18 | 7.6 | .053 | 2.6 | 11 | 100 |
| | **ELAPSED TIME METERS** | | | | | | | | | | | | | | | |
| 12.3 | ETM-AC | | 10 | 20 | 120 | 70 | 180 | 50 | 80 | 160 | 250 | 260 | 5.0 | 140 | 380 | * |
| 12.3 | ETM-Inverter Driver | | 15 | 30 | 180 | 105 | 270 | 75 | 120 | 240 | 375 | 390 | 7.5 | 210 | 570 | * |
| 13.3 | ETM-Commutator DC | | 40 | 80 | 480 | 280 | 720 | 200 | 320 | 640 | 1000 | 1040 | 20 | 560 | 1520 | * |
| | **RELAYS** | | | | | | | | | | | | | | | |
| 13.1 | General Purpose | | .13 | .28 | 2.1 | 1.1 | 3.8 | 1.1 | 1.4 | 1.9 | 2.1 | 7.0 | .066 | 3.5 | 10 | * |
| 13.1 | Contactor, High Current | | .43 | .89 | 6.9 | 3.6 | 12 | 3.4 | 4.4 | 6.2 | 6.7 | 22 | .21 | 11 | 32 | * |
| 13.1 | Latching | | .13 | .28 | 2.1 | 1.1 | 3.8 | 1.1 | 1.4 | 1.9 | 2.1 | 7.0 | .066 | 3.5 | 10 | * |
| 13.1 | Reed | | .11 | .23 | 1.8 | .92 | 3.3 | .96 | 1.2 | 2.1 | 2.3 | 6.3 | .054 | 3.0 | 9.0 | * |
| 13.1 | Thermal, Bi-metal | | .29 | .60 | 4.6 | 2.4 | 8.2 | 2.3 | 2.9 | 4.1 | 4.5 | 15 | .14 | 7.6 | 22 | * |
| 13.1 | Meter Movement | | .88 | 1.8 | 14 | 7.4 | 26 | 7.1 | 9.1 | 13 | 14 | 46 | .44 | 24 | 67 | * |
| 13.2 | Solid State | | .40 | 1.2 | 4.8 | 2.4 | 6.8 | 4.8 | 7.6 | 8.4 | 13 | 9.2 | .16 | 4.8 | 13 | 240 |
| 13.2 | Hybrid and Solid State Time Delay | | .50 | 1.5 | 6.0 | 3.0 | 8.5 | 6.0 | 9.5 | 11 | 16 | 12 | .20 | 6.0 | 17 | 300 |
| | **SWITCHES** | | | | | | | | | | | | | | | |
| 14.1 | Toggle or Pushbutton | | .0010 | .0030 | .018 | .0080 | .029 | .010 | .018 | .013 | .022 | .046 | .0005 | .025 | .067 | 1.2 |
| 14.2 | Sensitive | S-8805 | .15 | .44 | 2.7 | 1.2 | 4.3 | 1.5 | 2.7 | 1.9 | 3.3 | 6.8 | .074 | 3.7 | 9.9 | 180 |
| 14.3 | Rotary Wafer | S-3786 | .33 | .99 | 5.9 | 2.6 | 9.5 | 3.3 | 5.9 | 4.3 | 7.2 | 15 | .16 | 8.2 | 22 | 390 |
| 14.4 | Thumbwheel | S-22710 | .56 | 1.7 | 10 | 4.5 | 16 | 5.6 | 10 | 7.3 | 12 | 26 | .28 | 14 | 38 | 670 |
| 14.5 | Circuit Breaker, Thermal | C-83383 | .11 | .23 | 1.7 | .91 | 3.1 | .80 | 1.0 | 1.3 | 1.4 | 5.2 | .057 | 2.8 | 7.5 | N/A |
| 14.5 | Circuit Breaker, Magnetic | C-55629 | .060 | .12 | .90 | .48 | 1.6 | .42 | .54 | .66 | .72 | 2.8 | .030 | 1.5 | 4.0 | N/A |
| | **CONNECTORS** | | | | | | | | | | | | | | | |
| 15.1 | Circular/Rack/Panel | | 0.011 | 0.14 | .12 | .069 | .20 | .059 | .098 | .23 | .34 | .37 | .0054 | .16 | .53 | 6.8 |
| 15.1 | Coaxial | | .012 | .015 | .13 | .075 | .21 | .060 | .10 | .22 | .32 | .38 | .0061 | .16 | .54 | 7.3 |
| 15.2 | Printed Circuit Board Connector | | .0054 | .021 | .063 | .035 | .10 | .059 | .11 | .085 | .16 | .19 | .0027 | .078 | .27 | 3.4 |
| 15.3 | IC Sockets | | .0019 | .0058 | .027 | .012 | .035 | .015 | .023 | .021 | .025 | .048 | .00097 | .027 | .070 | 1.3 |
| 16.1 | Interconnection Assemblies (PCBs) | | .053 | .11 | .37 | .69 | .27 | .27 | .43 | .85 | 1.5 | 1.0 | .027 | .53 | 1.4 | 27 |

NOTE: 1) * Not normally used in this environment
2) $T_A$ = Default Component Ambient Temperature (°C)

**Generic Failure Rate, $\lambda_g$ (Failures/$10^6$ Hours) for Miscellaneous Parts**

| Section # | Part Type Dielectric | MIL- | Env.→ $G_B$ $T_A$ (°C)→ 30 | $G_F$ 40 | $G_M$ 45 | $N_S$ 40 | $N_U$ 45 | $A_{IC}$ 55 | $A_{IF}$ 55 | $A_{UC}$ 70 | $A_{UF}$ 70 | $A_{RW}$ 55 | $S_F$ 30 | $M_F$ 45 | $M_L$ 55 | $C_L$ 40 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SINGLE CONNECTIONS | | | | | | | | | | | | | | | |
| 17.1 | Hand Solder, w/o Wrapping | | .0026 | .0052 | .018 | .010 | .029 | .010 | .016 | .016 | .021 | .042 | .0013 | .023 | .062 | 1.1 |
| 17.1 | Hand Solder, w/Wrapping | | .00014 | .00028 | .00098 | .00056 | .0015 | .00056 | .00084 | .00084 | .0011 | .0022 | .00007 | .0013 | .0034 | .059 |
| 17.1 | Crimp | | .00026 | .00052 | .0018 | .0010 | .0029 | .0010 | .0016 | .0016 | .0021 | .0042 | .00013 | .0023 | .0062 | .11 |
| 17.1 | Weld | | .000050 | .000100 | .000350 | .000200 | .000560 | .000200 | .000300 | .000300 | .000400 | .000800 | .000025 | .000450 | .001200 | .021000 |
| 17.1 | Solderless Wrap | | .0000035 | .000007 | .000025 | .000014 | .000039 | .000014 | .000021 | .000021 | .000028 | .000056 | .0000018 | .000031 | .000084 | .0015 |
| 17.1 | Clip Termination | | .00012 | .00024 | .00084 | .00048 | .0013 | .00048 | .00072 | .00072 | .00096 | .0019 | .00006 | .0011 | .0029 | .050 |
| 17.1 | Reflow Solder | | .000069 | .000138 | .000483 | .000276 | .000759 | .000276 | .000414 | .000414 | .000552 | .001104 | .000035 | .000621 | .001656 | .02898 |
| | METERS, PANEL | | | | | | | | | | | | | | | |
| 18.1 | DC Ammeter or Voltmeter | M-10304 | 0.09 | 0.36 | 2.3 | 1.1 | 3.2 | 2.5 | 3.8 | 5.2 | 6.6 | 5.4 | 0.099 | 5.4 | N/A | N/A |
| 18.1 | AC Ammeter or Voltmeter | M-10304 | 0.15 | 0.61 | 3.8 | 1.8 | 5.4 | 4.3 | 6.4 | 8.9 | 11 | 9.2 | 0.17 | 9.2 | N/A | N/A |
| 19.1 | Quartz Crystals | C-3098 | .032 | .096 | .32 | .19 | .51 | .38 | .54 | .70 | .90 | .74 | .016 | .42 | 1.0 | 16 |
| 20.1 | Lamps, Incandescent, AC | | 3.9 | 7.8 | 12 | 12 | 16 | 16 | 16 | 19 | 23 | 19 | 2.7 | 16 | 23 | 100 |
| 20.1 | Lamps, Incandescent, DC | | 13 | 26 | 38 | 38 | 51 | 51 | 51 | 64 | 77 | 64 | 9.0 | 51 | 77 | 350 |
| | ELECTRONIC FILTERS | | | | | | | | | | | | | | | |
| 21.1 | Ceramic-Ferrite | F-15733 | .022 | .044 | .13 | .088 | .20 | .15 | .20 | .24 | .29 | .24 | .018 | .15 | .33 | 2.6 |
| 21.1 | Discrete LC Comp. | F-15733 | .12 | .24 | .72 | .48 | 1.1 | .84 | 1.1 | 1.3 | 1.6 | 1.3 | .096 | .84 | 1.8 | 14 |
| 21.1 | Discrete LC & Crystal Comp. | F-18327 | .27 | .54 | 1.6 | 1.1 | 2.4 | 1.9 | 2.4 | 3.0 | 3.5 | 3.0 | .22 | 1.9 | 4.1 | 32 |
| 22.1 | FUSES | | .010 | .020 | .080 | .050 | .11 | .090 | .12 | .15 | .18 | .16 | .009 | .10 | .21 | 2.3 |

### $\pi_Q$ Factor for Use with Section 11-22 Devices

| Section # | Part Type | Established Reliability | MIL-SPEC | Non-MIL |
|---|---|---|---|---|
| 11.1, 11.2 | Inductive Devices | .25* | 1.0 | 10 |
| 12.1, 12.2, 12.3 | Rotating Devices | N/A | N/A | N/A |
| 13.1 | Relays, Mechanical | .60 | 3.0 | 9.0 |
| 13.2 | Relays, Solid State and Time Delay (Hybrid & Solid State) | N/A | 1.0 | 4 |
| 14.1, 14.2 | Switches, Toggle, Pushbutton, Sensitive | N/A | 1.0 | 20 |
| 14.3 | Switches, Rotary Wafer | N/A | 1.0 | 50 |
| 14.4 | Switches, Thumbwheel | N/A | 1.0 | 10 |
| 14.5 | Circuit Breakers, Thermal | N/A | 1.0 | 8.4 |
| 15.1, 15.2, 15.3 | Connectors | N/A | 1.0 | 2.0 |
| 16.1 | Interconnection Assemblies | N/A | 1.0 | 2.0 |
| 17.1 | Connections | N/A | N/A | N/A |
| 18.1 | Meters, Panel | N/A | 1.0 | 3.4 |
| 19.1 | Quartz Crystals | N/A | 1.0 | 2.1 |
| 20.1 | Lamps, Incandescent | N/A | N/A | N/A |
| 21.1 | Electronic Filters | N/A | 1.0 | 2.9 |
| 22.1 | Fuses | N/A | N/A | N/A |

* Category applies only to MIL-C-39010 Coils.

## Default Parameters for Discrete Semiconductors

| Section # | Part Type | $\lambda_b$ | $\pi_T$ | $\pi_M$ | $\pi_S$ | $\pi_C$ | $\pi_A$ | $\pi_R$ | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 5.0 | MICROCIRCUITS | All Defaults provided with $\lambda_g$ Table | | | | | | | |
| | DIODES | | | | | | | | |
| 6.1 | General Purpose Analog | .0038 | | | .42 | 1.0 | | | Voltage Stress = .7, Metallurgically Bonded Contacts |
| 6.1 | Switching | .001 | | | .42 | 1.0 | | | Voltage Stress = .7, Metallurgically Bonded Contacts |
| 6.1 | Fast Recovery Power Rectifier | .069 | | | .42 | 1.0 | | | Voltage Stress = .7, Metallurgically Bonded Contacts |
| 6.1 | Transient Suppressor/Varistor | .0031 | | | 1.0 | 1.0 | | | Metallurgically Bonded Contacts |
| 6.1 | Power Rectifier | .003 | | | .42 | 1.0 | | | Voltage Stress = .7, Metallurgically Bonded Contacts |
| 6.1 | Voltage Ref/Reg. (Avalanche & Zener) | .002 | | | 1.0 | 1.0 | | | Metallurgically Bonded Contacts |
| 6.1 | Current Regulator | .0034 | | | 1.0 | 1.0 | | | Metallurgically Bonded Contacts |
| 6.2 | Si Impatt (≤ 35 GHz) | .22 | | | | | 1.0 | 1.0 | |
| 6.2 | Gunn/Bulk Effect | .18 | | | | | 1.0 | 1.0 | |
| 6.2 | Tunnel and Back | .0023 | | | | | 1.0 | 1.0 | |
| 6.2 | PIN | .0081 | | | | | 1.0 | 2.0 | Rated Power = 1000W |
| 6.2 | Schottky Barrier and Point Contact (200 MHz ≤ frequency ≤ 35 GHz) | .027 | | | 1.0 | 1.0 | | | |
| 6.2 | Varactor | .0025 | | | 2.5 | 1.0 | | | Multiplier Application |
| 6.10 | Thyristor/SCR | .0022 | | | .51 | | | 1.0 | Voltage Stress = .7, Rated Forward Current = 1 Amp |
| | TRANSISTORS | | | | | | | | |
| 6.3 | NPN/PNP (f < 200 MHz) | .00074 | | | .21 | | .70 | .77 | Voltage Stress = .5, Switching Application, Rated Power = .5W |
| 6.3 | Power NPN/PNP (f < 200 MHz) | .00074 | | | .54 | | 1.5 | 5.5 | Voltage Stress = .8, Linear Application, Rated Power = 100W |
| 6.4 | Si FET (f ≤ 400 MHz) | .012 | | | | | .70 | | MOSFET, Small Signal Switching |
| 6.9 | Si FET (f > 400 MHz) | .060 | | | | | | | MOSFET |
| 6.8 | GaAs FET (P < 100 mW) | .052 | | 1.0 | | | 1.0 | | Low Noise Application, 1 ≤ f ≤ 10 GHz, Input and Output Matching |
| 6.8 | GaAs FET (P ≥ 100 mW) | .13 | | 1.0 | | | 1.0 | | Pulsed Application, 5 GHz, 1W Average Output Power, Input and Output Matching |
| 6.5 | Unijunction | .0083 | | | | | | | |
| 6.6 | RF, Low Noise, Bipolar (f > 200 MHz, P < 1W) | .18 | | | .39 | | | .77 | Voltage Stress = .7, Rated Power = .5W |
| 6.7 | RF, Power (P ≥ 1W) | .08 | .36 | 1.0 | | | 1.6 | | 1 GHz, 100W, $T_J$ = 130°C for all Environments, Voltage Stress = .45, Gold Metallization, Pulsed Application, 20% Duty Factor, Input and Output Matching |

**Default Parameters for Discrete Semiconductors**

| Section # | Part Type | $\lambda_b$ | $\pi_T$ | $\pi_M$ | $\pi_S$ | $\pi_C$ | $\pi_A$ | $\pi_R$ | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | OPTO-ELECTRONICS | | | | | | | | |
| 6.11 | Photodetector | .0055 | | | | | | | Phototransistor |
| 6.11 | Opto-Isolator | .013 | | | | | | | Phototransistor, Single Device |
| 6.11 | Emitter | .00023 | | | | | | | LED |
| 6.12 | Alphanumeric Display | .0030 | | | | | | | 7 Character Segment Display |
| 6.13 | Laser Diode, GaAs/Al GaAs | 3.23 | | | 1.0 ($\pi_P$) | | .77 | | For Environments with $T_J$ > 75°C, assume $T_J$ = 75°C, Forward Peak Current = .5 Amps ($\pi_I$ = .62), Pulsed Application, Duty Cycle = .6, Pr/Ps = .5 ($\pi_P$ = 1) |
| 6.13 | Laser Diode, In/GaAs/In GaAsP | 5.65 | | | 1.0 ($\pi_P$) | | .77 | | For Environments with $T_J$ > 75°C, assume $T_J$ = 75°C, Forward Peak Current = .5 Amps ($\pi_I$ = .62), Pulsed Application, Duty Cycle = .6, Pr/Ps = .5 ($\pi_P$ = 1) |

**Default Parameters for Resistors**

| Section # | Part Type | Style | MIL-R-SPEC | $\pi_R$ | $\pi_V$ | $\pi_{TAPS}$ | Comments |
|---|---|---|---|---|---|---|---|
| 9.1 | Composition | RCR | 39008 | 1.1 | | | Pwr. Stress = .5, 1M ohm |
| 9.1 | Composition | RC | 11 | 1.1 | | | Pwr. Stress = .5, 1M ohm |
| 9.2 | Film, Insulated | RLR | 39017 | 1.1 | | | Pwr. Stress = .5, 1M ohm |
| 9.2 | Film, Insulated | RL | 22684 | 1.1 | | | Pwr. Stress = .5, 1M ohm |
| 9.2 | Film, RN (R, C or N) | RNR | 55182 | 1.1 | | | Pwr. Stress = .5, 1M ohm |
| 9.2 | Film | RN | 10509 | 1.1 | | | Pwr. Stress = .5, 1M ohm |
| 9.3 | Film, Power | RD | 11804 | 1.0 | | | Pwr. Stress = .5, 100 ohm |
| 9.4 | Fixed, Network | RZ | 83401 | | | | Pwr. Stress = .5, $T_C = T_A + 28°C$, 10 Film Resistors |
| 9.5 | Wirewound, Accurate | RBR | 39005 | 1.7 | | | Pwr. Stress = .5,100K ohms |
| 9.5 | Wirewound, Accurate | RB | 93 | 1.7 | | | Pwr. Stress = .5, 100K ohms |
| 9.6 | Wirewound, Power | RWR | 39007 | 1.1 | | | Pwr. Stress = .5, 5K ohms, RWR 84 |
| 9.6 | Wirewound, Power | RW | 26 | 1.0 | | | Pwr. Stress = .5, 5K ohms, RW10 |
| 9.7 | Wirewound, Power, Chassis Mounted | RER | 39009 | 1.1 | | | Pwr. Stress = .5, Noninductively Wound, 5K ohm, RER 55 |
| 9.7 | Wirewound, Power, Chassis Mounted | RE | 18546 | 1.1 | | | Pwr. Stress = .5, MIL-R-18546, Char. N, 5K ohm, RE75 |
| 9.8 | Thermistor | RTH | 23648 | | | | Disk Type |
| 9.9 | Wirewound, Variable | RTR | 39015 | 1.4 | 1.1 | 1.0 | Pwr. Stress = .5, 5K ohms, 3 Taps, Voltage Stress = .1 |
| 9.9 | Wirewound, Variable | RT | 27208 | 1.4 | 1.1 | 1.0 | Pwr. Stress = .5, 3 Taps, Voltage Stress = .1 |
| 9.10 | Wirewound, Variable, Precision | RR | 12934 | 1.4 | 1.1 | 1.0 | Pwr. Stress = .5, Construction Class 5 ($\pi_C$ = 1.5), 50K ohm, 3 Taps, Voltage Stress = .1 |
| 9.11 | Wirewound, Variable, Semiprecision | RA | 19 | 1.4 | 1.0 | 1.0 | Pwr. Stress = .5, 5K ohms, 3 Taps, Voltage Stress = .5 |
| 9.11 | Wirewound, Semiprecision | RK | 39002 | 1.4 | 1.0 | 1.0 | Pwr. Stress = .5, 3 Taps, Voltage Stress = .5 |
| 9.12 | Wirewound, Variable, Power | RP | 22 | 1.4 | 1.0 | 1.0 | Pwr. Stress = .5, 3 Taps, Voltage Stress = .5, Unenclosed ($\pi_C$ = 1) |
| 9.13 | Nonwirewound, Variable | RJR | 39035 | 1.2 | 1.0 | 1.0 | Pwr. Stress = .5, 200K ohm, 3 Taps, Voltage Stress = .5 |
| 9.13 | Nonwirewound, Variable | RJ | 22097 | 1.2 | 1.0 | 1.0 | Pwr. Stress = .5, 200K ohm, 3 Taps, Voltage Stress = .5 |
| 9.14 | Composition, Variable | RV | 94 | 1.2 | 1.0 | 1.0 | Pwr. Stress = .5, 200K ohm, 3 Taps, Voltage Stress = .5 |
| 9.15 | Nonwirewound, Variable Precision | RQ | 39023 | 1.2 | 1.0 | 1.0 | Pwr. Stress = .5, 200K ohm, 3 Taps, Voltage Stress = .5 |
| 9.15 | Film, Variable | RVC | 23285 | 1.2 | 1.0 | 1.0 | Pwr. Stress = .5, 200K ohm, 3 Taps, Voltage Stress = .5 |

**Default Parameters for Capacitors**

| Section # | Part Type or Dielectric | Style | MIL-C-SPEC | $\pi_{CV}$ | Temp. Rating | Comments |
|---|---|---|---|---|---|---|
| 10.1 | Paper, By-Pass | CP | 25 | 1.0 | 125 | Voltage Stress = .5, .15 μF |
| 10.1 | Paper, By-Pass | CA | 12889 | 1.0 | 85 | Voltage Stress = .5, .15 μF |
| 10.2 | Paper/Plastic, Feed-through | CZR | 11693 | 1.0 | 125 | Voltage Stress = .5, .061 μF |
| 10.3 | Paper/Plastic Film | CPV | 14157 | 1.0 | 125 | Voltage Stress = .5, .027 μF |
| 10.3 | Paper/Plastic Film | CQR | 19978 | 1.0 | 125 | Voltage Stress = .5, .033 μF |
| 10.4 | Metallized Paper/Plastic | CHR | 39022 | 1.0 | 125 | Voltage Stress = .5, .14 μF |
| 10.4 | Metallized Plastic/Plastic | CH | 18312 | 1.0 | 125 | Voltage Stress = .5, .14 μF |
| 10.5 | Metallized Paper/Plastic | CFR | 55514 | 1.0 | 125 | Voltage Stress = .5, .33 μF |
| 10.6 | Metallized Plastic | CRH | 83421 | 1.0 | 125 | Voltage Stress = .5, .14 μF |
| 10.7 | MICA (Dipped or Molded) | CMR | 39001 | 1.0 | 125 | Voltage Stress = .5, 300 pF |
| 10.7 | MICA (Dipped) | CM | 5 | 1.0 | 125 | Voltage Stress = .5, 300 pF |
| 10.8 | MICA (Button) | CB | 10950 | 1.0 | 150 | Voltage Stress = .5, 160 pF |
| 10.9 | Glass | CYR | 23269 | 1.0 | 125 | Voltage Stress = .5, 30 pF |
| 10.9 | Glass | CY | 11272 | 1.0 | 125 | Voltage Stress = .5, 30 pF |
| 10.10 | Ceramic (Gen. Purpose) | CK | 11015 | 1.0 | 125 | Voltage Stress = .5, 3300 pF |
| 10.10 | Ceramic (Gen. Purpose) | CKR | 39014 | 1.0 | 125 | Voltage Stress = .5, 3300 pF |
| 10.11 | Ceramic (Temp. Comp.) | CCR | 20 | 1.0 | 125 | Voltage Stress = .5, 81 pF |
| 10.11 | Ceramic Chip | CDR | 55681 | 1.0 | 125 | Voltage Stress = .5, 81 pF |
| 10.12 | Tantalum, Solid | CSR | 39003 | 1.0 | 125 | Voltage Stress = .5, 1.0 μF, .6 ohms/volt, series resistance, $\pi_{SR}$ = .13 |
| 10.13 | Tantalum, Non-Solid | CLR | 39006 | 1.0 | 125 | Voltage Stress = .5, Foil, Hermetic, 20 μF, $\pi_C$ = 1 |
| 10.13 | Tantalum, Non-Solid | CL | 3965 | 1.0 | 125 | Voltage Stress = .5, Foil, Hermetic, 20 μF, $\pi_C$ = 1 |
| 10.14 | Aluminum Oxide | CUR | 39018 | 1.3 | 125 | Voltage Stress = .5, 1700 μF |
| 10.15 | Aluminum Dry | CE | 62 | 1.3 | 85 | Voltage Stress = .5, 1600 μF |
| 10.16 | Variable, Ceramic | CV | 81 | | 85 | Voltage Stress = .5 |
| 10.17 | Variable, Piston | PC | 14409 | | 125 | Voltage Stress = .5 |
| 10.18 | Variable, Air Trimmer | CT | 92 | | 85 | Voltage Stress = .5 |
| 10.19 | Variable, Vacuum | CG | 23183 | | 85 | Voltage Stress = .5, Variable Configuration |

**Default Parameters for Inductive and Electromechanical Parts**

| Section # | Part Type | MIL-SPEC | $\pi_C$ | $\pi_{CYC}$ | $\pi_F$ | Comments |
|---|---|---|---|---|---|---|
| | INDUCTIVE | | | | | |
| 11.1 | Low Pwr. Pulsed, XFMR | MIL-T-21038 | | | | Max. Rated Temp. = 130°C, ΔT = 10°C |
| 11.1 | Audio XFMR | MIL-T-27 | | | | Max. Rated Temp. = 130°C, ΔT = 10°C |
| 11.1 | High Pwr. Pulse and Pwr. XFMR, Filter | MIL-T-27 | | | | Max. Rated Temp. = 130°C, ΔT = 30°C |
| 11.1 | RF Transformers | MIL-T-55631 | | | | Max. Rated Temp. = 130°C, ΔT = 10°C |
| 11.2 | RF Coils, Fixed or Molded | MIL-C-15305 | 1 | | | Max. Rated Temp. = 125°C, ΔT = 10°C |
| 11.2 | RF Coils, Variable | MIL-C-15305 | 2 | | | Max. Rated Temp., = 125°C, ΔT = 10°C |
| | ROTATING DEVICES | | | | | |
| 12.1 | Motors | | | | | t = 15,000 hours (Assumed Replacement Time) |
| 12.2 | Synchros | | | | | $T_F = T_A + 40$, Size 10 - 16, 3 Brushes |
| 12.2 | Resolvers | | | | | $T_F = T_A + 40$, Size 10 - 16, 3 Brushes |
| | Elapsed Time Meters (ETM) | | | | | |
| 12.3 | ETM-AC | | | | | Op. Temp/Rated Temp. = .5 ($\pi_T$ = .5) |
| 12.3 | ETM-Inverter Driver | | | | | Op. Temp/Rated Temp. = .5 ($\pi_T$ = .5) |
| 12.3 | ETM-Commutator DC | | | | | Op. Temp/Rated Temp. = .5 ($\pi_T$ = .5) |
| | RELAYS | | | | | |
| 13.1 | General Purpose | | 3 | 1 | 5 | Max. Rated Temp. = 125°C , DPDT, MIL-SPEC, 10 Cycles/Hour, 4 Amp., General Purpose, Balanced Armature, Resistive Load, s = .5 |
| 13.1 | Contactor, High Current | | 3 | 1 | 5 | Max. Rated Temp. = 125°C, DPDT, MIL-SPEC, 10 Cycles/Hour, 600 Amp., Solenoid, Inductive Load, s = .5 |
| 13.1 | Latching | | 3 | 1 | 5 | Max. Rated Temp. = 125°C, MIL-SPEC, 4 Amp., Mercury Wetted, 10 Cyles/Hour, DPDT, Resistive Load, s = .5 |
| 13.1 | Reed | | 1 | 2 | 6 | Max. Rated Temp. = 85°C, MIL-SPEC, Signal Current, Dry Reed, 20 Cycles/Hour, SPST, Resistive Load, s = .5 |
| 13.1 | Thermal Bi-Metal | | 1 | 1 | 10 | Max. Rated Temp. = 125°C, MIL-SPEC, Bi-Metal, 10 Cycles/Hour, SPST, Inductive Load, 5 Amp., s = .5 |
| 13.1 | Meter Movement | | 1 | 1 | 100 | Max. Rated Temp. = 125°C, MIL-SPEC, Polarized Meter Movement, 10 Cycles/Hour, SPST, Resistive Load, s = .5 |
| 13.2 | Solid State | MIL-R-28750 | | | | No Defaults |
| 13.2 | Time Delay Hybrid and Solid State | MIL-R-83726 | | | | No Defaults |