

## NOTICE OF CHANGE

<b>NOT MEASUREMENT SENSITIVE</b>
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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New Page(s)	Date	Superseded Page(s)	Date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
A-5		A-5	2 December 1991
A-6		A-6	2 December 1991
A-7		A-7	2 December 1991
A-8		A-8	2 December 1991
A-9		A-9	2 December 1991
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

AMSC N/A

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AREA-RELI

## **MIL-HDBK-217F NOTICE 1**

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

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### 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.

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## NOTICE 1

### 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	MOS
	$C_1$	$C_1$
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

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## 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 ≤ 64K	.0013	.0017	.0025	.016	.019	.011
64K < B ≤ 256K	.0026	.0034	.0050	.031	.038	.021
256K < B ≤ 1M	.0052	.0068	.010	.062	.075	.042

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

Total No. of Programming Cycles Over EEPROM Life, C	Flotox <sup>1</sup>	Textured-Poly <sup>2</sup>
Up to 100	.00070	.0097
100 < C ≤ 200	.0014	.014
200 < C ≤ 500	.0034	.023
500 < C ≤ 1K	.0068	.033
1K < C ≤ 3K	.020	.061
3K < C ≤ 7K	.049	.14
7K < C ≤ 15K	.10	.30
15K < C ≤ 20K	.14	.30
20K < C ≤ 30K	.20	.30
30K < C ≤ 100K	.68	.30
100K < C ≤ 200K	1.3	.30
200K < C ≤ 400K	2.7	.30
400K < C ≤ 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 ≤ 400K	1.1
400K < C ≤ 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	

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## 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

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

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

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

Package Type	$\pi_{PT}$	
	Hermetic	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 (cm <sup>2</sup> )				
	$A \leq .4$	$.4 < A \leq .7$	$.7 < A \leq 1.0$	$1.0 < A \leq 2.0$	$2.0 < A \leq 3.0$
.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<sup>2</sup>     $X_s$  = Feature Size (microns)

Die Area Conversion: cm<sup>2</sup> = MIL<sup>2</sup> ÷ 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

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

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.

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**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 ( $\leq 100$ 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

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**5.5 MICROCIRCUITS, HYBRIDS**

**DESCRIPTION**  
**Hybrid Microcircuits**

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

$N_c$  = 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, $\pi_E = 1$ .
<b>NOTE:</b> 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
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## 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 commercial 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

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## 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 -  $\pi_T$

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

Use:

$E_a$  = .8 to Calculate  $\pi_{T1}$

$E_a$  = .55 to Calculate  $\pi_{T2}$

$T_J$  = Junction Temperature ( $^{\circ}\text{C}$ ),  
 $25 \leq T_J \leq 175$

$T_J$  =  $T_{\text{CASE}} + 10^{\circ}\text{C}$

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.),  $N_1 \leq 1000$

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**5.7 MICROCIRCUIT, MAGNETIC BUBBLE MEMORIES**

**Write Duty Cycle Factor -  $\pi_W$**

$$\pi_W = \frac{10D}{(RW)^3}$$

$$\pi_W = 1 \quad \text{for } D \leq .03 \text{ or } RW \geq 2154$$

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

$$RW = \text{No. of Reads per Write}$$

**NOTE:**

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

**Duty Cycle Factor -  $\pi_D$**

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

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

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

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

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

$$N_2 = \text{Number of Bits, } N_2 \leq 9 \times 10^6$$

**All Other Model Parameters**

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

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5.8 MICROCIRCUITS,  $\pi_T$  TABLE FOR ALL

Temperature Factor For All Microcircuits -  $\pi_T$

	TL, STL, ASTL, CAL, HTL, FTL, DTL, ECL	BICMOS, LSTL, LTTL, ALSTL	III, ISL	Digital MOS, VHSIC CMOS	Linear (Bipolar & MOS)	Memories (Bipolar & MOS), MNOS	GaAs MMIC	GaAs Digital
$E_a(eV) \rightarrow$ $T_J(^{\circ}C)$	.4	.5	.6	.35	.65	.6	1.5	1.4
25	.10	.10	.10	.10	.10	.10	3.20E-08	1.00E-08
30	.13	.14	.15	.13	.15	.15	8.40E-08	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	59	210	8.7	400	210	8.40E-01	5.70E-01
175	18	68	250	9.6	480	250	9.90E-01	8.50E-01

$$\pi_T = .1 \exp \left( \frac{-E_a}{8.617 \times 10^{-5} \left( \frac{1}{T_J + 273} - \frac{1}{298} \right)} \right) \quad \text{Silicon Devices} \quad \pi_T = .1 \exp \left( \frac{-E_a}{8.617 \times 10^{-5} \left( \frac{1}{T_J + 273} - \frac{1}{423} \right)} \right) \quad \text{GaAs Devices}$$

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

$T_J$  = Worst 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 ( $^{\circ}C$ )

$P$  = Device Power Dissipation (W)

$\theta_{JC}$  = Junction to Case Thermal Resistance ( $^{\circ}C/W$ )

$\theta_{JC}$  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 I<sup>2</sup>C, 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.

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5.9 MICROCIRCUITS,  $C_2$  TABLE FOR ALLPackage Failure Rate for all Microcircuits -  $C_2$ 

Number of Functional Pins, $N_p$	Package Type				
	Hermetic: DIPs w/Solder or Weld Seal, Pin Grid Array (PGA) <sup>1</sup> , SMT (Leaded and Nonleaded)	DIPs with Glass Seal <sup>2</sup>	Flatpacks with Axial Leads on 50 Mil Centers <sup>3</sup>	Cans <sup>4</sup>	Nonhermetic: DIPs, PGA, SMT (Leaded and Nonleaded) <sup>5</sup>
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.

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**NOTICE 1**

**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, $K_i$ ( $\frac{W}{in^2 \cdot ^\circ C/in}$ )	$\left(\frac{1}{K_i}\right)(L_i)$ ( $in^2 \cdot ^\circ C/W$ )
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:  $\geq 2W$ , 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 ( $\frac{W}{in^2 \cdot ^\circ C/in}$ ) (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 ( $^\circ C$ ). If unknown, use the  $T_C$  Default Table shown in Section 5.11.

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

$P_D$  = Die Power Dissipation (W)

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**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.

$$\lambda_p = (C_1 \pi_T + C_2 \pi_E) \pi_Q \pi_L \quad \text{Section 5.1}$$

$$C_1 = .020 \quad 1000 \text{ Transistors} = 250 \text{ Gates, MOS } C_1 \text{ Table, Digital Column}$$

$$\pi_T = .29 \quad \begin{array}{l} \text{Determine } T_J \text{ from Section 5.11} \\ T_J = 48^\circ\text{C} + (28^\circ\text{C/W})(.075\text{W}) = 50^\circ\text{C} \\ \text{Determine } \pi_T \text{ from Section 5.8, Digital MOS Column.} \end{array}$$

$$C_2 = .011 \quad \text{Section 5.9}$$

$$\pi_E = 4.0 \quad \text{Section 5.10}$$

$$\pi_Q = 3.1 \quad \begin{array}{l} \text{Section 5.10} \\ \text{Group 1 Tests} \quad 50 \text{ Points} \\ \text{Group 3 Tests (B-level)} \quad 30 \text{ Points} \\ \text{TOTAL} \quad 80 \text{ Points} \end{array}$$

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

$$\pi_L = 1 \quad \text{Section 5.10}$$

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

**Example 2: EEPROM**

Given: A 128K Flotax 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.

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

$$C_1 = .0034 \quad \text{Section 5.2}$$

$$\pi_T = 3.8 \quad \text{Section 5.8}$$

$$C_2 = .014 \quad \text{Section 5.9}$$

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6.8 TRANSISTORS, HIGH FREQUENCY, GaAs FET

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



## MIL-HDBK-217F

## 6.9 TRANSISTORS, HIGH FREQUENCY, SI FET

SPECIFICATION  
MIL-S-19500

## DESCRIPTION

Si FETs (Avg. Power &lt; 300 mW, Freq. &gt; 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

Quality Factor -  $\pi_Q$ 

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

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)

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

## MIL-HDBK-217F

## 7.1 TUBES, ALL TYPES EXCEPT TWT AND MAGNETRON

## DESCRIPTION

All Types Except Traveling Wave Tubes and Magnetrons.  
Includes Receivers, CRT, Thyatron, 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	$\lambda_b$	Tube Type	$\lambda_b$
Receiver		Klystron, Low Power,	
Triode, Tetrode, Pentode	5.0	(e.g. Local Oscillator)	30
Power Rectifier	10		
CRT	9.6	Klystron, Continuous Wave*	
Thyatron	50	3K3000LQ	9.0
Crossed Field Amplifier		3K50000LF	54
QK681	260	3K210000LQ	150
SFD261	150	3KM300LA	64
Pulsed Gridded		3KM3000LA	19
2041	140	3KM50000PA	110
6952	390	3KM50000PA1	120
7835	140	3KM50000PA2	150
Transmitting		4K3CC	610
Triode, Peak Pwr. $\leq 200$ KW, Avg.	75	4K3SK	29
Pwr. $\leq 2$ KW, Freq. $\leq 200$ MHz		4K50000LQ	30
Tetrode & Pentode, Peak Pwr.	100	4KM50LB	28
$\leq 200$ KW, Avg. Power $\leq 2$ KW,		4KM50LC	15
Freq. $\leq 200$ KW		4KM50SJ	38
If any of the above limits exceeded	250	4KM50SK	37
Vidicon		4KM3000LR	140
Antimony Trisulfide ( $Sb_2S_3$ )		4KM50000LQ	79
Photoconductive Material	51	4KM50000LR	57
Silicon Diode Array Photoconductive		4KM170000LA	15
Material	48	8824	130
Twystron		8825	120
VA144	850	8826	280
VA145E	450	VA800E	70
VA145H	490	VA853	220
VA913A	230	VA856B	65
Klystron, Pulsed*		VA888E	230
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.		* If the CW Klystron of interest is not listed above, use the Alternate CW Klystron $\lambda_b$ Table on the following page.	

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## NOTICE 1

### 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,  $0.2 \leq F \leq 6$

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

\*See previous page for other Klystron Base Failure Rates.

Learning Factor -  $\pi_L$

T (years)	$\pi_L$
$\leq 1$	10
2	2.3
$\geq 3$	1.0

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

$$= 10, T \leq 1$$

$$= 1, T \geq 3$$

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

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,  $0.1 \leq P \leq 100$  and  $P \leq 8.0(10)^6(F)^{-1.7}$

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

\*See previous page for other Klystron Base Failure Rates.

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**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  
 $T_F = 40^\circ\text{C} + \text{Ambient Temperature}$

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

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

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**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

## MIL-HDBK-217F

**APPENDIX A: PARTS COUNT RELIABILITY PREDICTION**

**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:

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

for a given equipment environment where:

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

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

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

$N_i$  = Quantity of  $i^{\text{th}}$  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.

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## APPENDIX A: PARTS COUNT

Generic Failure Rate,  $\lambda_g$  (Failures/10<sup>6</sup> Hours) for Microcircuits. See Page A-4 for  $\lambda_g$  Values  
(Defaults:  $\sigma_T$  Based on Ea Shown, Solder or Weld Seal DIPs/PQAs (No. Pins as Shown Below),  $\kappa_L = 1$  (Device in Production  $\geq 2$  Yr.))

Section #	Part Type	Emitted $T_J$ (°C) →	C <sub>B</sub>	C <sub>E</sub>	C <sub>M</sub>	N <sub>S</sub>	N <sub>U</sub>	A <sub>C</sub>	A <sub>F</sub>	A <sub>UC</sub>	A <sub>UF</sub>	A <sub>RW</sub>	S <sub>F</sub>	M <sub>F</sub>	M <sub>L</sub>	C <sub>L</sub>
5.1	<b>Bipolar Technology</b> Gate/Logic Arrays, Digital (Ea = 4) 1 - 100 Gates 101 - 1000 Gates 1001 to 3000 Gates 3001 to 10,000 Gates 10,001 to 30,000 Gates 30,001 to 99,000 Gates	(16 Pin DIP)	.0038	.012	.024	.024	.035	.025	.030	.032	.049	.047	.0038	.030	.089	1.2
		(24 Pin DIP)	.0060	.020	.038	.037	.055	.039	.048	.051	.077	.074	.0060	.046	.11	1.9
		(40 Pin DIP)	.011	.035	.066	.065	.087	.070	.085	.091	.14	.13	.011	.082	.19	3.3
		(128 Pin PGA)	.033	.12	.22	.22	.33	.23	.28	.30	.46	.44	.033	.28	.65	12
		(180 Pin PGA)	.052	.17	.33	.33	.48	.34	.42	.45	.68	.65	.052	.41	.95	17
5.1	<b>Gate/Logic Arrays, Linear (Ea = .65)</b> 1 - 100 Transistors 101 - 300 Transistors 301 - 1000 Transistors 1001 - 10,000 Transistors	(224 Pin PGA)	.075	.23	.44	.43	.63	.48	.56	.61	.90	.85	.075	.53	1.2	21
		(14 Pin DIP)	.0095	.024	.039	.034	.049	.057	.082	.12	.13	.076	.0095	.044	.096	1.1
		(18 Pin DIP)	.017	.041	.065	.064	.078	.10	.11	.22	.24	.13	.017	.072	.15	1.4
		(24 Pin DIP)	.033	.074	.11	.082	.13	.19	.19	.41	.44	.22	.033	.12	.26	2.0
		(40 Pin DIP)	.060	.12	.18	.15	.21	.29	.30	.63	.67	.35	.050	.19	.41	3.4
5.1	<b>Programmable Logic Arrays (Ea = 4)</b> Up to 200 Gates 201 to 1000 Gates 1001 to 5000 Gates	(16 Pin DIP)	.0061	.016	.028	.027	.040	.032	.037	.044	.061	.054	.0061	.034	.076	1.2
		(24 Pin DIP)	.011	.028	.046	.045	.065	.054	.063	.077	.10	.089	.011	.057	.12	1.9
		(40 Pin DIP)	.022	.052	.087	.082	.12	.099	.11	.14	.19	.18	.022	.10	.22	3.3
		(16 Pin DIP)	.0057	.015	.027	.027	.039	.029	.035	.039	.056	.052	.0057	.033	.074	1.2
		(24 Pin DIP)	.010	.028	.045	.043	.062	.049	.057	.066	.092	.083	.010	.053	.12	1.9
5.1	<b>MOS Technology</b> Gate/Logic Arrays, Digital (Ea = .35) 1 to 100 Gates 101 to 1000 Gates 1001 to 3000 Gates 3001 to 10,000 Gates 10,001 to 30,000 Gates 30,001 to 99,000 Gates	(40 Pin DIP)	.019	.047	.080	.077	.11	.088	.10	.12	.17	.15	.019	.085	.21	3.3
		(128 Pin PGA)	.049	.14	.25	.24	.36	.27	.32	.36	.51	.48	.049	.30	.69	12
		(180 Pin PGA)	.084	.22	.39	.37	.54	.42	.49	.56	.79	.72	.084	.46	1.0	17
		(224 Pin PGA)	.13	.31	.53	.51	.73	.59	.69	.82	1.1	.98	.13	.63	1.4	21
		(14 Pin DIP)	.0095	.024	.039	.034	.049	.057	.082	.12	.13	.076	.0095	.044	.096	1.1
5.1	<b>Gate/Logic Arrays, Linear (Ea = .65)</b> 1 to 100 Transistors 101 to 300 Transistors 301 to 1,000 Transistors 1001 to 10,000 Transistors	(18 Pin DIP)	.017	.041	.065	.064	.078	.10	.11	.22	.24	.13	.017	.072	.15	1.4
		(24 Pin DIP)	.033	.074	.11	.082	.13	.19	.19	.41	.44	.22	.033	.12	.26	2.0
		(40 Pin DIP)	.06	.12	.18	.15	.21	.28	.30	.63	.67	.35	.05	.19	.41	3.4
		(16 Pin DIP)	.0095	.024	.039	.034	.049	.057	.082	.12	.13	.076	.0095	.044	.096	1.1
		(24 Pin DIP)	.017	.041	.065	.064	.078	.10	.11	.22	.24	.13	.017	.072	.15	1.4
5.1	<b>Floating Gate Programmable Logic Array, MOS (Ea = .35)</b> Up to 10K Gates 10K to 64K Gates 64K to 256K Gates 256K to 1M Gates	(24 Pin DIP)	.0046	.018	.035	.035	.052	.035	.044	.044	.070	.070	.0046	.044	.10	1.9
		(28 Pin DIP)	.0056	.021	.042	.042	.062	.042	.052	.053	.084	.083	.0056	.052	.12	2.3
		(28 Pin DIP)	.0061	.022	.043	.042	.063	.043	.054	.055	.086	.084	.0061	.053	.13	2.3
		(40 Pin DIP)	.0095	.033	.064	.063	.094	.065	.080	.083	.13	.13	.0095	.079	.19	3.3
		(40 Pin DIP)	.028	.061	.098	.091	.13	.12	.13	.17	.22	.18	.028	.11	.24	3.3
5.1	<b>Microprocessors, Bipolar (Ea = 4)</b> Up to 8 Bits Up to 16 Bits Up to 32 Bits	(64 Pin PGA)	.052	.11	.18	.16	.23	.21	.24	.32	.39	.31	.052	.20	.41	5.6
		(128 Pin PGA)	.11	.23	.36	.33	.47	.44	.49	.65	.81	.65	.11	.42	.86	12
		(40 Pin DIP)	.048	.089	.13	.12	.16	.16	.17	.24	.28	.22	.048	.15	.28	3.4
		(64 Pin PGA)	.093	.17	.24	.22	.29	.30	.32	.45	.52	.40	.093	.27	.50	5.6
		(128 Pin PGA)	.19	.34	.49	.45	.60	.61	.66	.90	1.1	.82	.19	.54	1.0	12

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## APPENDIX A: PARTS COUNT

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

Section #	Part Type	Environ. $\rightarrow$ $T_J(^{\circ}\text{C}) \rightarrow$	Gg	Gf	Gm	Ns	Nu	Ac	Af	Auc	Auf	Arw	Sf	Mf	Ml	Cl
5.2	MOS Technology Memories, ROM (Ea = .5) Up to 16K 16K to 64K 64K to 256K 256K to 1 MB	(24 Pin DIP) (28 Pin DIP) (28 Pin DIP) (40 Pin DIP)	.0047 .0059 .0087 .011	.018 .022 .023 .036	.036 .043 .045 .088	.035 .042 .044 .066	.053 .063 .068 .098	.037 .045 .048 .075	.045 .055 .059 .090	.048 .080 .088 .11	.074 .080 .089 .15	.071 .086 .089 .14	.0047 .0059 .0067 .011	.044 .053 .067 .083	.11 .13 .23 .20	60
5.2	Memories, PROM, LVEPRAM, EEPROM, EAPROM (Ea = .5) (NOTE: $\lambda_{typ} = 0$ assumed for EEPROM)															
	Up to 16K 16K to 64K 64K to 256K 256K to 1 MB	(24 Pin DIP) (28 Pin DIP) (28 Pin DIP) (40 Pin DIP)	.0049 .0081 .0072 .012	.018 .022 .024 .038	.036 .044 .046 .071	.036 .043 .045 .068	.053 .064 .067 .10	.037 .046 .051 .080	.046 .058 .061 .095	.049 .082 .073 .12	.075 .093 .10 .16	.072 .087 .092 .14	.0048 .0062 .0072 .012	.045 .054 .057 .086	.11 .13 .23 .20	60
5.2	Memories, DRAM (Ea = .5) Up to 16K 16K to 64K 64K to 256K 256K to 1 MB	(18 Pin DIP) (22 Pin DIP) (24 Pin DIP) (28 Pin DIP)	.0040 .0055 .0074 .011	.014 .019 .023 .032	.027 .036 .043 .057	.027 .034 .040 .053	.040 .051 .060 .077	.029 .039 .049 .070	.035 .047 .058 .080	.040 .056 .076 .12	.059 .079 .10 .15	.055 .070 .074 .11	.0040 .0055 .0074 .011	.034 .043 .051 .067	.080 .10 .12 .15	2.3
5.2	Memories, SRAM, (MOS & BiMOS) (Ea = .5) Up to 16K 16K to 64K 64K to 256K 256K to 1 MB	(18 Pin DIP) (22 Pin DIP) (24 Pin DIP) (28 Pin DIP)	.0079 .014 .023 .043	.022 .034 .053 .092	.038 .057 .084 .14	.034 .050 .071 .11	.050 .073 .10 .16	.048 .077 .12 .22	.054 .085 .13 .23	.083 .14 .25 .46	.10 .17 .27 .49	.073 .11 .16 .26	.0079 .014 .023 .043	.044 .065 .092 .15	.098 .14 .19 .30	2.3
5.2	Bipolar Technology Memories, ROM, PROM (Ea = .5) Up to 16K 16K to 64K 64K to 256K 256K to 1 MB	(24 Pin DIP) (28 Pin DIP) (28 Pin DIP) (40 Pin DIP)	.010 .017 .028 .053	.028 .043 .065 .12	.050 .071 .10 .18	.048 .063 .085 .15	.067 .091 .12 .21	.062 .095 .15 .27	.070 .11 .16 .29	.10 .18 .30 .56	.13 .21 .33 .61	.098 .14 .19 .33	.010 .017 .028 .053	.058 .081 .11 .19	.13 .18 .23 .39	1.9
5.2	Memories, SRAM (Ea = .5) Up to 16K 16K to 64K 64K to 256K 256K to 1 MB	(24 Pin DIP) (28 Pin DIP) (28 Pin DIP) (40 Pin DIP)	.0075 .012 .018 .033	.023 .033 .045 .073	.043 .058 .074 .13	.041 .054 .065 .11	.060 .079 .085 .16	.050 .072 .10 .18	.058 .083 .11 .20	.077 .12 .19 .35	.10 .15 .22 .39	.084 .11 .14 .24	.0075 .012 .018 .033	.052 .069 .084 .14	.12 .15 .18 .30	1.9
5.3	VHSIC Microcircuit CMOS															
5.4	GaAs MMIC (Ea = 1.5) 1 to 100 Elements 101 to 1000 Active Elements (Default: Device and Input Power to 100 mW)	(8 Pin DIP) (16 Pin DIP)	.0013 .0028	.0052 .011	.010 .022	.010 .022	.018 .034	.011 .023	.013 .028	.015 .030	.022 .047	.021 .045	.0013 .0028	.013 .028	.031 .068	57 1.2
5.4	GaAs Digital (Ea = 1.4) 1 to 1000 Active Elements 1001 to 10,000 Active Elements	(36 Pin DIP) (64 Pin PGA)	.0066 .013	.028 .050	.052 .10	.052 .10	.078 .15	.054 .10	.067 .13	.078 .15	.12 .23	.11 .20	.0066 .013	.065 .13	.16 .30	2.9 5.5

Refer to Section 5.3, VHSIC CMOS



## MIL-HDBK-217F

## APPENDIX A: PARTS COUNT

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 2008 (External Visual)	50
2*	TM 1010 (Temperature Cycle, Cond B Minimum) or TM 2001 (Constant Acceleration, Cond B Minimum)	37
3	TM 5004 (or 5008 for Hybrids) (Final Electricals @ Temp Extremes) and TM 1014 (Seal Test, Cond A, B, or C) and TM 2008 (External Visual)	30 (B Level) 38 (S Level)
4*	Pre-Burn in Electricals	
5	TM 1015 (Burn-In B-Level/S-Level) and TM 5004 (or 5008 for Hybrids) (Post Burn-In Electricals @ Temp Extremes)	
6	TM 2020 Pin (Particle Impact Noise Detection)	11
7*	TM 5004 (or 5008 for Hybrids) (Final Electricals @ Temperature Extremes)	11 (Note 1)
8	TM 2010* 7 (Internal Visual)	7
9	TM 1014 (Seal Test, Cond A, B, or C)	7 (Note 2)
10	TM 2012 (Radiography)	7
11	TM 2009 (External Visual)	7 (Note 2)
	TM 5007/5013 (GaAs) (Welder Acceptance)	1
	TM 2023 (Non-Destructive Bond Puff)	1

87

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

\*NOT APPROPRIATE FOR PLASTIC PARTS

## NOTES:

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

## EXAMPLES:

- Mfg. performs Group 1 test and Class B burn-in:  $\pi_Q = 2 + \frac{87}{50 \times 30} = 3.1$
- 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

$$\pi_Q = 10$$

Quality Factors -  $\pi_Q$ 

Description	$\pi_Q$
<b>Class S Categories:</b>	
1. Procured in full accordance with MIL-A-38510, Class S requirements.	
2. Procured in full accordance with MIL-I-38536 and Appendix B thereto (Class U).	.25
3. Hybrid: (Procured to Class S requirements (Quality Level K) of MIL-H-38534.	
<b>Class B Categories:</b>	
1. Procured in full accordance with MIL-A-38510, Class B requirements.	
2. Procured in full accordance with MIL-I-38536, (Class Q).	1.0
3. Hybrid: Procured to Class B requirements (Quality Level H) of MIL-H-38534.	
<b>Class B-1 Categories:</b>	
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 see 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
$\pi_L = .01 \exp(5.36 - .35Y)$	
Y = Years generic device type has been in production	

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NOTICE 1

## APPENDIX A: PARTS COUNT

Generic Failure Rate - $\lambda_g$ (Failures/ $10^6$ Hours) for Discrete Semiconductors																
Section #	Part Type	Env. $\rightarrow$ $T_j(^{\circ}\text{C}) \rightarrow$	$G_E$	$G_F$	$G_M$	$N_S$	$N_U$	$A_{IC}$	$A_{IF}$	$A_{UC}$	$A_{UF}$	$A_{RW}$	$S_F$	$M_F$	$M_L$	$C_L$
		50	60	65	65	60	65	75	75	90	90	75	50	65	75	60
DIODES																
6.1	General Purpose Analog	.0036	.028	.049	.049	.043	.10	.082	.21	.20	.44	.17	.0018	.076	.23	1.5
6.1	Switching	.00094	.0075	.013	.013	.011	.027	.024	.054	.054	.12	.045	.00047	.020	.060	.40
6.1	Fast Recovery Pwr. Rectifier	.065	.52	.89	.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	.039	.034	.082	.073	.16	.16	.35	.13	.0014	.060	.18	1.2
6.1	Transient Suppressor/Varistor	.0029	.023	.040	.040	.035	.084	.075	.17	.17	.36	.14	.0015	.062	.18	1.2
6.1	Voltage Ref/Reg. (Avalanche and Zener)	.0033	.024	.039	.039	.035	.082	.066	.15	.13	.27	.12	.0016	.060	.16	1.3
6.1	Current Regulator	.0056	.040	.066	.066	.060	.14	.11	.25	.22	.46	.21	.0028	.10	.28	2.1
6.2	SI Impatt ( $f \leq 35$ GHz)	.89	2.8	8.9	8.9	5.6	20	11	14	36	62	44	.43	16	67	350
6.2	Gunn/Bulk Effect	.31	.76	2.1	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	.0066	.027	.027	.019	.058	.025	.032	.057	.097	.10	.002	.048	.15	1.2
6.2	PIN	.023	.068	.19	.19	.14	.41	.18	.22	.40	.69	.71	.014	.34	1.1	8.5
6.2	Schottky Barrier and Point Contact (200 MHz $\leq f \leq 25$ GHz)	.047	.11	.31	.31	.23	.68	.30	.37	.67	1.1	1.2	.023	.56	1.8	14
6.2	Varactor	.0043	.010	.029	.029	.021	.063	.028	.034	.062	.11	.11	.0022	.052	.17	1.3
6.10	Thyristor/SCR	.0025	.020	.034	.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	.0017	.0037	.0030	.0067	.0080	.013	.0056	.000073	.0027	.0074	.056
6.3	Power NPN/PNP ( $f < 200$ MHz)	.0057	.042	.069	.069	.063	.15	.12	.26	.23	.50	.22	.0029	.11	.29	2.2
6.4	Si FET ( $f \leq 400$ MHz)	.014	.099	.16	.16	.15	.34	.28	.62	.53	1.1	.51	.0069	.25	.68	5.3
6.9	Si FET ( $f > 400$ MHz)	.089	.24	.64	.64	.47	1.4	.81	.76	1.3	2.3	2.4	.049	1.2	3.6	30
6.8	GeAs FET ( $P < 100$ mW)	.17	.51	1.5	1.5	1.0	3.4	1.8	2.3	5.4	9.2	7.2	.083	2.8	11	63
6.8	GeAs FET ( $P \geq 100$ mW)	.42	1.3	3.9	3.9	2.5	8.5	4.5	5.6	13	23	18	.21	6.9	27	160
6.5	Unijunction	.016	.12	.20	.20	.18	.42	.36	.80	.74	1.6	.66	.0079	.31	.88	6.4
6.6	RF, Low Noise ( $f > 200$ MHz, $P < 1$ W)	.094	.23	.63	.63	.46	1.4	.60	.75	1.3	2.3	2.4	.047	1.1	3.6	28
6.7	RF, Power ( $P \geq 1$ W)	.045	.091	.23	.23	.18	.50	.18	.23	.32	.55	.73	.023	.41	1.1	11

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NOTICE 1

## APPENDIX A: PARTS COUNT

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

Section #	Part Type	Env. $\rightarrow$ $T_j$ (°C) $\rightarrow$ 50	$Q_B$	$Q_F$	$Q_M$	$N_S$	$N_U$	$A_{IC}$	$A_{IF}$	$A_{JC}$	$A_{JF}$	$A_{RW}$	$S_F$	$M_F$	$M_L$	$C_L$
6.11	OPTO-ELECTRONICS															
	Photodetector	.011	.029	.13	.074	.20	.084	.13	.17	.23	.36	.0057	.15	.51	6.6	
6.11	Opto-Irradiator	.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	2.5	87	350	3500	
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 = 1.0 Nonhermetic with Facet Coating = 3.3 Nonhermetic without Facet Coating				

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## APPENDIX A: PARTS COUNT

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

Section #	Part Type	Style	MIL-R	Env. $T_A$ (°C) →	$G_B$	$G_F$	$G_M$	$N_S$	$N_U$	$A_C$	$A_F$	$A_{UC}$	$A_{UF}$	$A_{RW}$	$S_F$	$M_F$	$M_L$	$C_L$
9.1	Composition	RCR	36008	.00050	.0022	.0071	.0037	.012	.0052	.0065	.016	.025	.025	.0098	.0025	.0098	.035	.36
9.1	Composition	RC	11	.00050	.0022	.0071	.0037	.012	.0052	.0065	.016	.025	.025	.0098	.0025	.0098	.035	.36
9.2	Film, Insulated	FLR	36017	.0012	.0027	.011	.0054	.020	.0063	.013	.018	.030	.030	.0025	.014	.044	.69	.69
9.2	Film, Insulated	FL	22684	.0012	.0027	.011	.0054	.020	.0063	.013	.018	.030	.030	.0025	.014	.044	.69	.69
9.2	Film, RN (R, C or N)	RNR	55182	.0014	.0031	.013	.0061	.023	.0072	.014	.021	.034	.034	.00028	.016	.050	.78	.78
9.2	Film	FN	10509	.0014	.0031	.013	.0061	.023	.0072	.014	.021	.034	.034	.00028	.016	.050	.78	.78
9.3	Film, Power	FD	11804	.012	.025	.13	.062	.21	.078	.10	.19	.32	.32	.0060	.18	.47	8.2	8.2
9.4	Film, Network	RZ	83401	.0023	.0066	.031	.013	.055	.022	.043	.077	.15	.15	.10	.0011	.055	.15	1.7
9.5	Wirewound, Accurate	PER	36005	.0085	.018	.10	.045	.16	.15	.17	.30	.38	.38	.26	.0068	.13	.37	5.4
9.5	Wirewound, Accurate	PB	93	.0085	.018	.10	.045	.16	.15	.17	.30	.38	.38	.26	.0068	.13	.37	5.4
9.6	Wirewound, Power	RWR	36007	.014	.031	.16	.077	.26	.073	.15	.19	.39	.39	.42	.0042	.21	.62	9.4
9.6	Wirewound, Power	RW	26	.013	.028	.15	.070	.24	.066	.13	.18	.35	.35	.38	.0038	.19	.56	8.6
9.7	Wirewound, Power, Chassis Mounted	PER	36009	.0080	.018	.096	.045	.15	.044	.088	.12	.24	.24	.25	.0040	.13	.37	5.5
9.7	Wirewound, Power, Chassis Mounted	RE	18546	.0080	.018	.096	.045	.15	.044	.088	.12	.24	.24	.25	.0040	.13	.37	5.5
9.8	Thermistor	RTH	23848	.085	.32	1.4	.71	1.8	.71	1.9	1.0	2.7	2.7	2.4	.032	1.3	3.4	62
9.9	Wirewound, Variable	RTR	36015	.026	.056	.36	.17	.59	.17	.27	.36	.60	.60	1.1	.013	.53	1.6	25
9.9	Wirewound, Variable	RT	27208	.026	.056	.36	.17	.59	.17	.27	.36	.60	.60	1.1	.013	.53	1.6	25
9.10	Wirewound, Variable, Precision	FR	12934	.36	.80	7.7	3.2	13	3.9	5.8	7.8	11	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	36002	.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	RUR	36035	.033	.10	.50	.21	.87	.19	.27	.52	.79	.79	1.5	.017	.79	2.2	35
9.13	Nonwirewound, Variable	RJ	22097	.033	.10	.50	.21	.87	.19	.27	.52	.79	.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	7.5	3.3	.025	1.5	4.7	87
9.15	Nonwirewound, Variable Precision	RQ	36023	.043	.15	.75	.35	1.3	.39	.78	1.8	2.8	2.8	2.5	.021	1.2	3.7	49
9.15	Film, Variable	RVC	23285	.048	.16	.76	.38	1.3	.36	.72	1.4	2.2	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	S	Established Reliability Styles	M	ML-SPEC	Lower
$\pi_Q$	.030	.10	.30	1.0	10

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## NOTICE 1

### APPENDIX A: PARTS COUNT

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

Section #	Part Type or Dielectric	Style	MIL-C	Env. $\rightarrow$ $T_A$ (°C) $\rightarrow$ 30	$G_B$	$G_F$	$G_M$	$N_S$	$K_U$	$A_{IC}$	$A_{IF}$	$A_{JC}$	$A_{JF}$	$A_{RW}$	$S_F$	$M_F$	$M_L$	$C_L$
10.1	Paper, By-Pass	CP	25	.0036	.0072	.003	.033	.018	.055	.023	.03	.070	.13	.083	.0018	.044	.12	2.1
10.1	Paper, By-Pass	CA	12889	.0039	.0087	.042	.042	.022	.070	.035	.047	.19	.35	.13	.002	.056	.19	2.5
10.2	Paper/Plastic, Feed-through	CZR	11893	.0047	.0096	.044	.044	.034	.073	.030	.040	.084	.15	.11	.0024	.058	.16	2.7
10.3	Paper/Plastic Film	CPV	14157	.0021	.0042	.017	.010	.010	.030	.0088	.013	.026	.048	.044	.0010	.023	.063	1.1
10.3	Paper/Plastic Film	COF	19978	.0021	.0042	.017	.010	.010	.030	.0088	.013	.026	.048	.044	.0010	.023	.063	1.1
10.4	Metalized Paper/Plastic	CFR	39022	.0028	.0058	.023	.014	.014	.041	.012	.018	.037	.068	.060	.0014	.032	.088	1.5
10.4	Metalized Plastic/Plastic	CH	18312	.0028	.0058	.023	.014	.014	.041	.012	.018	.037	.068	.060	.0014	.032	.088	1.5
10.5	Metalized Paper/Plastic	CFF	55514	.0041	.0083	.042	.021	.021	.067	.026	.048	.086	.14	.10	.0020	.054	.15	2.5
10.6	Metalized Plastic	CFH	83421	.0023	.0092	.019	.012	.012	.033	.0088	.014	.034	.053	.048	.0011	.026	.07	1.2
10.7	MICA (Dipped or Molded)	CMR	39001	.0005	.0015	.0091	.0091	.0044	.014	.0068	.0095	.054	.069	.031	.00025	.012	.046	.45
10.7	MICA (Dipped)	CM	5	.0005	.0015	.0091	.0091	.0044	.014	.0068	.0095	.054	.069	.031	.00025	.012	.046	.45
10.8	MICA (Button)	CB	10960	.018	.037	.19	.094	.094	.31	.10	.14	.47	.60	.48	.0091	.25	.68	11
10.9	Glass	CVR	23288	.0032	.0098	.059	.059	.0029	.0094	.0044	.0062	.035	.046	.020	.00016	.0076	.030	.29
10.9	Glass	CV	11272	.0032	.0098	.059	.059	.0029	.0094	.0044	.0062	.035	.046	.020	.00016	.0076	.030	.29
10.10	Ceramic (Gen. Purpose)	CK	11015	.0036	.0074	.034	.019	.019	.056	.015	.015	.032	.048	.077	.0014	.049	.13	2.3
10.10	Ceramic (Gen. Purpose)	CKR	39014	.0036	.0074	.034	.019	.019	.056	.015	.015	.032	.048	.077	.0014	.049	.13	2.3
10.11	Ceramic (Temp. Comp.)	CCR	20	.0078	.0022	.013	.0056	.0056	.023	.0077	.015	.053	.12	.046	.00039	.017	.065	.68
10.11	Ceramic Chip	CCR	55681	.0078	.0022	.013	.0056	.0056	.023	.0077	.015	.053	.12	.046	.00039	.017	.065	.68
10.12	Tantalum, Solid	CSR	39003	.0018	.0039	.016	.0097	.0097	.028	.0081	.011	.034	.057	.055	.00072	.022	.066	1.0
10.13	Tantalum, Non-Solid	CLR	39008	.0061	.013	.069	.039	.039	.11	.031	.061	.13	.28	.18	.0030	.089	.26	4.0
10.13	Tantalum, Non-Solid	CL	3905	.0061	.013	.069	.039	.039	.11	.031	.061	.13	.28	.18	.0030	.089	.26	4.0
10.14	Aluminum Oxide	CLR	39018	.024	.061	.42	.18	.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	.24	.83	.73	.88	4.3	5.4	2.0	.015	.68	2.8	28
10.16	Variable, Ceramic	CV	81	.06	.27	1.2	.71	.71	2.3	.69	1.1	6.2	12	4.1	.032	1.9	5.9	85
10.17	Variable, Piston	PC	14408	.003	.13	.62	.31	.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	.87	3.0	1.0	1.7	9.9	19	6.1	.040	2.5	8.9	100
10.19	Variable, Vacuum	CQ	23183	.04	1.3	6.7	3.6	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	S	Established Reliability Styles	L	MIL-SPEC	Lower
$\lambda_Q$	.030	R	P	M	10
		.10	.30	1.0	3.0
				3.0	10

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## APPENDIX A: PARTS COUNT

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

Section	Part Type	MIL-	Env → $T_A$ (°C) → 30	$G_F$	$G_M$	$N_S$	$N_U$	$A_C$	$A_{IF}$	$A_{UC}$	$A_{UF}$	$A_{RW}$	$S_F$	$M_F$	$M_L$	$C_L$
<b>INDUCTIVE DEVICES</b>																
11.1	Low Power Pulse XFMR	T-21038	.0035	.023	.049	.019	.085	.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 Pow. Pulse and Pow. XFMR, Filter	T-27	.023	.16	.34	.13	.45	.21	.27	.35	.45	.82	.011	.37	1.2	16
11.1	RF XFMR	T-55831	.028	.18	.39	.15	.52	.22	.29	.33	.42	.88	.014	.42	1.2	19
11.2	RF Coils, Fixed or Molded	C-15305	.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
<b>ROTATING DEVICES</b>																
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
<b>ELAPSED TIME METERS</b>																
12.3	ETM-AC		10	20	120	70	180	50	80	160	260	280	5.0	140	390	*
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	*
<b>RELAYS</b>																
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	Connector, High Current		.43	.88	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	Fixed		.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	Motor Movement		.88	1.8	14	7.4	28	7.1	9.1	13	14	48	.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
<b>SWITCHES</b>																
14.1	Toggle or Pushbutton	S-6805	.0010	.0030	.018	.0080	.029	.010	.018	.013	.022	.046	.0005	.025	.067	1.2
14.2	Sensitive	S-3786	.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 Switch	S-22710	.33	.99	5.9	2.6	9.5	3.3	5.9	4.3	7.2	15	.16	8.2	22	380
14.4	Thumbwheel	C-83383	.56	1.7	10	4.5	16	5.6	10	7.3	12	26	.28	14	38	670
14.5	Circuit Breaker, Thermal		.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-58828	.060	.12	.90	.48	1.6	.42	.54	.66	.72	2.8	.030	1.5	4.0	N/A
<b>CONNECTORS</b>																
15.1	Circular/Rect/Panel		0.011	0.14	.12	.069	.20	.059	.098	.28	.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	.0056	.027	.012	.035	.015	.023	.021	.025	.048	.00097	.027	.070	1.3
15.3	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 Ambient Temperature (°C)

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## APPENDIX A: PARTS COUNT

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

Section #	Part Type Dielectric	MIL	Env. $\rightarrow$ $T_A$ (°C) $\rightarrow$ 30	$G_F$	$G_M$	$N_S$	$N_U$	$A_C$	$A_{IF}$	$A_{UC}$	$A_{UF}$	$A_{RW}$	$S_F$	$M_F$	$M_L$	$C_L$
17.1	SINGLE CONNECTIONS Hard Solder, w/o Wrapping Hard Solder, w/ Wrapping Crimp Weld Solderless Wrap Clip Termination Rework Solder METERS, PANEL		.0026	.0052	.018	.010	.029	.010	.016	.016	.021	.042	.0013	.023	.062	1.1
17.1			.00014	.00028	.00098	.00056	.0015	.00056	.00084	.00084	.0011	.0022	.00007	.0013	.0034	.059
17.1			.00028	.00052	.0018	.0010	.0028	.0010	.0016	.0016	.0021	.0042	.00013	.0023	.0062	.11
17.1			.00050	.00100	.000350	.000200	.000550	.000200	.000300	.000300	.000400	.000800	.000025	.000450	.001200	.021000
17.1			.0000035	.000007	.000025	.000014	.000039	.000014	.000021	.000021	.000028	.000056	.0000018	.000031	.000084	.0015
17.1			.00012	.00024	.00084	.00048	.0013	.00048	.00072	.00072	.00086	.0019	.00006	.0011	.0028	.050
17.1			.000069	.000138	.000483	.000276	.000739	.000276	.000414	.000414	.000562	.001104	.000035	.000621	.001656	.02898
18.1		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		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 Lamps, Incandescent, AC Lamps, Incandescent, DC	C-3098	.002	.096	.32	.19	.51	.38	.54	.70	.90	.74	.016	.42	1.0	16
20.1			3.9	7.8	12	12	16	16	16	19	23	19	2.7	16	23	100
20.1			13	26	38	38	51	51	51	64	77	64	9.0	51	77	350
21.1	ELECTRONIC FILTERS Ceramic-Ferrite Discrete LC Comp. Discrete LC & Crystal Comp.	F-15733	.022	.044	.13	.088	.20	.15	.20	.24	.29	.24	.018	.15	.33	2.6
21.1		F-15733	.12	.24	.72	.48	1.1	.84	1.1	1.3	1.6	1.3	.086	.84	1.8	14
21.1		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

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## APPENDIX A: PARTS COUNT

 $\pi_Q$  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	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.



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## APPENDIX A: PARTS COUNT

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							
6.1	DIODES	.0038			.42	1.0			Voltage Stress = .7, Metallurgically Bonded Contacts
6.1	General Purpose Analog								
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 ( $\leq 35$ 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 $\leq$ frequency $\leq 35$ GHz)	.027			1.0	1.0			Multiplier Application
6.2	Varactor	.0025			2.5	1.0			Voltage Stress = .7, Rated Forward Current = 1 Amp
6.10	Thyristor/SCR	.0022			.51			1.0	
6.3	TRANSISTORS	.00074			.21		.70	.77	Voltage Stress = .5, Switching Application, Rated Power = .5W
6.3	NPN/PNP ( $f < 200$ MHz)								
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 ( $f \leq 400$ MHz)	.012					.70		MOSFET, Small Signal Switching
6.4	SI FET ( $f > 400$ MHz)	.060							MOSFET
6.6	GaAs FET ( $P < 100$ mW)	.052		1.0			1.0		Low Noise Application, $1 \leq f \leq 10$ GHz, Input and Output Matching
6.6	GaAs FET ( $P \geq 100$ mW)	.13		1.0			1.0		Pulsed Application, 5 GHz, 1W Average Output Power, Input and Output Matching
6.5	Unijunction	.0083						.77	Voltage Stress = .7, Rated Power = .5W
6.6	RF, Low Noise, Bipolar ( $f > 200$ MHz, $P < 1$ W)	.18			.39				1 GHz, 100W, $T_J = 130^\circ\text{C}$ for all Environments,
6.7	RF, Power ( $P \geq 1$ W)	.06	.36	1.0			1.6		Voltage Stress = .45, Gold Metallization, Pulsed Application, 20% Duty Factor, Input and Output Matching

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## APPENDIX A: PARTS COUNT

Default Parameters for Discrete Semiconductors

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

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## APPENDIX A: PARTS COUNT

Default Parameters for Resistors

Section #	Part Type	Style	MIL-R-SPEC	$\tau_R$	$\tau_V$	$\tau_{TAPS}$	Comments
9.1	Composition	ROR	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, $T_C = T_A + 28^\circ\text{C}$ , 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	PER	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 ( $\tau_C = 1.5$ ), 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 ( $\tau_C = 1$ )
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	RQ	39023	1.2	1.0	1.0	Pwr. Stress = .5, 200K ohm, 3 Taps, Voltage Stress = .5
9.15	Precision Film, Variable	RVC	23285	1.2	1.0	1.0	Pwr. Stress = .5, 200K ohm, 3 Taps, Voltage Stress = .5

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## APPENDIX A: PARTS COUNT

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 $\mu F$
10.1	Paper, By-Pass	CA	12889	1.0	85	Voltage Stress = .5, .15 $\mu F$
10.2	Paper/Plastic, Feed-through	CZR	11693	1.0	125	Voltage Stress = .5, .061 $\mu F$
10.3	Paper/Plastic Film	CPV	14157	1.0	125	Voltage Stress = .5, .027 $\mu F$
10.3	Paper/Plastic Film	CCR	19978	1.0	125	Voltage Stress = .5, .033 $\mu F$
10.4	Metallized Paper/Plastic	CHR	39022	1.0	125	Voltage Stress = .5, .14 $\mu F$
10.4	Metallized Plastic/Plastic	CH	18312	1.0	125	Voltage Stress = .5, .14 $\mu F$
10.5	Metallized Paper/Plastic	CFR	55514	1.0	125	Voltage Stress = .5, .33 $\mu F$
10.6	Metallized Plastic	CFH	83421	1.0	125	Voltage Stress = .5, .14 $\mu F$
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	CCR	55681	1.0	125	Voltage Stress = .5, 81 pF
10.12	Tantalum, Solid	CSR	39003	1.0	125	Voltage Stress = .5, 1.0 $\mu F$ , .8 ohms/volt, series resistance, $\pi_{SR} = .13$
10.13	Tantalum, Non-Solid	CLR	39006	1.0	125	Voltage Stress = .5, Foil, Hermetic, 20 $\mu F$ , $\pi_C = 1$
10.13	Tantalum, Non-Solid	CL	3965	1.0	125	Voltage Stress = .5, Foil, Hermetic, 20 $\mu F$ , $\pi_C = 1$
10.14	Aluminum Oxide	CLR	39018	1.3	125	Voltage Stress = .5, 1700 $\mu F$
10.15	Aluminum Dry	CE	62	1.3	85	Voltage Stress = .5, 1600 $\mu F$
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

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NOTICE 1

## APPENDIX A: PARTS COUNT

Default Parameters for Inductive and Electromechanical Parts

Section #	Part Type	MIL-SPEC	$\tau_C$	$\tau_{CYC}$	$\tau_F$	Comments
11.1	INDUCTIVE Low Pwr. Pulsed, XFMR	MIL-T-21038				Max. Rated Temp. = 130°C, $\Delta T = 10^\circ\text{C}$
11.1	Audio XFMR	MIL-T-27				Max. Rated Temp. = 130°C, $\Delta T = 10^\circ\text{C}$
11.1	High Pwr. Pulse and Pwr. XFMR, Filter	MIL-T-27				Max. Rated Temp. = 130°C, $\Delta T = 30^\circ\text{C}$
11.1	RF Transformers	MIL-T-55631				Max. Rated Temp. = 130°C, $\Delta T = 10^\circ\text{C}$
11.2	RF Coils, Fixed or Molded	MIL-C-15305	1			Max. Rated Temp. = 125°C, $\Delta T = 10^\circ\text{C}$
11.2	RF Coils, Variable	MIL-C-15305	2			Max. Rated Temp., = 125°C, $\Delta T = 10^\circ\text{C}$
12.1	ROTATING DEVICES 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
12.3	Elapsed Time Meters (ETM) ETM-AC					Op. Temp./Rated Temp. = .5 ( $\tau_T = .5$ )
12.3	ETM-Inverter Driver					Op. Temp./Rated Temp. = .5 ( $\tau_T = .5$ )
12.3	ETM-Commutator DC					Op. Temp./Rated Temp. = .5 ( $\tau_T = .5$ )
13.1	RELAYS 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	Contactors, 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 Cycles/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