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System Name

Mil-HDBK-217F Notice 2 MTBF Prediction Report

Issue 1.0 / July 2018

This report has been prepared for:

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Prepared by:
xxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxx
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1. List of Changes

Issue	Date	Editor	Change description
1.0	July 26th 2018	Thomas Reiter	First issue

Table 1: List of Changes

2. Associated Documents

Document	Description
ABCDEF-01.xlsx	Bill of materials
Mil-HDBK-217F Notice 2	Reliability prediction for electronic equipment
ANSI/VITA 51.1 (2013)	Quality factor assessment for commercial electronic parts (Add On for Mil-HDBK-217F N2)

3. Introduction

This document contains the failure rate and MTBF assessment for the following unit

System Name

The assessment has been performed using

Mil-HDBK-217F Notice 2

including the recommendations given in

ANSI/VITA 51.1-2013

ANSI/VITA 51.1-2013 contains recommendations for quality factor assessment for today's (2013 and later) commercial electronic components.

MTBF values are given in hours [h] and failure rate values in "failures per million hours" [fpmh].
1 fpmh = 1 failure per 1,000,000 hours.

Conversion MTBF – fpmh:

<fpmh> = 1,000,000 / MTBF [h]
<MTBF> = 1,000,000 / Failure Rate [fpmh]

4. Summary

4.1 Failure Rates [fpmh] for Ground Benign, Controlled Environment (GB)

If your system is complex (e.g. hierarchical or modular), results may be reported for all assemblies accordingly. More environments, if requested, will be included.

Temp [°C]	xxxxxxxx	yyyyyyyy	zzzzzzzz
-40	2.457	11.058	9.847
-35	3.234	14.553	12.642
-30	3.557	16.008	13.807
-25	4.234	19.053	16.242
-20	4.657	20.958	17.767
-15	5.234	23.553	19.842
-10	5.757	25.908	21.727
-5	6.234	28.053	23.442
0	6.857	30.858	25.687
5	7.234	32.553	27.042
10	7.957	35.808	29.647
15	8.234	37.053	30.642
20	**9.234**	**41.553**	**34.242**
25	10.234	46.053	37.842
30	11.234	50.553	41.442
35	12.234	55.053	45.042
40	13.234	59.553	48.642
45	14.234	64.053	52.242
50	15.234	68.553	55.842
55	16.234	73.053	59.442
60	17.234	77.553	63.042
65	18.234	82.053	66.642
70	19.234	86.553	70.242
75	20.234	91.053	73.842
80	21.234	95.553	77.442
85	22.234	100.053	79.042

Table 2: Failure rates for ground benign, controlled (GB) environment

4.2 MTBF [h] for Ground Benign, Controlled Environment (GB)

Temp [°C]	xxxxxxxx	yyyyyyyy	zzzzzzzz
-40	447,628	99,473	110,590
-35	406,934	90,430	101,557
-30	309,215	68,714	79,099
-25	281,104	62,468	72,429
-20	236,183	52,485	61,567
-15	214,712	47,714	56,285
-10	191,058	42,457	50,397
-5	173,690	38,598	46,026
0	160,411	35,647	42,658
5	145,828	32,406	38,931
10	138,236	30,719	36,979
15	125,669	27,926	33,731
20	**121,448**	**26,988**	**32,635**
25	108,295	24,066	29,204
30	97,714	21,714	26,425
35	89,015	19,781	24,130
40	81,739	18,164	22,201
45	75,563	16,792	20,558
50	70,254	15,612	19,142
55	65,643	14,587	17,908
60	61,599	13,689	16,823
65	58,025	12,894	15,862
70	54,843	12,187	15,005
75	51,991	11,554	14,236
80	49,422	10,983	13,542
85	47,094	10,465	12,913

Table 3: MTBF for ground benign, controlled (GB) environment

5. Reliability Assessment

5.1 Mathematical Models

The analyzed system contains active and passive electronic components, which are mounted on printed circuit boards. This reliability assessment assumes that all components are equally necessary to perform the system function, which means that any component failure is assumed to result in functional failure of the system. As this is not the practical case, and some failures may only result in a maintenance action, the calculated MTBF is also called „Maintenance–related MTBF".

MTBF calculations are based on mathematical models for failure rates, which are published in certain international standards, e.g. Mil-HDBK-217, Telcordia SR-332, 217Plus, Siemens SN 29500.

5.1.1 Serial Reliability Model

Figure 1 shows a simple serial model.

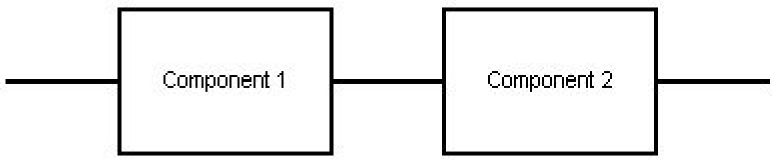

Figure 1: Serial Reliability Model

If an element failure rate is constant over time, the reliability for a single series element can be expressed as the following exponential distribution.

$$R(t)_i = e^{-\lambda_i t}$$

where:

$R(t)_i$ = the probability of survival for a single series element for a given operating time t
e = the base of the natural logarithm
λ_i = a constant representing the i^{th} element failure rate
t = the element operating time

If each exponentially distributed series element is independent, the series system reliability function can be expressed as the following product.

$$R(t)_{series} = \prod_{i=1}^{n} e^{-\lambda_i t}$$

where:

$R(t)_{series}$ = the probability of survival for a series system for a given operating time *t*.
e = the base of the natural logarithm
λ_i = a constant representing the i^{th} element failure rate
t = the element operating time

If each element is independent, it can be shown that the failure rate for an exponential distribution series system is the sum of the failure rates of the individual elements.

$$\lambda_{series} = \sum_{i=1}^{n} \lambda_i$$

where:
λ_{series} = a constant representing a series system failure rate
λ_i = a constant representing the i^{th} element failure rate
λ_n = a constant representing the last element failure rate

and

$$R(t)_{series} = e^{-\lambda_{series} t}$$

where:

$R(t)_{series}$ = the probability of survival for a series system for a given operating time t
e = the base of the natural logarithm
λ_{series} = a constant representing the series system failure rate
t = the series system operating time

The mean time between failures (MTBF) for an exponentially distributed single element or series system can be determined from the reliability function or, as shown below, directly from the failure rate.

$$MTBF = \int_0^{\infty} R(t)_i \, dt$$

$$MTBF = \int_0^\infty e^{-\lambda_i t}\,dt = \frac{1}{\lambda_i}$$

$$MTBF = \int_0^\infty e^{-\lambda_{seriessystem} t}\,dt = \frac{1}{\lambda_{seriessystem}}$$

where:

$MTBF_{seriessystem}$ = the mean time between failure of the series system

λ_i = the constant failure rate of the ith element

$\lambda_{seriessystem}$ = the constant failure rate of a series system

e = the base of the natural logarithm

t = the series system operating time

For a series system with exponentially distributed elements the, $MTBF_{series}$ can be expressed as shown below.

$$MTBF_{series} = \frac{1}{\lambda_1 + \ldots + \lambda_n}$$

where:

$MTBF_{series}$ = the mean time between failures for a series system

λ_n = a constant representing the nth series element failure rate

5.1.2 Data Sources and Assumptions

In order to perform a failure rate assessment on information typically given in BOMs, several assumptions must be made.

1. Mil-HDBK-217F Notice 2 has been used for all components except those mentioned below in topic 7, special components.
2. Failure rate of mechanical components (screws, chassis, etc.) is considered negligible.
3. Quality factors: The recommendations of ANSI/VITA 51.1-2013 have been used. The quality factors of those component types not covered by ANSI/VITA 51.1-2013 have been assessed one level above the Mil-HDBK-217 quality level "commercial".

   Connectors, for which ANSI/VITA 51.1-2013 recommends quality level "commercial", have been assessed one level above "commercial", too, because the Mil-HDBK-217 model for connectors addresses operating conditions which are substantially worse compared with civil applications.
4. Temperature rise during operation:
   - dT = +15°C for U1
   - dT = +5°C for all other piece parts.
5. Environmental factor GB (ground benign, controlled), has been used for calculation.
6. Stress levels: 50% power ratio, current ratio and stress ratio has been used for all applicable components.
7. Special components:

Component	Issue	Decision
Item 70 xxxxxxxxxxxxx DC-DC Converter Power Module TDK	This is a small PCB with electronic components. Data sheet information: "MTBF = 2,2 million hours (BELLCORE TR-NWT-000332)". No additional information is given. Comparison of this figure with the picture on the data sheet strongly suggests that the figure has been obtained by a very old version of Telcordia SR-332.	Judgment: 5 million hours @ 40°C, GF environment seems a reasonable figure under Mil-HDBK-217F N2 including ANSI/VITA 51.1-2013.
Item 14 abc	4 diodes in a single case.	Use the diode model. Multiplicative failure rate adjustment factor shall be = 2.

Table 4: Special piece parts

6. Reliability Assessment Details

The table below provides detailed failure rates on piece part level for +20°C, GB environment.

All failure rates are given in *failures per million hours (fpmh)*

Conversion MTBF – fpmh:

<fpmh> = 1,000,000 / MTBF [h]
<MTBF> = 1,000,000 / Failure Rate [fpmh]

Name	Item	Value	PN (2)	PN (2)	Reference Designator	Description	Mil 217 Category	Mil 217 Subcategory	FR/Unit [fpmh]	Quantity	FR [fpmh]
6.1 System Name									**1.22331**	**1**	**1.22331**
	1	10nF	xxxxxxxxxxx	GRM033R71A103KA01D	C1, C3, C10, C11, C12, C13, C107, C131, C1, C3, C10, C11, C12, C13, C107, C131	10nF 10V 10% X7R 0201 -55+125	Capacitor	General Ceramic (CK, CKR)	0.000232	13	0.004732
	2	0.1uF	xxxxxxxxxxx	C0603X5R1A104K	C1, C3, C10, C11, C12, C13, C107, C131	100nF 10V 10% X5R 0201 -55+85	Capacitor	General Ceramic (CK, CKR)	0.000232	12	0.023023
	10	LXES03AAA1-154	xxxxxxxxxxx	LXES03AAA1-154	D18, D19, D20	ESD Protection Diodes with Ultra Low Capacitance	Semiconductor	Diode	0.00772	2	0.02542
	29	1.2nH 500MHz	xxxxxxxxxxx	LQP03TN1N2B02D	L4, L7, L9	Thinfilm-Chip-Inductor 1.2nH+-0.1nH.14-Q (500MHz) 0.1ohm 750mA;<1GHz;	Inductor	Coil	0.000252	1	0.000302
	34	MMBT2907A	xxxxxxxxxxx	MMBT2907ALT1G	T1, T2, T3, T4	PNP SML SIG G.P. AMP&SWITCH SOT23.Uceo-xxxxxxx	Semiconductor	Transistor	0.000925	3	0.002745
	48	56R	xxxxxxxxxxx	RC0201JR-0756RL	R1 R2 R3 R4 R5	56R 5% 020 1/20W 200ppm	Resistor	Film (RL, RLR, RN, RNR, RM)	0.000222	4	0.000963
	49	510R	xxxxxxxxxxx	RC0201JR-07510RL	R1 R2 R3 R4 R5, R1 R2 R3 R4 R5	510R 5% 0603 1/10W	Resistor	Film (RL, RLR, RN, RNR, RM)	0.000222	3	0.000963
	64	W971GG6JB-25I	xxxxxxxxxxx	W971GG6JB-25I	U1	1G (64M x 16)800MHz DDR2 SDRAM	Integrated Circuit	Memory	0.023439	2	0.023439

Name	Item	Value	PN (2)	PN (2)	Reference Designator	Description	Mil 217 Category	Mil 217 Subcategory	FR/Unit [fpmh]	Quantity	FR [fpmh]
	65	FP6811-29NSAPTR	xxxxxxxxxxx	FP6811-29NSAPTR	U2	Microprocessor Voltage power monitor	Integrated Circuit	Linear	0.002762	2	0.002762
	71	40.000 MHz+-10ppm	xxxxxxxxxxx	SMD02016/4 40.000 MHz 10/15/-40+85/18pF	Y1	40.00000 MHz SMD02016	Miscellaneous	Quartz Crystal	0.003035	2	0.003035
	73		xxxxxxxxxxx		PCB	Board	PCB		0.053622	2	0.053622

Table 5: Failure rates on piece part level for GB20 environment