



**MP4502
MTBF Report**

by



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Revision History:

Version	Date	Comments	Contributors
1.0	1/6/2025	Initial draft	MB
1.1	3/7/2025	Update FIT value for FIL1301	MB

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1 Introduction

1.1 Overview

Failure rates were determined for the components in the Bill of Materials provided by HID Global. The BOM was PCA-01045 MP4502. A Mean Time Between Failure (MTBF) calculation was then performed using Telcordia SR332, Issue 4, ARPP Version 12.1a, 2017.

1.2 Scope

This report, prepared by Percept Technology Labs LLC, documents the failure rate analysis and the results of the calculation.

1.3 Definitions

BOM = Bill of Materials

FR = Failure Rate - units are failures/million hours

FIT = Failures in Time - units are failures/billion hours

MTBF = Mean Time Between Failure – units are hours

The predicted elapsed time between inherent failures of a system during operation is called the mean time between failures (MTBF). This is calculated as the arithmetic mean (average) time between failures of a system. The MTBF is typically part of a model that assumes the failed system is immediately repaired (zero elapsed time), as a part of a renewal process. In contrast, the mean time to failure (MTTF), measures average time between failures with the modeling assumption that the failed system is not repaired.

The definition of MTBF depends on the definition of what is considered a system failure. For complex, repairable systems, failures are considered to be those out of design conditions which place the system out of service and into a state for repair. Failures which occur that can be left or maintained in an unrepaired condition, and do not place the system out of service, are not considered failures under this definition. In addition, units that are taken down for routine scheduled maintenance or inventory control are not considered within the definition of failure.

For the purposes of this report, we are using the first definition of failure: that which places the system out of service and in need of repair.

1.4 Company Restricted Information

This document contains confidential and restricted information. Reproduction of this document outside of HID Global or Percept Technology Labs LLC is prohibited.

1.5 Reference Documents

Reference documents for this evaluation included the PCA-01045 MP4502 Bill of Materials and component specifications.

1.6 Client Information

HID GLOBAL
Unit 3, Cae Gwyrdd
Green Meadow Springs Business Park
CF15 7AB Cardiff
United Kingdom

1.7 Test Entrance Criteria

- All necessary product-related materials and support documentation required for Percept Technology Labs LLC to execute this project.
- Access to a technical resource (person) for operational questions.

1.8 Test Exit Criteria

- All data collected for specified test cases.
- Completed Test Report (This document).

2 Analysis

2.1 General Reliability Prediction Assumptions

- An electronic component can only fail when current is applied.
- The probability of failure for any electronic component is constant throughout its "useful life". The probability of failure is the same from the first it is turned on until the end of its useful life is reached (usually millions of hours of run time).
- $MTBF = 1/\text{failure rate}$. If the failure rate number is obtained from the Telcordia database or the supplier's datasheets it has assumed 100% duty cycle. The failure rate to be used in the MTBF prediction calculation is equal to the base failure rate times the duty cycle.
- Mechanical and electrical wearout are not part of the reliability prediction calculations.

2.2 Environmental Stress Factors

- Ambient temperature = 25°C.
- Electrical Stress is assumed to be 50% for all components.
- Component Quality Level 1 is used for the prediction.
- The Environment is assumed to be Ground, Fixed, Uncontrolled for all components
- The assumed Duty Cycle is 100% for all components.

3 Results:

Table 1: MP4502 Reliability Prediction

P/N	Quantity	Description	FIT
	1	MP4502	644.086
Failures per Billion Hours			644.086
MTBF			1,552,588

Assumptions:

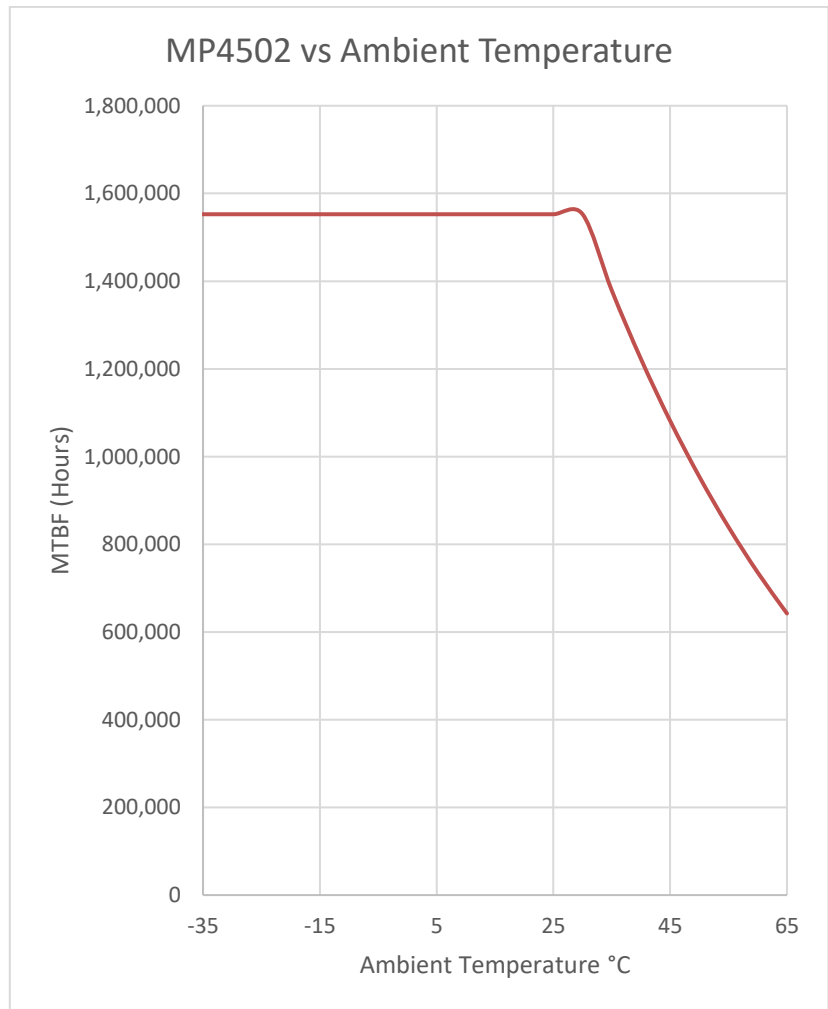
Part Stress Level = 50%

Ambient Temperature = 25°C

Environment = "Ground Fixed, Uncontrolled"

Table 2: MP4502 Prediction vs. Temperature

MP4502 MTBF vs Temperature		
Ambient	FIT	MTBF
-35	644.086	1,552,588
-30	644.086	1,552,588
-25	644.086	1,552,588
-20	644.086	1,552,588
-15	644.086	1,552,588
-10	644.086	1,552,588
-5	644.086	1,552,588
0	644.086	1,552,588
5	644.086	1,552,588
10	644.086	1,552,588
15	644.086	1,552,588
20	644.086	1,552,588
25	644.086	1,552,588
30	644.086	1,552,588
35	725.297	1,378,746
40	818.140	1,222,285
45	924.846	1,081,261
50	1048.196	954,020
55	1191.650	839,173
60	1359.517	735,555
65	1557.158	642,196



4 Appendix A — Component Detail Tables

4.1 MP4502

Table 3: MP4502 System Reliability @ Ambient Temp = 25°C

Description	Qty	Ref Design	Device Fit	System Fit
CONN HEADER STRAIGHT THRU HOLE 2.54MM 2-WAY	4	J1500,J1501,J1502,J1503	0.15	0.59
HDR STR SQ 0.1 2R4P .23/.1 LF	1	J1400	0.59	0.59
DIODE, LED CLEAR RED, 0805	20	D1200,D1401,D1403,D1404,D1405,D1406,D1407,D1409,D1411,D1412,D1413,D1414,D1415,D1416,D1417,D1418,D1801,D1802,D1803,D1804	0.32	6.37
SW DIP SMT TAPE SEAL 4 POS LF-ROHS	1	SW1400	12.18	12.18
TERM HDR FOR QWK DISC 3 POS ROHS	2	TB1500,TB1501	0.22	0.44
TERM HDR FOR QWK DISC 4 POS ROHS	4	TB1701,TB1703,TB1705,TB1707	0.29	1.18
TERM HDR FOR QWK DISC 6 POS ROHS	5	TB300,TB1601,TB1603,TB1800,TB1802	0.44	2.21
DIO TVS UNIDIRECTIONAL 28V DO-214AA(SMB)	4	D304,D305,D1610,D1611	0.13	0.50
RES SMT_0603 TC200 5% 120 OHM LF-ROHS	4	R1501,R1502,R1503,R1514	0.35	1.41
PTC SMT 30V 50MA FOOTPRINT:1210	2	PTC1600,PTC1601	1.20	2.40
CONN VERT USB MICRO-B MLX 105133	1	J1300	0.37	0.37
IC DRIVER 485 HALF-DUPLEX 3.3V SOIC-8	4	U1500,U1501,U1502,U1503	0.01	0.06
CONN HOLDER BU2032SM-HD-G COIN CELL 2032 SMD	1	J1000	0.15	0.15
XSTR NPN 40V SOT-323 (SC-70) LEAD FREE	14	Q501,Q502,Q508,Q509,Q1604,Q1605,Q1606,Q1607,Q1608,Q1609,Q1800,Q1801,Q1802,Q1803	0.04	0.53
DIODE, ESD 5V SOT23 ROHS TWO-LINE ESD PROTECTION	2	D1100,D1300	5.85	11.69
DIODE TVS 600W 24A UNIDIRECTIONAL DO-214AA (SMBJ)	2	D1604,D1605	1.38	2.75
XSTR PNP 40V MMBT3906 TO-236AX LEAD FREE	4	Q1600,Q1601,Q1602,Q1603	0.04	0.15
CAP X7R 10NF 50V 10% 0402 LEAD FREE	11	C301,C302,C305,C307,C309,C320,C525,C526,C530,C532,C1210	0.28	3.10
CAP X7R 5600PF 50V 10% 0402	1	C512	0.28	0.28
CAP COG 6.8PF 50V 2% 0402 LEAD FREE	4	C800,C801,C802,C803	0.28	1.13

Description	Qty	Ref Design	Device Fit	System Fit
RES FILM 10 OHM 0.125W (1/8W) 5% 1206 ROHS COMPLIANT	2	R1614,R1615	0.20	0.40
RES, FILM, 14K OHM, 1%, 100PPM, 1/16W, 0402	7	R321,R530,R534,R535,R536,R540,R546	0.20	1.40
RES FILM 4.7K .063W 5% 0402 LEAD FREE	40	R306,R324,R523,R524,R531,R543,R544,R545,R805,R1100,R1419,R1420,R1421,R1422,R1500,R1504,R1505,R1506,R1508,R1509,R1510,R1512,R1513,R1515,R1606,R1607,R1608,R1609,R1612,R1613,R1616,R1617,R1618,R1620,R1624,R1626,R1628,R1630,R1634,R1636	0.20	7.99
RES FILM 1.0K OHM 0.063W (1/16W) 1% 0402 ROHS COMPLIANT	53	R519,R520,R525,R526,R537,R538,R709,R710,R1400,R1402,R1403,R1404,R1405,R1406,R1407,R1408,R1409,R1410,R1411,R1412,R1414,R1415,R1416,R1417,R1418,R1423,R1424,R1425,R1426,R1700,R1701,R1704,R1705,R1708,R1709,R1712,R1713,R1718,R1719,R1722,R1723,R1726,R1727,R1730,R1731,R1800,R1801,R1802,R1803,R1804,R1805,R1806,R1807	0.20	10.59
RES FILM 10K OHM 0.063W (1/16W) 1% 0402 ROHS COMPLIANT	44	R511,R528,R529,R533,R708,R711,R712,R901,R902,R1000,R1001,R1101,R1102,R1103,R1104,R1105,R1106,R1107,R1108,R1109,R1112,R1219,R1220,R1239,R1516,R1519,R1520,R1523,R1702,R1703,R1706,R1707,R1710,R1711,R1714,R1715,R1716,R1717,R1720,R1721,R1724,R1725,R1728,R1729	0.20	8.79
RES FILM, 52.3K, 0.1W, 1%, 0402, LEAD FREE	1	R301	0.20	0.20
CAP X5R 22UF 25V 20% 0805	4	C325,C326,C505,C506	0.28	1.13
CAP CER 1UF 20% 6.3V X5R 0201	51	C407,C409,C412,C522,C524,C529,C531,C533,C600,C601,C602,C603,C604,C605,C606,C607,C610,C611,C612,C613,C614,C615,C616,C620,C621,C622,C623,C624,C625,C626,C627,C628,C629,C630,C633,C634,C643,C644,C645,C647,C648,C1212	0.28	14.39

Description	Qty	Ref Design	Device Fit	System Fit
		,C1213,C1700,C1701,C1702,C1703 ,C1704,C1705,C1706,C1707		
CAP CER 22UF 6.3V X5R 0603	8	C400,C401,C405,C418,C608,C609, C617,C618	0.28	2.26
CAP X7R .1UF 16V 10% 0402 LEAD FREE	43	C323,C501,C517,C518,C519,C520, C521,C523,C632,C635,C646,C700, C900,C901,C902,C905,C906,C907, C908,C909,C910,C911,C912,C913, C914,C915,C1001,C1003,C1101,C1 103,C1106,C1107,C1211,C1214,C1 400,C1401,C1402,C1500,C1501,C1 502,C1503,C1602,C1603	0.28	12.13
CAP, SMD ELECTROLYTIC,LOW IMPEDANCE,47UF 50V,6.3X7.7, 20%, 105 DEGREES C	2	C300,C308	1.34	2.69
CAP, SMD SUPER-CAPACITORS 3.5V 0.22F - 20/80%, 10.8X10.7MM, - 25 C TO + 70 C	1	C1005	1.05	1.05
CAPACITOR CERAMIC 16PF 1% 50V COG 0402 125°C T/R	1	C511	0.28	0.28
CAPACITOR, CERAMIC, 47PF, 5%, COG, 50V, 0402	1	C327	0.28	0.28
CAP CER 10UF 16V 10% X5R 0603	12	C402,C403,C404,C406,C417,C903, C904,C1000,C1002,C1105,C1208,C 1209	0.28	3.39
CAPACITOR, CERAMIC, CHIP, 10UF 20%, 50V, X5R 1206	10	C303,C304,C306,C321,C322,C500, C515,C516,C527,C1708	0.28	2.82
CAP CER XR7 1000PF 10% 25V 0201	8	C636,C637,C638,C639,C640,C641, C642,C1302	0.28	2.26
CAP CER, 2.2UF ±10%, 10V, X5R, 0201	3	C619,C631,C1104	0.28	0.85
CAPACITOR, CERAMIC, 22NF, 10%, X7R, 50V, 0402	1	C1200	0.28	0.28
CAP CER, 3.3NF ±10%, X7R, 50V, 0402	1	C328	0.28	0.28
CAPACITOR, CERAMIC, 470PF 5% 50V NPO 0402	1	C1216	0.28	0.28
CAPACITOR, CERAMIC, CHIP, 10P, 5%, NPO, 50V, 0402	2	C324,C504	0.28	0.56
CAPACITOR, CERAMIC, CHIP, 22PF, 5%, 50V, NPO, 0402	4	C1600,C1601,C1604,C1605	0.28	1.13
CAPACITOR, CERAMIC, CHIP, 18PF 5% 50V NPO 0402	2	C1217,C1218	0.28	0.56

Description	Qty	Ref Design	Device Fit	System Fit
CAPACITOR, CERAMIC, CHIP, 4.7UF, 20%, 10V, X5R, 0402	11	C408,C410,C411,C413,C414,C415, C416,C1100,C1102,C1215,C1301	0.28	3.10
CONN HEADER STRAIGHT THRU HOLE 2.54MM 3-WAY	2	J503,J1002	0.15	0.29
CONN MICRO SD R/A 8WAY PUSH/PUSH W DETECT SMD	1	J1100	0.22	0.22
CONN MODULAR, 100 BASE-TX, RJ45, 1X1 TAB-DOWN, LEDS, INTEGRATED MAGNETICS	1	J1200	0.37	0.37
XTAL 25.000MHZ, 18PF, FTOL=30PPM, STAB=30PPM, -10C~+70C, 3.2X2.5MM SMD	1	Y1200	5.70	5.70
CRYSTAL, SMD, 32.7680KHZ, 7PF	1	Y801	5.70	5.70
XTAL CRYSTAL 24MHZ, CL=8PF, TOL: ±15PPM, SMD 2016	1	Y800	5.70	5.70
DIODE ZENER SINGLE 5.1V 2% 200MW 2-PIN SOD-323F	4	D1606,D1607,D1608,D1609	0.05	0.20
DIO ZENER 15V 200MW SOD-323F	4	D300,D503,D506,D507	0.05	0.20
DIO TVS 5.0V SMBJ UNIDIRECTIONAL LEAD FREE	18	D1602,D1603,D1702,D1703,D1704,D1705,D1706,D1707,D1710,D1711,D1712,D1713,D1714,D1715,D1718,D1719,D1722,D1723	2.32	41.67
DIODE SCHOTTKY 40V 3.0A SMA	1	D504	2.64	2.64
DIODE, LL4148, SMALL SIGNAL SILICON, MINI-MELF, 200MA	6	D1600,D1601,D1805,D1806,D1807,D1808	0.02	0.15
DIODE, SCHOTTKY, 100V, 0.15A, LOW FORWARD VOLTAGE, SOD-323	7	D1000,D1001,D1002,D1201,D1202,D1400,D1408	0.09	0.61
SMD 2 LINE COMMON MODE FILTER WITH ESD PROTECTION, 90OHMS, 25%,1210-6	1	FIL1301	63.41	63.41
FERRITE BEAD, 1K@100MHZ, 2A,100MOHMS, SMD, 1210	2	FB300,FB301	0.25	0.50
FILTER, SD CARD EMI FILTER AND ESD PROTECTION, 45OHM, 20PF, QFN16L	1	FL1100	0.29	0.29
FILTER, FERRITE BEAD, 1000R@0.1GHZ , 0.8R @ DC, 200MA, 0402	2	L1200,L1201	0.25	0.50
FUSE, PTC RESETTABLE 33V 1.1A SMD 2920	2	PTC500,PTC501	0.00	0.01
IC, SMT, 74H32, QUAD OR GATE, SO-14 PACKAGE	1	U1400	0.01	0.01
IC, 10/100 ETHERNET RMII PHY, 1.6-3.6V, 0 TO +85 DEGREES C,QFN-24	1	U1200	0.59	0.59
IC DUAL COMP SO8, SOIC8	3	U502,U1600,U1601	0.14	0.41
IC CRYPTO ELEMENT SOIC-8	1	U1102	0.16	0.16

Description	Qty	Ref Design	Device Fit	System Fit
IC, SERIAL NOR FLASH MEMORY, SPI - QUAD, 133MHZ 128MBIT, SOIC8	2	U1000,U1001	0.46	0.93
IC,PMIC, 2.8-5.5V, 7 X LDOS, 5 X DC2DC, -40 TO 105C, WFQFN44L	1	U400	0.01	0.01
IC, SECURE BOOT CPU, ARM A7, 650MHZ, -40 TO 125C, TFBGA320	1	U600	0.55	0.55
IC ,BUCK, 3.8-40V, 3.5A, 570KHZ, SS, -40 TO +85C, SOIC-8EP	2	U301,U500	0.06	0.11
IC, NAND FLASH, EMMC 5.1 8GB, -25 TO +85C, TFBGA-153	1	U1100	1.72	1.72
IC, DDR3L, 8GBIT (512M X 16), 933MHZ, 0 TO +95C, VFBGA -96	1	U900	1.72	1.72
IND, WIREWOUND, 4.7UH, ±20%, 10A, 0.015OHMS, SHIELDED, SMD 13.2X12.9X3.5.2MM SMD	1	L303	0.06	0.06
IND, WIREWOUND, 8.2UH, ±20%, 8.5A, 0.028OHMS, SHIELDED, SMD 13.2X12.9X3.5MM SMD	1	L500	0.06	0.06
FERRITE BEAD, 120R@100MHZ, 0.05R @DC, 2A,0603	3	FIL1300,L501,L502	0.25	0.75
INDUCTOR, SHIELDED, POWER,1UH, ±20%, 3A, 0.056R 2.5 X 2.0MM SMT	4	L400,L401,L402,L403	0.60	2.40
RES SMD 22K OHM 5% 1/16W 0402	10	R1603,R1604,R1622,R1623,R1625, R1627,R1632,R1633,R1635,R1637	0.20	2.00
RES FILM 10R 1% 1/4W 0603 ANTI-SURGE	8	R1517,R1518,R1521,R1522,R1524, R1525,R1526,R1527	0.20	1.60
RESISTOR, 0402, 453K, 1%, 1/16W	3	R319,R504,R507	0.20	0.60
RESISTOR, CHIP, THICK FILM, 34K, +-1%, 0.063W, 0402, SMT	1	R515	0.20	0.20
RES FILM 13K OHM 1% 1/16W 0402	1	R323	0.20	0.20
RES, FILM, 12.4K OHM, 1%, 100PPM, 1/16W, 0402	1	R1300	0.20	0.20
RES, FILM, 3K OHM, 1%, 100PPM, 1/16W, 0402	3	R532,R539,R700	0.20	0.60
RES, FILM, 68.1K OHM, 1%, 100PPM, 1/16W, 0402	1	R320	0.20	0.20
RES, FILM, 1.4K OHM, 1%, 100PPM, 1/16W, 0402	1	R517	0.20	0.20
RES, FILM, 21K OHM, 1%, 100PPM, 1/16W, 0402	2	R508,R1301	0.20	0.40

Description	Qty	Ref Design	Device Fit	System Fit
RESISTOR, CHIP, THICK-FILM, 33R+-5%, 0.1W 0805	1	R1002	0.20	0.20
RES, FILM, 33R OHM, 5%, 100PPM, 1/4W, 1206	4	R1600,R1602,R1610,R1611	0.20	0.80
RESISTOR, THICK FILM, CHIP, 47K, 1%, 0.063W, 0402	2	R1401,R1413	0.20	0.40
RESISTOR, CHIP, THICK FILM, OR, +-5%, 0.063W, 0402	12	R514,R600,R800,R804,R1200,R1201,R1210,R1211,R1236,R1241,R1244,R1732	0.20	2.40
RESISTOR, CHIP, THICK FILM, CHIP, 100K ±1%, 0.063W, 0402	5	R303,R521,R522,R541,R1114	0.20	1.00
RESISTOR, THICK FILM, CHIP, 100R, 1%, 0.063W, 0402	2	R904,R1003	0.20	0.40
RESISTOR, THICK FILM, CHIP, 330R, 1%, 0.063W, 0402	3	R1212,R1215,R1217	0.20	0.60
RESISTOR, THICK FILM, CHIP, 33R, 1%, 0.063W, 0402	1	R1213	0.20	0.20
RESISTOR, THICK-FILM, 560 OHM, ±1%, 0.063W, 0402	1	R1221	0.20	0.20
RESISTOR, THICK FILM, CHIP, 10R, 1%, 0.063W, 0402	3	R318,R500,R502	0.20	0.60
RESISTOR, THICK FILM, CHIP, 470R, 1%, 0.063W, 0402	2	R1507,R1511	0.20	0.40
RESISTOR, THICK FILM, CHIP, 2.2K 1% 0.063W 0402	6	R1601,R1605,R1619,R1621,R1629,R1631	0.20	1.20
RESISTOR, THICK FILM, CHIP, 1.5K, 1%, 0.063W, 0402	6	R703,R704,R705,R706,R1216,R1218	0.20	1.20
RESISTOR, CHIP, THICK-FILM, 240R +-1%, 0.063W 0402	3	R501,R900,R903	0.20	0.60
RESISTOR, THICK FILM, CHIP, 12K 1% 50V 0.063W 0402	1	R305	0.20	0.20
RESISTOR, THICK FILM, CHIP, 200K, 1%, 0.063W, 0402	2	R322,R516	0.20	0.40
RESISTOR, CHIP, THICK-FILM, 49.9R +-1% 0.1W 0603	4	R1202,R1203,R1204,R1205	0.20	0.80
RESISTOR, CHIP, THICK-FILM, 18R +-1%, 0.063W 0402	7	R701,R702,R1206,R1207,R1208,R1209,R1214	0.20	1.40
RESISTOR, CHIP, THICK-FILM, 12.1K +-1%, 0.063W, 0402	1	R1223	0.20	0.20
RLY SPDT 10A 5V SEALED SMD	4	K1801,K1802,K1803,K1804	33.45	133.79
SWITCH, TACTILE SPST-NO 0.05A 32V	1	SW400	3.66	3.66

Description	Qty	Ref Design	Device Fit	System Fit
TRANSISTOR, NTMS4177PR2G, P-CHANNEL POWER MOSFET, VDS(MAX) -30V, LD(MAX) - 8.9A, SOIC8, SMT	5	Q300,Q500,Q503,Q506,Q507	0.04	0.20
TRANSISTOR, N-CHANNEL MOSFET, 0.115A. 60V, SOT23	2	Q1500,Q1501	0.10	0.20
SMD 4 LINE ESD DIODE, ULTRA LOW CAPACITANCE, 5V WORKING VOLTAGE, 9.7V BREAKDOWN VOLTAGE,0.19PF	1	D1402	0.30	0.30
TVS, BI-DIR, 28V STANDOFF, 45.4V TO 59V MAX CLAMP, 1500W, DO214AB (SMC)	1	D301	5.85	5.85
TRANSORB, SM712, RS485, 12V TO -7V FULL RANGE, 400W, SOT23	4	D1500,D1501,D1612,D1613	0.06	0.23
TVS DIODE ARRAY, 4WAY, NON-ISOLATED, LOW CAPACITANCE, 3.3V, 40A, UDFN PACKAGE	1	D1210	0.80	0.80
RES FILM 33K 0.063W 1% 0402 LEAD FREE	1	R506	0.20	0.20
Total FIT			429.390	
Environmental Factor			1.500	
System Duty Cycle			100%	
System FIT			644.086	
System MTBF			1,552,588	

5 Appendix B — MTBF Input Factors

5.1 Failure Rate

$$\lambda = \lambda b * \pi 1 * \pi 2 * \pi 3 * \pi 4$$

where

λ = failure rate

λb = base failure rate

πt = operating temperature factor

πes = electrical stress factor

πq = quality factor

πec = environmental condition factor

5.2 Temperature Factor

The prediction process uses a Temperature Factor to model the effect of temperature on failure rate. The value of this factor is based on the device operating temperature and the type of device. The value is normalized to a temperature of 40°C, which produces a Temperature Factor of 1.0 for all device types. When actual device operating temperature differs from the normalized temperature, the actual device operating temperature may be used. In general, temperatures less than 40°C result in a factor less than 1 and temperatures greater than 40°C result in factors greater than 1. The prediction program contains temperature models for each component type which calculates the factor.

5.3 Electrical Stress Factor

The prediction process assumes an electrical stress percentage of 50% (electrical stress factor = 1). If the device's application produces electrical stress percentage higher or lower than this base value, then the failure rate must be adjusted using the electrical stress factor. The prediction program contains electrical stress models for each component type which calculates the factor.

Part	Electrical Stress Percentage
Capacitor	(Sum of applied dc voltage plus ac peak voltage) / (rated voltage)
Resistor, fixed	Applied power / rated power
Resistor, variable	(V ² _{in} / total resistance) / rated power
Relay, switch	Contact current / rated current
Diode, general	Average forward current / rated forward current
Diode zener	Actual zener current or power / rated current or power
Transistor	Power dissipated / rated power

5.4 Quality Factor

The device failure rates used for the prediction process reflect the expected field reliability performance of generic device types. The actual reliability of a specific device will vary as a function of the degree of effort and attention paid by an equipment manufacturer to factors such as device selection/application, supplier selection/control, electrical/mechanical design margins, equipment manufacture process control, and quality program requirements. The table below describes the four quality levels and presents the values for their associated Quality Factor:

Quality Level 0	<p>This level shall be assigned to commercial-grade, reengineered, remanufactured, reworked, salvaged, or gray-market components that are procured and used without device qualification, lot-to-lot controls, or an effective feedback and corrective action program by the primary equipment manufacturer or its outsourced lower-level design or manufacturing subcontractors. However, steps must have been taken to ensure that the components are compatible with the design application.</p> <p>Quality Factor = 6</p>
Quality Level 1	<p>This level shall be assigned to commercial-grade components that are procured and used without thorough device qualification or lot-to-lot controls by the equipment manufacturer. However,</p> <p>(a) steps must have been taken to ensure that the components are compatible with the design application and manufacturing process; and</p> <p>(b) an effective feedback and corrective action program must be in place to identify and resolve problems quickly in manufacture and in the field.</p> <p>Quality Factor = 3</p>
Quality Level 2	<p>This level shall be assigned to components that meet requirements (a) and (b) of Quality Level 1, plus the following:</p> <p>(c) purchase specifications must explicitly identify important characteristics (electrical, mechanical, thermal, and environmental) and acceptable quality levels (i.e. AQLs, Defects per Million, etc) for lot control;</p> <p>(d) devices and device manufacturers must be qualified and identified on approved parts/manufacture's lists (device qualification must include appropriate life and endurance tests);</p> <p>(e) lot-to-lot controls, either by the equipment manufacturer or the device manufacturer, must be in place at adequate AQLs/DPMs to ensure consistent quality.</p> <p>Quality Factor = 1</p>
Quality Level 3	<p>This level shall be assigned to components that meet requirements (a) thru (e) of Quality Levels 1 and 2 plus the following:</p> <p>(f) device families must be re-qualified periodically;</p> <p>(g) lot-to-lot controls must include early life reliability control of 100% screening (temperature cycling and burn-in), which, if the results warrant it, may be reduced to a "reliability audit" (i.e. a sample basis) or to an acceptable "reliability monitor" with demonstrated and accepted cumulative early failure values of less than 200ppm out to 10,000 hours;</p> <p>(h) where burn-in screening is used, the Percent Defective Allowed (PDA) shall be specified and shall not exceed 2% and</p> <p>(i) and ongoing, continuous reliability improvement program must be implemented by both the device and equipment manufacturers.</p> <p>Quality Factor = .8</p>

5.5 Environmental Condition Factor

The prediction process defines 6 environmental conditions. A separate prediction should be made for each environmental condition to which the equipment may be exposed. The prediction process uses an Environment Factor as a quantitative expression for a condition's effect on failure rate. The factor goes from 1 (ground-based, fixed, controlled environment) to 15 (for a space based commercial environment such as a commercial communication satellite).

Environment	Factor	Nominal Environmental Conditions
Ground, Fixed, Controlled	1	Vibration/shock stresses: Low Atmospheric variations: Low Temp cycling stresses: Low Application examples: Central offices, data center, environmentally controlled vaults, environmentally controlled remote shelters, and environmentally controlled customer premise areas.
Ground, Fixed, Uncontrolled (limited)	1.5	Vibration/shock stresses: Low to moderate Atmospheric variations: Low to moderate Temp cycling stresses: Moderate to High Application examples: Weather-protected remote terminals, outdoor equipment, and radio tower equipment.
Ground Fixed, Uncontrolled (moderate)	2.0	Vibration/shock stresses: Moderate to High Atmospheric variations: Low to moderate Temp cycling stresses: Moderate to High Application examples: Remote terminals and outdoor equipment in manholes, and near direct path of railroad, highway, and air traffic.
Ground, Mobile (both vehicular mounted and portable)	4.0	Vibration/shock stresses: Extreme Atmospheric variations: Low to moderate Temp cycling stresses: High Application examples: Equipment that can be in rapid motion relative to the ground, including cell phones and hand-held devices, portable operating equipment, and test equipment
Airborne, Commercial	6.0	Vibration/shock stresses: Extreme Atmospheric variations: High Temp cycling stresses: High Application examples: Passenger compartment of commercial aircraft
Space-based, Commercial (low earth orbit)	15.0	Vibration/shock stresses: Extreme Atmospheric variations: High Temp cycling stresses: High Application examples: Commercial satellites

5.6 Definition of Failure

The definition of a failure should be well understood. This is a crucial element in predicting system reliability parameters.

The following is not included in failure rate predictions:

- Manufacturing process-induced errors.
- Software failures.
- Failures from procedural errors.

Failures in systems with multiple functions may be hard to define. In complex equipment, it may be useful to distinguish between failures affecting maintenance or repair and those affecting service. For example, the failure of an LED is likely to cause a return, but may not cause a service outage. Consequently, LEDs should be included in the failure rate estimate when the estimate is used to determine return rates, but they could likely be disregarded if the estimate is used to determine service availability.