MR50 SIO
MTBF Report

by

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Revision History:

Version	Date	Comments	Contributors
1.0	1/6/2025	Initial draft	MB

Approved:

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Project Manager: Marty Best	2/14/2025

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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-00964 MR50-S3B. 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 HID Global PCA-00964 MR50-S3B 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/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:

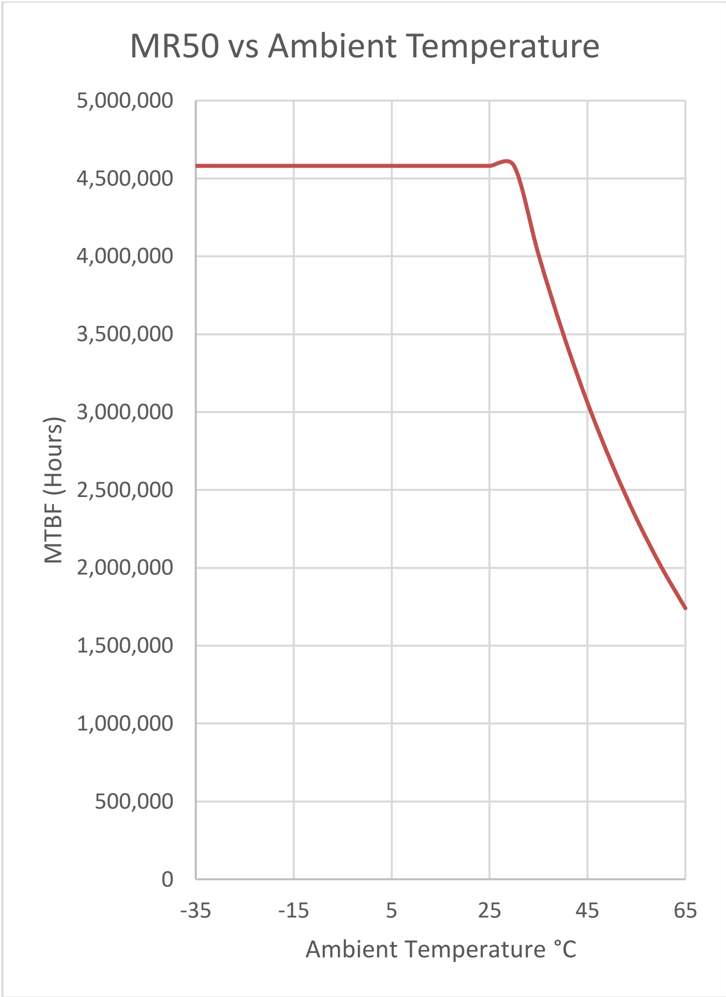
Table 1: MR50 SIO Reliability Prediction

P/N	Quantity	Description	FIT
	1	MR50 SIO	218.347
		Failures per Billion Hours	218.347
		MTBF	4,579,866

<u>Assumptions:</u>
Part Stress Level = 50%
Ambient Temperature = 25ºC
Environment = "Ground Fixed, Uncontrolled"

Table 2: MR50 SIO Prediction vs. Temperature

MR50 SIO MTBF vs Temperature		
Ambient	**FIT**	**MTBF**
-35	218.300	4,580,852
-30	218.300	4,580,852
-25	218.300	4,580,852
-20	218.300	4,580,852
-15	218.300	4,580,852
-10	218.300	4,580,852
-5	218.300	4,580,852
0	218.300	4,580,852
5	218.300	4,580,852
10	218.300	4,580,852
15	218.300	4,580,852
20	218.300	4,580,852
25	218.300	4,580,852
30	218.300	4,580,852
35	249.300	4,011,231
40	285.200	3,506,311
45	326.800	3,059,976
50	375.100	2,665,956
55	431.600	2,316,960
60	497.500	2,010,050
65	574.700	1,740,038



4 Appendix A — Component Detail Tables

4.1 MR50 SIO

Table 3: MR50 SIO System Reliability @ Ambient Temp = 25˚C

Description	Qty	Ref Design	Device Fit	System Fit
DIO SW 70V BAV99LT1 TO-236AX LEAD FREE	8	D501,D504,D507,D701,D702,D706, D802,D804	0.02	0.20
XSTR PNP 40V MMBT3906 TO-236AX LEAD FREE	2	Q701,Q702	0.04	0.08
XSTR NFET 60V SOT-23 LEAD FREE	1	Q601	0.04	0.04
XSTR NPN 40V SOT-323 (SC-70) LEAD FREE	5	Q703,Q704,Q705,Q801,Q802	0.04	0.19
CAP X7R 10NF 50V 10% 0402 LEAD FREE	2	C902,C915	0.28	0.56
CAP X5R 1.0UF 10V 10% 0402 LEAD FREE	4	C501,C502,C503,C908	0.28	1.13
CAP X7R 1.0UF 10% 50V 1206	1	C912	0.28	0.28
CAP X7R 220PF 50V 5% 0603	1	C911	0.28	0.28
CAP COG 1000PF 25V 5% 0402 LEAD FREE	1	C305	0.28	0.28
CAP COG 18PF 50V 5% 0402 LEAD FREE	2	C303,C304	0.28	0.56
RES FILM 0K OHM 50V 1A 0.063W 0402	2	R301,R302	0.20	0.40
Res Thick Film 0603 120 Ohm 5% 0.1W(1/10W) ±200ppm/°C Lead Free	2	R605,R611	0.20	0.40
RES FILM 4.7K .063W 5% 0402 LEAD FREE	29	R303,R304,R305,R306,R307,R308,R309,R310,R311,R401,R402,R403,R404,R409,R410,R509,R510,R601,R606,R608,R612,R702,R707,R709,R711,R713,R714,R717,R720	0.20	5.79
RES FILM 1.0K OHM 0.063W (1/16W) 1% 0402 ROHS COMPLIANT	13	R411,R412,R501,R504,R505,R508,R614,R701,R704,R801,R802,R803,R804	0.20	2.60
RES FILM 10K OHM 0.063W (1/16W) 1% 0402 ROHS COMPLIANT	4	R502,R503,R506,R507	0.20	0.80
RES FILM 68.1K 0.1W (1/10W) 1% 0603, ROHS COMPLIANT	1	R903	0.20	0.20
CONN HEADER STRAIGHT THRU HOLE 2.54MM 2-WAY	3	J1,J2,J602	0.15	0.44
SW DIP SMT TAPE SEAL 8 POS LF-ROHS	1	S1	14.97	14.97
TERM HDR FOR QWK DISC 3 POS ROHS	1	TB1	0.22	0.22

Description	Qty	Ref Design	Device Fit	System Fit
TERM HDR FOR QWK DISC 6 POS ROHS	3	TB2,TB3,TB4	0.44	1.32
RES FILM 33R 5% 0.1W 0603	2	R705,R712	0.35	0.70
PTC SMT 30V 50MA FOOTPRINT:1210	1	F702	1.20	1.20
CAP CER, 10UF ±10%, 16V, X5R, 0805	5	C909,C910,C914,C1001,C1002	0.28	1.41
CAPACITOR, CERAMIC, CHIP, 10UF, 20%, X5R, 10V, 0603	1	C308	0.28	0.28
CAP X7R .1UF 16V 10% 0402 LEAD FREE	21	C306,C307,C309,C310,C311,C312,C313,C314,C315,C316,C317,C318,C319,C320,C321,C401,C601,C602,C701,C703,C1003	0.28	5.93
CAP CER 12PF 50V 1% COG 0402	2	C301,C302	0.28	0.56
CAPACITOR, CERAMIC, 10UF, 50V, 10%, X5R, 1206	3	C903,C904,C913	0.28	0.85
OSC XTAL 32.7680KHZ ±20PPM -40°C - +85°C SMD 3.2X1.5MM	1	Y301	5.70	5.70
CRYSTAL 12.000MHZ, 18-20PF LOAD, <30PPM FTOL, <30PPM STAB, -10 TO +70 DEG, 3.2X2.5MM (X4 PAD) SMD	1	Y302	5.70	5.70
DIO TVS 12.0V SM712 SOT-23-3 LEAD FREE	1	D601	0.06	0.06
DIO TVS UNIDIRECTIONAL 28V DO-214AA(SMB)	3	D703,D707,D902	0.27	0.80
DIO TVS 5.0V SMBJ UNIDIRECTIONAL LEAD FREE	6	D502,D503,D505,D506,D508,D704	2.32	13.89
DIODE SCHOTTKY 40V 3.0A SMA	1	D905	2.64	2.64
FILTER FERRITE BEAD 600OHM @ 100MHZ 1A 1206	2	L301,L901	0.25	0.50
IC DUAL COMP SO8, SOIC8	1	U701	0.14	0.14
IC TRANSCEIVER RS485/ RS422 HALF DUPLEX 8SOIC LEAD FREE	2	U601,U602	0.01	0.03
IC REG LDO 3.3V 1A SOT-89-5	1	U1002	1.29	1.29
IC MICROCONTROLLER ARM CORTEX-M4 RA6M2-SERIES 120MHZ 512KB FLASH, 384K RAM, LQFP-144	1	U301	0.01	0.01
IC REG SWITCHING 1.2-12V 2A 300KHZ SOP-FD-8	1	U902	1.03	1.03
INDUCTOR SMT 22UH >2A <7MM	1	L903	0.48	0.48
LED 2X1.2MM RED WTR CLR SMD 0805 LEAD FREE	4	D401,D402,D801,D803	0.32	1.27

Description	Qty	Ref Design	Device Fit	System Fit
RESISTOR, THICK FILM, CHIP, 470R, 1%, 0.063W, 0402	1	R613	0.20	0.20
RESISTOR, THICK FILM, CHIP, 2.2K 1% 0.063W 0402	2	R708,R718	0.20	0.40
RES FILM 13K 0.1W (1/10W) 1% 0603	1	R904	0.20	0.20
RES SMD 22K OHM 5% 1/16W 0402	7	R602,R607,R703,R706,R710,R715,R719	0.20	1.40
RES FILM 10R 1% 1/4W 0603 ANTI-SURGE	1	R716	0.20	0.20
FLTR, FERRITE BEAD, 600OHM 0603 1A, LEAD FREE	4	R603,R604,R609,R610	0.25	1.00
RLY SPDT 10A 5V SEALED SMD	2	K801,K803	33.45	66.89
TRANSORB, SM712, RS485, 12V TO -7V FULL RANGE, 400W, SOT23	1	D705	0.06	0.06
			Total FIT	145.565
			Environmental Factor	1.500
			System Duty Cycle	100%
			System FIT	218.347
			System MTBF	4,579,866

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 40ºC, 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 40ºC result in a factor less than 1 and temperatures greater than 40ºC 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	(V2in / 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	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. **Quality Factor = 6**
Quality Level 1	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, (a) steps must have been taken to ensure that the components are compatible with the design application and manufacturing process; and (b) an effective feedback and corrective action program must be in place to identify and resolve problems quickly in manufacture and in the field. **Quality Factor = 3**
Quality Level 2	This level shall be assigned to components that meet requirements (a) and (b) of Quality Level 1, plus the following: (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; (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); (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. **Quality Factor = 1**
Quality Level 3	This level shall be assigned to components that meet requirements (a) thru (e) of Quality Levels 1 and 2 plus the following: (f) device families must be re-qualified periodically; (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; (h) where burn-in screening is used, the Percent Defective Allowed (PDA) shall be specified and shall not exceed 2% and (i) and ongoing, continuous reliability improvement program must be implemented by both the device and equipment manufacturers. **Quality Factor = .8**

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 and 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.