

MTBF OF ACOUSTIC CONTROL CARD

TABLE OF CONTENTS

1. Reliability factor	4
2. Environment.....	4
3. Reliability Prediction Analysis of Acoustic Control Card	4
4. Input for Reliability Prediction	5
4. Sample Calculation Rate of Component.....	9
5. Results of Reliability Prediction	11
6. Reliability Calculation	23



LIST OF TABLES

Table 1 Capacitors Failure rate	11
Table 2 Resistors Failure rate	12
Table 3 OP amps Failure rate	15
Table 4 Digital Isolator Failure rate	16
Table 5 Ferrite Chip Bead Failure rate.....	16
Table 6 Regulators Failure rate	17
Table 7 Diode Failure rate.....	17
Table 8 Terminal Block Failure rate	19
Table 9 LED Failure rate.....	19
Table 10 DC-DC Converter Failure rate.....	20
Table 11 Crystal Quartz Failure rate	20
Table 12 Microcontroller Failure rate	21
Table 13 Connector Failure rate.....	22

1. Reliability factor

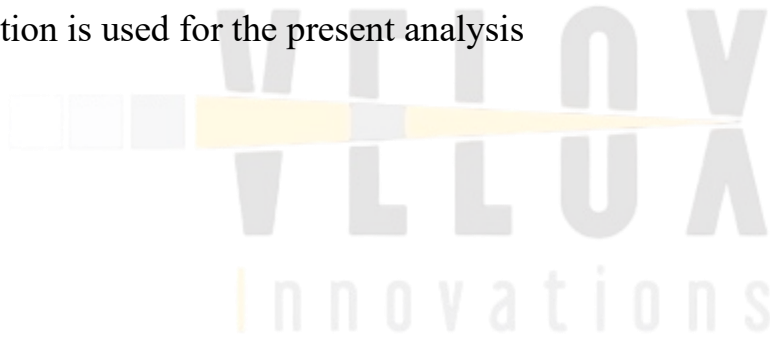
The following topics described the major factors that contribute to predicting failure in most calculation models

2. Environment

For the calculation, the environment in which the system operates has a considerable effect on prediction results, because environment choices vary from model to model. Here we have considered Ns (Naval Sheltered).

3. Reliability Prediction Analysis of Acoustic Control Card

The Reliability prediction parts stress analysis of Acoustic Control Card is performed. The standards used for the prediction analysis are MIL-HDBK 217F notice 2. The Naval Sheltered environment condition is used for the present analysis



4. Input for Reliability Prediction

This section contains the overall Bill of Materials of Acoustic Control Card

SL NO	COMPONENTS	VALUE	Description	SMD/TH	PACKAGE	REFERENCE(S)
1	CAPACITOR	0.1uF	Multilayer Ceramic Capacitors MLCC - SMD/SMT 25V .1uF X7R 0805 10%	SMD	0805	C89,C25,C38,C31,C37,C28,C39,C36,C43,C68,C69,C75,C55,C62,C53,C54,C56,C59,C60,C63,C58,C84,C91,C1,C2,C3
2	CAPACITOR	0.22uF	220NF 0805 SMD Ceramic Capacitor 50V 5%	SMD	0805	C78
3	CAPACITOR	10uF	Multilayer Ceramic Capacitors MLCC - SMD/SMT 10 uF 25 VDC 10% 0805 X7S	SMD	0805	C83,C19,C22,C23,C24,C32,C46,C29,C35,C41,C42
4	CAPACITOR	1uF	Multilayer Ceramic Capacitors MLCC - SMD/SMT NEW GLOBAL PN KGM21AR71E105JU 25V 1uF X7R 0805 5%	SMD	0805	C76,C77,C81,C30,C45,C57,C61,C70,C73,C82,C85
5	CAPACITOR	1nF 5%	Multilayer Ceramic Capacitors MLCC - SMD/SMT 1000 pF 50 VDC 5% 0805 X8G AEC-Q200	SMD	0805	C20,C21
6	CAPACITOR	10nF	SMD Multilayer Ceramic Capacitor, 0.01 µF, 50 V, 0805 [2012 Metric], ± 5%, X7R	SMD	0805	C80,C79
7	CAPACITOR	100PF	100PF 0805 SMD Ceramic Capacitor 50V 5% 101	SMD	0805	C87,C88
8	CAPACITOR	2nF 5%	Multilayer Ceramic Capacitors MLCC - SMD/SMT 50V 2000pF X7R 0805 5%	SMD	0805	C34,C33
9	CAPACITOR	22nF	22nf SMD Ceramic Capacitor -0805 PACKAGE 50V	SMD	0805	C86
10	CAPACITOR	22pF	Multilayer Ceramic Capacitors MLCC - SMD/SMT 50V 22pF C0G 0805 5%	SMD	0805	C51,C52
11	CAPACITOR	2.7nF	Multilayer Ceramic Capacitors MLCC - SMD/SMT 16V 2700pF X8R 0805 5%	SMD/SMT	0805(2012 metric)	C64,C65
12	CAPACITOR	2.2uF	Multilayer Ceramic Capacitors MLCC - SMD/SMT 16V 2.2uF X7R 0805 5%	SMD	805	C71,C72,C49,C50
13	CAPACITOR	270pF	Multilayer Ceramic Capacitors MLCC - SMD/SMT 16V 270pF X8R 0805 5% AEC-Q200	SMD/SMT	0805(2012 metric)	C67,C66
14	CAPACITOR	5.1nF	Multilayer Ceramic Capacitors MLCC - SMD/SMT 16V 5100pF X8R 0805 5%	SMD/SMT	0805(2012 metric)	C26,C27

15	CAPACITOR	6.2nF	Multilayer Ceramic Capacitors MLCC - SMD/SMT 6200 pF 50 VDC 5% 0805 C0G (NP0)	SMD/SMT	0805(2012 metric)	C40,C44
16	RESISTOR	1.3K 1%	Thick Film Resistors - SMD 0805 1.3Kohms 1% AEC-Q200	SMD	0805(2012 metric)	R51
17	RESISTOR	100E	Thick Film Resistors - SMD 0805 100ohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R22,R45,R67,R77,R78
18	RESISTOR	150E	Thick Film Resistors - SMD CRGCQ 0805 150R 1% SMD Resistor	SMD/SMT	805	R84,R85,R86,R87
19	RESISTOR	100k	Thick Film Resistors - SMD CRGCQ 0805 100K 1% SMD Resistor	SMD	0805	R88
20	RESISTOR	10K 1%	Thick Film Resistors - SMD 0805 10Kohms 1% AEC-Q200	SMD	805	R55,R61,R65,R52
21	RESISTOR	15K	Thick Film Resistors - SMD 0805 15Kohms 1% AEC-Q200	SMD	0805 (2012 metric)	R5
22	RESISTOR	1k	Thick Film Resistors - SMD 1/8watt 1Kohms 1% 100ppm	SMD	0805	R39,R58,R9,R21,R6,R83
23	RESISTOR	10.2K 1%	Thick Film Resistors - SMD 0805 10.2Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R31
24	RESISTOR	17.4K 1%	Thick Film Resistors - SMD 0805 17.4Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R30
25	RESISTOR	18.2K 1%	Thick Film Resistors - SMD 0805 18.2Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R35
26	RESISTOR	2.1K 1%	Thick Film Resistors - SMD 0805 2.1Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R69,
27	RESISTOR	2.2K	SMD Chip Resistor, 2.2 kohm, $\pm 1\%$, 125 mW, 0805 [2012 Metric], Thick Film, General Purpose	SMD	0805(2012 metric)	R89,R90,R93,R92
28	RESISTOR	22E	22 ohm, $\pm 1\%$, 125 mW, 0805 [2012 Metric], Thick Film, General Purpose	SMD	0805(2012 metric)	R63,R64
29	RESISTOR	3.4K	Thick Film Resistors - SMD 0805 3.4Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R4
30	RESISTOR	3.74K 1%	Thick Film Resistors - SMD 0805 3.74Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R38
31	RESISTOR	3.92K 1%	Thick Film Resistors - SMD 0805 3.92Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R36
32	RESISTOR	330E	Thick Film Resistors 1/8watt 330ohms 1% 100ppm	SMD	0805 (2012 metric)	R60,R62
33	RESISTOR	330K	SMD Chip Resistor, 330 kohm, $\pm 1\%$, 125 mW, 0805 [2012 Metric], Thick Film, General Purpose	SMD	806 (2012 metric)	R71
34	RESISTOR	47E	Thick Film Resistors 47ohm 1% 0805	SMD	0805 (2012 metric)	R66
35	RESISTOR	4.7K	Thick Film Resistors - SMD 0805 4.7Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R57,R73,R74,R75

36	RESISTOR	47.5K 1%	Thick Film Resistors - SMD 0805 47.5Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R32,R40
37	RESISTOR	49.9K	Thick Film Resistors - SMD 1/4W 49.9Kohms 1% 100ppm	SMD	0805	R48,R68
38	RESISTOR	5.11K 1%	Thick Film Resistors - SMD 0805 5.11Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R54
39	RESISTOR	59K 1%	Thick Film Resistors - SMD 0805 59Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R70
40	RESISTOR	5M	Thin Film Resistors 1/4W 5MOhm 0.1% AEC Q200 Qualified 1206	SMD	1206	R79,R80
41	RESISTOR	6.65K 1%	Thick Film Resistors - SMD 0805 6.65Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R37
42	RESISTOR	6.8K	Thick Film Resistors - SMD 1/8watt 6.8Kohms 1% 100ppm	SMD/SMT	0805(2012 metric)	R1,R2,R3,R44
43	RESISTOR	64.9K 1%	Thick Film Resistors - SMD 0805 64.9Kohms 1% AEC-Q200	SMD/SMT	0805(2012 metric)	R49
44	RESISTOR	620K	SMD Chip Resistor, 620 kohm, $\pm 1\%$, 125 mW, 0805 [2012 Metric], Thick Film, General Purpose	SMD/SMT	0805(2012 metric)	R81,R82
45	RESISTOR	8.2K	Thick Film Resistors - SMD CRGP 0805 8K2 1% SMD Resistor	SMD	0805	R56,R91
46	RESISTOR	80.6k	Thick Film Resistors 1/8watt 80.6Kohms 1% 100ppm	smd	0805(2012 metric)	R94
47	Potentiometer	20K	Trimmer Resistors - Through Hole 3/8" 20Kohms Sealed Vertical Adjust	THT		R53,R23,R76,R72
48	OPAMP	ADA4084-1ARJZ-R7	Operational Amplifiers - Op Amps 30V RRIO LowPwr Single OpAmp	SMD	SOT-23-5	U21,U17
49	AMPLIFIER	AD8531AR T-REEL7	Operational Amplifiers - Op Amps SINGLE 250mA RAIL TO RAIL OP AMP	SMD	SOT-23-5	U7,U15,U16
50	Instrumentation amplifier	AD8422BR MZ	Instrument Amplifier, 1 Channels, 50 μ V, 0.8 V/ μ s, 2.2 MHz, ± 2.3 V to ± 18 V, 4.6V to 36V, MSOP	SMD	MSOP	U18
51	Digital Isolator	ADUM120 1BR	Dual, 2 Channels, 2.7 V, 5.5 V, NSOIC, 8 Pins, 10 Mbps	SMD	NSOIC	U14
52	OPAMP	MAX4252E UA+	Operational Amplifier, Rail to Rail Output, 2 Channels, 3 MHz, 0.3 V/ μ s, 2.4V to 5.5V, μ MAX, 8 Pins	SMD	UMAX-8	U19
53	Ferrite Chip Beads	MPZ1608S 101ATD	Ferrite Beads 0603 100ohms 3000mA Power Line AEC-Q200	SMD	603	FB1-FB5,L1
54	LDO Voltage Regulators	AMS1117-2.5V	AMS1117-2.5V, 1A, SOT-223 Voltage Regulator IC	SMD/SMT	SOT-223-4	U10

55	LDO Voltage Regulators	AMS1117-3.3V	AMS1117-3.3V, 1A, SOT-223 Voltage Regulator IC	SMD/SMT	SOT-223-4	U11
56	Diode	SS14	SS14 DO-214AC SMD 40V 1A Schottky Diode Rectifier ET1431	SMD/SMT	DO-214AC	D1,D2,D6,D7
57	LED	LED_GREEN	Standard LEDs - SMD WL-SMCW SMDMono TpVw Waterclr 0805 BrtGrn	SMD	805	D4,D8
58	LED	LED_BLUE	Standard LEDs - SMD WL-SMCW SMDMono TpVw Waterclr 0805 Blue	SMD	805	D5,D9
59	OP-AMPS	LTC6262I MS8#PBF	Operational Amplifiers - Op Amps 2x 30MHz, 240 A Pwr Eff R2R I/O Op Amps	SMD/SMT	MSOP-8	U8,U12,U9,U13,U20
60	Terminal Block	5.08mm-2 Pin	Fixed Terminal Blocks Terminal block, screw type, 5.08 , horizontal, 2 poles, CUI Blue, slotted screw, PCB mount	TH		J1,J11
61	Terminal Block	5.08-3pin	Fixed Terminal Blocks BC-508X10- 3 GN 5.08 MM PITCH	THT		J12,J13
62	Solderjumper_2_Bridged	0R	Thick Film Resistors Zero ohm Jumper	SMD	805	R8,R10,R11,R43,R7
63	TVS DIODE	SMAJ5.0C A-TP	ESD Suppressors / TVS Diodes 5V 400 Watts	SMD	DO-214AC, SMA	D10
64	TVS DIODE	SMAJ15A	ESD Suppressors / TVS Diodes 400W 15V 5% Uni-Directional	SMD	DO-214	D3
65	DC-DC CONVERTER	K7805-1000R3	Non-Isolated PoL Module DC DC Converter 2 Output 5V -5V 1A, 500mA 8V - 36V Input	THT		U2
66	Crystal	ABM3B-8.000MHZ-B2-T	Crystals 8.0 MHZ 18PF 200OHM			Y1
67	Microcontroller	STM32F407VGT6TR	ARM Microcontrollers - MCU ARM Cortex M4 1024kB 210DMIPs 4kB Flash		LQFP-100	U6
68	Connector	8 Pin	Female Berge strip			J2,J3,J9
69	Connector	3 pin	Female Berge strip		DNP	J4
70	Connector	4 pin	Female Berge strip		DNP	J7
71	Connector	2 Pin	Male Berge strip			JP2,JP3,JP4

4. Sample Calculation Rate of Component

Capacitor

Ref: Acoustic Control Card BOM

Item Ref: C39

Description: Chip ceramic capacitor MLCC-SMD

Specification: 25V

Category: Capacitor, Chip ceramic

Reference: MIL HDBK 217F, Section 10.1

Failure rate equation: $\lambda_p = \lambda_b \pi_T \pi_C \pi_V \pi_{SR} \pi_Q \pi_E$ Failures/10⁶hours

λ_p = Part failure rate, λ_b = Base failure rate, π_T = Temperature factor, π_C = Capacitance Factor,

π_V = Voltage Stress Factor, π_{SR} = Series Resistance factor, π_Q = Quality Factor, and

π_E = Environment Factor

FACTOR	VALUE
Base failure rate	0.002
Temperature Factor	8.362
Capacitance Factor	0.813
Voltage Stress Factor	1.049
Series Resistance Factor	1.0
Quality Factor	0.032
Environment Factor	7

Hence

$$\lambda_p = 0.002 * 8.3362 * 0.813 * 1.049 * 1.0 * 0.032 * 7 \text{ Failures}/10^6 \text{ Hours}$$

$$= 0.00319 \text{ Failures}/10^6 \text{ Hours}$$

Resistor

Ref: Acoustic Control Card BOM

Item Ref: R51

Description: Resistor, Fixed Thick Film, Chip-SMD

Specification: 1.3 K Ω

Category: Resistor, Chip Thick Film (RM)

Reference: MIL HDBK 217F, Section 9.1

Failure rate equation:

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

λ_b = Base failure rate, π_T = Temperature factor, π_P = Power factor, π_S = Electronic stress factor

π_Q = Quality factor, π_E = Environment factor

FACTOR	VALUE
Base failure rate	0.0037
Temperature Factor	1.624
Power Factor	0.2304
Stress Factor	0.87
Quality Factor	0.03
Environment Factor	12

Hence

$$\lambda_p = 0.0037 * 1.624 * 0.2304 * 0.87 * 0.03 * 12$$

$$= 0.00043 \text{ Failures}/10^6 \text{ Hours}$$

5. Results of Reliability Prediction

Table 1 Capacitors Failure rate

$\lambda_p = \lambda_b \pi_T \pi_C \pi_V \pi_{SR} \pi_Q \pi_E$								
Component	Base Failure Rate	Capacitance Factor	Stress Ratio	Stress Factor	Quality Factor	Temp Factor	ENV Factor	Failures per 10 ⁶ hours
						T=80°C	NS Env	
SMD/SMT 25V .1 μ F	0.002	0.813	0.22	1.049	0.032	8.362	7	0.00319
SMD 50V, 0.22 μ F	0.002	0.873	0.11	1.006	0.032	8.362	7	0.00329
SMD 25V, 10 μ F	0.002	1.230	0.6	2	0.032	8.362	7	0.00921
SMD/SMT 25V, 1 μ F	0.002	1	0.22	1.049	0.032	8.362	7	0.00392
SMD /SMT 50V, 1000 pF	0.002	0.537	0.11	1.006	0.032	8.362	7	0.00202
SMD 50V, 0.01 μ F	0.002	0.661	0.11	1.006	0.032	8.362	7	0.00249
SMD 50V, 100 pF	0.002	0.437	0.11	1.006	0.032	8.362	7	0.00164
SMD/SMT 50V, 2000 pF	0.002	0.572	0.11	1.006	0.032	8.362	7	0.00215
SMD 50V, 22 nf	0.002	0.709	0.11	1.006	0.032	8.362	7	0.00267
SMD/SMT 50V, 22 pF	0.002	0.381	0.07	1.002	0.032	8.362	7	0.00143

SMD/SMT 16V, 2700 pF	0.002	0.587	0.34	1.188	0.032	8.362	7	0.00261
SMD/SMT 16V, 2.2 μ F	0.002	1.074	0.34	1.188	0.032	8.362	7	0.00477
SMD/SMT 16V, 270 pF	0.002	0.477	0.34	1.188	0.032	8.362	7	0.00212
SMD/SMT 16V, 5100 pF	0.002	0.622	0.34	1.188	0.032	8.362	7	0.00276
SMD/SMT 50V, 6200 pF	0.002	0.633	0.11	1.006	0.032	8.362	7	0.00238
Total Failure Rate								0.04665 Failures per 10^6 hours

Table 2 Resistors Failure rate

$\lambda_p = \lambda_b \pi_T \pi_P \pi_S \pi_Q \pi_E$ Failures/ 10^6 Hours								
Component	Base Failure Rate	Power Factor	Stress Ratio	Stress Factor	Quality Factor	Temp Factor	ENV Factor	Failures per 10^6 hours
						T=80°C	NS Env	
Thick Film-SMD, 1.3 K Ω s, 1%	0.0037	0.2304	0.184	0.87	0.03	1.624	12	0.00043
Thick Film-SMD, 100 Ω s, 1%	0.0037	0.626	2.416	10.12	0.03	1.624	12	0.0137
Thick Film-SMD, 150 Ω s, 1%	0.0037	0.534	1.608	4.163	0.03	1.624	12	0.0048
Thick Film-SMD, 100 K Ω s, 1%	0.0037	0.0424	0.0024	0.711	0.03	1.624	12	0.000065
Thick Film-SMD, 10 K Ω s, 1%	0.0037	0.104	0.024	0.729	0.03	1.624	12	0.000164

Thick Film-SMD, 15 K Ω s, 1%	0.0037	0.0887	0.016	0.722	0.03	1.624	12	0.000139
Thick Film-SMD, 1 K Ω s, 1%	0.0037	0.255	0.24	0.926	0.03	1.624	12	0.000512
Thick Film-SMD, 10.2 K Ω s, 1%	0.0037	0.088	0.016	0.722	0.03	1.624	12	0.000139
Thick Film-SMD, 17.4 K Ω s, 1%	0.0037	0.067	0.008	0.716	0.03	1.624	12	0.000105
Thick Film-SMD, 18.2 K Ω s, 1%	0.0037	0.0812	0.012	0.72	0.03	1.624	12	0.000127
Thick Film-SMD, 2.1 K Ω s, 1%	0.0037	0.077	0.112	0.718	0.03	1.624	12	0.000120
Thick Film-SMD, 2.2 K Ω s, 1%	0.0037	0.182	0.104	0.796	0.03	1.624	12	0.000317
Thick Film-SMD, 22 Ω s, 1%	0.0037	0.795	4.448	94.66	0.03	1.624	12	0.1629
Thick Film-SMD, 3.4 K Ω s, 1%	0.0037	0.152	0.064	0.761	0.03	1.624	12	0.000251
Thick Film-SMD, 3.74 K Ω s, 1%	0.0037	0.152	0.064	0.762	0.03	1.624	12	0.000252
Thick Film-SMD, 3.92 K Ω s, 1%	0.0037	0.144	0.056	0.755	0.03	1.624	12	0.000236
Thick Film-SMD, 330 Ω s, 1%	0.0037	0.276	0.296	0.983	0.03	1.624	12	0.000588
Thick Film-SMD, 330 K Ω s, 1%	0.0037	0.0264	0.00072	0.710	0.03	1.624	12	0.000041
Thick Film-SMD, 47 Ω s, 1%	0.0037	0.591	2.08	6.997	0.03	1.624	12	0.00895
Thick Film-SMD, 4.7 K Ω s, 1%	0.0037	0.135	0.048	0.748	0.03	1.624	12	0.000220

Thick Film-SMD, 47.5 K Ω s, 1%	0.0037	0.055	0.0048	0.712	0.03	1.624	12	0.000086
Thick Film-SMD, 49.9 K Ω s, 1%	0.0037	0.055	0.0024	0.711	0.03	1.624	12	0.000085
Thick Film-SMD, 5.11 K Ω s, 1%	0.0037	0.135	0.047	0.747	0.03	1.624	12	0.000219
Thick Film-SMD, 59 K Ω s, 1%	0.0037	0.0519	0.004	0.712	0.03	1.624	12	0.000080
Thick Film-SMD, 5 M Ω s, 1%	0.0037	0.00919	0.00002	0.71	0.03	1.624	12	0.000014
Thick Film-SMD, 6.65 K Ω s, 1%	0.0037	0.121	0.036	0.738	0.03	1.624	12	0.000194
Thick Film-SMD, 6.8 K Ω s, 1%	0.0037	0.12	0.035	0.738	0.03	1.624	12	0.000192
Thick Film-SMD, 64.9 K Ω s, 1%	0.0037	0.0499	0.0036	0.712	0.03	1.624	12	0.000077
Thick Film-SMD, 620 K Ω s, 1%	0.0037	0.0206	0.00032	0.710	0.03	1.624	12	0.000032
Thick Film-SMD, 8.2 K Ω s, 1%	0.0037	0.112	0.0296	0.732	0.03	1.624	12	0.000179
Thick Film-SMD, 80.6 K Ω s, 1%	0.0037	0.0458	0.00296	0.712	0.03	1.624	12	0.000071
Potentiometer, 20 K Ω s, THT	0.0037	0.0791	0.012	0.719	0.03	1.624	12	0.000123
Zero-Ohm Solder Jumper	NA	NA	NA	NA	NA	NA	NA	NA
Total Failure Rate								0.195408 Failures per 10 ⁶ hours

Table 3 OP amps Failure rate

$\lambda_p = (C_1\pi_T + C_2\pi_E) \pi_Q\pi_L$ Failures/ 10^6 Hours							
Component	Die Complexity Failure Rate	Package failure rate	Learning Factor	Quality Factor	Temp Factor	ENV Factor	Failures per 10^6 hours
					T=80°C	NS Env	
Single RRIO LowPwr, 30V	0.060	0.0034	1.0	2.0	5.2	4.0	0.6512
Single RRIO Lowpwr, 250mA	0.060	0.0034	1.0	2.0	5.2	4.0	0.6512
Instrumentation Amplifier (Single, IC Op-Amp family)	0.060	0.0034	1.0	2.0	5.2	4.0	0.6512
Op-Amp — Dual (RRIO), 8-pin	0.060	0.0034	1.0	2.0	5.2	4.0	0.6512
Dual (LTC6262, MSOP-8, RRIO, 30 MHz)	0.060	0.0034	1.0	2.0	5.2	4.0	0.6512
Total Failure Rate							3.256 Failures per 10^6 hours

Table 4 Digital Isolator Failure rate

$\lambda_p = (C_1\pi_T + C_2\pi_E) \pi_Q\pi_L$ Failures/ 10^6 Hours							
Component	Die complexity failure rate constant	package failure rate constant	Learning Factor	Quality Factor	Temp Factor	ENV Factor	Failures per 10^6 hours
					T=80°C	NS Env	
Logic, Line Driver/Receiver (Dual, SOIC-8)	0.010	0.0034	1	2	0.24	4.0	0.032
Total Failure Rate							0.032 Failures per 10^6 hours

Table 5 Ferrite Chip Bead Failure rate

$\lambda_p = \lambda_b\pi_T\pi_Q\pi_E$ Failures/ 10^6 Hours					
Component	Base Failure Rate	Quality Factor	Temp Factor	ENV Factor	Failures per 10^6 hours
			T=80°C	NS Env	
Fixed, Chip (Ferrite Bead, 0603, AEC-Q200)	0.000030	0.03	1.9	5.0	0.00000855
Total Failure Rate					0.00000855 Failures per 10^6 hours

Table 6 Regulators Failure rate

$\lambda_p = \lambda_b \pi_T \pi_S \pi_C \pi_Q \pi_E$ Failures/ 10^6 Hours								
Component	Base Failure Rate	Contact Construction Factor	Stress Ratio	Stress Factor	Quality Factor	Temp Factor	ENV Factor	Failures per 10^6 hours
						T=80°C	NS Env	
Linear, Voltage Regulator (LDO, SOT-223)	0.0020	1.0	0.4583	0.15	8	2.7	9	0.058
Linear Regulator — LDO (AMS1117-3.3V), SOT-223)	0.0020	1.0	0.4583	0.15	8	2.7	9	0.058
Total Failure Rate								0.116 Failures per 10^6 hours

Table 7 Diode Failure rate

$\lambda_p = \lambda_b \pi_T \pi_S \pi_C \pi_Q \pi_E$ Failures/ 10^6 Hours									
Component	Base Failure Rate	Application Factor	Contact Construction factor	Power Rating Factor	Stress Factor	Quality Factor	Temp Factor	ENV Factor	Failures per 10^6 hours
							T=80°C	NS Env	
Diode, Schottky Rectifier (SS14, DO-214AC, 40 V, 1 A)	0.027	1.0	NA	1.0	NA	2.5	3.0	4.0	0.81

Diode – TVS / ESD Suppressor (SMAJ5.0CA-TP, 5 V, 400 W, SMA package)	0.0013	NA	1.0	NA	1.0	5.5	5.0	9.0	0.32175
Diode – TVS / ESD Suppressor (SMAJ15A, 15 V, 400 W, Uni-Directional, SMA)	0.0013	NA	1.0	NA	1.0	5.5	5.0	9.0	0.32175
Total Failure Rate									1.4535 Failures per 10 ⁶ hours

Note: The failure rate for Schottky was calculated with $\lambda_p = \lambda_b \pi_T \pi_A \pi_R \pi_Q \pi_E$ Failures/10⁶ Hours (section 6.2 DIODES, HIGH FREQUENCY (MICROWAVE, RF))



Table 8 Terminal Block Failure rate

$\lambda_p = \lambda_b \pi_T \pi_K \pi_Q \pi_E$ Failures/10 ⁶ Hours						
Component	Base Failure Rate	Mating/ Unmating Factor	Quality Factor	Temp Factor	ENV Factor	Failures per 10 ⁶ hours
				T=80°C	NS Env	
Connector – Terminal Block, Screw Type, 2-pin, 5.08 mm, PCB mount	0.046	1.5	2	2.3	5	1.587
Connector – Terminal Block, Screw Type, 3-pin, 5.08 mm, PCB mount	0.046	1.5	2	2.3	5	1.587
Total Failure Rate						3.174 Failures/10 ⁶ Hours

Table 9 LED Failure rate

$\lambda_p = \lambda_b \pi_U \pi_A \pi_E$ Failures/10 ⁶ Hours					
Component	Base Failure Rate	Utilization Factor	Application Factor	ENV Factor	Failures per 10 ⁶ hours
				NS Env	
Standard LEDs - SMD WL-SMCW SMDMono TpVw Waterclr 0805 Green	0.59	1.0	3.3	3.0	5.841

Standard LEDs - SMD WL-SMCW SMDMono TpVw Waterclr 0805 Blue	0.59	1.0	3.3	3.0	5.841
Total Failure Rate					11.682 Failures/10 ⁶ Hours

Table 10 DC-DC Converter Failure rate

Component	Method	Failures per 10 ⁶ hours	Notes
DC-DC Converter – Non-Isolated PoL Module (K7805-1000R3, 5 V/1 A, – 5 V/500 mA, 8–36 V Input)	Datasheet MTBF	0.5	For the DC-DC Converter (K7805-1000R3), the failure rate is taken directly from the manufacturer's datasheet: 0.5 failures per 10 ⁶ hours (MTBF = 2000 khrs at 25 °C, GB environment). MIL-HDBK-217 factors are not applied for this part

Table 11 Crystal Quartz Failure rate

$\lambda_p = \lambda_b \pi_Q \pi_E$ Failures/10 ⁶ Hours				
Component	Base Failure Rate	Quality Factor	ENV Factor	Failures per 10 ⁶ hours
			NS Env	
Crystal – Quartz SMD (ABM3B, 8 MHz, 18 pF, 200 Ω)	0.0209	2.1	6	0.26334
Total Failure Rate				0.26334 Failures per 10 ⁶ hours

Table 12 Microcontroller Failure rate

$\lambda_p = (C_1\pi_T + C_2\pi_E) \pi_Q\pi_L$ Failures/10 ⁶ Hours							
Component	Die complexity failure rate constant	package failure rate constant	Learning Factor	Quality Factor	Temp Factor	ENV Factor	Failures per 10 ⁶ hours
					T=80°C	NS Env	
Microcontroller – ARM Cortex-M4 MCU (STM32F407VGT6TR, 1024 kB Flash, LQFP)	0.56	0.043	1.0	2.0	1.153	45	1.635
Total Failure Rate							1.635 Failures/10 ⁶ Hours

Table 13 Connector Failure rate

$\lambda_p = \lambda_b \pi_P \pi_Q \pi_E$ Failures/ 10^6 Hours					
Component	Base Failure Rate	Active Pin Factor	Quality Factor	ENV Factor	Failures per 10^6 hours
				NS Env	
Connector – Female Pin Header / Strip, 8-pin, Berge Strip	0.00064	2.4	1.0	6.0	0.0092
Connector – Female Pin Header / Strip, 3-pin, Berge Strip	0.00064	1.7	1.0	6.0	0.0065
Connector – Female Pin Header / Strip, 4-pin, Berge Strip	0.00064	1.9	1.0	6.0	0.0072
Connector – Male Pin Header / Strip, 2-pin, Berge Strip	0.00064	1.5	1.0	6.0	0.0057
Total Failure Rate					0.0286 Failures/ 10^6 Hours

By summing up the failure rates of the individual electronics and mechanical components, the failure rate of complete Acoustic Control Card is obtained.

Mean time between failures (MTBF) in hours can be calculated by the reciprocal of the failure rates

Acoustic Control Card failure rate = 21.8825 Failures/ 10^6 Hrs.

Mean time between failures (MTBF) = 45698.617 Hrs.

6. Reliability Calculation

Reliability of the Acoustic Control Card can be calculated by the following formula

$$\text{Reliability } (R) = e^{-\lambda t}$$

Where

λ := Failure rate/ 10^6 Hrs

t = Time in Hrs

Conclusion: Reliability analysis for Acoustic Control Card has been carried out and the reliability for 1 Operational hour is found to be 0.9999781 (99.998%).