Reliability and Safety Analysis

Year: 2022 Semester: Fall Team: 12 Project: R.A.C.H.E.L.

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Assignment Evaluation:

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| --- | --- | --- | --- | --- |
| **Item** | **Score (0-5)** | **Weight** | **Points** | **Notes** |
| **Assignment-Specific Items** | | | | |
| **Reliability Analysis** |  | x2 |  |  |
| **MTTF Tables** |  | x3 |  |  |
| **FMECA Analysis** |  | x2 |  |  |
| **Schematic of Functional Blocks (Appendix A)** |  | x2 |  |  |
| **FMECA Worksheet (Appendix B)** |  | x3 |  |  |
| **Writing-Specific Items** | | | | |
| **Spelling and Grammar** |  | x2 |  |  |
| **Formatting and Citations** |  | x1 |  |  |
| **Figures and Graphs** |  | x2 |  |  |
| **Technical Writing Style** |  | x3 |  |  |
| **Total Score** |  | | |  |

5: Excellent 4: Good 3: Acceptable 2: Poor 1: Very Poor 0: Not attempted

Comments:

*Comments from the grader will be inserted here.*

1. Reliability Analysis
2. LD117S33TR Low Dropout Regulator

Responsible for converting 5 to 3 Volts in our power circuit. The 3V goes to the microcontroller, so it is very important that the component does not fail as it could harm the mcu.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter Name | Description | Value | Comments |
| λb | Base Failure Rate | .0020 | 6.1 Section |
| πT | Temperature Factor | 1.0 | TJ = 25 Celsius |
| πC | Contact Construction F. | 1.0 | CW |
| πE | Environmental Factor | 1.0 | GB |
| πS | Electrical Stress Factor | .2 | S = 12/15 |
| πQ | Quality Factor | 8.0 | Plastic Casing |

λp = 0.0020 \* 1.0 \* 1.0 \* 1.0 \* .2 \* 8.0 = 0.0032 Failures per 10k hours

MTTF = 312.5

The product could be improved if the Quality Factor of the product was a lot lower. Improving to a more reliable form of casing could make it avoid failure. For our project, the only forces it must withstand is reckless moving of the ping pong table.

1. LM324N OpAmp

Responsible for amplifying the hardware filtered piezo signal to the microcontroller. In failure, it could send high voltages to the microcontroller to the GPIO pins of the MCU. But that is at worst case, another case of failure is that we will not be able to read ball bounces as the signal would be too small to discern in the MCU.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter Name | Description | Value | Comments |
| C1 | Die complexity | 0.01 | 6.1 Section |
| πT | Temperature Factor | 3.1 | TJ = 45 Celsius |
| πC | Contact Construction F. | 1.0 | CW |
| πE | Environmental Factor | 1.0 | GB |
| πL | Electrical Stress Factor | 1.0 | S = 12/15 |
| πQ | Quality Factor | 10 | Commercial Use |

λp = 0.01 \* 3.1 \* 1 \* 1 \* 1 \* 10 = 0.31 Failures per 10k hours

MTTF = 3.225

The LM324N is faulty. I have personally had very bad experiences using faulty LM324Ns in ECE 20007. The quality factor being so high for such a commercial product make sense and a better production quality could make the product avoid failure for a lot longer.

1. STM32F091RCT

The most important electronic in our circuit. The microcontroller is in charge of taking input from piezos and sending it to the laptop. This data is vital to discern when the ball has hit the table.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter Name | Description | Value | Comments |
| C1 | Die complexity | .56 | 32 MOS MCU |
| C2 | Package Failure Rate | 0.13095 | 3\*10-5\*1001.82 |
| πT | Temperature Factor | .10 | TJ = 25 Celsius |
| πE | Environmental Factor | 0.5 | GB |
| πL | Learning Factor | 1.0 | 5 Years |
| πQ | Quality Factor | 1.0 | Class B |

λp = (.56 \* .10 + .13095 \* .5) \* 1.0 \* 1.0 = 0.121475 Failures per 10k hours

MTTF = 8.23214653221

The handbook may has not been updated in a very long time. So the microprocessor section may not be as reliable as the others. However, it still puts a very high number of failures towards microcontrollers rather than other parts which is still very true. I personally have went through 2 dev boards due to shorting microcontrollers.

1. Failure Mode, Effects, and Criticality Analysis (FMECA)

The criticality of a failure will be defined by it’s level of harmfulness. Low – simply short the circuit and will need to replace part. Medium – started a chain and has caused multiple damages to the PCB. High – user level harmfulness. Potential failure will be assessed starting at high then going to low.

3.0 Sources Cited:

[1]“Military Handbook Reliability Prediction of Electronic Equipment” Department of Defense. Washington DC. MIL-HDBK-217F, Dec. 2, 1991.

[2]“LD1117” Adjustable and fixed low drop positive voltage regulator – Mouser, Feb. 2020.

<https://www.mouser.com/datasheet/2/389/CD00000544-310772.pdf>

[3] “LMx24-N, LM2902-N Low-Power, Quad-Operational Amplifiers” – Texas Instruments, Mar. 2000.

<https://www.ti.com/lit/ds/symlink/lm324-n.pdf?ts=1667675409437&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FLM324-N>

[4] “STM32F091xB STM32F091xC” – ST, Jan. 2017.

<https://www.mouser.com/datasheet/2/389/dm00115237-1798191.pdf>

Appendix A: Schematic Functional Blocks

Diagram, schematic

Description automatically generated

Fig. 1: Serial to USB Circuit

A picture containing chart

Description automatically generated

Fig. 2: 1/8 Piezo Circuit

Diagram, schematic

Description automatically generated

Fig. 3: Regulator Circuit

A picture containing timeline

Description automatically generated

Fig. 4: MicrocontrollerAppendix B: FMECA Worksheet

Subsystem A: Serial to USB Circuit

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Failure No.** | **Failure Mode** | **Possible Causes** | **Failure Effects** | **Method of Detection** | **Criticality** | **Remarks** |
| A1 | High 5.0 Volts from connector | Input Voltage +5V from USB | Voltage regulator outputting higher voltage, damaging MCU | Observation | Medium | Depending on the voltage, may cause more damage |
| A2 | Low 5.0 Volts from connector | Input Voltage >>5V from USB | Not enough power supplied to PCB | Observation | Low | Underpowered components, no damage |
| A3 | Serial to USB Converter Failure | Chip malfunction, bad first drag soldering job | No communication with MCU and Laptop | Observation | Low | Just lack of communication |

Subsystem B: Piezo Circuit

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Failure No.** | **Failure Mode** | **Possible Causes** | **Failure Effects** | **Method of Detection** | **Criticality** | **Remarks** |
| B1 | Spike from piezo | Pressing on the piezo | GPIO pin from MCU reads the spike | Observation | Medium |  |

Subsystem C: Regulator Circuit

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Failure No.** | **Failure Mode** | **Possible Causes** | **Failure Effects** | **Method of Detection** | **Criticality** | **Remarks** |
| C1 | High 5.0 Volts | Input Voltage +5V | Voltage regulator outputting higher voltage, damaging MCU | Observation | Medium | Depending on the voltage, may cause more damage |
| C2 | Low 5.0 Volts | Input Voltage >>5V | Not enough power supplied to PCB | Observation | Low | Underpowered components, no damage |
| C3 | High 3 Volts | Regulator failure | Not enough power supplied to PCB | Observation | Low | Underpowered components, no damage |

Subsystem D: Microcontroller

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Failure No.** | **Failure Mode** | **Possible Causes** | **Failure Effects** | **Method of Detection** | **Criticality** | **Remarks** |
| B1 | Constant Reset | Button malfunction | MCU won’t work | Observation | Low |  |
| B2 | Micro Stops working | Possible short | Need new micro | Check for 5V short | Medium |  |