MTBF analysis of production DRXP board

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# Revision History

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| --- | --- |
| Date | Revision |
| 01/01/2019 | ● Initial release |
| 15/04/2019 | ● Added SFP+ module to the target of calculation MTBF. And recalculated the MTBF of the production DRXP board.  ● Change the calculation result of MTBF value to the exact value form the approximate value.  ● Added the description how to calculate production DRXP board MTBF. |
| 27/09/2019 | ● Added Revision History.  ●　Fixed the description how to calculate MTBF.  ● Added the description about the define of FIT.  ● Added generic components list.  ● Added non-generic parts list.  ● Fixed DC-DC converter failure rate.  At 15/04/2019 version the FIT of DC-DC converter at No.2 in the top 20 worst MTBFs is incorrect. Ceramic capacitor 4.7uF (No.20) is added instead of this component in this version. MTBF per production DRXP board is also re-calculated. |
| 27/04/2020 | ● Fixed model number of TPS51200DRC(TPS51200DRC->TPS51200DRCT) |

# MTBF

The MTBF per the production DRXP board is 20 years(\*1) under 45 ° C temperature environment.　This value was calculated from the FIT (\*2) value of the all parts used on the board excluding connectors. Among the components on the board, the top 20 worst MTBFs are shown in section 3.

(\*1) In this document, the MTBF value’s upper bound is limited.

The failure rate of SFP+ module is only valid under 20 years in this calculation. Therefore, the maximum MTBF value is 20 years. For the detail, please refer the footnote (\*7) in the section 3. In the case that it doesn’t take into account of SFP+ module’s FIT, the MTBF value is 36.99 years.

(\*2) FIT (Failure In Time) is the unit for expressing the expected failure rate of devices.

One FIT equals one failure per billion (10^9) hours.

# MTBF’s Worst Top 20 components list

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| MTBF Worst No | Component | Quantity | FIT | FIT Subtotal | MTBF Subtotal  [H] | MTBF Subtotal [Year] |
| 1 | Ceramic capacitor 0.22uF(\*2) | 112 | 6 | 672 | 1488095 | 170 |
| 2 | Inductor 4.7uH | 12 | 36 | 432 | 2314815 | 264 |
| 3 | Ceramic capacitor 0.1uF (\*2) | 67 | 6 | 402 | 2487562 | 284 |
| 4 | Ceramic capacitor 4.7uF  (\*1) (\*2) | 38 | 6 | 228 | 4385965 | 501 |
| 5 | Ceramic capacitor 22uF(\*2) | 33 | 6 | 198 | 5050505 | 577 |
| 6 | DDR3 SDRAM(\*3) | 8 | 20 | 160 | 6250000 | 713 |
| 7 | Ceramic capacitor 22uF(\*2) | 24 | 6 | 144 | 6944444 | 793 |
| 8 | Ceramic capacitor 10uF(\*2) | 21 | 6 | 126 | 7936508 | 906 |
| 9 | Ceramic capacitor 47uF(\*2) | 19 | 6 | 114 | 8771930 | 1001 |
| 10 | Ceramic capacitor 100uF(\*2) | 18 | 6 | 108 | 9259259 | 1057 |
| 11 | Ceramic capacitor 1500pF(\*2) | 13 | 6 | 78 | 12820513 | 1464 |
| 12 | NPN Transistor (\*4) | 5 | 15 | 75 | 13333333 | 1522 |
| 13 | Aluminum solid electrolytic capacitor 220uF (\*5) | 5 | 13.5 | 67.5 | 14814815 | 1691 |
| 14 | Ceramic capacitor 820pF(\*2) | 10 | 6 | 60 | 16666667 | 1903 |
| 15 | Ceramic capacitor 0.01uF(\*2) | 8 | 6 | 48 | 20833333 | 2378 |
| 16 | Ceramic capacitor 220pF(\*2) | 5 | 6 | 30 | 33333333 | 3805 |
| 17 | Crystal oscillator 200MHz(\*6) | 2 | 12 | 24 | 41666667 | 4756 |
| 18 | Crystal oscillator 125MHz(\*6) | 2 | 12 | 24 | 41666667 | 4756 |
| 19 | SFP+ module (\*7) | 4 | 6 | 24 | 41666667 | 4756 |
| 20 | Ceramic capacitor 4.7uF  (\*1) (\*2) | 3 | 6 | 18 | 55555556 | 6342 |

(\*1) Ceramic capacitor 4.7uF is listed at No. 20 is different from No. 4 in that size.

(\*2) The FIT value is based on manufacture’s reliability report.

This value is the result of accelerated test at rated temperature.

Failure rate is calculated in the confidence level 60%.

Following formula is used to calculate the failure rate.

FR = (r/T) x K x 10^9 [FIT]

FR: Failure rate

r: Number of accumulated failures.

T: Accumulated component hours

K: Coefficient of confidence level 60%.

(\*3) The FIT value is based on manufacture’s answer.

(\*4) The FIT value is based on manufacture’s reliability report.

This value is the result of accelerated test at rated temperature.

Failure rate is calculated in the confidence level 90%.

(\*5) The FIT value is based on manufacture’s report.

(\*6) The FIT value is based on manufacture’s report.

Following formula is used to calculate the MTTF from manufacture’s reliability test.

MTTF = (2 x T x A) /(Chi-square)

Chi-square : Chi-squared value at the confidence level 90%.

(2r + 2) degrees of freedom.

r is the number of failures.

T: Accumulated component hours

A: Acceleration factor

(\*7) The FIT value is based on manufacture’s report.

In the case of FIT value for 20-year lifetime is calculated from following method.

The random failure rate (90% C.L, 55degC) is 3.97 [FIT].

The wear-out failure rate for 20-year lifetime at 55 degC is 0.03 [FIT].

Therefore, a total failure rate for 20-year lifetime is 4(=3.97+0.03) [FIT].

This value is valid under 20 years.

The MTBF value including wear-out period (> 20 years) is equal to median life.

The medial life of SFP+ module is 152.1 [years] at 55degC.

Note : The FIT value of FPGA

The FPGA is one of the main component in the DRXP board.

For that reason, addresses this component’s fit briefly.

The FPGA’s FIT value is based on manufacture’s reliability report.

This value is the result of accelerated test.

Failure rate is calculated in the confidence level 60%, 55degC.

The calculated FIT value 11[FIT].

FR = (Chi-square x 10^9)/(2 x T x A)

FR: Failure rate

Chi-square : Chi-squared value at the confidence level 60%.

(2r + 2) degrees of freedom.

r is the number of failures.

T: Accumulated component hours

A: Acceleration factor

And also, the FPGA’s lifetime is designed that it is more than 20 years

at Tj (junction temperature) = 85 degC.

Note : The FIT value of DCDC converter

The DCDC converters are important components in the DRXP board.

For that reason, addresses these components fit briefly.

The FIT value of these is based on manufacture’s reliability report.

These values are the result of accelerated test.

# Generic components list

The following table represents the MTBF value for all production DRXP board we derived (The total number of board is 12). And this table only has entries their MTBF value are less than 17 years. The production DRXP specification PROD-DRXP-070110-02 requires if the lifetime of component is less than 17 years, vendor should provide the adequate spare parts or document the specification of the component.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No | Component | Quantity | FIT | FIT Subtotal | MTBF Subtotal  [H] | MTBF Subtotal [Year] |
| 1 | Ceramic capacitor 0.22uF | 1344 | 6 | 8064 | 124008 | 14 |

■Ceramic capacitor 0.22uF

The ceramic capacitor 0.22[uF] MTBF value for all production DRXPs is 14 [years].

Therefore, at least vendor should have a 1 ceramic capacitor 0.22[uF] in stock to fulfill the production DRXP boards specification PROD-DRXP-070110-02.

We have an adequate amount (>10) of ceramic capacitor 0.22[uF].

# Non-generic components list

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No | Component  Type | Manufacture | Model Name | Quantity |
| 1 | FPGA | Xilinx, Inc. | XCKU15P-1FFVA1156E | 1 |
| 2 | Flash | Micron Technology, Inc. | MT25QU256ABA1EW9-0SIT | 2 |
| 3 | SDRAM | Micron Technology, Inc. | MT41K128M16JT-125K | 8 |
| 4 | DC-DC  Converter | Analog Devices, Inc. | LTM4620AEV#PBF | 3 |
| 5 | DC-DC  Converter | Analog Devices, Inc. | LTM4630AEV#PBF | 1 |
| 6 | DC-DC  Converter | Intel Corporation | EP5368QI | 1 |
| 7 | Termination  Regulator | Texas Instruments Inc. | TPS51200DRCT | 2 |
| 8 | RS485  Driver | Texas Instruments Inc. | SN65HVD1781D | 1 |
| 9 | Amplifier | Texas Instruments Inc. | INA199C2DCKR | 1 |
| 10 | Crystal | TAITIEN ELECTRONICS CO.,LTD | OTETGCVANF-200.000000MHz | 2 |
| 11 | Crystal | TAITIEN ELECTRONICS CO.,LTD | OTETGCLTNF-125.000000MHz | 2 |
| 12 | SFP+ module  Cage | TE Connectivity | 2007251-1 | 1 |