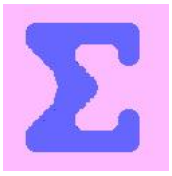

# Rambutan (-I)

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## Telcordia Issue 3 MTBF – Prediction Report

Issue 1.0 / February 2018

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# 1. List of Changes

| Issue | Date | Editor | Change description |
|---|---|---|---|
| 1.0 | February 8th, 2017 | Thomas Reiter | First issue |
| | | | |
| | | | |

**Table 1: List of Changes**

## 2. Introduction

This report contains the failure rate and MTBF assessment for the

**Rambutan (-I)**

assembly.

All components have been calculated with

**Telcordia Issue 3 (2011)**.

# 3. Summary

Calculations have been performed for several temperatures and ground fixed, uncontrolled (GF) environment.
Application examples: Remote terminals and outdoor equipment in manholes, and near direct path of railroad, highway, and air traffic.

Failure rates are given in failures per million hours (fpmh), and MTBF values are given in hours.

| Ambient Temp [°C] | FR [fpmh] | MTBF [h] |
|---|---|---|
| -40 | 0,031035 | 32.221.685 |
| -35 | 0,033762 | 29.619.098 |
| -30 | 0,03678 | 27.188.690 |
| -25 | 0,040161 | 24.899.778 |
| -20 | 0,044004 | 22.725.207 |
| -15 | 0,048445 | 20.641.965 |
| -10 | 0,053675 | 18.630.647 |
| -5 | 0,059955 | 16.679.176 |
| 0 | 0,067650 | 14.781.966 |
| 5 | 0,077264 | 12.942.638 |
| 10 | 0,089491 | 11.174.308 |
| 15 | 0,105282 | 9.498.300 |
| 20 | 0,125939 | 7.940.352 |
| 25 | 0,153191 | 6.527.799 |
| 30 | 0,189561 | 5.275.347 |
| 35 | 0,238144 | 4.199.140 |
| 40 | 0,303291 | 3.297.163 |
| 45 | 0,390723 | 2.559.358 |
| 50 | 0,507994 | 1.968.527 |
| 55 | 0,664999 | 1.503.762 |
| 60 | 0,874622 | 1.143.351 |
| 65 | 1,153519 | 866.912 |
| 70 | 1,523070 | 656.569 |
| 75 | 2,010543 | 497.378 |
| 80 | 2,650471 | 377.291 |
| 85 | 3,486305 | 286.837 |

**Table 2: Failure rate and MTBF Summary**

A detailed analysis on component level for 25°C ambient temperature, ground fixed uncontrolled (GF) environment, is contained in paragraph 5.

# 4. Reliability Assessment

## *4.1 Mathematical Model*

The analysed system contains active and passive electronic components, which are mounted on printed circuit boards.
This reliability assessment includes the assumptions that all electronic standards make:

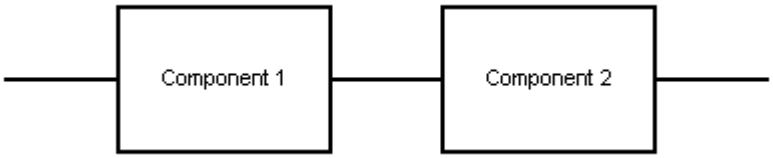
1. All components are equally necessary to perform the system function, which means that any component failure is assumed to result in functional failure of the system. As this is not the practical case and some failures may only result in a maintenance action the calculated MTBF is also called „Maintenance related MTBF".

2. All failure rates are constant and independent.
   Early failures and wear out phases are not covered.
   As a result, only the useful product life phase is addressed.

Like other standards, Telcordia is a well-known international standard published for many years.
MTBF calculations are based on specific mathematical models for failure rates.
Each part is categorized in category and subcategory, then the respective Telcordia term is applied for that part. Finally, the results of all terms are added up and give the system failure rate.

### 4.1.1 Serial Reliability Model

Figure 2 shows a simple serial model.




**Picture 1: Serial reliability model**

Note:

In a mathematical context it is easier to calculate in failure rates rather than MTBFs.
MTBFs are given in hours [h], failure rates are given in failures per million hours [fpmh].
The following relationship applies:

MTBF [h]= 1.000.000 / Failure Rate [fpmh]

If a part failure rate is constant over time, the reliability for a single series element can be expressed as the following exponential distribution.

$$R(t)_i = e^{-\lambda_i t}$$

where:

$R(t)_i$ = the probability of survival for a single series element for a given operating time $t$
$e$ = the base of the natural logarithm
$\lambda_i$ = a constant representing the i[th] element failure rate
$t$ = the element operating time

If each exponentially distributed series element is independent, the series system reliability function can be expressed as the following product.

$$R(t)_{series} = \prod_{i=1}^{n} e^{-\lambda_i t}$$

where:

$R(t)_{series}$ = the probability of survival for a series system for a given operating time $t$.
$e$ = the base of the natural logarithm
$\lambda_i$ = a constant representing the i[th] element failure rate
$t$ = the element operating time

If each element is independent, it can be shown that the failure rate for an exponential distribution series system is the sum of the failure rates of the individual elements.

$$\lambda_{series} = \sum_{i=1}^{n} \lambda_i = \lambda_1 + \lambda_2 + \lambda_3 + ... + \lambda_n$$

where:
$\lambda_{series}$ = a constant representing a series system failure rate
$\lambda_i$ = a constant representing the i[th] element failure rate
$\lambda_n$ = a constant representing the last element failure rate

and

$$R(t)_{series} = e^{-\lambda_{series} t}$$

where:

$R(t)_{series}$ = the probability of survival for a series system for a given operating time $t$
$e$ = the base of the natural logarithm
$\lambda_{series}$ = a constant representing the series system failure rate
$t$ = the series system operating time

The mean time between failure ($MTBF$) for an exponentially distributed single element or series system can be determined from the reliability function or, as shown below, directly from the failure rate.

$$MTBF = \int_0^\infty R(t)_i \, dt$$

$$MTBF = \int_0^\infty e^{-\lambda_i t} dt = \frac{1}{\lambda_i}$$

$$MTBF = \int_0^\infty e^{-\lambda_{seriessystem} t} dt = \frac{1}{\lambda_{seriessystem}}$$

where:

$MTBF_i$ = the mean time between failure of single series element
$MTBF_{seriessystem}$ = the mean time between failure of the series system
$\lambda_i$ = the constant failure rate of the i[th] element
$\lambda_{seriessystem}$ = the constant failure rate of a series system
$e$ = the base of the natural logarithm
$t$ = the series system operating time

For a series system with exponentially distributed elements the, $MTBF_{series}$ can be expressed as shown below.

$$MTBF_{series} = \frac{1}{\lambda_1 + \lambda_2 + \lambda_3 + ... + \lambda_n}$$

where:

$MTBF_{series}$ = the mean time between failure for a series system

$\lambda_n$ = a constant representing the n$^{th}$ series element failure rate

See also special notes on Telcordia standard in section 5.1.

### 4.1.2 Data Sources and Assumptions

In order to perform a failure rate assessment, several assumptions have to be made to minimize the complexity of the analysis.

1. Telcordia Issue 3 (2011) has been used for calculation.
2. This Analysis assumes mean stress values for all components (typically 50% of rated values).
3. Environmental factor „ ground fixed, uncontrolled “ ($Pi_E$=2) has been used.
4. Failure rate of mechanical components (screws, chassis, etc.) is negligible.
5. Quality factor:

   For all components, “Level 2” has been used. Level 2 represents today’s industrial component quality.
6. Special components: None

## 5. Reliability Assessment Details

The results of the failure rate assessments at 25°C ambient temperature, ground fixed, uncontrolled (GF) environment are listed in the tables below.

Failure rates are given in Failures per Million Hours (fpmh).

| Name | Item | Value | PN-1 | PN-2 | Reference Designator | Description | Telcordia Category | Telcordia Subcategory | FR/Unit [fpmh] | Quantity | FR [fpmh] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***5.1 Rambutan (-I)*** | | | | | | | | | **0,153191** | **1** | **0,153191** |
| | 1 | 10nF | 00005168W | GRM033R71A103KA01D | C1 C17 C24 C36 C37 C44 C59 C61 C68 C70 C77 C79 C81 C83 C90 C92 C95 C97 C99 C105 C107 C109 C116 C122 C130 C131 | 10nF 10V 10% X7R 0201 -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 26 | 0,004732 |
| | 2 | 0.1uF | 00005300W | C0603X5R1A104K | C2 C6 C7 C12-C16 C20 C25 C30 C32 C35 C38-C40 C42 C43 C45 C49 C51 C52 C56 C58 C60 C63 C65-C67 C69 C71 C74 C76 C78 C80 C82 C85 C87 C89 C91 C94 C96 C98 C102 C104 C106 C108 C110 C112 C114 C115 C118 C120 C121 C124 C126-C129 C132 C140 C164-C178 C189 C191 C192 C | 100nF 10V 10% X5R 0201 -55+85 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 99 | 0,018018 |
| | 3 | 10uF 6.3V | 00000572 | GRM188R60J106ME47D | C3 C4 C26 C33 C41 C47 C55 C93 C100 C101 C111 C117 C123 C125 C148 C181 C193 C743 | 10uF 6.3V 20% X5R 0603 -55+85 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 18 | 0,003276 |
| | 4 | 1uF 6.3V | 00005551 | GRM155R60J105KE19D | C5 C8 C19 C21 C22 C27 C29 C34 C48 C62 C119 C141 C196 C643 C683 C695 | 1uF 6.3V 10% X5R 0402 -55+85;h=0.5mm | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 16 | 0,002912 |

| Name | Item | Value | PN-1 | PN-2 | Reference Designator | Description | Telcordia Category | Telcordia Subcategory | FR/Unit [fpmh] | Quantity | FR [fpmh] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 10pF | 00005118W | GRM0335C1E100JD01D | C9-C11 C23 C28 C31 C50 C53 C54 C57 C64 C72 C75 C86 C698 C699 C701 C702 C704 C706 C717 C718 C720 C722 C727-C731 C733 C735-C740 | 10pF 25V +-5% COG 0-30ppm 0201(0.6x0.3x0.3) -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 36 | 0,006552 |
| | 6 | 22uF 6.3V | 00000578W | CL10A226MQ8NRNC | C18 C46 C73 C746 | 22uF 6.3V 20% X5R 0603,h=0.9mm; -55+85 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 4 | 0,000728 |
| | 7 | 2.2uF 6.3V | 00005563 | JMK105BJ225MV-F | C84 C721 C734 | 2.2uF 6.3V 20% X5R 0402 -55+85;h=0.5mm | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 3 | 0,000546 |
| | 8 | 2.2pF | 00005106W | C0603C0G1E2R2B | C88 | 2.2pF 25V +-0.1pF COG 0-30ppm 0201(0.6x0.3x0.3) -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 1 | 0,000182 |
| | 9 | 1nF 16V | 00005158W | GRM033R71C102KA01J | C103 C113 C179 C180 | 1000pF 16V 10% X7R 0201 -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 4 | 0,000728 |
| | 10 | 8.2pF | 00005117W | GRM0335C1E8R2DA01D | C197 C198 C714 C715 | 8.2pF 25V +-0.5pF COG 0-30ppm 0201(0.6x0.3x0.3) -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 4 | 0,000728 |
| | 11 | 0.5pF | 00005090W | C0603C0G1E0R5B | C202 C203 C205 C206 | 0.5pF 25V +-0.1pF COG 0-30ppm 0201(0.6x0.3x0.3) -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 4 | 0,000728 |
| | 12 | 27pF | 00005425 | CL05C270JBNC | C403 C404 | 27pF 50V +-5% COG 0-30ppm 0402 -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 2 | 0,000364 |

| Name | Item | Value | PN-1 | PN-2 | Reference Designator | Description | Telcordia Category | Telcordia Subcategory | FR/Unit [fpmh] | Quantity | FR [fpmh] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 100pF | 00005148W | C0603C0G1E101J | C405 C406 | 100pF 25V +-5% COG 0-30ppm 0201(0.6x0.3x0.3) -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 2 | 0,000364 |
| | 14 | 0R | 10008000W | RC0201JR-070RL | C705 C707 R30 R32 R610 | 0R 5% 0201(0603 metric) 1/20W 200ppm | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 5 | 0,000605 |
| | 15 | 3.6pF | 00005109W | GRM0335C1E3R6BA01D | C712 C716 | 3.6pF 25V +-0.1pF COG 0-30ppm 0201(0.6x0.3x0.3) -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 2 | 0,000364 |
| | 16 | 220pF | 00005151W | GRM033R71E221KA01D | C719 C732 | 220pF 25V +-10% X7R 0201(0.6x0.3x0.3) -55+125 | Capacitor | General Ceramic (CK, CKR) | 0,000182 | 2 | 0,000364 |
| | 17 | LXES03AAA1-154 | 31502511W | LXES03AAA1-154 | D27 D28 | ESD Protection Diodes with Ultra Low Capacitance, 1nA, 0.05pF,bidirectional 4V;0.6x0.3x0.3mm;-40+85 | Semiconductor | Diode | 0,00771 | 2 | 0,01542 |
| | 18 | 10Z/100MHz_1A | 20000204W | BLM15AG100SN1D | FB1-FB9 FB11-FB16 FB19 FB29 FB30 FB58 FB59 | MULTILAYER CHIP IMPEDER 10Ohms/100MHz;1A Rdc=0.05;0402 ;-55+125 | Inductor | Coil | 0,000151 | 20 | 0,00302 |

| Name | Item | Value | PN-1 | PN-2 | Reference Designator | Description | Telcordia Category | Telcordia Subcategory | FR/Unit [fpmh] | Quantity | FR [fpmh] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 19 | 60Z/100 MHz_1.7 A | 20000210W | BLM15PD600SN1D | FB10 FB17 FB18 FB20-FB23 FB56 FB57 FB61 FB62 | MULTILAYER CHIP IMPEDER 10Ohms/100MHz;1.7A Rdc=0.06;0402 ;-55+125 | Inductor | Coil | 0,000151 | 11 | 0,001661 |
| | 20 | U.FL-R-SMT(10) | 78100221w | U.FL-R-SMT(10) | J1 J2 | U.FL series Receptacle,male pin;50Ohm, 0-6GHz(VSWR 1,3);3.1x3.1x1.25; -40+90, | Connection | General | 0,00018 | 2 | 0,00036 |
| | 21 | 2.2uH 1.5A | 20100071W | NR3015T2R2M | L1 | Shielded SMD Power Inductors ser NR3015; 2.2uH Rdc=72mOhm;Irms=1.5 A Isat=1,48A;3.0x3.0x1.5 mm;-40+85 | Inductor | Coil | 0,000363 | 1 | 0,000363 |
| | 22 | 1.2nH 500MHz | 20000402W | LQP03TN1N2B02D | L5 L6 | Thinfilm-Chip-Inductor 1.2nH+-0.1nH,14-Q (500MHz) 0.1ohm 750mA;<6GHz; 0201(0603 metric);-55+125 | Inductor | Coil | 0,000151 | 2 | 0,000302 |
| | 23 | MMBT2907A | 40010106Wa | MMBT2907ALT1G | Q3-Q5 | PNP SML SIG G.P. AMP&SWITCH SOT23,Uceo-60V,Ic=0.6A,hfe=100-300;200MHz | Semiconductor | Transistor | 0,000915 | 3 | 0,002745 |
| | 24 | 49.9R 1% | 10008312W | ERJ-1GEF49R9C | R1 R4 R70 R606 R623-R625 | 49.9R 1% 0201(0603 metric) 1/20W 200ppm | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 7 | 0,000847 |

| Name | Item | Value | PN-1 | PN-2 | Reference Designator | Description | Telcordia Category | Telcordia Subcategory | FR/Unit [fpmh] | Quantity | FR [fpmh] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 | 4.7K | 10011096 | RC0402JR-4K7L | R2 | 4K7 5% 0402 1/16W 100ppm RC0402JR-4K7L | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 1 | 0,000121 |
| | 26 | 22R | 10008018W | RC0201JR-0722RL | R3 R5-R8 R11-R29 R31 R33 R44 R60 R61 R68 R605 | 22R 5% 0201(0603 metric) 1/20W 200ppm | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 31 | 0,003751 |
| | 27 | 1K | 10011080 | RC0402JR-1KL | R10 R59 R63 R748 | 1K 5% 0402 1/16W 100ppm RC0402JR-1KL | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 4 | 0,000484 |
| | 28 | 10K | 10008104W | RC0201JR-0710KL | R34 R36 R38-R40 R122 R123 R128 R131 R133 R135 R149 R150 R341 R501 R502 R508 R584 R601-R603 R611 R619-R621 R749 | 10K 5% 0201(0603 metric) 1/20W 200ppm | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 26 | 0,003146 |
| | 29 | 200R | 10008048W | RC0201JR-07200RL | R45 | 200R 5% 0201(0603 metric) 1/20W 200ppm | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 1 | 0,000121 |
| | 30 | 33R | 10008023W | RC0201JR-0733RL | R90 R95 R98 R100 R103 R106 R108 R111 R113 R116 R119 R121 R124 R126 R127 R129 R630-R633 | 33R 5% 0201(0603 metric) 1/20W 200ppm | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 20 | 0,00242 |
| | 31 | 2.37K 1% | 10012065A | RC0402FR-072K37L | R120 | 2K37 1% 0402 1/16W 100ppm RC0402FR-2K37L | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 1 | 0,000121 |
| | 32 | 56R | 10008032W | RC0201JR-0756RL | R568 R569 R572 R573 R576 R577 R580 R581 | 56R 5% 0201(0603 metric) 1/20W 200ppm | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 8 | 0,000968 |
| | 33 | 510R | 10008062W | RC0201JR-07510RL | R570 R571 R574 R575 R578 R579 R582 R583 | 510R 5% 0201(0603 metric) 1/20W 200ppm | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 8 | 0,000968 |

| Name | Item | Value | PN-1 | PN-2 | Reference Designator | Description | Telcordia Category | Telcordia Subcategory | FR/Unit [fpmh] | Quantity | FR [fpmh] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 34 | 1K | 10008079W | RC0201 JR-071KL | R750 R751 | 1K 5% 0201(0603 metric) 1/20W 200ppm | Resistor | Film (RL, RLR, RN, RNR, RM) | 0,000121 | 2 | 0,000242 |
| | 35 | QCA9550 -AT4B | 50101814W | QCA9550-AT4B | U1 | IEEE802.11abgn SoC;Microcontroller ,3T3R 2.4/5GHz CMOS RF ,RGMII,SGMII;PCIE 1.1; MAC;2xUSB2.;1.2V int switch;BGA415_0.65 18x18,-40+85 | Integrated Circuit | Microprocesso r | 0,021254 | 1 | 0,021254 |
| | 36 | W971GG 6JB-25I | 50200564W | W971GG6JB-25I | U2 | 1G (64M x 16)800MHz DDR2 SDRAM (400MHz clock) 2.5ns;1.7-1.9V;84-WBGA(8x12.5mm);-40+85 | Integrated Circuit | Memory | 0,013439 | 1 | 0,013439 |
| | 37 | FP6811-29NSAPT R | 51300009W | FP6811-29NSAPTR | U5 | Microprocessor Voltage power monitor with manual Reset ,Open-Drain SOT143 Ures=2.93V -40 +85 | Integrated Circuit | Linear | 0,001761 | 1 | 0,001761 |
| | 38 | S34ML01 G200BHI 000 | 50310510W | S34ML01G200 BHI000 | U18 | IC NAND FLASH 1Gb(128Mx8bit);2.7-3.6V; 63-VFBGA(9x11);-40+85 | Integrated Circuit | EEPROM | 0,023167 | 1 | 0,023167 |
| | 39 | AR8032-BL1B | 50600419W | AR8032-BL1B | U73 | Integrated 10/100 Ethernet PHYceiver;3.3V&1A;QFN32_0.5_5x5mm;-40+85 | Integrated Circuit | Logic, CGA or ASIC | 0,003537 | 1 | 0,003537 |

| Name | Item | Value | PN-1 | PN-2 | Reference Designator | Description | Telcordia Category | Telcordia Subcategory | FR/Unit [fpmh] | Quantity | FR [fpmh] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 40 | SE5516A | 52000360W | SE5516A | U74 U75 | 3.3V,Dual Band(2.4&5GHz) 1T1R;PA,LNA,TX/RX SWITCH;LGA24(4x4x1.0mm);-40+85 | Integrated Circuit | Linear | 0,002856 | 2 | 0,005712 |
| | 41 | 40.000 MHz+-10ppm | 25000281W | SMD02016/4 40.000 MHz 10/15/-40+85/18pF | Y1 | 40.00000 MHz SMD02016 Series Ultra Miniatur Quartz crystal ,2.0x1.6x0.7mm,Cl=18pF;+-10ppm(+25C) ;-40+85 | Miscellaneous | Quartz Crystal | 0,003035 | 1 | 0,003035 |
| | 42 | 25.00000 MHz+-20ppm | 25000275W | ABM11-25.000MHZ-D2X-T3 | Y2 | 25.00000 MHz ser ABM11 Series Ultra Miniatur Quartz crystal ,2.0x1.6x0.7mm,Cl=10pF;+-20ppm(+25C) ;-40+85 | Miscellaneous | Quartz Crystal | 0,003035 | 1 | 0,003035 |
| | 999 | | PCB | | PCB | Board | PCB | Not explicitly taken into consideration by Telcordia | 0 | 1 | 0 |

**Table 3: Failure Rates [fpmh] @ ground fixed uncontrolled environment, 25 °C**