MTBF Calculation of CBQ100 Series Quarter Size Converter

The MTBF, calculated in accordance with Bellcore TR-332 issue 6, December 1997, are 4,954,910 hours@+25ºC, 1,606,709 hours@+50ºC and 554,105 hours@+70ºC for CBQ100 series dc/dc converters. This represents an average failure rate of 201.82(+25ºC), 622.39(+50ºC) and 1804.71(+70ºC) failures per billion unit hours of operations. The assumptions are full load at +25ºC, +50ºC and +70ºC case temperature under Ground, Fixed, Controlled (GB) environment condition. The detail MTBF calculation of CBQ100 series dc/dc converters are listed as following:

MTBF@+25ºC:

MICROCIRCUITS:

(1) Controller: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=46\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=0.35$, N=1

$\lambda_{SS}=46\times10^{-9}\times1.0\times1.0\times0.35\times1=16.10\times10^{-9}$

(2) Timer: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=33\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=0.35$, N=1

$\lambda_{SS}=33\times10^{-9}\times1.0\times1.0\times0.35\times1=11.55\times10^{-9}$

(3) Error Amplifier: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=0.35$, N=2

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times0.35\times2=13.30\times10^{-9}$

(4) Voltage Comparator: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=0.35$, N=1

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times0.35\times1=6.65\times10^{-9}$

(5) Schmitt Trigger: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=14.5\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=0.43$, N=1

$\lambda_{SS}=14.5\times10^{-9}\times1.0\times1.0\times0.43\times1=6.24\times10^{-9}$

(6) Photo-electronic: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=30\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=0.27$, N=2

$\lambda_{SS}=30\times10^{-9}\times1.0\times1.0\times0.27\times2=16.20\times10^{-9}$

DISCRETE SEMICONDUCTORS:

(1) SR MOSFET: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=20\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.55$, $\pi_T=0.66$, N=4

$\lambda_{SS}=20\times10^{-9}\times1.0\times0.55\times0.66\times4=29.04\times10^{-9}$

(2) Switching Diodes: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=3\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.3$, $\pi_T=0.66$, N=9

$\lambda_{SS}=3\times10^{-9}\times1.0\times0.3\times0.66\times9=5.35\times10^{-9}$

(3) Auxiliary Power Bipolar Transistors: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.64$, $\pi_T=0.66$, N=1

$\lambda_{SS}=4\times10^{-9}\times1.0\times0.64\times0.66\times1=1.69\times10^{-9}$

(4) MOSFET: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=20\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=0.66$, N=1

$\lambda_{SS}=20\times10^{-9}\times1.0\times0.4\times0.66\times1=5.28\times10^{-9}$

(5) Reset MOSFET: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=20\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=0.66$, N=1

$\lambda_{SS}=20\times10^{-9}\times1.0\times0.4\times0.66\times1=5.28\times10^{-9}$

(6) Zener Diodes: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=3\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=0.76$, N=4

$\lambda_{SS}=3\times10^{-9}\times1.0\times0.4\times0.76\times4=3.65\times10^{-9}$

(7) Small Signal Bipolar Transistors: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.16$, $\pi_T=0.66$, N=7

$\lambda_{SS}=4\times10^{-9}\times1.0\times0.16\times0.66\times7=2.96\times10^{-9}$

RESISTORS: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=0.5\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.6$, $\pi_T=0.76$, N=58

$\lambda_{SS}=0.5\times10^{-9}\times1.0\times0.6\times0.76\times58=13.22\times10^{-9}$

THERMISTOR: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_TN$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=0.47$, N=1

$\lambda_{SS}=4\times10^{-9}\times1.0\times1.0\times0.47\times1=1.88\times10^{-9}$

CAPACITORS:

(1) Input Ceramic Capacitors: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=1\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=2.3$, $\pi_T=0.91$, N=1

$\lambda_{SS}=1\times10^{-9}\times1.0\times2.3\times0.91\times1=2.09\times10^{-9}$

(2) Output Ceramic Capacitors: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=1\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=0.91$, N=4

$\lambda_{SS}=1\times10^{-9}\times1.0\times1.0\times0.91\times4=3.64\times10^{-9}$

(3) Ceramic Chip Capacitors: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=1\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=0.91$, N=27

$\lambda_{SS}=1\times10^{-9}\times1.0\times0.4\times0.91\times27=9.83\times10^{-9}$

INDUCTIVE DEVICES:

(1) Power Transformer: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=0.76$, N=1

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times0.76\times1=14.44\times10^{-9}$

(2) Pulse Transformer: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=0.76$, N=1

$\lambda_{SS}=4\times10^{-9}\times1.0\times1.0\times0.76\times1=3.04\times10^{-9}$

(3) Power inductor: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=0.76$, N=1

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times0.76\times1=14.44\times10^{-9}$

(4) Load Coils: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=7\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=0.76$, N=3

$\lambda_{SS}=7\times10^{-9}\times1.0\times1.0\times0.76\times3=15.95\times10^{-9}$

Total equipment failure rate:

λ_p=16.10+11.55+13.30+6.65+6.24+16.20+29.04+5.35+1.69+5.28
+5.28+3.65+2.96+13.22+1.88+2.09+3.64+9.83+14.44+3.04+14.44+15.95
= 201.82 Failures/10^9 hours.

MTBF=4,954,910 hours @+25ºC GB.

MTBF@+50ºC:

MICROCIRCUITS:

(1) Controller: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=46\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=1.9$, N=1

$\lambda_{SS}=46\times10^{-9}\times1.0\times1.0\times1.9\times1=87.40\times10^{-9}$

(2) Timer: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=33\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=1.9$, N=1

$\lambda_{SS}=33\times10^{-9}\times1.0\times1.0\times1.9\times1=62.70\times10^{-9}$

(3) Error Amplifier: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=1.9$, N=2

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times1.9\times2=72.20\times10^{-9}$

(4) Voltage Comparator: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=1.9$, N=1

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times1.9\times1=36.10\times10^{-9}$

(5) Schmitt Trigger: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=14.5\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=1.70$, N=1

$\lambda_{SS}=14.5\times10^{-9}\times1.0\times1.0\times1.70\times1=24.65\times10^{-9}$

(6) Photo-electronic: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=30\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=2.2$, N=2

$\lambda_{SS}=30\times10^{-9}\times1.0\times1.0\times2.2\times2=132.00\times10^{-9}$

DISCRETE SEMICONDUCTORS:

(1) SR MOSFET: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=20\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.55$, $\pi_T=1.20$, N=4

$\lambda_{SS}=20\times10^{-9}\times1.0\times0.55\times1.20\times4=52.80\times10^{-9}$

(2) Switching Diodes: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=3\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.3$, $\pi_T=1.20$, N=9

$\lambda_{SS}=3\times10^{-9}\times1.0\times0.3\times1.20\times9=9.72\times10^{-9}$

(3) Auxiliary Power Bipolar Transistors: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.64$, $\pi_T=1.20$, N=1

$\lambda_{SS}=4\times10^{-9}\times1.0\times0.64\times1.20\times1=3.07\times10^{-9}$

(4) MOSFET: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=20\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=1.20$, N=1

$\lambda_{SS}=20\times10^{-9}\times1.0\times0.4\times1.20\times1=9.60\times10^{-9}$

(5) Reset MOSFET: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=20\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=1.20$, N=1

$\lambda_{SS}=20\times10^{-9}\times1.0\times0.4\times1.20\times1=9.60\times10^{-9}$

(6) Zener Diodes: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=3\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=1.10$, N=4

$\lambda_{SS}=3\times10^{-9}\times1.0\times0.4\times1.10\times4=5.28\times10^{-9}$

(7) Small Signal Bipolar Transistors: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.16$, $\pi_T=1.20$, N=7

$\lambda_{SS}=4\times10^{-9}\times1.0\times0.16\times1.20\times7=5.38\times10^{-9}$

RESISTORS: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=0.5\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.6$, $\pi_T=1.10$, N=58

$\lambda_{SS}=0.5\times10^{-9}\times1.0\times0.6\times1.10\times58=19.14\times10^{-9}$

THERMISTOR: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.60$, N=1

$\lambda_{SS}=4\times10^{-9}\times1.0\times1.0\times1.60\times1=6.40\times10^{-9}$

CAPACITORS:

(1) Input Ceramic Capacitors: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=1\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=2.3$, $\pi_T=1.00$, N=1

$\lambda_{SS}=1\times10^{-9}\times1.0\times2.3\times1.00\times1=2.30\times10^{-9}$

(2) Output Ceramic Capacitors: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=1\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.00$, N=4

$\lambda_{SS}=1\times10^{-9}\times1.0\times1.0\times1.00\times4=4.00\times10^{-9}$

(3) Ceramic Chip Capacitors: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=1\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=1.00$, N=27

$\lambda_{SS}=1\times10^{-9}\times1.0\times0.4\times1.00\times27=10.80\times10^{-9}$

INDUCTIVE DEVICES:

(1) Power Transformer: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.10$, N=1

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times1.10\times1=20.90\times10^{-9}$

(2) Pulse Transformer: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.10$, N=1

$\lambda_{SS}=4\times10^{-9}\times1.0\times1.0\times1.10\times1=4.40\times10^{-9}$

(3) Power inductor: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.10$, N=1

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times1.10\times1=20.90\times10^{-9}$

(4) Load Coils: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=7\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.10$, N=3

$\lambda_{SS}=7\times10^{-9}\times1.0\times1.0\times1.10\times3=23.10\times10^{-9}$

Total equipment failure rate:

λ_p=87.40+62.70+72.20+36.10+24.60+132.00+52.80+9.72+3.07+9.60
+9.60+5.28+5.38+19.14+6.40+2.30+4.00+10.80+20.90+4.40+20.90+23.10
= 622.39 Failures/10^9 hours.

MTBF=1,606,709 hours @+50ºC GB.

MTBF@+70ºC:

MICROCIRCUITS:

(1) Controller: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=46\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=6.14$, N=1

$\lambda_{SS}=46\times10^{-9}\times1.0\times1.0\times6.14\times1=282.44\times10^{-9}$

(2) Timer: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=33\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=6.14$, N=1

$\lambda_{SS}=33\times10^{-9}\times1.0\times1.0\times6.14\times1=202.62\times10^{-9}$

(3) Error Amplifier: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=6.14$, N=2

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times6.14\times2=233.32\times10^{-9}$

(4) Voltage Comparator: $\lambda_{SS}=\lambda_G \pi_Q \pi_S \pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=6.14$, N=1

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times6.14\times1=116.66\times10^{-9}$

(5) Schmitt Trigger: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=14.5\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1$, $\pi_T=4.30$, N=1

$\lambda_{SS}=14.5\times10^{-9}\times1.0\times1.0\times4.30\times1=62.35\times10^{-9}$

(6) Photo-electronic: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=30\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=9.67$, N=2

$\lambda_{SS}=30\times10^{-9}\times1.0\times1.0\times9.67\times2=580.20\times10^{-9}$

DISCRETE SEMICONDUCTORS:

(1) SR MOSFET: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=20\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.55$, $\pi_T=2.04$, N=4

$\lambda_{SS}=20\times10^{-9}\times1.0\times0.55\times2.04\times4=89.76\times10^{-9}$

(2) Switching Diodes: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=3\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.3$, $\pi_T=2.04$, N=9

$\lambda_{SS}=3\times10^{-9}\times1.0\times0.3\times2.04\times9=16.52\times10^{-9}$

(3) Auxiliary Power Bipolar Transistors: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.64$, $\pi_T=2.04$, N=1

$\lambda_{SS}=4\times10^{-9}\times1.0\times0.64\times2.04\times1=5.22\times10^{-9}$

(4) MOSFET: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=20\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=2.04$, N=1

$\lambda_{SS}=20\times10^{-9}\times1.0\times0.4\times2.04\times1=16.32\times10^{-9}$

(5) Reset MOSFET: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=20\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=2.04$, N=1

$\lambda_{SS}=20\times10^{-9}\times1.0\times0.4\times2.04\times1=16.32\times10^{-9}$

(6) Zener Diodes: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=3\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=1.63$, N=4

$\lambda_{SS}=3\times10^{-9}\times1.0\times0.4\times1.63\times4=7.82\times10^{-9}$

(7) Small Signal Bipolar Transistors: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.16$, $\pi_T=2.04$, N=7

$\lambda_{SS}=4\times10^{-9}\times1.0\times0.16\times2.04\times7=9.14\times10^{-9}$

RESISTORS: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=0.5\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.6$, $\pi_T=1.63$, N=58

$\lambda_{SS}=0.5\times10^{-9}\times1.0\times0.6\times1.63\times58=28.36\times10^{-9}$

THERMISTOR: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=3.70$, N=1

$\lambda_{SS}=4\times10^{-9}\times1.0\times1.0\times3.70\times1=14.80\times10^{-9}$

CAPACITORS:

(1) Input Ceramic Capacitors: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=1\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=2.3$, $\pi_T=1.18$, N=1

$\lambda_{SS}=1\times10^{-9}\times1.0\times2.3\times1.18\times1=2.71\times10^{-9}$

(2) Output Ceramic Capacitors: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=1\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.18$, N=4

$\lambda_{SS}=1\times10^{-9}\times1.0\times1.0\times1.18\times4=4.72\times10^{-9}$

(3) Ceramic Chip Capacitors: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=1\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=0.4$, $\pi_T=1.18$, N=27

$\lambda_{SS}=1\times10^{-9}\times1.0\times0.4\times1.18\times27=12.74\times10^{-9}$

INDUCTIVE DEVICES:

(1) Power Transformer: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.63$, N=1

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times1.63\times1=30.97\times10^{-9}$

(2) Pulse Transformer: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=4\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.63$, N=1

$\lambda_{SS}=4\times10^{-9}\times1.0\times1.0\times1.63\times1=6.52\times10^{-9}$

(3) Power inductor: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=19\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.63$, N=1

$\lambda_{SS}=19\times10^{-9}\times1.0\times1.0\times1.63\times1=30.97\times10^{-9}$

(4) Load Coils: $\lambda_{SS}=\lambda_G\pi_Q\pi_S\pi_T N$, $\lambda_G=7\times10^{-9}$, $\pi_Q=1.0$, $\pi_S=1.0$, $\pi_T=1.63$, N=3

$\lambda_{SS}=7\times10^{-9}\times1.0\times1.0\times1.63\times3=34.23\times10^{-9}$

Total equipment failure rate:

λ_p***=282.44+202.62+233.32+116.66+62.35+580.20+89.76+16.52+5.22+16.32***
+16.32+7.82+9.14+28.36+14.80+2.71+4.72+12.74+30.97+6.52+30.97+34.23
= 1804.71 Failures/10^9 hours.

MTBF=554,105 hours @+70ºC GB.