Comparison of MCA and Discrete Failure Rates

Summary

MIL-HDBK-217F is used to compare the reliability of a discrete vs an MCA design. The system is assumed to consist of 12 2N2222A transistors, operating in an Airborne Inhabited Fighter environment.

Discrete System: $\lambda_p = \boldsymbol{0.81}$ failures/10^6 operating hours

MCA System: $\lambda_p = \boldsymbol{0.32}$ failures/10^6 operating hours

Discrete Calculation

Transistor, Low Frequency, Bipolar (MIL-HDBK-217F Section 6.3)

Transistor failure rate $\lambda_p = \lambda_b \pi_T \pi_A \pi_R \pi_S \pi_Q \pi_E$

Base failure rate $\lambda_b = 0.00074$

Temperature factor $\pi_T = 2.1$ (Assume $T_j = T_{case} = 60°C$)

Application factor $\pi_A = 1.5$ (Linear Amplification)

Power Rating Factor $\pi_R = 1.0$ (Power = 1W)

Voltage Stress Factor $\pi_S = 1.0$ ($V_{CE} = V_{CEO}$, $V_s = 1.0$)

Quality factor $\Pi_Q = 1.0$ (JANTX)

Environmental factor $\Pi_E = 29$ (Aircraft Inhabited Fighter)

$\Rightarrow \lambda_p = 0.00074 * 2.1 * 1.5 * 1.0 * 1.0 * 1.0 * 29 = 0.06760$

Number of 2N2222A die $N = 12$

$\Rightarrow N\lambda_p = 12 * 0.06760 = 0.8112$

MCA Calculation

Transistor, Low Frequency, Bipolar (MIL-HDBK-217F Section 6.3)

Transistor failure rate $\lambda_p = \lambda_b \pi_T \pi_A \pi_R \pi_S \pi_Q \pi_E$

Base failure rate $\lambda_b = 0.00074$

Temperature factor $\pi_T = 2.1$ (Assume $T_j = T_{case} = 60°C$)

Application factor $\pi_A = 1.5$ (Linear Amplification)

Power Rating Factor $\pi_R = 1.0$ (Assume Power = 1W)

Voltage Stress Factor $\pi_S = 1.0$ (Assume $V_{CE} = V_{CEO}$, $V_s = 1.0$)

Quality factor $\Pi_Q = 1$ (Hybrid)

Environmental factor $\Pi_E = 1$ (Hybrid)

$\Rightarrow \lambda_p = 0.00074 * 2.1 * 1.5 * 1.0 * 1.0 * 1 * 1 = 0.002331$

Hybrid (MIL-HDBK-217F Section 5.5)

Hybrid failure rate $\lambda_p = [N_C \lambda_C](1 + 0.2\pi_E)\pi_F \pi_Q \pi_L$

Number of 2N2222A die $N_C = 12$

2N2222A failure rate $\lambda_C = 0.002331$

Environmental factor $\pi_E = 5.0$ (Airborne Inhabited Fighter)

Circuit function factor $\pi_F = 5.8$ (Linear, f < 10MHz))

Quality factor $\Pi_Q = 1.0$ (Class B)

Learning factor $\Pi_L = 1.0$ (> 2yrs in production)

$$\Rightarrow \lambda_p = [12 * 0.002331] * (1 + 0.2 * 5.0) * 5.8 * 1.0 * 1.0 = 0.3245$$

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