

July 8th, 2024

TSNJ-5A6L26 FIT & MTTF Prediction

1. Calculating Method of Failure Rate

Failure rate at accelerated life testing (λ_2) is used to assume value (λ_1) in field condition

1.1 Result of accelerate life testing

Test sample	:	TSNJ-5A6L26
Condition	:	$T_2 = 85^\circ\text{C}$ at VIN and VOUT, $V_2 = 4\text{ V}$ applied
Test time	:	$t = 1000$ hours
Number of test samples	:	$n = 500$
pieces Number of failure	:	$r = 0$ piece
Confidence coefficient (60%)	:	$k = 0.917$ (JIS C5003 table)

(a) Component Hours (T)

$$T = \sum t_i + (n - r) t$$

Since $r = 0$ (no failed units), $\sum t_i = 0$. Therefore:

$$T = (500 - 0) \times 1000 = 500,000 \text{ hours}$$

(b) Failure-rate at stress, per hour (λ_2)

With 60% confidence and $r=0$:

$$\lambda_2 \text{ [failures/hour]} = \frac{k}{T} = \frac{0.917}{500,000} = 1.834 \times 10^{-6}$$

(c) Convert to FIT (failures per 10^9 device-hours)

$$\text{FIT}_2 = \lambda_2 \times 10^9 = 1.834 \times 10^{-6} \times 10^9 = 1834 \text{ FIT}$$

1.2 Acceleration Coefficients

Voltage exponent: $n = 6$

Temperature “doubling interval”: $\theta = 8$

Field (use) condition: $V_1 = 3.3\text{ V}$, $T_1 = 45^\circ\text{C}$

Stress condition: $V_2 = 4\text{ V}$, $T_2 = 85^\circ\text{C}$

(a) Voltage acceleration (inverse power law)

$$\text{AF}_V = \left(\frac{V_2}{V_1}\right)^n = \left(\frac{4}{3.3}\right)^6 = 3.1715846605$$

(b) Temperature acceleration (Arrhenius in “×2 per 9 °C” form)

$$AF_T = 2^{\frac{T_2 - T_1}{9}} = 2^{\frac{85 - 45}{9}} = 2^5 = 32$$

(c) Combined acceleration factor

$$AF = AF_V \times AF_T = 3.1715846605 \times 32 = 101.4907091358$$

1.3 Estimated failure rate in the field (λ_1)

(Units: failures per 10^9 device-hours.)

$$\lambda_1 = \frac{\lambda_2}{AF} = \frac{1834 \text{ FIT}}{101.4907091358} = 18.0706196224 \text{ FIT}$$

1.4 MTTF Prediction

(a) Mean Time To Failure (MTTF)

$$\text{FIT} = \frac{10^9}{\text{MTTF (hours)}} \Rightarrow \text{MTTF} = \frac{10^9}{\text{FIT}}$$

So with $\lambda_1 = 18.0706196224 \text{ FIT}$:

$$\text{MTTF (hours)} = \frac{10^9}{18.0706196224} = 55,338,445.55 \text{ hours}$$

$$\text{MTTF (years)} = \frac{55,338,445.55}{8760} \approx 6317 \text{ years}$$

The following are the calculated FIT and MTTF at 25 °C derived from the JIS C5003 FIT model using the stressed test results above at 4V and 85 °C, with temperature measured at the VIN and VOUT terminals of TSNJ-5A6L26.

[Calculated at 25°C]

Voltage (V)	AF_total	FIT (field)	MTTF (hours)	MTTF (years)
0.5	47453132.8	0.000039	2.58741E+13	2953666463
1	741455.2	0.002474	4.04283E+11	46151038
2	11585.238	0.158305	6316923393	721110
3.3	574.118	3.194464	313041520.9	35735
4	181.019	10.131514	98701928.02	11267
5	47.453	38.64866	25874118.22	2954
6	15.892	115.404281	8665189.84	989

Caution:

Calculated FIT and MTTF values are estimations; they are not guarantees.