

IEC TR 62380 FIT Rate Scaling for different mission profile

IEC TR 62380

**Model for reliability predictions
of electronic components**

**Commonly used for failure rate
estimation used in safety related
analysis**

**TECHNICAL
REPORT**

**IEC
TR 62380**

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Universal model for reliability prediction
of electronics components, PCBs
and equipment**

IEC TR 62380 FIT Rate Analysis for Integrated Circuit

General formula for IEC TR 62380 IC failure rate can be modeled as sum of the die related failure rate and the package related failure rate where

- **Die** related failure rate formula includes terms for IC type and IC technology, transistor count, thermal mission profile, junction temperature, operating and non-operating lifetime.
- **Package** related failure rate formula includes terms for mechanical stress due to thermal expansions, thermal cycles, thermal mission profile, package type and package materials.
- **EOS** failure rate formula includes terms for external interface and electrical environment.

IEC TR 62380 Intrinsic Failure Rate

$$\lambda = \left\{ \underbrace{\lambda_1 \times N \times e^{-0.35 \times a}}_{\text{Total FIT}} + \underbrace{\lambda_2}_{\text{Die FIT}} \times \left\{ \frac{\sum_{i=1}^y (\pi_t)_i \times \tau_i}{\tau_{on} + \tau_{off}} \right\} + \underbrace{\left\{ 2.75 \times 10^{-3} \times \pi_\alpha \times \underbrace{\left(\sum_{i=1}^z (\pi_n)_i \times (\Delta T_i)^{0.68} \right)}_{\lambda_{package}} \times \lambda_3 \right\}}_{\text{Package FIT}} + \underbrace{\left\{ \frac{\pi_I \times \lambda_{EOS}}{\lambda_{overstress}} \right\}}_{\text{EOS FIT}} \right\} \times 10^{-9} / h$$

Total FIT = Die FIT + Package FIT + EOS FIT

Figure 1: TR 62380 Integrated Circuit Failure Rate Model Equation

NECESSARY INFORMATION:	
$(t_{ae})_i$: average outside ambient temperature surrounding the equipment, during the i^{th} phase of the mission profile.
$(t_{ae})_i$: average ambient temperature of the printed circuit board (PCB) near the components, where the temperature gradient is cancelled.
λ_1	: per transistor base failure rate of the integrated circuit family. See Table 16.
λ_2	: failure rate related to the technology mastering of the integrated circuit. See Table 16.
N	: number of transistors of the integrated circuit.
a	: [(year of manufacturing) – 1998].
$(\pi_t)_i$: i^{th} temperature factor related to the i^{th} junction temperature of the integrated circuit mission profile.
τ_i	: i^{th} working time ratio of the integrated circuit for the i^{th} junction temperature of the mission profile.
τ_{on}	: total working time ratio of the integrated circuit. With: $\tau_{on} = \sum_{i=1}^y \tau_i$
τ_{off}	: time ratio for the integrated circuit being in storage (or dormant). With $\tau_{on} + \tau_{off} = 1$
π_α	: influence factor related to the thermal expansion coefficients difference, between the mounting substrate and the package material.
$(\pi_n)_i$: i^{th} influence factor related to the annual cycles number of thermal variations seen by the package, with the amplitude ΔT_i .
ΔT_i	: i^{th} thermal amplitude variation of the mission profile.
λ_3	: base failure rate of the integrated circuit package. See Table 17a and 17b
π_I	: influence factor related to the use of the integrated circuit (interface or not).
λ_{EOS}	: failure rate related to the electrical overstress in the considered application..

Figure 2: TR 62380 Interated Circuit Failure Rate Model Terms

Scaling IEC TR 62380 Die Fit for different mission profiles

Technology & Transistor information
unchanged for different mission profile

**Temperatures, durations , Ton and Toff
change for different mission profiles.**

Delta Tja unchanged for mission profile
Temperature factor pie_t unchanged for mission profile

$$\underbrace{\left\{ \lambda_1 \times N \times e^{-0.35 \times a} + \lambda_2 \right\}}_{\lambda_{die}} \times \underbrace{\left\{ \frac{\sum_{i=1}^y (\pi_t)_i \times \tau_i}{\tau_{on} + \tau_{off}} \right\}}$$

For mission profile 1:

Lambda die 1 = Tech info x mission profile 1

For mission profile 2:

Lambda die 2 = Tech info x mission profile 2

Tech info is independent of the mission profile
If you know Lambda die 1 for mission profile 1

The Lambda die 2 can be solved by substitution

Lambda die 2 = Lambda die 1 * $\frac{\text{mission profile 2}}{\text{mission profile 1}}$

Scaling IEC TR 62380 Die Fit for different mission profiles

Example: Lambda die fit of 3.5 FIT for Motor Control profile to be scaled to Passenger Compartment profile

Assume a HV BiCMOS technology A=4640 and Delta Tj of 15 deg C

Technological structure	Temperature factor π_t
MOS BiCMOS (low voltage)	$e^{\left[A \left(\frac{1}{328} - \frac{1}{273+t_j} \right) \right]}$ A=3480 ; (Ea=0.3 eV)
Bipolar BiCMOS (high voltage)	$e^{\left[A \left(\frac{1}{328} - \frac{1}{273+t_j} \right) \right]}$ A=4640 ; (Ea=0.4 eV)

Mission profile phases	Temp. 1		Temp. 2		Temp. 3		Ratios on/off	
	(t _{ac}) ₁ °C	τ ₁	(t _{ac}) ₂ °C	τ ₂	(t _{ac}) ₃ °C	τ ₃	τ _{on}	τ _{off}
Application types								
Motor control	32	0.020	60	0.015	85	0.023	0.058	0.942
Passenger compartment	27	0.006	30	0.046	85	0.006	0.058	0.942

Motor Control

$$T_j 1 = 32C + 15C = 47C$$

$$T_j 2 = 60C + 15C = 75C$$

$$T_j 3 = 85C + 15C = 100C$$

$$\pi_{t1} = e^{(4640 (1/328 - 1/(273+47)))} = 0.702$$

$$\pi_{t2} = e^{(4640 (1/328 - 1/(273+75)))} = 2.254$$

$$\pi_{t3} = e^{(4640 (1/328 - 1/(273+100)))} = 5.510$$

$$\Delta T_j = \text{Power} * \text{Theta Ja} = 90\text{mW} * 171 \text{ C/W} = 15 \text{ deg C}$$

See datasheet

$$3.5 \text{ die FIT} = (\text{tech info}) * ((0.02*0.702 + 0.015 * 2.254 + 0.023 * 5.510) / (0.94 + 0.058)); 3.5 \text{ die FIT} = (\text{tech info}) * 0.1746$$

Passenger Compartment

$$T_j 1 = 27C + 15C = 42C$$

$$T_j 2 = 30C + 15C = 45C$$

$$T_j 3 = 85C + 15C = 100C$$

$$\pi_{t1} = e^{(4640 (1/328 - 1/(273+42)))} = 0.5577$$

$$\pi_{t2} = e^{(4640 (1/328 - 1/(273+45)))} = 0.6409$$

$$\pi_{t3} = e^{(4640 (1/328 - 1/(273+100)))} = 5.510$$

See FIT rate report assumptions

$$\text{Pass Comp die FIT} = (\text{tech info}) * ((0.006*0.5577 + 0.046 * 0.6409 + 0.006 * 5.510) / (0.94 + 0.058)); \text{Pass Comp die FIT} = (\text{tech info}) * 0.0659$$

$$\text{Pass Comp die FIT} = 3.5 \text{ FIT} * (0.0659 / 0.1746); \text{Passenger Compartment profile die FIT} = 1.4 \text{ FIT}$$

Scaling IEC TR 62380 Package Fit for different mission profiles

The thermal expansion factor π_{α} and the package factor fail rate λ_3 unchanged for different mission profile

Temp Cycle Factors change for different mission profiles.

Delta Tja unchanged for mission profile

$$\left\{ \underbrace{2.75 \times 10^{-3} \times \pi_{\alpha} \times \left(\sum_{i=1}^z (\pi_n)_i \times (\Delta T_i)^{0.68} \right)}_{\lambda_{package}} \times \lambda_3 \right\}$$

For mission profile 1:

$$\lambda_{package\ 1} = \text{Package info} \times \text{mission profile 1}$$

For mission profile 2:

$$\lambda_{package\ 2} = \text{Package info} \times \text{mission profile 2}$$

Package info is independent of the mission profile
If you know Lambda 1 and mission profile 1

The Lambda 2 can be solved by substitution

$$\lambda_{package\ 2} = \lambda_{package\ 1} \times \frac{\text{mission profile 2}}{\text{mission profile 1}}$$

Scaling IEC TR 62380 Package Fit for different mission profiles

Example: Lambda package fit of 1.9 FIT for Motor Control profile to be scaled to Passenger Compartment profile

Assume world wide climate t_{ae} and day/night ΔT . Assume Delta Tj of 15 deg C

Mathematical expression of the	$n_i \leq 8760$ Cycles/year	$(\pi_n)_i = n_i^{0.76}$
Influence factor $(\pi_n)_i$	$n_i > 8760$ Cycles/year	$(\pi_n)_i = 1.7 \times n_i^{0.60}$
n_i : Annual number of cycles with the amplitude ΔT_i		
For an on/off phase	$\Delta T_i = \left[\frac{\Delta T_j}{3} + (t_{ac})_i \right] - (t_{ac})_i$	
For a permanent working phase, storage or dormant	ΔT_i = average per cycle of the (t_{ac}) variation, during the i^{th} phase of the mission profile.	

Mission profile phases	2 night starts		4 day light starts		Non used vehicle	
Application types	n_1	ΔT_1	n_2	ΔT_2	n_3	ΔT_3
	cycles/year	°C/cycle	cycles/year	°C/cycle	cycles/year	°C/cycle
Motor control	670	$\frac{\Delta T_j}{3} + 55$	1340	$\frac{\Delta T_j}{3} + 45$	30	10
Passenger compartment	670	$\frac{\Delta T_j}{3} + 30$	1340	$\frac{\Delta T_j}{3} + 20$	30	10

Motor Control

$$dT1 = 15C/3 + 55C = 60C$$

$$dT2 = 15C/3 + 45C = 50C$$

$$dT3 = 10C$$

$$pie_n1 = 670^{0.76} = 140.5$$

$$pie_n2 = 1340^{0.76} = 238.0$$

$$pie_n3 = 30^{0.76} = 13.3$$

$$\Delta T_j = \text{Power} * \text{Theta Ja} = 90mW * 171 C/W = 15 \text{ deg C}$$

See FIT rate report assumptions

See datasheet

$$1.9 \text{ package FIT} = (\text{Package info}) * ((60^{0.68} * 140.5) + (50^{0.68} * 238.0) + (10^{0.68} * 13.3)); \quad 1.9 \text{ package FIT} = (\text{Package info}) * 5741.6$$

Passenger Compartment

$$dT1 = 15C/3 + 30C = 35C$$

$$dT2 = 15C/3 + 20C = 25C$$

$$dT3 = 10C$$

$$pie_n1 = 670^{0.76} = 140.5$$

$$pie_n2 = 1340^{0.76} = 238.0$$

$$pie_n3 = 30^{0.76} = 13.3$$

$$\text{Pass Comp package FIT} = (\text{package info}) * ((35^{0.68} * 140.5) + (25^{0.68} * 238.0) + (10^{0.68} * 13.3)); \quad \text{Pass Comp package FIT} = (\text{Package info}) * 3764.5$$

$$\text{Pass Comp package FIT} = 1.9 \text{ FIT} * (3764.5 / 5741.6); \quad \text{Passenger Compartment profile package FIT} = 1.3 \text{ FIT}$$

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