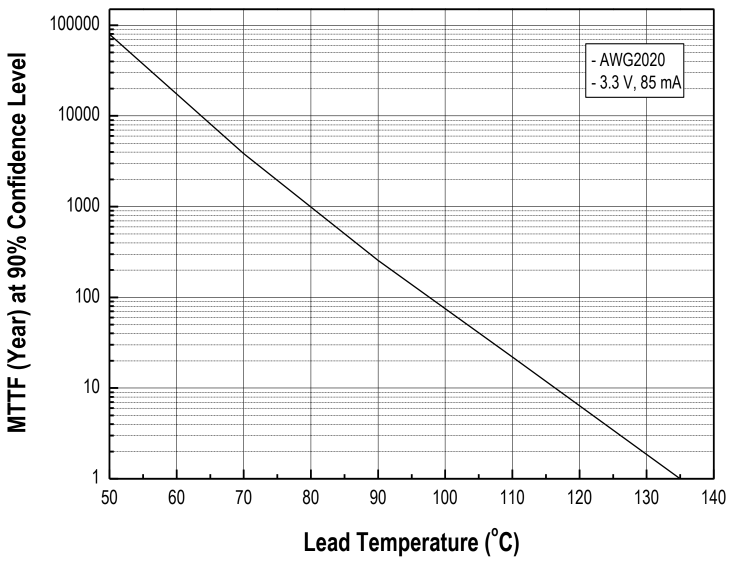
MTTF Prediction of AWG2020 InGaAs E-pHEMT Amplifiers

1. **Thermal Resistance: 80 °C/W**

2. **Accelerated Life Test Results**

Test Condition	Failure Criteria	Test Standard	Sample Size	Number of Failure
· Lead Temperature=125°C · DC-biased . 3.3 V, 85 mA · Duration Time=1,000 hours	- 10 % change in current - 10 % change in S_{21} gain	JESD22-A108-A	64	0

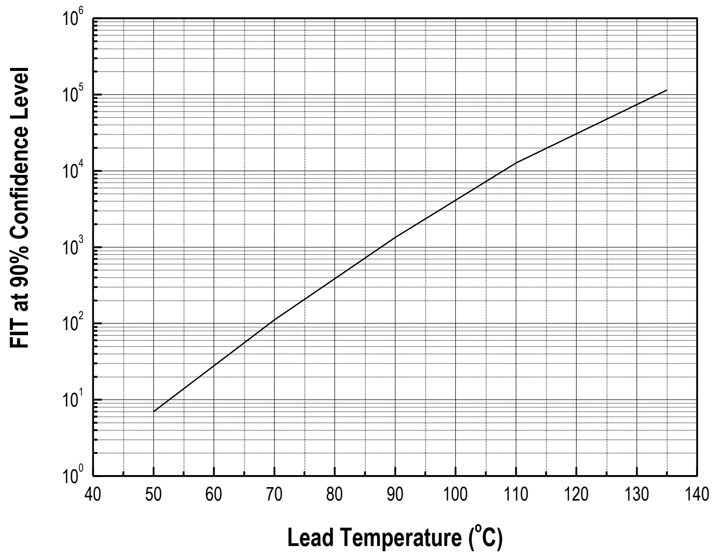
3. **MTTF Predicted at 90% Confidence Level**



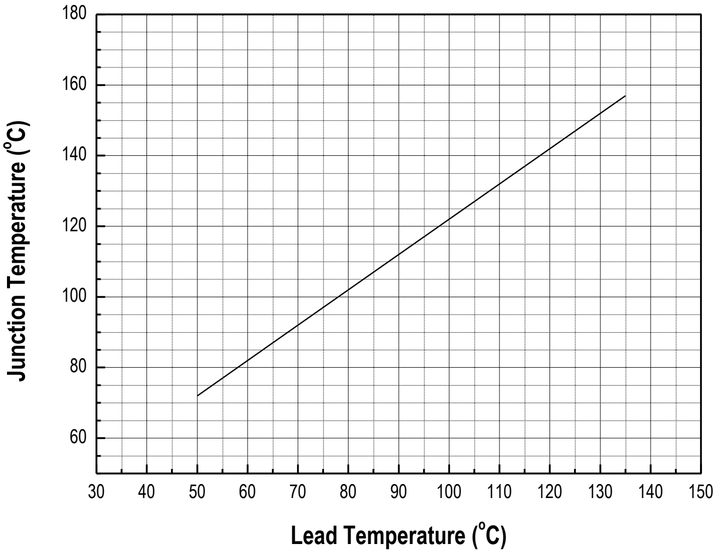
4. **FIT Predicted at 90% Confidence Level**

An FIT (failure in time) means the number of failures after 10^9 device hours of operation and is inversely related to the MTTF as follows;

$$FIT = \frac{10^9}{MTTF}$$ *where the MTTF is in hours.*



5. Junction Temperature with the Lead Temperature



6. Determination of the MTTF

In order to determine the MTTF of the amplifier, an accelerated aging test at an elevated temperature was carried out on randomly selected chips and a failure rate (FR) was obtained by a model given in MIL-HDBK-217E

A. Accelerated Life Test

The accelerated life test was done on plastic packaged chips on test board at a lead temperature of 125°C with a DC biasing. After a given period of time duration the samples were taken out to determine a temperature-induced degradation of device current and S_{21} gain.

B. Calculation of the MTTF

The relationship between MTTF and FR is as follows:

$$MTTF = \frac{1}{FR} \qquad (1)$$

$$FR = \frac{\chi^2}{2}\frac{1}{SS \times t} \qquad (2)$$

where $\chi^2/2$ is a statistical confidence factor which can be found from Chi square charts, *SS* is a sample size, and *t* is a time duration of life test. The temperature dependence of the FR is usually exponential and follows the Arrhenius empirical equation since in most semiconductors the failure is caused by the thermally activated process:

$$FR = A\exp\left(\frac{-E_A}{kT}\right)$$

From the above equation, the FR at use temperature, FR_O, can be obtained as follows:

$$FR_O = FR_A \exp\left[\frac{E_A}{k}\left(\frac{1}{T_{JA}} - \frac{1}{T_{JO}}\right)\right] \qquad (3)$$

where FR_O is the FR at a normal operating condition,
FR_A is the FR at the accelerated life test condition,
E_A is the activation energy in eV of failure process,
k is Boltzmann constant (8.62×10^{-5} eV/K),
T_{JO} is the junction temperature in Kelvin at the normal operating condition,
T_{JA} is the junction temperature in Kelvin at the accelerated life test condition.

Also the junction temperature, T_J (K), of the sample was inferred from the following relation:

$$T_J = T_L + R_{th} P_{DC}$$

where T_L is the lead temperature in Kelvin,
R_{th} is the thermal resistance of the sample,
P_{DC} is the dissipated power at a given DC bias condition.

The activation energy of the InGaAs Enhanced-mode pHEMT amplifiers listed in this document was applied as 1.5 eV which was calculated from median-time-to-failure experiment using bare dies at an accelerated temperature. From the above chi-square (χ^2) method, the MTTF is predicted at a 90% confidence level.