A Long-term Stability of IC Parameters and Temperature Acceleration Factor

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Summary: This presentation describes the typical shift of various datasheet parameters as a function of time and IC junction temperature. It talks about how the limits are set and the ways to self-guarantee specs that are shown in datasheet only as typical values by accepting certain failure rate. It introduces a concept of the Bathtub Curve and explains statistics behind MTBF/FIT numbers used to describe reliability during intrinsic failure period.

Keywords: Long-term Shift, Acceleration Factor, Arrhenius Equation, Bathtub Curve

Description of your Keynote Presentation

The long-term shift in IC's is NOT exactly a linear function of time – the shift is initially greater (curve is steeper) and it slows down (becomes more linear) over time. Therefore, the linear character of shift usually excludes the first few months that is dominated by the continuing self-curing of the molding compound used for packaging of IC.

Output Voltage Shift = 50ppm*√[time(hours)/1000hrs]

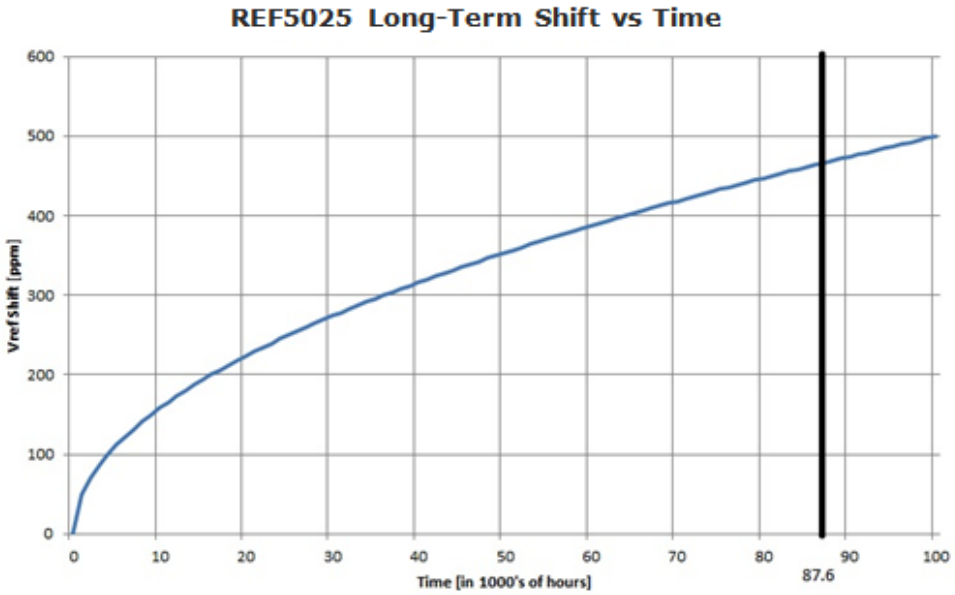


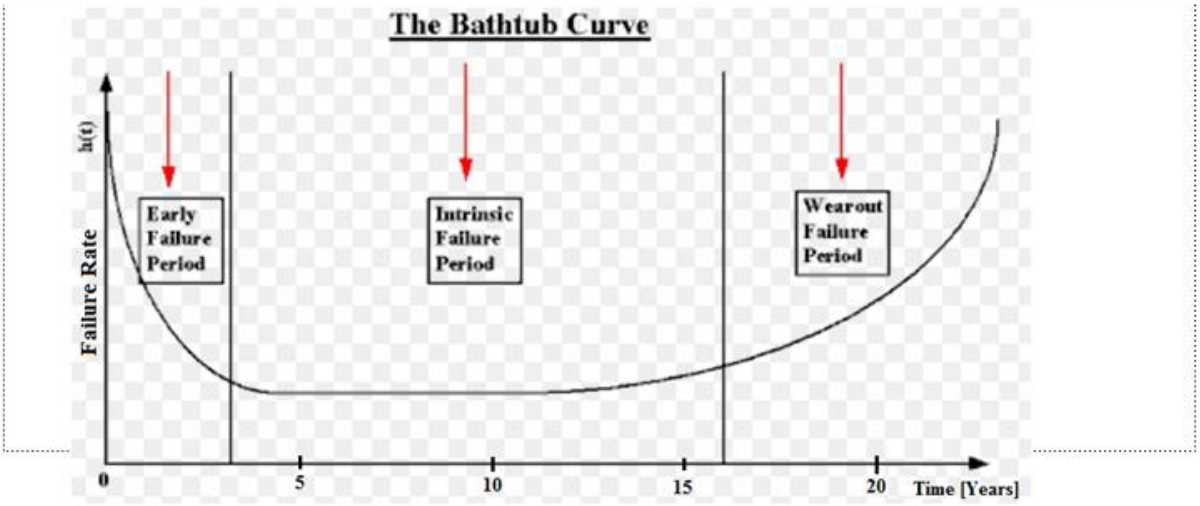
Figure 4 – REF5025 long-term stability

For example, after 25,000 hours of nonstop operation in the field, the typical output voltage shift in the REF5025 can be calculated using above equation, 50ppm*√25=250ppm, while after 10 years (87,600 hours) the shift would be 50ppm*√87.6=468pp. Therefore, at the end-of-life the REF5025 output voltage shift as expected is within the 500ppm allowable shift which equals to 0.05% of the datasheet maximum initial accuracy spec.

The quality and reliability data for the integrated circuits is provided in terms of Early Life Failure Rate (ELFR) and Mean Time Before Failures (MTBF) / Failure in Time (FIT) statistics. The probability of failure during different IC's life phases, from infant mortality thru intrinsic failure period to wear out failure time is represented by the Bathtub Curve shown below.

Semiconductor Quality and Reliability

	Early life failure rate	MTBF / FIT		Early life failure rate supporting data				MTBF / FIT supporting data						
Part number	ELFR-DPPM	MTBF	FIT	Conf level (%)	Test temp (°C)	Sample size	Fails	Usage temp (°C)	Conf level (%)	Activation energy (eV)	Test temp (°C)	Test duration (hours)	Sample size	Fails
OPA192ID	22	4.89x 10⁹	0.2	60	125	41306	0	55	60.0	0.7	125	1000	57098	0



Definition of Table Terminology
Part #:**The TI orderable part number**
ELFR: **Early Life Failure Rate**
DPPM: **Defective Parts Per Million**
MTBF: **Mean Time Between Failures**
FIT: **Failures-in-Time. The number of failures per 1E9 device-hours**
Conf level %: **Statistical confidence level**
Test temp (°C): **Temperature at which the stress test is performed**
Sample size: **Sample size is how many units were tested and would be based on the normalized value for duration**
Fails: **The number of failures per test**
Usage temp (°C): **Estimated usage temperature**
Activation energy (eV): **Energy in electron volts (eV) for a particular process to occur**
Test duration (hrs): **Test duration is a field that comes from the qualification testing of a product. Since more than one test is conducted and the duration varies, this field will be normalized based on calculations using temp, quantity and fails. This value would be equivalent unit hours.**