PRODUCT RELIABILITY REPORT

Product:
NB591/NB691/MP2329/MP2329C/MP2384/ MP2384C/MP2386/MP2386C

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1. Device Information

Product:	NB591/NB691/MP2329/MP2329C/MP2384/ MP2384C/MP2386/MP2386C
Package:	FCQFN2×2-11
Process Technology:	BCD
Report Date:	02/25/2019

2. Summary of Test Results

Test	Test Condition	Lot# or Date Code	Test Results (S.S./Rej)	Comment
Temperature, Bias, and Operating Life	JESD22-A108, @+125°C for 1000 hours or equivalent	HP4951 HP5341 HP495108	77/0 77/0 77/0	
ESD: Human Body Model (HBM)	ANSI/ESDA/JEDEC JS-001	HP495105 HP495107 HP495108	3/0 3/0 3/0	>2000V
ESD: Device Charged Model (CDM)	ANSI/ESDA/JEDEC JS-002	HP495105 HP495107 HP495108	3/0 3/0 3/0	>750V
Latch-up	EIA/JESD78	HP495105 HP495107 HP495108	6/0 6/0 6/0	>+/-100mA & >1.5Vccmax
Moisture/Reflow Sensitivity	J-STD-020	1631 1651 1717	276/0 276/0 276/0	MSL = 1
High Temperature Storage Life	JESD22-A103, @150°C for 1000 hours	1631 1651 1717	45/0 45/0 45/0	
Temperature Cycling	JESD22-A104, from -65°C to 150°C for 1000 cycles or equivalent	1631 1651 1717	77/0 77/0 77/0	
Accelerated Moisture Resistance- Unbiased Autoclave	JESD22-A102, @121°C/100%RH for 168 hours or equivalent	1631 1651 1717	77/0 77/0 77/0	

Steady State Temperature Humidity Bias Life Test	JESD22-A101, @85°C/85%RH static bias at Vinmax for 1000 hours or equivalent	1714 1728 1737	77/0 77/0 77/0	

3. Failure Rate Calculation

Sample Size:	2970
Rejects:	0
Activation Energy (eV):	0.7
Equivalent Device Hours:	2.32×10^{8} Hours
Failure Rate (FIT@60%CL):	3.9 FIT
MTBF (years):	28,902 Years

Revision / Update History

Revision	Reason for Change	Date	Rel Engineer
1.0	Initial release	January 2018	Ramon Lei
2.0	Update	February 2018	Ramon Lei
3.0	Update	March 2018	Ramon Lei
4.0	Update	December 2018	Ramon Lei
5.0	Update	February 2018	Ramon Lei

Appendix: Description of Reliability Test and Failure Rate Calculation

High Temperature Operating Life Test

Purpose: This test is a worst-case life test that checks the integrity of the product. The high temperature testing is for acceleration of any potential failures over time. The calculation for failure rate (FIT) is completed using the Arrhenius equation.
Condition: 125°C @ Vinmax
Pass Criteria: All units must pass the min/max limits of the datasheet.

ESD Test

Purpose: The purpose of the ESD test is to guarantee that the device can withstand electrostatic voltages during handling.
Condition: Human Body Model and Charged Device Model
Pass Criteria: ESD Testing on every pin. The device must be fully functional after testing and pass the min/max limits in the datasheet.

IC Latch-Up Test

Purpose: The purpose of this specification is to establish a method for determining IC latch-up characteristics and to define latch-up failure criteria. Latch-up characteristics are extremely important in determining product reliability and minimizing No Trouble Found (NTF) and Electrical Overstress (EOS) failures due to latch-up.
Condition: Voltage and current injection
Pass criteria: All pins with the exception of "no connect" pins and timing related pins, shall be latch-up tested. The device must be fully functional after testing and pass the min/max limits in the datasheet.

Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices

Purpose: The purpose of this standard is to identify the classification level of nonhermetic solid state surface mount devices (SMDs) that are sensitive to moisture-induced stress so that they can be properly packaged, stored, and handled to avoid damage during assembly solder reflow attachment and/or repair operations.
Condition: Bake + moisture sock + 3X reflow at 260°C
Pass criteria: All units must pass the min/max limits of the datasheet

High Temperature Storage Life

Purpose: The test is typically used to determine the effects of time and temperature, under storage conditions, for thermally activated failure mechanisms and time-to-failure distributions of solid state electronic devices, including nonvolatile memory devices (data retention failure mechanisms).
Condition: Bake at 150°C
Pass Criteria: All units must pass min/max limits of the datasheet

Accelerated Moisture Resistance- Unbiased Autoclave

Purpose: To check the performance of the device in humid environments. This test checks the integrity of the passivation, poor metal to plastic seal and contamination level during assembly and material compatibility.
Condition: 121°C/15psig/100% RH (no bias)
Pass Criteria: All units must pass min/max limits of the datasheet

Temperature Cycle Test

Purpose: This test is used to evaluate the die attach integrity and bond integrity. This is similar to the Thermal Shock test, but can generate different failure modes due to the longer dwell time and gradual temperature change.
Condition: -65°C to 150°C
Pass Criteria: All units must pass min/max limits of the datasheet

Steady State Temperature Humidity Bias Life Test

Purpose: This is to check the performance of the device in humid environments. This test checks the integrity of the passivation, poor metal to plastic seal and contamination level during assembly and material compatibility.

Condition: 85%RH at 85°C with Vin=Vinmax

Pass Criteria: All units must pass min/max limits of the datasheet

Highly Accelerated Temperature and Humidity Stress Test

Purpose: This is an equivalent test to Steady State Temperature Humidity Bias Life test with different (higher) temperature stress condition.

Condition: 85%RH at 130°C with Vin=Vinmax

Pass Criteria: All units must pass min/max limits of the datasheet

Failure Rate Calculation

The failure rate is gauged by a Failures-In-Time (FIT) based upon accelerated stress data. The unit for FIT is failure per billion device hour.

$$FIT\ Rate = \frac{(\chi^2/2) \times 10^9}{EDH}$$

Where

$\chi 2$ (Chi-Squared) is the goodness-of-fit test statistic at a specified level of confidence;
EDH= Equivalent Device Hours = AF × (Life test sample size) × (test duration);
AF= Acceleration Factor.

High Temperature Operating Life (HTOL) test is usually done under acceleration of temperature and voltage. The total number of failures from the stress test determines the chi-squared factor.

$$AF=AF_T \times AF_V$$

The Temperature Acceleration Factor AF_T:

$$AF_T = \exp\left(\frac{E_a}{K}\left(\frac{1}{T_{J(use)}} - \frac{1}{T_{J(stress)}}\right)\right)$$

T_{Juse} = Junction temp under typical operating conditions;
$T_{Jstress}$ =Junction temp under accelerated test conditions;
Ea is Activation energy=0.7eV;
K=Boltzmann's constant=8.62×10^{-5} eV/K.

The voltage Acceleration Factor AF_V:

$$AF_V = e^{\beta \times [V_{stress} - V_{use}]}$$

V_{use} = Gate voltage under typical operating conditions;
V_{stress} = Gate voltage under accelerated test conditions;
β = Voltage acceleration factor (in 1/Volts) and specified by technology.
Note: For calculation in the report, AF_V = 1 for simplicity.

MTBF (Mean Time Between Failure) equals to 10^9/FIT (in hours).