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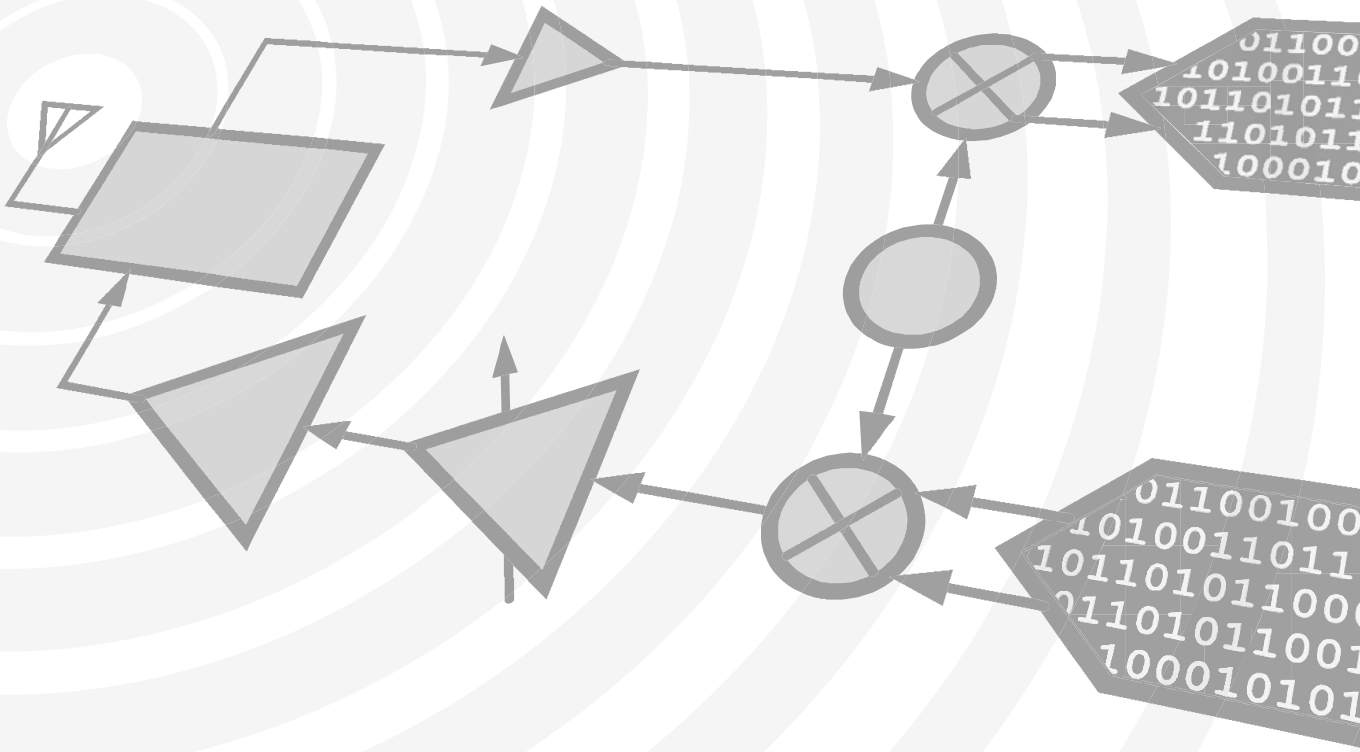
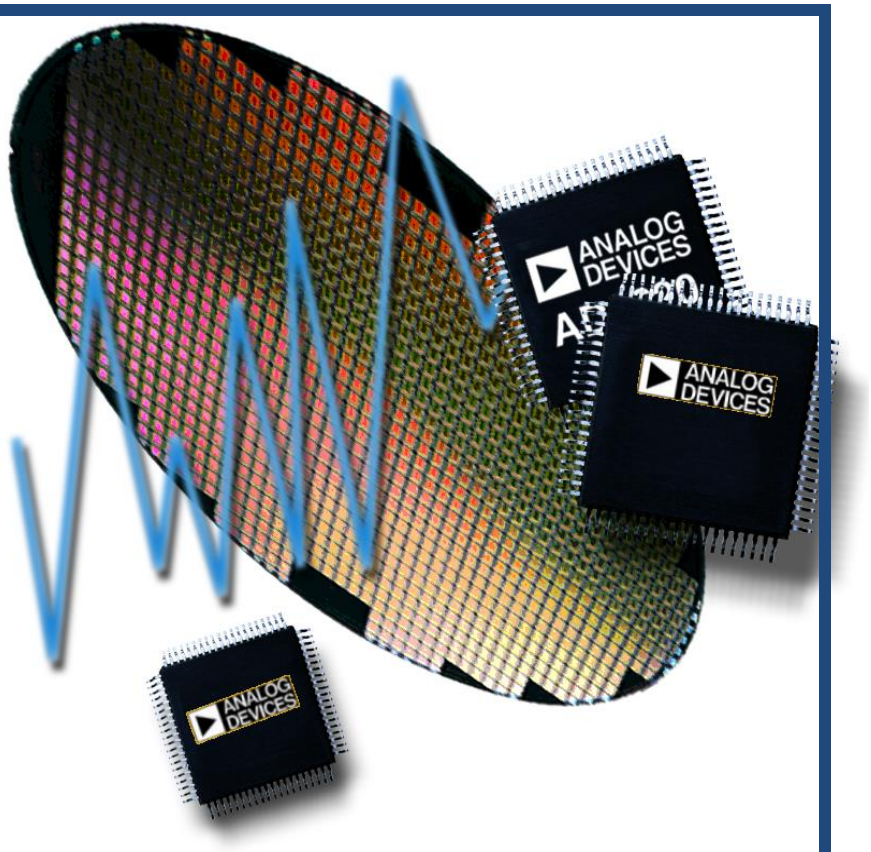


www.analog.com

www.hittite.com



Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

Process FIT Rate Report

QTR: 2013- 00254 **Rev: 04**

Wafer Process: PHEMT-D

HMC544	HMC708	HMC990
HMC545	HMC711	HMC1190
HMC550	HMC715	
HMC574	HMC716	
HMC593	HMC717	
HMC595	HMC718	
HMC603	HMC719	
HMC604	HMC742	
HMC605	HMC758	
HMC616	HMC770	
HMC617	HMC784	
HMC618	HMC788	
HMC624	HMC792	
HMC625	HMC800	
HMC627	HMC801	
HMC629	HMC802	
HMC641	HMC816	
HMC642	HMC817	
HMC647	HMC818	
HMC648	HMC849	
HMC649	HMC922	
HMC667	HMC936	
HMC668	HMC939	
HMC669	HMC941	
HMC707	HMC951	

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Process FIT Rate Report

QTR: 2013- 00254 **Rev: 04**

Wafer Process: PHEMT-D

Introduction

The testing performed for this report is designed to accelerate the predominant failure mode, electro-migration (EM), for the devices under test. The devices are stressed at high temperature and DC biased to simulate a lifetime of use at typical operating temperatures. Using the Arrhenius equation, the acceleration factor (AF) is calculated for the stress testing based on the stress temperature and the typical use operating temperature.

This report is intended to summarize all of the High Temperature Operating Life Test (HTOL) data for the PHEMT-D process. The FIT/MTTF data contained in this report includes all the stress testing performed on this process to date and will be updated periodically as additional data becomes available. Data sheets for the tested devices can be found at www.hittite.com.

Glossary of Terms & Definitions:

1. **Autoclave:** Unbiased Accelerated Stress Test. Devices are subjected to 96 hours of 100% relative humidity at a temperature of 121°C and pressure (14.7 PSIG). This test is performed in accordance with JESD22-A102.
2. **HTOL:** High Temperature Operating Life. This test is used to determine the effects of bias conditions and temperature on semiconductor devices over time. It simulates the devices' operating condition in an accelerated way, through high temperature and/or bias voltage, and is primarily for device qualification and reliability monitoring. This test was performed in accordance with JEDEC JESD22-A108.
3. **MSL:** Moisture sensitivity level pre-conditioning is performed per JESD22-A113.
4. **Operating Junction Temp (T_{oj}):** Temperature of the die active circuitry during typical operation.
5. **Stress Junction Temp (T_{sj}):** Temperature of the die active circuitry during stress testing.
6. **THB:** Temperature Humidity Bias. Devices are subjected to 1000 hours of 85% relative humidity at a temperature of 85°C, while DC biased. This test is performed in accordance with JESD22-A101.

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Qualification Sample Selection:

All qualification devices used were manufactured and tested on standard production processes and met pre-stress acceptance test requirements.

Summary of Qualification Tests:

HMC603 (QTR07002)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	231	231	Complete	
IR Reflow, MSL1 260°C	231	231	Complete	
HTOL, 1000 hours	77	77	Complete	
Post HTOL Electrical Test	77	77	Pass	
Autoclave	77	77	Complete	
Post Autoclave Electrical Test	77	77	Pass	
THB, 1000 hours	77	77	Complete	
Post THB Electrical Test	77	77	Pass	

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HMC605 (QTR08007)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	80	80	Complete	
HTOL, 1424 hours	80	80	Complete	
Post HTOL Electrical Test	80	80	Pass	
Wirebond Pull	10	10	Pass	30 wires were pulled from 10 devices
Cross-section Die Metal and Dielectric Thickness	5	5	Pass	
SEM Inspection	5	5	Pass	

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Process FIT Rate Report

QTR: 2013- 00254 **Rev: 04**

Wafer Process: PHEMT-D

HMC1190 (QTR2012-00515)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical Test	333	333	Complete	
HTOL	80	80	Complete	
Post HTOL Electrical test	80	80	Pass	
HTSL	80	80	Complete	
Post HTSL Electrical Test	80	80	Pass	
THB	27	27	Complete	
Post THB Electrical Test	27	27	Pass	
MSL-1 Preconditioning	80	80	Complete	
Post MSL1 Electrical Test	80	80	Pass	
Temp. Cycle (Preconditioned)	80	80	Complete	
Post Temp Cycle Electrical Test	80	80	Pass	
ESD Exposure	39	39	Complete	
Post ESD Electrical Test	39	39	Pass	HBM = Class 1B (500V) CDM = Class IV (2kV)
Physical Dimensions	15	15	Pass	
X-Ray	6	6	Pass	
Solderability	6	6	Pass	

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HMC849 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	159	159	Complete	
HTOL, 1000 hours	159	159	Complete	
Post HTOL Electrical Test	159	159	Pass	

HMC604 (QTR2013-00426)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	81	81	Complete	
HTOL, 1080 hours	81	81	Complete	
Post HTOL Electrical Test	81	81	Pass	

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PHEMT-D Failure Rate Estimate

Based on the HTOL test results, a failure rate estimation was determined using the following parameters:

With device ambient case temp, Tc = 85°C

HMC603 (QTR07002)
Operating Junction Temp (T_{oj}) =85°C(358 °K)
Stress Junction Temp (T_{sj}) = 125 °C(398 °K)

HMC605 (QTR08007)
Operating Junction Temp (T_{oj}) =104°C(377 °K)
Stress Junction Temp (T_{sj}) = 150 °C(423 °K)

HMC1190 (QTR2012-00515)
Operating Junction Temp (T_{oj}) =93°C(366°K)
Stress Junction Temp (T_{sj}) = 125°C(398°K)

HMC849 (QTR2013-00360)
Operating Junction Temp (T_{oj}) =100°C(373°K)
Stress Junction Temp (T_{sj}) = 109°C(382°K)

HMC604 (QTR2013-00426)
Operating Junction Temp (T_{oj}) =101°C(374°K)
Stress Junction Temp (T_{sj}) = 175°C(448°K)

Device hours:

HMC603 (QTR07002) = (77 X 1000hrs) = 77,000 hours
HMC605 (QTR08007) = (80 X 1424hrs) = 113,920 hours
HMC1190 (QTR2012-00515) = (80 X 1000hrs) = 80,000 hours
HMC849 (QTR2013-00360) = (159 X 1000hrs) = 159,000 hours
HMC604 (QTR2013-00426) = (81 X 1080hrs) = 87,480 hours

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For PHEMT-D MMIC, Activation Energy = 1.6 eV

Acceleration Factor (AF): $$AF = \exp\left[\left(\frac{E_A}{k}\right)\cdot\left(\left(\frac{1}{T_{USE}}\right)-\left(\frac{1}{T_{STRESS}}\right)\right)\right]$$

HMC603 (QTR07002) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/358-1/398)] = 185.5
HMC605 (QTR08007) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/377-1/423)] = 214.1
HMC1190 (QTR2012-00515) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/366-1/398)] = 59.6
HMC849 (QTR2013-00360) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/373-1/382)] = 3.2
HMC604 (QTR2013-00426) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/374-1/448)] = 3703

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (77,000x185.5)+(113,920x214.1)+(80,000x59.6)+(159,000x3.2)
+(87,480x3703) = 3.68x10^{8} hours

Since there were no failures and we used a time terminated test, F=0, and R = 2F+2 = 2

The failure rate was calculated using Chi Square Statistic:

$$\lambda_{CL} = \frac{\chi^2_{\%CL,2f+2}\cdot 10^9}{2\cdot t\cdot ss\cdot AF}$$ at 60% and 90% Confidence Level (CL), with 0 units out of spec and a 85°C package backside temp;

Failure Rate

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X\ \ 3.68x10^8)] = 1.8/\ 7.36x10^8 =\ \ 2.49x10^{-9}$ failures/hour or 2.5 FIT or MTTF = 4.02x10^8 Hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X\ \ 3.68x10^8)] = 4.6/\ 7.36x10^8 =\ \ 6.27x10^{-9}$ failures/hour or 6.3 FIT or MTTF = 1.60x10^8 Hours

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