ANALOG DEVICES

Hittite MICROWAVE PRODUCTS FROM ANALOG DEVICES

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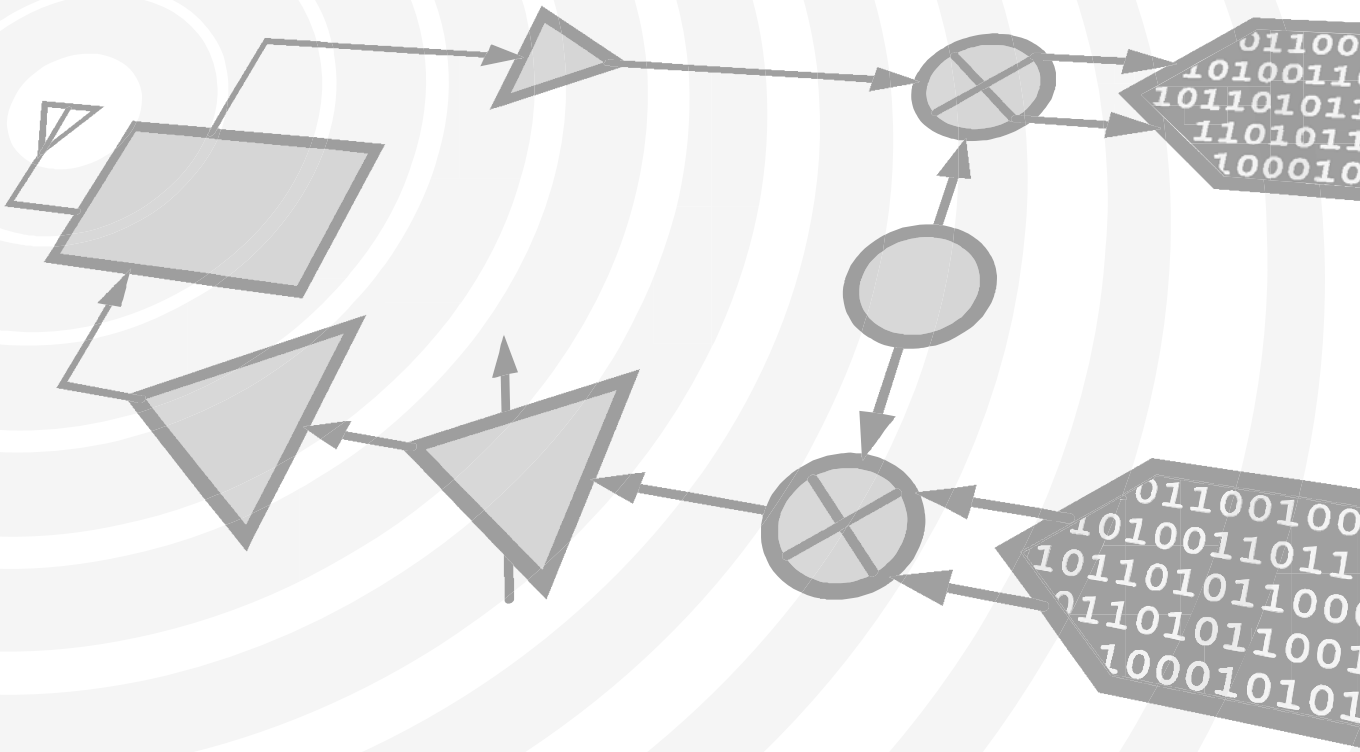
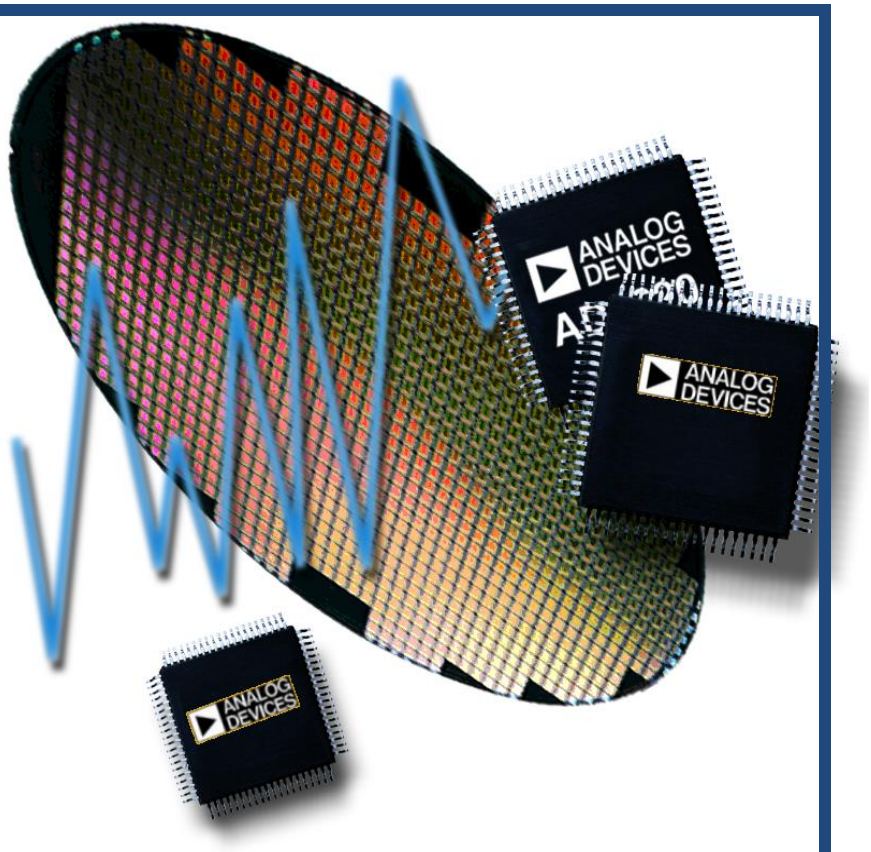
NO CONTENT ON THE ATTACHED DOCUMENT HAS CHANGED



www.analog.com

www.hittite.com



Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

HMC154
HMC356
HMC372
HMC373
HMC374
HMC375
HMC376
HMC382
HMC484
HMC486
HMC486
HMC487
HMC489
HMC536
HMC536
HMC546
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HMC590
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HMC646

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Process FIT Rate Report

QTR: 2013- 00233 **Rev: 03**

Wafer Process: PHEMT-B

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-B 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. **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.
2. **MSL:** Moisture sensitivity level pre-conditioning is performed per JESD22-A113.
3. **Operating Junction Temp (T_{oj}):** Temperature of the die active circuitry during typical operation.
4. **Stress Junction Temp (T_{sj}):** Temperature of the die active circuitry during stress testing.
5. **THB:** Temperature & Humidity Bias. Devices are subjected to 1000 hours of 85% relative humidity at a temperature of 85°C. This test is performed in accordance with JESD22-A101.
6. **Autoclave:** 96 hours of temperature, humidity, and pressure (121°C/100% RH, 14.7 psig). This test is performed in accordance with JESD22-A102.

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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:

HMC484 Qualification (QTR2007-00001)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	231	231	Complete	
MSL1 Preconditioning	231	231	Complete	
HTOL, 1000 hours	74	74	Complete	
Post HTOL Electrical Test	74	74	Pass	
Autoclave	75	75	Complete	
Post Autoclave Electrical Test	75	75	Pass	
THB, 1000 hours	77	77	Complete	
Post THB Electrical Test	77	77	Pass	

HMC374 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	158	158	Pass	
HTOL, 1000 hours (Tj=149°C)	158	158	Complete	
Final Electrical test – Post HTOL	158	158	Pass	

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HMC374 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	158	158	Pass	
HTOL, 1000 hours (Tj=144°C)	158	158	Complete	
Final Electrical test – Post HTOL	158	158	Pass	

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PHEMT-B 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 = 65°C

HMC484 (QTR2007-00001)
Operating Junction Temp (T_{oj}) =65°C (338°K)
Stress Junction Temp (T_{sj}) = 125°C (398°K)

HMC374 (QTR2013-00360)
Operating Junction Temp (T_{oj}) =120°C (393°K)
Stress Junction Temp (T_{sj}) = 149°C (422°K)

HMC374 (QTR2013-00360)
Operating Junction Temp (T_{oj}) =120°C (393°K)
Stress Junction Temp (T_{sj}) = 144°C (417°K)

Device hours:

HMC484 (QTR2007-00001) = (74 X 1000hrs) = 74,000 hours
HMC374 (QTR2013-00360) = (158 X 1000hrs) = 158,000 hours
HMC374 (QTR2013-00360) = (158 X 1000hrs) = 158,000 hours

For PHEMT-B MMIC, Activation Energy = 1.4 eV

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

HMC484 (QTR2007-00001) Acceleration Factor = exp[1.4/8.6x10^{-5}(1/338-1/398)] = 1423.3
HMC374 (QTR2013-00360) Acceleration Factor = exp[1.4/8.6x10^{-5}(1/393-1/422)] = 17.2
HMC374 (QTR2013-00360) Acceleration Factor = exp[1.4/8.6x10^{-5}(1/393-1/417)] = 10.8

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Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (74,000x1423.3)+(158,000x17.2)+(158,000x10.8) = 1.10×10^8 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 65°C package backside temp;

Failure Rate

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X\ 1.10x10^8\ )] = 1.8/\ 2.20x10^8 = \ 8.33x10^{-9}$ failures/hour or 8.3 FIT or MTTF = $1.20x10^8$ Hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X\ 1.10x10^8\ )] = 4.6/\ 2.20x10^8 = \ 2.10x10^{-8}$ failures/hour or 21.0 FIT or MTTF = $4.76x10^7$ Hours

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