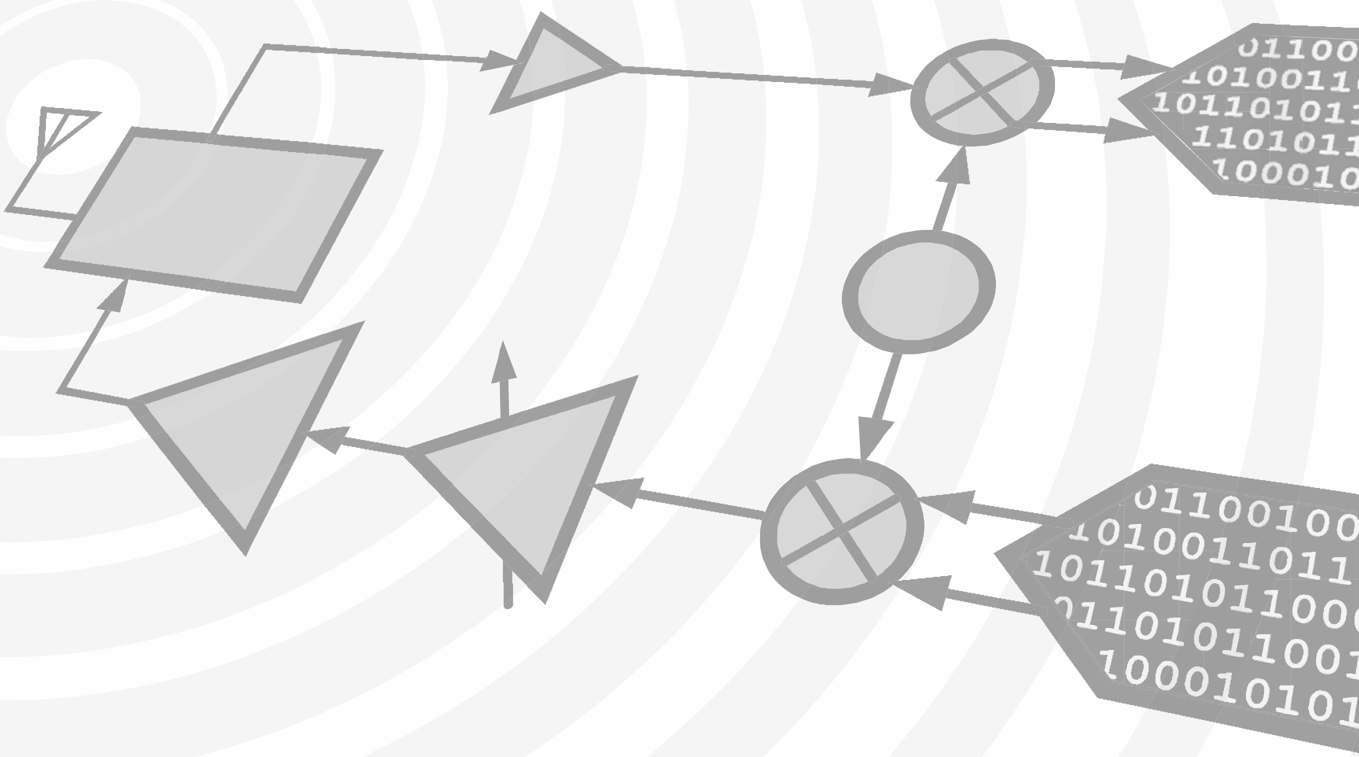
ANALOG DEVICES

Hittite MICROWAVE PRODUCTS FROM ANALOG DEVICES

Analog Devices Welcomes Hittite Microwave Corporation

NO CONTENT ON THE ATTACHED DOCUMENT HAS CHANGED



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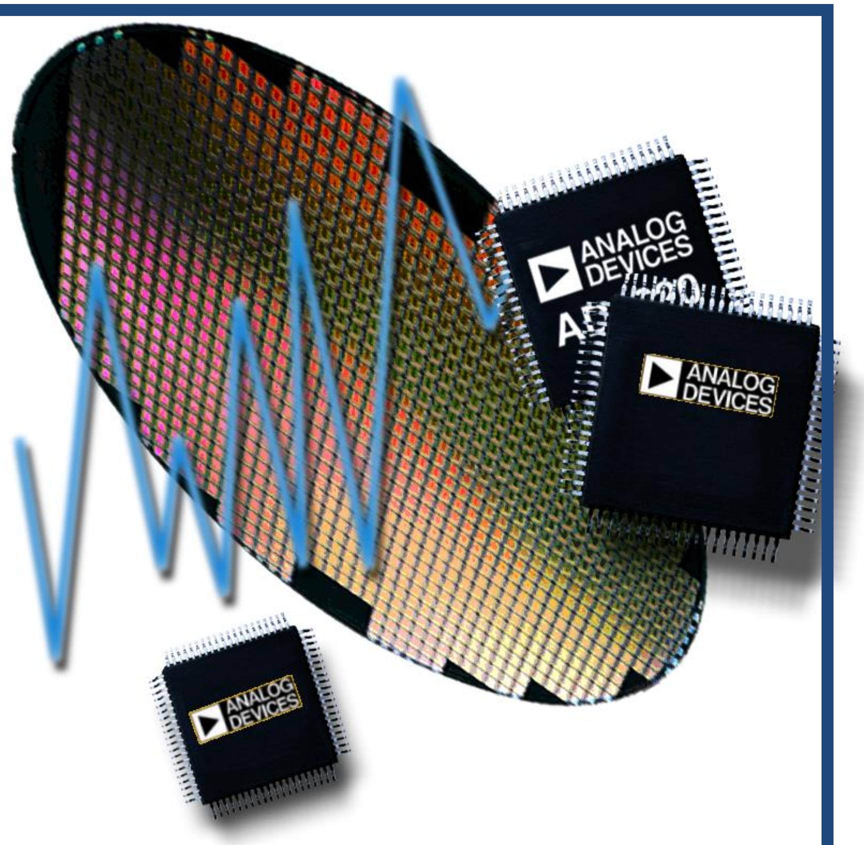

Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

HMC334
HMC426
HMC469
HMC471
HMC474
HMC474
HMC476
HMC476
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HMC482
HMC495
HMC496
HMC497
HMC548
HMC548
HMC597

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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 SIGE HBT-A 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-A108D.
2. **Operating Junction Temp (T_{oj}):** Temperature of the die active circuitry during typical operation.
3. **Stress Junction Temp (T_{sj}):** Temperature of the die active circuitry during stress testing.

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:

HMC481 Qualification (QTR2004-00007)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	96	96	Complete	
HTOL, 1000 hours	96	96	Complete	
Post Electrical Test	96	96	Pass	

HMC2169 Qualification (QTR2013-00339)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	81	81	Complete	
HTOL, 1000 hours	81	81	Complete	
Post Electrical Test	81	81	Pass	

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HMC2170 Qualification (QTR2013-00339)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	81	81	Complete	
HTOL, 1000 hours	81	81	Complete	
Post Electrical Test	81	81	Pass	

HMC6XXX (QTR2013-00340)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	6	6	Complete	
HTOL, 5039 hours	6	6	Complete	
Post HTOL Electrical Test	6	6	Pass	

HMC6XXX (QTR2013-00340)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	14	14	Complete	
HTOL, 2000 hours	14	14	Complete	
Post HTOL Electrical Test	14	14	Pass	

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HMC597 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	318	318	Complete	
HTOL, 1000 hours	318	318	Complete	
Post HTOL Electrical Test	318	318	Pass	

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SIGE HBT-A Failure Rate Estimate

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

With device case temp, T_c = 60°C

HMC481 (QTR2004-00007)
Operating Junction Temp (T_{oj}) = 111°C (384°K)
Stress Junction Temp (T_{sj}) = 191°C (464°K)

HMC2169 (QTR2013-00339)
Operating Junction Temp (T_{oj}) = 81°C (384°K)
Stress Junction Temp (T_{sj}) = 131°C (404°K)

HMC2170 (QTR2013-00339)
Operating Junction Temp (T_{oj}) = 77°C (350°K)
Stress Junction Temp (T_{sj}) = 130°C (403°K)

HMC6XXX (QTR2013-00340)
Operating Junction Temp (T_{oj}) = 69°C (342°K)
Stress Junction Temp (T_{sj}) = 99°C (372°K)

HMC597 (QTR2013-00360)
Operating Junction Temp (T_{oj}) = 69°C (342°K)
Stress Junction Temp (T_{sj}) = 125°C (398°K)

Device hours:

HMC481 (QTR2004-00007) = (96 X 1000hrs) = 96,000 hours
HMC2169 (QTR2013-00339) = (81 X 1000hrs) = 81,000 hours
HMC2170 (QTR2013-00339) = (81 X 1000hrs) = 81,000 hours
HMC6XXX (QTR2013-00340) = (6 X 5039hrs) = 30,234 hours
HMC6XXX (QTR2013-00340) = (14 X 2000hrs) = 28,000 hours
HMC597 (QTR2013-00360) = (318 X 1000hrs) = 318,000 hours

For SIGE HBT-A MMIC, Activation Energy = 0.7 eV

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

HMC481 (QTR2004-00007) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/384-1/464)] = 65.1
HMC2169 (QTR2013-00339) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/384-1/464)] = 25.8
HMC2170 (QTR2013-00339) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/384-1/464)] = 33.0
HMC6XXX (QTR2013-00340) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/342-1/372)] = 9.0
HMC597 (QTR2013-00360) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/342-1/398)] = 45.9

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (96,000 x 65.1)+(81,000 x 25.8)+(81,000 x 33.0)+(30,234 x 9.0)+(28,000 x 9.0) +(318,000 x 45.9) = 2.61x10^{7} 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 60°C package backside temp;

Failure Rate

λ_{60} = [(χ^2)$_{60,2}$]/(2X 2.61x10^{7})] = 1.83/ 5.23x10^{7} = 3.50x10^{-8} failures/hour or 35.0 FIT, or MTTF = 2.86x10^{7} hours
λ_{90} = [(χ^2)$_{90,2}$]/(2X 2.61x10^{7})] = 4.61/ 5.23x10^{7} = 8.82x10^{-8} failures/hour or 88.2 FIT, or MTTF = 1.13x10^{7} hours

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