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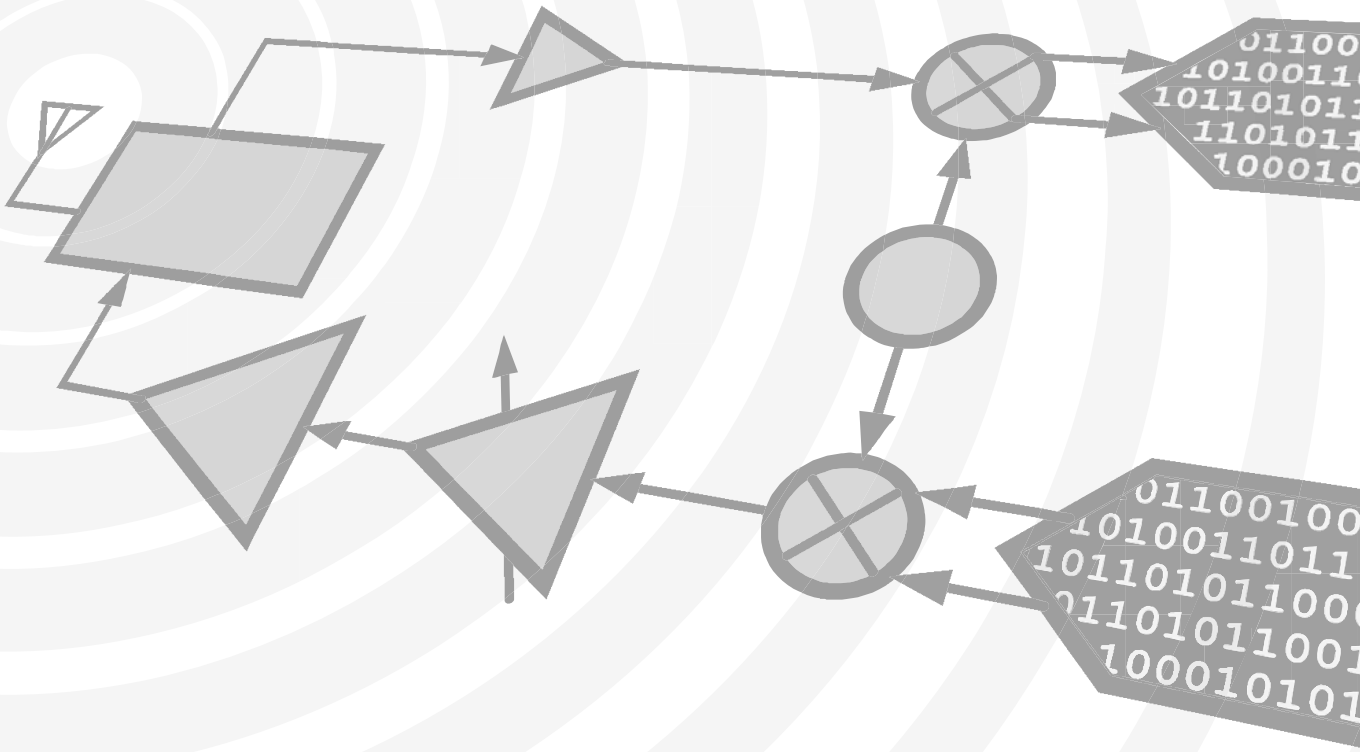

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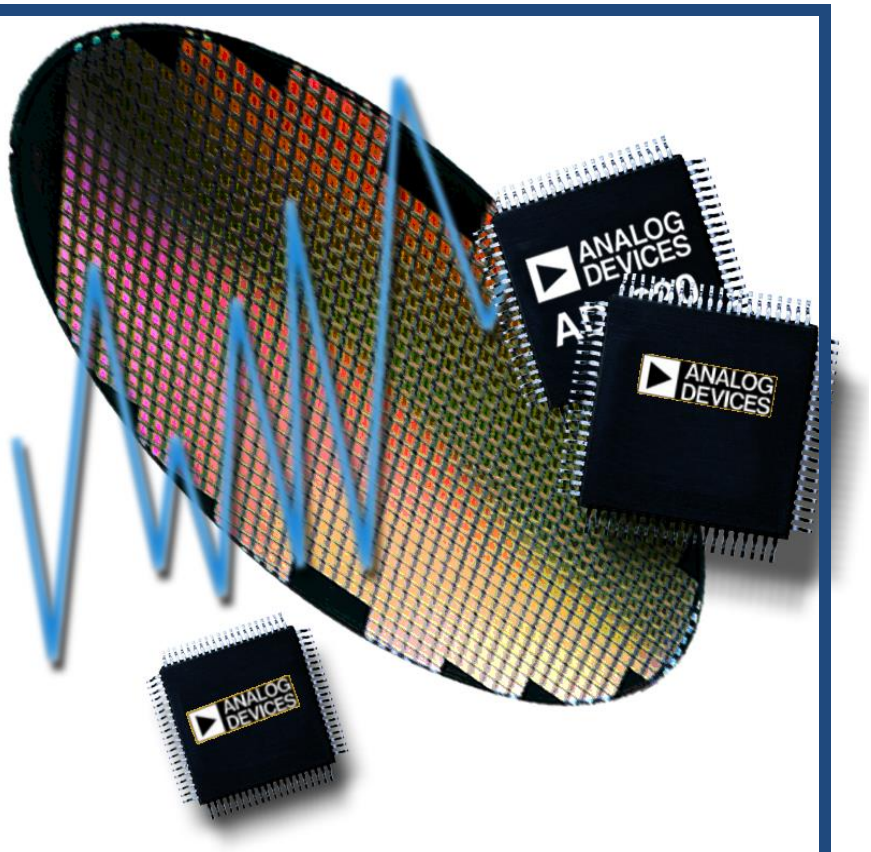

Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

Process FIT Rate Report

QTR: 2013- 00244 **Rev: 01**

Wafer Process: MESFET-A

HMC110	HMC221
HMC156	HMC223
HMC174	HMC224
HMC189	HMC235
HMC195	HMC239
HMC207	HMC240
HMC208	HMC272
HMC210	HMC285
HMC213	HMC296
HMC215	HMC340
HMC216	HMC410
HMC218	HMC411
HMC219	HMC412
HMC220	

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Process FIT Rate Report

QTR: 2013- 00244 **Rev: 01**

Wafer Process: MESFET-A

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 MESFET-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-A108.
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.

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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:

HMC207, 208, 213 (QTR2002-00004)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	25 18 27	25 18 27	Complete	HMC207 HMC208 HMC213
HTOL, 1240 hours	25 18 27	25 18 27	Complete	HMC207 HMC208 HMC213
Post HTOL Electrical Test	25 18 27	25 18 27	Pass	HMC207 HMC208 HMC213
Bond Pull	10 10	10 10	Pass	
Die Shear	10 10	10 10	Pass	
SEM Inspection	10 10	10 10	Pass	
Metal and Dielectric Thickness	10 10	10 10	Pass	

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HMC174 (QTR2002-00010)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	259	259	Complete	
HTOL, 1000 hours	20	20	Complete	
Post HTOL Electrical Test	20	20	Pass	
HTOL, 720 hours	239	239	Complete	
Post HTOL Electrical Test	239	239	Pass	
Bond Pull	5	5	Pass	
Die Shear	5	5	Pass	
SEM Inspection	5	5	Pass	
Metal and Dielectric Thickness	5	5	Pass	

HMC110, 297 (QTR2002-00012)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	34 34	34 34	Complete	HMC110 HMC297
HTOL, 1240 hours	34 34	34 34	Complete	HMC110 HMC297
Post HTOL Electrical Test	34 34	34 34	Pass Pass	HMC110 HMC297
Bond Pull	5 5	5 5	Pass Pass	HMC110 HMC297
Die Shear	5	5	Pass	HMC297
SEM Inspection	5 5	5 5	Pass Pass	HMC110 HMC297
Metal and Dielectric Thickness	5 5	5 5	Pass Pass	HMC110 HMC297

MESFET-A Failure Rate Estimate

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

With die Junction Temp = 85°C

HMC207, 208, 213 (QTR2002-00004)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC174 (QTR2002-00010)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC110, 297 (QTR2002-00012)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

Device hours:

HMC207, 208, 213 (QTR2002-00004) = (70 X 1240hrs) = 86,800 hours
HMC174 (QTR2002-00010) = (20 X 1000hrs) = 20,000 hours
HMC174 (QTR2002-00010) = (239 X 720hrs) = 172,080 hours
HMC110, 297 (QTR2002-00012) = (68 X 1240hrs) = 84,320 hours

For MESFET-A MMIC, Activation Energy = 1.8 eV

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

HMC207, 208, 213 (QTR2002-00004) Acceleration Factor = exp[1.8/8.6 e-5(1/358-1/423)] = 7973.5
HMC174 (QTR2002-00010) Acceleration Factor = exp[1.8/8.6 e-5(1/358-1/423)] = 7973.5
HMC110, 297 (QTR2002-00012) Acceleration Factor = exp[1.8/8.6 e-5(1/358-1/423)] = 7973.5

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (86,800x7973.5)+(20,000x7973.5)+(172,080x7973.5)+(84,320x7973.5) = 2.90×10^9 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

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X\ 2.90x10^9\ )] = 1.8/\ 5.80x10^9 = \ 3.16x10^{-10}$ failures/hour or 0.3 FIT or MTTF = $3.17x10^9$ Hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X\ 2.90x10^9\ )] = 4.6/\ 5.80x10^9 = \ 7.96x10^{-10}$ failures/hour or 0.8 FIT or MTTF = $1.29x10^9$ Hours