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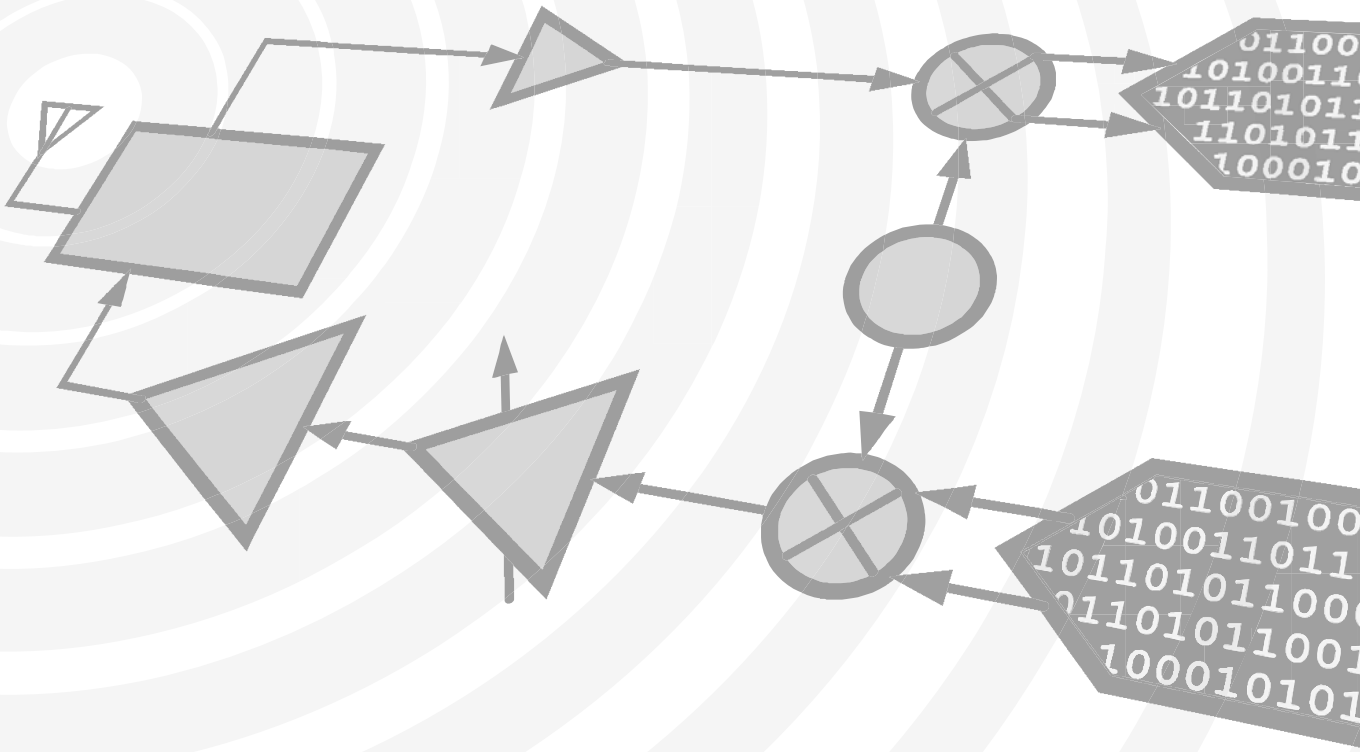

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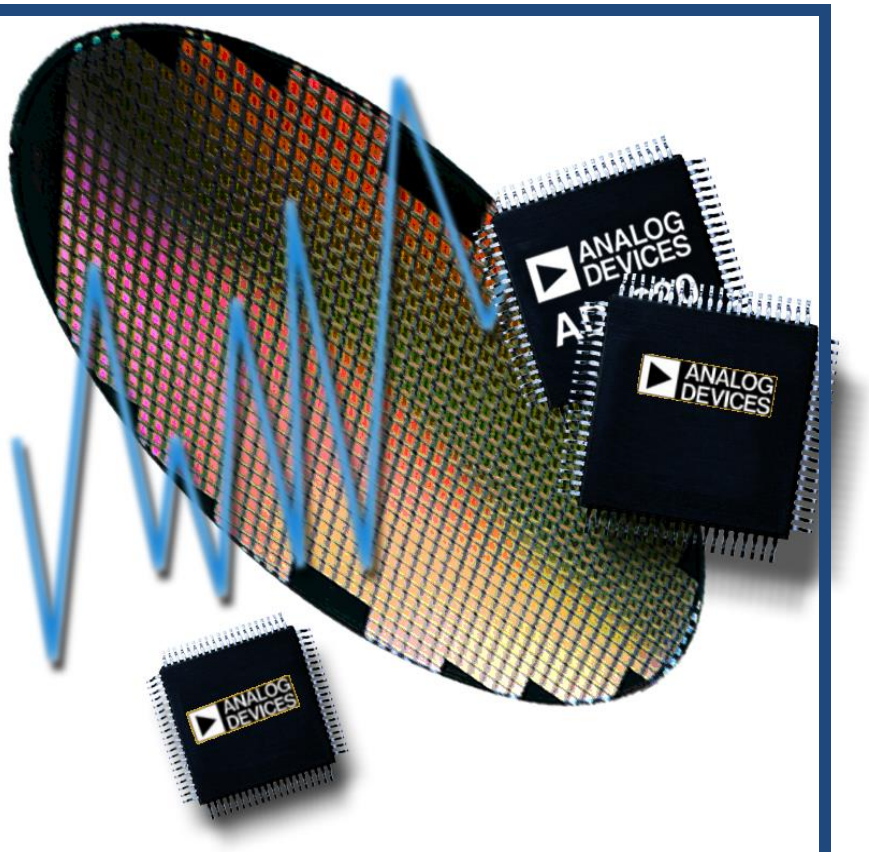

Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

Process FIT Rate Report

QTR: 2013- 00241 **Rev: 06**

Wafer Process: BiCMOS-C

HMC675	HMC748	HMC948
HMC675	HMC749	HMC954
HMC676	HMC791	HMC955
HMC676	HMC813	HMC974
HMC678	HMC813	HMC1020
HMC679	HMC841	HMC1027
HMC706	HMC842	HMC1094
HMC720	HMC843	HMC1120
HMC720	HMC844	
HMC721	HMC847	
HMC721	HMC848	
HMC722	HMC850	
HMC722	HMC851	
HMC723	HMC853	
HMC723	HMC854	
HMC724	HMC855	
HMC725	HMC856	
HMC726	HMC865	
HMC727	HMC866	
HMC728	HMC874	
HMC729	HMC875	
HMC744	HMC876	
HMC745	HMC905	
HMC746	HMC910	
HMC747	HMC913	

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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 BiCMOS-C 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:

HMC613 (QTR2009-00001)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	57	57	Complete	
HTOL, 1000 hours	57	57	Complete	
Post HTOL Electrical Test	57	57	Pass	
Bond Pull	10	10	Pass	30 wires from 10 devices.
SEM Inspection	5	5	Pass	
Metal and Dielectric Thickness	5	5	Pass	

HMC913 (QTR2009-00001)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	80	80	Complete	
HTOL, 1000 hours	80	80	Complete	
Post HTOL Electrical Test	80	80	Pass	

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HMC913 (QTR2012-00053)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	72	72	Complete	
HTOL, 1000 hours	72	72	Complete	
Post HTOL Electrical Test	72	72	Pass	

HMC913 (QTR2012-00358)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	78	78	Complete	
HTOL, 1000 hours	78	78	Complete	
Post HTOL Electrical Test	78	78	Pass	

HMC910 (QTR2012-00304)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	78	78	Complete	
HTOL, 1000 hours	78	78	Complete	
Post HTOL Electrical Test	78	78	Pass	

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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	

HMC1027 (QTR2013-00415)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	79	79	Complete	
HTOL, 1000 hours	79	79	Complete	
Post HTOL Electrical Test	79	79	Pass	

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HMC1020 (QTR2014-00405)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	81	81	Complete	
HTOL, 1000 hours, Tj=150°C	81	81	Complete	
Post HTOL Electrical Test	81	81	Pass	

BiCMOS-C Failure Rate Estimate

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

With device case temp, Tc = 60°C

HMC613 (QTR2009-00001)
Operating Junction Temp (T_{oj}) =83°C(356°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC913 (QTR2009-00001)
Operating Junction Temp (T_{oj}) =83°C(356°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC913 (QTR2012-00053)
Operating Junction Temp (T_{oj}) =83°C(356°K)
Stress Junction Temp (T_{sj}) = 175°C(448°K)

HMC913 (QTR2012-00358)
Operating Junction Temp (T_{oj}) =83°C(356°K)
Stress Junction Temp (T_{sj}) = 175°C(448°K)

HMC910 (QTR2012-00304)
Operating Junction Temp (T_{oj}) =88.5°C(361.5°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

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HMC6XXX (QTR2013-00340)
Operating Junction Temp (T_{oj}) =87°C(360°K)
Stress Junction Temp (T_{sj}) = 122°C(395°K)

HMC1027 (QTR2013-00415)
Operating Junction Temp (T_{oj}) =84°C(357°K)
Stress Junction Temp (T_{sj}) = 125°C(398°K)

HMC1020 (QTR2014-00405)
Operating Junction Temp (T_{oj}) =67°C(340°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

Device hours:

HMC613 (QTR2009-00001) = (57 X 1000hrs) = 57,000 hours
HMC913 (QTR2009-00001) = (80 X 1000hrs) = 80,000 hours
HMC913 (QTR2012-00053) = (72 X 1033hrs) = 72,000 hours
HMC913 (QTR2012-00358) = (78 X 1000hrs) = 78,000 hours
HMC910 (QTR2012-00304) = (78 X 1000hrs) = 78,000 hours
HMC6XXX (QTR2013-00340) = (6 X 5039hrs) = 30,234 hours
HMC6XXX (QTR2013-00340) = (14 X 2000hrs) = 28,000 hours
HMC1027 (QTR2013-00415) = (79 X 1000hrs) = 79,000 hours
HMC1020 (QTR2014-00405) = (81 X 1000hrs) = 81,000 hours

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For BiCMOS-C MMIC, Activation Energy = 0.7 eV

Acceleration Factor (AF):

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

HMC613 (QTR2009-00001) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/356-1/423)] = 37.4
HMC913 (QTR2009-00001) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/356-1/423)] = 37.4
HMC913 (QTR2012-00053) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/356-1/448)] = 109.4
HMC913 (QTR2012-00358) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/356-1/448)] = 109.4
HMC910 (QTR2012-00304) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/361.5-1/423)] = 26.4
HMC6XXX (QTR2013-00340) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/360-1/395)] = 7.4
HMC1027 (QTR2013-00415) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/357-1/398)] = 10.5
HMC1020 (QTR2014-00405) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/340-1/423)] = 109.7

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (57,000x37.4)+(80,000x37.4)+(72,000x109.4)+(78,000x109.4)+(78,000x26.4)+(30,234x7.4)+(28,000x7.4)+(79,000x10.5)+(81,000x109.7) = 4.17x10^{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

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X\ \ 4.17x10^7\ \ )] = 1.8/\ 8.33x10^7 =\ \ 2.20x10^{-8}$ failures/hour or 22.0 FIT or MTTF = 4.55x10^7 hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X\ \ 4.17x10^7\ )] = 4.6/\ 8.33x10^7 =\ \ 5.53x10^{-8}$ failures/hour or 55.3 FIT or MTTF = 1.81x10^7 hours

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