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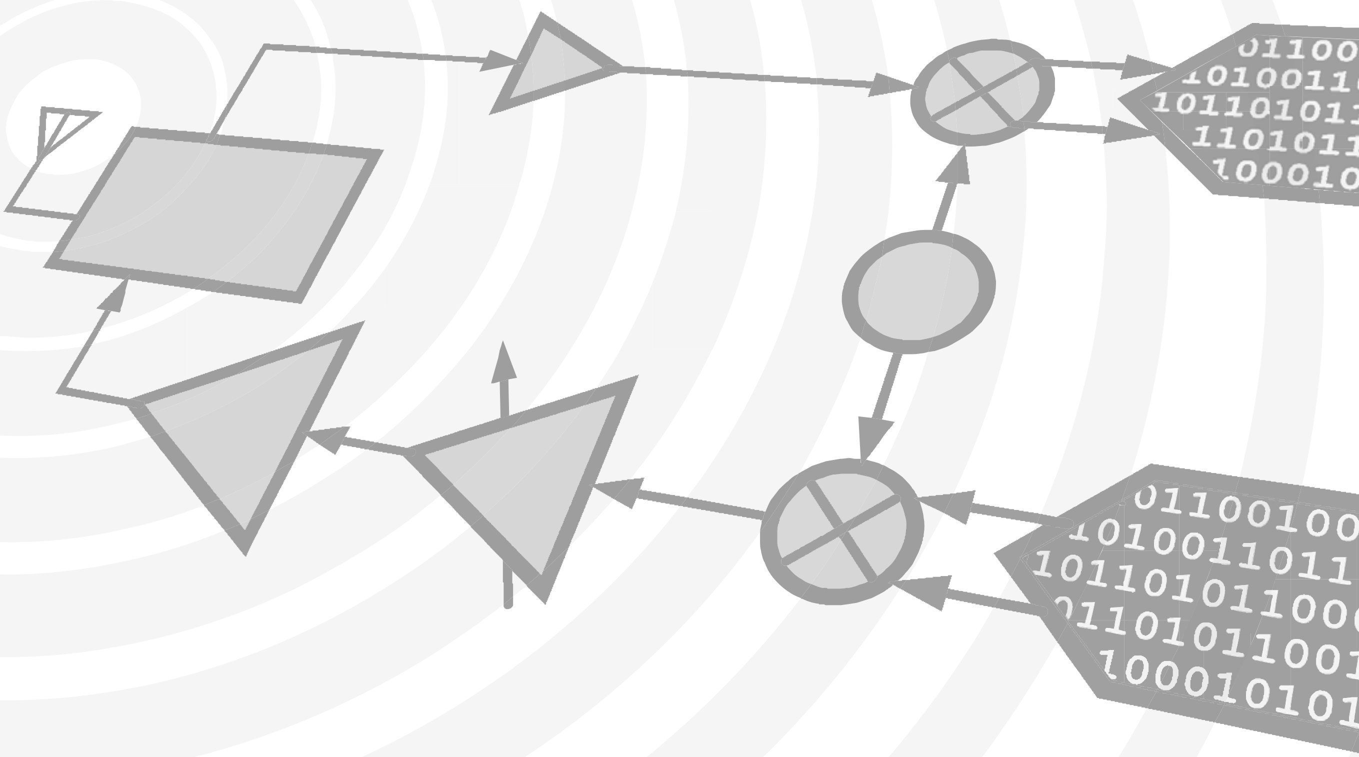
NO CONTENT ON THE ATTACHED DOCUMENT HAS CHANGED



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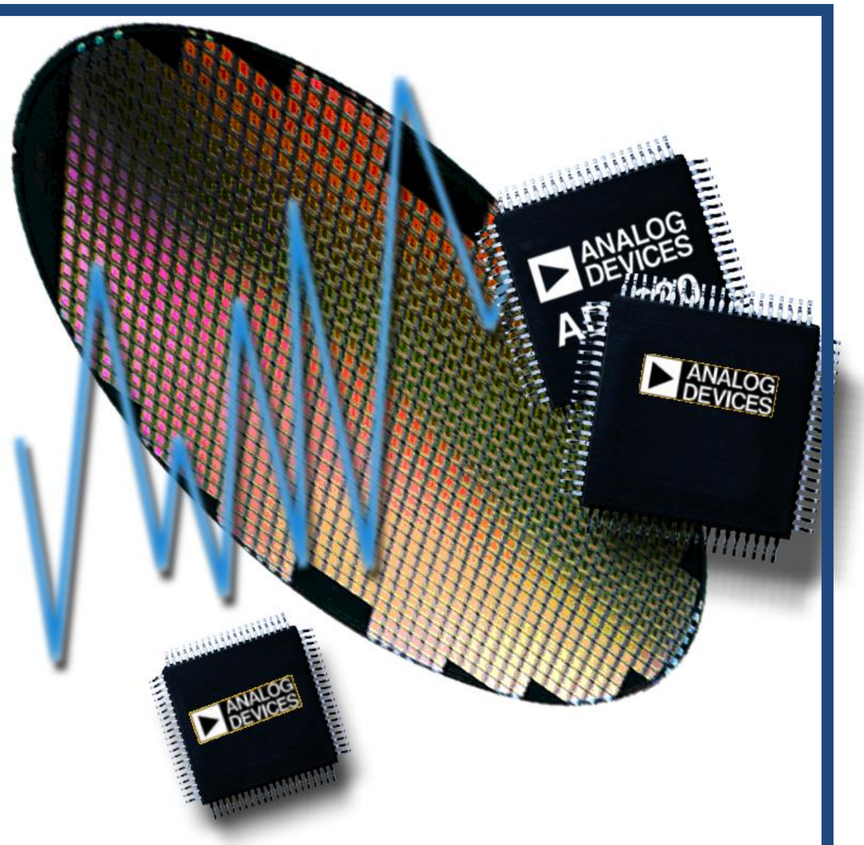
ANALOG DEVICES



Reliability Report

Report Title: **Qualification Test Report**

Report Type: **See Attached**

Date: **See Attached**

HMC797
HMC863
HMC864
HMC906
HMC907
HMC928
HMC929
HMC943
HMC968
HMC969
HMC1024
HMC5622
HMC5445
HMC5805
HMC5927
HMC5927C
HMC5929
HMC5929C
HMC5981
HMC6242
HMC6503

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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 PHEMT-H 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:

HMC863 (QTR11012)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	71	71	Complete	
HTOL, 1000 hours	71	71	Complete	
Post HTOL Electrical Test	71	71	Pass	

HMC1050 & HMC1051 (QTR2012-00166)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	24 24	24 24	Complete	HMC1050 HMC1051
HTOL, 2000 hours	24 24	24 24	Complete	
Post HTOL Electrical Test	24 24	24 24	Pass	

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HMC1050 & HMC1051 (QTR2012-00166)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	20 20	20 20	Complete	HMC1050 HMC1051
HTOL, 3500 hours	20 20	20 20	Complete	
Post HTOL Electrical Test	20 20	20 20	Pass	

HMC1050 & HMC1051 (QTR2012-00371)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	73 73	73 73	Complete	HMC1050 HMC1051
HTOL, 3500 hours	73 73	73 73	Complete	
Post HTOL Electrical Test	73 73	73 73	Pass	

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PHEMT-H Failure Rate Estimate

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

With Device Operating Case Temp = 85°C

HMC863 (QTR11012)
Operating Junction Temp (T_{oj}) =150°C(423°K)
Stress Junction Temp (T_{sj}) = 242°C(515°K)

HMC1050 & HMC1051 (QTR2012-00166)
Operating Junction Temp (T_{oj}) =131°C(404°K)
Stress Junction Temp (T_{sj}) = 131°C(404°K)

HMC1050 & HMC1051 (QTR2012-00166)
Operating Junction Temp (T_{oj}) =131°C(404°K)
Stress Junction Temp (T_{sj}) = 131°C(404°K)

HMC1050 & HMC1051 (QTR2012-00371)
Operating Junction Temp (T_{oj}) =150°C(423°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

Device hours:

HMC863 (QTR11012) = (71 X 1000hrs) = 71,000 hours
HMC1050 & HMC1051 (QTR2012-00166) = (48 X 2000hrs) = 96,000 hours
HMC1050 & HMC1051 (QTR2012-00166) = (40 X 3500hrs) = 140,000 hours
HMC1050 & HMC1051 (QTR2012-00371) = (146 X 1000hrs) = 146,000 hours

For PHEMT-H MMIC, Activation Energy = 1.7 eV

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

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HMC863 (QTR11012) Acceleration Factor = exp[1.7/8.6 e-5(1/423-1/515)] = 4222.4
HMC1050 & HMC1051 (QTR2012-00166) Acceleration Factor = exp[1.7/8.6 e-5(1/404-1/404)] = 1.0
HMC1050 & HMC1051 (QTR2012-00166) Acceleration Factor = exp[1.7/8.6 e-5(1/404-1/404)] = 1.0
HMC1050 & HMC1051 (QTR2012-00371) Acceleration Factor = exp[1.7/8.6 e-5(1/423-1/423)] = 1.0

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (71,000x4222.4)+(96,000x1.0)+(140,000x1.0)+(146,000x1.0) = 3.00×10^{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 85°C package backside temp;

Failure Rate

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X\ 3.00 \times 10^{8})] = 1.8/\ 6.00 \times 10^{8} = 3.05 \times 10^{-9}$ failures/hour or 3.0 FIT or MTTF = 3.28×10^{7} Hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X\ 3.00 \times 10^{8})] = 4.6/\ 6.00 \times 10^{8} = 7.68 \times 10^{-9}$ failures/hour or 7.7 FIT or MTTF = 1.30×10^{8} Hours

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