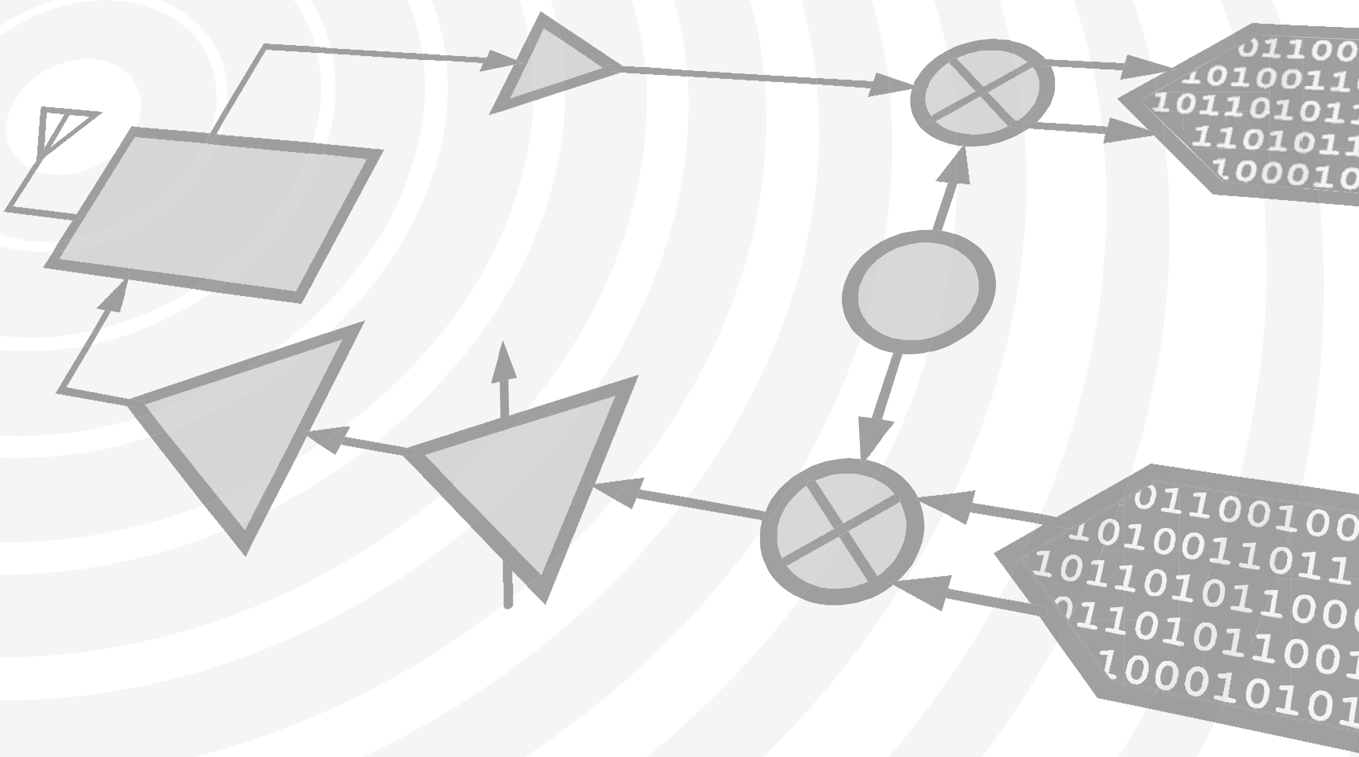
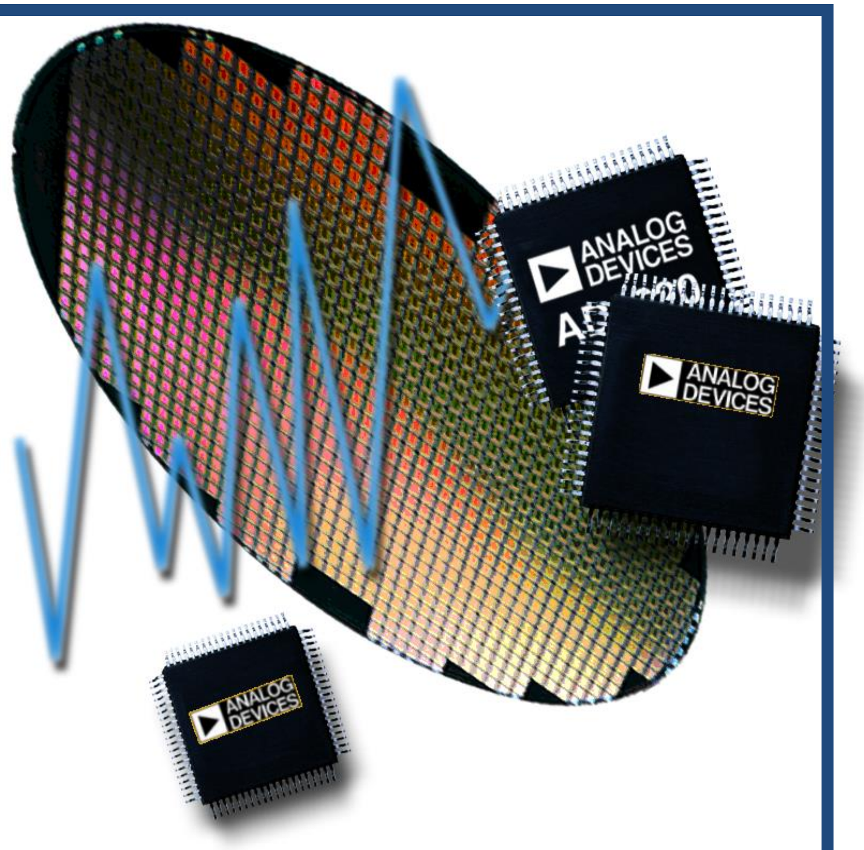
Analog Devices Welcomes Hittite Microwave Corporation

NO CONTENT ON THE ATTACHED DOCUMENT HAS CHANGED



ANALOG DEVICES



Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

HMC740
HMC741
HMC754
HMC789

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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 GaAs HBT-E 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.

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:

HMC789 (QTR10004)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	77	77	Complete	
HTOL, 1000 hours	77	77	Complete	
Post HTOL Electrical Test	77	77	Pass	
Bond Pull	10	10	Pass	30 wires from 10 devices.
Die Shear	10	10	Pass	
SEM Inspection	5	5	Pass	
Metal and Dielectric Thickness	5	5	Pass	

HMC2172 (QTR2013-00339)

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

GaAs HBT-E 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 = 85°C

HMC789 (QTR10004)
Operating Junction Temp (T_{oj}) = 143°C (416°K)
Stress Junction Temp (T_{sj}) = 183°C (456°K)

HMC2171 (QTR2013-00339)
Operating Junction Temp (T_{oj}) = 124°C (397°K)
Stress Junction Temp (T_{sj}) = 152°C (425°K)

Device hours:

HMC789 (QTR10004) = (77 X 1000hrs) = 77,000 hours
HMC2171 (QTR2013-00339) = (81 X 1000hrs) = 81,000 hours

For GaAs HBT-E MMIC, Activation Energy = 1.5 eV

Acceleration Factor (AF):

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

HMC789 (QTR10004) Acceleration Factor = exp[1.5/8.6 e-5(1/416-1/456)] = 39.6
HMC2171 (QTR2013-00339) Acceleration Factor = exp[1.5/8.6 e-5(1/397-1/425)] = 18.1

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (77,000x39.6)+(81,000x18.1) = 4.51×10^6 hours

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Since there was 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 device case temp;

Failure Rate

λ_{60} = [(χ^2)$_{60,2}$]/(2X 4.51x10^6)] = 1.8/ 9.02x10^6= 2.03x10^{-7} failures/hour or 202 FIT or MTTF = 4.93x10^6 Hours

λ_{90} = [(χ^2)$_{90,2}$]/(2X 4.51x10^6)] = 4.6/ 9.02x10^6= 5.11x10^{-7} failures/hour or 511 FIT or MTTF = 1.96x10^6 Hours