ANALOG
DEVICES

Hittite
MICROWAVE PRODUCTS
FROM ANALOG DEVICES

Analog Devices Welcomes Hittite Microwave Corporation

NO CONTENT ON THE ATTACHED DOCUMENT HAS CHANGED

![Analog Devices logo]
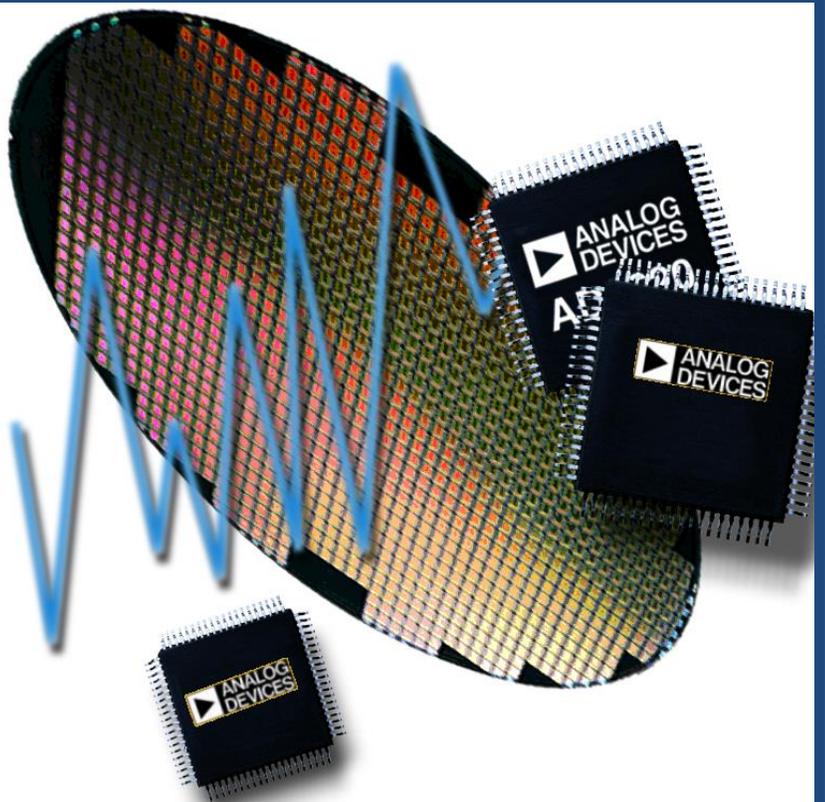
Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

HMC599
HMC650
HMC651
HMC652
HMC653
HMC654
HMC655
HMC656
HMC657
HMC658

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-G 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.

Hittite MICROWAVE CORPORATION

20 Alpha Road, Chelmsford, MA 01824
Ph: 978.250.3343   Fax: 978.250.3373
www.hittite.com

RoHS ✓
EARTH FRIENDLY

TÜV SÜD

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:

HMC656 (QTR11011)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	12	12	Complete	
RF HTOL, 1000 hours	12	12	Complete	
Post HTOL Electrical Test	12	12	Pass	

PHEMT-G Failure Rate Estimate

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

With Device Die Junction Temp, $T_j = 60°C$

HMC656 (QTR11011)
Operating Junction Temp (T_{oj}) = 60°C(333°K)
Stress Junction Temp (T_{sj}) = 125°C(398°K)

Device hours:

HMC656 (QTR11011) = (12 X 1000hrs) = 12,000 hours

For PHEMT-G MMIC, Activation Energy = 1.3 eV

Acceleration Factor (AF):

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

HMC656 (QTR11011) Acceleration Factor = exp[1.3/8.6 e-5(1/333-1/398)] = 1658.4

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (12,000x1658.4) = 1.99×10^7 hours

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 60°C device junction temp;

Failure Rate

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X$ 1.99x10^7)] = 1.8/ 3.98x10^7= 4.60x10^{-8} failures/hour or 46.0   FIT or MTTF = 2.17x10^7 Hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X$ 1.99x10^7)] = 4.6/ 3.98x10^7= 1.16x10^{-7} failures/hour or 116   FIT or MTTF = 8.63x10^6 Hours

Hittite MICROWAVE CORPORATION

20 Alpha Road, Chelmsford, MA 01824
Ph: 978.250.3343 Fax: 978.250.3373
www.hittite.com

RoHS✓
EARTH FRIENDLY

TÜV SÜD