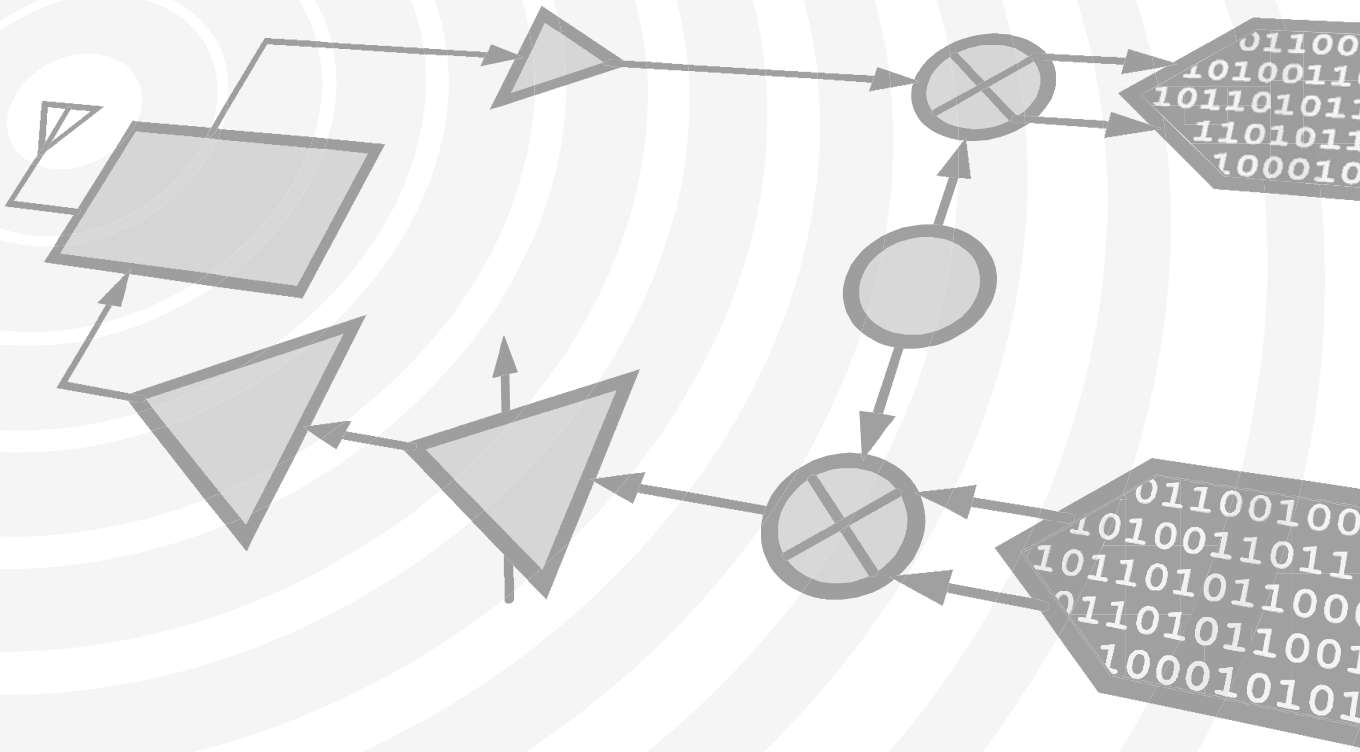
ANALOG DEVICES

Hittite MICROWAVE PRODUCTS FROM ANALOG DEVICES

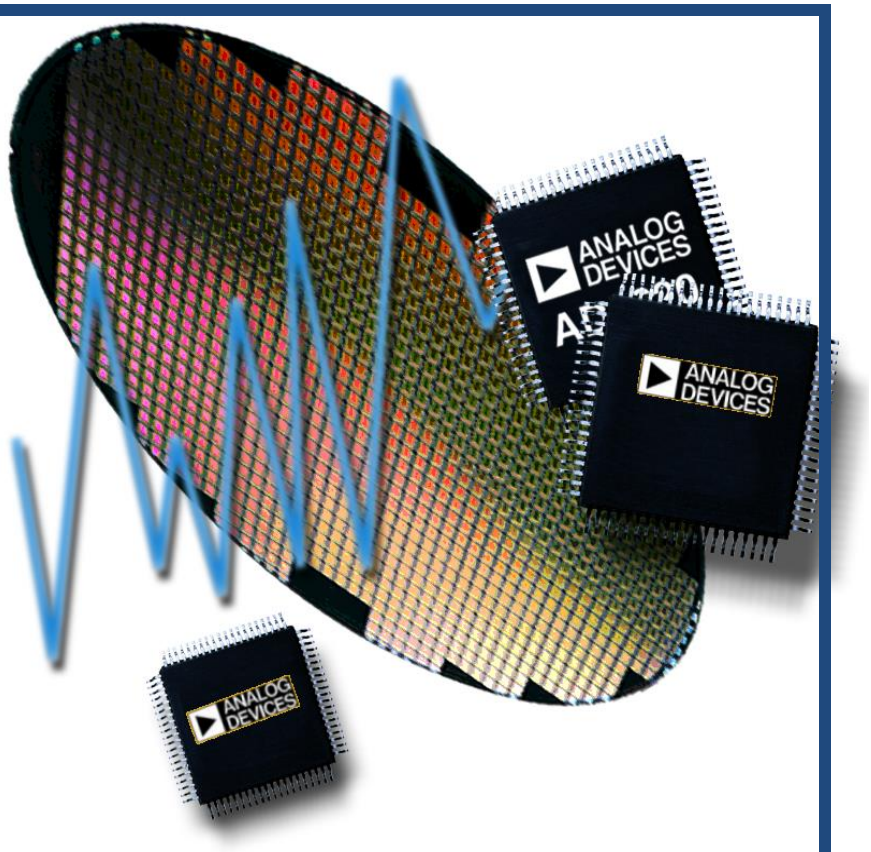
Analog Devices Welcomes Hittite Microwave Corporation

NO CONTENT ON THE ATTACHED DOCUMENT HAS CHANGED



www.analog.com

www.hittite.com



Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

Process FIT Rate Report

QTR: 2013- 00245 **Rev: 04**

Wafer Process: MESFET-B

HMC128	HMC266	HMC567
HMC129	HMC292	HMC568
HMC130	HMC294	HMC569
HMC135	HMC329	HMC619
HMC136	HMC330	HMC620
HMC137	HMC331	HMC637
HMC141	HMC446	HMC663
HMC142	HMC473	HMC710
HMC143	HMC520	HMC773
HMC144	HMC521	HMC774
HMC158	HMC522	HMC775
HMC170	HMC523	HMC787
HMC171	HMC524	HMC798
HMC175	HMC525	HMC1042
HMC187	HMC526	HMC1048
HMC188	HMC526	HMC7641
HMC199	HMC527	
HMC203	HMC528	
HMC204	HMC553	
HMC205	HMC554	
HMC226	HMC555	
HMC256	HMC556	
HMC258	HMC557	
HMC259	HMC558	
HMC260	HMC560	

Hittite MICROWAVE CORPORATION

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

Process FIT Rate Report

QTR: 2013- 00245 **Rev: 04**

Wafer Process: MESFET-B

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-B 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. **ESD:** Electro-Static Discharge. A sudden transfer of electrostatic charge between bodies or surfaces at different electrostatic potentials.
2. **HBM:** Human Body Model. A specified ESD testing circuit characterizing an event that occurs when a device is subjected to an electro-static charge stored in the human body and discharged through handling of the electronic device. This test was performed in accordance with JEDEC 22-A114.
3. **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.
4. **HTSL:** High Temperature Storage Life. Devices are subjected to 1000 hours at 150°C per JESD22-A103.
5. **MSL:** Moisture sensitivity level pre-conditioning is performed per JESD22-A113.
6. **Operating Junction Temp (T_{oj}):** Temperature of the die active circuitry during typical operation.
7. **Stress Junction Temp (T_{sj}):** Temperature of the die active circuitry during stress testing.
8. **UHAST:** Unbiased Highly Accelerated Stress Test. Devices are subjected to 96 hours of 85% relative humidity at a temperature of 130°C and pressure (18.6 PSIG). This test is performed in accordance with JESD22-A118.

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

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:

HMC260, HMC292 (QTR2002-00001)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	23 20	23 20	Complete	HMC260 HMC293
HTOL, 1000 hours	23 20	23 20	Complete	
Post HTOL Electrical Test	23 20	23 20	Pass	
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	

Hittite MICROWAVE CORPORATION

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

HMC128, HMC129 (QTR2002-00003)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	33 12	33 12	Complete	HMC128 HMC129
HTOL, 1000 hours	33 12	33 12	Complete	
Post HTOL Electrical Test	33 12	33 12	Pass	
Bond Pull	5 5	5 5	Pass	
Die Shear	4 4	4 4	Pass	
SEM Inspection	5 5	5 5	Pass	
Metal and Dielectric Thickness	5 5	5 5	Pass	

Hittite MICROWAVE CORPORATION

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

HMC6505 (QTR2012-00267)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	350	350	Pass	
MSL-3	160	160	Complete	
Final Electrical Test Post MSL-3	160	160	Pass	
UHAST – Post PC	80	80	Complete	
Final electrical Test – Post UHAST	80	80	Pass	
Temp. Cycle – Post PC	80	80	Complete	
Final electrical Test – Post T/C	80	80	Pass	
HTSL	80	80	Complete	
Final Electrical Test – Post HTSL	80	80	Pass	
HTOL	80	80	Complete	
Final Electrical test – Post HTOL	80	80	Pass	
Physical Dimensions	15	15	Pass	
Solderability	6	6	Pass	
ESD Exposure - HBM	9	9	Complete	
Electrical Test – Post ESD	9	9	Pass – 250V	HBM Class 1A

Hittite MICROWAVE CORPORATION

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

HMC7641 (QTR2014-00349)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	164	164	Pass	
MSL-3 Preconditioning	30	30	Complete	
Final Electrical Test Post MSL-3	30	30	Pass	
UHAST (Preconditioned)	30	30	Complete	
UHAST Final electrical Test	30	30	Pass	
HTSL	30	30	Complete	
HTSL Final Electrical Test	30	30	Pass	
HTOL	80	80	Complete	
HTOL Final Electrical Test	80	80	Pass	
ESD Exposure	24	24	Complete	
Electrical Test – Post ESD	24	24	Pass	HBM pass 250V (Class 1A) CDM Pass 2kV (Class C3)

Hittite MICROWAVE CORPORATION

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

MESFET-B Failure Rate Estimate

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

With device backside case temp, T_C = 85°C

HMC260, HMC292 (QTR2002-00001)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC128, HMC129 (QTR2002-00003)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC6505 (QTR2012-00267)
Operating Junction Temp (T_{oj}) =135°C(408°K)
Stress Junction Temp (T_{sj}) = 175°C(448°K)

HMC7641 (QTR2014-00349)
Operating Junction Temp (T_{oj}) =145°C(418°K)
Stress Junction Temp (T_{sj}) = 175°C(448°K)

Device hours:

HMC260, HMC292 (QTR2002-00001) = (43 X 1000hrs) = 43,000 hours
HMC128, HMC129 (QTR2002-00003) = (45 X 1000hrs) = 45,000 hours
HMC6505 (QTR2012-00267) = (80 X 1000hrs) = 80,000 hours
HMC7641 (QTR2014-00349) = (80 X 1000hrs) = 80,000 hours

For MESFET-B MMIC, Activation Energy = 1.6 eV

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

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

HMC260, HMC292 (QTR2002-00001) Acceleration Factor = exp[1.6/8.6 e-5(1/358-1/423)] = 2938.6
HMC128, HMC129 (QTR2002-00003) Acceleration Factor = exp[1.6/8.6 e-5(1/358-1/423)] = 2938.6
HMC6505 (QTR2012-00267) Acceleration Factor = exp[1.6/8.6 e-5(1/408-1/448)] = 58.6
HMC7641 (QTR2014-00349) Acceleration Factor = exp[1.6/8.6 e-5(1/418-1/448)] = 19.7

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (43,000x2938.6)+(45,000x2938.6)+(80,000x58.6)+(80,000x19.7) = 2.65×10^8 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

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X\ \ 2.65x10^8\ )] = 1.8/\ 5.30x10^8 =\ \ 3.45x10^{-9}$ failures/hour or 3.5 FIT or MTTF = $2.89x10^8$ Hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X\ \ 2.65x10^8\ )] = 4.6/\ 5.30x10^8 =\ \ 8.70x10^{-9}$ failures/hour or 8.7 FIT or MTTF = $1.15x10^8$ Hours

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