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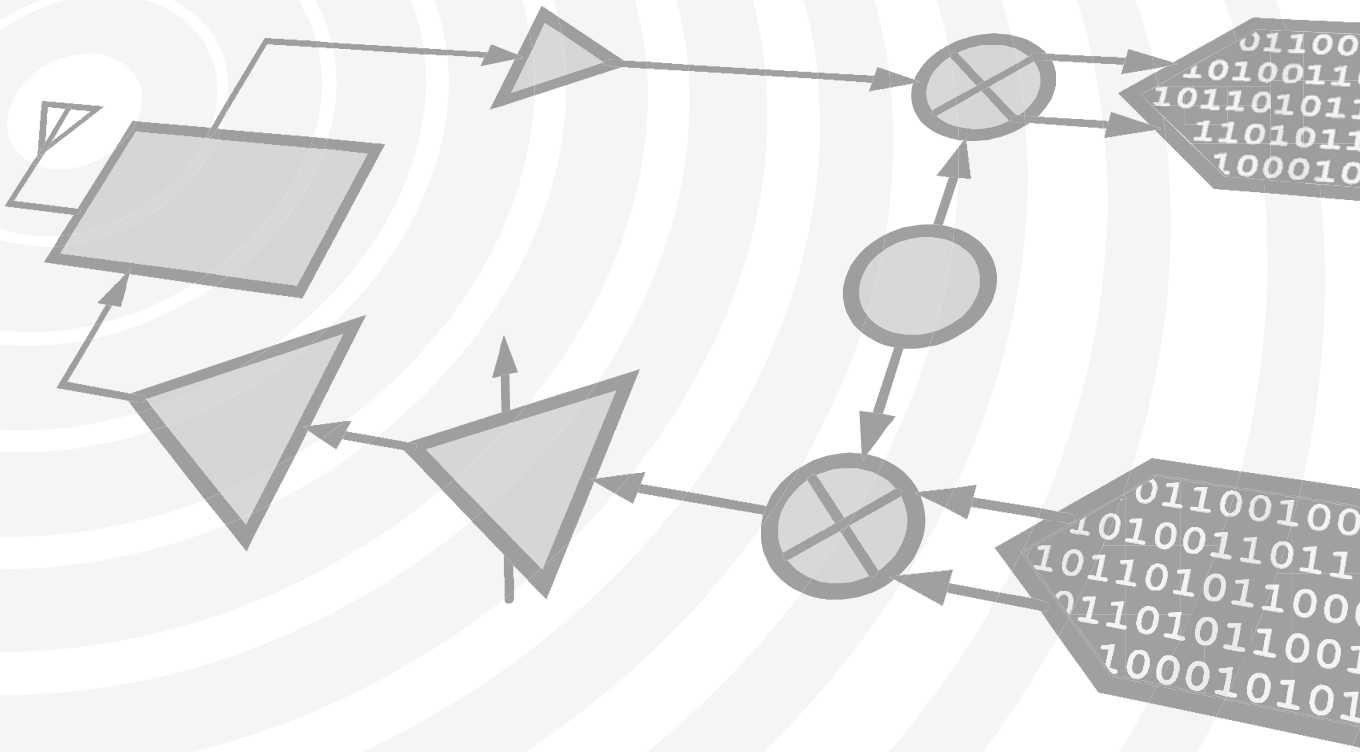

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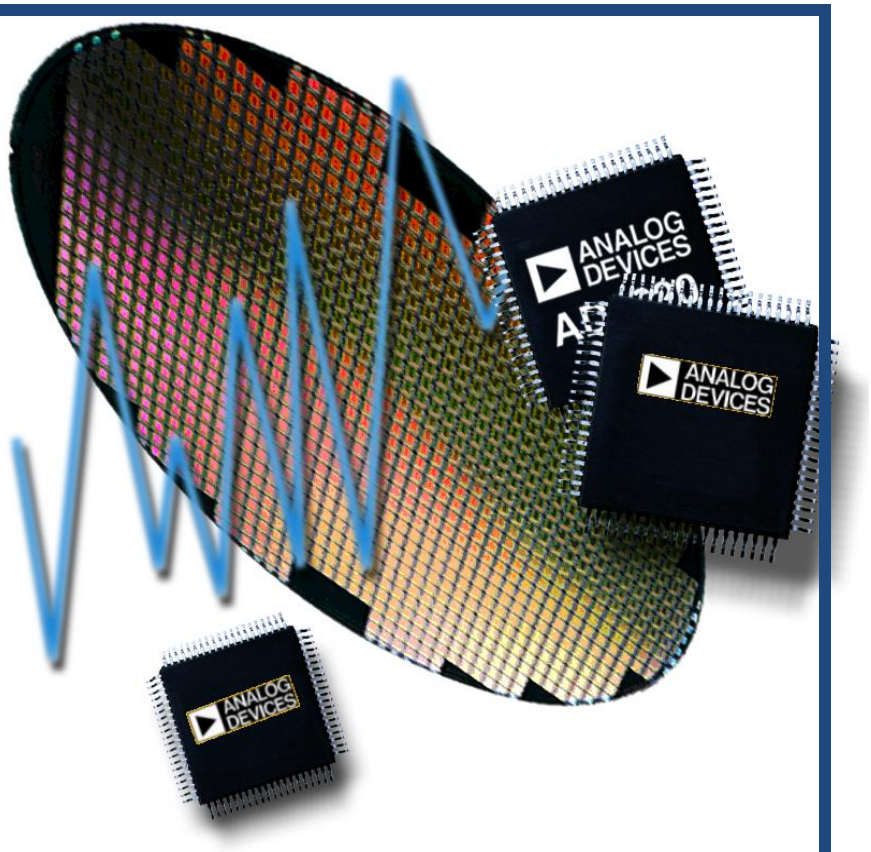

Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

Process FIT Rate Report

QTR: 2013- 00247 **Rev: 06**

Wafer Process: MESFET-F

HMC156A	HMC271A	HMC321	HMC412	HMC552
HMC165	HMC271	HMC322	HMC420	HMC581
HMC172	HMC273	HMC332	HMC421	HMC585
HMC182	HMC274	HMC333	HMC422	HMC607
HMC183	HMC276	HMC335	HMC423	HMC615
HMC187A	HMC277	HMC336	HMC424	HMC621
HMC189A	HMC278	HMC344	HMC425	HMC622
HMC194	HMC279	HMC345	HMC427	HMC623
HMC207A	HMC280	HMC346	HMC435	HMC626
HMC213A	HMC284	HMC347	HMC467	HMC665
HMC214	HMC286	HMC348	HMC468	HMC681
HMC219A	HMC287	HMC349	HMC470	HMC712
HMC221A	HMC288	HMC350	HMC472	HMC742
HMC222	HMC290	HMC351	HMC483	HMC743
HMC230	HMC291	HMC352	HMC485	HMC915
HMC231	HMC304	HMC353	HMC488	HMC944
HMC232	HMC305A	HMC377	HMC491	HMC972
HMC233	HMC305	HMC380	HMC538	HMC973
HMC234	HMC306	HMC387	HMC539	HMC985
HMC241	HMC307	HMC392	HMC540	HMC6982
HMC244	HMC308	HMC393	HMC541	
HMC245	HMC310	HMC399	HMC542A	
HMC252	HMC316	HMC400	HMC542	
HMC253	HMC318	HMC402	HMC547	
HMC270	HMC320	HMC410A	HMC551	

Hittite Microwave Corporation is committed to:

- *Supplying products of the highest quality*
- *Advance in state-of-the-art technology that supports our products*
- *Enhance our competitive position with superior product standards*

Hittite's employees recognize the responsibility to:

- *Take the initiative to ensure product quality*
- *Create an environment where the highest standards are maintained*
- *Continue to improve quality practices*

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Process FIT Rate Report

QTR: 2013- 00247 **Rev: 06**

Wafer Process: MESFET-F

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-F 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. **Operating Junction Temp (T_{oj}):** Temperature of the die active circuitry during typical operation.
6. **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:

HMC273 (QTR2002-00007)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	33 35	33 35	Complete	HMC273 HMC424
HTOL, 1240 hours	33 35	33 35	Complete	
Post HTOL Electrical Test	33 35	33 35	Pass	
Bond Pull	5 10	5 10	Pass	
Die Shear	10	10	Pass	HMC424
SEM Inspection	5 5	5 5	Pass	
Metal and Dielectric Thickness	5 5	5 5	Pass	

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HMC424 (QTR2002-00007)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	33 35	33 35	Complete	HMC273 HMC424
HTOL, 620 hours	33 35	33 35	Complete	
Post HTOL Electrical Test	33 35	33 35	Pass	
Bond Pull	5 10	5 10	Pass	
Die Shear	10	10	Pass	HMC424
SEM Inspection	5 5	5 5	Pass	
Metal and Dielectric Thickness	5 5	5 5	Pass	

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HMC2416, 2417 (QTR2002-00011)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	89 54	89 54	Complete	HMC2416 HMC2417
HTOL, 1240 hours	89 54	89 54	Complete	
Post HTOL Electrical Test	89 54	89 54	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	

HMC2402 (QTR2002-00014)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	23	23	Complete	HMC2402
HTOL, 1240 hours	23	23	Complete	
Post HTOL Electrical Test	23	23	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	

HMC423 (QTR2004-00002)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	31	31	Complete	HMC423
HTOL, 2240 hours	31	31	Complete	
Post HTOL Electrical Test	31	31	Pass	
Bond Pull	10	10	Pass	
Die Shear	10	10	Pass	
SEM Inspection	5	5	Pass	
Metal and Dielectric Thickness	5	5	Pass	

HMC306 (QTR2006-00001)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial Electrical	108	108	Complete	
HTOL, 1000 hours	108	108	Complete	
Post HTOL Electrical Test	108	108	Pass	

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HMC218A (QTR2011-00015)

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	

HMC915 (QTR2012-00022)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	199	199	Pass	
HTSL, 1000 hours	80	80	Complete	
Final Electrical Test – Post HTSL	80	80	Pass	
HTOL, 1000 hours	80	80	Complete	
Final Electrical test – Post HTOL	80	80	Pass	
ESD Exposure	39	39	Complete	
Electrical Test – Post ESD	39	39	Complete	HBM Class 1C CDM Class IV (2000V) MM Pass 100V

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HMC2165 (QTR2013-00339)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	243	243	Pass	
HTOL, 1000 hours	243	243	Complete	
Final Electrical test – Post HTOL	243	243	Pass	

HMC2167 (QTR2013-00339)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	162	162	Pass	
HTOL, 1000 hours	162	162	Complete	
Final Electrical test – Post HTOL	162	162	Pass	

HMC743 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	318	318	Pass	
HTOL, 1000 hours	318	318	Complete	
Final Electrical test – Post HTOL	318	318	Pass	

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HMC472 (QTR2013-00031)

TEST	QTY IN	QTY OUT	PASS/FAIL	NOTES
Initial electrical Test	264	264	Pass	
HTOL, 1000 hours	80	80	Complete	
Final Electrical Test – Post HTOL	80	80	Pass	
HTSL	80	80	Complete	
Final Electrical Test – Post HTSL	80	80	Pass	
MSL1 Precondition	80	80	Complete	
Final Electrical Test – Post MSL1 Precondition	80	80	Pass	
UHAST (Preconditioned)	80	80	Complete	
Final Electrical Test – Post UHAST	80	80	Pass	
ESD Exposure	24	24	Complete	
Post Electrical Test - ESD	24	24	Pass	HBM Pass 500V CDM Pass 1000V

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MESFET-F Failure Rate Estimate

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

With Device Backside Operating Temp, T_C = 85°C

HMC273 (QTR2002-00007)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC424 (QTR2002-00007)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC2416, 2417 (QTR2002-00011)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC2402 (QTR2002-00014)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 100°C(373°K)

HMC423 (QTR2004-00002)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 125°C(398°K)

HMC306 (QTR2006-00001)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 125°C(398°K)

HMC218A (QTR2011-00015)
Operating Junction Temp (T_{oj}) =85°C(358°K)
Stress Junction Temp (T_{sj}) = 125°C(398°K)

HMC915 (QTR2012-00022)
Operating Junction Temp (T_{oj}) =150°C(423°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

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HMC2165 (QTR2013-00339)
Operating Junction Temp (T_{oj}) =101°C(374°K)
Stress Junction Temp (T_{sj}) = 123°C(396°K)

HMC2167 (QTR2013-00339)
Operating Junction Temp (T_{oj}) =104°C(377°K)
Stress Junction Temp (T_{sj}) = 129°C(402°K)

HMC743 (QTR2013-00360)
Operating Junction Temp (T_{oj}) =115°C(388°K)
Stress Junction Temp (T_{sj}) = 141°C(414°K)

HMC472 (QTR2013-00031)
Operating Junction Temp (T_{oj}) =89°C(362°K)
Stress Junction Temp (T_{sj}) = 158°C(431°K)

Device hours:

HMC273 (QTR2002-00007) = (33 X 1240hrs) = 40,920 hours
HMC424 (QTR2002-00007) = (35 X 620hrs) = 21,700 hours
HMC2416, 2417 (QTR2002-00011) = (143 X 1240hrs) = 177,320 hours
HMC2402 (QTR2002-00014) = (23 X 1240hrs) = 28,520 hours
HMC423 (QTR2004-00002) = (31 X 2240hrs) = 69,440 hours
HMC306 (QTR2006-00001) = (108 X 1000hrs) = 108,000 hours
HMC218A (QTR2011-00015) = (78 X 1000hrs) = 78,000 hours
HMC915 (QTR2012-00022) = (80 X 1000hrs) = 80,000 hours
HMC2165 (QTR2013-00339) = (243 X 1000hrs) = 243,000 hours
HMC2167 (QTR2013-00339) = (163 X 1000hrs) = 163,000 hours
HMC743 (QTR2013-00360) = (318 X 1000hrs) = 318,000 hours
HMC472 (QTR2013-00031) = (80 X 1000hrs) = 80,000 hours

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For MESFET-F MMIC, Activation Energy = 1.6 eV

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

HMC273 (QTR2002-00007) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/358-1/423)] = 2938.6
HMC424 (QTR2002-00007) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/358-1/423)] = 2938.6
HMC2416, 2417 (QTR2002-00011) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/358-1/423)] = 2938.6
HMC2402 (QTR2002-00014) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/358-1/373)] = 8.1
HMC423 (QTR2004-00002) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/358-1/398)] = 185.5
HMC306 (QTR2006-00001) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/358-1/398)] = 185.5
HMC218A (QTR2011-00015) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/358-1/398)] = 185.5
HMC915 (QTR2012-00022) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/423-1/423)] = 1.0
HMC2165 (QTR2013-00339) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/374-1/396)] = 15.9
HMC2167 (QTR2013-00339) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/377-1/402)] = 21.5
HMC743 (QTR2013-00360) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/388-1/414)] = 20.3
HMC472 (QTR2013-00031) Acceleration Factor = exp[1.6/8.6x10^{-5}(1/362-1/431)] = 3743.7

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours = (40,920x2938.6)+(21,700x2938.6)+(177,320x2938.6)+(28,520x8.1)+(69,440x185.5)+(108,000x185.5)+(78,000x185.5)+(80,000x1.0)+(243,000x15.9)+(163,000x21.5)+(318,000x20.3)+(80,000x3743.7) = 1.07x10^{9} hours

Since there were no failures and we used a time terminated test, F=0, and R = 2F+2 = 2

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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

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X\ \ 1.07x10^9\ )] = 1.8/\ 2.13x10^9 =\ \ 8.58x10^{-10}$ failures/hour or 0.9 FIT or MTTF = $1.17x10^9$ Hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X\ \ 1.07x10^9\ )] = 4.6/\ 2.13x10^9 =\ \ 2.16x10^{-9}$ failures/hour or 2.2 FIT or MTTF = $4.62x10^8$ Hours

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