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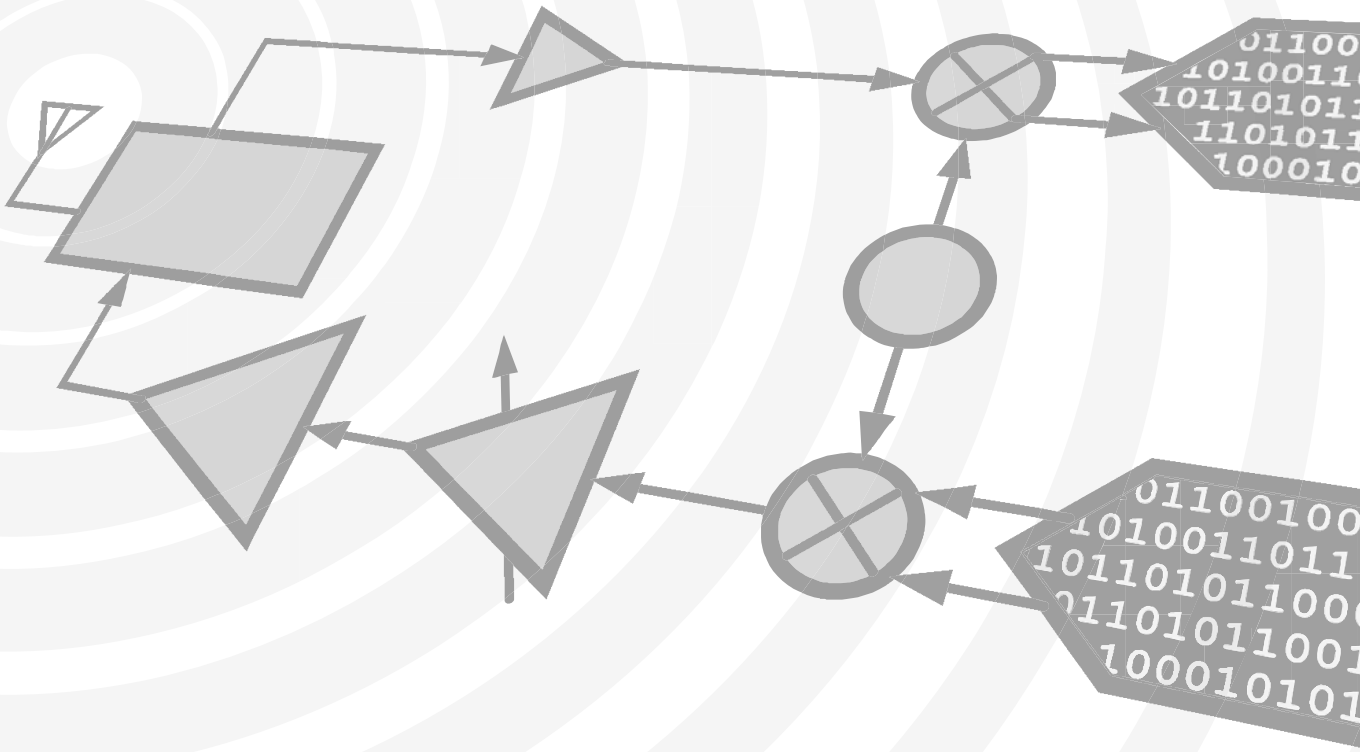

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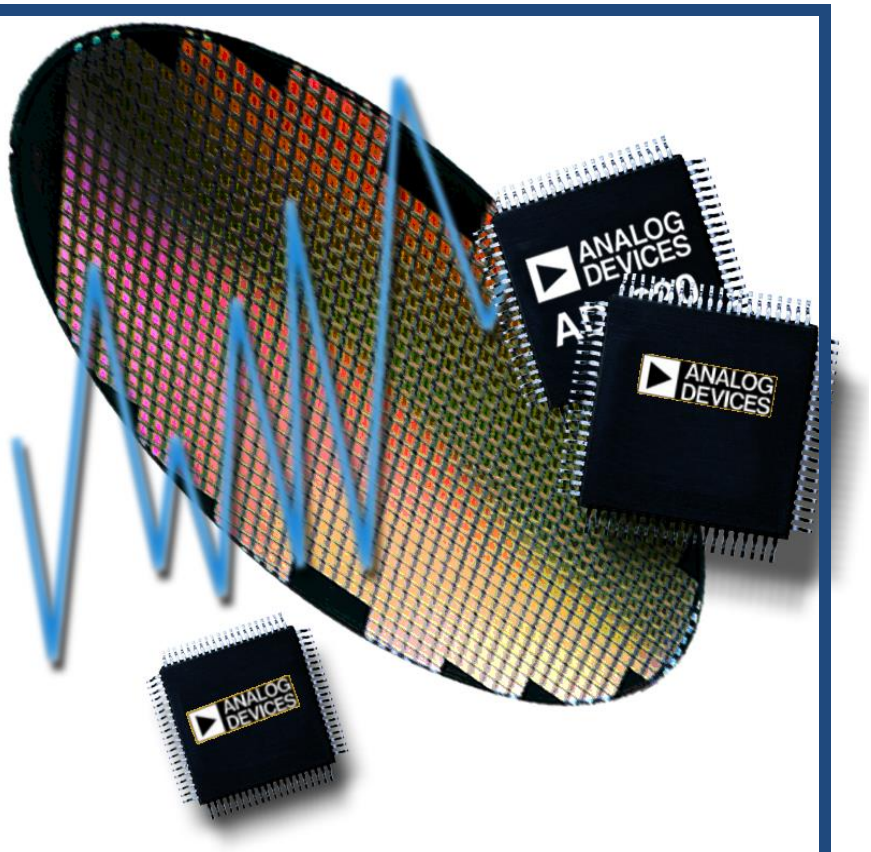

Reliability Report

Report Title: Qualification Test Report

Report Type: See Attached

Date: See Attached

Process FIT Rate Report

QTR: 2013- 00235 **Rev: 08**

Wafer Process: BiCMOS-A

HMC600	HMC759	HMC909
HMC601	HMC785	HMC914
HMC602	HMC786	HMC940
HMC611	HMC794	HMC960
HMC612	HMC795	HMC976
HMC628	HMC799	HMC987
HMC640	HMC820	HMC988
HMC666	HMC821	HMC993
HMC677	HMC822	HMC1010
HMC680	HMC824	HMC1020
HMC682	HMC826	HMC1021
HMC683	HMC828	HMC1023
HMC684	HMC829	HMC1030
HMC685	HMC830	HMC1031
HMC686	HMC831	HMC1032
HMC687	HMC832	HMC1033
HMC688	HMC832A	HMC1034
HMC689	HMC833	HMC1035
HMC700	HMC836	HMC1044
HMC701	HMC837	HMC1060
HMC702	HMC838	HMC1097
HMC703	HMC839	HMC1190
HMC704	HMC840	HMC1197
HMC713	HMC860	HMC7846
HMC750	HMC900	

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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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 BiCMOS-A 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. **CDM:** Charged Device Model. A specified ESD testing circuit characterizing an event that occurs when a device acquires charge through some triboelectric (frictional) or electrostatic induction processes and then abruptly touches a grounded object or surface. This test was performed in accordance with JEDEC 22-C101.
2. **ESD:** Electro-Static Discharge. A sudden transfer of electrostatic charge between bodies or surfaces at different electrostatic potentials.
3. **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.
4. **HAST:** Highly Accelerated Stress Test (biased). Devices are subjected to 96 hours of 85% relative humidity at a temperature of 130°C and pressure (15 PSIG), while DC biased. This test is performed in accordance with JESD22-A110.
5. **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.
6. **HTSL:** High Temperature Storage Life. Devices are subjected to 1000 hours at 150ºC per JESD22-A103.
7. **MSL:** Moisture sensitivity level pre-conditioning is performed per JESD22-A113.
8. **Operating Junction Temp (T_{oj}):** Temperature of the die active circuitry during typical operation.
9. **Stress Junction Temp (T_{sj}):** Temperature of the die active circuitry during stress testing.

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10. Temperature Cycle: Cond C (-65°C to 150°C), 500 cycles per JESD22-A104.

11. UHAST: Unbiased Highly Accelerated Stress Test. Devices are subjected to 96 hours of 85% relative humidity at a temperature of 130°C and pressure (15 PSIG). This test is performed in accordance with JESD22-A118.

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:

HMC610 (QTR2008-00003)

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	
Bond Pull	10	10	Pass	
Die Shear	10	10	Pass	
Metal and Dielectric Thickness	5	5	Pass	
SEM Inspection	5	5	Pass	

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HMC701 (QTR2011-00002)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	933	933	Complete	
HTOL, 1000 hours	240	240	Complete	
Post HTOL Electrical Test	240	240	Pass	
MSL1 Preconditioning	693	693	Complete	
MSL1 Preconditioning Final Test	693	693	Pass	
UHAST (Preconditioned)	231	231	Complete	
UHAST Final Test	231	231	Pass	
HAST (Preconditioned)	231	231	Complete	
HAST Final Test	231	231	Pass	
Temperature Cycle (Preconditioned)	231	231	Complete	
Temperature Cycle Final Test	231	231	Pass	
ESD	45	45	Complete	HBM Class 1B CDM Class IV MM 110V
Latch Up	6	6	Pass	

HMC701 (QTR2012-00249)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	240	240	Complete	
HTOL, 1033 hours	240	240	Complete	
Post HTOL Electrical Test	240	240	Pass	

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HMC976 (QTR2012-00028)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	241	241	Complete	
HTOL, 1000 hours	80	80	Complete	
Post HTOL Electrical Test	80	80	Pass	
MSL1 Preconditioning	161	161	Complete	
MSL1 Preconditioning Final Test	161	161	Pass	
UHAST (Preconditioned)	81	81	Complete	
UHAST Final Test	81	81	Pass	
Temperature Cycle (Preconditioned)	80	80	Complete	
Temperature Cycle Final Test	80	80	Pass	

HMC701 (QTR2012-00343)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	239	239	Complete	
HTOL, 1033 hours	239	239	Complete	
Post HTOL Electrical Test	239	239	Pass	

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HMC830 (QTR2012-00024)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	160	160	Complete	
HTOL, 1029 hours	80	80	Complete	
Post HTOL Electrical Test	80	80	Pass	
HTSL, 1123 hours	80	80	Complete	
Post HTSL Electrical Test	80	80	Pass	

HMC1020 (QTR2012-00276)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	160	160	Complete	
HTOL, 1080 hours	80	80	Complete	
Post HTOL Electrical Test	80	80	Pass	
HTSL, 1008 hours	80	80	Complete	
Post HTSL Electrical Test	80	80	Pass	

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HMC1190 (QTR2012-00515)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical Test	333	333	Complete	
HTOL	80	80	Complete	
Post HTOL Electrical test	80	80	Pass	
HTSL	80	80	Complete	
Post HTSL Electrical Test	80	80	Pass	
THB	27	27	Complete	
Post THB Electrical Test	27	27	Pass	
MSL-1 Preconditioning	80	80	Complete	
Post MSL1 Electrical Test	80	80	Pass	
Temp. Cycle (Preconditioned)	80	80	Complete	
Post Temp Cycle Electrical Test	80	80	Pass	
ESD Exposure	39	39	Complete	
Post ESD Electrical Test	39	39	Pass	HBM = Class 1B (500V) CDM = Class IV (2kV)
Physical Dimensions	15	15	Pass	
X-Ray	6	6	Pass	
Solderability	6	6	Pass	

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HMC1197 (QTR2012-00516)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical Test	332	332	Complete	
HTOL	79	79	Complete	
Post HTOL Electrical test	79	79	Pass	
HTSL	80	80	Complete	
Post HTSL Electrical Test	80	80	Pass	
THB	27	27	Complete	
Post THB Electrical Test	27	27	Pass	
MSL-1 Preconditioning	80	80	Complete	
Post MSL1 Electrical Test	80	80	Pass	
Temp. Cycle (Preconditioned)	80	80	Complete	
Post Temp Cycle Electrical Test	80	80	Pass	
ESD Exposure	39	39	Complete	
Post ESD Electrical Test	39	39	Pass	HBM = Class 1A (250V) CDM = Class II (200V) MM = Pass 100V
Physical Dimensions	15	15	Pass	
X-Ray	6	6	Pass	
Solderability	6	6	Pass	

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HMC7271 (QTR2013-00339)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	168	168	Complete	
HTOL, 1000 hours	81	81	Complete	
Post HTOL Electrical Test	81	81	Pass	
HTSL, 1000 hours	25	25	Complete	
Post HTSL Electrical Test	25	25	Pass	
MSL1 Preconditioning	50	50	Complete	
MSL1 Preconditioning Final Test	50	50	Pass	
THB (Preconditioned)	25	25	Complete	
THB Final Test	25	25	Pass	
Temperature Cycle (Preconditioned)	25	25	Complete	
Temperature Cycle Final Test	25	25	Pass	
ESD	12	12	Complete	HBM Class 1A

HMC830 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	159	159	Complete	
HTOL, 1000 hours (Tj=118°C)	159	159	Complete	
Post HTOL Electrical Test	159	159	Pass	

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HMC830 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	159	159	Complete	
HTOL, 1000 hours (Tj=111°C)	159	159	Complete	
Post HTOL Electrical Test	159	159	Pass	

HMC900 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	159	159	Complete	
HTOL, 1000 hours (Tj=117°C)	159	159	Complete	
Post HTOL Electrical Test	159	159	Pass	

HMC900 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	159	159	Complete	
HTOL, 1000 hours (Tj=116°C)	159	159	Complete	
Post HTOL Electrical Test	159	159	Pass	

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HMC960 (QTR2013-00360)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical	318	318	Complete	
HTOL, 1000 hours (Tj=110°C)	318	318	Complete	
Post HTOL Electrical Test	318	318	Pass	

HMC832A (QTR2013-00386)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical Test	570	570	Complete	
HTOL	80	80	Complete	
Post HTOL Electrical test	80	80	Pass	
HTSL	160	160	Complete	
Post HTSL Electrical Test	160	160	Pass	
MSL-1 Preconditioning	318	318	Complete	
Post MSL1 Electrical Test	318	318	Pass	
UHAST (Preconditioned)	158	158	Complete	
Post UHAST Electrical Test	158	158	Pass	
Temp. Cycle (Preconditioned)	158	158	Complete	
Post Temp Cycle Electrical Test	158	158	Pass	
ESD Exposure	12	12	Complete	
Post ESD Electrical Test	12	12	Pass	HBM = Class 1B (500V)

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HMC838 (QTR2014-00291)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical Test	80	80	Complete	
HTOL, 1000hours, Tj=150°C	80	80	Pass	

HMC830 (QTR2013-00446)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical Test	170	170	Pass	
HTOL, 1000hours, Tj=150°C	80	80	Pass	
HTSL	30	30	Pass	
UHAST (MSL1 Preconditioned)	30	30	Pass	
THB (MSL1 Preconditioned)	30	30	Pass	

HMC7846 (Q11709)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical Test	318	318	Pass	
HTOL	49	49	Pass	
HTSL	135	135	Pass	3 lots of 45 units
UHAST (MSL3 Preconditioned)	77	77	Pass	
ESD	57	57	Pass	CDM = Pass 1250V HBM = Pass 6000V

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HMC1190 (Q11869)

TEST	QTY IN	QTY OUT	PASS / FAIL	NOTES
Initial Electrical Test	229	229	Pass	
HTOL	49	49	Pass	
HTSL	135	135	Pass	3 lots of 45 units
THB (MSL3 Preconditioned)	45	45	Pass	

BiCMOS-A Failure Rate Estimate

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

With device ambient case temp, Tc = 60°C

HMC610 (QTR2008-00003)
Operating Junction Temp (T_{oj}) =65°C(338°K)
Stress Junction Temp (T_{sj}) = 160°C(433°K)

HMC701 (QTR2011-00002)
Operating Junction Temp (T_{oj}) =69°C(342°K)
Stress Junction Temp (T_{sj}) = 160°C(433°K)

HMC701 (QTR2012-00249)
Operating Junction Temp (T_{oj}) =69°C(342°K)
Stress Junction Temp (T_{sj}) = 175°C(448°K)

HMC976 (QTR2012-00028)
Operating Junction Temp (T_{oj}) =70°C(343°K)
Stress Junction Temp (T_{sj}) = 110°C(383°K)

HMC701 (QTR2012-00343)
Operating Junction Temp (T_{oj}) =69°C(342°K)

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Stress Junction Temp (T_{sj}) = 178°C(451°K)

HMC830 (QTR2012-00024)
Operating Junction Temp (T_{oj}) =70°C(343°K)
Stress Junction Temp (T_{sj}) = 136°C(409°K)

HMC1020 (QTR2012-00276)
Operating Junction Temp (T_{oj}) =68°C(341°K)
Stress Junction Temp (T_{sj}) = 131°C(404°K)

HMC1190 (QTR2012-00515)
Operating Junction Temp (T_{oj}) =68°C(341°K)
Stress Junction Temp (T_{sj}) = 125°C(398°K)

HMC1197 (QTR2012-00516)
Operating Junction Temp (T_{oj}) =68°C(341°K)
Stress Junction Temp (T_{sj}) = 110°C(383°K)

HMC7271 (QTR2013-00339)
Operating Junction Temp (T_{oj}) =68°C(341°K)
Stress Junction Temp (T_{sj}) = 112°C(385°K)

HMC830 (QTR2013-00360)
Operating Junction Temp (T_{oj}) =70°C(343°K)
Stress Junction Temp (T_{sj}) = 118°C(391°K)

HMC830 (QTR2013-00360)
Operating Junction Temp (T_{oj}) =70°C(343°K)
Stress Junction Temp (T_{sj}) = 111°C(384°K)

HMC900 (QTR2013-00360)
Operating Junction Temp (T_{oj}) =67°C(340°K)
Stress Junction Temp (T_{sj}) = 117°C(390°K)

HMC900 (QTR2013-00360)
Operating Junction Temp (T_{oj}) =67°C(340°K)
Stress Junction Temp (T_{sj}) = 116°C(389°K)

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HMC960 (QTR2013-00360)
Operating Junction Temp (T_{oj}) =64°C(337°K)
Stress Junction Temp (T_{sj}) = 110°C(383°K)

HMC832A (QTR2013-00386)
Operating Junction Temp (T_{oj}) =64°C(337°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC838 (QTR2014-00291)
Operating Junction Temp (T_{oj}) =66°C(339K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC830 (QTR2014-00446)
Operating Junction Temp (T_{oj}) =70°C(343°K)
Stress Junction Temp (T_{sj}) = 150°C(423°K)

HMC830 (Q11709)
Operating Junction Temp (T_{oj}) =61°C(334°K)
Stress Junction Temp (T_{sj}) = 125°C(398°K)

HMC1190 (Q11869)
Operating Junction Temp (T_{oj}) =68°C(341°K)
Stress Junction Temp (T_{sj}) = 125°C(398°K)

Device hours:

HMC610 (QTR2008-00003) = (78 X 1000hrs) = 78,000 hours
HMC701 (QTR2011-00002) = (240 X 1000hrs) = 240,000 hours
HMC701 (QTR2012-00249) = (240 X 1033hrs) = 247,920 hours
HMC976 (QTR2012-00028) = (80 X 1000hrs) = 80,000 hours

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HMC701 (QTR2012-00343) = (239 X 1084hrs) = 259,076 hours
HMC830 (QTR2012-00024) = (80 X 1029hrs) = 82,320 hours
HMC1020 (QTR2012-00276) = (80 X 1080hrs) = 86,400 hours
HMC7271 (QTR2013-00339) = (81 X 1000hrs) = 81,000 hours
HMC1190 (QTR2012-00515) = (80 X 1000hrs) = 80,000 hours
HMC1197 (QTR2012-00516) = (79 X 1000hrs) = 79,000 hours
HMC830 (QTR2013-00360) = (159 X 1000hrs) = 159,000 hours
HMC830 (QTR2013-00360) = (159 X 1000hrs) = 159,000 hours
HMC900 (QTR2013-00360) = (159 X 1000hrs) = 159,000 hours
HMC900 (QTR2013-00360) = (159 X 1000hrs) = 159,000 hours
HMC960 (QTR2013-00360) = (318 X 1000hrs) = 318,000 hours
HMC832A (QTR2013-00386) = (80 X 1000hrs) = 80,000 hours
HMC838 (QTR2014-00291) = (80 X 1000hrs) = 80,000 hours
HMC830 (QTR2014-00446) = (80 X 1000hrs) = 80,000 hours
HMC830 (Q11709) = (49 X 1000hrs) = 49,000 hours
HMC1190 (Q11869) = (49 X 1000hrs) = 49,000 hours

For BiCMOS-A MMIC, Activation Energy = 0.7 eV

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

HMC610 (QTR2008-00003) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/338-1/433)] = 38$
HMC701 (QTR2011-00002) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/342-1/433)] = 149$
HMC701 (QTR2012-00249) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/342-1/448)] = 279$
HMC976 (QTR2012-00028) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/343-1/383)] = 11.9$
HMC701 (QTR2012-00343) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/342-1/451)] = 315$
HMC830 (QTR2012-00024) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/343-1/409)] = 46$
HMC1020 (QTR2012-00276) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/341-1/404)] = 41.4$
HMC1190 (QTR2012-00515) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/335-1/398)] = 30.5$
HMC1197 (QTR2012-00516) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/335-1/383)] = 13.7$
HMC7271 (QTR2013-00339) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/341-1/385)] = 15.3$
HMC830 (QTR2013-00360) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/343-1/391)] = 18.4$
HMC830 (QTR2013-00360) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/343-1/384)] = 12.6$
HMC900 (QTR2013-00360) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/340-1/390)] = 21.5$
HMC900 (QTR2013-00360) Acceleration Factor = $\exp[0.7/8.6\text{x}10^{-5}(1/340-1/389)] = 20.4$

HMC960 (QTR2013-00360) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/337-1/383)] = 18.2
HMC832A (QTR2013-00386) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/337-1/423)] = 134.7
HMC838 (QTR2014-00291) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/339-1/423)] = 121.1
HMC830 (QTR2014-00446) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/343-1/423)] = 88.9
HMC830 (Q11709) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/334-1/383)] = 50.3
HMC1190 (Q11869) Acceleration Factor = exp[0.7/8.6x10^{-5}(1/341-1/383)] = 30.5

Equivalent hours = Device hours x Acceleration Factor

Equivalent hours =
(78,000x38)+(240,000x149)+(247,920x279)+(80,000x11.9)+(259,076x315)+(82,320x46)+(86,400x41.4)
+(80,000x30.5)+(79,000x13.7)+(81,000x15.3)+(80,000x134.7)+(159,000x18.4)+(159,000x12.6)
+(159,000x21.5)+(159,000x20.4)+(318,000x18.2) +(80,000x121.1) +(80,000x88.9) +(49,000x50.3)
+(49,000x30.5) = 2.51x10^{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 60°C package backside temp;

Failure Rate

$\lambda_{60} = [(\chi^2)_{60,2}]/(2X\ 2.51x10^8\ )] = 1.8/\ 5.03x10^8 =\ 3.64x10^{-9}$ failures/hour or 3.6 FIT or MTTF = 2.75x10^8 Hours

$\lambda_{90} = [(\chi^2)_{90,2}]/(2X\ 2.51x10^8\ )] = 4.6/\ 5.03x10^8 =\ 9.17x10^{-9}$ failures/hour or 9.2 FIT or MTTF = 1.09x10^8 Hours