RELIABILITY QUALIFICATION REPORT FOR LEAD-FREE/RoHS-COMPLIANT AP601-F, AP602-F, AP603-F +28V InGaP HBT POWER AMPLIFIERS

I. SUMMARY

The AP60X-F Amplifier family is a first on the market of power amplifier devices using the new TriQuint +28 Volt InGaP HBT process. Exceptional linearity, efficiency and a small low-cost package top the list of the many benefits afforded by this new amplifier family. The leadfree/RoHS-compliant power DFN (Dual side Flat-pack No Lead) package is delivered on tape and reel; the devices are easily assembled onto a PWB using standard lead-free or tin-lead SMT processes. The power DFN package utilizes a eutectic solder attachment of the die to a thick leadframe to allow for a low junction-to-case thermal resistance and dissipate the heat generated by the device. Included in the AP60X-F amplifier family are the AP601-F (1.8W), AP602-F (4W) and AP603-F (7W) devices.

Two foundry locations and two subcontract assembly have been fully qualified for AP60X power amplifiers. To identify each foundry in this report, they will be mentioned as FAB1 and FAB2 and each subcontract assembly as SCA1 and SCA2. A full qualification schedule was necessary for this entirely new device.

II. SCOPE

This qualification of the AP603-F includes die manufactured at two fabrication facilities FAB1 and FAB2, and covers processes and procedures for assembly from two subcontract assembly houses; SCA1 and SCA2. Tests defined herein are intended to establish a level of confidence in reliability and performance by subjecting the device to accelerated environmental stresses as detailed in the JESD-22. The testing also includes MSL (Moisture Sensitivity) and ESD (Electro-Static Discharge) in accordance with JEDEC standards for the purpose of establishing the performance rating for each of those tests.

Each device in the AP60X-F family uses the same semiconductor design architecture differing in device size and the number of transistor fingers. The AP603-F was chosen as the qualification device because it has the highest power dissipation and contains the largest number of transistors for the device family. Successful qualification of the AP603-F will be considered as successful qualification for the AP60X device family by similarity.

Electrical Tests used for determining compliance and their pass fail limits were as follows: Gain within +/-1dB, ACPR1 within +/- 2dBc, Icc and Icq do not change by more than 10%. The amplifiers were biased with a +28 Vcc and 160 mA Icq as specified in the AP603 datasheet.

III. APPLICABLE DOCUMENTS

Environmental Stress Tests, Testing Procedures, and measure of accomplishment for the AP603-F qualification are derived from the industry accepted qualification standard of choice: JEDEC Standard JESD22. Also reference the following AP601, AP602, and AP603 datasheets for application and technical information:

IV. QUALIFICATION TEST PLAN (FAB1 & FAB2)

Stress or Test	Procedures / Conditions	Device Hours/Cycles	Sample Size	Failed Units	Reference Document	Part Tested
High Temp Op Life (HTOL)	Test Condition: Biased Device mounting Temp. 125°C (+5, -0°C)	1000 Hrs	3 lots, a total of 135 parts	0	JESD22 A108-B	AP603-F (FAB1)
		1000 Hrs	3 lots, a total of 135 parts	0		AP603-F (FAB2)
High Temperature Storage (HTB)	Temp. 125°C (+5, -0°C)	1000 Hrs	1 lot of 45 parts	0	JESD22 A103-C	AP603-F (FAB1)
		1000 Hrs	1 lot of 45 parts	0		AP603-F (FAB2)
Temperature Cycle	Test Condition C: Temp -65°C (+0°/-10°C) to +150°C (+10°/-0°C)	500 cycles	3 lots, a total of 135 parts	0	JESD22 A104-C	AP603-F (FAB1)
		500 cycles	3 lots, a total of 135 parts	0		AP603-F (FAB2)
Highly Accelerated Temperature and Humidity (HAST)	Test Condition A: Temp 130°C (+/-2°C) 33.3 +/- 1psig 85% RH	96 Hrs (-0, +2Hrs)	3 lots, a total of 135 parts	0	JESD22 A110B	AP603-F (FAB1)
		96 Hrs (-0, +2Hrs)	3 lots, a total of 135 parts	0		AP603-F (FAB2)
Unbiased Auto Clave	Test Condition C: Temp 121°C (+/-1°C) RH 100% Vapor Pressure 29.7 psia	96 Hrs (-0, +2Hrs)	3 lots, a total of 135 parts	0	JESD22 A102-C	AP603-F (FAB1)
Preconditioning Leaded Profile MSL Level III	External visual 40x +125°C Storage: 24Hrs 192hrs +30C/60% RH Convection Reflow 3 cycles, peak temp: 260°C	N/A	3 lots, a total of 300 parts	0	JESD22-A113 JESD22-A101 JESD22-B101 JESD22-103 JESD22-A112.4	AP603-F (FAB1)
		N/A	3 lots, a total of 450 parts	0		AP603-F (FAB2)
ESD	Human Body Model (HBM)	N/A	15	Class 1A	JESD22-A114C	AP603-F (FAB1)
		N/A	15	Class 1A		AP603-F (FAB2)
	Charged Device Model (CDM)	N/A	12	Class IV	JESD22-C101C	AP603-F (FAB1)
		N/A	12	Class IV		AP603-F (FAB2)

V. DISCUSSION OF RESULTS (FAB1 & FAB2)

A) Testing Procedures

Devices for qualification were obtained by testing new parts from three production lots from each foundry using a semi-automated production test station. Baseline and post environmental exposure measurements were made and compared in order to determine whether the performance of any device had significantly been affected by the environmental exposure. Each of the environmental exposure tests were performed using loose parts except for HTOL and HAST where it was necessary to mount the devices using an automated SMT assembly line to a standard AP60x application board.

The Temperature Cycling, HTOL, HAST, and Autoclave were performed at Nano Measurements Labs in Santa Clara California. The HAST was performed at Infiniti Solutions. The ESD tests were performed at Amkor Labs in San Jose, CA. The HTB test was performed at TriQuint in San Jose California.

B) Qualification Results

1) High Temp Op Life (HTOL)

A total of 135 AP603-F devices (3 lots) from FAB1 and 135 AP603-F devices (3 lots) from FAB2 completed 1000 hours of HTOL with no failures.

2) High Temp Storage Life (HTB)

A total of 45 AP603-F devices (1 lot) from FAB1 and 45 AP603-F devices (1 lot) FAB2 completed 1000 hours of HTB with no failures.

3) Temperature Cycle (TC)

A total of 135 AP603-F devices (3 lots) from FAB1 and 135 devices (3 lots) from FAB2 completed 500 temperature cycles with no failures.

4) Highly Accelerated Temperature and Humidity (HAST)

A total of 135 AP603-F devices (3 lots) from FAB1 and 135 AP603-F devices (3 lots) from FAB2 completed HAST with no failures.

5) Unbiased Autoclave (UA)

A total of 135 AP603-F devices (3 lots) from FAB1 completed 96 hours pressure pot exposure with no failures.

6) Preconditioning Leaded Profile MSL Level III

A total of 300 AP603-F devices from three lots from FAB1 and 450 devices from three lots from FAB2 were subject to MSL testing for Level III rating. The devices successfully completed qualification testing installed in the HAST application boards, Temperature Cycled as loose units, and Exposed to Pressure Pot as loose units. As such, the AP60X is rated at MSL Level III.

6) Charge Device Model ESD

A total of 12 devices each from FAB1 and 12 devices from FAB2 were used to determine the CDM ESD level for the AP603-F. Three devices were tested at each of four exposure levels (200V, 500V, 1000V, 2000V). The highest exposure level survived was 2000V, which gives AP603-F a CDM classification: Level IV.

7) Human Body Model ESD

A total of 15 devices each from FAB1 and 15 devices from, FAB2 were used to determine the HBM ESD level for the AP603-F. Three devices were tested at each of four exposure levels (100V, 250V, 300V, 500V). The highest exposure level survived was 250V which gives the AP603-F an HBM Classification: Class 1A.

IV. QUALIFICATION TEST PLAN (SCA1 & SCA2)

Stress or Test	Procedures / Conditions	Device Hours/Cycles	Sample Size	Failed Units	Reference Document	Part Tested
High Temp Op Life (HTOL)	Test Condition: Biased Device mounting Temp. 125°C (+5, -0°C)	1000 Hrs	3 lots, a total of 135 parts	0	JESD22 A108-B	AP603-F (SCA1)
		1000 Hrs	1 lot, a total of 77 parts	0		AP603-F (SCA2)
Temperature Cycle	Test Condition C: Temp -65°C (+0°/-10°C) to +150°C (+10°/-0°C)	500 cycles	3 lots, a total of 135 parts	0	JESD22 A104	AP603-F (SCA1)
	Test Condition G: Temp -40°C (+0°/-10°C) to +125°C (+10°/-0°C)	1000 cycles	2 lots, a total of 154 parts	0		AP603-F (SCA2)
Preconditioning Leaded Profile MSL Level III	External visual 40x +125°C Storage: 24Hrs 192hrs +30C/60% RH Convection Reflow 3 cycles, peak temp: 260°C	N/A	3 lots, a total of 300 parts	0	JESD22-A113 JESD22-A101 JESD22-B101 JESD22-103 JESD22-A112.4	AP603-F (SCA1)
		N/A	2 lots, a total of 400 parts	0		AP603-F (SCA2)
High Temperature Storage (HTB)	Temp. 125°C (+5, -0°C)	1000 Hrs	1 lot, a total of 45 parts	0	JESD22 A103-C	AP603-F (SCA1)
Highly Accelerated Temperature and Humidity (HAST)	Test Condition A: Temp 130°C (+/-2°C) 33.3 +/- 1psig 85% RH	96 Hrs (-0, +2Hrs)	3 lots, a total of 135 parts	0	JESD22 A110B	AP603-F (SCA1)
Unbiased Auto Clave	Test Condition C: Temp 121°C (+/-1°C) RH 100% Vapor Pressure 29.7 psia	96 Hrs (-0, +2Hrs)	3 lots, a total of 135 parts	0	JESD22 A102-C	AP603-F (SCA1)
Thermal Shock	Test Condition C: except -40°C (+0°/-10°C) to +125°C (+10°/-0°C)	100 cycles	2 lots, a total of 154 parts	0	JESD22-A106	AP603-F (SCA2)
Solderability	Surface Mount Simulation solderability test (Pb-free)	8 Hrs Steam age	2 lots, a total of 6 parts	0	JESD22 B102	AP603-F (SCA1)
		8 Hrs Steam age	2 lots, a total of 6 parts	0		AP603-F (SCA2)
ESD	Human Body Model (HBM)	N/A	1 lot, a total of 9 parts	Class 1A	JESD22-A114C	AP603-F (SCA1)
		N/A	1 lot, a total of 9 parts	Class 1A		AP603-F (SCA2)
	Charged Device Model (CDM)	N/A	1 lot, a total of 12 parts	Class IV	JESD22-C101C	AP603-F (SCA1)
		N/A	1 lot, a total of 12 parts	Class IV		AP603-F (SCA2)

V. DISCUSSION OF RESULTS (SCA1 & SCA2)

A) Testing Procedures

Devices for qualification were obtained by testing new parts from three production lots from SCA1 and two production lots from SCA2 using a semi-automated production test station. Baseline and post environmental exposure measurements were made and compared in order to determine whether the performance of any device had significantly been affected by the environmental exposure. Each of the environmental exposure tests were performed using loose parts except for HTOL and HAST where it was necessary to mount the devices using an automated SMT assembly line to a standard AP60x application board.

The Temperature Cycling, HTOL, HAST, and Autoclave were performed at Nano Measurements Labs in Santa Clara California. The Preconditioning, Temperature Cycling, Thermal Shock were performed at Infiniti Solutions in Santa Clara, CA. The ESD tests were performed at Amkor Labs in San Jose, CA. The HTB (FAB1 & FAB2) test was performed at TriQuint in San Jose California. Solderability tests were performed at Six Sigma at Milpitas, CA. Physical Dimension, Bond Pull and Bond Shear were performed at the subcontractor assembly.

B) Qualification Results

1) High Temp Op Life (HTOL)

A total of 135 AP603-F devices (3 lots) from SCA1 and 77 AP603-F devices (1 lot) from SCA2 completed 1000 hours of HTOL with no failures.

2) Temperature Cycle (TC)

A total of 135 AP603-F devices (3 lots) from SCA1 completed 500 cycles with no failures. Also a total of 154 devices (2lots) from SCA2 completed 1000 temperature cycles with no failures.

6) Preconditioning Leaded Profile MSL Level III

A total of 300 AP603-F devices from three lots from SCA1 and 400 devices from two lots from SCA2 were subject to MSL testing for Level III rating. The devices successfully completed qualification testing installed in the HAST application boards, Temperature Cycled, Thermal shocked as loose units, and Exposed to Pressure Pot as loose units. As such, the AP60X is rated at MSL Level III

3) High Temp Storage Life (HTB)

A total of 45 AP603-F devices (1 lot) from SCA1 completed 1000 hours of HTB with no failures.

4) Highly Accelerated Temperature and Humidity (HAST)

A total of 135 AP603-F devices (3 lots) from SCA1 and completed HAST with no failures.

5) Unbiased Autoclave (UA)

A total of 135 AP603-F devices (3 lots) from SCA1 completed 96 hours pressure pot exposure with no failures.

6) Thermal Shock (TS)

A total of 154 AP603-F devices (2 lots) from SCA2 completed 500 temperature cycles with no failures.

7) Solderability

A total of 6 AP603-F devices (2 lots) from SCA1 and 6 devices (2 lots) from SCA2 passed Surface mount simulation solderability test, Pb-free with eight hours steam age.

10) Charge Device Model ESD
A total of 12 devices each from SCA1 and 12 devices from SCA2 were used to determine the CDM ESD level for the AP603-F. Three devices were tested at each of four exposure levels (200V, 500V, 1000V, 2000V). The highest exposure level survived was 2000V, which gives AP603-F a CDM classification: Level IV.

11) Human Body Model ESD
A total of 9 devices each from SCA1 and 9 devices from, SCA2 were used to determine the HBM ESD level for the AP603-F. Three devices were tested at each of three exposure levels (100V, 250V, 500V). The highest exposure level survived was 250Vwhich gives the AP603-F an HBM Classification: Class 1A.

VI. CONCLUSIONS

The successful results obtained from the Qualification Testing completed demonstrate that the AP603-F with die fabricated both at FAB1 and FAB2 and packaged in 5x6mm Power DFN at either SCA1 and SCA2 meet the level of reliability and quality accepted by the industry and as defined by standard JEDEC 22.

The AP603-F Power Amplifier is qualified for production. By similarity, the AP601-F and AP602-F are also considered qualified for production.