

# LEAD-FREE / RoHS-COMPLIANT / GREEN SOT-89 GaAs MESFET/HFET SEMICONDUCTORS RELIABILITY QUALIFICATION REPORT

## I. SUMMARY

The GaAs MESFET / HFET devices housed in a lead-free/RoHS-compliant/green SOT-89 package have been qualified to a maximum reflow profile of 260 °C. These components will have the notation of “AGxxx-G”, “FHxxx-G”, “FPxxx-G” or “AHxxx-G”. Two package suppliers have been fully qualified for the MESFET/HFET components mentioned in this report. To identify each contract manufacturer in this report, they will be mentioned as CM1 and CM2. The SOT-89 packages from both suppliers are form, fit, functional replacements of each other. The die and die attach material used by both suppliers of the RoHS-compliant SOT-89 package are the same. In addition, the plating material on the leads is NiPdAu for both suppliers. The packages from both suppliers will fit onto the same land pattern on a PCB. Electrical performances of components from both suppliers are identical. The MSL rating of the lead-free/RoHS-compliant/green SOT-89 from both suppliers meet a Level 3 with a 260 °C peak reflow temperature.


The AH102A-G was selected to qualify the MESFET/HFET amplifier family of devices in the SOT-89 package from both package suppliers. The die used in the AH102A-G is larger than any die used in the MESFET/HFET amplifier product family in the SOT-89 package. The parameters monitored for the qualification tests were Supply Current, Gain, and IP3. Failures were defined as any variation, relative to pre-stress testing, of: 10% or greater for Supply Current, a variation of 1 dB or greater for Gain, or a variation of 2 dB or greater for IP3.

## II. SCOPE

This report summarizes the reliability qualification of the AH102A-G from CM1 and CM2. By similarity, these are the devices that are fully qualified by both WJ’s packaging contract manufacturers for the SOT-89: AG101-G, AG102-G, AG103-G, AH1-G, AH1-1G, AH2-G, AH3-G, AH31-G, AH101-G, AH102A-G, AM1-G, FH1-G, FH101-G, FP101-G, FP1189-G, and FP2189-G. The reliability data are obtained through the performance of the specified accelerated stress tests described in this document. The Application Note “453654 Solderability Test Report for WJ Products With Lead-Free Package Finish” has a detailed description of the lead-free solderability tests; results of the solderability testing are shown in Section IV. The reliability data are obtained through the performance of specified accelerated stress tests described in this document.

## III. APPLICABLE DOCUMENTS

All the test procedures and test methods are consistent with industry standards. The standards referenced in this document are JEDEC standard 22.

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## IV. QUALIFICATION TEST PLAN

Stress or Test	Procedures/Conditions	Device Hours/ Cycles	Sample Size	Failed Units	Reference Document	Part Tested
Preconditioning Level 3 Lead Free	External visual 40x High Temp. Storage Life 24 hrs @+125°C Temp. & Humidity Test 192 hrs. @ +30°C/ 60% RH Convection Solder Reflow test 3 cycles w/flux immersion, peak temperature 260°C	N/A	3 lots, a total of 630 parts	0	JESD22-A113D JESD22-A101-B JESD22-B101A JESD22-A103C J-STD-020C	AH102A-G (CM1)
			3 lots, a total of 480 parts	0	JESD22-A113E JESD22-A101-B JESD22-B101A JESD22-A103C J-STD-020C	AH102A-G (CM2)
Highly-Accelerated Temperature and Humidity Stress Test (HAST)	Test Condition A Temp. 130°C (+/- 2°C) Pressure = 33.3 +/-1psia Relative Humidity = 85%	96 (-0, +2) hours	3 lots, a total of 135 parts	0	JESD22-A110-B	AH102A-G (CM1)
			3 lots, a total of 135 parts	0	JESD22-A110-B	AH102A-G (CM2)
Unbiased High Temperature Storage (HTB)	Temp. 150°C (+ 5°C, -0°C)	1000 hours	1 lot, a total of 45 parts	0	JESD22-A103-C	AH102A-G (CM1)
High Temp Op Life (HTOL)	Test Condition B Temp. 125°C (+5, -0°C)	1,000 (-0, +10) hours	3 lots, a total of 135 parts	0	JESD22-A108-B	AH102A-G (CM1)
Unbiased Autoclave (UA)	Test Condition C Temp. 121°C (+/-1°C) Pressure = 15 +/-1psig Relative Humidity = 100%	96 (-1, +5) hours	3 lots, a total of 135 parts	0	JESD22-A102-C	AH102A-G (CM1)
Temperature Cycle (TC)	Test Condition C Temp. -55°C (+0°/-10°C) to +150°C (+10°/-0°C) Dwell time = 10 to 15 min.	500 cycles	3 lots, a total of 135 parts	0	JESD22-A104C	AH102A-G (CM1)
			3 lots, a total of 135 parts	0	JESD22-A104-B	AH102A-G (CM2)
Solderability Lead-Free solder	Lead-Free Solder: Sn96Ag4 Flux Type: R145 Solder Bath Requirements: 260°C	N/A	3 lots, a total of 10 parts, 40 leads	0	JESD22-B102D Condition C	AH102A-G (CM1)
Solderability Lead-Free solder	Lead-Free Solder: 100% Sn Solder Bath Requirements: 245°C	N/A	1 lots, a total of 5 parts, 20 leads	0	JESD22-B102D Condition C	AH102A-G (CM2)
Solderability Lead solder	Lead-Free Solder: Sn63Pb37 Flux Type: R145 Solder Bath Requirements: 245°C	N/A	3 lots, a total of 10 parts, 40 leads	0	JESD22-B102D Condition C	AH102A-G (CM1)
Physical Dimensions	N/A	N/A	2 lots, a total of 2 parts	0	JESD22-B100-B	AH102A-G (CM1)
			2 lots, a total of 2 parts	0	JESD22-B100B	AH102A-G (CM2)
Moisture/Reflow Sensitivity (MSL) MSL level 3 lead free	Electrical test, External Visual C-SAM Die, Paddle and leads Dry Bake 125°C, 24 hours 30°C/60 RH, 192 hours Convection reflow 260°C, 3X External Visual, Electrical test C-SAM Die, Paddle and leads	N/A	1 lot, a total of 77 parts	0	J-STD-20C	AH102A-G (CM1)
			1 lot, a total of 90 parts	0	J-STD-20C	AH102A-G (CM2)
Electrostatic Discharge (ESD)	Charged Device Model (CDM)	N/A	15 parts	Class IV	JESD22-C101-A	AH101
	Human Body Model (HBM)	N/A	15 parts	Class 1C	JESD22-A114	AH101
	Charged Device Model (CDM)	N/A	15 parts	Class IV	JESD22-C101-A	AH1
	Human Body Model (HBM)	N/A	15 parts	Class 1B	JESD22-A114	AH1
	Charged Device Model (CDM)	N/A	21 parts	Class IV	JESD22-C101-A	FP2189
Human Body Model (HBM)	N/A	21 parts	Class 1B	JESD22-A114	FP2189	



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## V. DISCUSSION OF RESULTS

### 1. Testing procedures

The HAST and the HTOL test were performed with the devices mounted to a PCB. The PCB layout is the same as the application circuit published in the WJ Communications Data Sheet, including the recommended via pattern. The application circuit was duplicated 21 times on one large PCB for the qualification testing. The PCB layout is the same as the application circuit published in the WJ Communications Data Sheet, including the recommended via pattern. A control board consisting of 21 devices was tested before and after each set of the stressed devices to ensure measurement accuracy and repeatability.

Components are considered to have failed if any of the following occurs after being tested post-stress and compared to respective pre-stressed testing parameters for the AH102A-G: any variation of 10% or greater for Supply Current, a variation of 1 dB or greater for Gain and a variation of 2 dB or greater for OIP3. Acceptance criterion consists of having zero failures out of 45 parts to meet WJ's requirement of LTPD=5 for each test.

### 2. Pre-Conditioning

A total of 624 AH102A-G devices from CM1 and 480 AH102A-G devices from CM2 completed pre-conditioning to MSL 3 lead-free 260 °C max reflow temperature with no electrical failures. 24 of the 624 devices from CM1 and 30 of the 480 devices from CM1 underwent pre and post stress Scanning Acoustic Microscope inspection with no failures.

### 3. Highly Accelerated Temperature and Humidity (HAST)

Devices from three lots for a total of 135 AH102A-G devices from CM1 and devices from three lots for a total of 135 AH102A-G devices from CM2 completed HAST with no failures.

### 4. Unbiased High Temperature Storage (HTB)

Devices from one lot for a total of 45 AH102A-G devices from CM1 completed 1000 hours of Unbiased High Temperature Storage with no failures. The die, die attach material, leadframe material, and leadframe plating are the same from both suppliers and thus CM2 is qualified by similarity.

### 5. High Temp Op Life (HTOL)

Devices from three lots for a total of 135 AH102A-G from CM1 devices completed 1,000 hours of HTOL with no failure. This is a stress test of the die, die attach material, and leadframe material. Because these items are the same from both suppliers, a secondary test is not required.

### 6. Unbiased Autoclave (UA)

Devices from three lots for a total of 135 AH102A-G from CM1 completed Autoclave with no failures. The die attach material, leadframe material, and leadframe plating are the same from both suppliers and thus CM2 is qualified by similarity.

### 7. Temperature Cycle (TC)

Devices from three lots for a total of 135 AH102A-G devices from CM1 and devices from three lots for a total of 135 AH102A-G devices from CM2 completed 500 temperature cycles (-65 to 150 °C) with no failures. The AH102A-G contains the largest die size that WJ uses in a SOT-89 package.

### 8. Solderability

Devices from three lots for a total of 10 AH102A-G devices (40 leads) from CM1 and devices from one lot for a total of 5 AH102A-G devices (20 leads) from CM2 completed solderability testing with no failures.



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9. Physical Dimensions

2 AH102A-G devices from CM1 and 2 AH102A-G devices from CM2 completed inspection with no failures.

10. Moisture/Reflow Sensitivity Classification (MSL)

77 AH102A-G devices from CM1 and 90 AH102A-G devices from CM2 completed MSL 3 lead-free testing with no failures. The MSL results are confirmed by the pre and post preconditioning Scanning Acoustic Microscope testing of 24 pre-conditioned AH102A-G devices from CM1 and 30 pre-conditioned AH102A-G devices from CM2 (MSL level 3 lead free profile, 260 °C peak Temperature).

11. Electrostatic Discharge (ESD)

The AH1 device has been classified as a Class 1B device (Highest Voltage Level Passed between 500V and 1000V) for Human Body Model (HBM) testing according to JEDEC Standard JESD22-A114, failing at voltage levels of 800V and higher. This device has also been classified at least as high as a Class IV device (Highest Voltage Level Passed between 1000V and 2000V) for Charged Device Model (CDM) testing according to JEDEC Standard JESD22-C101. They passed at all 6 voltage levels through 1000V. These devices will also have the same ESD rating by similarity: AG101-G, AG102-G, AG103-G, AM1, AH1-1G, AH2-G, AH3-G, AH31-G, FH1-G, and FH101-G.

The AH101 has been classified as a Class 1C device (Highest Voltage Level Passed between 1000V and 2000V) for Human Body Model (HBM) testing according to JEDEC Standard JESD22-A114. They passed at all 6 voltage levels through 1000V. These devices have also been classified at least as high as a Class IV device (Highest Voltage Level Passed between 1000V and 2000V) for Charged Device Model (CDM) testing according to JEDEC Standard JESD22-C101. They also passed at all 6 voltage levels through 1000V. The AH102A-G will also have the same ESD rating by similarity.

The FP2189 has been classified as a Class 1C device (Highest Voltage Level Passed between 1000V and 2000V) for Human Body Model (HBM) testing according to JEDEC Standard JESD22-A114. Failures occurred at 1,000 volts for HBM ESD tests. The failed devices displayed a complete loss of functionality as opposed to partial degradation of RF characteristics. These devices have also been classified at least as high as a Class IV device (Highest Voltage Level Passed between 1000V and 2000V) for Charged Device Model (CDM) testing according to JEDEC Standard JESD22-C101. They also passed at all 6 voltage levels through 1000V. The FP101-G and FP1189-G G will also have the same ESD rating by similarity.

For the ESD testing, 3 units were subjected at each test voltage for both CDM and HBM ESD testing. These parts were serialized and the RF characteristics were tested. The parts were then sent to Amkor Test Services in San Jose, California to receive the controlled HBM and CDM discharges. For each of the following six voltage levels, three parts received a discharge (AH1 and AH101 testing → HBM Voltage Levels: 250, 400, 500, 600, 800, 1000V, CDM Voltage Levels: 200, 400, 500, 600, 800, 1000V; FP2189 testing → HBM Voltage Levels: 50, 100, 150, 250, 500, 750, and 1,000V, CDM Voltage Levels: 100, 250, 500, 750, 1,000 and 2,000V). Three devices for each test were used as control units, not receiving any discharge. After the respective discharges, the parts were returned to WJ Communications to determine the post-discharge RF characteristics. If any one of the three devices failed at a given voltage level, the device was said to fail at that level. If any one of the three devices failed at a given voltage level, the device was said to fail at that level. The classification level was assigned according to the last voltage level at which all three parts passed post-ESD RF testing according to the test specifications set by WJ Communications.



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## VI. CONCLUSIONS

The reliability qualification data demonstrates that GaAs MESFET/HFET devices assembled in a lead-free / RoHS-compliant / green SOT-89 surface-mount package from both of WJ's suppliers demonstrate high reliability and quality levels. The following devices are fully qualified by similarity:

AG101-G	AH1-G	FH1-G
AG102-G	AH1-1G	FH101-G
AG103-G	AH2-G	FP101-G
AM1-G	AH3-G	FP1189-G
	AH31-G	FP2189-G
	AH101-G	
	AH102A-G	



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