



I. SUMMARY

The AG Product family consists of InGaP HBT products in a Darlington Pair configuration with all of the products having the same basic design. Differences in product power consumption and performance are related to the number of second stage transistors that are connected in the circuit. Otherwise, the layouts of the circuits are identical. The surface-mount packages (SOT-363, SOT-86, & SOT-89) were chosen by considering the existing footprints of competing parts and thermal properties of the die-package combination. For the purpose of this qualification, the available device with the highest operating temperature was chosen for each of the package styles: AG303-63, AG403-86, and AG604-89. All other devices in the same packaging and having a lower junction temperature are qualified by similarity. The AG60x-86 devices were not available during the start of the qualification testing and thus are not covered in this qualification report. A separate report will cover the reliability for those devices. The parameters monitored for the qualification tests were Supply Current, Voltage, Gain, and Input Return Loss. Failures are defined as any variation of 10% or greater for supply current or a variation of 1 dB or greater for the RF parameters as compared to the initial pre-stressed testing. The results of the individual qualification tests are located in Section VII, VIII, and IX.

II. SCOPE

This report summarizes the reliability qualification of the AG Series gain blocks, with the models listed below. They are produced at an outsourced fabrication facility and assembled in various surface mount plastic packages - SOT-363, SOT-86, & SOT-89. The reliability data are obtained through the performance of specified accelerated stress tests described in this document.

AG201-63	AG201-86	AG402-86	AG402-89
AG202-63	AG202-86	AG403-86	AG403-89
AG203-63	AG203-86	AG503-86	AG503-89
AG302-63	AG302-86	AG602-89	AG604-89
AG303-63	AG303-86	AG603-89	

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.

IV. QUALIFICATION TEST PLAN AND RESULTS

SOT-363 PACKAGE

Stress or Test	Procedures / Conditions	Device Hours/ Cycles	Sample Size	Failed Units	Date	Reference Document	Part Tested
Preconditioning Level 1	External visual 40x High temp storage life: 24 hrs @ +125°C Temp. & Humidity Test 168 hrs. @ +85°C / 85% RH Infrared Solder Reflow (IR) test 3 cycles w/flux immersion, peak temp: 235°C	N/A	3 lots, a total of 693 parts (used for TC, UA, & HAST tests)	N/A	Q2 - Q3 2002	JESD22-A113 JESD22-A101 JESD22-B101 JESD22-103 JESD22-A112.4	AG303-63
Temperature Cycle	Test Condition C Temp. -65° C to +150° C Dwell time = 10 to 15 min.	500 cycles	3 lots, 77 parts per lot	0	Q2 - Q3 2002	JESD22-A104-B	AG303-63
Unbiased Autoclave	Test Condition C Temp. 121°C, 15 psig, RH = 100%	96 hours	3 lots, 77 parts per lot	0	Q2 - Q3 2002	JESD22-A102-C	AG303-63
Unbiased High Temperature Storage	Temp. 150° C	1000 hours	1 lot, 77 total parts	0	Q2 - Q3 2002	JESD22-A108-B	AG303-63
Highly-Accelerated Temperature & Humidity Stress Test (HAST)	Test Condition A Temp. 130°C, 33.3 psig, RH = 85%	96 hours	3 lots, 77 parts per lot	1	Q2 - Q3 2002	JESD22-A110-A	AG303-63
High Temp Op Life (HTOL)	Test Condition B Temp. 125°C (+5, -0°C)	1,000 hours	3 lots, 77 parts per lot	0	Q2 - Q3 2002	JESD22-A108-B	AG303-63
Electrostatic Discharge (ESD)	Charged Device Model (CDM)	N/A	18 total parts	Pass at 250V	Q2 - Q3 2002	JESD22-C101-A	AG604-89
	Human Body Model (HBM)	N/A	18 total parts	Pass at 150V		JESD22-A114	AG604-89



SOT-363 PACKAGE (continued)

Stress or Test	Procedures / Conditions	Device Hours	Sample Size	Failed Units	Date	Reference Document	Part Tested
Physical Dimensions	N/A	N/A	1 lot, 10 total parts	0	Q2 - Q3 2002	JESD22-B100-A	AG303-63
Solderability	N/A	N/A	1 lot, 3 total parts	0	Q2 - Q3 2002	JESD22-B102	AG303-63

SOT-86 PACKAGE

Stress or Test	Procedures / Conditions	Device Hours/ Cycles	Sample Size	Failed Units	Date	Reference Document	Part Tested
Preconditioning Level 1	External visual 40x High temp storage life: 24 hrs @ +125°C Temp. & Humidity Test 168 hrs. @ +85°C / 85% RH Infrared Solder Reflow (IR) test 3 cycles w/flux immersion, peak temp: 235°C	N/A	3 lots, a total of 693 parts (for TC, UA, & HAST tests)	N/A	Q2 - Q3 2002	JESD22-A113 JESD22-A101 JESD22-B101 JESD22-103 JESD22-A112.4	AG403-86
Temperature Cycle	Test Condition C Temp. -65° C to +150° C Dwell time = 10 to 15 min.	500 cycles	3 lots, 77 parts per lot	0	Q2 - Q3 2002	JESD22-A104-B	AG403-86
Unbiased Autoclave	Test Condition C Temp. 121°C, 15 psig, RH = 100%	96 hours	3 lots, 77 parts per lot	0	Q2 - Q3 2002	JESD22-A102-C	AG403-86
Unbiased High Temperature Storage	Temp. 150° C	1000 hours	1 lot, 77 total parts	0	Q2 - Q3 2002	JESD22-A108-B	AG403-86
Highly-Accelerated Temperature & Humidity Stress Test (HAST)	Test Condition A Temp. 130°C, 33.3 psig, RH = 85%	96 hours	3 lots, 77 parts per lot	1	Q2 - Q3 2002	JESD22-A110-A	AG403-86
High Temp Op Life (HTOL)	Test Condition B Temp. 125°C (+5, -0°C)	1,000 hours	3 lots, 77 parts per lot	0	Q2 - Q3 2002	JESD22-A108-B	AG403-86
Electrostatic Discharge (ESD)	Charged Device Model (CDM) Human Body Model (HBM)	N/A N/A	18 total parts 18 total parts	Pass at 250V Pass at 150V	Q2 - Q3 2002	JESD22-C101-A JESD22-A114	AG604-89 AG604-89
Physical Dimensions	N/A	N/A	1 lot, 10 total parts	0	Q2 - Q3 2002	JESD22-B100-A	AG403-86
Solderability	N/A	N/A	1 lot, 3 total parts	0	Q2 - Q3 2002	JESD22-B102	AG403-86

SOT-89 PACKAGE

Stress or Test	Procedures / Conditions	Device Hours/ Cycles	Sample Size	Failed Units	Date	Reference Document	Part Tested
Preconditioning Level 1	External visual 40x High temp storage life: 24 hrs @ +125°C Temp. & Humidity Test 168 hrs. @ +85°C / 85% RH Infrared Solder Reflow (IR) test 3 cycles w/flux immersion, peak temp: 235°C	N/A	3 lots, a total of 693 parts (for TC, UA, & HAST tests)	N/A	Q2 - Q3 2002	JESD22-A113 JESD22-A101 JESD22-B101 JESD22-103 JESD22-A112.4	AG604-89
Temperature Cycle	Test Condition C Temp. -65° C to +150° C Dwell time = 10 to 15 min.	500 cycles	3 lots, 77 parts per lot	1	Q2 - Q3 2002	JESD22-A104-B	AG604-89
Unbiased Autoclave	Test Condition C Temp. 121°C, 15 psig, RH = 100%	96 hours	3 lots, 77 parts per lot	0	Q2 - Q3 2002	JESD22-A102-C	AG604-89
Unbiased High Temperature Storage	Temp. 150° C	1000 hours	1 lot, 77 total parts	0	Q2 - Q3 2002	JESD22-A108-B	AG604-89
Highly-Accelerated Temperature & Humidity Stress Test (HAST)	Test Condition A Temp. 130°C, 33.3 psig, RH = 85%	96 hours	3 lots, 77 parts per lot	1	Q2 - Q3 2002	JESD22-A110-A	AG604-89
High Temp Op Life (HTOL)	Test Condition B Temp. 125°C (+5, -0°C)	1,000 hours	3 lots, 77 parts per lot	2*	Q2 - Q3 2002	JESD22-A108-B	AG604-89
Electrostatic Discharge (ESD)	Charged Device Model (CDM) Human Body Model (HBM)	N/A N/A	18 total parts 18 total parts	Pass at 250V Pass at 150V	Q2 - Q3 2002	JESD22-C101-A JESD22-A114	AG604-89 AG604-89
Physical Dimensions	N/A	N/A	1 lot, 10 total parts	0	Q2 - Q3 2002	JESD22-B100-A	AG604-89
Solderability	N/A	N/A	1 lot, 3 total parts	0	Q2 - Q3 2002	JESD22-B102	AG604-89

* Please refer to Section IX (9) for further information.



V. STRESS AND TEST METHODOLOGY

All of the qualification tests were performed with the devices mounted to a PCB except for the following tests: ESD, Physical Dimensions and Solderability, which were performed on loose parts. Each board consists of up to 20 separate amplifiers with blocking capacitors, bias resistors, RF chokes, and RF connectors similar to the application circuits shown on their respective datasheets. Prior to each electrical test, a control board was measured to ensure proper test system calibration. Components are considered to have failed if the bias current varies by 10% or more or if gain changes by greater than 1 dB. Acceptance criterion consists of having zero or one failure out of 77 parts to meet WJCI's requirement of LTPD=5 for each test. Components that failed the post stress test were removed from the qualification board for analysis. Once the failure had been confirmed, I-V curves were measured using an HP 4156A Semiconductor Parametric Analyzer. In some cases, de-encapsulation was required for visual inspection of the failed device.

VI. COMPONENT CHARACTERISTICS

The design of the AG family of products consists of InGaP HBTs in a Darlington configuration (Figure 1). Higher gain and power are realized by adding additional second stage, Q2, transistors. These Q2 transistors have higher power dissipation than the Q1 transistors. As a result, Q2 is the likely failure site for thermal or electrical over-stress type failures.

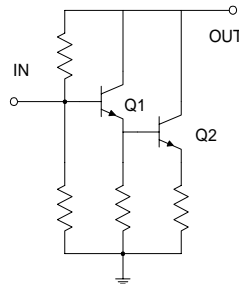


Figure 1

In characterizing Darlington circuits as a part of a failure analysis, it is useful to measure the I_c - V_{ce} curve. This data is plotted as dI_c/dV_{ce} vs. V_{ce} for easier interpretation. Each step in the curve, shown in Figure 2, represents the voltage at which the next stage turns on. The part of the curve between 0 and 1.8 V is current flowing through the voltage divider at the input of Q1. The step at 1.8 V is a result of Q1 turning on and the step at 4.2 V is due to Q2 turning on. Changes in this characteristic provide insight into which part of the circuit is not functioning properly. In instances in which it is not clear from the dI_c/dV_{ce} curve which stage is compromised, it is helpful to measure the transconductance, gm, of Q1. This measurement can isolate a problem to Q1.

dI_c/dV_{ce} vs. V_{ce}
AG403-86 Control Unit

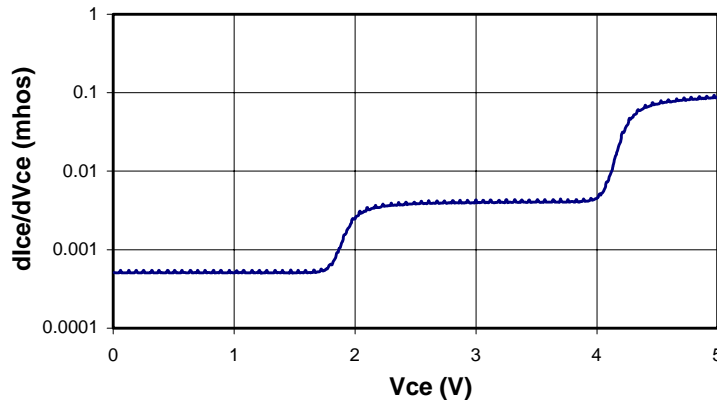


Figure 2



VII. DISCUSSION OF RESULTS – SOT-363 PACKAGE

1. Pre-Conditioning

A total of 693 AG303-63 devices (3 lots) completed pre conditioning.

2. Temperature Cycle

A total of 231 AG303-63 devices (3 lots) passed Temperature Cycle with no failures or anomalies.

3. Unbiased Autoclave

A total of 231 AG303-63 devices (3 lots) passed Unbiased Autoclave with no failures or anomalies.

4. Unbiased High Temperature Storage

A total of 77 AG303-63 devices (1 lot) passed Unbiased High Temperature Storage with no failures or anomalies.

5. ESD

The AG303-63 series parts were classified by similarity to the AG604-89 series. This data is discussed in Section IX (6).

6. Physical Dimensions

A total of 10 AG303-63 devices passed inspection with no failures.

7. Solderability

A total of 3 AG303-63 devices passed inspection with no failures.

8. Highly Accelerated Temperature and Humidity Stress Test (HAST)

77 devices from each of three lots for a total of 231 AG303-63 devices completed 96 hours of HAST. For the three lots, only one part failed. This device had Vc increase by 0.65 V and gain decrease by 0.59 dB after stress testing. Unfortunately due to the small size of the SOT-363 package, the device suffered lead damage during board removal for the failure investigation and thus will be considered a failure of indeterminate cause. The one failure, from a single lot sample of 77 parts, meets the WJCI requirement of LTPD=5 for this test.

9. High Temperature Operation Life (HTOL)

A total of 231 AG303-63 devices (3 lots) passed High Temperature Operation Life with no failures or anomalies.

10. Conclusion

The following WJ products are fully qualified and meet the failure criteria for all tests shown in the Qualification Test Plan: AG201-63, AG202-63, AG203-63, AG302-63, and AG303-63.

VIII. DISCUSSION OF RESULTS – SOT-86 PACKAGE

1. Pre-Conditioning

A total of 693 AG403-86 devices (3 lots) completed pre conditioning.

2. Temperature Cycle

A total of 231 AG403-86 devices (3 lots) passed Temperature Cycle with no failures or anomalies.

3. Unbiased Autoclave

A total of 231 AG403-86 devices (3 lots) passed Unbiased Autoclave with no failures or anomalies.

4. Unbiased High Temperature Storage

A total of 77 AG403-86 devices (1 lot) passed Unbiased High Temperature Storage with no failures or anomalies.

5. ESD

The AG403-86 series parts were classified by similarity to the AG604-89 series. This data is discussed in Section IX (6).

6. Physical Dimensions

A total of 10 AG403-86 devices passed inspection with no failures.

7. Solderability

A total of 3 AG403-86 devices passed inspection with no failures.



8. Highly Accelerated Temperature and Humidity Stress Test (HAST)

77 devices from each of three lots for a total of 231 AG403-86 devices completed 96 hours of HAST. For the three lots, only one part failed. This device had Vc increase by 0.84 V after stress testing. This part measured as a short after disassembly but root cause could not be conclusively determined. Although root cause was not found for this part, the one failure from a single lot sample of 77 parts meets the WJCI requirement of LTPD=5 for this test.

9. High Temperature Operation Life (HTOL)

A total of 231 AG403-86 devices (3 lots) passed High Temperature Operation Life with no failures or anomalies.

10. Conclusion

The following WJ products are fully qualified and meet the failure criteria for all tests shown in the Qualification Test Plan: AG201-86, AG202-86, AG203-86, AG302-86, AG303-86, AG402-86, AG403-86, and AG503-86. The qualification and reliability testing for the remaining gain blocks in a SOT-86 package – the AG602-86, AG603-86, and AG604-86 – will be covered in a separate report.

IX. DISCUSSION OF RESULTS – SOT-89 PACKAGE

1. Pre-Conditioning

A total of 693 AG604-89 devices (3 lots) completed pre conditioning.

2. Temperature Cycle

77 devices from each of three lots for a total of 231 AG604-89 devices completed Temperature Cycle. During post-stress on-board testing, one lot had 7 parts measuring as opens on the qualification board. One of the seven parts was lost during removal from the board. The remaining 6 parts passed RF screening when measured in a fixture. This suggests that a problem existed with the qualification board as a result of the stress. It was observed that all of the boards were warped and some exhibited cracking. The lost part will be considered a failure. The one failure from a single lot sample of 77 parts meets the WJCI requirement of LTPD=5 for this test. The other two lot samples had no failures.

3. Unbiased Autoclave

A total of 231 AG604-89 devices (3 lots) passed Unbiased Autoclave with no failures or anomalies.

4. Unbiased High Temperature Storage

A total of 77 AG604-89 devices (1 lot) passed Unbiased High Temperature Storage with no failures or anomalies.

5. ESD

18 AG604-89 devices completed CDM testing and another 18 AG604-89 devices completed HBM ESD testing at a variety of different voltage level with no unexpected failures. 3 additional AG604-89 devices were used in the testing as control units. The AG series devices have been classified as a **Class 0 device** (Highest Voltage Level Passed for 150V) for Human Body Model (HBM) testing according to JEDEC Standard JESD22-A114 and as a **Class II device** (Highest Voltage Level Passed at 250V) for Charged Device Model (CDM) testing according to JEDEC Standard JESD22-C101.

3 units were subjected at each test voltage for both CDM and HBM ESD testing. The CDM and HBM test voltages were 50, 100, 150, 200, and 250 volts. For the Charged Device Model, no failures were observed up to 250 V. For the Human Body Model, the components began to degrade at 200 V. The characteristic reduction in current and gain was observed in the degraded parts. 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.

6. Physical Dimensions

A total of 10 AG604-89 devices passed inspection with no failures.

7. Solderability

A total of 3 AG604-89 devices passed inspection with no failures.

8. Highly Accelerated Temperature and Humidity Stress Test (HAST)

77 devices from each of three lots for a total of 231 AG604-89 devices completed 96 hours of HAST. For the three lots, only one part failed. This device had Vc increase by 0.84 V after stress testing. When performing DC testing on this part, the device began to oscillate and shorted out. Thus root cause of the failure was unable to be determined. Although root cause was not found for this part, the one failure from a single lot sample of 77 parts meets the WJCI requirement of LTPD=5 for this test.



9. High Temperature Operation Life (HTOL)

77 devices from each of three lots for a total of 231 AG604-89 devices completed High Temperature Operation Life. Two of the lots had zero failures. For the third lot, two parts had the gain increase by 1.09 dB after stress testing. After de-assembly for one of the devices, the failure analysis concluded that the cause of the failure was due to an ESD event. It should be noted that this type of failure mode is not a targeted failure mode for the HTOL stress test and this unit will not be considered as a stress failure for this lot. The second failed device was damaged due to human error during the de-assembly process and thus will be considered a failure of indeterminate cause.

In summary, two lots contained zero failures from a sample size of 154 parts. The third lot contained two failures out of a sample size of 77 parts, one unrelated to the HTOL stress testing. . In addition, 6 other lots of 77 parts per lot went through HTOL testing with no failures (refer to Sections VII.9 and VIII.9). Thus overall for all nine lots shown in this qualification report, only two failures occurred out of a total of 693 parts. On the basis of the extensive HTOL testing, it can safely be concluded that the AG604-89 devices also pass HTOL testing.

10. Conclusion

The following WJ products are fully qualified and meet the failure criteria for all tests shown in the Qualification Test Plan: AG402-89, AG403-89, AG403-89, AG602-89, AG603-89, and AG604-89.

X. CONCLUSIONS

The data presented demonstrates that the WJ Communications' InGaP HBT gain blocks (AG series) meet WJ's rigorous high quality standards and conform to WJ's long history of producing high quality products. The test results described in this document support the full qualification of the products listed in the following table:

AG201-63	AG201-86	AG402-86	AG402-89
AG202-63	AG202-86	AG403-86	AG403-89
AG203-63	AG203-86	AG503-86	AG503-89
AG302-63	AG302-86	AG602-89	AG604-89
AG303-63	AG303-86	AG603-89	