FP31QF-F QUALIFICATION REPORT

I. INTRODUCTION

The FP31QF-F is a 2-Watt GaAs Heterostructure Field Effect Transistors (HFETs). The FP31QF-F is targeted for use as driver amplifiers and is encapsulated in a Lead-Free RoHS-compliant 28 pin 6x6 mm QFN package. The die for the FP31QF-F is produced at WJ Communications' GaAs fabrication facility in Milpitas, CA.

II. SCOPE

This report summarizes the reliability qualification for FP31QF-F HFET. The reliability data are obtained through the performance of specified accelerated and stress tests described in this document. The qualification of the FP31QF-F is obtained by similarity to qualification testing performed on the FP31QF-F and CV210-1F. The die is qualified using FP31QF-F while the package is qualified by similarity to CV210-1F. CV210-1F uses the same 28-pin 6x6 mm RoHS-compliant QFN package.

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. Pass/Failure criteria are defined in JEDEC publication, JEP 118. Qualification Family is defined in JESD47-A.

IV. QUALIFICATION TEST PLAN/RESULTS

DIE TEST PLAN

Stress or Test	Procedures/Conditions	Device Hours/ Cycles	Sample Size	Failed Units	Reference Document	Part Tested
Preconditioning Level 1	Moisture Sensitivity Level 1, Pb free High temp storage life: 24 hrs @ +125°C Temp. & Humidity Test 168 hrs. @ +85°C / 85% RH Convection Reflow test 3 cycles w/ flux immersion, peak temp: 250°C	N/A	3 lots, a total of 600 parts (for TC, UA, & HAST tests)	N/A	JESD22-A113B J-STD-020A	FP31QF-F
Temperature Cycle (TC)	Test Condition C Temp. -65°C to +150°C Dwell time = 10 to 15 min.	500 cycles	3 lots, 45 parts per lot	0	JESD22-A104-B	FP31QF-F
Unbiased Autoclave (UA)	Test Condition C Temp. 121°C, 29.7 psia, RH = 100%	96 hours	3 lots, 45 parts per lot	0	JESD22-A102-C	FP31QF-F
Unbiased High Temperature Storage (HTB)	Temp. 150°C (+/- 10 C)	1000 hours	1 lot, 45 total parts	0	JESD22-A103-B	FP2189 AH201
Highly-Accelerated Temperature and	Test Condition A Temp. 130°C, 33.3 psia , RH = 85%	96 hours	3 lots, a total of 135 parts	0	JESD22-A110-B	FP31QF-F

Humidity Stress Test (HAST)	Bias Conditions: Pinched Off with Vg = -4 V, Vd = +9 V					
High Temp Op Life (HTOL)	Test Condition B Temp. 125°C (+5, -0°C)	1,000 hours	3 lots, a total of 135 parts	0	JESD22-A108-B	FP31QF-F
Electrostatic Discharge (ESD)	Charged Device Model (CDM)	Class IV	1 lot, 15 total parts	0 failures through 2000 V	JESD22-C101-A	FP31QF-F
	Human Body Model (HBM)	Class 1C	1 lot, 15 total parts	0 failures through 1000 V	JESD22A-A114	FP31QF-F

PACKAGE TEST PLAN

Stress or Test	**Procedures/Conditions**	**Device Hours/ Cycles**	**Sample Size**	**Failed Units**	**Reference Document**	**Part Tested**
Preconditioning Level 1 Lead Free	External visual 40x High Temp. Storage Life 24 hrs @+125°C Temp. & Humidity Test 168 hrs. @ +85°C/ 85% RH Convection Solder Reflow test 3 cycles w/flux immersion, peak temperature 260°C	N/A	3 lots, a total of 660 parts	0	JESD22-A113C JESD22-A101-B JESD22-B101 JESD22-A103-B J-STD-020B	CV210-1F
Temperature Cycle (TC)	Test Condition C Temp. -65°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-A104-B	CV210-1F
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	CV210-1F
Unbiased High Temperature Storage (HTB)	Temp. 150°C (+ 5°C, -0°C)	1000 hours	1 lot, a total of 80 parts	0	JESD22-A103-B	CV210-3
Highly-Accelerated Temperature and Humidity Stress Test (HAST)	Test Condition A Temp. 130°C (+/- 2°C) Pressure = 33.3 +/-1psig Relative Humidity = 85%	96 (-0, +2) hours	3 lots, a total of 135 parts	0	JESD22-A110-B	CV210-1F
Solderability Lead-Free solder	Lead-Free Solder: Sn96Ag4 Flux Type: R145 Solder Bath Requirements: 260°C	N/A	3 lot, a total of 30 parts, 840 pins	0	IPC/EIA/JEDEC J-STD-002B Method 2003)	CV210-1F
Solderability Lead solder	Solder: Sn63Pb37 Flux Type: R145 Solder Bath Requirements: 245°C	N/A	3 lot, a total of 30 parts, 840 pins	0	IPC/EIA/JEDEC J-STD-002B Method 2003)	CV210-1F
Moisture/Reflow Sensitivity (MSL) MSL level 1 lead free	Electrical test External Visual C-SAM Die, Paddle and leads Dry Bake 125°C, 24 hours 85°C/85 RH, 168 hours Convection reflow 250°C, 3X External Visual Electrical test C-SAM Die, Paddle and leads	N/A	3 lot, a total of 300 parts	0	J-STD-20B	CV210-1F

V. STRESS AND TEST METHODOLOGY

All of the qualification tests were performed with the devices mounted to a PCB except for the following tests: Autoclave, Temperature Cycle, and ESD, which were performed on loose parts. Fifteen identical application circuits with active biasing were designed into each Qualification Circuit Board used. The active bias network supplies the devices with a required negative gate-to-source voltage, a positive drain voltage, and targeted drain current. More details regarding the active bias network can be found on a separate Application Note found on the website as "**Active-Bias Constant - Current Source Recommended for WJ HFET devices**." The input and output matching circuitry were designed so that the amplifier circuit was unconditionally stable.

Prior to each electrical test, a control board consisting of fifteen unstressed FP31QF-F devices with their respective application circuits was measured 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 their respective pre-stressed testing parameters: a) a variation of more than 20% in drain current, b) a variation of more than 1 dB in small-signal gain, or c) a variation of more than 1 dB for P1dB. Acceptance criterion consists of having zero failures out of 45 parts to meet WJ's requirement of LTPD=5 for each test.

The parameters monitored for the CV210-1F qualification were Supply Current, Conversion Gain, OIP3 and OIP2. Failures are defined as any variation of 10% or greater for Supply Current, a variation of 2 dB or greater for OIP3 and OIP2 and a variation of 1 dB or greater for Conversion Gain.

VI. DISCUSSION OF RESULTS

1. **Pre-Conditioning**
   For die qualification, a total of 600 FP31QF-F devices from three lots, 200 devices per lot, completed pre-conditioning.

   For package qualification, three lots of 220, a total of 660 CV210-1F devices, completed pre-conditioning with no electrical failures. Sixty of the 660 devices underwent pre and post stress Scanning Acoustic Microscope inspection with no failures.

2. **Temperature Cycle**
   For die qualification, a total of 135 FP31QF-F devices from three lots, 45 per lot, completed 500 temperature cycles with no failures.

   For package qualification, 135 CV210-1F devices from three lots completed 500 temperature cycles with 0 failures.

3. **Unbiased Autoclave**
   For die qualification, a total of 135 FP31QF-F devices from three lots, 45 per lot, completed 96 hours of Autoclave with no failures.

   For package qualification, 135 CV210-1F devices from three lots completed Autoclave with 0 failures.

4. **Unbiased High Temperature Storage (HTB)**
   For die qualification, device is qualified by similarity to the FP2189 and package is qualified by 6x6 mm QFN package family.

   For package qualification, a total of 80 CV210-3 devices from one lot completed 1000 hours of Unbiased High Temperature Storage with 0 failures.

5. **Highly Accelerated Temperature and Humidity Stress Test (HAST)**

For die qualification, a total of 135 FP31QF-F devices from three lots completed 96 hours of HAST with no failures. Parts were biased for Pinchoff conditions with –4 volts on the gate and +9 volts on the drain to minimize power dissipation, distribute potential differences across chip metallization as much as possible and maximize voltage within operating range of bias conditions.

For package qualification, 135 CV210-1F devices from three lots completed HAST with 0 failures.

6. High Temperature Op Life (HTOL)

A total of 135 FP31QF-F devices from three lots, 45 per lot, completed 1000 hours of HTOL with no failures.

7. ESD

A total of 30 FP31QF-F devices completed CDM and HBM ESD testing at a variety of different voltage levels with no unexpected failures. The FP31QF-F device 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 and as a Class IV device (Highest Voltage Level Passed up to 2000V) 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 test voltages were 100, 200, 500, 1000 and 2000 volts. The HBM test voltages were 250, 500, 750, 1000 and 2000 volts. Failures occurred at 2000 volts for HBM ESD tests. The failed devices displayed a complete loss of functionality as opposed to partial degradation of RF characteristics. 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. There were no failures of devices subjected to CDM test voltages up through 2000 volts.

8. Solderability

30 CV210-1F devices from three lots completed Lead-Free and Lead solderability testing with 0 failures. The samples were subjected to the solderability test in accordance with IPC/EIA/JEDEC J-STD-002B. The temperature of the solder bath was maintained at 260°C, and usage was made of a lead-free solder Sn96Ag4 for this test. The solderability test involved an 8-hour steam aging step to verify the durability of the finish plating.

It should be noted that the terminal finish for this lead-free QFN package is matte-tin over copper. The Application Note "*453654 Solderability Test Report for WJ Products With Lead-Free Package Finish*" on the WJ website has a detailed description of the lead-free solderability tests.

9. Moisture/Reflow Sensitivity Classification (MSL)

300 CV210-1F devices from three lots completed MSL level 1 lead free testing with no failures. The MSL results are confirmed by the pre and post preconditioning Scanning Acoustic Microscope testing that the 60 pre-conditioned CV210-1F devices underwent (MSL level 1 lead free profile, 260 °C peak Temperature).

The MSL rating of the QFN 6X6 28-pin package is MSL 2, 260°C. While the package did pass MSL l preconditioning, it is being rated MSL 2 so that the parts will be baked out and dry packed. This will also force better handling of the device at contract manufacturers, and should improve the robustness of the device.

VII. CONCLUSION

The FP31QF-F amplifier in the Lead-Free RoHS-compliant, 28-pin 6x6mm QFN package is reliable product that has passed industry standard qualification testing.