EPC eGaN® FET Qualification Report EPC21701

Dr. Shengke Zhang, VP of Reliability, Efficient Power Conversion

This report summarizes the Product Qualification results for EPC part number EPC21701 which meets all required qualification requirements and is released for production.

Scope

The testing matrix in this qualification report covers the qualification tests performed on EPC21701 and EPC21601 for the component-level qualification. EPC21701 is an 80 V, 15 A, 3.3 V Logic, eToF™ Laser Driver Integrated Circuit (IC) and it uses wafer level chip scale packaging with a ball grid array (BGA) configuration.

Part Number	Die Size (mm x mm)
EPC21701	S (1.7 x 1)
EPC21601	S (1.5 x 1)

Qualification Test Overview

Devices of EPC21701 and EPC21601 were subjected to a wide variety of stress tests, according to JEDEC standard JESD47K. The stress tests include the following:

- High Temperature Operating Life (HTOL): Parts are subjected to recommended operating conditions at TJ=125°C for 1000 hours.
- Temperature Humidity Bias (THB): Parts are tested at recommended operating conditions while exposed to ambient temperature of 85°C and 85% relative humidity (RH) for 1000 hours.
- High Temperature Storage Life (HTSL): Parts are subjected to a bake at 150°C for 1000 hours.
- Preconditioning (PC): Parts undergo the following steps in sequence: (1) 125°C bake for a minimum of 24 hours; (2) Moisture Sensitivity Level 1 (MSL1) conditions (see MSL1 details below); (3) three times reflow.
- Unbiased highly accelerated test (uHAST): Parts are stressed in a non-condensing humid environment for 96 hours at 130°C, 85% RH, and vapor pressure 33.3 psia.
- Temperature cycling (TC): Parts are subjected to alternating low and high temperature extremes from -40°C to +125°C for a total of 850 cycles.
- MSL1: Parts are subjected to moisture, temperature, and three cycles of reflow. MSL1 is the most stringent of the moisture sensitivity levels, requiring 85°C and 85% humidity for 168 hours.
- Electrostatic Discharge (ESD) Characterization: Parts are tested under both Human Body Model (HBM) to assess device susceptibility to electrostatic discharge events.

All devices tested in this qualification underwent external visual inspection. Chips were inspected using an optical microscope to check for signs of physical damage to the chip-scale package, e.g., edge chipping or cracks, resulting from assembly, transit, or inadequate handling. Damaged parts were removed from the test population.

Parametric measurements were performed at 25°C on all the samples before and after the stress tests to verify compliance with the specifications listed on the product datasheet. The parameters measured include quiescent and operating currents of the driver (V_{DD} pin), DC static parameters of the output transistor such as threshold voltage and drain-source leakage current, and input threshold voltages and hysteresis for the logic input signal (V_{IN}).

For most of the qualification tests, parts were mounted onto high T_g FR-4 adaptor cards with four layers and 1.6 mm in thickness. Type-4 SAC305 solder paste with water-soluble (W/S) flux was used for mounting the parts onto the adaptor cards. After assembly, flux residue was cleaned using deionized (DI) water.

High Temperature Operating Life

Parts were subjected to the maximum recommended operating voltages at the maximum recommended operating temperature for a stress period of 1000 hours. As shown in Table 1 below, three lots and 77 samples per lot were tested for EPC21701 and EPC21601, respectively. Parts were mounted on high T_g FR-4 adapter cards. The test was conducted in accordance with JESD22-A108.

Stress Test	Part Number	Voltage (V)	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Hrs)
HTOL	EPC21701	80	S (1.7 x 1)	T_J = 125°C, V_{DD} = 5.5 V V_{D_DC} = 60 V, R_{LOAD} = 4 Ω V_{IN} = 3.3 V_{P-P} (10-pulse burst; burst frequency = 1 kHz; pulse frequency = 25-30 MHz)	0	77 x 3	1000
HTOL	EPC21601	40	S (1.5 x 1)	T_J = 125°C, V_{DD} = 5.5 V V_{D_DC} = 30 V, R_{LOAD} = 2 Ω V_{IN} = 3.3 V_{P-P} (10-pulse burst; burst frequency = 1 kHz; pulse frequency = 25-30 MHz)	0	77 x 3	1000

Table 1. High Temperature Operating Life Test

Temperature Humidity Bias

Parts from EPC21701 were subjected to maximum recommended operating voltages (V_{D_DC} = 60 V and V_{DD} = 5.5 V) and 85°C and 85% relative humidity for a stress period of 1000 hours. Devices from EPC21601 were also subjected to maximum recommended operating voltage (V_{D_DC} = 30 V and V_{DD} = 5.5 V) and 85°C and 85% relative humidity for a stress period of 1000 hours. The results are shown in Table 2 below, three lots and 25 samples per lot were tested. Parts were mounted on high T_g FR-4 adapter cards. Stress testing was conducted in accordance with JESD22-A101.

Stress Test	Part Number	Voltage (V)	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Hrs)
THB	EPC21701	80	S (1.7 x 1)	T_A = 85°C, R_H = 85%, V_{DD} = 5.5 V V_{D_DC} = 60 V, R_{LOAD} = 4 Ω, V_{IN} = 0 V	0	25 x 3	1000
THB	EPC21601	40	S (1.5 x 1)	T_A = 85°C, R_H = 85%, V_{DD} = 5.5 V V_{D_DC} = 30 V, R_{LOAD} = 2 Ω, V_{IN} = 0 V	0	25 x 3	1000

Table 2. High Temperature Gate Bias Test

High Temperature Storage Life

Parts from one lot of EPC21701 and three lots of EPC21601 (25 parts per lot) were exposed to ambient temperature of 150°C for a total of 1000 hours.

Stress Test	Part Number	Voltage (V)	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Hrs)
HTS	EPC21701	80	S (1.7 x 1)	T_A = 150°C Air, Unbiased	0	25 x 1	1000
HTS	EPC21601	40	S (1.5 x 1)		0	25 x 3	1000

Table 3. High Temperature Storage Test

Unbiased Highly Accelerated Test

One lot of EPC21701 and three lots of EPC21601 (25 parts per lot) were subjected to 96 hours at a temperature of 130°C, relative humidity of 85%, and vapor pressure of 33.3 psia. As summarized in Table 4 below.

Stress Test	Part Number	Voltage (V)	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Hrs)
uHAST	EPC21701	80	S (1.7 x 1)	T_A = 130°C, RH = 85%, VP = 33.3 psia, Unbiased	0	25 x 1	96
uHAST	EPC21601	40	S (1.5 x 1)		0	25 x 3	96

Table 4. Unbiased Highly Accelerated Test

Temperature Cycling

Three lots of EPC21701 and 25 parts per lot were subjected to temperature cycling between -40°C and 125°C for a total of 850 cycles. Three lots of EPC21601 and 25 parts per lot were subjected to temperature cycling between -40°C and 125°C for a total of 1000 cycles. In accordance with JEDEC Standard JESD22-A104, minimum dwell time was five minutes and heating/cooling rates were approximately 5°C per minute.

Stress Test	Part Number	Voltage (V)	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Cys)
TC	EPC21701	80	S (1.7 x 1)	T_A = -40°C to +125°C Unbiased	0*	25 x 3	850
TC	EPC21601	40	S (1.5 x 1)		0	25 x 3	850

Table 5. Temperature Cycling Test

* During the 500 cycles of post electrical screening, one device from EPC21701 failed due to a leakage current test that is not specified in the datasheet. All datasheet specified parameters passed the datasheet limits. Failure analysis is completed, where we did not find any evidence suggesting that the leakage failure characteristic was caused by the temperature cycling stress that is intended to test the solder joint reliability. In addition, as we continued the temperature cycling stress to 850 cycles, no additional failure was found in any of the three lots. Based on the findings and analyses discussed previously, we decided to discount this soft failure on a test item that is not included in the datasheet.

Moisture Sensitivity Level 1

Parts were subjected to MSL1 conditions in accordance with the IPC/JEDEC joint Standard J-STD-020 for Pb-free solder.

Stress Test	Part Number	Voltage (V)	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Hrs)
MSL1	EPC21701	80	S (1.7 x 1)	T_A = 85°C, RH = 85% 3x reflow	0	25 x 3	168
MSL1	EPC21601	40	S (1.5 x 1)		0	25 x 3	168

Table 6. Moisture Sensitivity Level Test

Electrostatic Discharge (ESD) Sensitivity

One lot of EPC21701 and one lot of EPC21601 were subjected to ESD sensitivity test using the human body model (HBM). Testing was conducted according to JS-001-2017 JEDEC standard. Device parameters were measured before and after ESD testing. Results are shown in Table 7 below. EPC21701 passed HBM with a rating of 500 V and EPC21601 passed HBM with a rating of 250 V.

The charged device model (CDM) rating is highly dependent on the total package size of a device, where a small part is less susceptible to the CDM damage at a given voltage as compared to a larger part. EPC21701 and EPC21601 both are chip scale package (CSP) products that do not have a package. In addition, the intrinsic die areas of both devices are very small, which are measured at 1.87 mm^2 and 1.65 mm^2, respectively. CDM testing was previously conducted on a large quantity of CSP products that have significantly larger die size than EPC21701 and EPC21601, where 1 kV CDM rating was found consistently. Therefore, both EPC21701 and EPC21601 shall be capable of a CDM rating of 1 kV by matrix.

Stress Test	Part Number	Voltage (V)	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)
ESD-HBM	EPC21701	80	S (1.7 x 1)	500 V	0	3 x 1
ESD-HBM	EPC21601	40	S (1.5 x 1)	250 V	0	3 x 1

Table 7. Electrostatic Discharge (ESD) Sensitivity