

# EPC eGaN<sup>®</sup> FET

## Qualification Report

### EPC21603



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

***This report summarizes the Product Qualification results for EPC part number EPC21603 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 EPC21603 for the component-level qualification. EPC21603 is an 40V, 10A, eToF™ Laser Driver Integrated Circuit (IC) that is controlled by low voltage differential signal (LVDS) logic using wafer level chip scale package with a ball grid array (BGA) configuration. Devices of EPC21603 are matrix qualified with EPC21601 and EPC21701 because they share the same technology platform and use identical packaging technology.

Part Number	Die Size (mm x mm)
EPC21603	S (1.50 x 1.00)
EPC21601	S (1.50 x 1.00)
EPC21701	S (1.70 x 1.00)

#### Qualification Test Overview

Parts of EPC21603 were subjected to a wide variety of stress tests, according to JEDEC standard JESD47L. HTOL and HBM ESD tests were conducted due to the GaN driver circuitry change. This implementation added two differential voltage logic inputs (IN+ and IN-) in place of the previous single logic input (IN) used in EPC21601 or EPC21701. Adding two differential voltage logic inputs requires changes to the solder bump pinout which subsequently leads to modifications to the metal routing layers. Therefore, THB and TC tests are warranted due to changes to the package and the metal routing layers. Parts underwent preconditioning prior to THB and TC tests.

The stress tests include the following:

- High Temperature Operating Life (HTOL): Parts are subjected to recommended operating conditions at  $T_J = 125^\circ\text{C}$  for 1000 hours.

- Preconditioning (PC): Parts undergo the following steps in sequence: (1)  $125^\circ\text{C}$  bake for a minimum of 24 hours; (2) Moisture Sensitivity Level 1 (MSL1) conditions (see MSL1 details below); (3) three times reflow.
- MSL1: Parts are subjected to moisture, temperature, and three cycles of reflow. MSL1 is the most stringent of the moisture sensitivity levels, requiring  $85^\circ\text{C}$  and 85% humidity for 168 hours.
- Temperature Humidity Bias (THB): Parts are tested at recommended operating conditions while exposed to ambient temperature of  $85^\circ\text{C}$  and 85% relative humidity (RH) for 1000 hours.
- Temperature cycling (TC): Parts are subjected to alternating low and high temperature extremes from  $-40^\circ\text{C}$  to  $+125^\circ\text{C}$  for a total of 1000 cycles.
- Electrostatic Discharge (ESD) Characterization: Parts are tested under both Human Body Model (HBM) to assess device susceptibility to electrostatic discharge events. ESD testing is required due to the active circuit changes in EPC21603.

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  $25^\circ\text{C}$  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), differential input voltage, DC static parameters of the output transistor such as threshold voltage and drain-source leakage current.

For all the qualification tests, parts were mounted onto high  $T_g$  FR-4 adaptor cards with four layers and 1.6mm 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, one lot of 77 samples were tested for EPC21603. Parts were mounted on high  $T_g$  FR-4 adapter cards. The test was conducted in accordance with JESD22-A108.

Stress Test	Part Number	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Hrs)
HTOL	EPC21603	S (1.50 x 1.00)	$T_J = 125^\circ\text{C}$ $V_{D-D} = 5.5\text{ V}, V_{D-DC} = 30\text{ V}, R_{LOAD} = 2\ \Omega$ $V_{IN} = 3.3\text{ V}_{p-p}$ (10-pulse burst; burst frequency = 1 kHz; pulse frequency = 25-30 MHz)	0	77 x 1	1000
HTOL	EPC21601	S (1.70 x 1.00)	$T_J = 125^\circ\text{C}$ $V_{D-D} = 5.5\text{ V}, V_{D-DC} = 60\text{ V}, R_{LOAD} = 4\ \Omega$ $V_{IN} = 3.3\text{ V}_{p-p}$ (10-pulse burst; burst frequency = 1 kHz; pulse frequency = 25-30 MHz)	0	77 x 3	1000
HTOL	EPC21701	S (1.50 x 1.00)	$T_J = 125^\circ\text{C}$ $V_{D-D} = 5.5\text{ V}, V_{D-DC} = 30\text{ V}, R_{LOAD} = 2\ \Omega$ $V_{IN} = 3.3\text{ V}_{p-p}$ (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 were subjected to maximum recommended operating voltages and 85°C and 85% relative humidity for a stress period of 1000 hours. As 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	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Hrs)
THB	EPC21603	S (1.50 x 1.00)	$T_A = 85^\circ\text{C}, R_H = 85\%$ $V_{DD} = 5.5\text{ V}, V_{D-DC} = 30\text{ V}$ $R_{LOAD} = 2\ \Omega$	0	77 x 1	1000
THB	EPC21601	S (1.50 x 1.00)	$T_A = 85^\circ\text{C}, R_H = 85\%$ $V_{DD} = 5.5\text{ V}, V_{D-DC} = 30\text{ V}, V_{IN} = 0\text{ V}$ $R_{LOAD} = 2\ \Omega$	0	25 x 3	1000
THB	EPC21701	S (1.70 x 1.00)	$T_A = 85^\circ\text{C}, R_H = 85\%$ $V_{DD} = 5.5\text{ V}, V_{D-DC} = 60\text{ V}, V_{IN} = 0\text{ V}$ $R_{LOAD} = 4\ \Omega$	0	25 x 3	1000

Table 2. High Temperature Gate Bias Test

**Temperature Cycling**

One lot of EPC21603 and 77 parts 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 15°C per minute.

Stress Test	Part Number	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Cys)
TC	<b>EPC21603</b>	S (1.50 x 1.00)	T <sub>A</sub> = -40°C to +125°C Unbiased	0	77 x 1	1000
TC	<b>EPC21601</b>	S (1.50 x 1.00)		0	25 x 3	850
TC	<b>EPC21701</b>	S (1.70 x 1.00)		0	25 x 3	850

Table 3. Temperature Cycling Test

**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	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)	Duration (Hrs)
MSL1	<b>EPC21603</b>	S (1.50 x 1.00)	T <sub>A</sub> = 85°C, RH = 85% 3x reflow	0	160 x 1	168
MSL1	<b>EPC21601</b>	S (1.50 x 1.00)		0	25 x 3	168
MSL1	<b>EPC21701</b>	S (1.70 x 1.00)		0	25 x 3	168

Table 4. Moisture Sensitivity Level Test

**Electrostatic Discharge (ESD) Sensitivity**

One lot of EPC21603 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 5 below. EPC21603 passed HBM with a rating of 250 V.

The charged device model (CDM) rating is highly dependent on the 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. EPC21603 is a small (1.5 x 1.0 mm) chip scale package (CSP) product that does not have a package. CDM testing was previously conducted on a large quantity of CSP products that have significantly larger devices, where a 1 kV CDM rating was consistently tested. Therefore, all three devices listed below including EPC21603 shall be capable of a CDM rating of 1 kV by matrix.

Stress Test	Part Number	Die Size (mm x mm)	Test Condition	# of Failure	Sample Size (unit x lot)
ESD-HBM	<b>EPC21603</b>	S (1.50 x 1.00)	250V	0	3 x 1
ESD-HBM	<b>EPC21601</b>	S (1.50 x 1.00)	250 V	0	3 x 1
ESD-HBM	<b>EPC21701</b>	S (1.70 x 1.00)	500 V	0	3 x 1

Table 5. Electrostatic Discharge (ESD) Sensitivity