

AOS Semiconductor Product Reliability Report

AOZ5311NQi rev 1.1

Plastic Encapsulated Device

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This AOS product reliability report summarizes the qualification results for AOZ5311NQi in QFN5x5 - 31L package.

Review of the electrical test results confirmed that AOZ5311NQi passes AOS quality and reliability requirements for final product and package release.

I. Table of Contents:

General Description:

AOZ5311NQi is a high-efficiency synchronous buck power stage module consisting of two asymmetrical MOSFETs and an integrated driver. AOZ5311NQi is available in a tiny 5mm x 5mm 31-pin QFN package and is rated over a -40°C to +125°C operating temperature range.

Absolute Maximum Ratings	
Parameter	
Low Voltage Supply VCC, PVCC	-0.3V to 7V
High Voltage Supply VIN	-0.3V to 25V
Control Inputs PWM, FCCM	-0.3V to (VCC+0.3V)
Bootstrap Voltage DC (BOOT - PGND)	-0.3V to 32V
Bootstrap Voltage DC (BOOT - VSWH)	-0.3V to 7V
Bootstrap Voltage Transient (1) (BOOT - VSWH)	-0.3V to 9V
Switching Node Voltage DC VSWH	-0.3V to 25V
Switching Node Voltage Transient (2) VSWH	-8V to 33V
Low Side Gate Voltage DC GL	(PGND-0.3V) to (PVCC+0.3V)
Low Side Gate Voltage Transient (2) GL	(PGND-2.5V) to (PVCC+0.3V)
Storage Temperature (Ts)	-65°C to 150°C
Max Junction Temperature (Tj)	150°C
ESD Rating (3)	2kV
Recommended Operating Ratings	
High Voltage Supply VIN, VSWH	4.5V to 20V
Low Voltage Supply, Logic VCC, PVCC	4.5V to 5.5V

Note:

- (1) Peak voltages can be applied for 10ns per switching cycle
- (2) Peak voltages can be applied for 20ns per switching cycle
- (3) Devices are inherently ESD sensitive. Handling precautions are required. Human Body Model rating: 1.5 kΩ in series with 100 pF

II. Package and Die Information:

Product ID	AOZ5311NQI
Package Type	QFN5x5-31L
Die Size	IC: 960x1040 um ² HS MOSFET: 1150x1820 um ² LS MOSFET: 1800x2250 um ²
Die attach material	IC: non-conductive epoxy MOSFETs: solder paste
Bond wire	Au, 1.0 mil
Mold Material	EME-G700HC D14*5.8g
Lead Plating	Pure Sn
MSL	Level 1

III. Qualification Tests Requirements

- AOZ5311NQI is a derivative product
 - 3 lots 1000hrs HTOL
 - 3 lots preconditioning, 96hr PCT, 96hr uHAST, 1000 cycle TC, 1000hr HTS
 - 1 lot HBM, CDM ESD, Latchup
 - 2 lots 1000hr HTRB, HTGB (MOSFETs, derivative qualification)
 - 3x IR reflow + 250 cycle TC

IV. Qualification Tests Result

Test Item	Test Condition	Sample Size	Result	Comment
HTOL	Per JESD 22-A108B $V_{IN} = 25V$ $T_J = 150^{\circ}C$	3 lots (80 /lot)	pass 1000hrs	
ESD	JESD 22-A114E (HBM) JESD 22-A115A (MM) JESD 22-C101C (CDM)	3 units	pass	2.0kV (HBM) 200V (MM) 1.0kV (CDM)
Latch-up	Per JESD 78A	6 units	pass	$\pm 100mA$
Power Cycling	$V_{IN} = 19V$, $V_{OUT} = 1.0V$, $F_{SW} = 800kHz$, $I_{OUT} = 30A$, VCC cycled 0V-5V	10 units	pass	35hr, >63k cycles
HTGB (MOSFETs)	Temp = $150^{\circ}C$ $V_{GS} = 12V$	1 lot HS MOSFET (77 pcs) 1 lot LS MOSFET (77 pcs) 9 lots MOSFET (77/lot)	pass 1000hrs pass 1000hrs pass 1000hrs	Derivative process Derivative process Platform process
HTRB (MOSFETs)	Temp = $150^{\circ}C$ $V_{DS} = 25V$	1 lot HS MOSFET (77 pcs) 1 lot LS MOSFET (77 pcs) 9 lots MOSFET (77/lot)	pass 1000hrs pass 1000hrs pass 1000hrs	Derivative process Derivative process Platform process
H3TRB (MOSFETs)	$T_A = 85^{\circ}C$, 85% RH, $V_{DS} = 25V$	3 lots (77/lot)	Pass 1000hr	Platform process
HAST (MOSFETs)	$130^{\circ}C \pm 2^{\circ}C$, 85% RH, 33.3 psi	3 lots (77/lot)	pass 96hrs	Platform process
Power Cycling (MOSFETs)	$T_A = 25^{\circ}C$, $T_J = 125^{\circ}C$	3 lots (77/lot)	pass 15k cycles	Platform process

Test Item	Test Condition	Sample Size	Result	Comment
3x IR reflow and 250 Temperature Cycles	3x IR reflow @ 260°C; TC test condition: -65 °C to +150°C, air to air (2cyc/hr)	3 lots (3000 /lot)	pass	
Pre-Conditioning (MSL1)	Per JESD 22-A113 85°C, 85% RH, 3 cycle reflow @ 260°C	3 lots (308 /lot)	pass MSL1	
PCT	121°C, 15 ± 1 PSI, RH = 100%	3 lots (77 /lot)	pass 96hrs	
UHAST	130 +/- 2°C, 85% RH, 33.3 psi	3 lots (77/lot)	pass 96hrs	
Temperature Cycle	-65°C to +150°C, air to air (2cyc/hr)	3 lots (77 /lot)	pass 1000 cycles	
HTS	T _A = +150°C	3 lots (77 /lot)	pass 1000hrs	

V. Reliability Evaluation

The presentation of FIT rate for the individual product reliability is restricted by the actual burn-in sample size of the product. Failure Rate Determination is based on JEDEC Standard JESD 85. FIT means one failure per billion hours.

FIT rate (failures per billion device hours): 0.150

MTTF = 6,649.6 million hrs

Condition: $V_o = 20V$, $T_o = 55^\circ C$, $V_{s(DriverIC)} = 28V$, $V_{s(MOSFET)} = 25V$ and $T_s = 150^\circ C$

Sample Size: MOSFET = 6,153, Driver IC = 3,874

The failure rate (λ) is calculated as follows:

$$\lambda = \chi^2 [CL, (2f+2)] / 2 \times [1 / (SS \times t \times AF)]; \text{ [equation 1]} \quad \text{where} \quad \begin{array}{l} CL = \% \text{ of confidence level} \\ f = \text{number of failure} \\ SS = \text{sample size} \\ t = \text{stress time} \end{array}$$

Looking up the $\chi^2/2$ table for zero failure (burn-in) with 60% confidence, the value of $\chi^2 [CL, (2f+2)] / 2$ is 0.92.

The Acceleration Factor (AF) is calculated from the following formula (both temperature and voltage acceleration factors are used in the final acceleration factor calculation) :

$$AF = AF_T \times AF_V = \exp[(E_a/k) \times (1/T_o - 1/T_s)] \times \exp[\beta (V_s - V_o)] \quad \text{where} \quad \begin{array}{l} E_a = \text{activation energy} \\ k = \text{Boltzmann constant} \\ T_o = \text{operating } T_j \\ T_s = \text{stress } T_j \\ V_s = \text{stress voltage} \\ V_o = \text{operating voltage} \\ \beta = \text{voltage acceleration coefficient} \end{array}$$

Assuming typical operating environment, $V_o = 20V$, $T_o = 55^\circ C$, $E_a = 0.7eV$, $V_{s(DriverIC)} = 28V$, $V_{s(MOSFET)} = 25V$, $T_s = 150^\circ C$, $\beta = 0.5$ (silicon defect)

$$AF(DriverIC) = \exp\left[\left(\frac{0.7}{8.617E-5}\right) \cdot \left(\frac{1}{273+55} - \frac{1}{273+150}\right)\right] \cdot \exp[0.5 \cdot (28V - 20V)]$$

$$AF(MOSFET) = \exp\left[\left(\frac{0.7}{8.617E-5}\right) \cdot \left(\frac{1}{273+55} - \frac{1}{273+150}\right)\right] \cdot \exp[0.5 \cdot (25V - 20V)]$$

Substituting the values in equation 1, we have $\lambda = 2 \cdot \lambda(MOSFET) + \lambda(DriverIC) =$

$$0.92 \cdot \frac{2}{\text{Sample Size} \cdot \text{Stress Duration} \cdot AF(MOSFET)} + \frac{1}{\text{sample Size} \cdot \text{Stress Duration} \cdot AF(DriverIC)} \text{ hr}^{-1}$$

$\lambda = 0.150 \cdot 10^{-9} \text{ hr}^{-1}$ or 0.150 FIT; $MTTF = (1/\lambda) = 6,649.6 \text{ million hrs} = 759,089 \text{ years}$

The calculation shows failure rate is 0.150 FIT, MTTF is 6,649.6 million hours under typical operating conditions.

The qualification test results confirm that AOZ5311NQL passes AOS quality and reliability requirements for product manufacturing release.

Revision	Release Date	Comments
1.0	April 1, 2019	Initial Release
1.1	May 1, 2019	Updated FIT to include voltage acceleration factor