LX2410A 30-Year Life Qualification Testing

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Purpose

This application note describes the test methodologies used to qualify the LX2410A IDEAL™ Solar Bypass device for 30-year life expectancy.

Accelerated Life Testing

Microsemi uses accelerated life testing to determine the useful life period of the LX2410A. Standard requirements for accelerated life testing are found in JESD22-A103, -A104, -A105, -A108, -A110, and AEC-Q100 and -Q101 specifications.

Accelerated testing is performed on units randomly selected from one to three lots, depending on the test performed. Details on sample sizes used for most tests are available in the preceding specifications. For those tests that are not covered in the specifications, the details are available in the *Microsemi Quality Assurance Specification (SGQ1274T)*. Before and after the accelerated tests, production electrical tests are performed on the sample lots to ensure that datasheet specifications are met.

Qualification Tests

The following qualification tests are performed under accelerated temperature conditions:

- High-temperature operating life (HTOL) test: Three lots containing 77 units are tested at 132 °C ambient temperature for 2000 hours.
- High-temperature reverse bias (HTRB) test: One lot containing 77 units is tested at 132 °C ambient temperature for 2000 hours.
- High-temperature storage life (HTSL) test: One lot containing 45 units is tested at 150 °C ambient temperature for 1000 hours.
- Power temperature cycle test: One lot containing 50 units is tested at –40 °C to 125 °C for 1000 cycles, with ten minutes of dwell time.
- Highly-accelerated temperature and humidity stress test (HAST) test: Three lots containing 25 units are tested at 130 °C ambient temperature and 85% RH for 96 hours.

- Package temperature cycle test: Three lots of 77 units each are tested at –65 °C to 150 °C for 500 cycles.

The following sections describe how these tests were successfully performed on the LX2410A.

HTOL Qualification

The HTOL qualification test is performed under accelerated temperature conditions using the mathematically-derived acceleration factor (AF) and mean time between failure (MTBF) values.

Acceleration Factor

Acceleration Factor (AF) is used to predict how time-to-fail varies with temperature.It is calculated as follows:

$$AF = e^{\left(\frac{Ea}{k}\right)\times\left[\left(\frac{1}{Ts}\right)-\left(\frac{1}{Tt}\right)\right]}$$

EQ1

where:

AF = Acceleration factor

Ea = Activation energy for silicon in electron-volts (eV) = 0.53 eV

k = Boltzmann's constant = 8.617 × 10-5 eV/T

Ts = Temperature of normal operation in degrees Kelvin

Tt = Temperature of operation during test in degrees Kelvin

As indicated in the above equation, AF is based on normal operating junction temperature and testing junction temperature.

Example AF Calculation

- Normal operating ambient temperature = 85 °C
- Thermal resistance (Theta JA) = 27 °C/W
- Tests were performed at 8.8 A forward current. At this current:
  - Forward voltage drop at *normal* temperature (85 °C) is 0.103V. Therefore, power at normal temperature = 8.8 A × 0.103 V = 0.91 W.
  - Forward voltage drop at *testing* temperature (132 °C) is 0.140 V. Therefore, power at testing temperature = 8.8 A × 0.140 V = 1.23 W

Based on the preceding conditions:

- Normal operating junction temperature = 85 °C + (27 °C/W × 0.91 W) = 109.5 °C (382.63 degrees Kelvin)
- Testing junction temperature = 132 °C + (27 °C/W × 1.23 W) = 165.2 °C (438.42 degrees Kelvin)

Then

$$AF = e^{\left(\frac{0.53}{8.617\times10^{-5}}\right)\times\left[\left(\frac{1}{382.63}\right)-\left(\frac{1}{438.42}\right)\right]} = 7.733$$

Total Accelerated Testing Time

To determine the total accelerated testing time required, the operating percentage of 30-year life is calculated. This value is then divided by the acceleration factor (AF).

- 30 years = 262,800 hours
- Number of hours of operation in 30 years assuming 12 hours per day = 131,400 hours
- Number of hours in forward bias assuming 10% of the total time = 13,140 hours

Total accelerated testing time is:

$$\frac{13{,}140}{7.733} = 1699\,hours$$

LX2410A was tested at an 8.8 A load for a total of 2000 hours, exceeding the preceding value.

Mean Time Between Failure

Mean time between failure (MTBF) is used to determine the minimum cycles or hours required for the test. It is calculated as follows:

$$MTBF = \frac{T}{R}$$

EQ2

where:

T = Total time consumed by all devices during normal operation

R = Number of devices in the tested population

MTBF is based on the total time in service.

- 30 years = 262,800 hours
- Population = 231 units (three lots of 77 units each)

Therefore,

$$MTBF = \frac{262800}{231} = 1138\,hours$$

LX2410A was tested at 8.8 A load for a total of 2000 hours, exceeding the preceding value. The testing time used for LX2410A also exceeds the criteria of 1000 hours specified for HTOL in the JESD47I specification.

HTOL Burn-in Circuit

LX2410A BI Schematic (Forward Bias)

- There are 50 small DUT boards, 4.156″ × 1.93″.
- See the BI and/or TEMP_CYCLE block diagram for connections.
- See the power switch schematic for detail adjustments.
- The connection between DUT boards are established through a hard wire that can take 35 A.
- The burn-in temperature is set at 132 °C ambient (measured junction temperature = 165 °C).

  Tj = Ta + (Pin × Theta JA) = 132 °C + (8.8 A × 0.140 V × 27 °C/W) = 165 °C

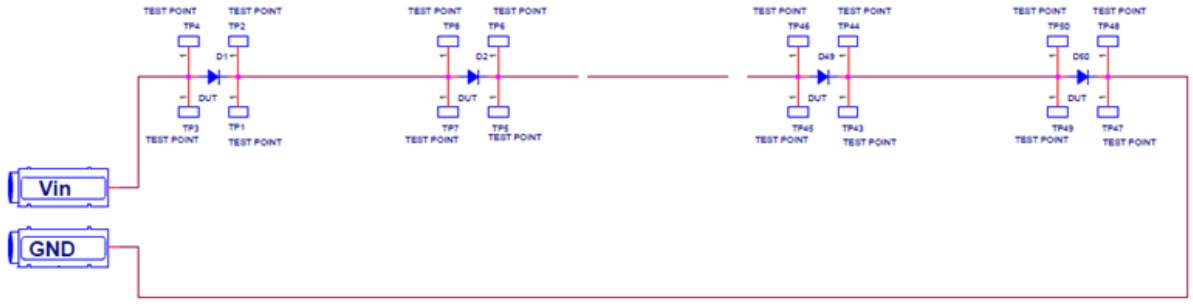

***Figure 1* • HTOL Burn-in Circuit**

HTRB Qualification

The HRTB qualification involves testing the reverse bias of the device in high-temperature conditions according to AEC-Q101-Rev D1.Section 4.1, table 2, item 5 of this specification requires the following for this test:

- 1000 hours at maximum-rated reverse voltage
- Sample size in accordance with note B

One lot of 77 units of LX2410A was tested at reverse bias of 35 V for a total of 2000 hours, exceeding the preceding requirements.

HTRB Burn-in Circuit

LX2410A BI Schematic (HTRB)

- There are 50 small DUT boards, 7″ × 23″, mounted on a BI2410 motherboard. Each DUT board contains a resistor, a jumper, a DUT, and four test points as shown in the schematic below. Each DUT has a flow solder on a small PCB. The DUT boards are piggybacked onto the motherboard using aluminum spacers.
- The DC supply is 35 V. This circuit can be used for HTRB and 85/85 testing.

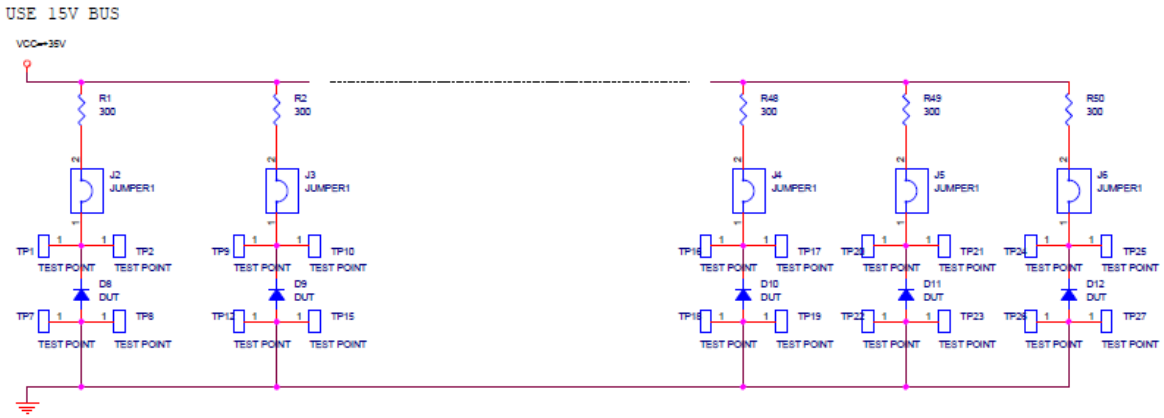

***Figure 2* • HTRB Burn-in Circuit**

HTSL Qualification

The HTSL qualification involves testing the storage life of a device in high-temperature conditions according to the following specifications:

- JESD22-A103: According to section 4.1, table 1, condition B, a temperature of 150 °C is used for a duration of 1000 hours.
- AEC-Q100-Rev H: Sample size and temperature cycles according to Section 4.1, Table 2, Grade 1 test level.

One lot of 45 units of LX2410A were stored under no operating conditions at 150 °C for 1000 hours in a controlled temperature environment.

Power Temp Cycle Qualification

The power temperature cycle test is performed according to the following specifications:

- JESD-A105
  - Section 3.0: Units are powered ON and OFF at five-minute intervals. Power cycling is done continuously throughout the temperature cycle. Temperature cycle times conform to Figure 1.
  - Section 3.1: Test conditions according to table 1, condition B. Recommended temperature cycles = 1000.
- AEC-Q100-Rev H
  - Sample size and temperature cycles according to Section 4.1, Table 2.
  - One lot, 45 units, at 1000 cycles, –40 °C to +125 °C.

One lot of 50 units of LX2410A were power cycled for 1000 cycles with a forward bias current of 9.5 A at temperatures ranging from –40 °C to +125 °C.

HAST Qualification

The HAST qualification involves testing the device under highly-accelerated temperature and humidity conditions according to the JESD22-A110 specification and the Microsemi internal quality specification (SGQ1274T).

- JESD22-A110
  - Section 3.1: 130 °C, at 85% Relative Humidity, for 96 hours.
  - Section 3.2, paragraph e: Low bias condition with less than 200 mW dissipation.
- SGQ1274T
  - Section 6.2.1, Table II.
  - Three lots, 25 units, for 96 hours - grade I industrial devices.

Three lots of 25 units of LX2410A each were operated at a low bias of 700 mA for 96 hours at 130 °C and 85% RH. Characterization data shows that 1 A forward bias dissipates 82 mW.

Package Temperature Cycle Qualification

Package temperature cycle testing is done according to the JESD22-A104 and AEC-Q100 specifications:

- JESD22-A104
  - Section 5.2: Table 1– Condition C. –65 °C to +150 °C cycle.
  - Section 5.5: Table 2 – Soak mode 2. Five minute soak.
  - Section 5.6: Table 3 – Cycle frequency. Two cycles per hour.
- AEC-Q100-Rev H
  - Section 4.1: Table 2; Grade 1 device. Three lots, 77 units per lot, 500 cycles at –65 °C to +150 °C.

Three lots of 77 units of LX2410A were cycled at –65 °C to +150 °C for 500 cycles.

Conclusion

The LX2410A IDEAL Solar Bypass device, by going through the accelerated life testing procedures, is qualified to have 30-year life expectancy.

List of Changes

The following table shows the important changes made in this document for each revision.

Revision	Changes	Page
Revision 1 (June 2016)	Initial release.	NA

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1/06.16