NXP LED Driver lifetime as good as LED lifetime

Governments or industry initiatives all over the world introduce regulations or recommendation for the transition to higher efficiency, longer life and better quality of lighting systems used in offices and private houses.

LED lighting is well accepted as a breakthrough in lifetime of light source. LED manufacturers report lifetime figures exceeding 50,000 hours depending on operating conditions (mainly temperature). However, most applications using LED requires electronics. To benefit from the unique lifetime performance of LEDs, the other components of the light source need to have similar performance!

NXP now announces that its range of LED drivers SSL2101 / SSL2102 matches the lifetime of the LED. This makes the NXP solution the perfect electronics solution when used in LED based light sources!

Testing lifetime is a challenge

Lifetime figures in excess of 50,000 hours are often communicated by the LED industry. Testing 50,000 hours would mean about 6 years of permanent test! This makes the lifetime testing practically impossible when not considering acceleration tricks in lifetime testing procedure.

The semiconductors industry traditionally establish standard lifetime testing procedures based on a 1,000 hours testing time and acceleration factors. The end of life acceleration results from stress factors like high temperature, etc.

Industry standards describe the lifetime acceleration models like Peck model or the Arrhenius model.

> For more detail, refer to JEDEC standard JEP122D (Peck model - page 38). Acceleration factors used in the NXP extended lifetime test are based on the coefficients as defined in the Peck model).
> http://www.jedec.org/download/search/jep122e.pdf

The 1,000 hour stress test usually leads to lifetime estimates of 10,000 hours at standard operating temperature. This is still far below the estimated lifetime of LEDs exceeding the 50,000 hrs. Standard semiconductor testing & qualification methods are therefore limited to cope with the new lifetime performance of light sources.

NXP specifically initiated a dedicated project aiming at assessing the actual lifetime of its latest LED drivers for General Lighting application. This project consists in running reliability test beyond the standard industry practices until product end of life.

What limits lifetime?

The classic “bathtub” curve that we know from our school textbook shows the failure rate of devices over time. Initially there are some early failures (also called infant mortality), followed by a long period in which no failures are expected (also called intrinsic or useful life where a relatively constant failure rate is observed). Over time wear-out or fatigue by the extended use will take its toll and products failure rate accelerate. This is the typically slow increase in the likelihood of failure. The underlying process is called a failure mode.

In semiconductor devices most known failure modes are oxidation, metal fatigue and intense use.

We also know that there are ways to accelerate these effects like stressing a product, the use at a very high temperature, etc. In LED's and in LED driver IC's we can also identify the failure modes. NXP has build up failure-mode knowledge over the many years that we make ICs. Actually, failure modes are accelerated by operation at a higher temperature. This allows the lifetime test duration to be reduced.

How is lifetime defined?

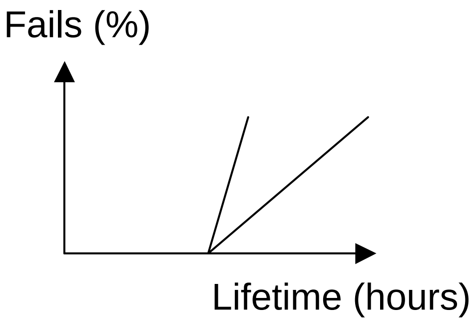
Lifetime is typically defined as the time it takes until a product fails. In industry there are different interpretations of what "failure" means:

> An LED is considered to have reached end of life when the lumen maintenance of the LED has reached 70% of its rated light output.

In the semiconductor industry (IC) lifetime means that less than 2% of the drivers have failed

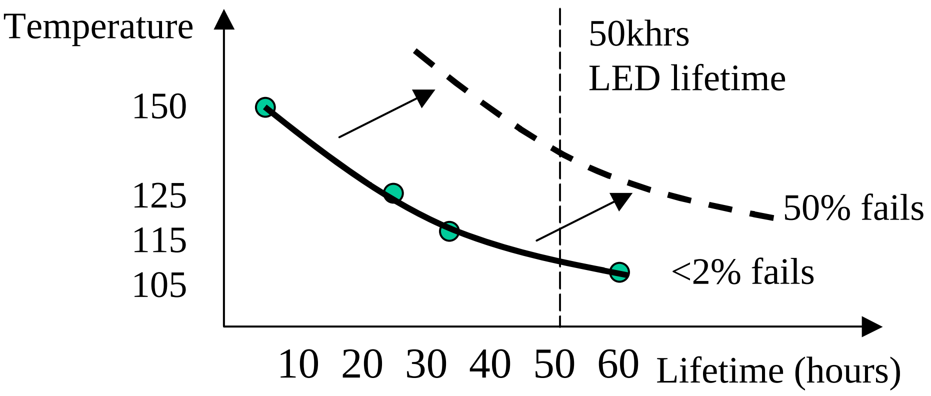
What did NXP test to prove 50,000 hours lifetime?

NXP tested a random lot of SSL2101 IC drivers from standard production in high stress conditions. Multiple tests and set-ups where used to detect all possible failure modes in several use cases: continuous-on, on/off switching cycle and combinations. The type of failure leads to end of life scenarios that greatly vary: abrupt (all devices fail at the same time), or spread (large dispersion of product mortality over time).



To date (September 30th, 2009), all SSL2101 tests have been running for over 6,000 hours at 150 °C (IC junction temperature). All devices are still fully functional. Test continues. Extrapolated lifetime test based on normative acceleration factors leads to the estimated lifetime in real lighting applications:

Lifetime	IC junction temperature
60,000 hours	105 °C
35,000 hours	115 °C
20,000 hours	125 °C
6,000 hours	150 °C



The on-off switching test uses elevated temperature to accelerate the failure modes. In this specific test, the ambient temperature varies from –65 °C to +150 °C. The 3,000 cycles reached to date (30/09/2009) under these conditions represents 50,000 on/off cycles at room temperature.

Test results to date: no failure.
Tests are being continued.

Technical Details

The table below gives the details of the test mentioned above, and additional tests to cover all possibilities. The Arrhenius model describes the relationship between failure rate and temperature for electronic components. It derives from the observed dependence of chemical-reaction rates on temperature changes. The Peck model his model accounts for temperature and humidity stresses separately. In a similar manner all tests have their own models to describe the failure rate.

Please refer to http://www.jedec.org/download/search/jep122e.pdf for details on failure mechanisms and models as mentioned in the table below.

Stress Test (target&conditions)	Last Read point (Target)	Life time equivalent (Target)	Test is finished	Model,assumptions, extra information
HTSL (175°C)	3kh (4kh)	75kh (100kh)	940	Arrhenius Model Ea=1eV, Tj=125°C, ON=24/day
HTOL (150°C)	6kh (9kh)	20kh (30kh) at Tj=125 °C Current status equals: 33kh at Tj=115 °C 59kh at Tj=105 °C	Early 2010 – required critical	Arrhenius Model Ea=0.7eV, Tj=125°C, ON=24/day, From: ABL / ICN8, SNW-FQ-611A / 2007,
TMCL (-65°C, 150 °C)	3kcls (5kcls)	30kcls (50kcls)	941	Coffin-Manson Equation, dT_{use}=100°C, n=3 (JEP122), continue with 76 products
TFAT (230V, ON time=2.5min, OFF time=6.5min)	3kcls (8kcls)	3kcls (8kcls)	W40- required	dT>100°C, T_{max}~150°C (OTP limit), Products soldered to the boards, real application, open air, no active cooling, Troom=20°C
HTSL (175°C) + TMCL(-65°C, 150 °C)	1kh, 300cls		Done	An additional test upon our standard requirements.
THB (85%, 85°C)	48h	>30kh	Done	Peck model: Ea=0.7, n=2.7, ON/OFF 1 time per 4h, time for heating up product 20-100°C is 20min ->AF between 113 and 10000, V_{max}=400V.
UHST	192h	>30kh	Done	Peck model: Ea=0.7,n=2.7, 24h/day OFF time