How smart thermal protection provided by LED Driver ICs can help to extend lifetime of LED lighting systems

Hakan Yilmazer - Head of Application Marketing for Lighting

Agenda

- LED Life Time
- Basic Thermal Protection
- Intermediate Thermal Protection with Slope
- Advance Thermal Protection
- Summary

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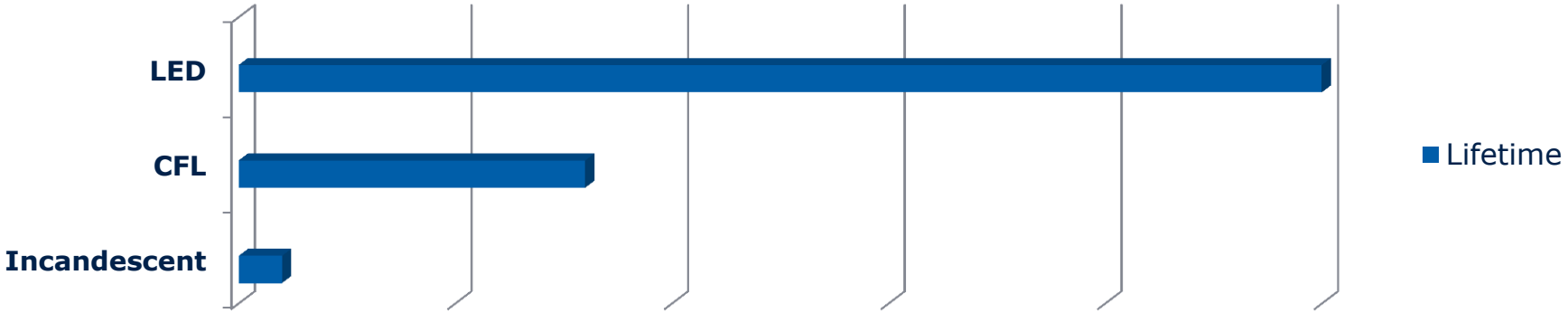
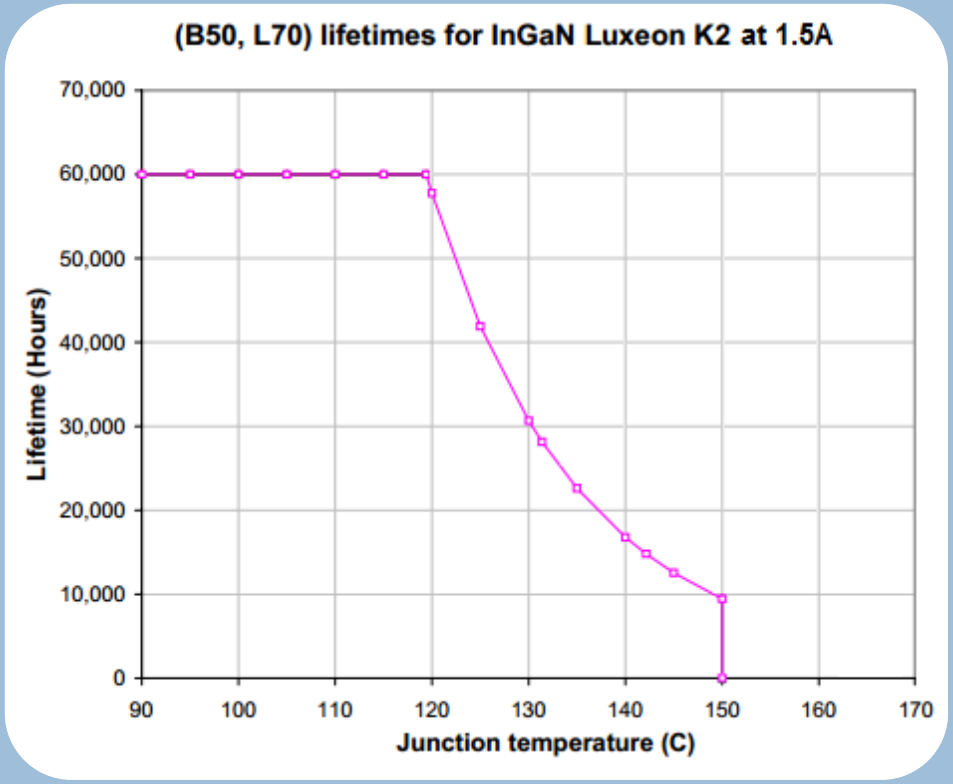
Very Long Lifetime of LED Products is a Significant Advantage for TCO

http://www.mnn.com/sites/default/files/user/130296/MNN-MGR-CFLvsLEDlightbulbs-003.jpg



- **4 times** higher Lm/w compared to traditional lamp
- **25 times** higher lifetime

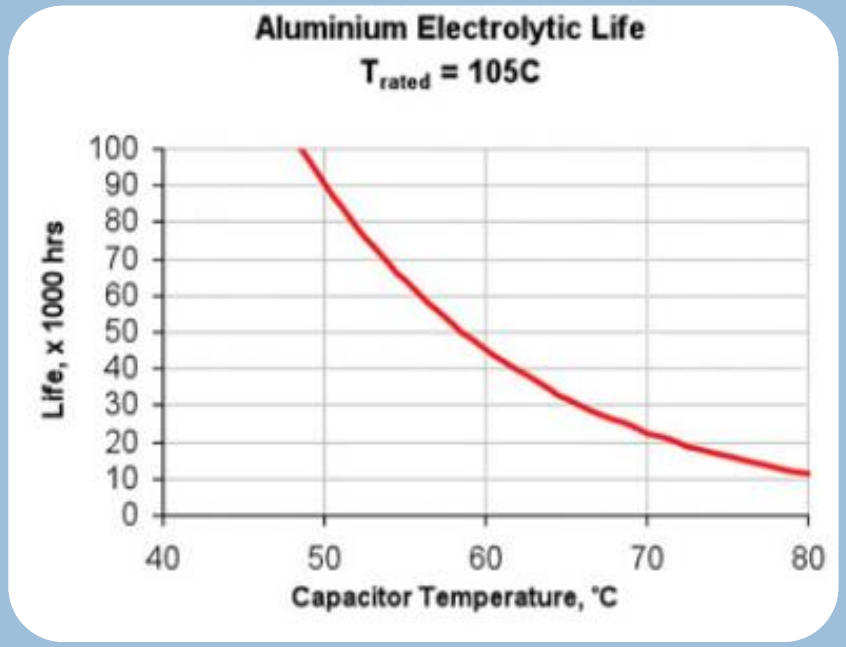
LED Lifetime decreases significantly Above 120°C Junction Temperature



Source : Philips white paper – Understanding LED power lifetime analysis

- Lifetime of LEDs is a function of the junction temperature
- Above 120°C junction temperature the LED lifetime decreases sharply
- At **150°C** T_j the lifetime goes **below 10k hours**

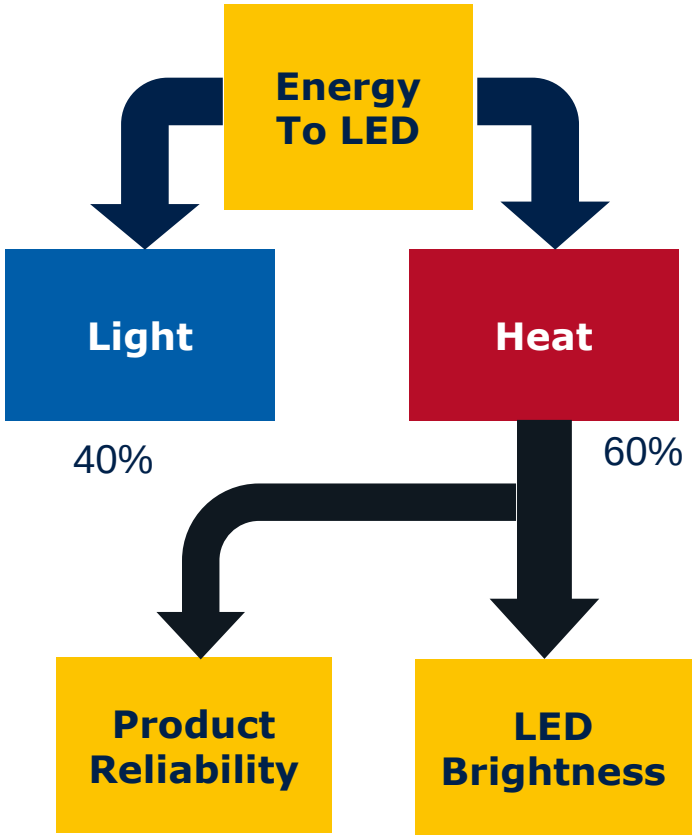
Lifetime of Electrolytic Capacitors also Strongly Depends on the Capacitor Temperature



Source : Digikey articles by Convergence Promotions LLC

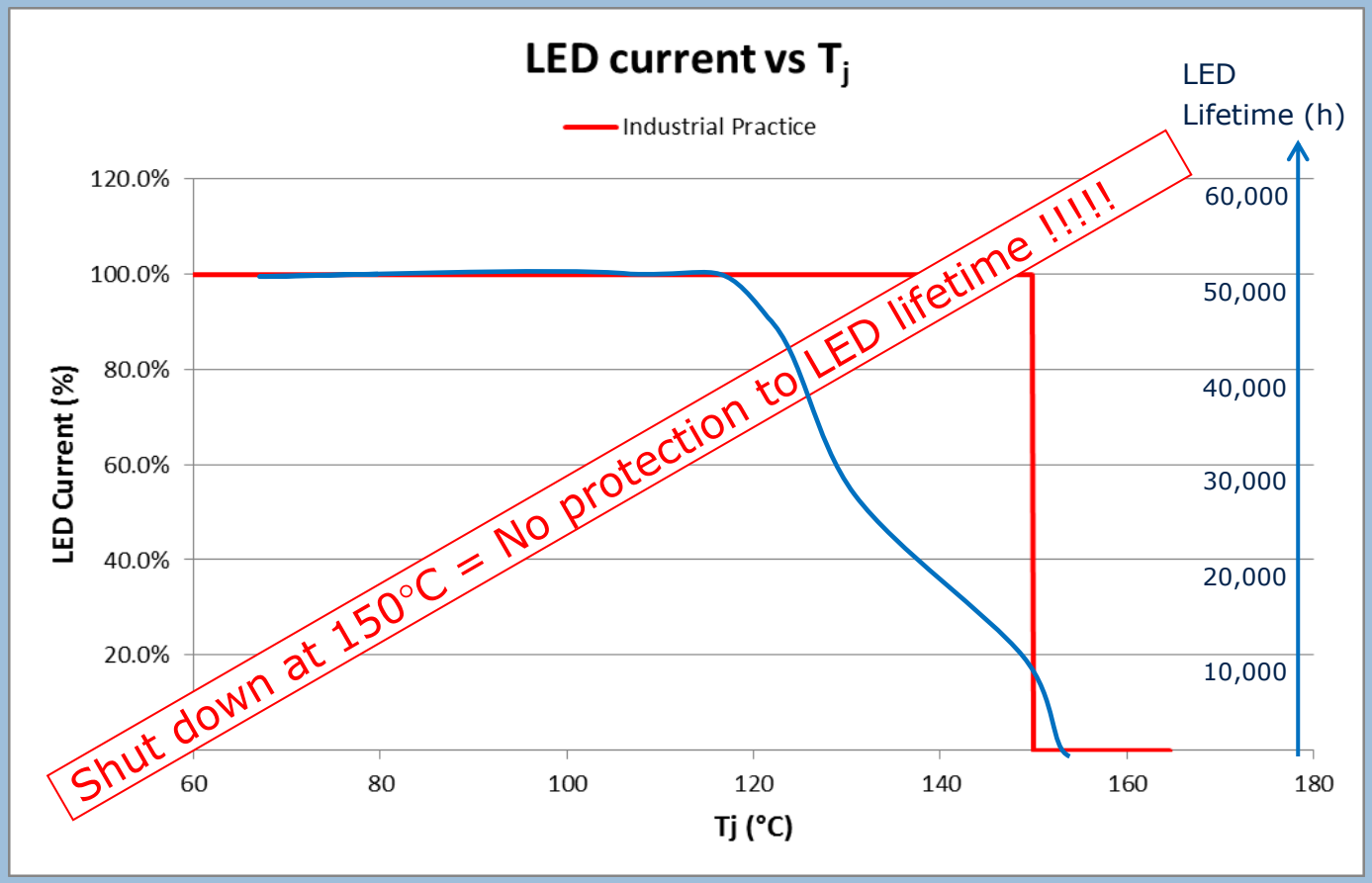
- E-caps are even more sensitive towards temperature increases than LEDs
- E-caps can be kept cooler by positioning them further away from LEDs

Real Life Example for LED Failures due to High Ambient Temperature

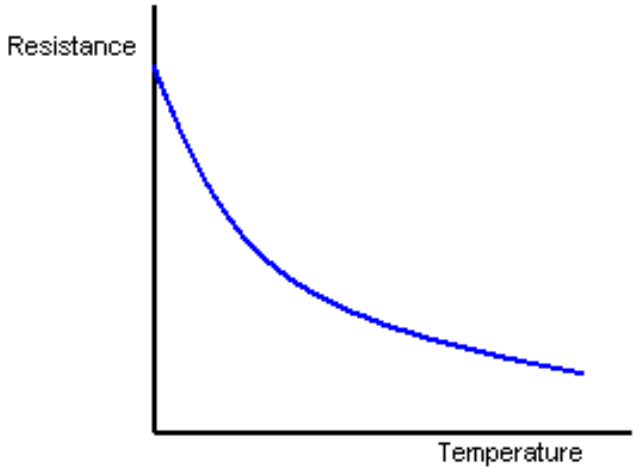


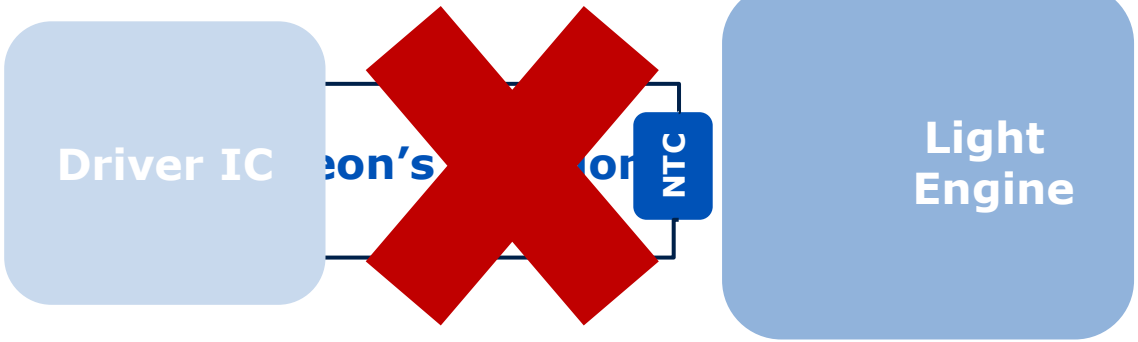
→ In 2 years of time

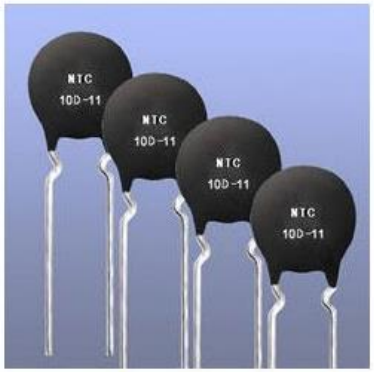
Sharp Thermal Shutdown of LED Driver IC does not Protect LED System Lifetime!



Using NTC Thermistor for Thermal Sensing Increases Cost & Design Effort







NTC

NTC would effect:

- ✓ An additional cost
- ✓ Additional wiring
- ✓ Additional space needed

Heat Sinks for LED Products Will Account for 1/3 of the Total Product Cost in 2020

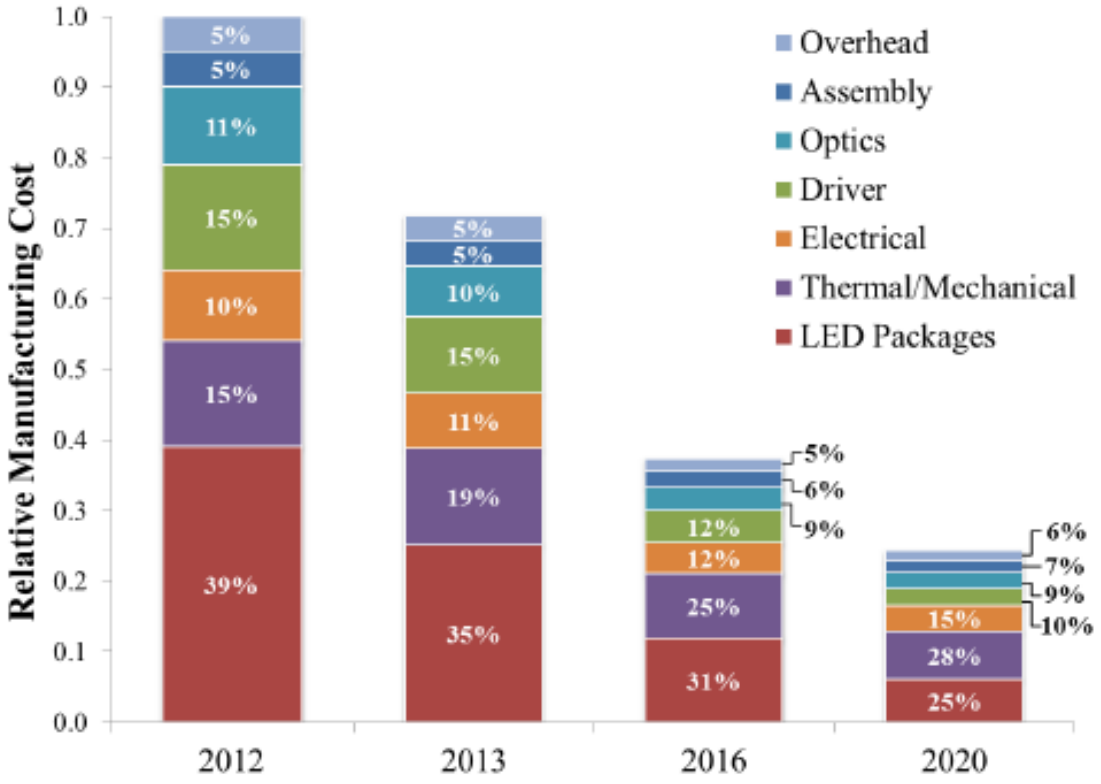


Figure 1.10 Cost Breakdown Projection for a Typical A19 Replacement Lamp

Source: DOE SSL Roundtable and Workshop attendees

- While the LED cost is going down the share of heat sink will go up in LED products

→ Carrying unnecessary safety margin for heat sinks for singular thermal peaks in LED products will be more painful in the future

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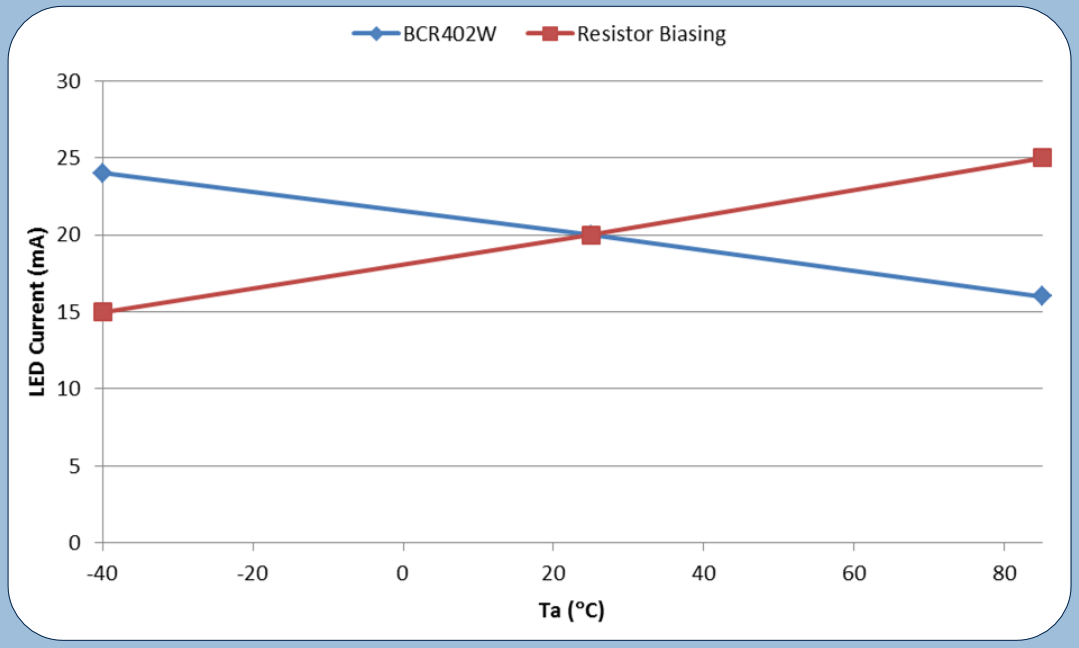
Negative Temperature Coefficient – BCR4xx - Low Cost Linear LED Driver ICs

- LED current is reduced with a slope during the entire operating temperature range
- Thermal runaway is prevented

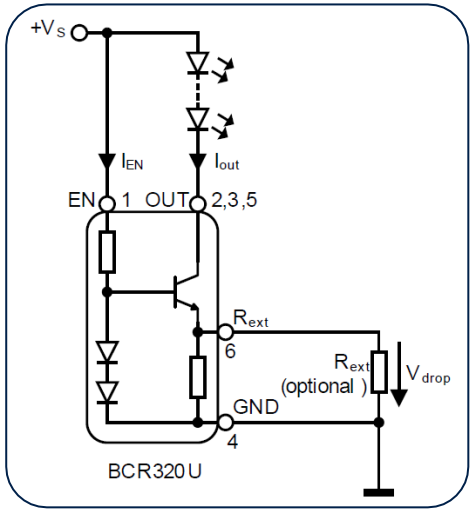
Required driving current is 20mA @ 12.0V



LED current comparison based on resistor biasing vs BCR402W

Negative Temperature Coefficient – Pros & Cons

- **Advantages**
  - Simple design
  - Low cost
  - Usually sufficient protection of LED lifetime since low / mid power LEDs are spread over PCB
- **Challenges**
  - Light output is reduced before reaching critical state
  - Reduction of current might not be sufficient



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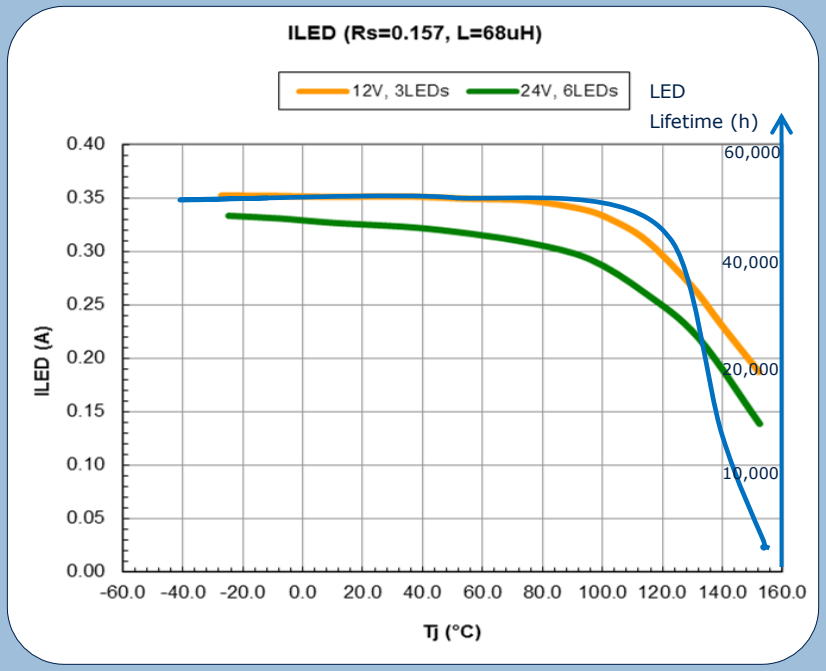
Thermal Shutdown with Slope Curve –
ILD4035 / ILD4120 - DC/DC buck LED driver ICs

- LED current is regulated until the OTP kicks in, then the LED current will be reduced
- Power to the LED is reduced and temperature at LEDs stabilized
- When temperature is stabilized current & light output remain at equilibrium

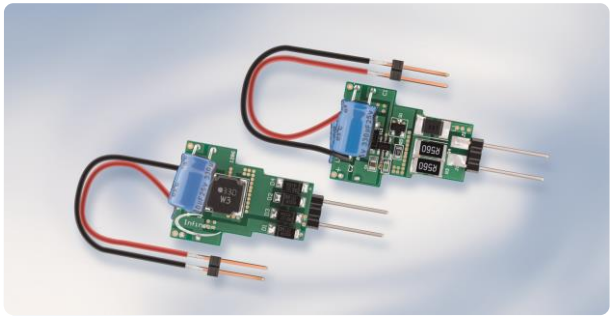


LED current vs ambient temperature of ILD4035

Thermal Shut Down with Slope Curve – Pros & Cons

- **Advantages** :
  - Very effective to protect lifetime of LED products
  - Easy to implement
  - Relatively low cost

- **Challenges:**
  - Reduced LED current can cause color shift
  - Over temperature trigger level cannot be adjusted



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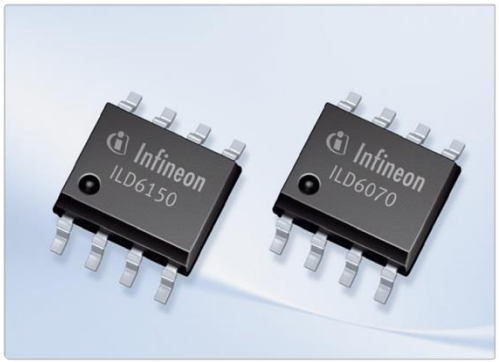
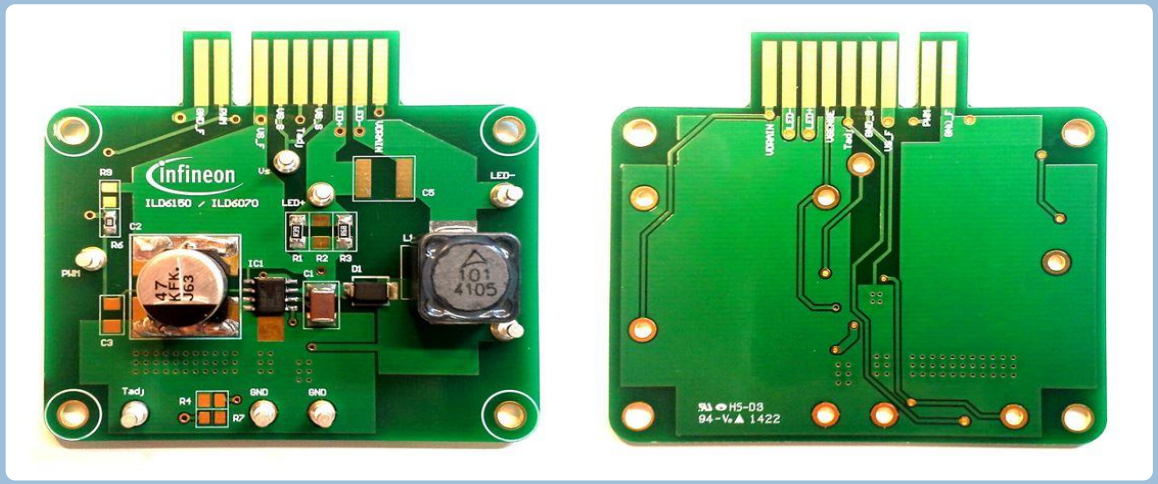
Advanced thermal protection – ILD6070 / ILD6150 - DC/DC buck LED driver ICs

With Infineon advanced thermal protection,

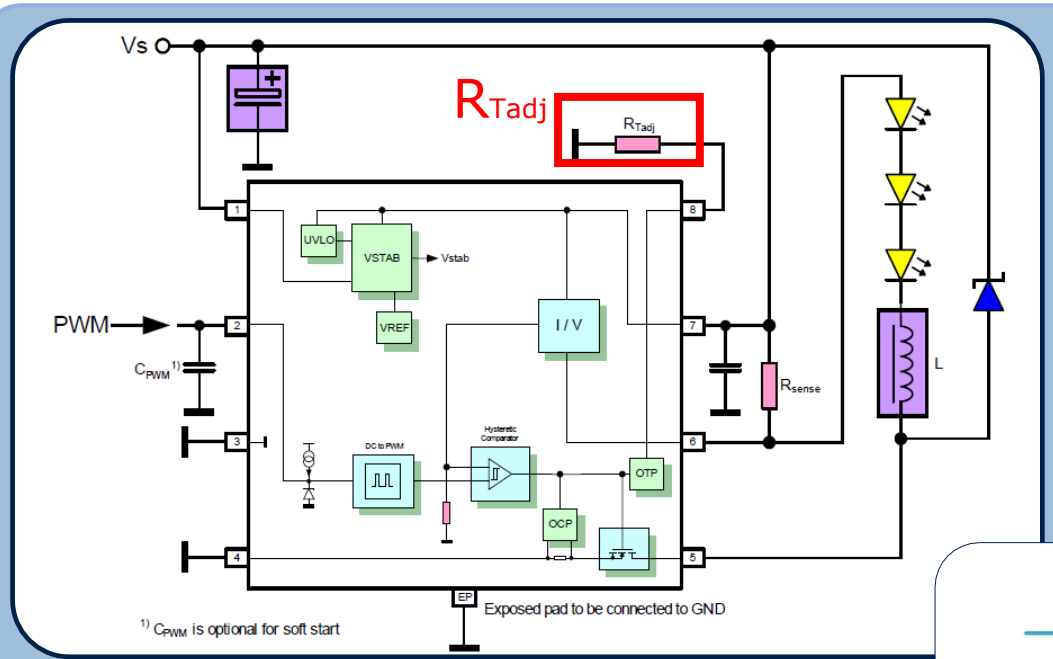
- Using IC as a thermal sensor
- Slope current reduction to protect LED lifetime
- **Adjustable trigger point (1)**
- **PWM output keeps constant color (2)**
- **External NTC still possible (3)**



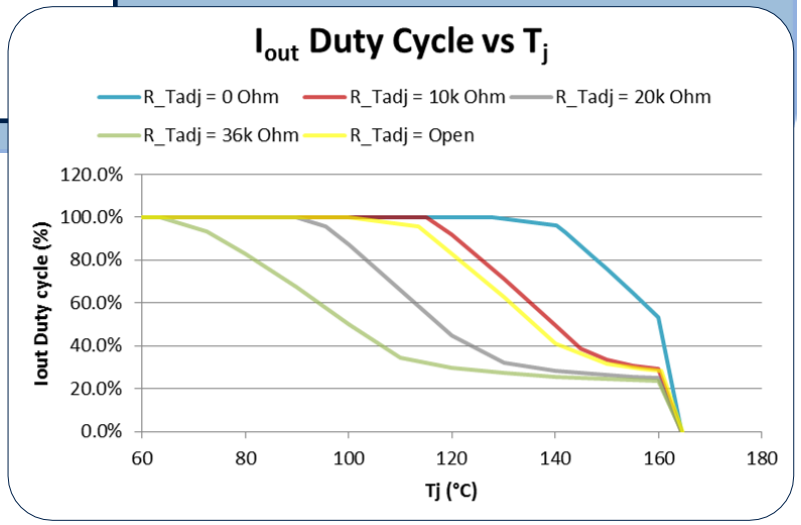


Board picture of ILD6150

(1) Adjustable Trigger Point Enables Optimization of Design Between Lifetime & lm/$



Application schematic of ILD6150

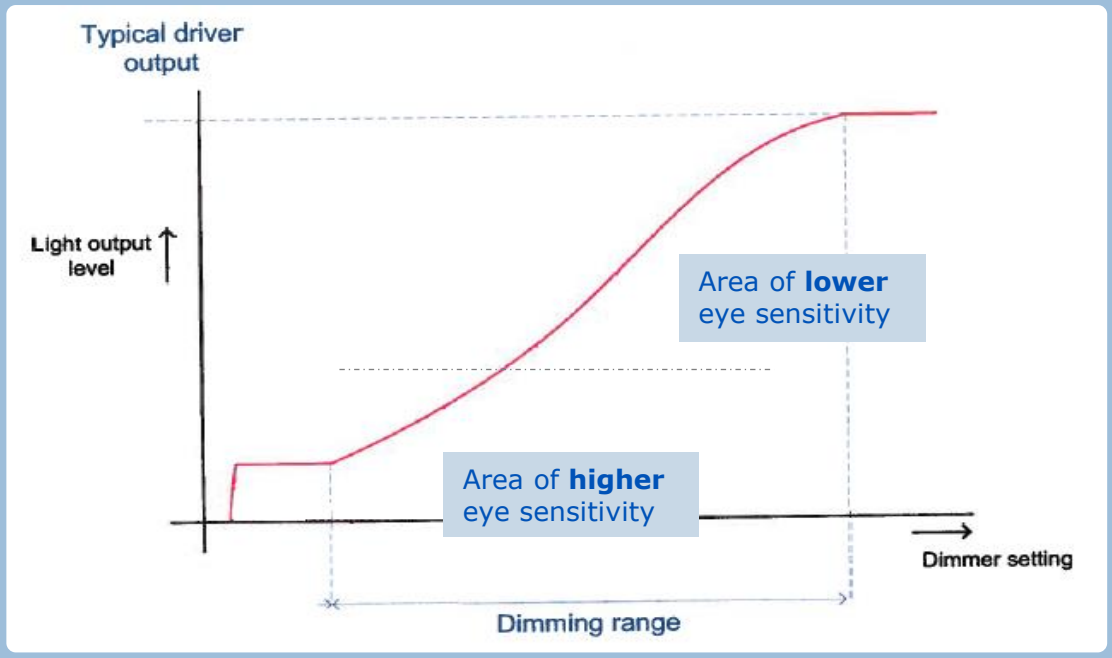


- Trigger point of thermal protection is simply adjustable by an external resistor

(2) Human Eye is Less Sensitive Towards Light Intensity Changes at High Light Output Level

- At high light level the human eye is not very sensitive towards light intensity variation
- The exponential dimming curve stipulated in NEMA SSL6 takes the increased eye sensitivity at low dim levels into account

SSL Dimming Curve

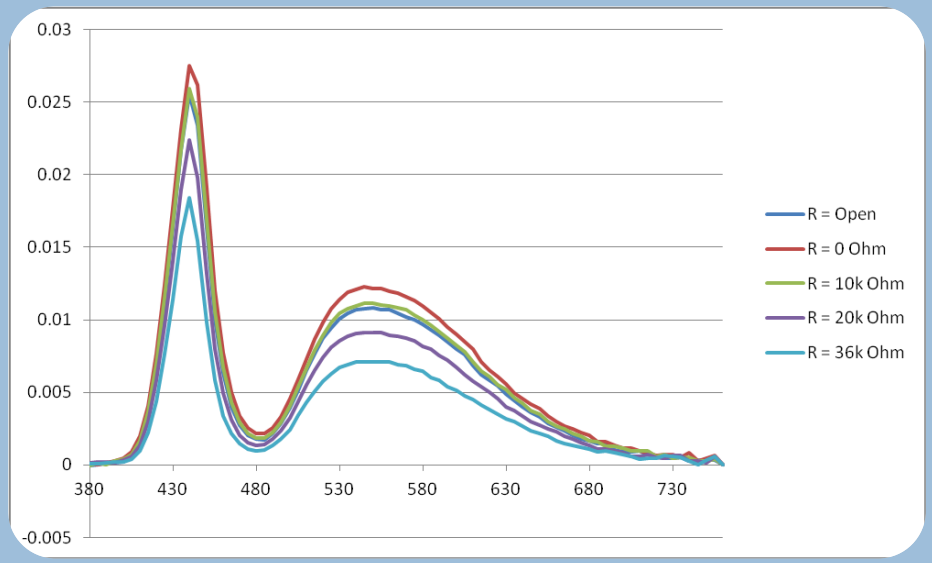


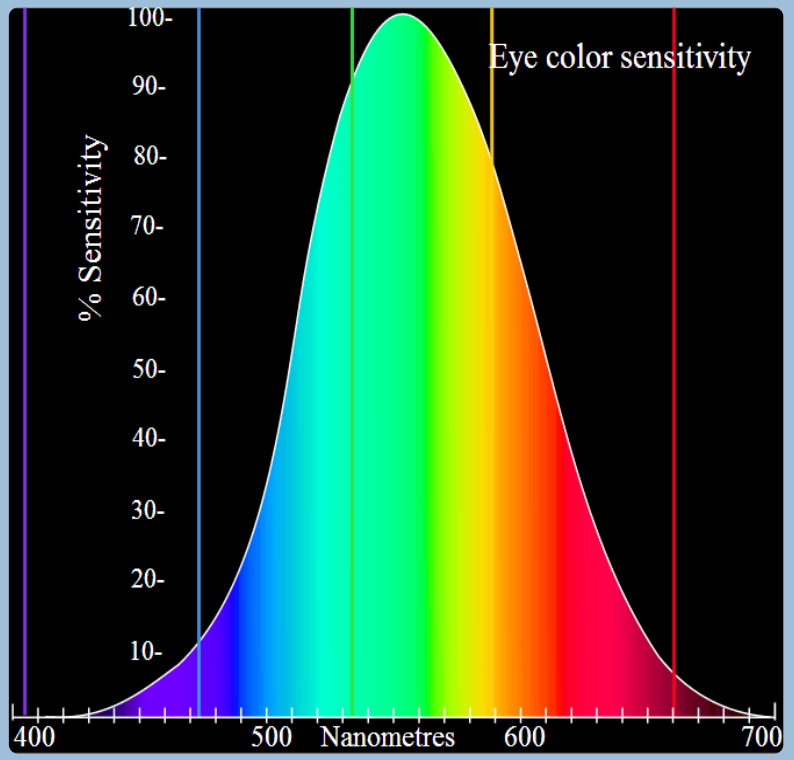
Source : Nema SSL 6

(2) Color Temperature is Kept Constant During Thermal Protection Mode

- Average output current is reduced by PWM during thermal protection mode
- Color temperature of LED's is kept constant due to current reduction with PWM mode
- Lower eye sensitivity at high brightness level combined with maintaining the light color mode makes operation in thermal protection mode hardly recognizable for users

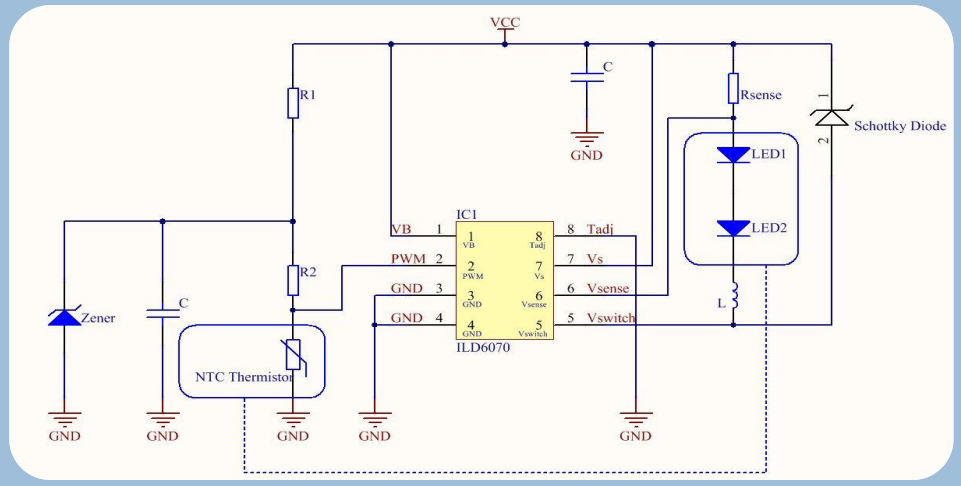
Wavelength spectrum of LED during OTP mode





(3) Flexibility to use External NTC Remains in Parallel to use the IC as a Thermal Sensor

- Not only internal sensing, external sensor is possible too !



Schematic of ILD6070

- Light engines is away from the LED driver
- NTC thermally couples to Light Engine

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Summary

- Key selling point for LED products is their long lifetime besides energy efficiency
- LED lifetime is highly dependent on the junction temperature of LEDs
- LED current reduction in a slope curve during OTP protects lifetime of LED systems
- Using LED driver IC as a thermal sensor reduces cost & design effort by making use of NTC's obsolete
- Smart thermal management of the new ILD6000 family offers in addition to slope and IC as thermal sensor:
  - simple adjustment of trigger point of thermal protection
  - keeping light color unchanged during thermal protection mode
  - the use of an external NTC for lighting systems where light engine cannot be thermally coupled with the LED driver IC

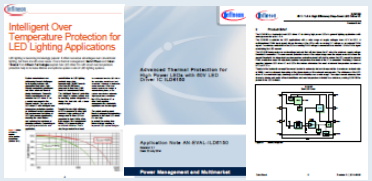
Support Material LED Lighting

LED Lighting

- Application Brochure
- Application Examples
- Application Notes
- On Demand Webinars

- www.infineon.com/lighting
- www.infineon.com/webinar

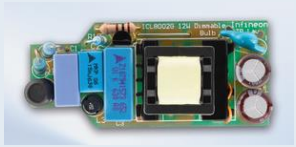
Technical Material



- Products + Datasheets
- Simulation Models
- MCDS files
- PCB Design Data
- App Notes, White Paper

- www.infineon.com/lowcostleddriver
- www.infineon.com/ledoffline
- www.infineon.com/led.documents

Evaluation Boards



- Evaluation Boards
- Demoboards
- Reference Designs

- www.infineon.com/led.evalboards
- www.infineon.com/led.appnotes

- LED Driver Online Design Tool

- www.infineon.com/lightdesk

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