LED Driver and System Reliability
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All LED drivers are not created equal and need to be used in their intended applications.
SSL Luminaire Burn-in

- 24 hour burn-in revealed limited driver mortality
- AQL reduced burn-in time
- 100% “Glow-n-Go” may be just as effective

Old school approach that is expensive.

- Blown fuses
- Blown chokes
- Failed MOVs
- Damaged MOSFETs
- Cracked solder joints
- Damaged 0-10V dimming circuit

Not only electrolytic capacitors
Definition for LED driver / system failure?

• Only if it generates a warranty claim?
• Falls below DLC, Energy Star, CA Title 24 requirements?
• Efficiency decrease? ROI is reduced?
• Parametric performance drift?
  • Increased ripple or flicker?
  • PF or THD out of tolerance?
• Mortality – no light output
Definition for Lifetime?

- What is a failure?
- What is the failure rate?
- At what confidence level?
- Ambient vs. case temperature?
- Is max case temp important?
- Is MTBF useful?

No industry consistency at all
MTBF = Mean Time Between Failure

- Original calculations defined by MIL-HDBK-217F
- Other similar commercial standards have evolved (Telcordia SR-332)
- Assumes constant failure rate for each component which may/is not be true
- For example:
  - A product with MTBF of 50,000 hours will exhibit about 15% failures in the first year (8000 hours)
  - A product with MTBF of 500,000 hours will exhibit about 1.5% failures in the first year (8000 hours)

Over-emphasis on MTBF as a measure of reliability is misleading and dangerous.
Expected Lifetime & Sources of Failures

“BATHTUB CURVE”

Component & Manufacturing Process Issues

“Random” Events that exceed component specifications

True Wear-Out Mechanisms

Teenage mortality (marginal designs for the application)

4. The "bathtub" curve, which is the most basic illustration of reliability, shows product failure rates at given life-cycle points.
Recommended Levels of Surge Protection

120V only applications

120-277V light commercial
Primarily 277V industrial
347/480V indoor

347/480V outdoor

Usually requires added surge protector device

Solid State Light Sources Used in Roadway and Area Lighting
(ANSI C136.37-20xx)
Driver/System Reliability Methodology

• What causes system failures?
  – Elevated temperatures
  – Thermal cycling
  – Surge / transient events
  – Repeat switching

• How to mimic this in “reasonable” amount of time to create failure distribution?
Driver Reliability Test Procedure

• 24 drivers and LED loads in environmental chamber
• Powered at maximum voltage: 277V, 347V, or 480V
• Cycled for 2 sec ON, 12 sec OFF
• 80°C to -20°C to 80°C (repeat)
  – 3°C/min ramp time
  – Relative Humidity ranges from 85% to 20%
  – 1 hour dwell time at temperature
• Demonstrate 99% reliability at 90% confident level
  – Exponential distribution (constant failure rate) used to model zero (or low) failures
  – Weibull analysis for failure distribution when sufficient failures occur
  – 2 to 3 week test depending on number of failures
Luminaire System Reliability Test Procedure

• 8 “Production” Luminaires
• Thermal Cycling (1 hour dwell time)
  – Outdoor fixtures: -20°C to 60°C
  – Indoor fixtures: 15°C to 60°C
• Electrical Cycling
  – Fixtures powered as temp is raised, de-energized as temper is lowered
  – Minimum energized time of 1½ hours each cycle
• Humidity Cycling
  – 30% to 85% R.H., saturation period across multiple thermal cycles
  – Promotes saturation and drying, accelerate potential aging of susceptible materials
• Single failure constitutes failure to meet requirements
  – Corrective action necessary to improve design or manufacturing process
Parametric Performance

• Chroma C8000 automated system
  – 120V, 277V, 347V and 480V testing

• Full parametric pre-stress testing
  – Sets performance baseline
  – Keep LED driver suppliers honest

• Repeat post-stress testing
  – Parametric out-of-spec “failure”
LED Driver Selection – Rules of Thumb

• LED driver selection should be very early in NPD process, not last
• Forget max case temperature; design to desired lifetime case temp
• Design surge protection for Location Category of worst environment
  – Surge matters! And designs should be tested!
• Limit number of drivers per fixture
  – Failure rates are additive
  – FCC Title 47 CFR Part 15 troubles (remember to test)
  – How many LED drivers will be on sole dimming circuit?
  – Uses isolated electrical components
• Ask for driver manufacturers’ reliability test data and quality plan
Thank you!

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