Implementation and Comparison of the LM-85 Measurement Methods

CIE Meeting, October 7, 2014

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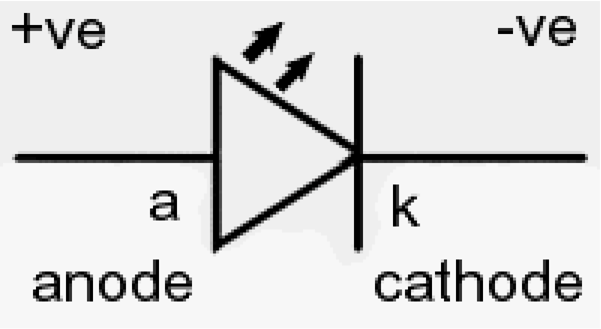
LED JOKE:



Vektrex Is Focused On LED Test & Measurement

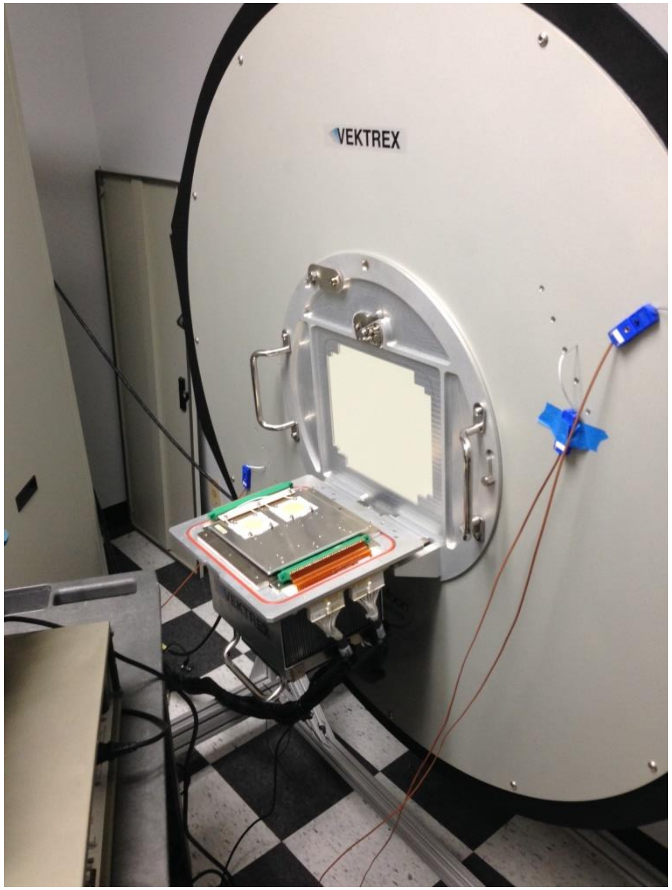
- Corporate/R&D headquarters in CA
- Current Sources for LED measurements
- LED Burn-in Reliability and Test Systems (LM-80)
  - Participation in standards committees defining LED test methods
  - Reliability, burn-in, production, device characterization and special systems run 7/24 worldwide
- International Support, Service
  - Japan, Korea, Hong Kong
  - China, Malaysia Singapore, Taiwan
  - Germany

Research Goal: Test & Compare LM-85's Methods

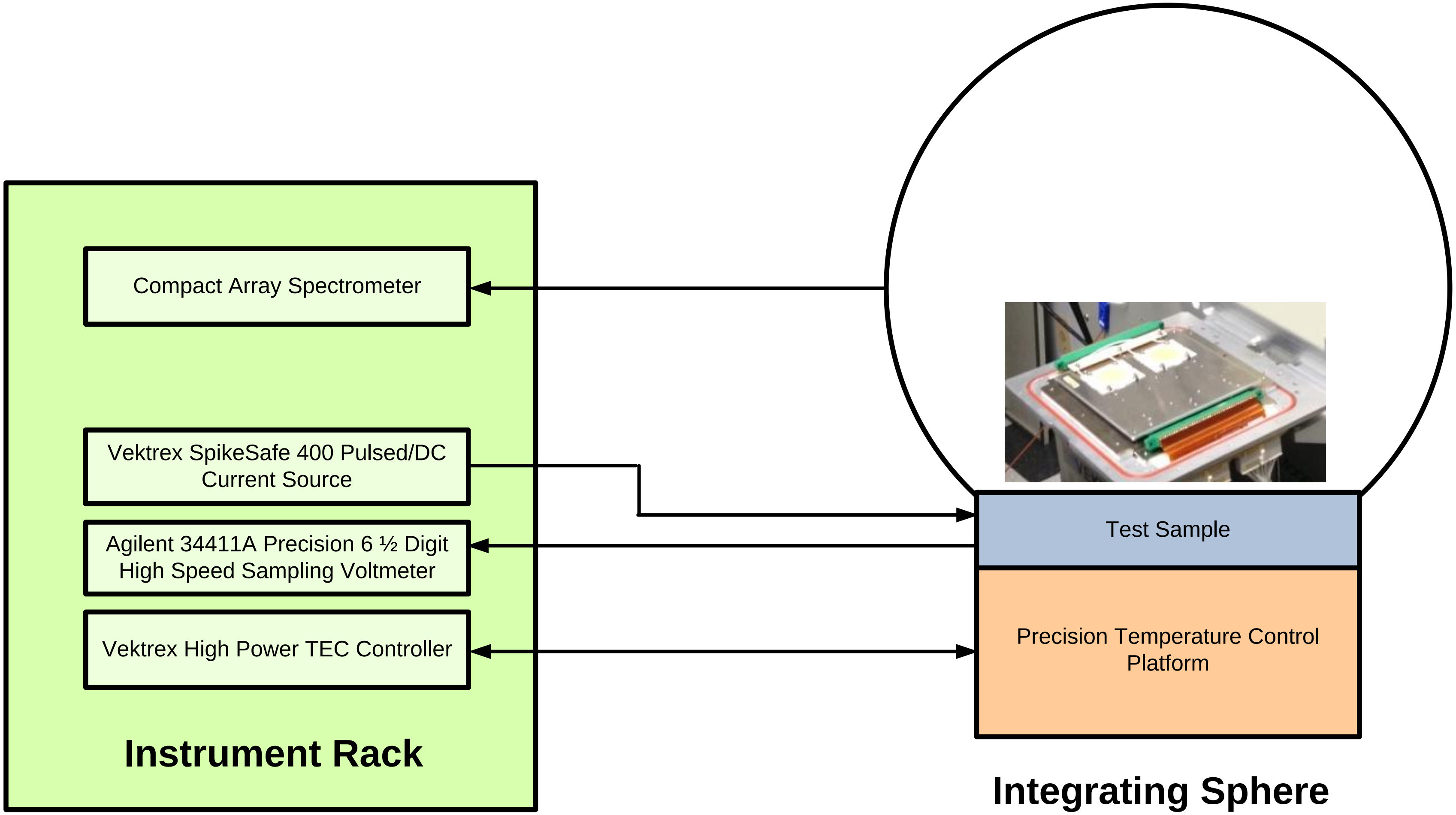
- Validate the methodology in the standard
- Compare measurement results with a high power LED device
- Uncover any instrumentation issues

Test Setup Allows Precision Control of Temperature, Current, Spectrometer

- Vektrex Automatic Light Measurement System (ALMS)
- SpikeSafe 200 precision pulsed current source
- Hemisphere integrating sphere
- Thermoelectric Cooler temperature control
- CAS-140

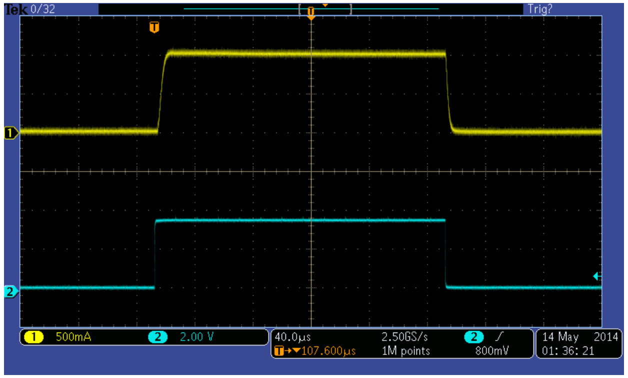


Vektrex Automatic Light Measurement System (ALMS) Used For Measurements



Key ALMS Instrument Characteristics

- Vektrex SpikeSafe 200 Current Source
  - Low current uncertainty -0.05% typical
  - Fast clean pulses - rise time <5uS
  - Low jitter trigger - <30nS typical
- Vektrex Thermal Control Platform
  - 0.01C stability
- Agilent 34411A Sampling Voltmeter
  - 15-18 bit digitization
  - 20uS sampling
  - Programmable trigger and aperture
- CAS 140 Spectrometer
  - Programmable trigger delay and aperture

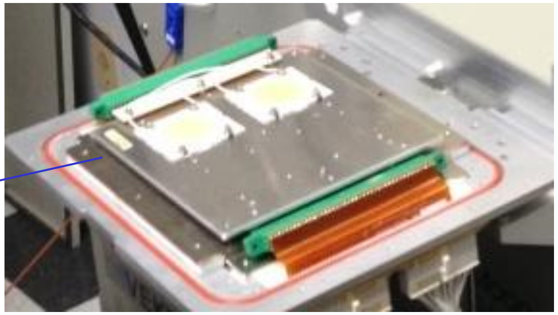


200uS Current Pulse and Trigger

Test LED: High Power COB Array

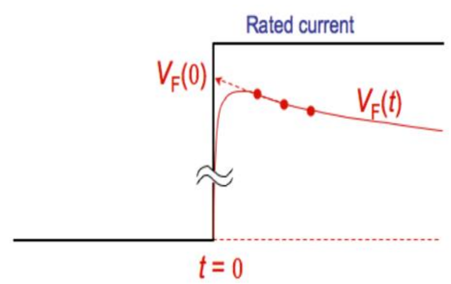
DUT:	Picture:	Forward Current:	Power	Flux:	Chromaticity:	CCT:	CRI:
Bridgelux BXRA-W3500-00Q0G		2.1A	50W	3600lm	X=.4223-.4431 Y=.3990-.4213	3000K	90

Array mounted on standard LM-80 Load Board



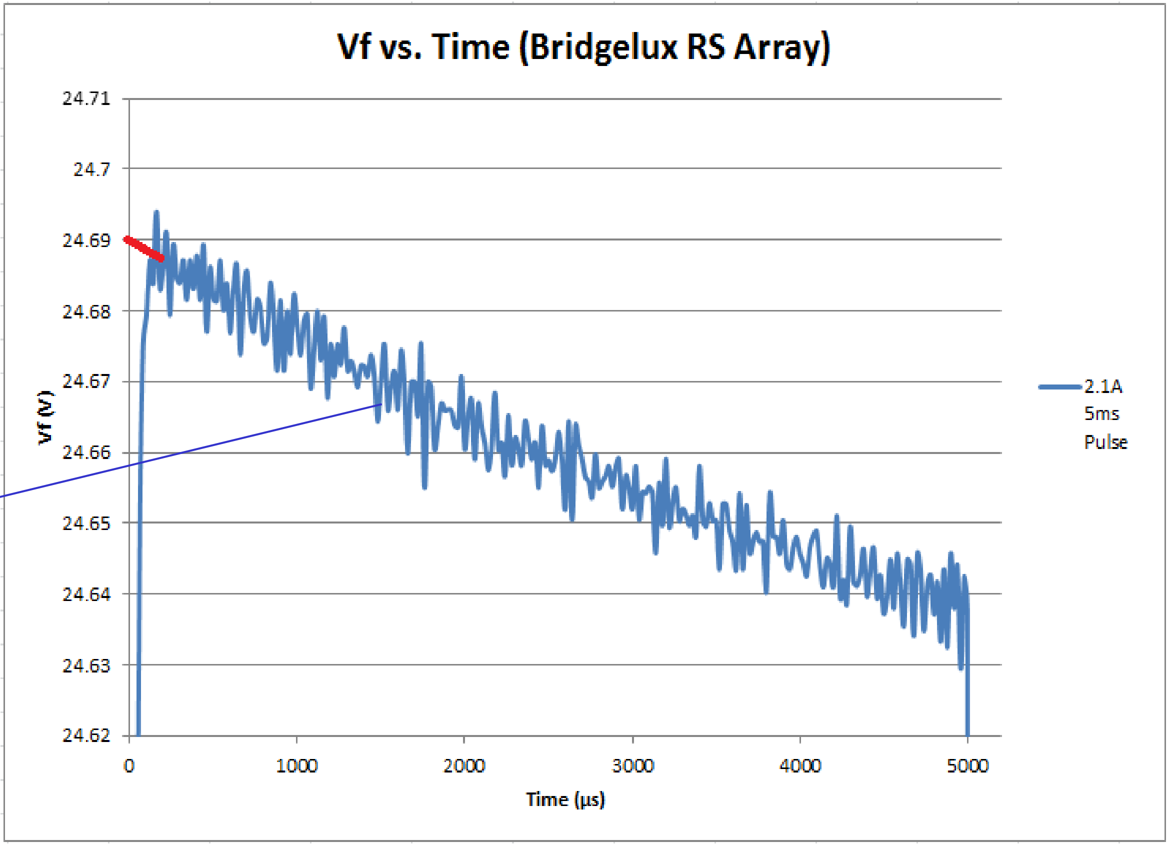
DC Test Method: 7 Steps

1. Set TCP Temperature To Tj and Stabilize DUT
2. Drive LED With Current Pulse(s) at If
3. Capture Vf, Determine Vf(0)
4. Drive LED With DC Current at If
5. Continuously Measure Vf
6. Lower TCP Temperature Until Vf = Vf(0)
7. Make Optical Measurement



Pulses must have sharp, clean rising edge

Tj = 25C: Bridgelux Array Vf(0) = 24.69V



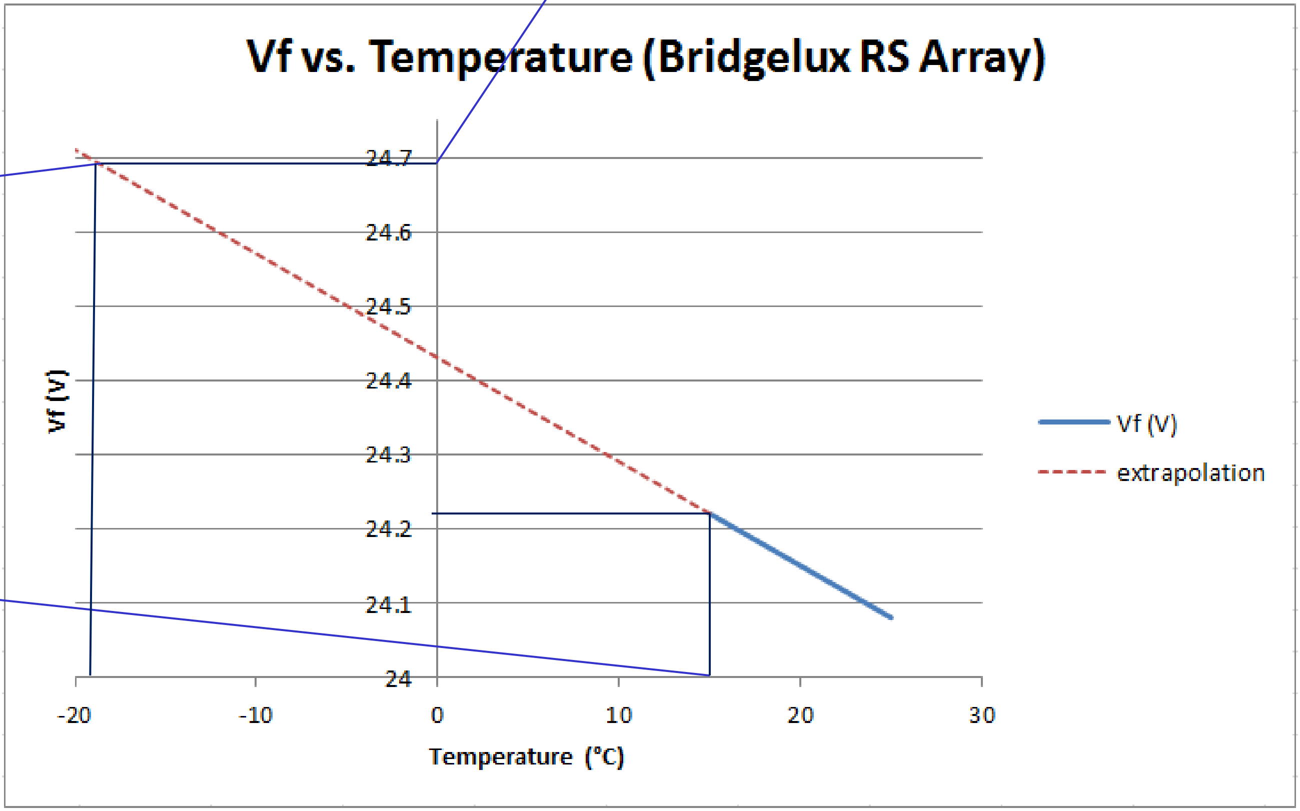
Effective quantization 14.5 bits

Issue: TCP Only Able To Drive Vf Down To 24.22

Vf(0) = 24.69

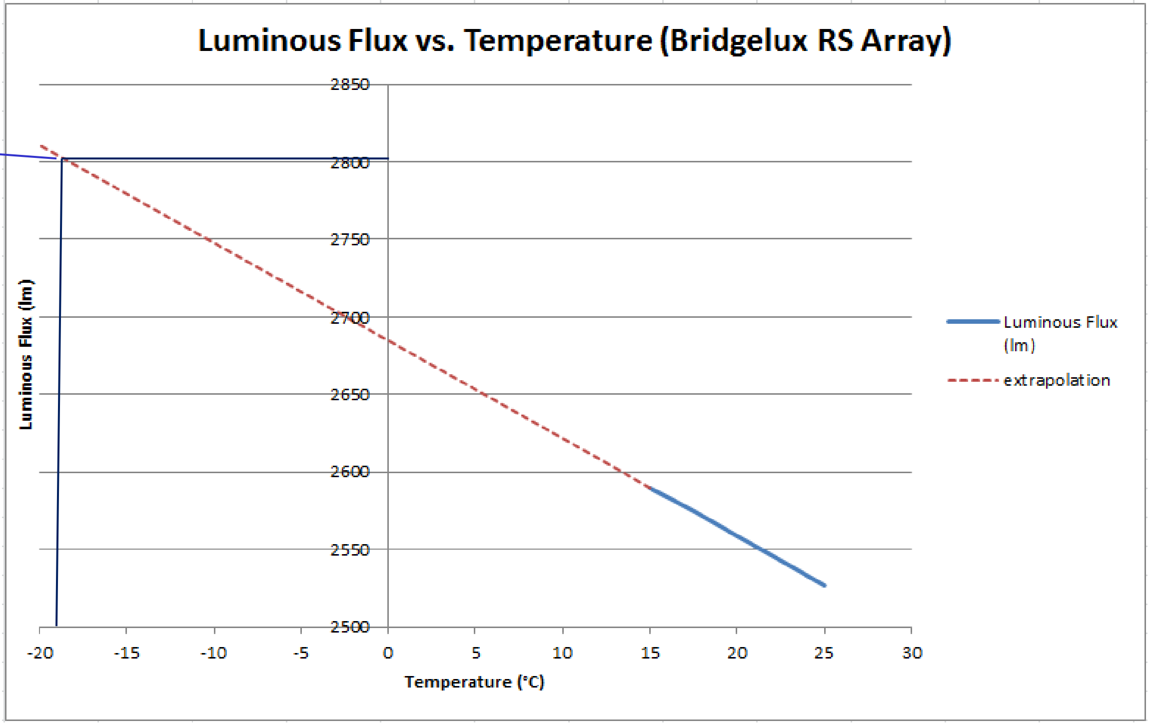
Projected Vf=Vf(0) temperature => -18.57C

15C Lower Operating Limit For TCP



Solution: Take Actual Measurements Within Operating Range of TCP and Extrapolate

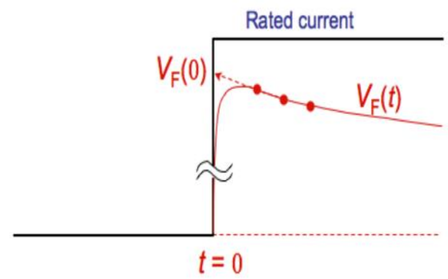
Projected Flux,
Tj = 25C:
2801.99



Junction Temperature Rise = 43.57C

Adjusted DC Test Method: 7 Steps

Set TCP Temperature To Tj and Stabilize DUT → Drive LED With Current Pulse(s) at If → Capture Vf, Determine Vf(0) → Drive LED With DC Current at If → Decrease TCP Temperature To Lowest Operating Point → Log V(f) and Optical Measurements At Temperatures From Tj to Lowest Operating Point → Extrapolate To Determine Optical Measurements



Pulses must have sharp, clean rising edge

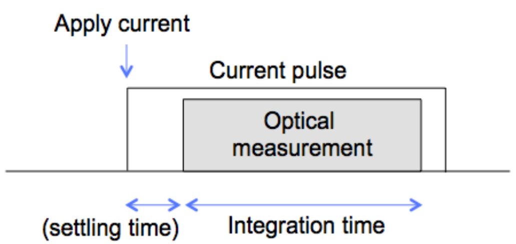
DC Method: Observations & Results

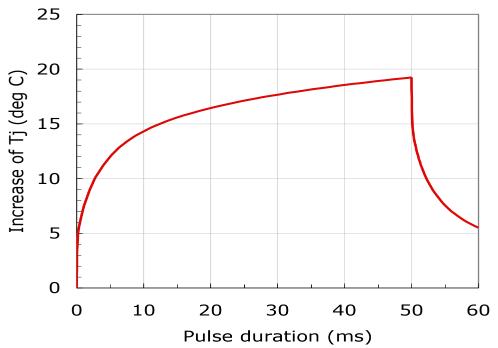
- Data acquisition/extrapolation is required to determine Vf(0)
- Junction temperature rise: 25+18.57C = 43.57C
- Minimum practical Tj test temperature = 15+43.57C = 58.57C
- Multistep methodology is tedious, especially with adjustments

DUT:	Luminous Flux:	x:	y:	CCT:	CRI:
Bridgelux BXRA-W3500-00Q0G	2801.99	.4301	.4054	3132.46	99.15

Single Pulse Test Method: 4 Steps

Set TCP Temperature To Tj and Stabilize DUT → Drive LED With Current Pulse at If → Trigger Spectrometer For Optical Measurement → Apply Corrections Based Upon Thermal Model





Triggering of optical measurement must be accurate and repeatable

How corrections are applied is vague; they may be used as input to uncertainty calculation

Single Pulse Test Conditions

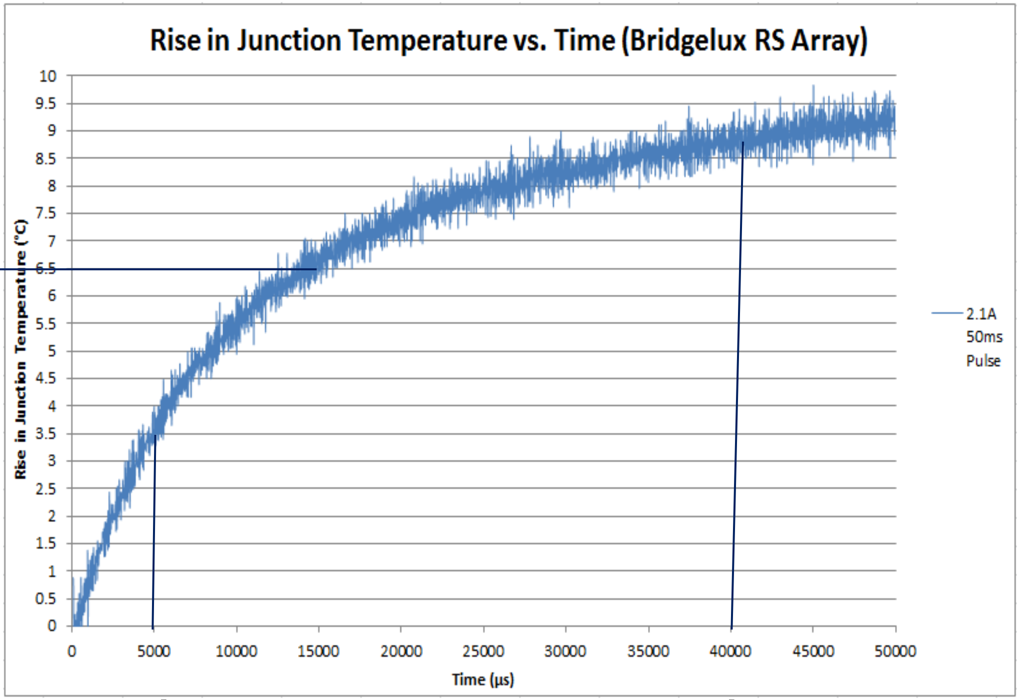
- Tj = 25C, initial TCP Temp = 25C
- 50mS, 2.1A current pulse
- Spectrometer integration from 5-40mS (35mS)
- Initial lumen measurements roughly 50lm lower than DC method
- Clearly LED was heating
- But no thermal model available for DUT

Adjustment: Estimate Tj Rise Using Vf Data

- Capture Vf vs t for 50mS pulse
- Obtain an average Vf measurement over integration time
- Repeat at different temperatures
- Calculate dV/dt
- Use dV/dt and Vf data to calculate dT/dt
- Calculate an average rise in junction temperature over the integration window

Method Adjustment Yields Average Tj Rise

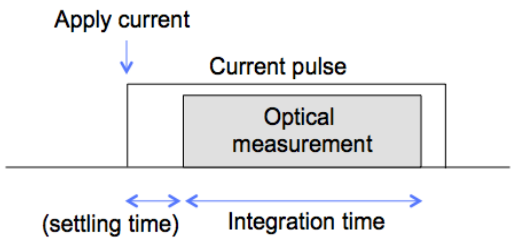
Average rise over the integration time: roughly 6.5C

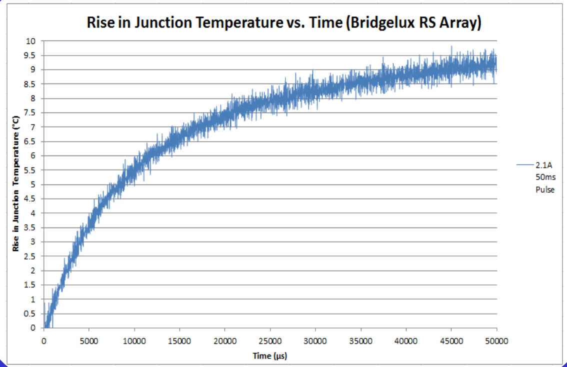


Measurement Integration Time

Adjusted Single Pulse Test Method: 7 Steps

Set TCP Temperature To Tj and Stabilize DUT → Drive LED With Current Pulse at If → Collect Vf vs t → Repeat at different TCP temperatures to obtain Vf vs T → Calculate T vs t and average Tj rise → Lower TCP temperature by Tj rise → Make Optical Measurement





Triggering of optical measurement must be accurate and repeatable

TCP adjustment is within TCP capability for 25C Tj

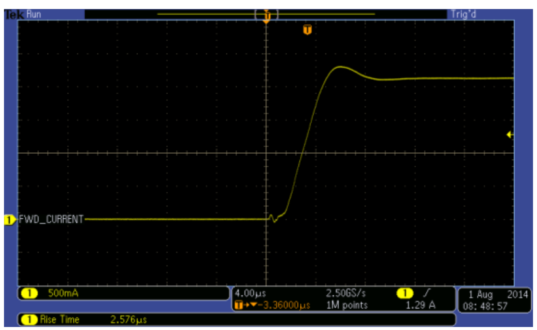
Single Pulse Method: Observations & Results

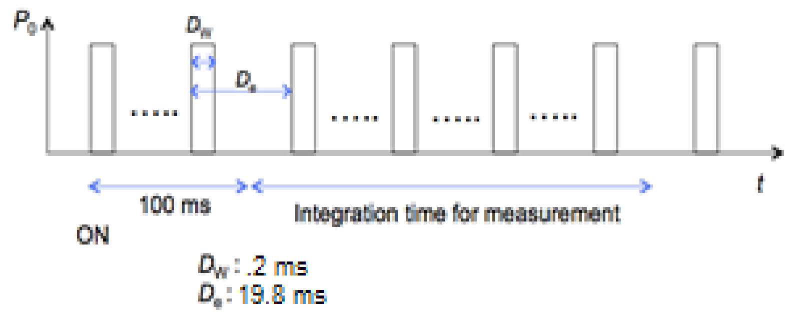
- Data acquisition/extrapolation is required
- Junction temperature rise: 6.5C
- Minimum practical Tj test temperature = 15+6.5C = 21.5C
- May be used without temperature adjustment for less accurate results
- Faster to perform than DC method

DUT:	Luminous Flux:	x:	y:	CCT:	CRI:
Bridgelux BXRA-W3500-00Q0G	2800.98	.4293	.4068	3154.53	98.04

Continuous Pulse Test Method: 4 Steps

Set TCP Temperature To Tj and Stabilize DUT → Determine Suitable Pulse Duration → Drive DUT with pulse train at If → Make optical measurement





Pulses must have uS level rise time and excellent timing accuracy

Continuous Pulse Method:

No Issues, No Adjustments To Method

Continuous Method: Observations & Results

- No data acquisition required
- Spectrometer integration times adjusted by 100X
- Junction temperature rise: negligible
- Minimum practical Tj test temperature = 15C
- Practical with ambient control, even with COB
- Very simple, very fast measurements

DUT:	Luminous Flux:	x:	y:	CCT:	CRI:
Bridgelux BXRA-W3500-00Q0G	2801.96	.4303	.4064	3133.5	97.62

Results Show Excellent Flux Correlation

DC

DUT:	Luminous Flux:	x:	y:	CCT:	CRI:
Bridgelux BXRA-W3500-00Q0G	2801.99	.4301	.4054	3132.46	99.15

Single Pulse

DUT:	Luminous Flux:	x:	y:	CCT:	CRI:
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Continuous Pulse

DUT:	Luminous Flux:	x:	y:	CCT:	CRI:
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Instrumentation Review: Surprise -- Continuous Pulse Is Simplest Method

Method	Pulsed Current	Temperature Control	Drive Current	Triggering	Data Acquisition	Complexity
DC	Yes	High power TCP with extrapolation	High continuous power, fast rise time	None	Yes	High
Single Pulse	Yes	High power TCP	High continuous power	Precision	Yes	High
Continuous Pulse	Yes	Low power TCP or ambient	High peak power, fast rise/fall	Optional	No	Low

Thank You

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