Minimizing Current Source-Induced Errors in LM-85 Measurements

Jeff Hulett, CTO, Vektrex, LM-80 Working Group Chair
jhulett@vektrex.com

Abstract

LM-85 describes three methods for powering LEDs during optical measurements: DC, Single Pulse, and Continuous Pulse. This paper discusses the demands each of these methods makes on the current source that powers the LED, especially when the LED is operating at the new super high power level. This paper describes the major contributors to flux measurement errors that are associated with the current source and it presents some simplified models useful to estimate the magnitude of these errors. Finally it compares the three methods in common measurement scenarios and it provides system design recommendations to reduce errors.

.

Outline

- Vektrex background
- A bit about LEDs
- LM-85 test types
- Experimental data: example LEDs/LM-85 tests
- Major error sources
- Recommendations

Vektrex Is Focused On LEDs

- Incorporated 1986, corporate/R&D headquarters in CA
- Supplier of LM-80 and reliability test systems for LEDs
- Current Sources for LED measurements
- Expert 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
  - China, Malaysia Singapore, Taiwan
  - Germany

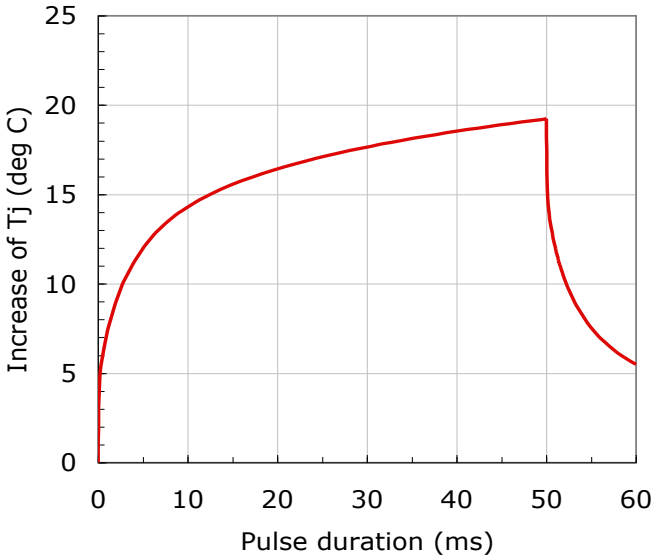
A Bit About LEDs

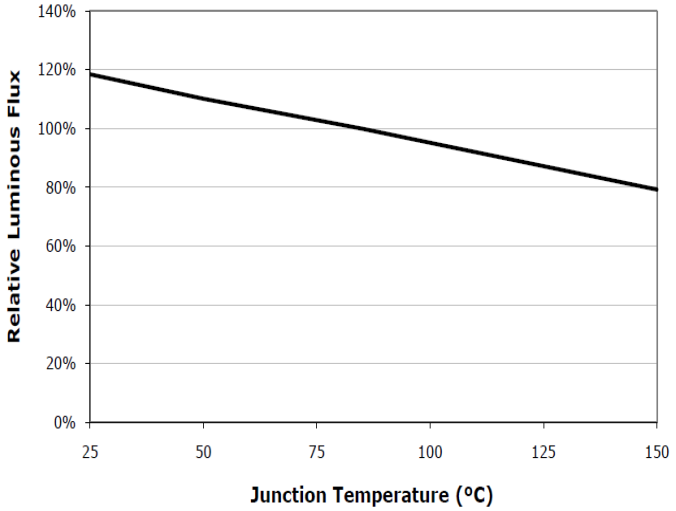
(From a EE perspective)

LEDs Are Temperature Sensors That Happen To Emit Light

Type	Property	Sensitivity
Platinum RTD	Resistance	0.4%/Degree C
K-Type Thermocouple	Voltage	40uV/Degree C
White LED	Voltage	-2.5mV/Degree C
White LED	Lumens	-0.24%/Degree C

LED Characteristics Change Rapidly With Temperature

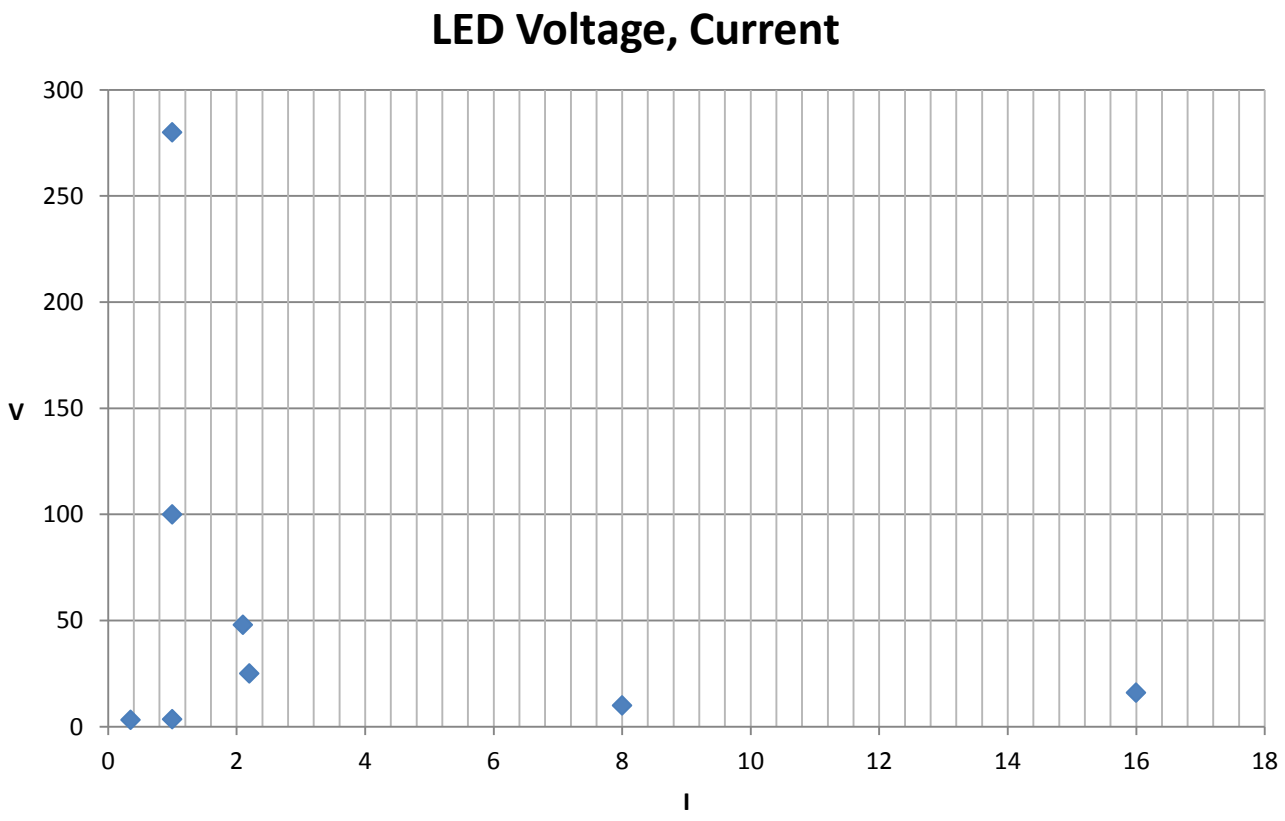




LEDs heat fast – 50mS pulse heating

Flux droops 0.2%/Degree C

LEDs Are Moving To Higher I,V

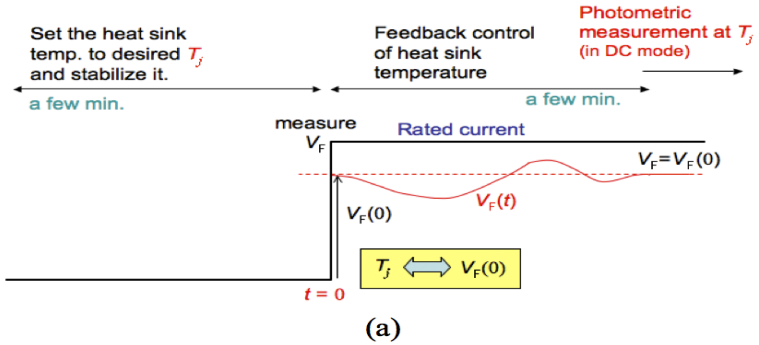


LM-85 Measurements

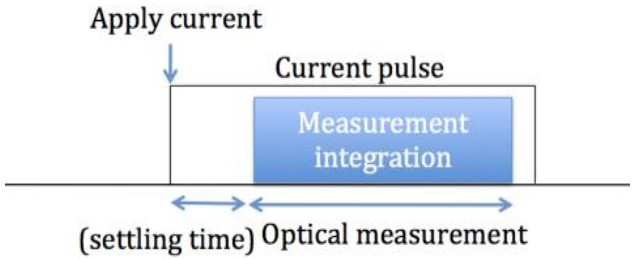
LM-85 is Like LM-79 But Completely Different

All LM-85 Methods Require Pulsed Current

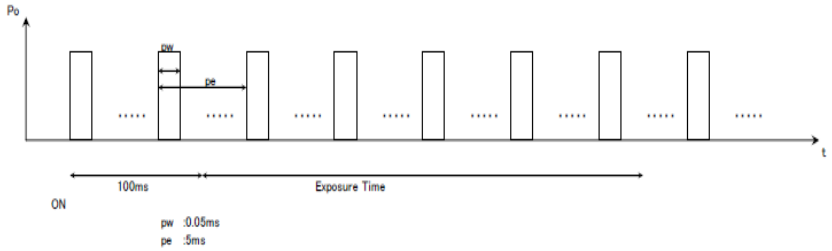
- DC Constant Current



- One Shot Pulse



- Continuous Pulse



LM-85 Has Many Benefits

- Light measurements are tied to the junction temperature
- The three methods provide flexibility for laboratories
- New continuous and single pulse methods are fast
- Methods are optimized for LEDs

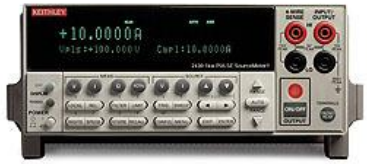
Available Current Sources For LM-85 Measurements

Got Drive?

Precision Pulsed Current Provides Best Performance

- General Purpose Laboratory Power Supply
  - Constant voltage or current
  - Often used with external shunt

- 4 Quadrant Source Meter
  - Widely used in industry
  - Pulse width limited

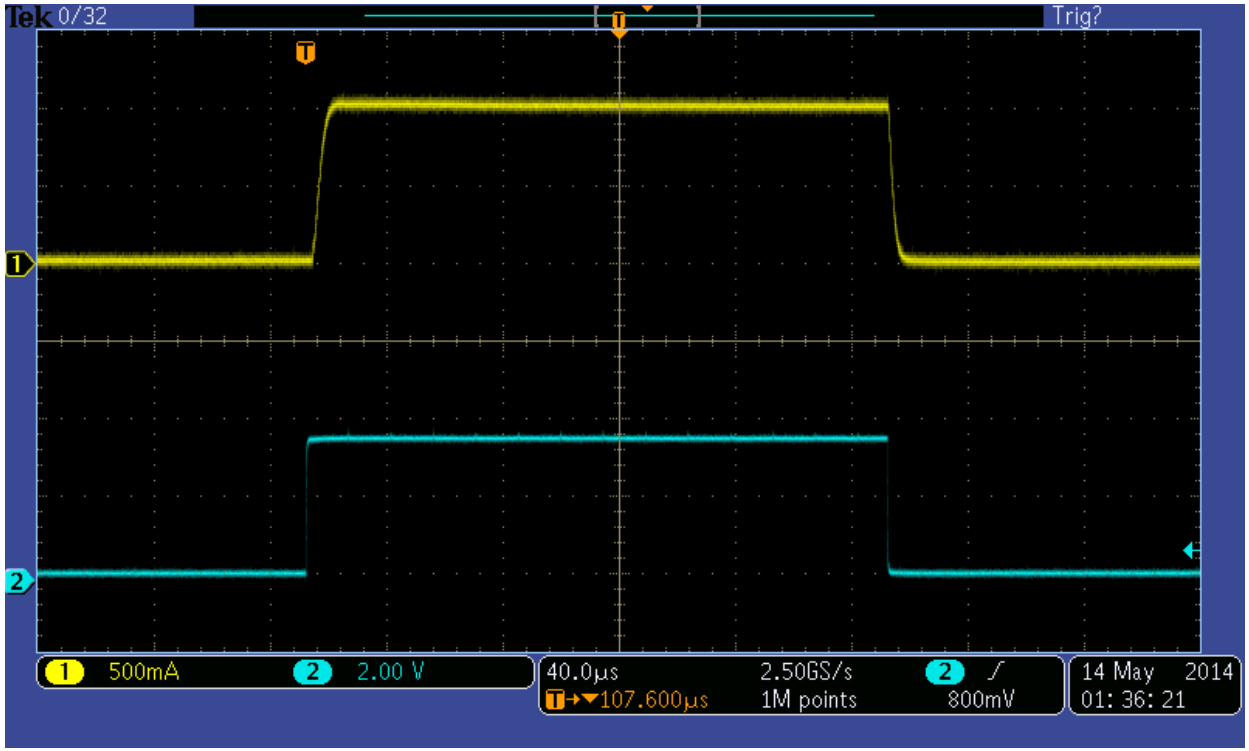


- Precision Pulsed Current Source
  - Designed for LED drive
  - True current source
  - High performance pulsing/DC

Current Source Comparison

Instrument Type	DC Accuracy	Programming Latency	Pulse Rise/Fall	Trigger	Continuous Power
Laboratory Power Supply	0.40%	15mS	60mS	No	500W
4 Quadrant Source Meter	0.40%	10mS	500-800uS	Yes	100W
Precision Pulsed Current Source	0.13%	5mS	2-4uS	Precision	800W
Performance evaluated at 50V, 2A					

Precision Pulsed Current Source Has Precise Trigger



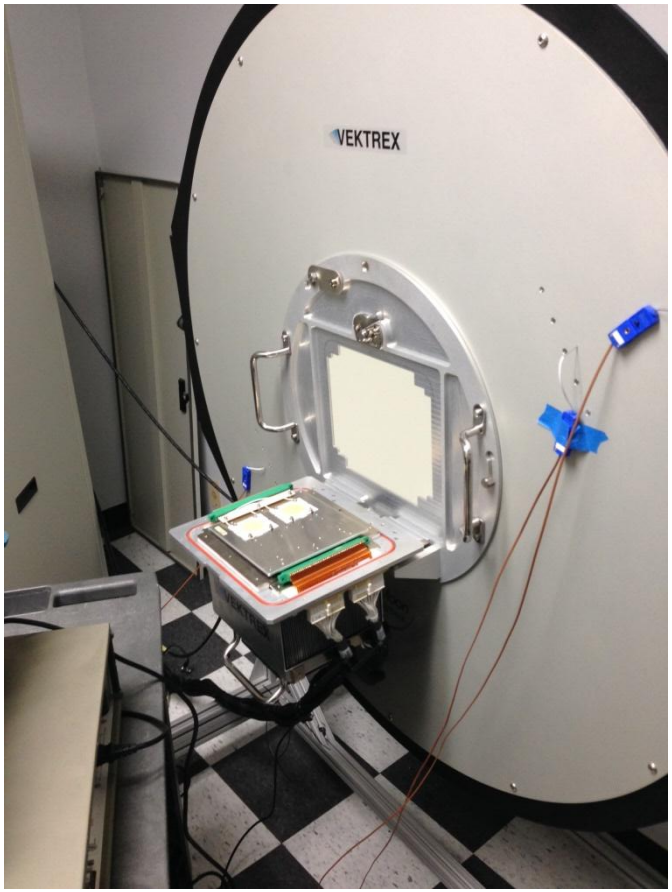
1A, 200uS Pulse and Trigger

Example Tests

What's The Flux?

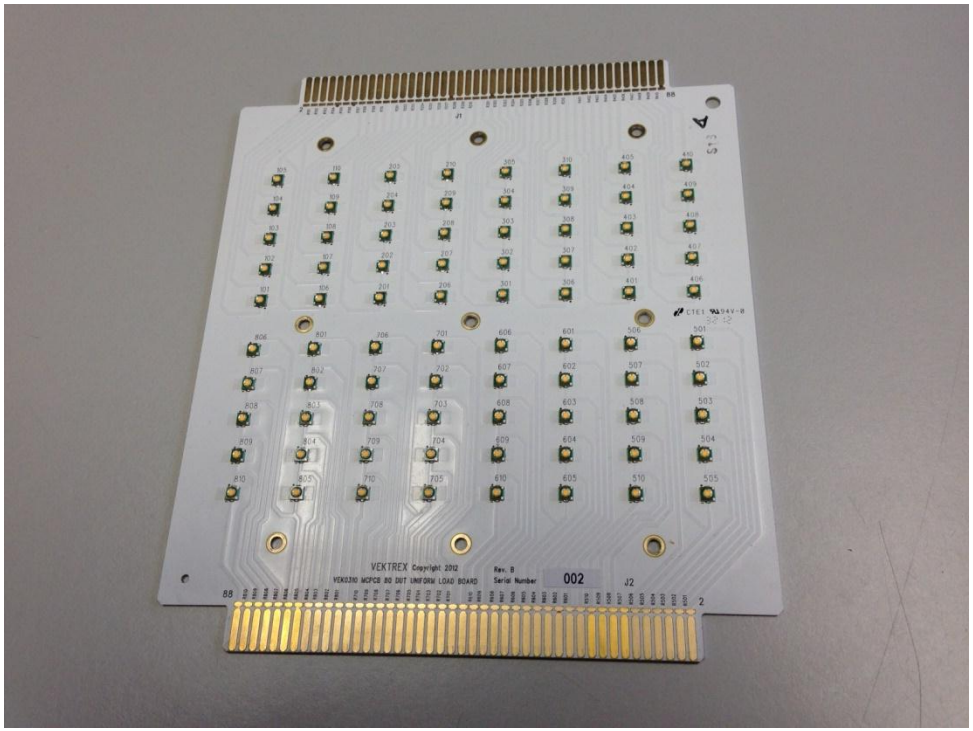
Test Setup Allows Control of Temperature, Current

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



Test Sample Cree Xlamp On Load Board

- White LEDs
- If=1A
- Vf=3.5V
- P=3.5W
- Rth=9C/W
- Single DUT tested



DC Test: Temperature Adjustment Not Performed

- At 3.5W, Rth=9, Tj = Tplatform + 31.5C
- To achieve Tj =25C, platform would need to be at -6.5C

- Instead thermal platform set to 25C
- Device stabilized at 25C for roughly 10 minutes
- No LM-85 temperature adjustment, estimated Tj = 56.5C
- DC current
- 50mS integration time

- 193.8 lumens @ 25C

- Measurement variation <0.1 lumen

Single Pulse Test: Variation Due To Triggering

- Thermal platform set to 35C
- Device stabilized at 35C for 10 minutes
- 1A, 50mS pulse
- 35mS integration time

Measurement Delay	Lumens
0mS	196.3
5mS	195.9
10mS	195.6

- Measurement variation 0.2 lumen

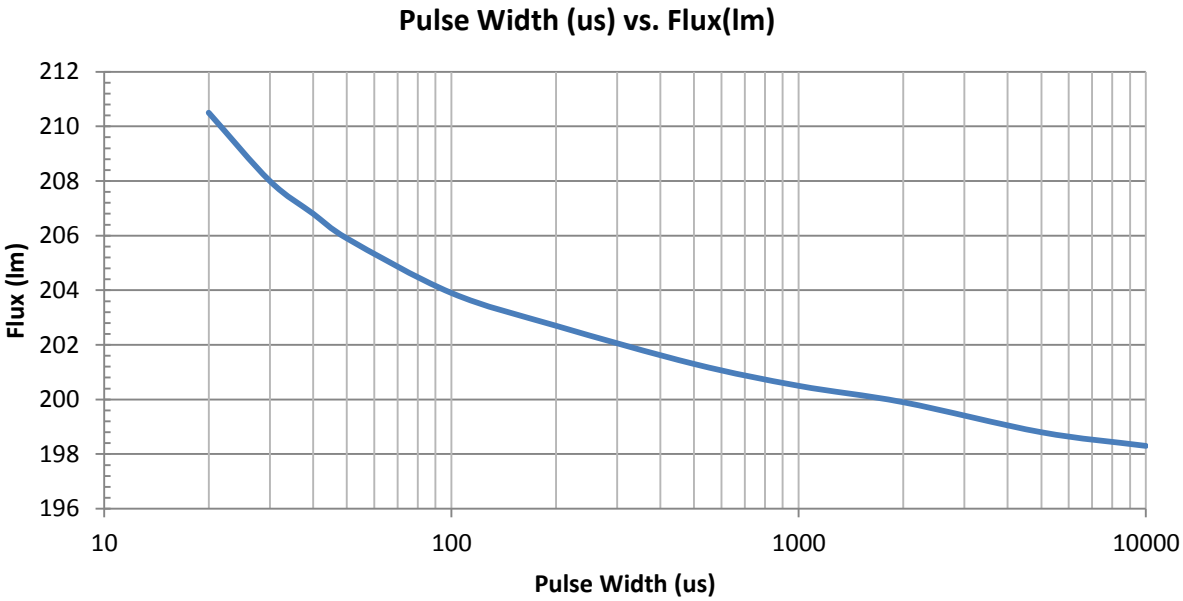
Continuous Pulse Test: Fast & Stable

- Thermal platform set to 25C
- Device stabilized at 25C for 1 minute
- 1% duty cycle
- Various pulse widths
- Pulse width error <500nS

- Measurement variation <0.1 lumen

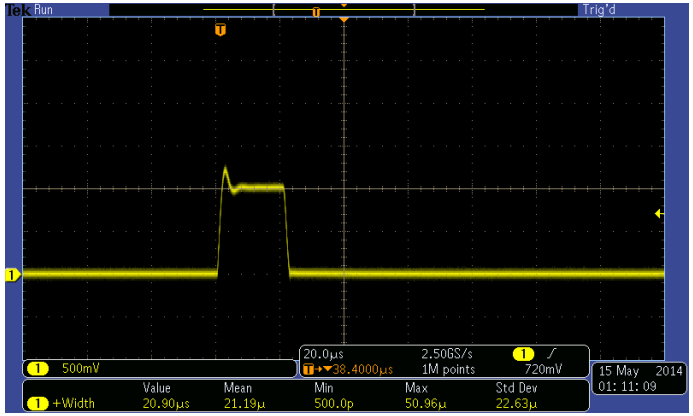
Continuous Pulse Test Results

Pulse Width(uS)	Duty Cycle(%)	Flux(lm)
10000	1%	198.3
5000	1%	198.8
2000	1%	199.9
1000	1%	200.5
500	1%	201.3
200	1%	202.7
100	1%	203.9
50	1%	205.9
40	1%	206.8
30	1%	208
20	1%	210.5



Pulse Fidelity Essential For Continuous Pulse Test

- Rise/fall time if >10% of pulse width
- Overshoot during early part of pulse
- Pulse width errors become significant when pulses are short



Pulse Width(uS)	Duty Cycle(%)	Error
10000	1%	0.005%
5000	1%	0.010%
2000	1%	0.025%
1000	1%	0.050%
500	1%	0.100%
200	1%	0.250%
100	1%	0.500%
50	1%	1.000%
20	1%	2.500%
Pulse Width Error, uS		0.5

Recommendations For Labs

What should I do?

Current Source Contributors To Measurement Error

- "Can't Do It"
  - Many sources/power supplies just don't have sufficient voltage/current/power capability for high power LM-85 measurements
- Triggering Jitter
  - Uncertainty of the trigger point can mean unknown heating
- Pulse Shape
  - Slow rise times overheat LEDs
  - Overshoot and width errors matter with fast pulses

Recommendations

- Select current sources that meet continuous power requirements
  - Pulsing is mandatory for LM-85, even in DC
- Minimize trigger uncertainty for single pulse measurements
- Try continuous pulsed measurements
  - They are quick and avoid density filters
  - Don’t require thermal model or Vf measurement
- Ensure current pulses have good rise time with <5% overshoot and <10% rise time

Thank You

Contact: Jeff Hulett, jhulett@vektrex.com