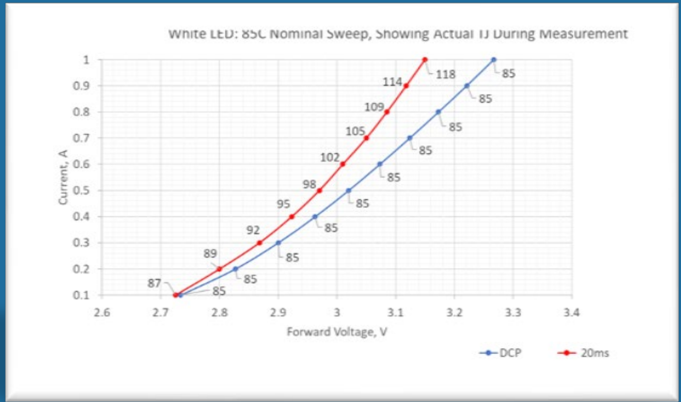
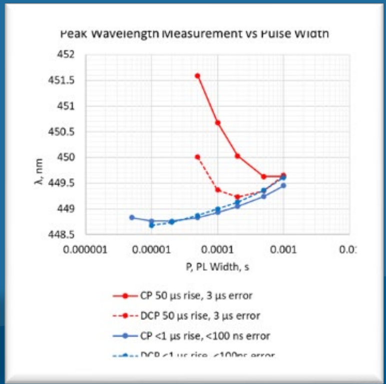
High-performance LED test solutions.

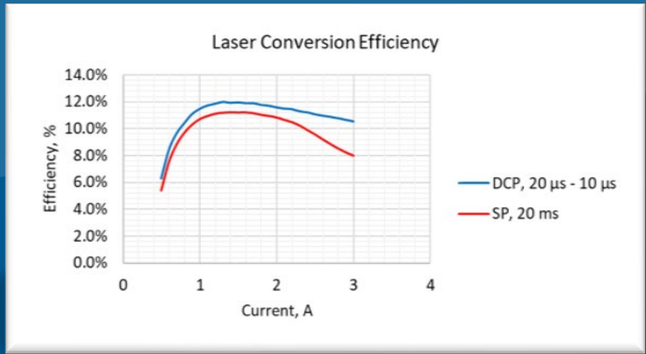
Practical Implementation and Applications of DCP Measurements

Jeff Hulett, Vektrex, 11/16/2021

jhulett@vektrex.com

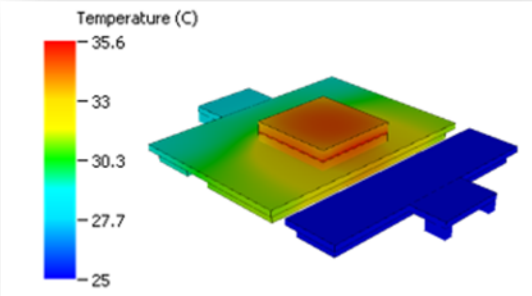






It is really about better measurements

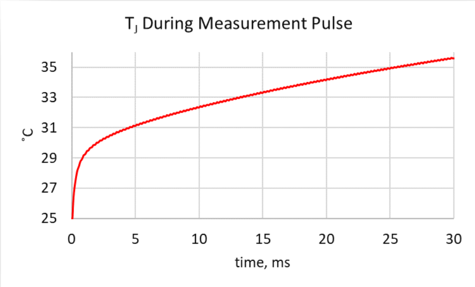
- Today's LEDs challenge traditional measurement methods
  - Optimized thermal designs
  - Very high-power devices
  - Pulsed operation



Modern LEDs lack large thermal reservoirs; they heat quickly during pulsed measurements

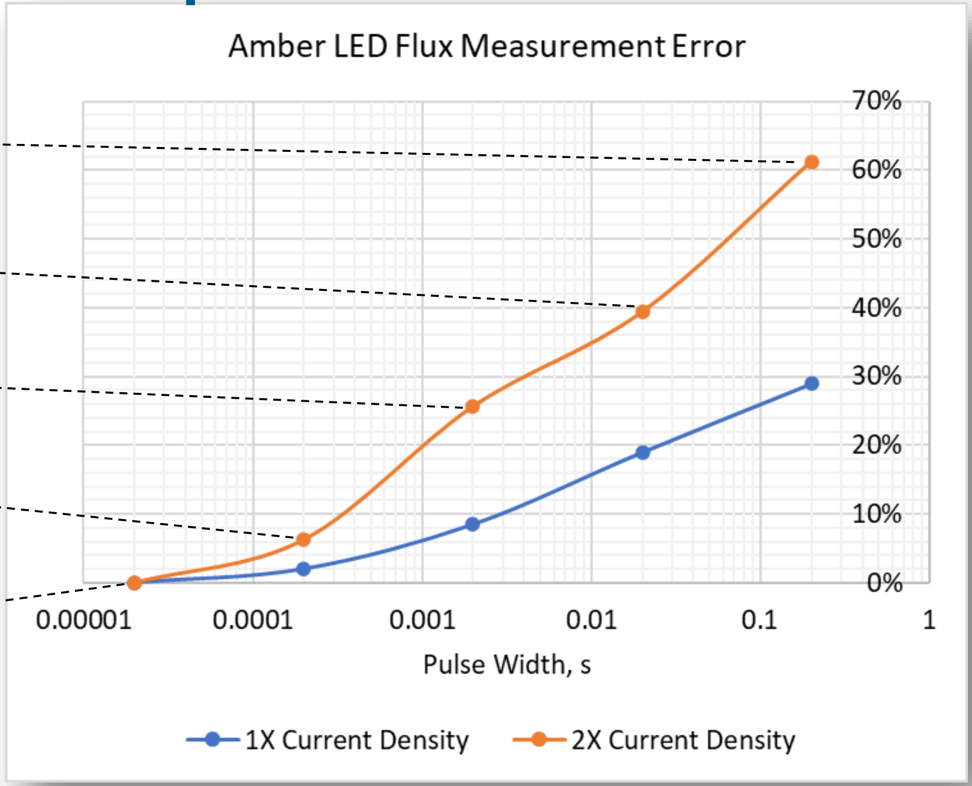
- DC and Single Pulse involve too much heating to be effective

- This talk presents the new DCP measurement which improves measurements by 1-2 orders of magnitude

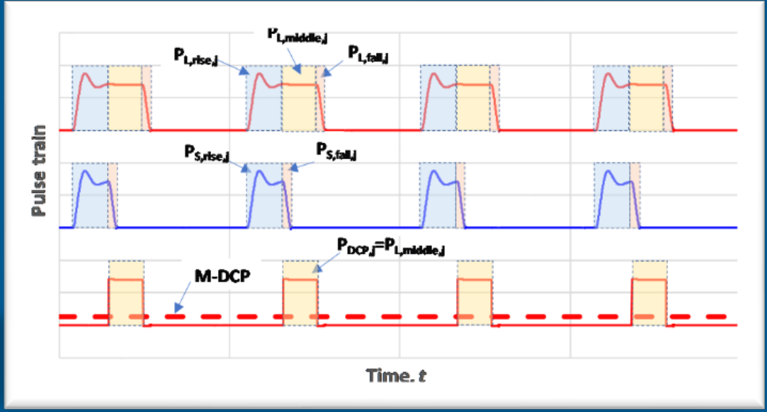


The accuracy of in-use LED measurement methods roughly corresponds to current pulse width

- **DC** – Long stabilization times, high heating
- **SP** – Most popular, but heating causes errors
- **FP** – New proposed method to reduce heating
- **CP** – Reduces heating but errors due to pulse shape
- **DCP** – Error elimination makes very short pulses possible

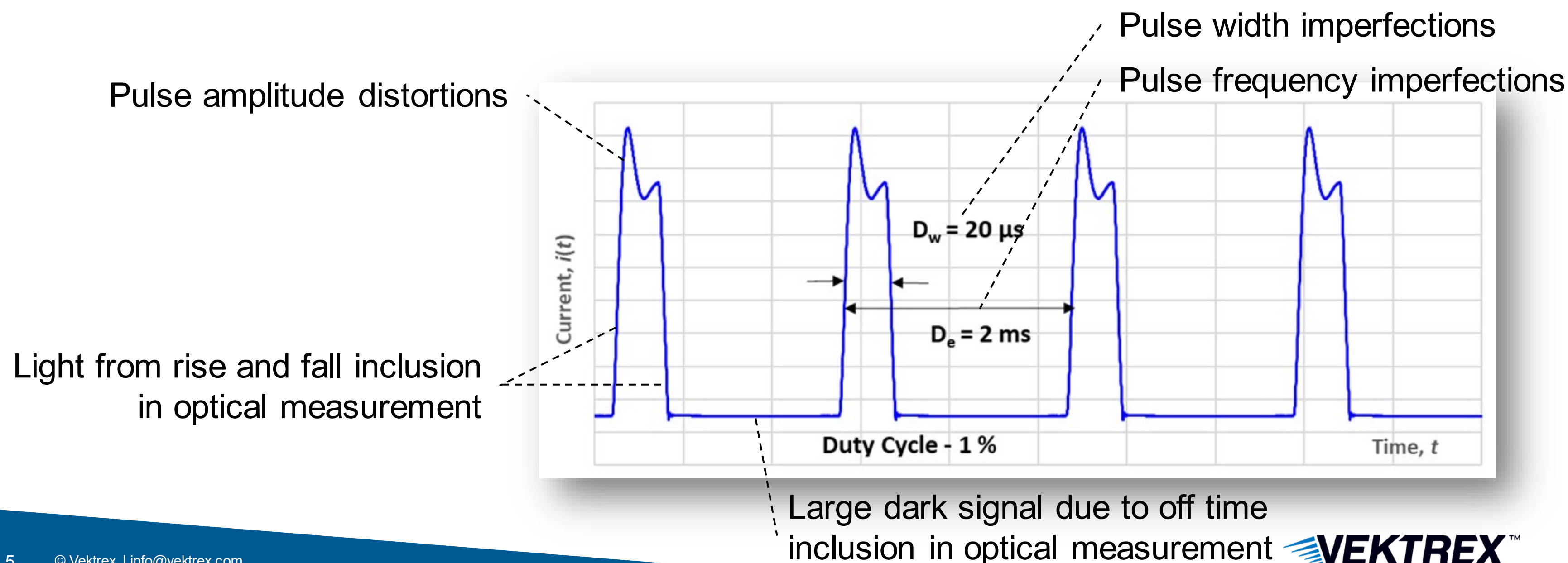


Differential Continuous Pulse (Also Known as DCP) Test Method



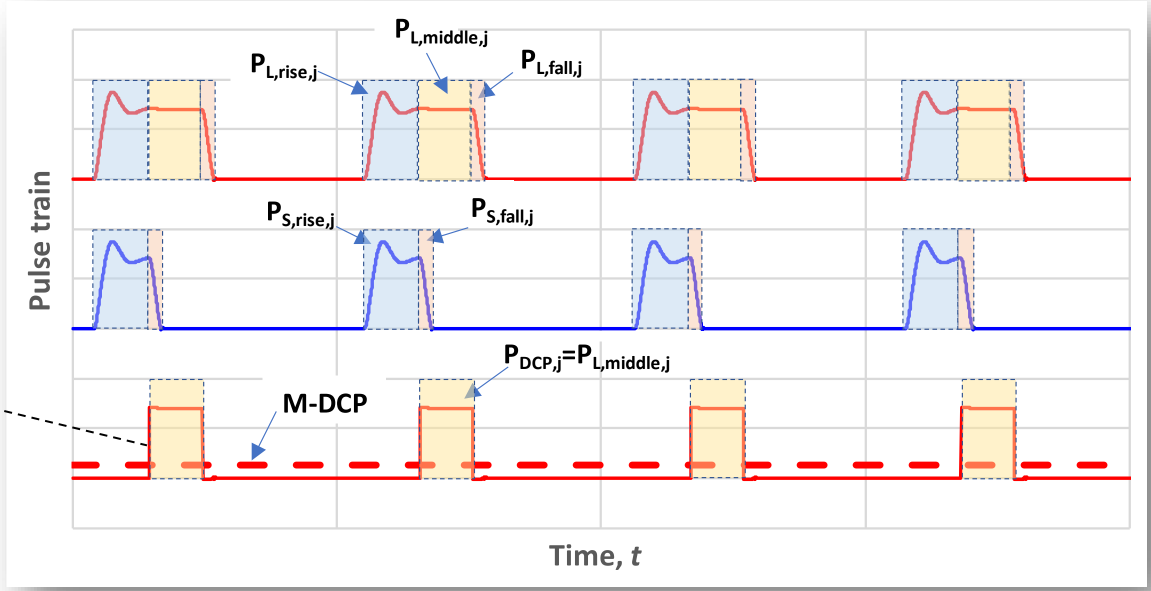
DCP is based on Continuous Pulse (CP) measurements

- CP powers the DUT with a continuous, low-duty-cycle train of narrow pulses.
- The optical measurement is made for the time-averaged signal including both on and off time.
- CP measurements are subject to several significant errors.



Differential Continuous Pulse (DCP) takes the difference of two CP measurements – one with long pulses (e.g. 20 µs) and one with short pulses (e.g. 10 µs)

Light remaining after subtraction is from middle, flat portion of long pulse, amplitude, timing, and dark current errors subtract out



The DCP method is quickly being incorporated into standards

- Method is being added to the IES LM-85 standard, along with a variant that uses a DMM to make additional corrections called M-DCP
- DCP measurements are required in new IES LM-92 UV LED testing standard

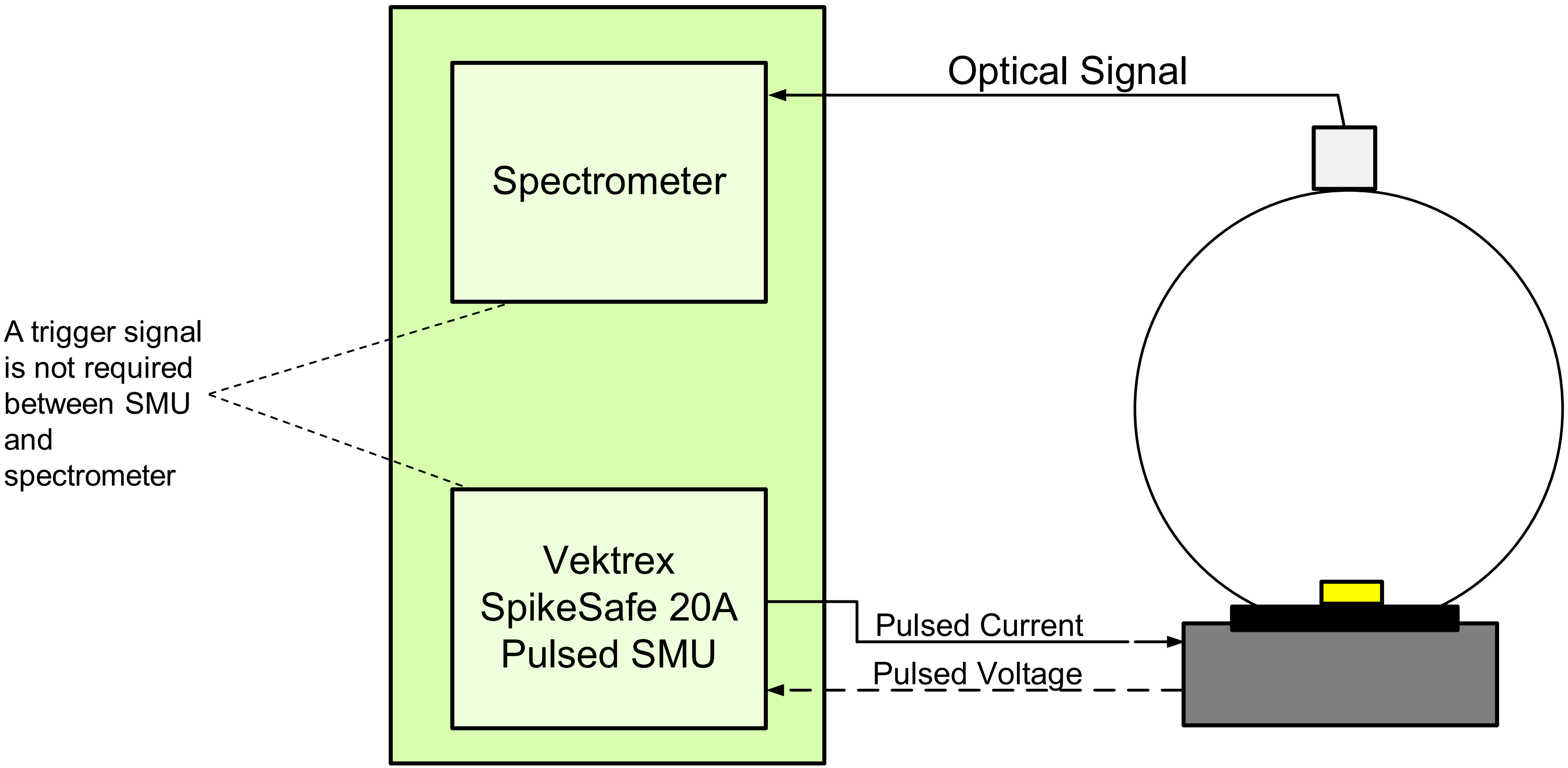
LM-92 Test Requirements

Test Current, I_T	**Pulse 1 Parameters**	**Pulse 2 Parameters**
I_T > 10% of $I_{nominal}$	10 µs, 1% duty cycle	20 µs, 2% duty cycle
1% < I_T < 10% of $I_{nominal}$	25 µs, 10% duty cycle	50 µs, 20% duty cycle

VEKTREX™

An Example DCP Measurement System Architecture

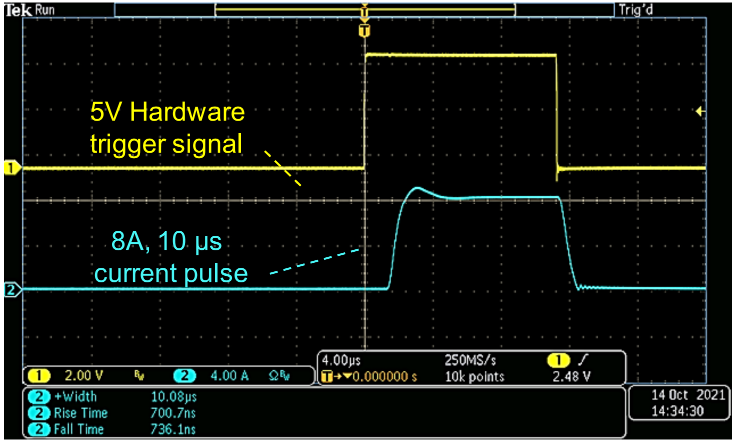
DCP measurement system needs only pulsed SMU and a spectrometer



A high-performance pulsed SMU with 10µs minimum pulse capability is required for DCP measurements

	SMU Feature Comparison					
SMU Type:	Pulsed Current	10µs Pulse Width	Digitizer	Timing acuracy	Rise Time	Use for DCP?
Gen 1 SMU	No	No	No	milliseconds	100s of microseconds	No
Gen 2 SMU	Yes	No	No	10s of microseconds	10s of microseconds	Possible, PL > 500 µs
Graphical SMU	Yes	No	Yes, ground-referenced	100s of microseconds	10s of microseconds	No
Pulser/SMU	Yes	Yes	Yes, ground-referenced	2µs	9 µs	Possible, PL > 20 µs
Precision Pulsed SMU	Yes	Yes	Yes, true-differential	30ns	0.5-2 µs	Yes, PL > 2 µs

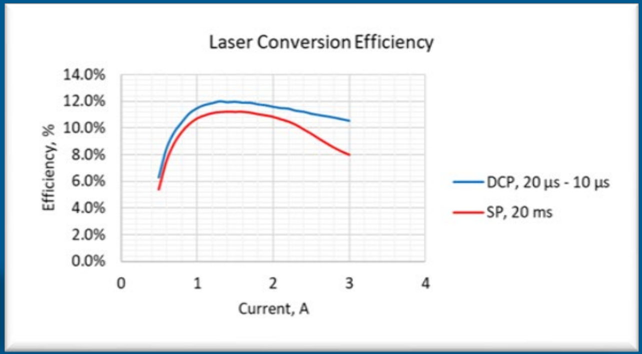
Precision Pulsed SMU



Precision Pulsed SMU current pulse

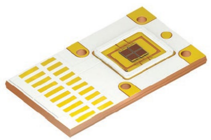
VEKTREX™

DCP measurement examples – illustrating the benefits of the DCP method

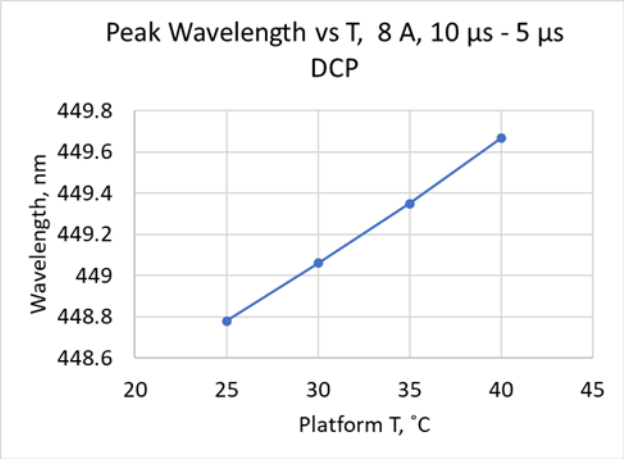


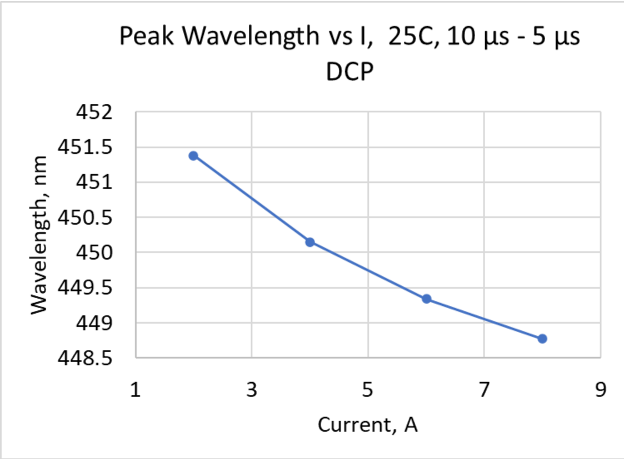
DCP Measurement Example 1: high-power LED, compare CP vs DCP for 2 types of SMUs

- 8A, 7V blue LED requires CP or DCP to limit heating in sphere



- Key part characteristics that contribute to measurement errors:
  - Radiant Flux **DECREASES** by about 0.2-0.3%/˚C
  - Peak wavelength **INCREASES** by 0.06 nm/˚C
  - Peak wavelength **DECREASES** by 0.435 nm/A



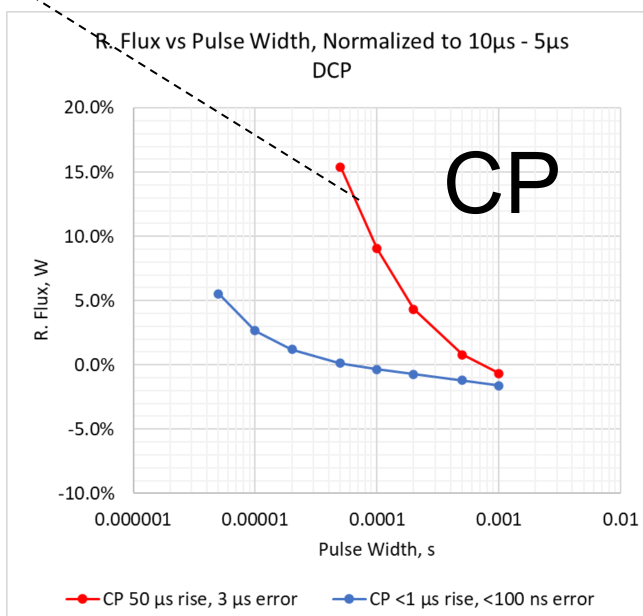


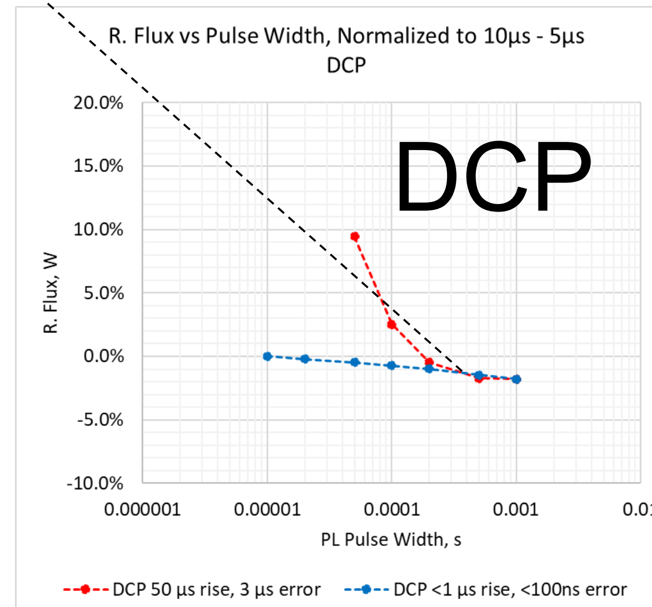
8A,1% CP and DCP R. flux measurements compared

CP Slow pulse rise/fall produces positive error at short pulse widths due to increased quantum efficiency at lower currents

DCP eliminates errors until P_S width < sum of rise and fall times, in this case about 100 µs for slower SMU

Source Type	CP R. Flux Error	DCP R. Flux Error
Gen 2 SMU 50µs rise time, 3µs width error	15%	9.5%
Performance Pulsed SMU <1µs rise time, 100ns width error	5.5%	0%





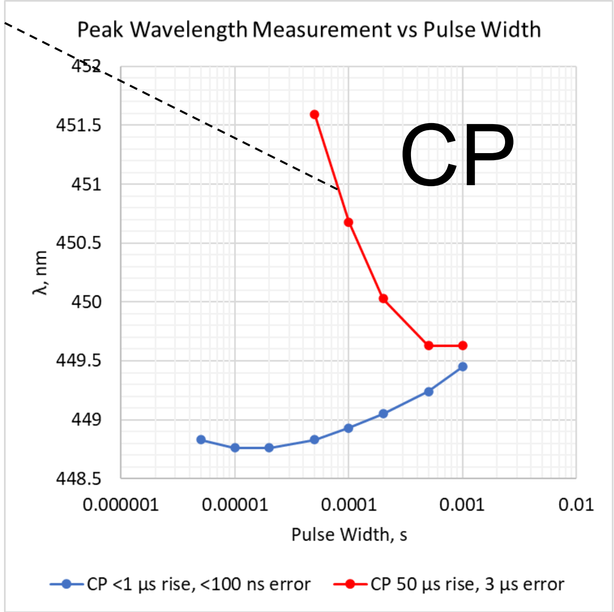
VEKTREX™

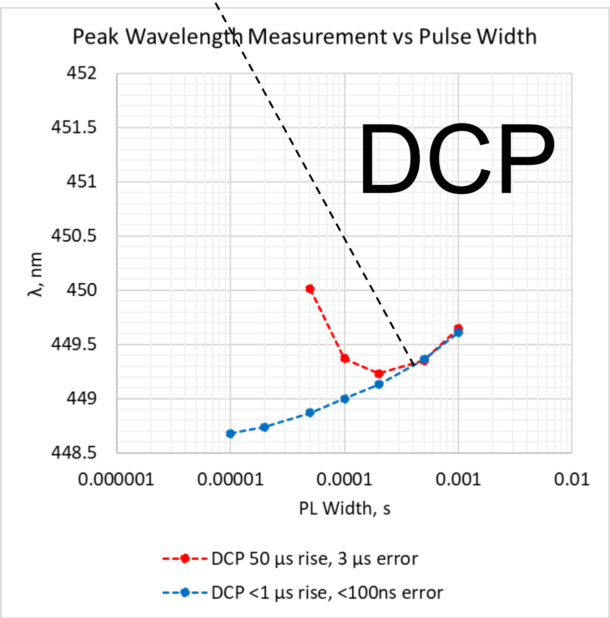
8A,1% CP and DCP R. peak wavelength measurements compared

DUT characteristic of increasing wavelength at lower currents causes slow-SMU CP peak wavelength curves to depart from the true temperature trend and bend up sharply at narrower pulse widths

DCP is only useable at 500 µs or longer, but such long pulses still involve too much heating, shifting the wavelength measurement up

Source Type	Peak W. Error	Peak W. Error
Gen 2 SMU 50µs rise time, 3µs width error	2.9 nm	1.2 nm
Performance Pulsed SMU <1µs rise time, 100ns width error	0.15 nm	0 nm

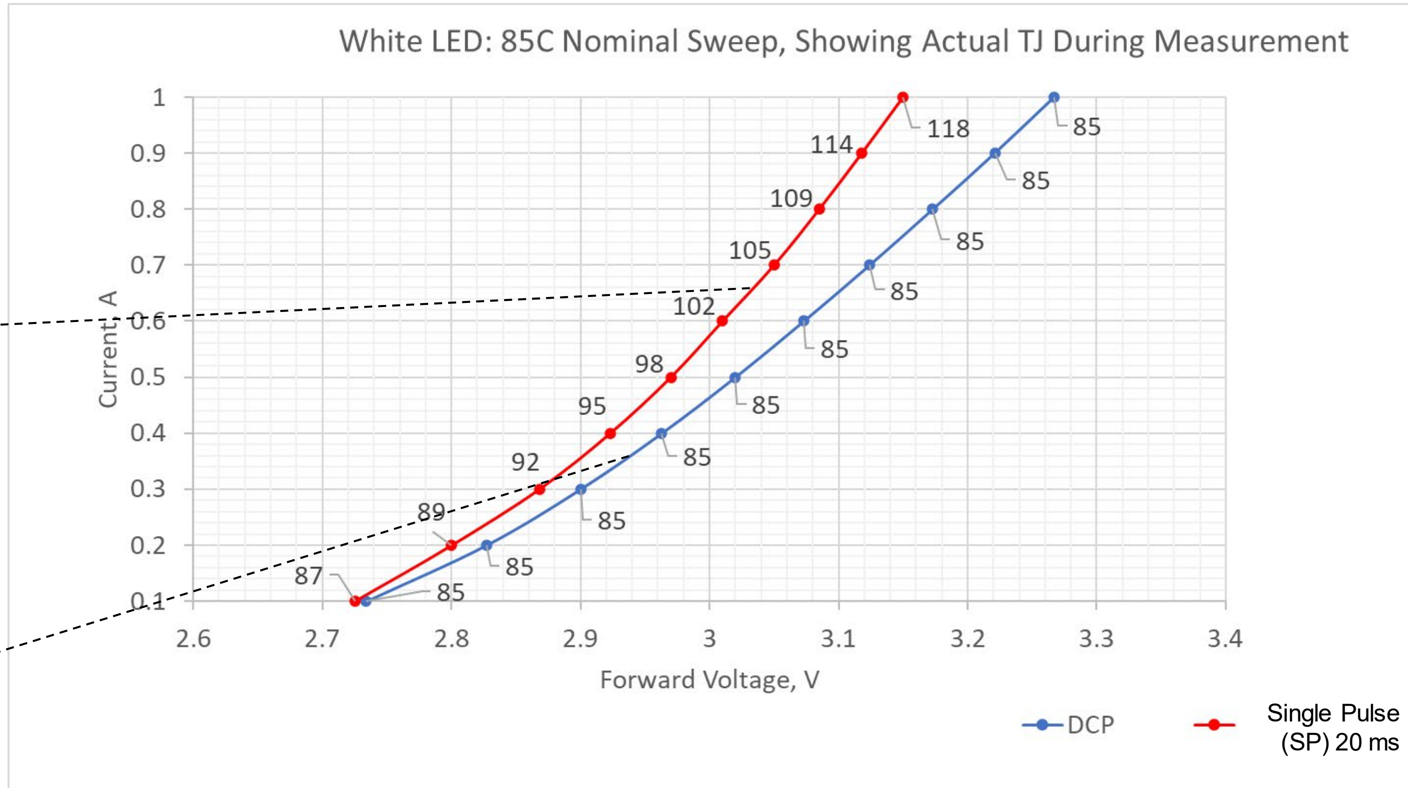




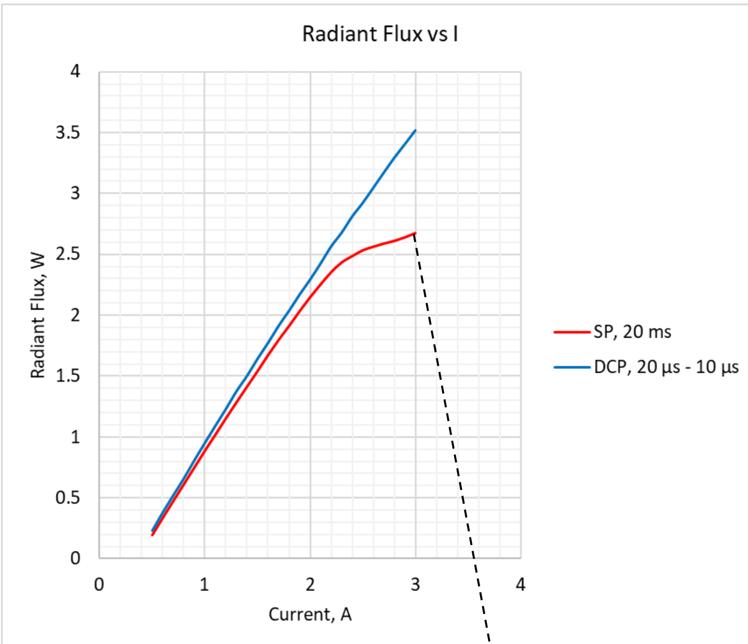
Example 2: White LED 85˚C I-V curve measurement – compare SP and DCP

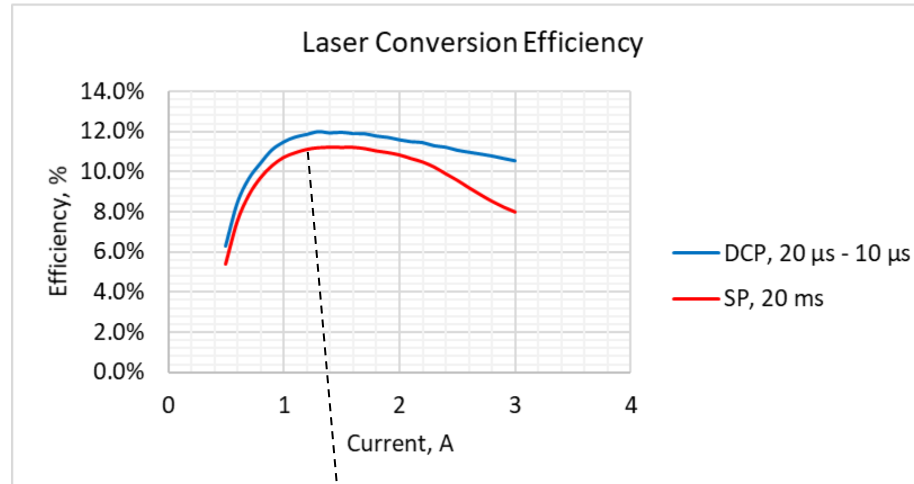
20ms measurements used by this manufacturer for its datasheet, result in significant T_J rise at higher currents. This shifts curve left

DCP measurements have minimal heating. T_J remains at thermal control platform temperature of 85 ˚C



Example 3: Power and efficiency testing of laser-based illumination component – compare DCP and SP





Heating lowers SP efficiency curve by 10%-25%

SP measurement error at 3A is 24%

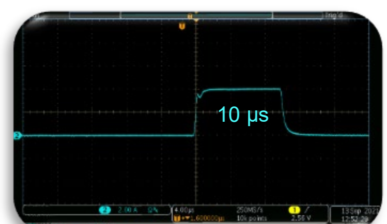
DCP is a game-changer. With DCP you can measure devices accurately with almost no heating. It is easy to implement, and it doesn't require a complete upgrade of your measurement systems

- <u>Take advantage of this new powerful method to improve your measurements</u>

- Add a precision pulsed SMU to your measurement system
  - Look for rise times < 5 µs
  - Don't try to get by with older SMUs – the rise time is too slow

- No need to upgrade spectrometer if it has good dark signal capability

- Test with short pulses – below 20 µs



VEKTREX™

Acknowledgements

- I would like to thank the following companies that graciously provided sample parts and advice for my research over the last two years:
  - Bolb
  - Cree
  - Lumileds
  - Nichia
  - Osram
  - SLD Laser

- Thanks also to Yuqin Zong of NIST for guidance and suggestions