DIGITAL WE DAYS 2023

PCB HEAT MANAGEMENT

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

TODAY'S SPEAKERS

PRESENTATION
Alexandre Chaillet
FAE trainer

MODERATION
Markus Eberle
Marketing Department

INFORMATION ABOUT THE WEBINAR

You are muted during the webinar.
However, you can ask us questions using the chat function.

Duration of the presentation	30 Min
Q&A:	10 – 15 Min

Any questions?
No problem! Email us digital-we-days@we-online.com

Please help us to optimize our webinars!
We are looking forward to your feedback.

On our channel	Würth Elektronik Group
And on	Digital WE Days 2023 YouTube Playlist

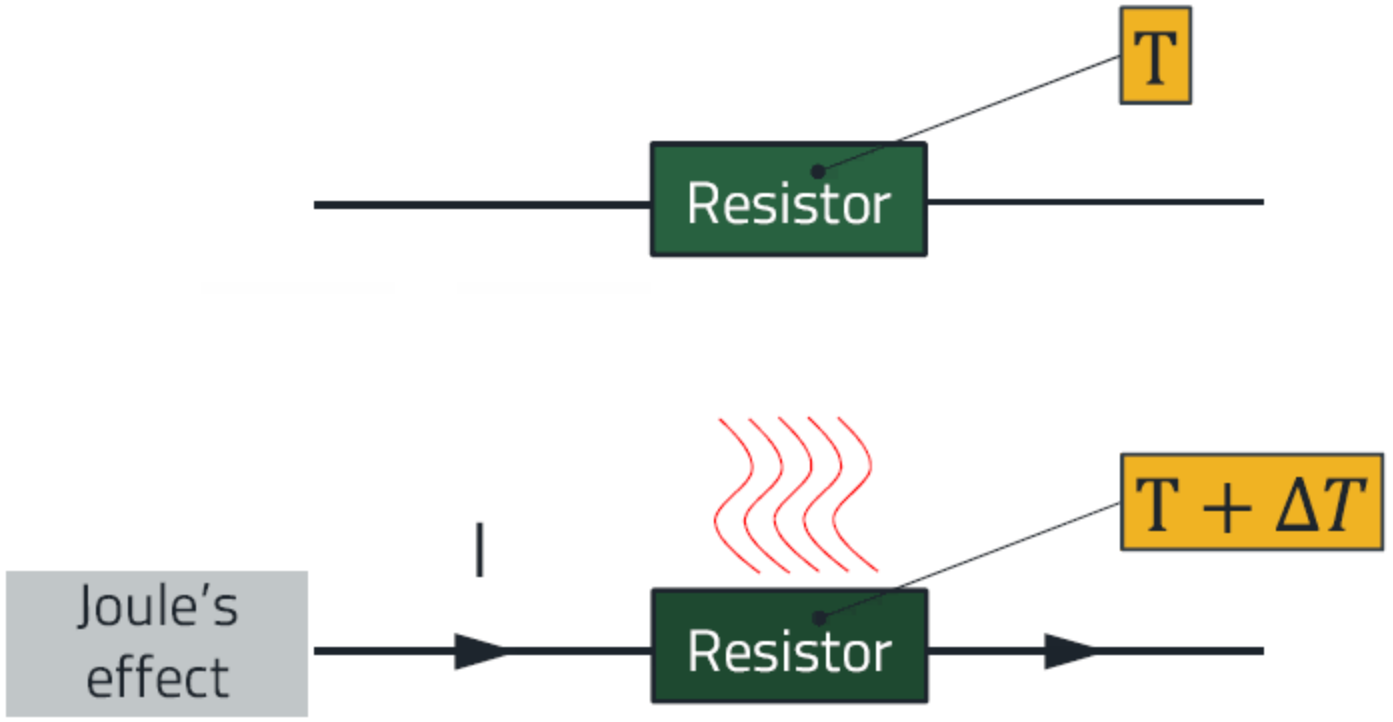
AGENDA

- Consequence of temperature
- PCB current / temperature design standards
- Temperature rise: how to do better
- leds

AGENDA

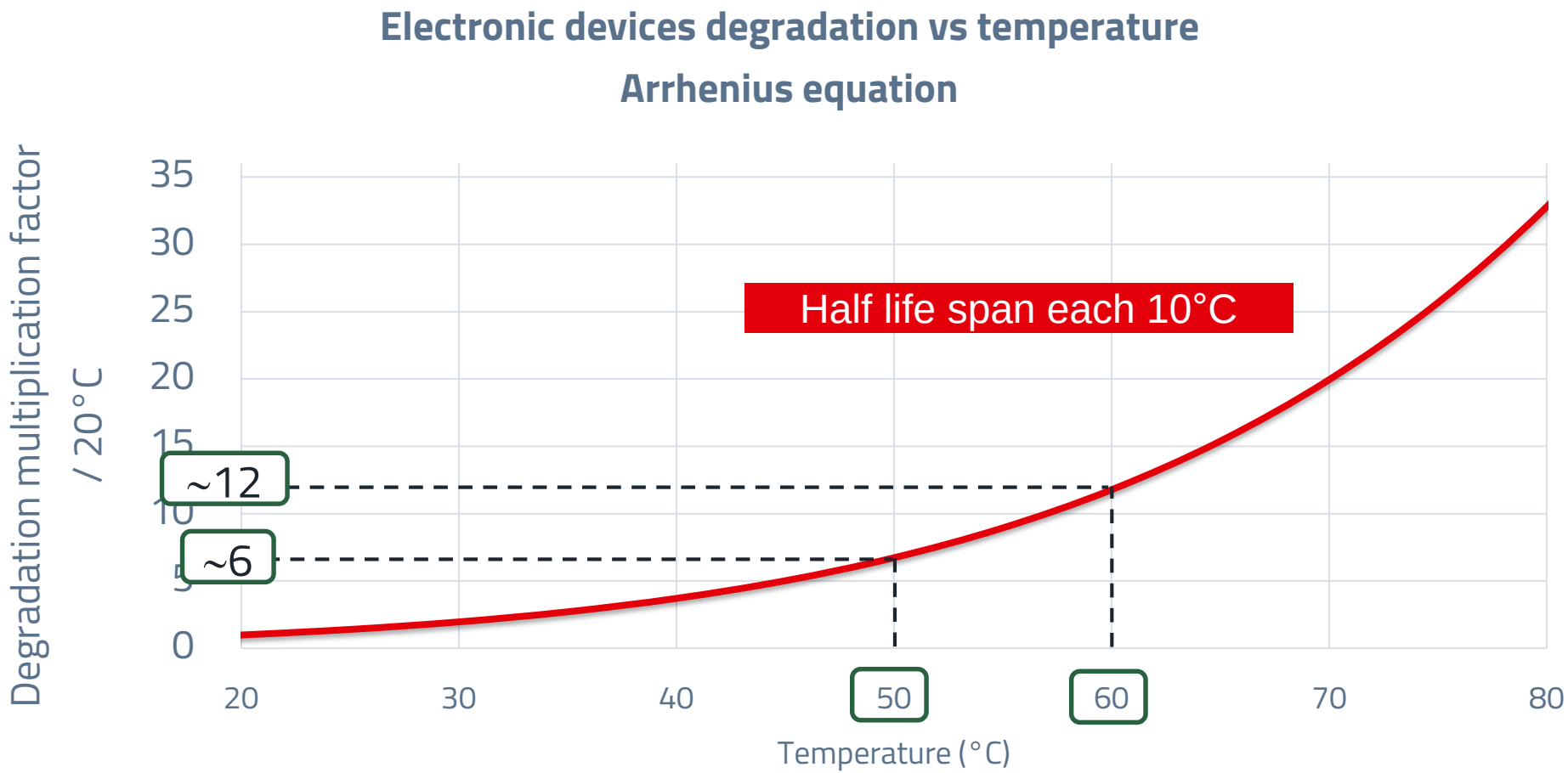
- **Consequence of temperature**
- PCB current / temperature design standards
- Temperature rise: how to do better
- leds

TEMPERATURE RISE



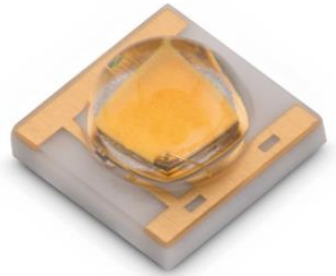
HEAT IS COOL ?

For a resistor - connector
ΔT is proportional to I^2
I x 2 → ΔT x 4



CONSEQUENCES OF A TOO HIGH TEMPERATURE

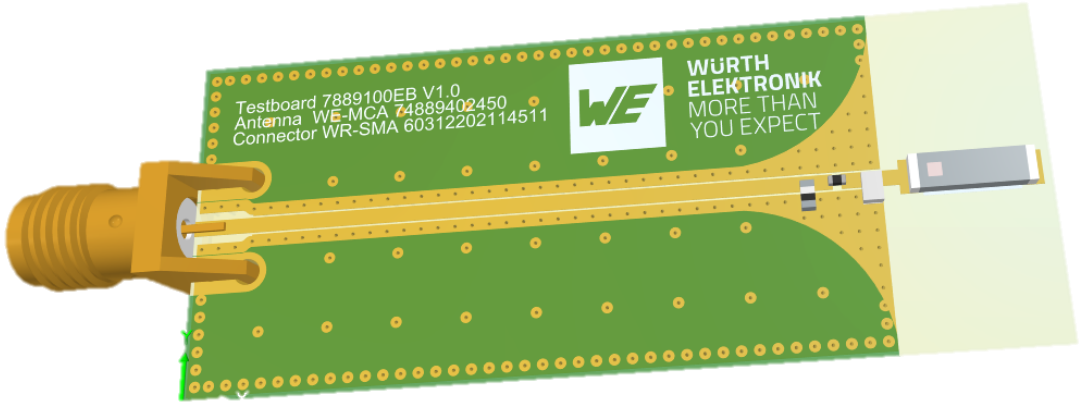
- Sensitive component destruction



Picture WE eiCan

picture Pixabay.com

- High frequency transmission lines damage



CONSEQUENCES OF A TOO HIGH TEMPERATURE

Thermal expansion

- Loss of PCB structural integrity

Copper: **16,5** µm/m/K

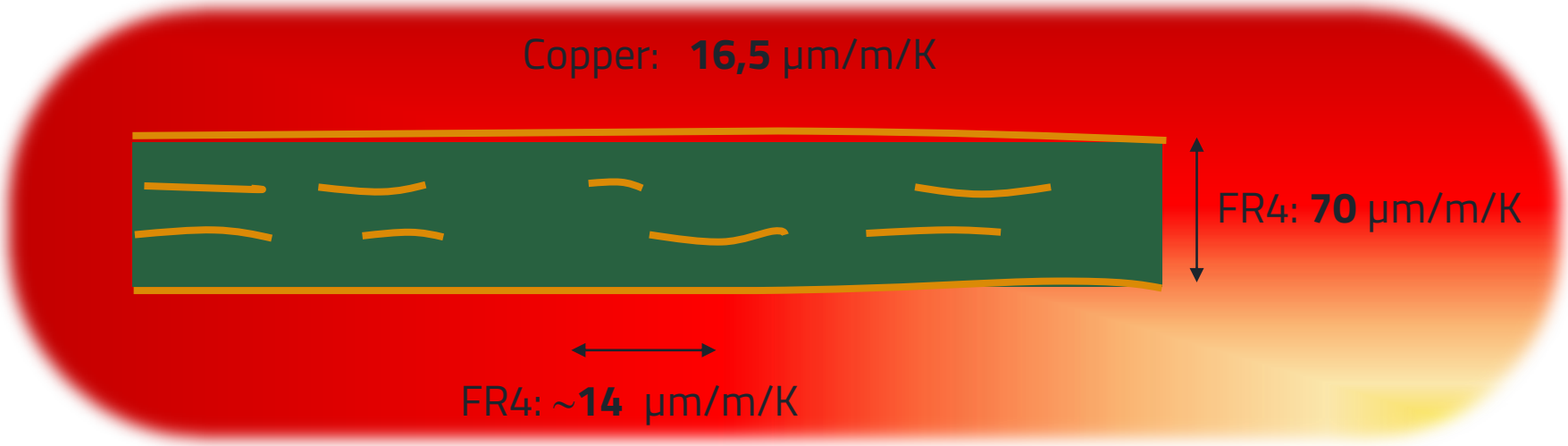
FR4: **70** µm/m/K

FR4: ~**14** µm/m/K

CONSEQUENCES OF A TOO HIGH TEMPERATURE

Thermal expansion

- Loss of PCB structural integrity

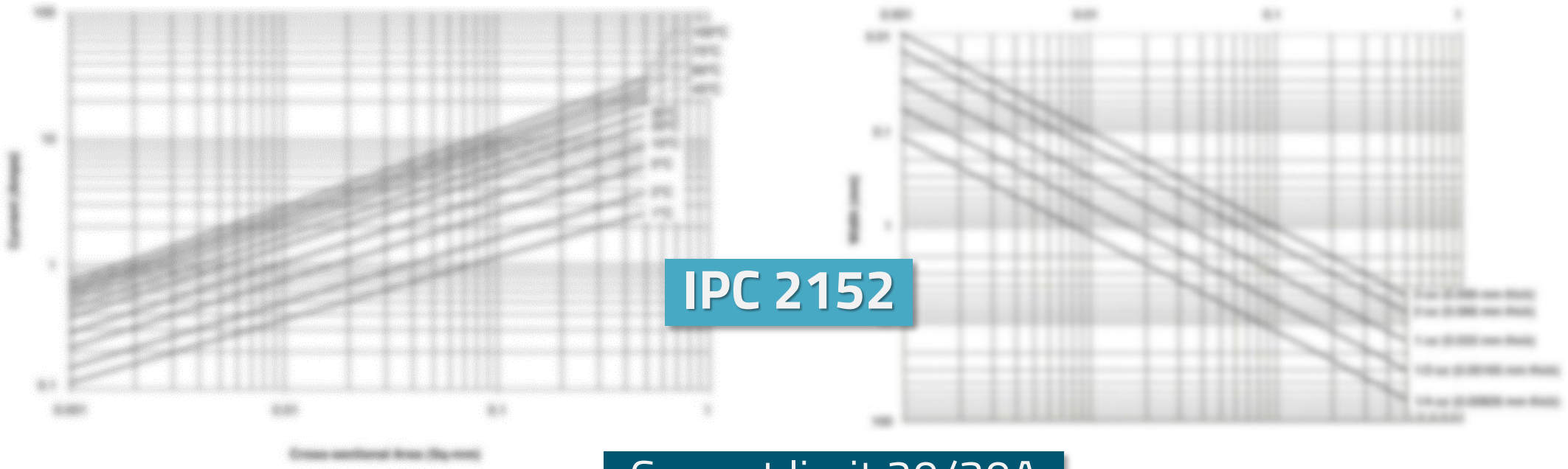


AGENDA

- Consequence of temperature
- **PCB current / temperature design standards**
- Temperature rise: how to do better
- leds

WHAT KIND OF IPC ?

- Association Connection Electronics Industries
- IPC-**2152**: Standard for Determining Current Carrying Capacity in Printed Circuit Board

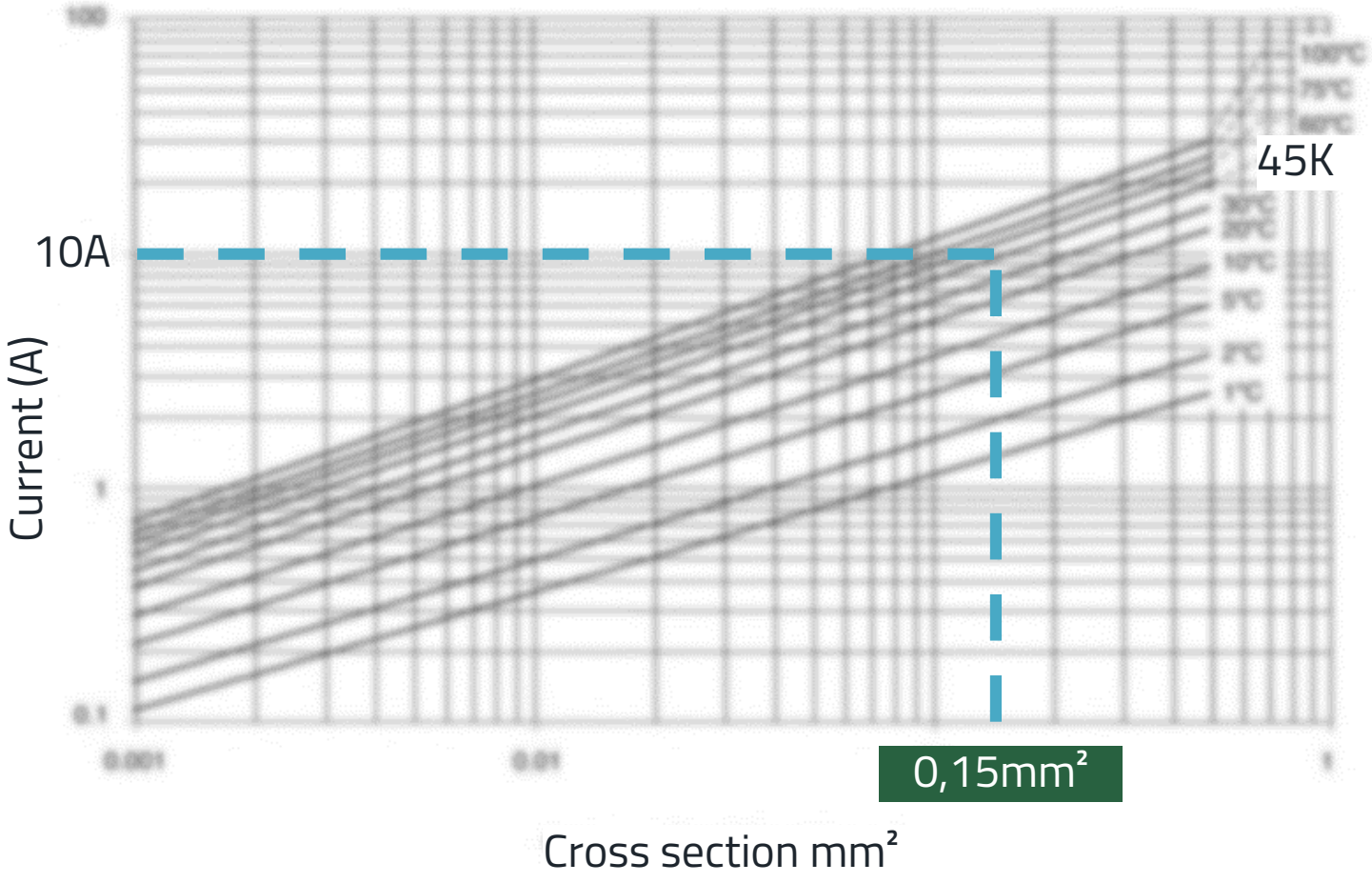


IPC 2152

Current limit 20/30A

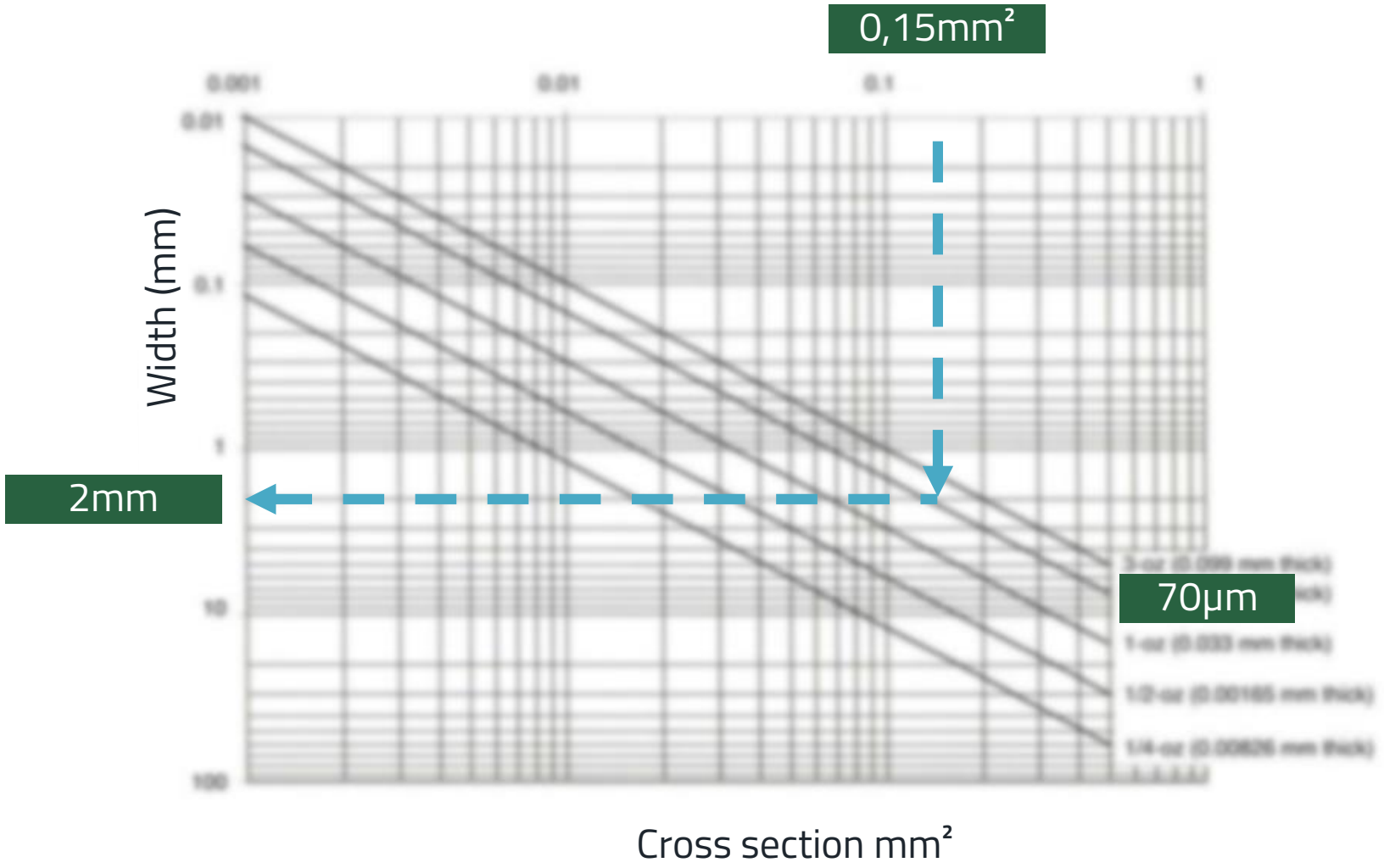
IPC2152 ABACUS

10A – 45K



IPC2152 ABACUS

10A – 45K – 70µm → 0,15mm²



WHAT KIND OF IPC ?

- Association Connection Electronics Industries
- IPC-**2221B**: Generic Standard on Printed Circuit Board

IPC 2221B

$$A = \sqrt[0,725]{\frac{I}{k \cdot \Delta T^{0,44}}}$$

ΔT: temperature rise in °C or K

I: current (A)

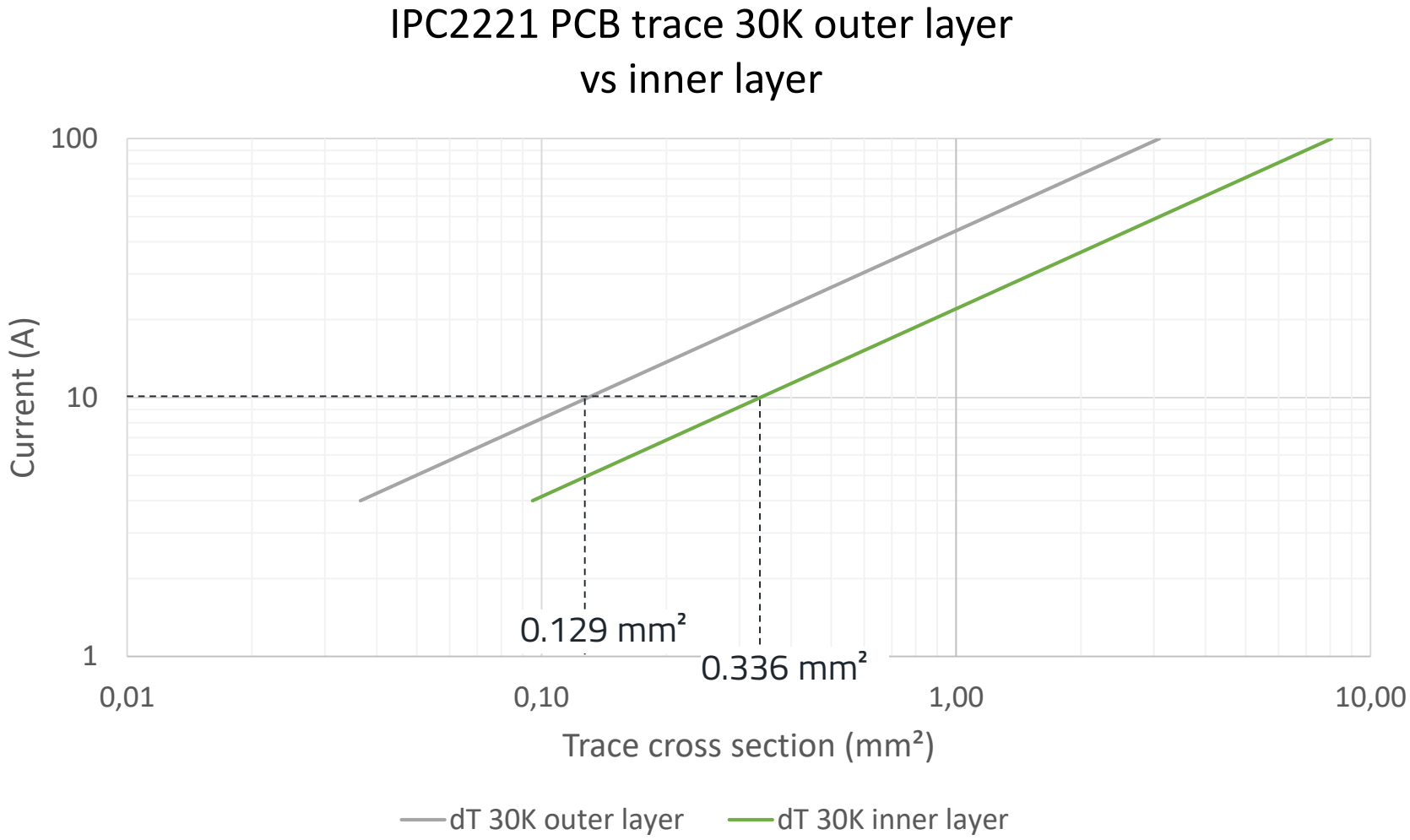
k=0,048 for outer layers

k=0,024 for inner layers

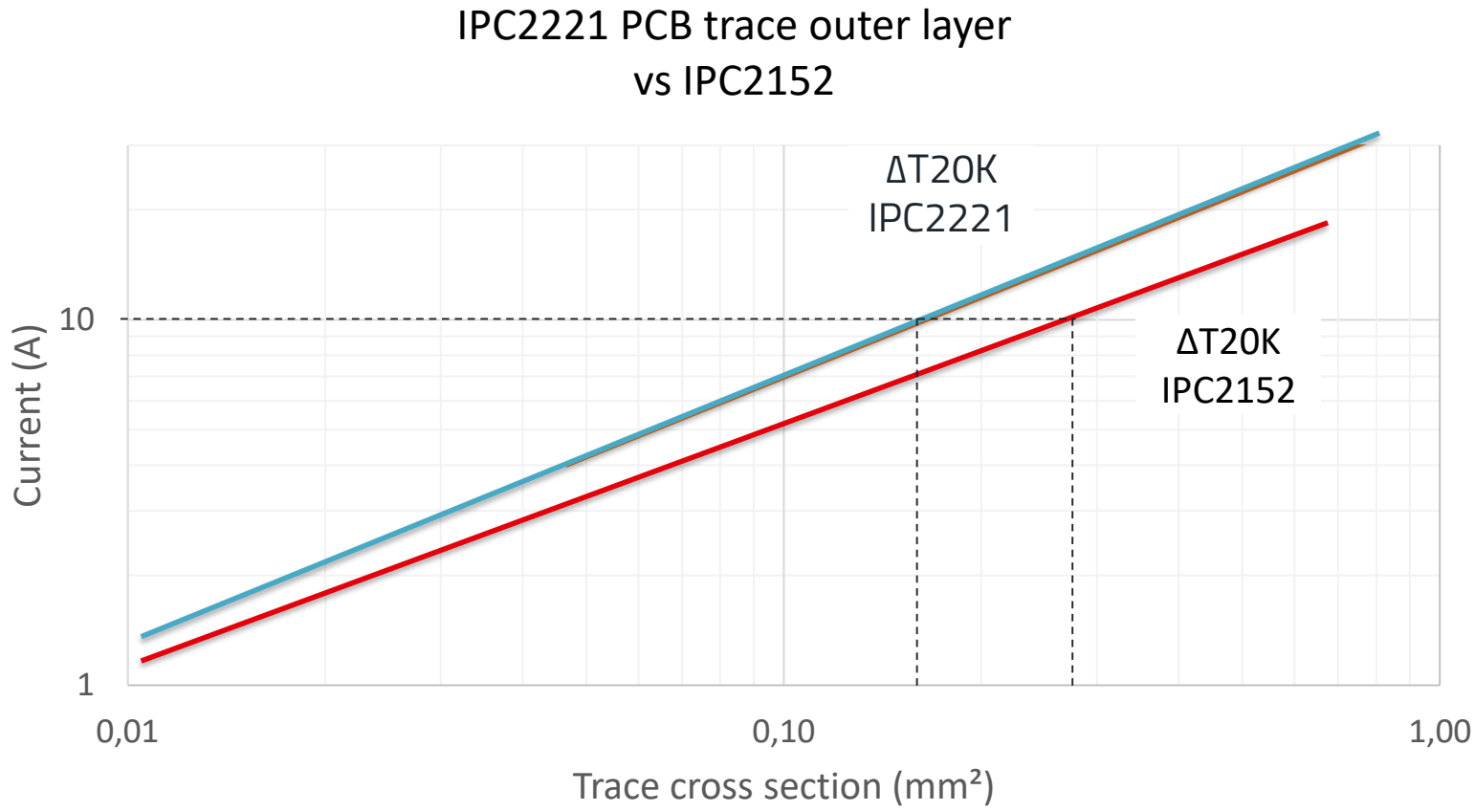
A= cross section in sq.mils

No current limit

IPC2221B RULE

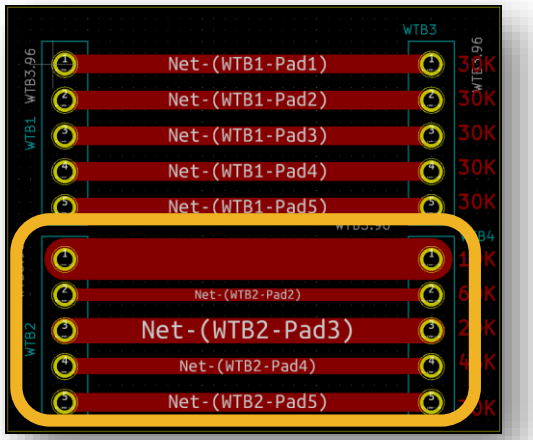


WHICH STANDARD ?

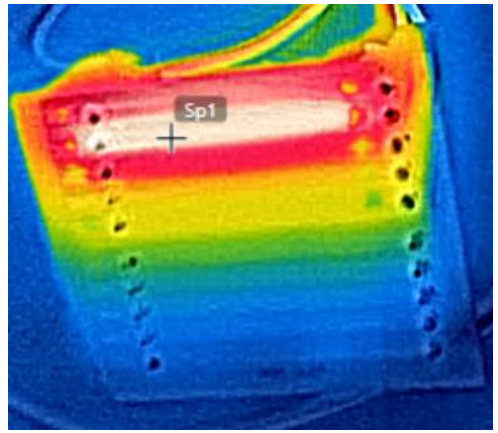


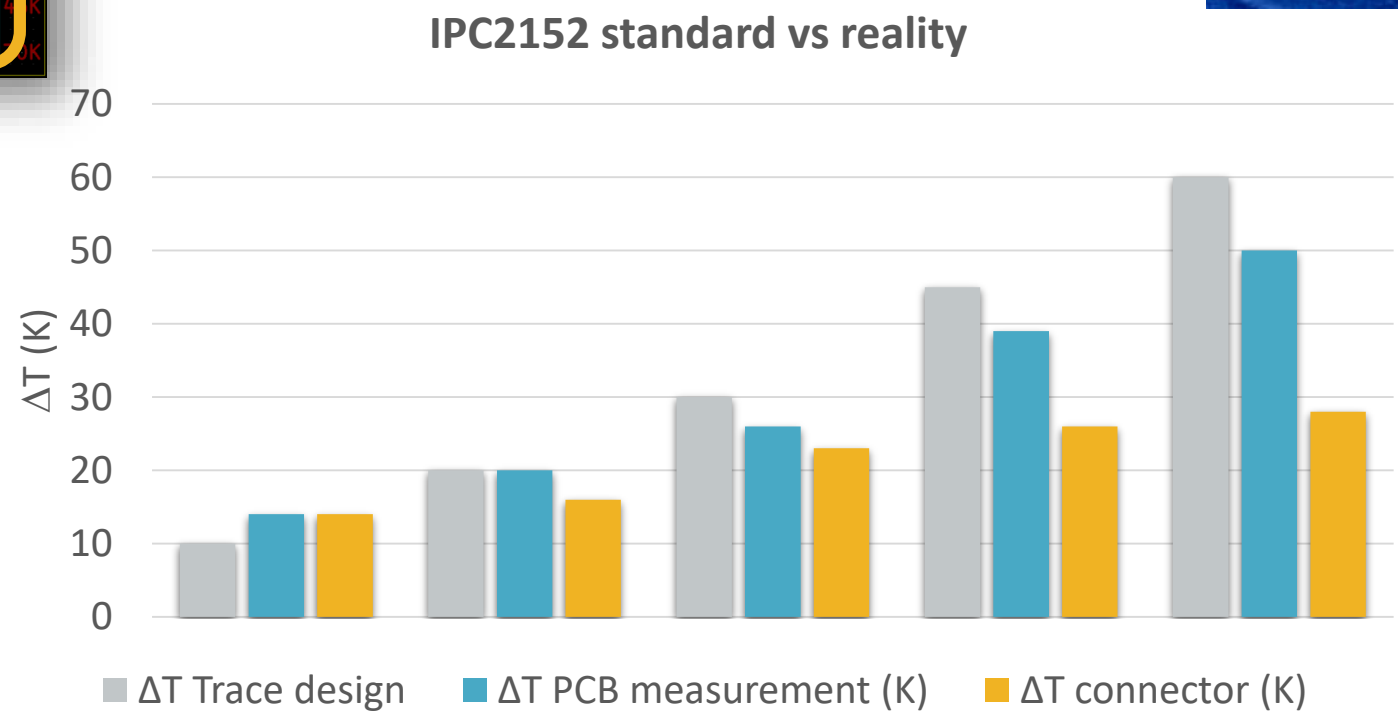
IPC2152 should heat less than IPC2221

IPC2152: DOES IT WORK ?



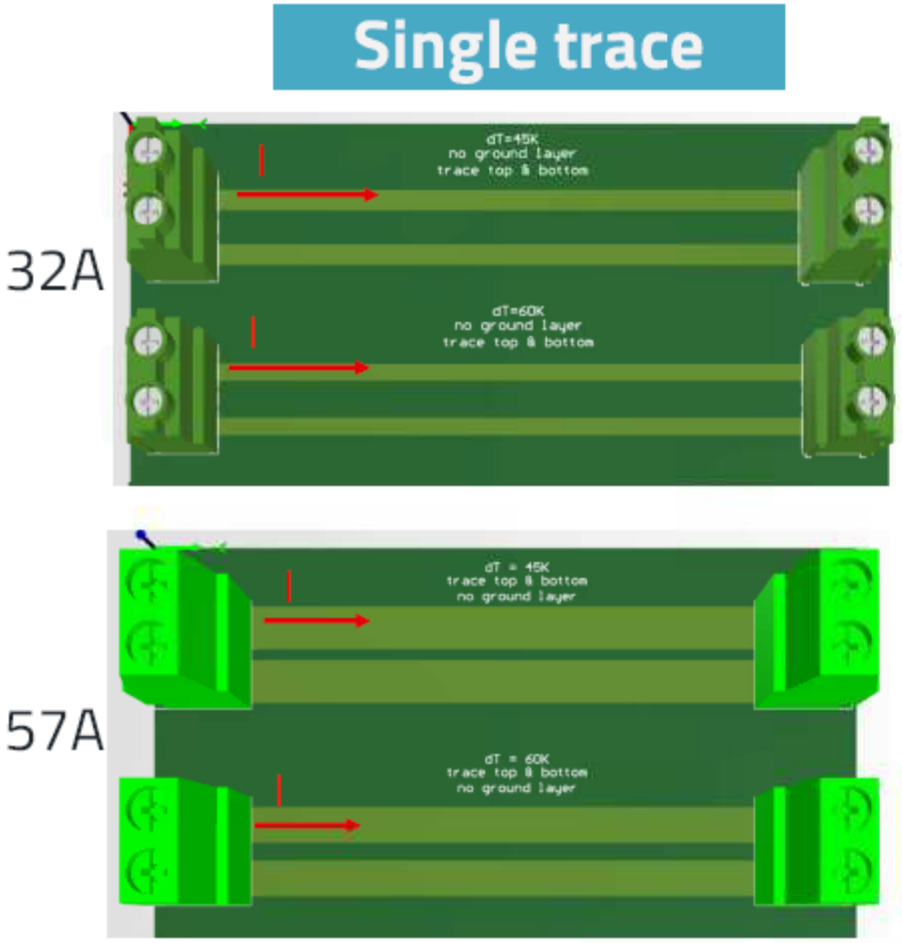
IPC2152 gives predictable values

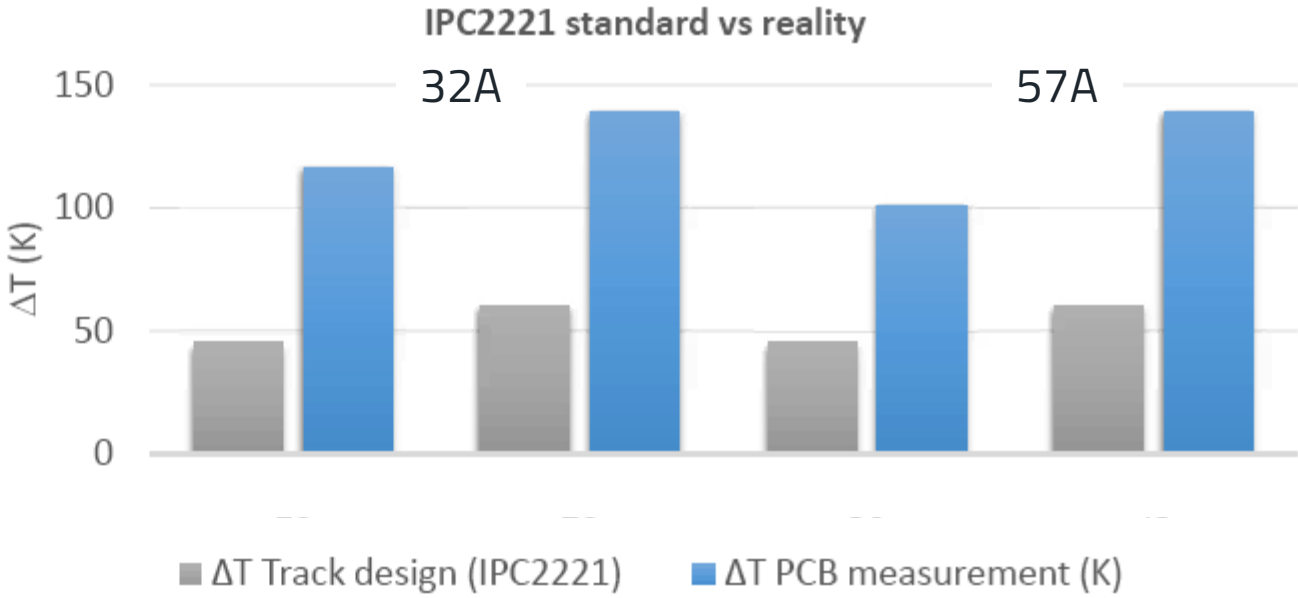




All pictures WE eiCan

IPC2221: DOES IT WORK ?



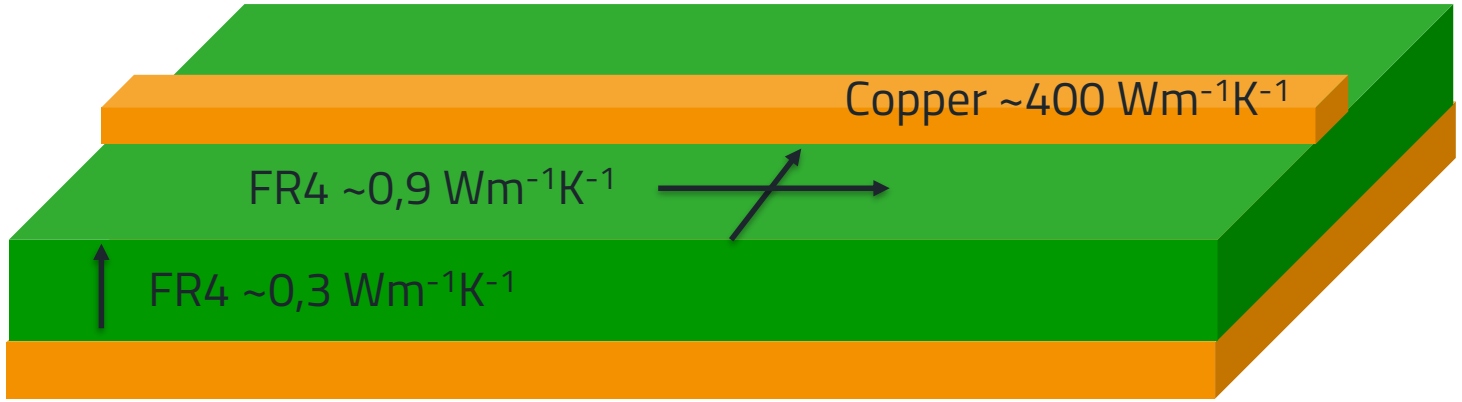


IPC2221 design is hotter than expected

AGENDA

- Consequence of temperature
- PCB current / temperature design standards
- **Temperature rise: how to do better**
- leds

THERMAL CONDUCTIVITY

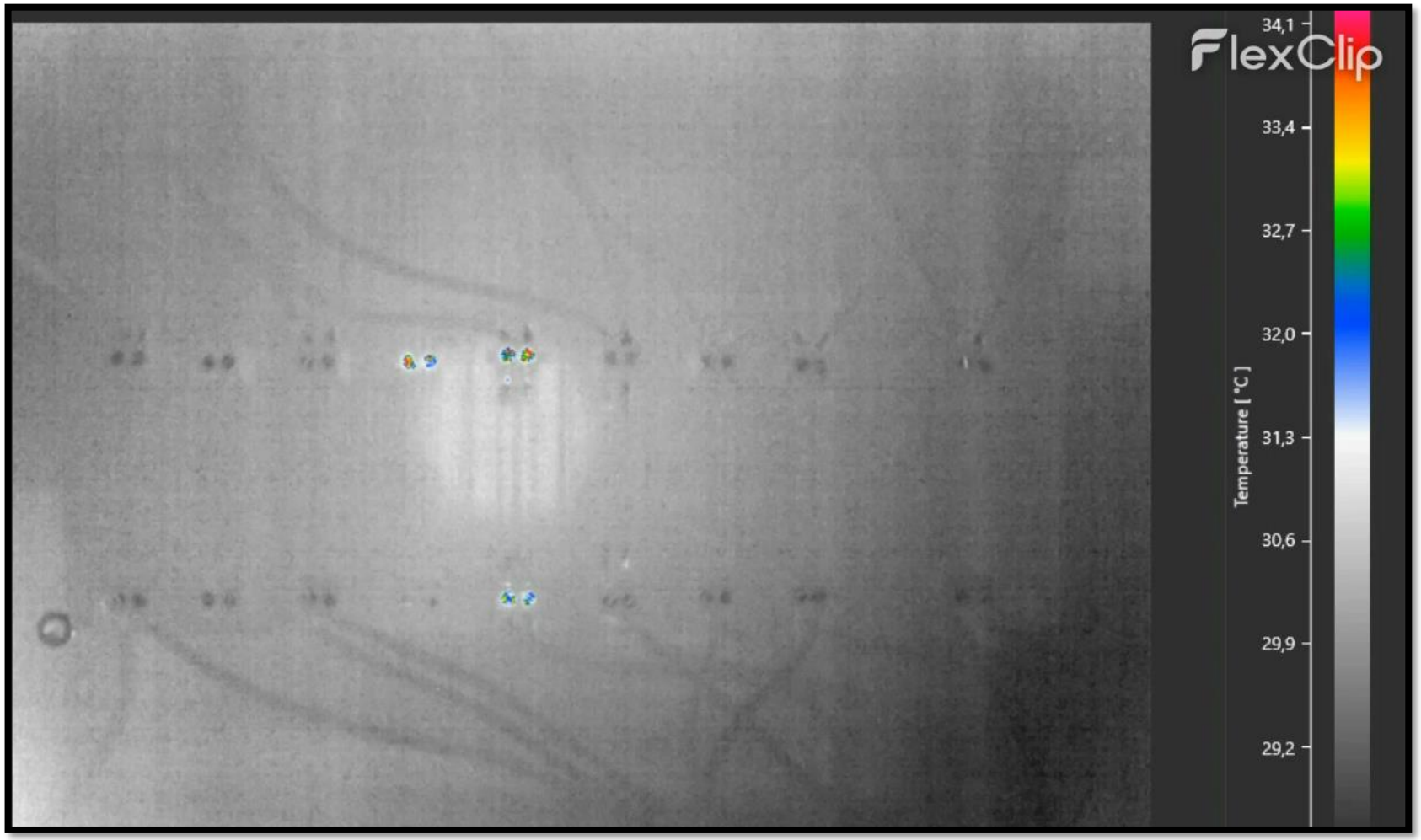


Material	Thermal conductivity ($Wm^{-1}K^{-1}$)
Still air	0,0276
PA66	~0,4
Water	~0,6
Steel	~50
Brass	~120
Aluminum	~200

Temperature will be:
- stopped by FR4
- Conduct by copper (trace, ground plane, wire)

TEASER

Same connectors – same traces cross section



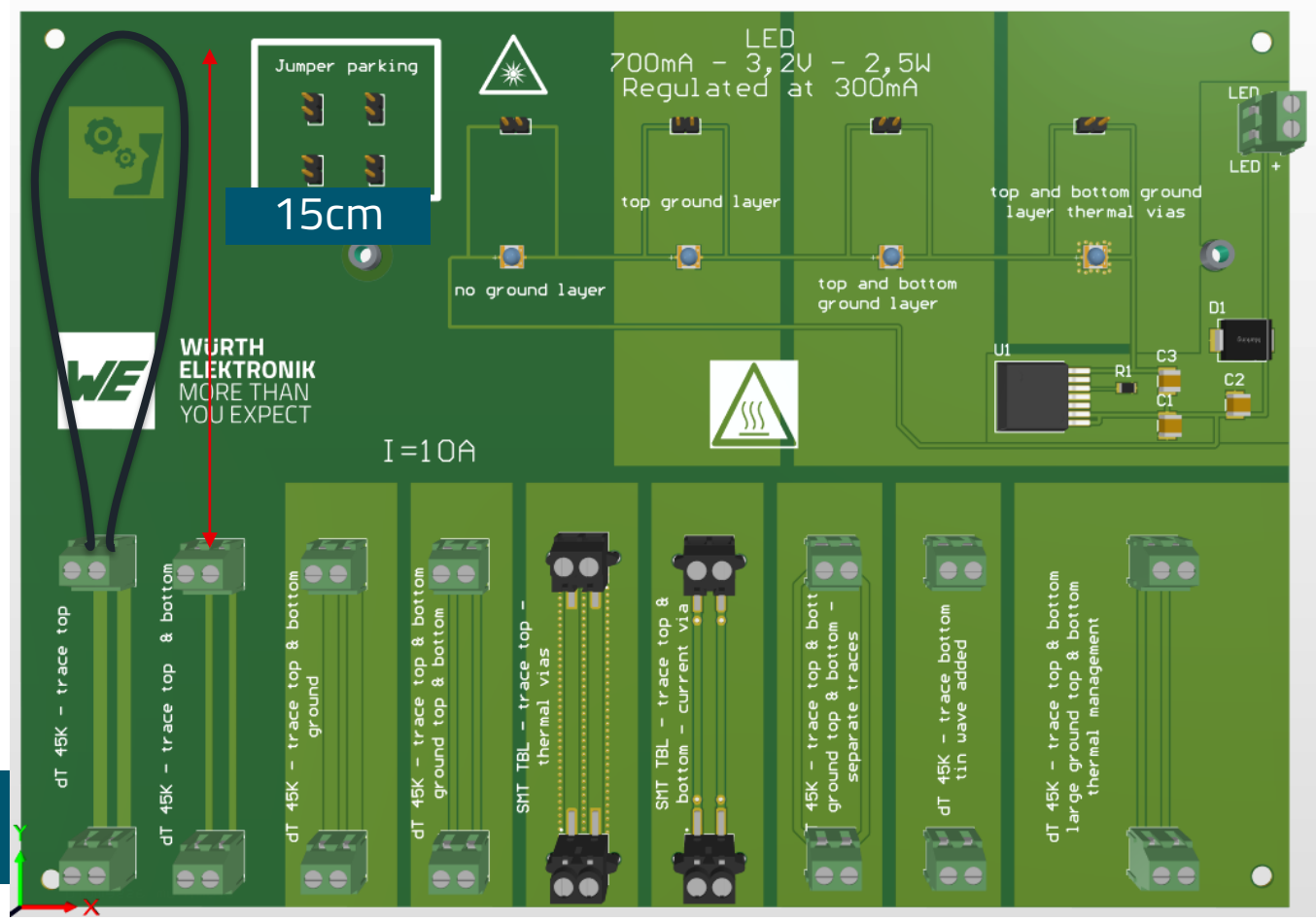
Real duration: 11mn

All pictures WE eiCan

10A PCB

IPC2152 design

16AWG
(10A)



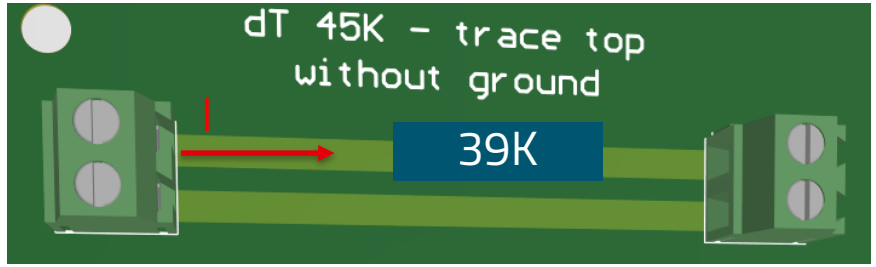
Width
2mm

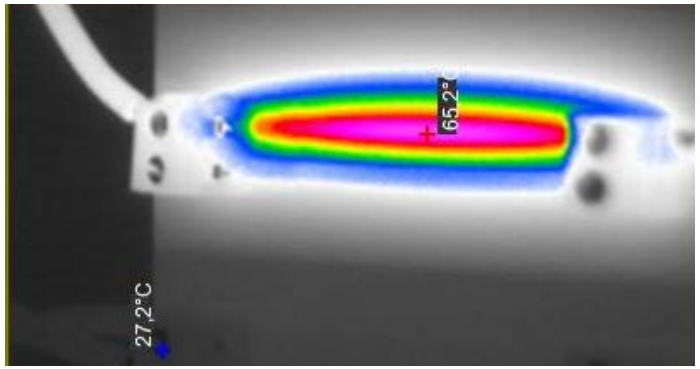
Width
2x1mm

10A PCB TEST

Single trace

Trace ΔT





IPC2152 gives right estimations

All pictures WE eiCan

10A PCB TEST

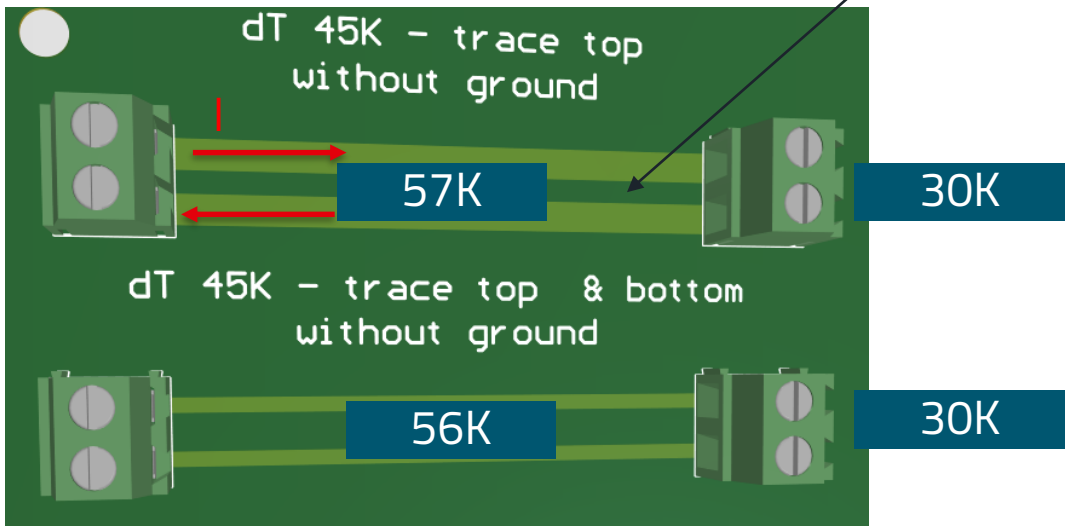
Double traces

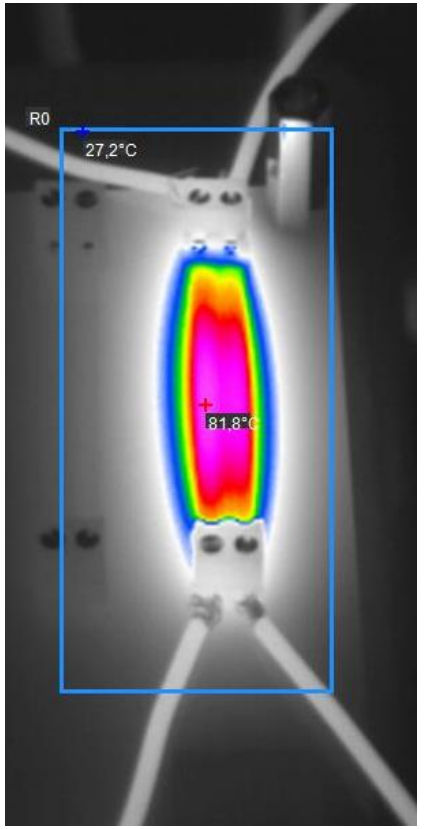
Trace ΔT

Connector ΔT

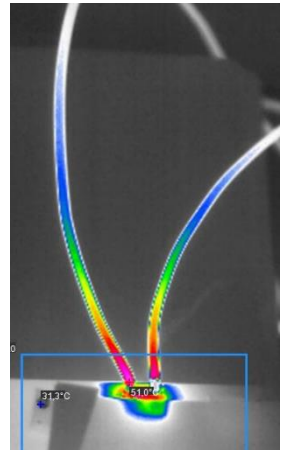
ELECTRICAL	cULus
CURRENT RATING:	10A
WORKING VOLTAGE:	300VAC
WITHSTANDING VOLTAGE:	1.6KV
CONTACT RESISTANCE:	20 mOhm max

Smaller than 25mm





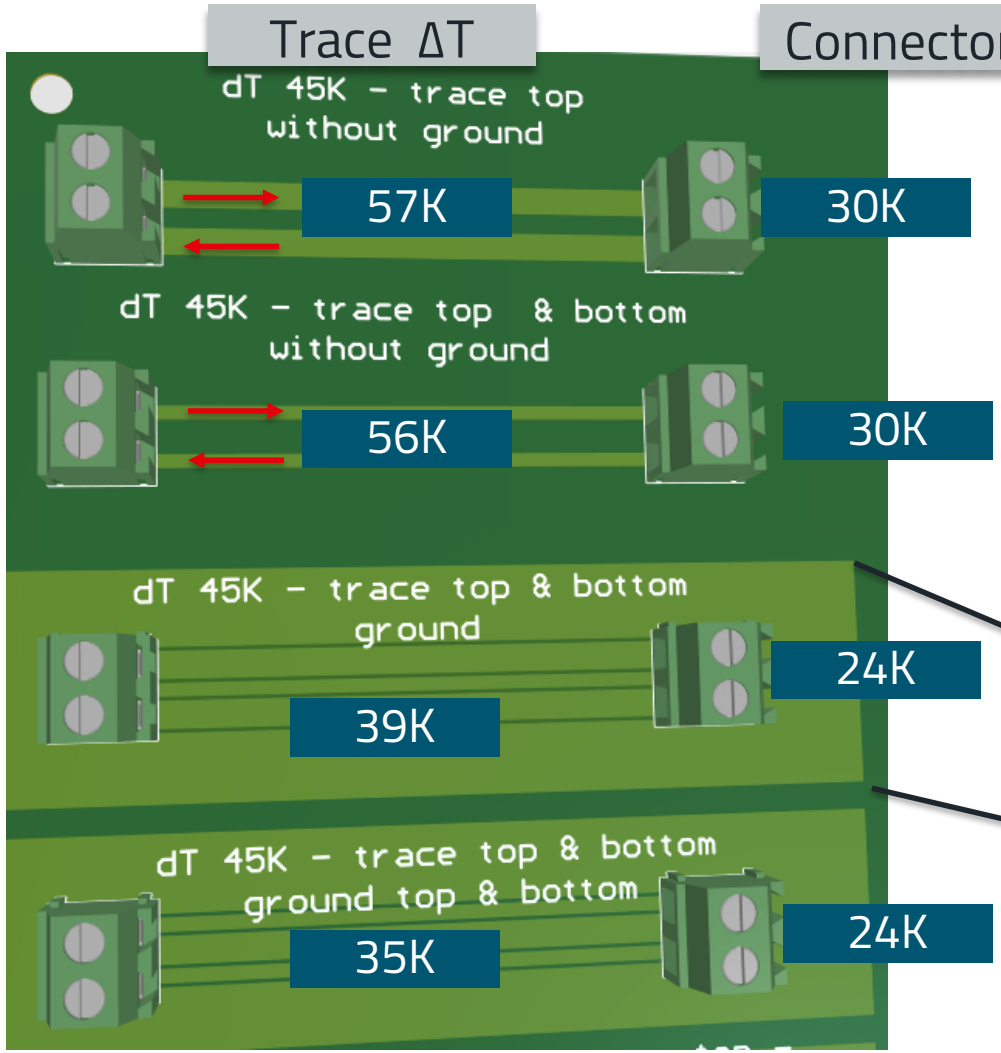
Cable heat

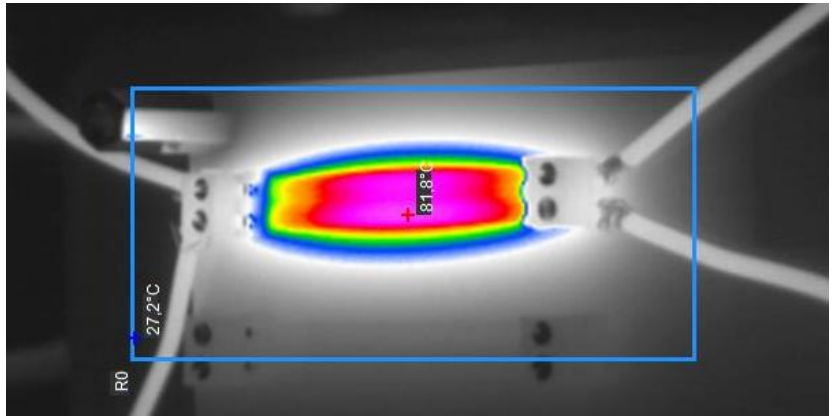


≈15cm

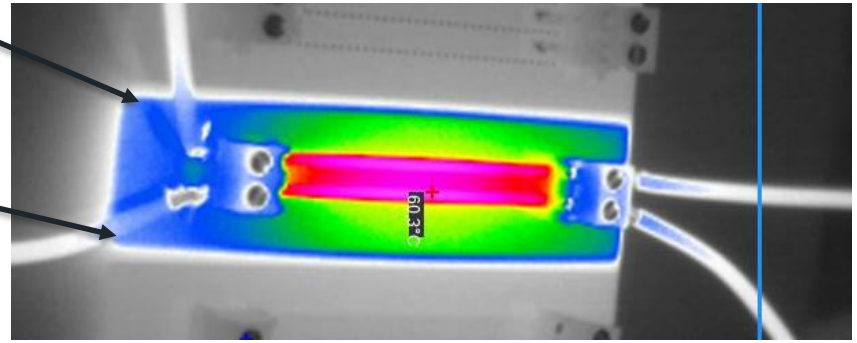
All pictures WE eiCan

10A PCB TEST





Ground layer improvement -20K

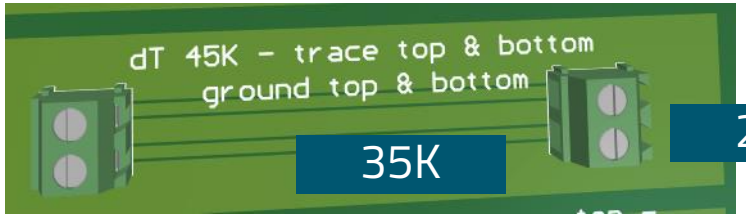


All pictures WE eiCan

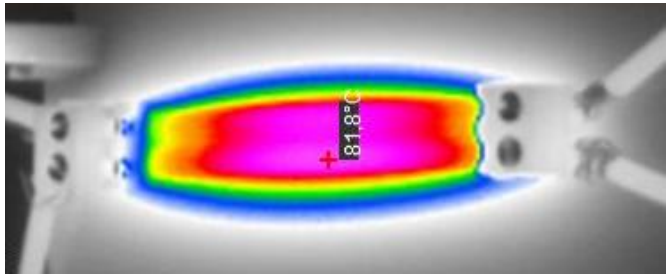
10A PCB TEST

Trace ΔT

Connector ΔT

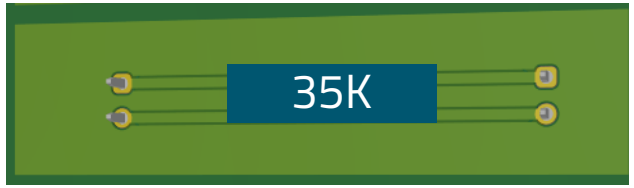


24K

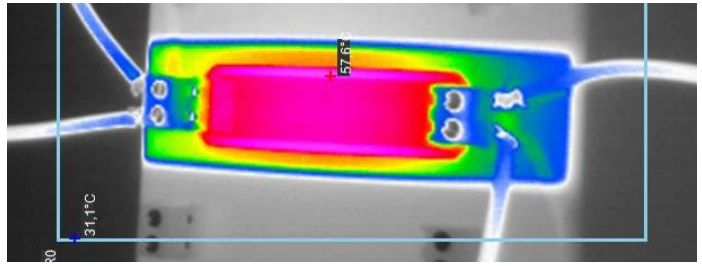


Traces not aligned
-2K

top

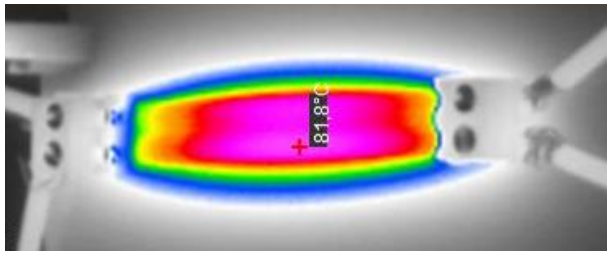


bottom



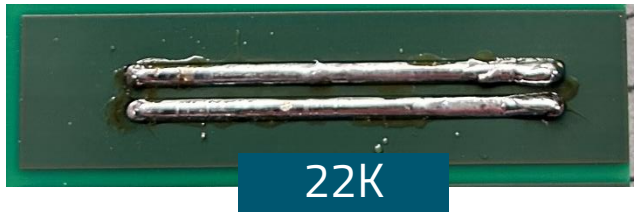
All pictures WE eiCan

10A PCB TEST

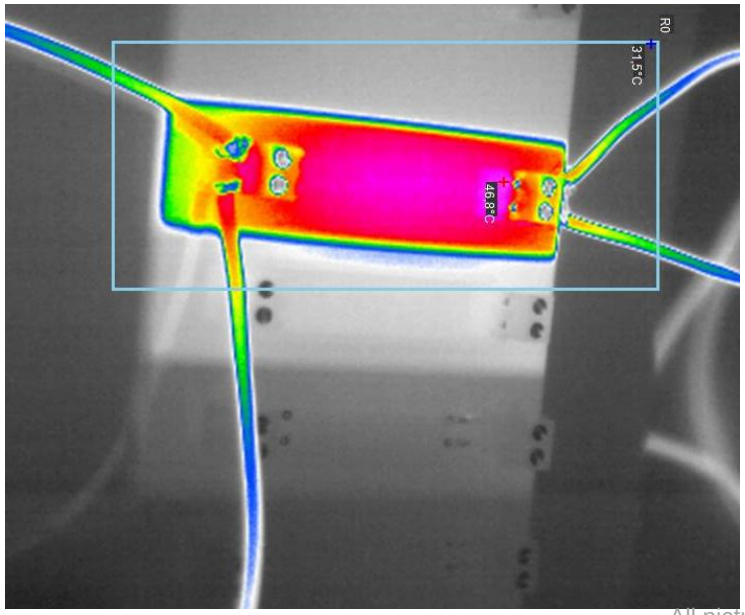


Additional tin
-17K

top



bottom



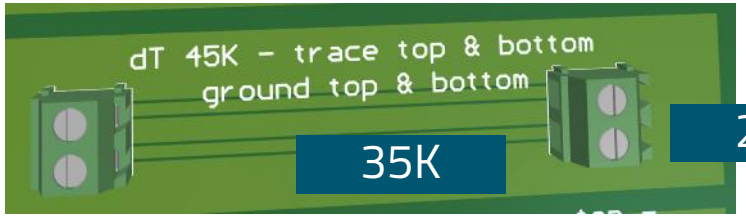
Electrical conductivity (IACS) :
- copper 100%
- tin 14%

All pictures WE eiCan

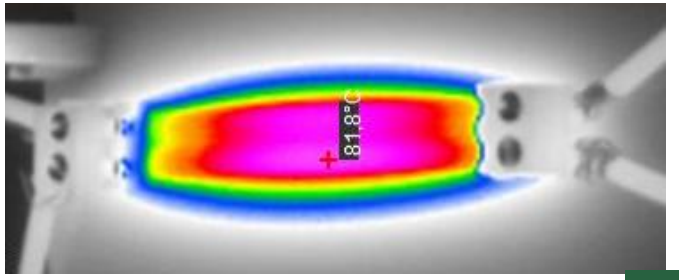
10A PCB TEST

Trace ΔT

Connector ΔT

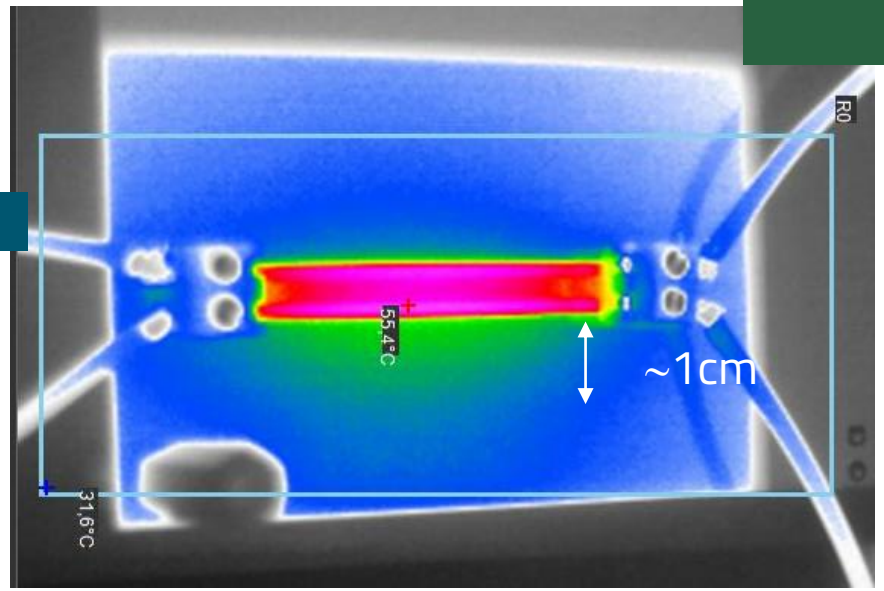


24K



Increase ground plane
-5K

23K



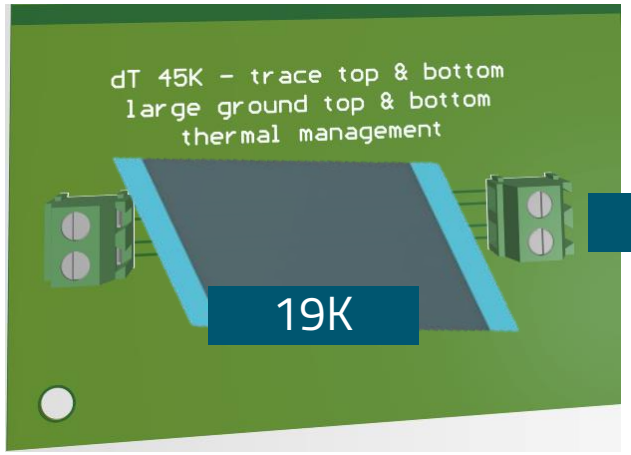
All pictures WE eiCan

10A PCB TEST

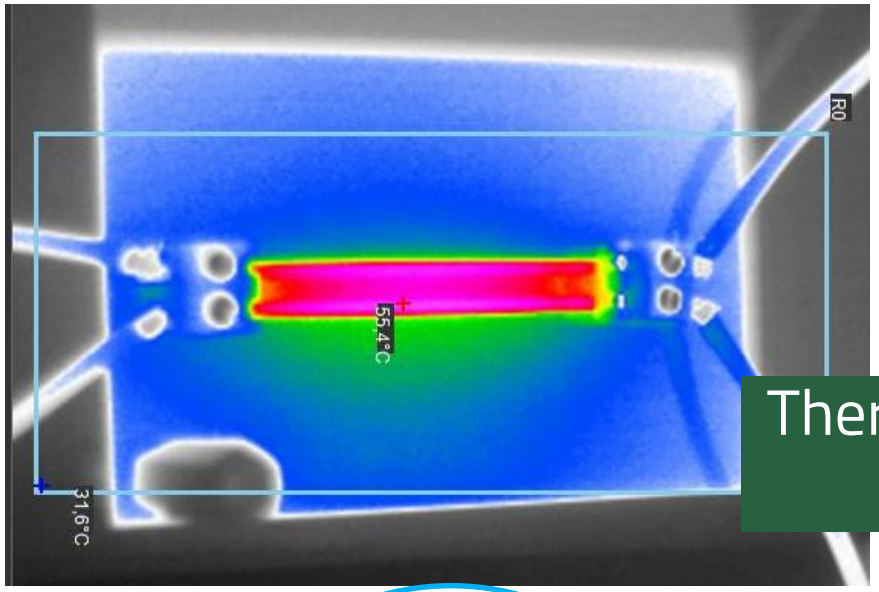
Trace ΔT

Connector ΔT

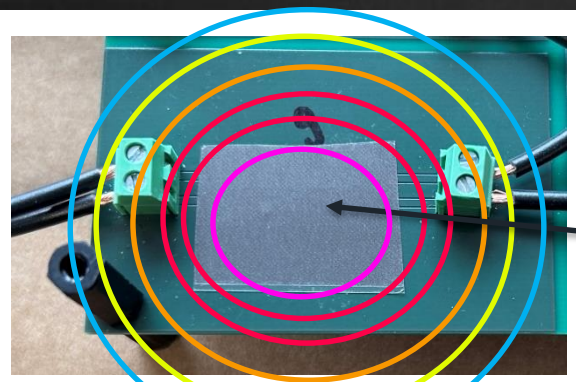
23K



22K



Thermal management
-10K



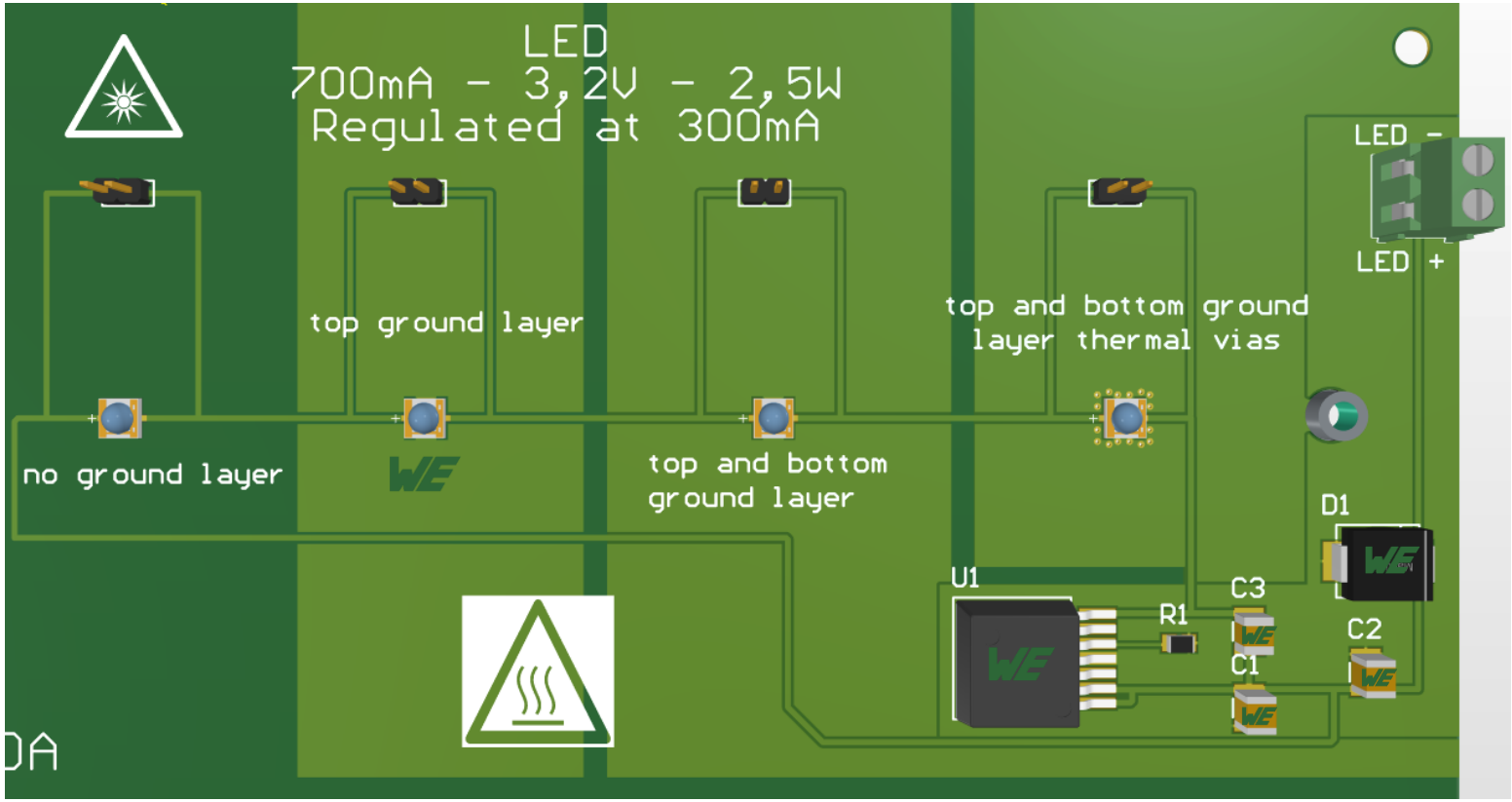
graphite sheet
1800 $Wm^{-1}K^{-1}$

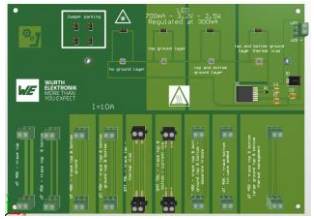
All pictures WE eiCan

AGENDA

- Consequence of temperature
- PCB current / temperature design standards
- Temperature rise: how to do better
- **leds**

LEDS





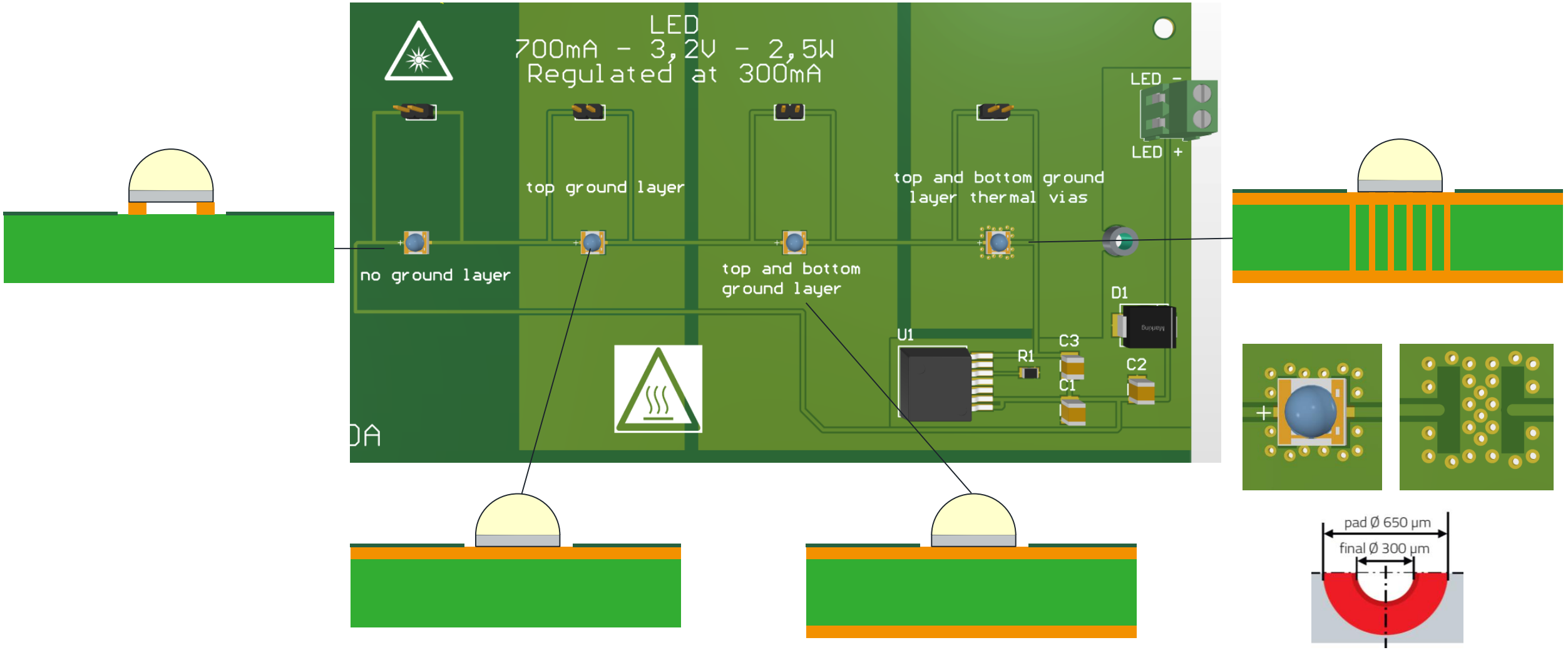
Max current:700mA

Dissipated power 2,5W

Max temperature: 125°C

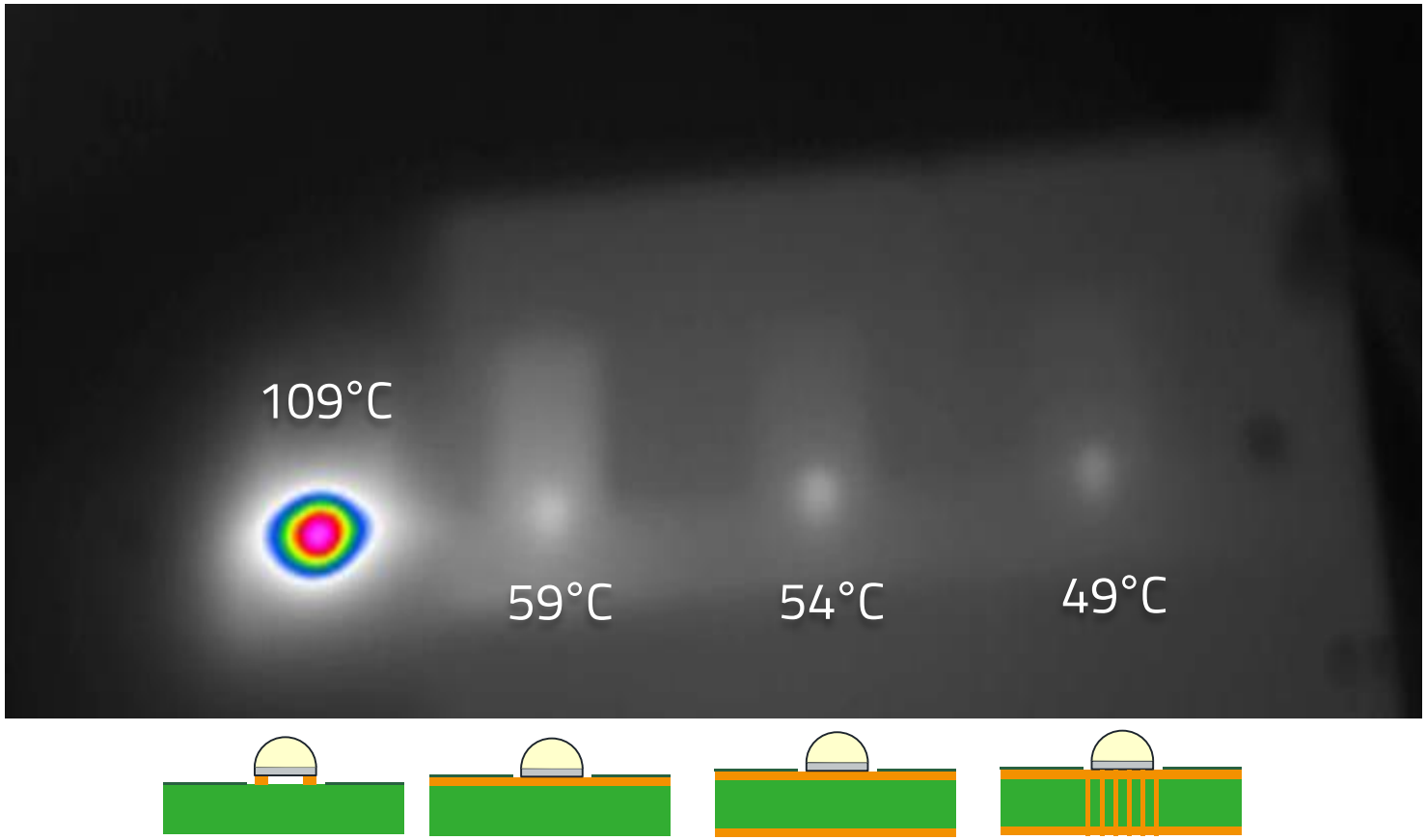
All pictures WE eiCan

LEDS


LED
700mA - 3,2V - 2,5W
Regulated at 300mA
LED -
LED +
top ground layer
top and bottom ground
layer thermal vias
no ground layer
top and bottom
ground layer
D1
U1
R1
C3
C1
C2
pad Ø 650 µm
final Ø 300 µm

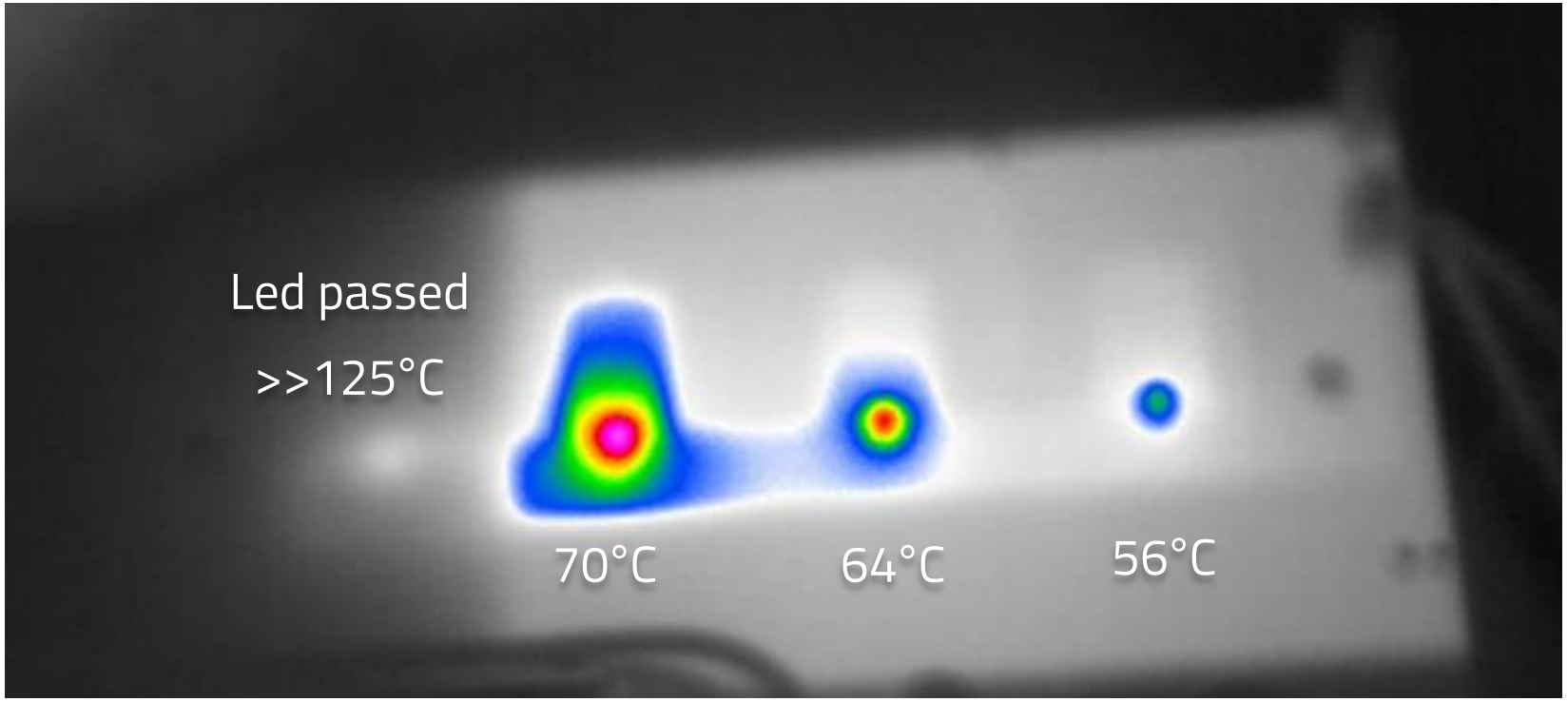
LEDS

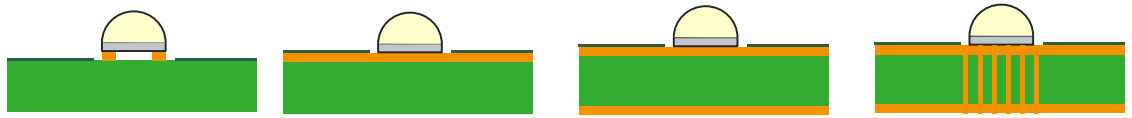
0.3A



LEDS

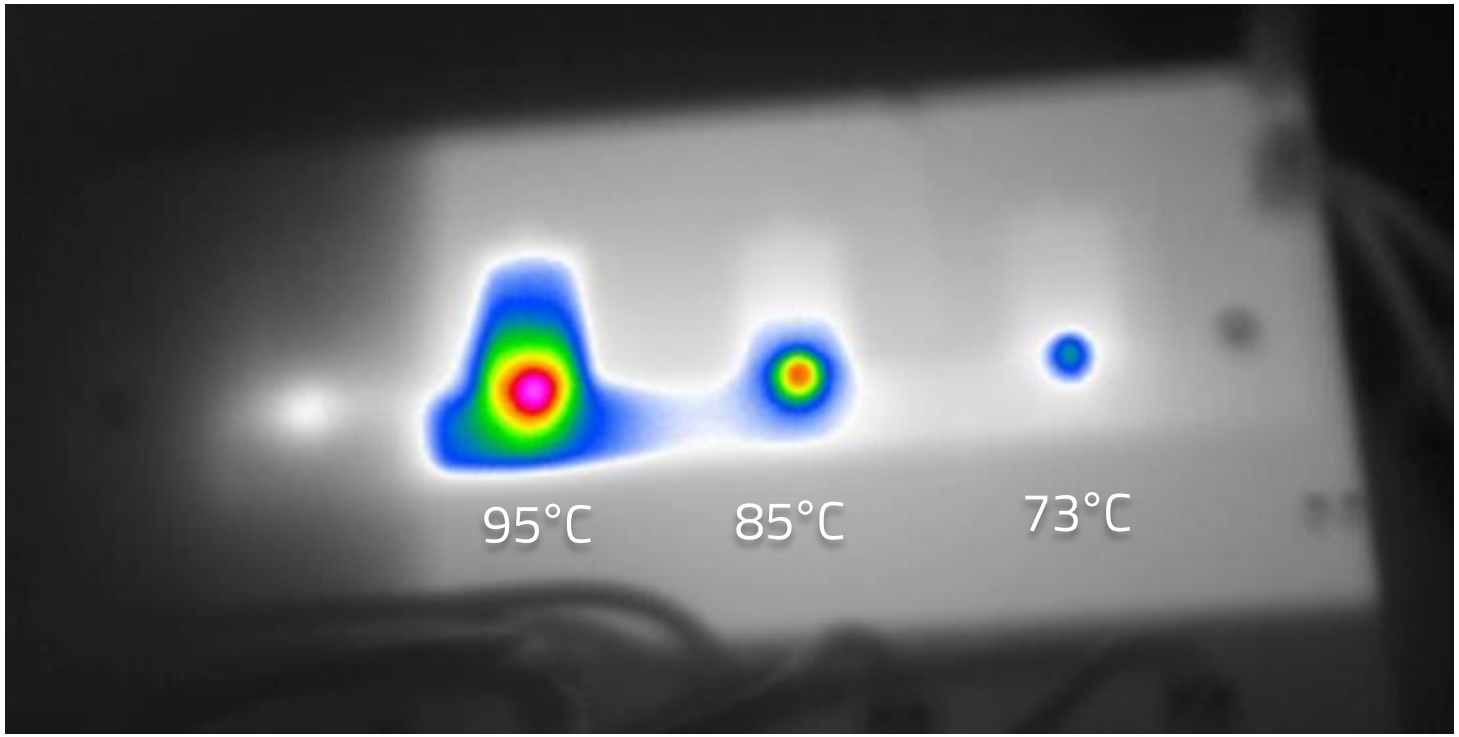
0.4A



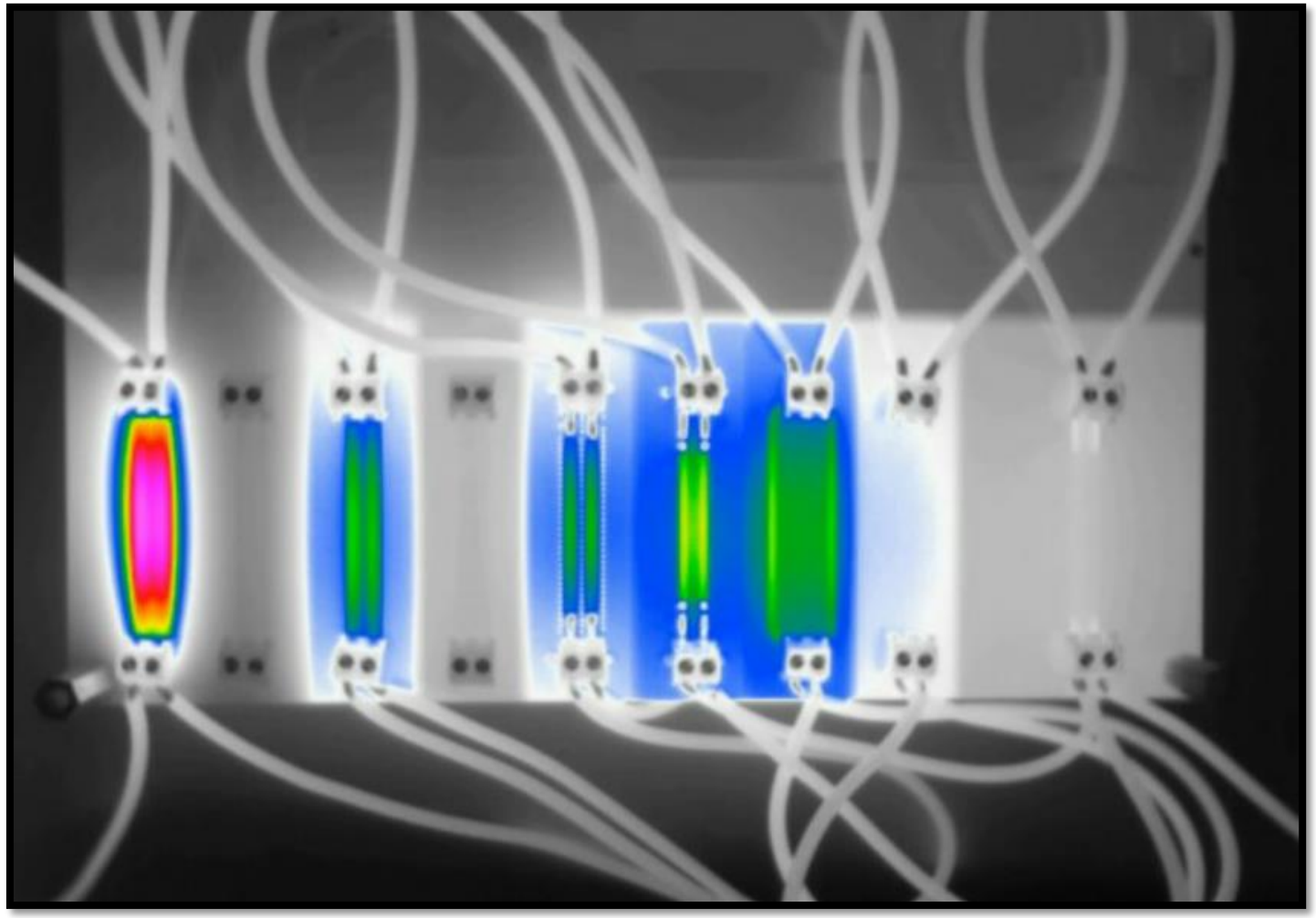


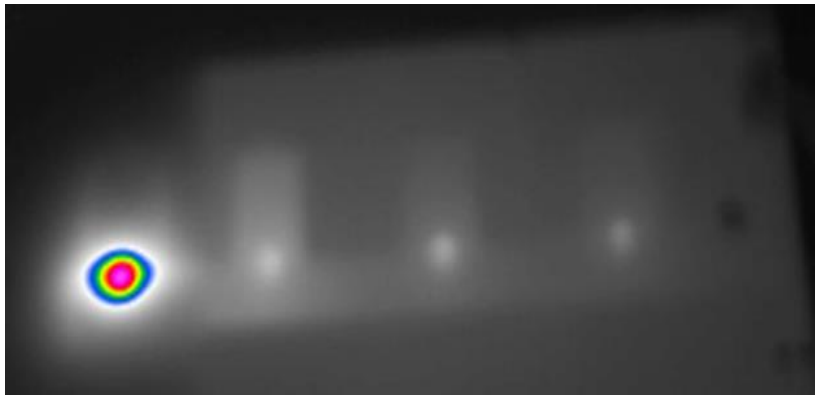
LEDS

0.7A



CONCLUSION

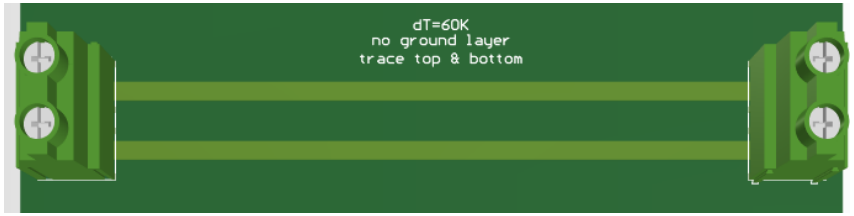


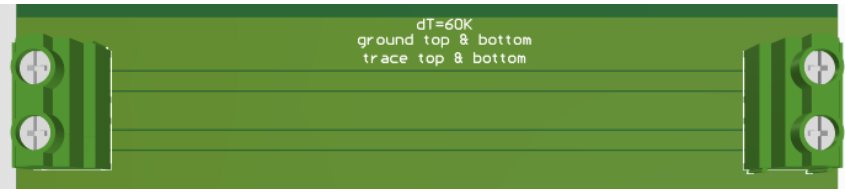


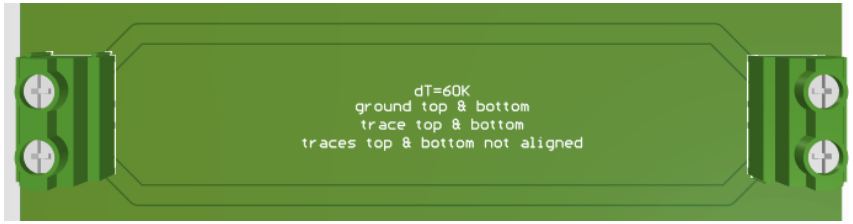
All pictures WE eiCan

CONCLUSION

- 10°C lower double life span
- If possible oversize your traces
- IPC2152 design fits to reality
- IPC2221 design gives higher temperatures
- IPC2221 is usable up to high currents
- Easy tips to decrease temperature:
  - Ground layer
  - Thermal vias
  - Misalign power traces
  - Use bottom tin
  - Put PCB on vertical position
  - Use thermal management







All pictures WE eiCan

Temperature rise is easy to understand
BUT
Very hard to guess
→ Simulate or prototype

Questions

& Answers

We are here for you now!
Ask us directly via our chat or via E-Mail.

digital-we-days@we-online.com
Alexandre.Chaillet@we-online.com