Karlsruher Institut für Technologie

**Light Technology Institute (LTI)**
Light, ECG and Plasma Technologies

# Constant current paralling controller for mid-power LEDs

Patented, cost-effective current sharing controller integrated in an LED module

Michael Heidinger*, Christoph Simon, Fabian Denk, Rainer Kling, Wolfgang Heering

*michael.heidinger@kit.edu

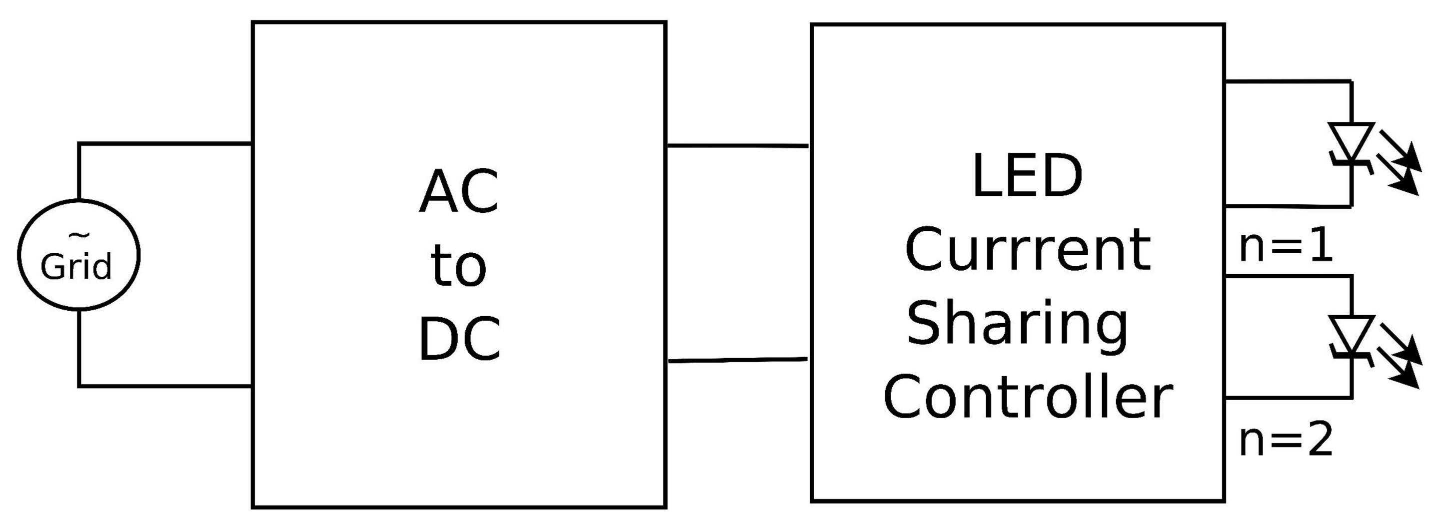
## Introduction

Observation: MidPower LED are far more cost-effective and energy saving.
(Up to 47% more Lumen per Watt)

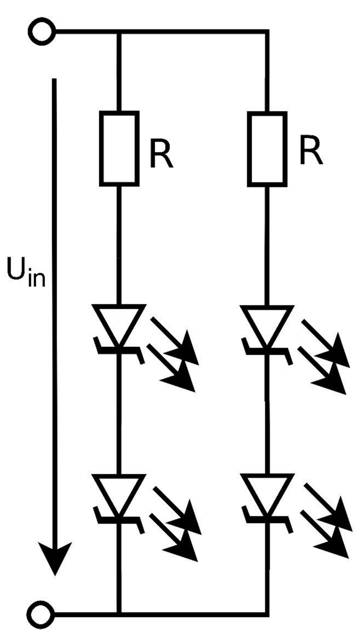
Task: Drive 144 MidPwr LEDs for 7200 lm.

Series wiring:
Series wiring is limited to 120V (SELV), therefore max. 40 LEDs can be used.

Low voltage approach:
To reduce the voltage of the LED module paralleling is required.




## State of the Art




Paralleling LEDs
LEDs have differend forward voltages and need to be balanced by a resistor. To achieve a decent matching a high resistance is required. Therefore high losses occure at the resistors.

Goal:
Dissipate only energy if the LED current is too high.

## Novel Approach

Stability circterium Constant Current Source

$$G_{\mathrm{CS}}\,G_{\mathrm{OPV}}(f)\,G_{\mathrm{filter}}(f) < 1$$

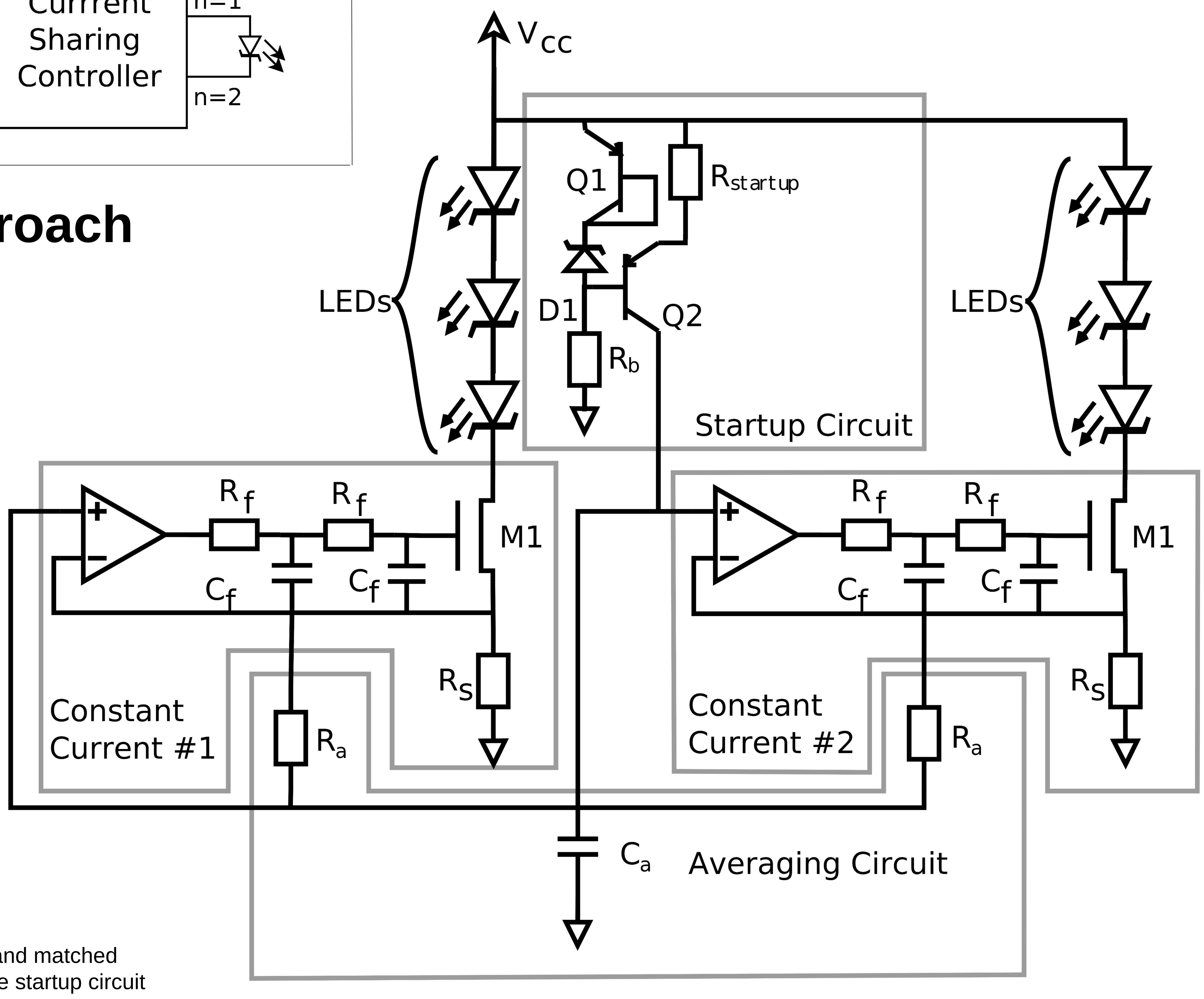
Mosfet Resistor gain:

$$G_{\mathrm{CS}} = g_{\mathrm{M1}} R_{\mathrm{S}}$$

Damping network:
40dB / Decade

$$f_{\mathrm{B}} = GBW\left(10^{-\frac{G_{\mathrm{CS}}[dB]}{G_{\mathrm{Filter}}[dB]}}\right)$$

$$f_{\mathrm{B}} = \frac{1}{4\pi\sqrt{2}R_{\mathrm{f}}C_{\mathrm{f}}}$$




Startup Circuit:
The circuit has two stable operating points, 0A and matched current. To reach the second operating point, the startup circuit is required.
The startup circuit is temperature compensated as Q1 and Q2 are matched and have the same voltages. D1 produces a voltage offset which is translated by $R_{\mathrm{startup}}$ to a current.
The current pulls the averaging circuit out of the 0A operating point.

Averaging Circuit:
All measured currents are averaged by all samples and time and fed back as a set value to the constant current sources. Thereby the currents are shared and no external mircocontroller needs to specify a limit.

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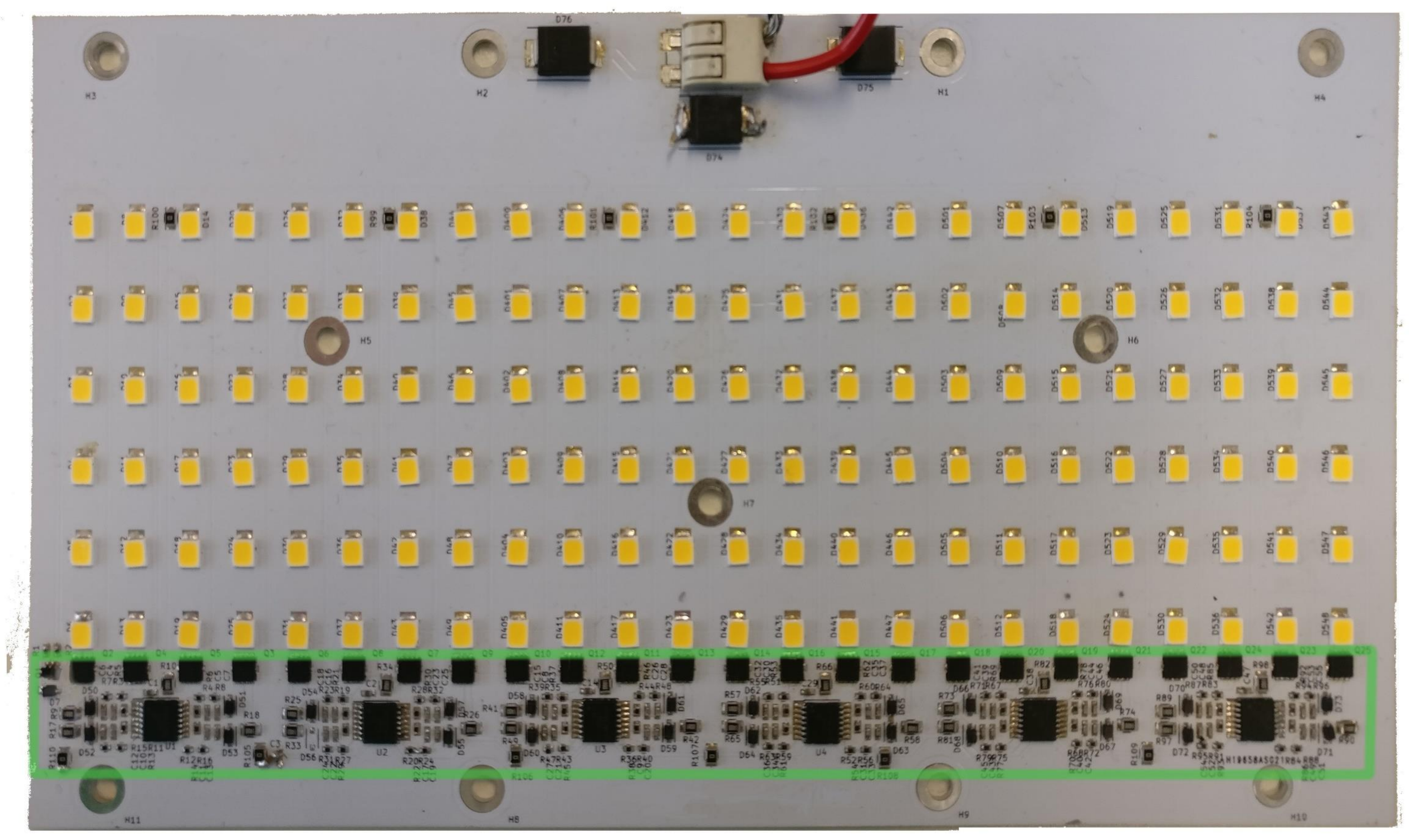
## Results

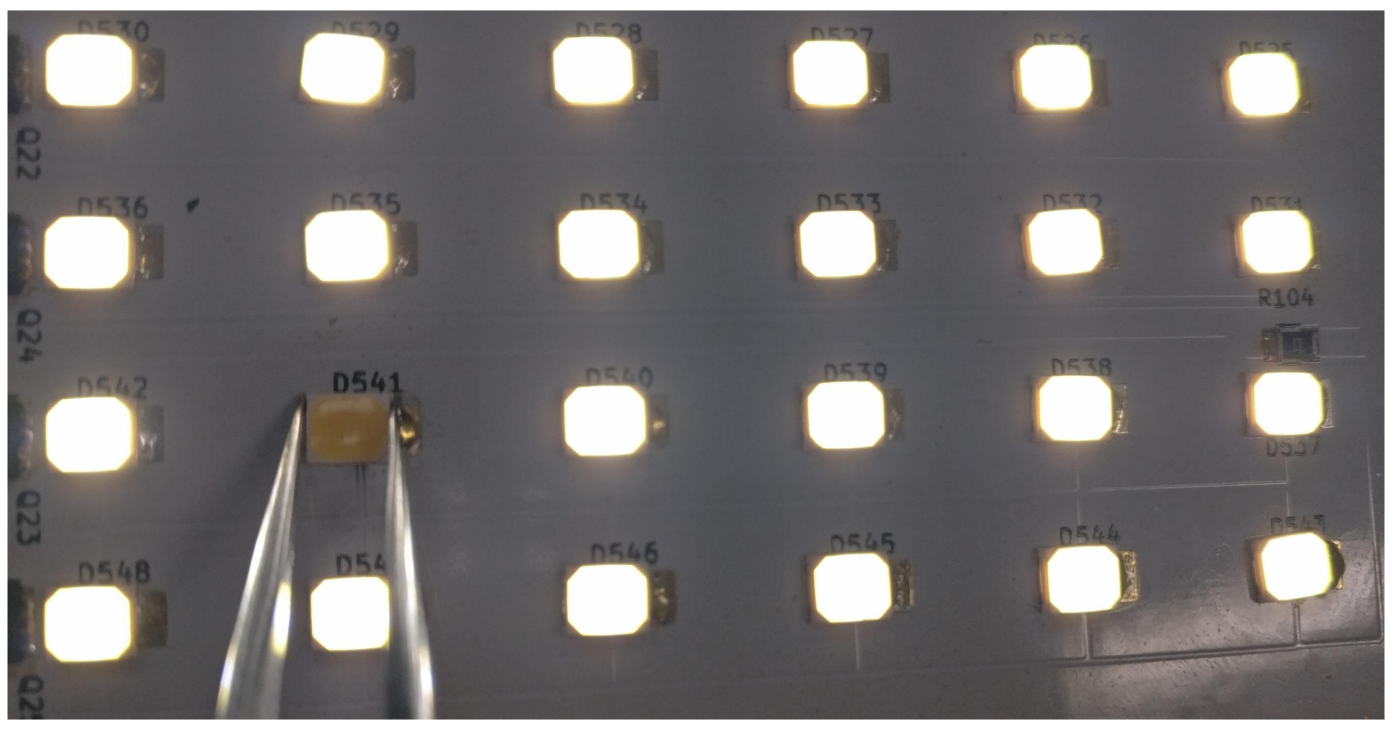
### Integration on LED PCB

The paralleling circuit can be directly implemented on the LEDs Aluminium PCB.



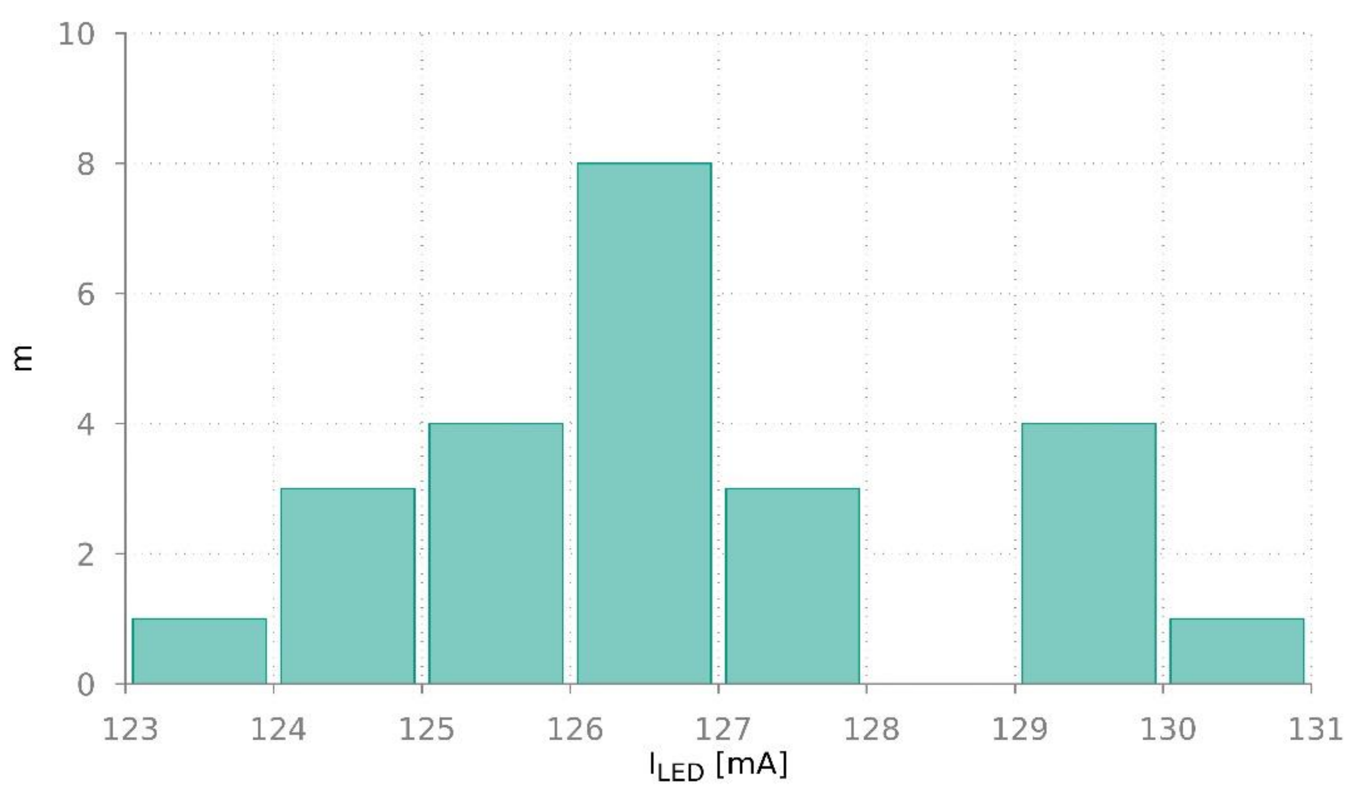
### Short Circuit Behavior

A short circuit of one or several LEDs does not compromise the modules functionality.

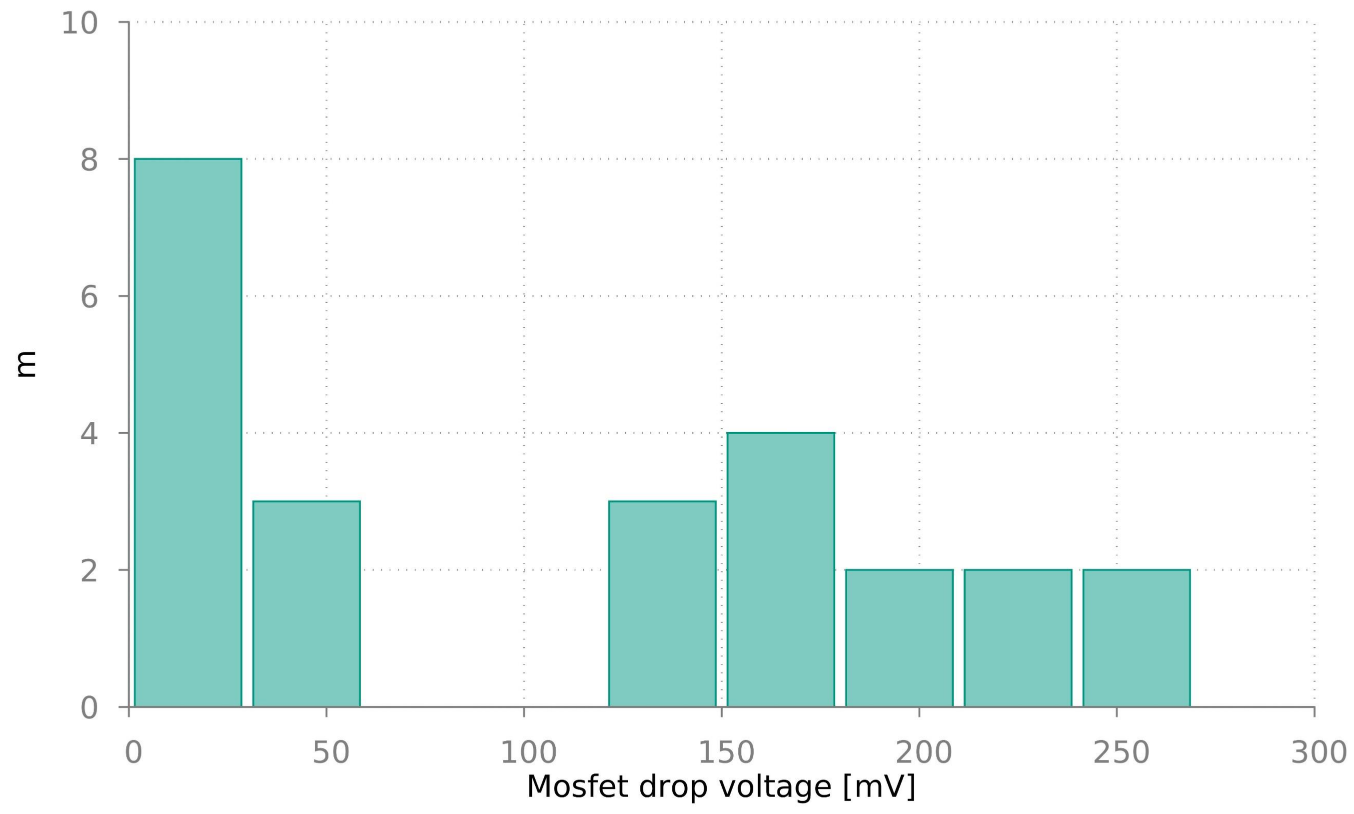


### String current distribution

The current is distributed equally. +- 3%




### Voltage Drop over MOSFET




### Loss Summation

| Loss source | Losses |
|---|---|
| Quiescent losses | 90 mW |
| Equalizing losses | 302 mW |
| Sensing losses | 345 mW |
| **Total** | **737 mW** |

The losses of balancing parallel LEDs are only 1.5%.

### System Efficiency

| | |
|---|---|
| High Power: | 120lm/W |
| Mid Power: | 180lm/W |
| Paralleled MidPower LEDs: | 177lm/W |

### Efficiency gain

# 47.5%

### Partners