

Infineon® LED Driver

November 2014

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Dept. Automotive

Body Segment Marketing



Agenda

- Introduction
- Infineon LED Drivers
- LED Lighting Architecture and Infineon's solutions
- Future Trend LED Lighting
- Summary

Agenda

■ Introduction

■ Infineon LED Drivers

■ LED Lighting Architecture and Infineon's solutions

■ Future Trend LED Lighting

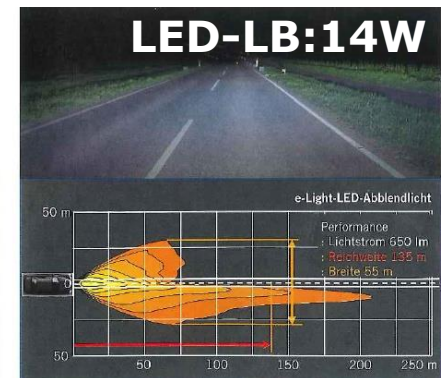
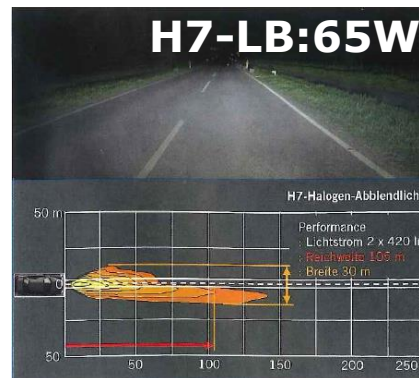
■ Summary

Major Enforcers for LED in Automotive

Today – Design



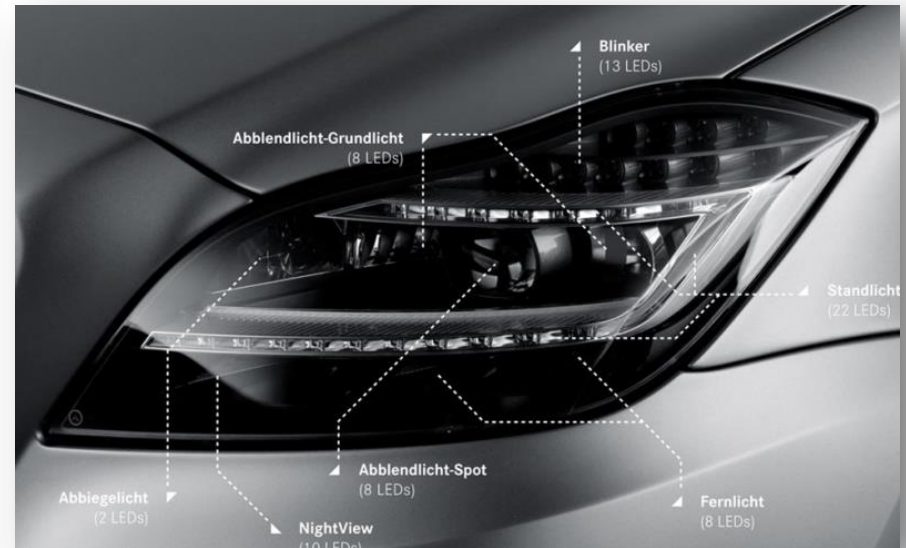
In Future – Design & Energy Efficiency



LED Frontlight as selling proposition



Source: AUDI AG

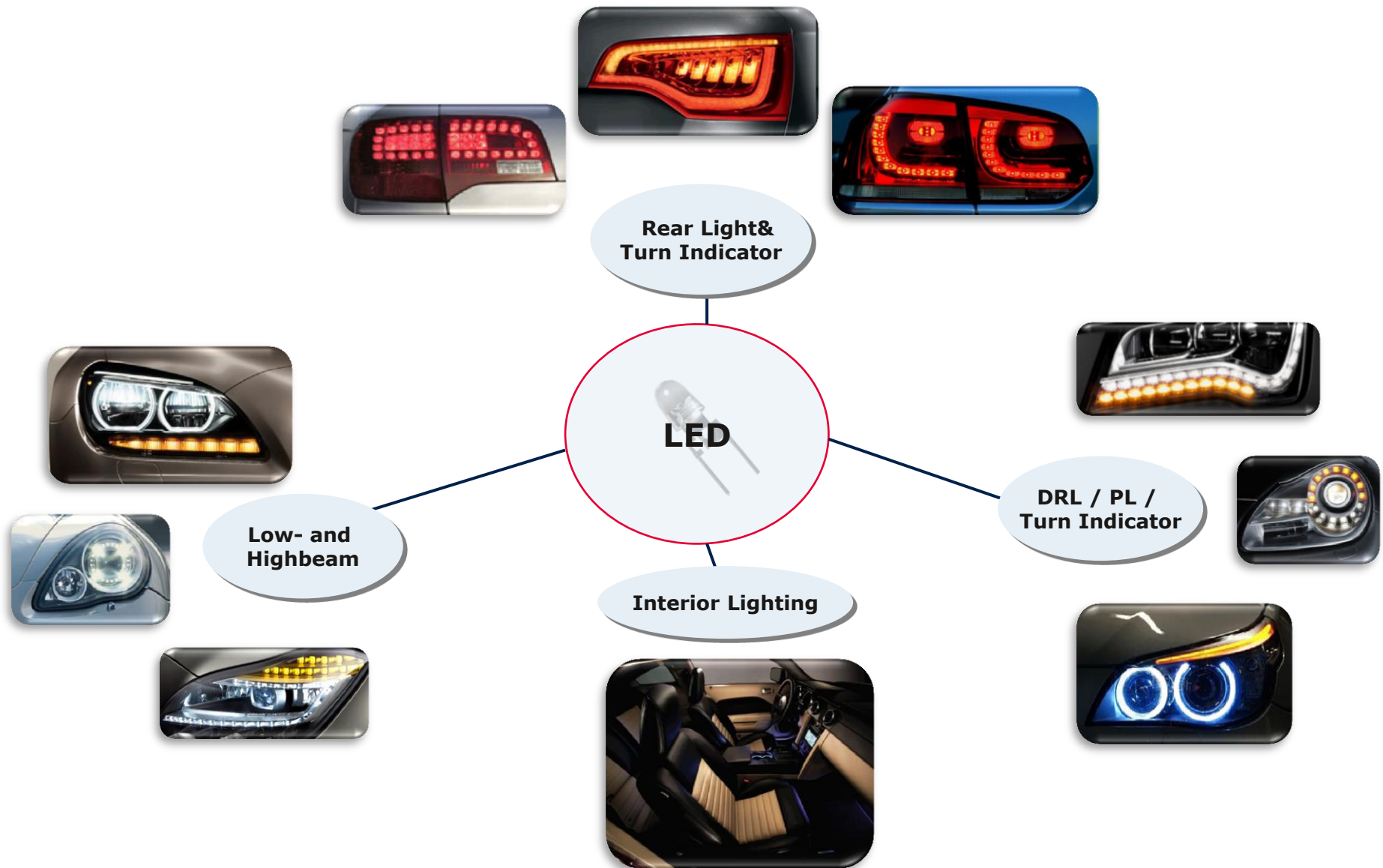


Source: Daimler AG



Source: BMW

Target LED automotive applications



The world of the halogen bulbs seem to be easy because there are fixed standards!



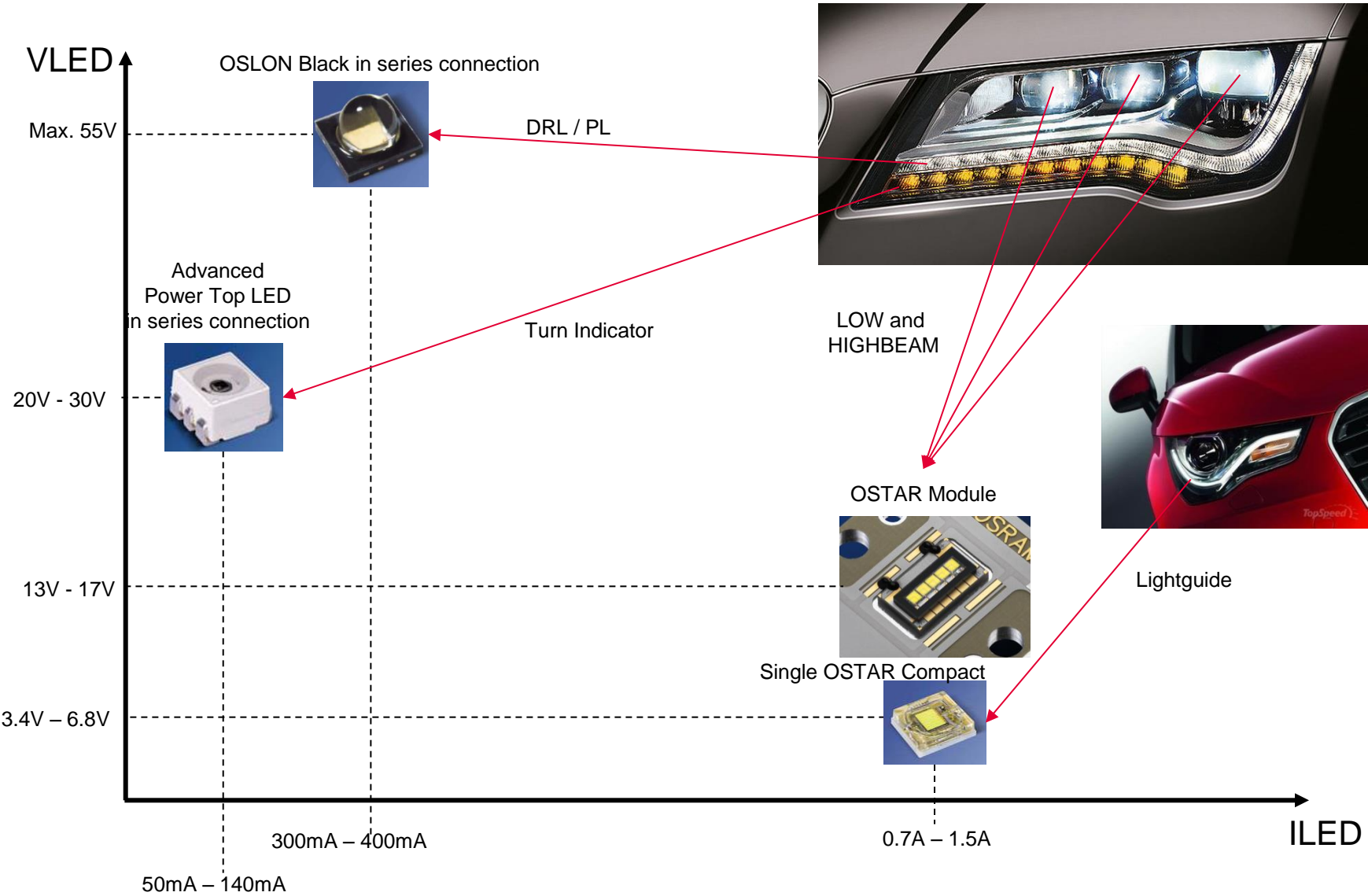
The LED world appears more complex!



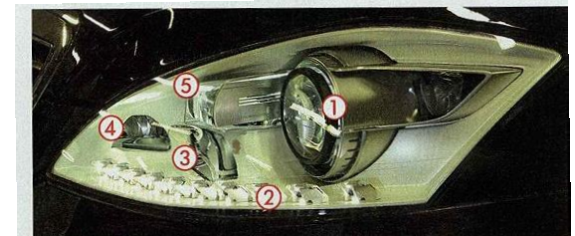
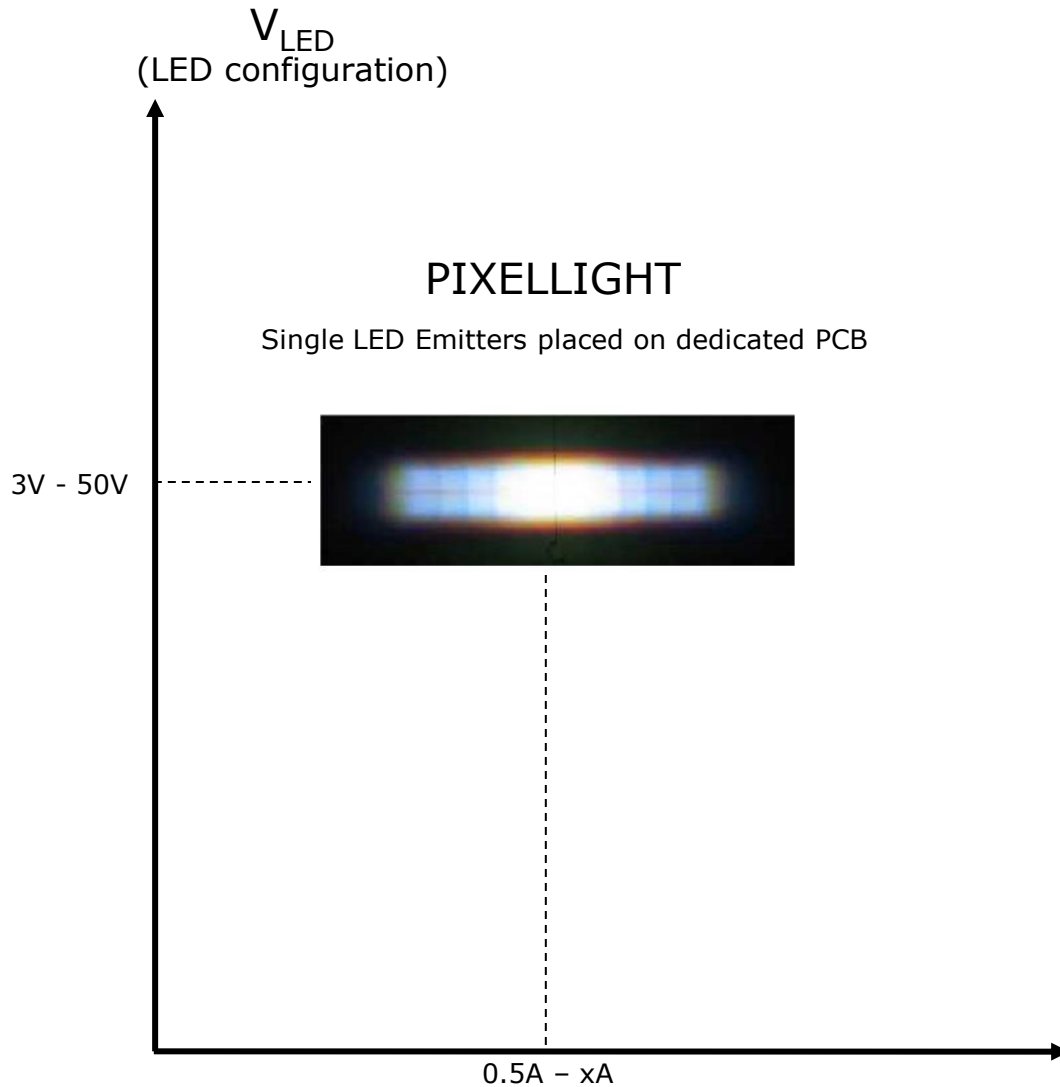
SEOUL SEMICONDUCTOR

Source: Internet

Different LED light functions require different requirements and driving concepts!



New Applications - PIXELLIGHT



Im Mercedes-Scheinwerfer gibt es fünf Lichtquellen ① Abblend- und Fernlicht ② Blinker und Tagfahrlicht ③ zusätzlicher Fernlichtspot ④ Abbiegelicht ⑤ Basislicht



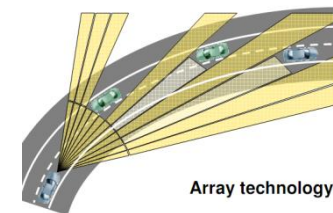
Volles Fernlicht, die 96 LED im Mercedes-Scheinwerfer leuchten bis zu 300 Meter weit

Typische Abblendlicht-Verteilung, die beim Prototyp noch einzelne Pixel zeigt



Eine Kamera erkennt entgegenkommende Autos, die durch Abschalten einzelner LED aus dem Lichtkegel ausgeblendet werden

Gefahrenquellen am Straßenrand wie Wildtiere sollen mit einzelnen Pixelspots gezielt angeleuchtet werden



Array technology



Agenda

- Introduction

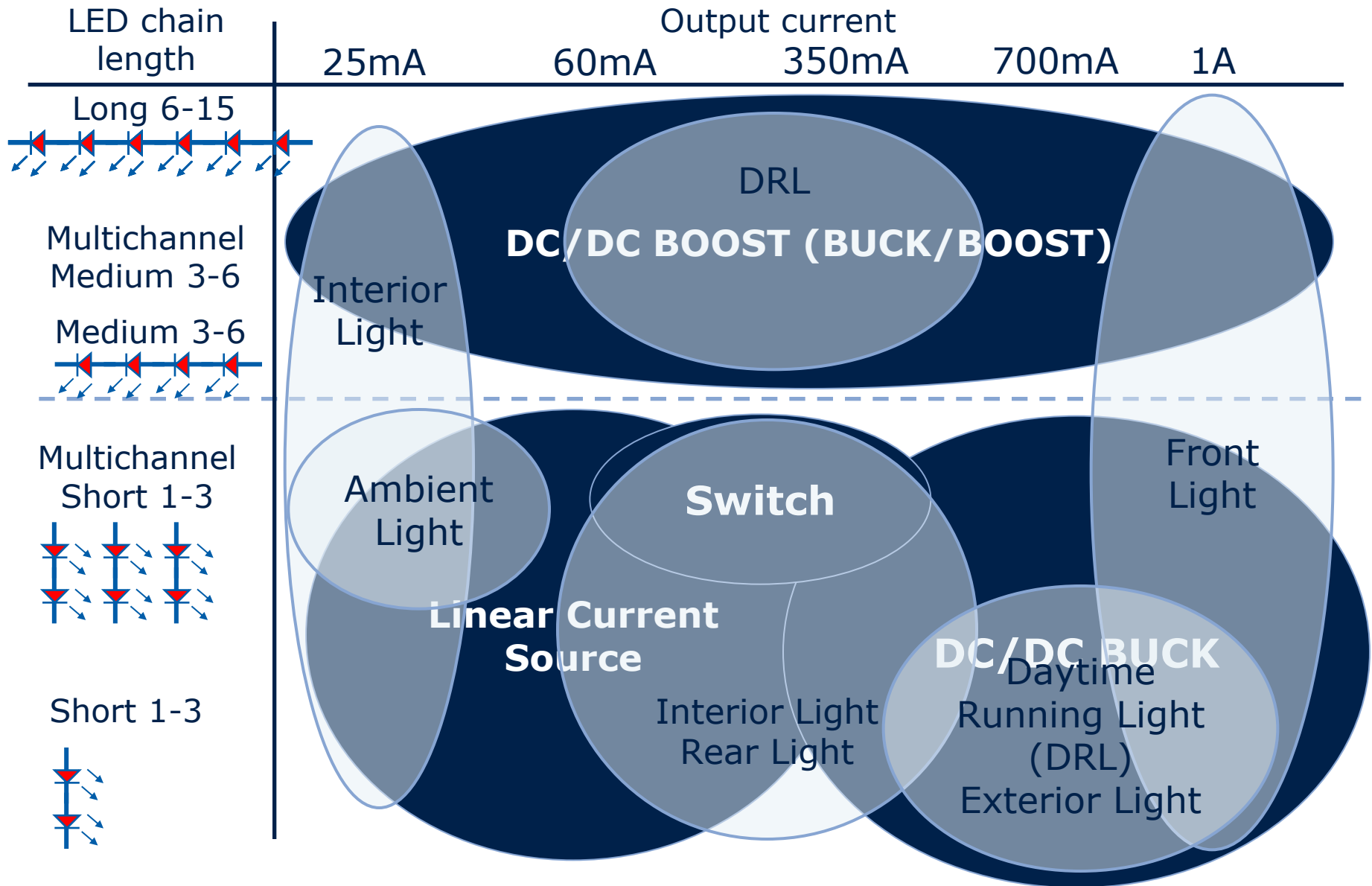
- Infineon LED Drivers

- LED Lighting Architecture and Infineon's solutions

- Future Trend LED Lighting

- Summary

The selection of the LED driver concept on the required current and the setup of the LED's

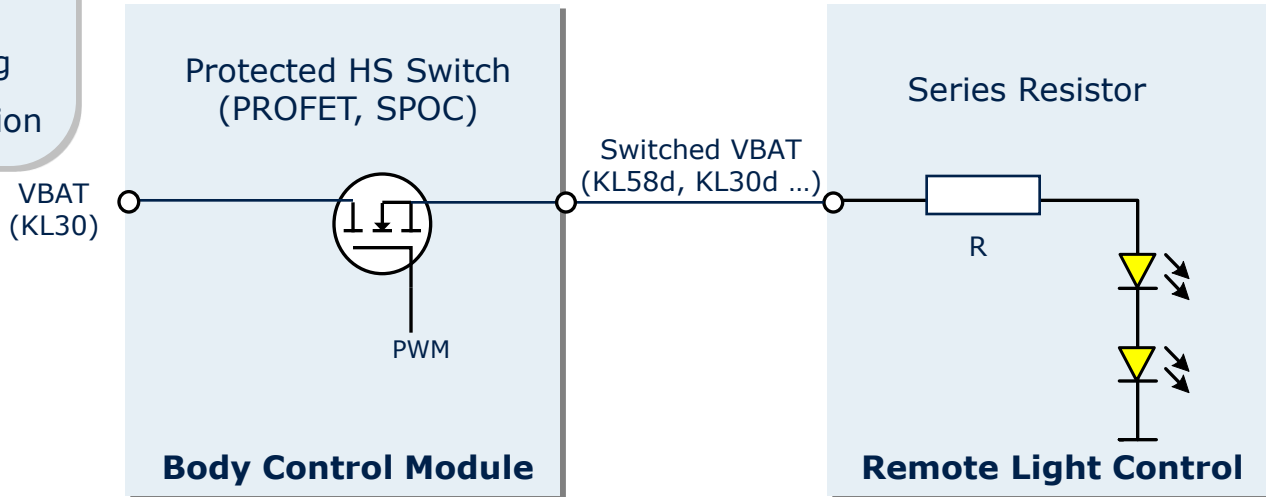


Generic LED Driving Concept I

Exterior Light Module with Simple Series Resistor

Applications:

- Rear Lighting
- Interior Lighting
- Ambient Lighting
- Front Signal Lighting
- Dual Bulb/LED operation



- Supports Dual Bulb/LED Operation
- Protection against Shorts and Transients
- Diagnosis and PWM control on BCM

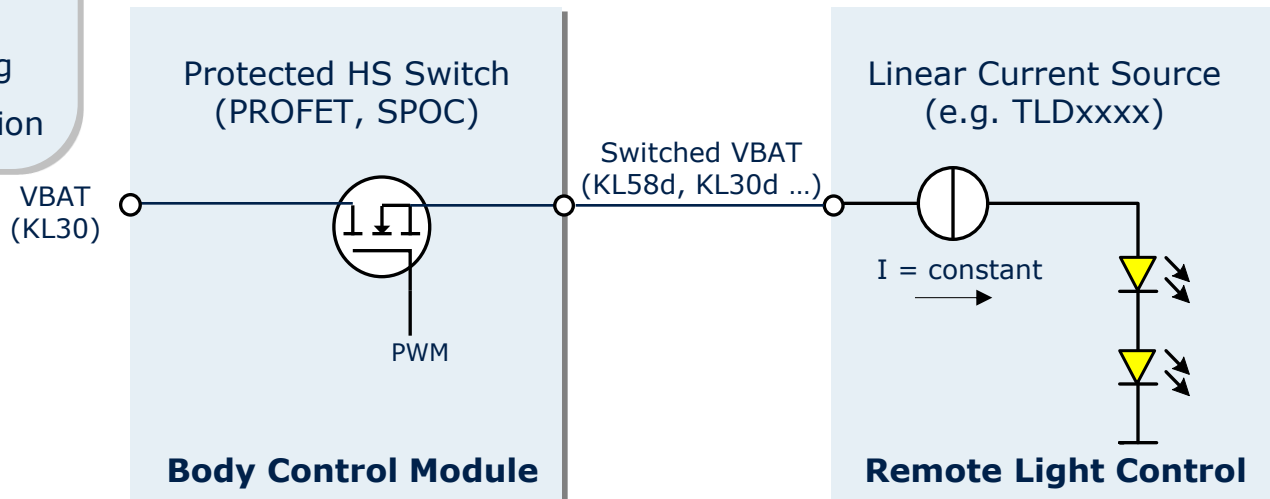
- Medium Power Dissipation
- Reduced LED lifetime Due To Current Peaks
- No Intrinsic Overvoltage Protection
- Usable LED Current Lower Than Nominal Current

Generic LED Driving Concept II

Exterior Light Module with Linear Current Source

Applications:

- Rear Lighting
- Interior Lighting
- Ambient Lighting
- Front Signal Lighting
- Dual Bulb/LED operation



- Supports Dual Bulb/LED Operation
- Protection against Shorts and Transients
- Diagnosis and PWM control on BCM

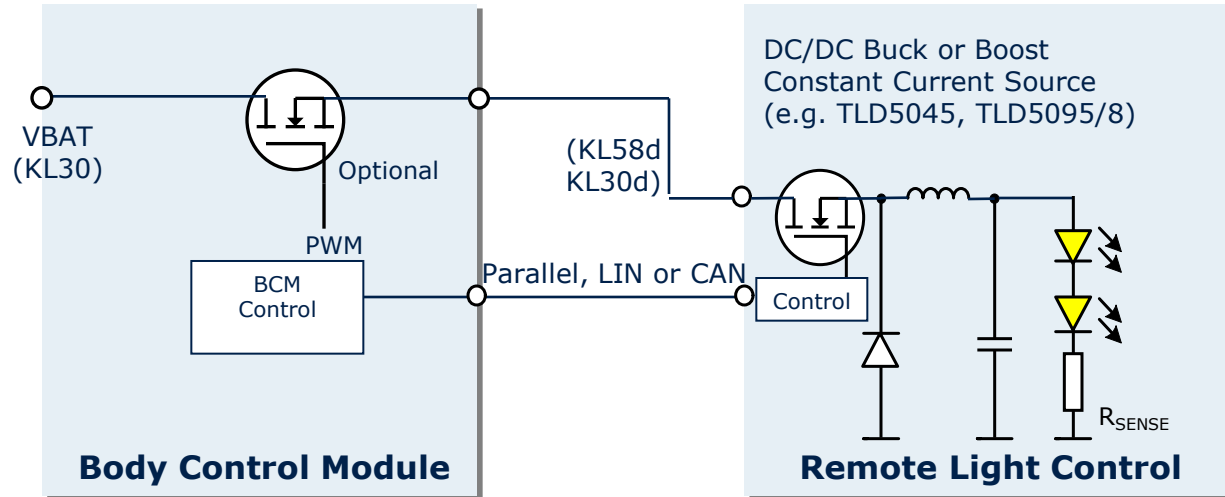
- High Power dissipation
- Extended LED lifetime
- Intrinsic Overvoltage Protection
- Usage of LED Nominal Current possible

Generic LED Driving Concept III

Exterior Light Module with DC/DC Current Source

Applications:

- Low Beam
- High Beam
- DRL
- Fog Light



- Direct or Networked Control

- Highest Efficiency / Lowest Power Loss
- High Power LED capable
- Extended LED lifetime
- Diagnosis and PWM Capability on Remote Module
- Usage of LED Nominal Current

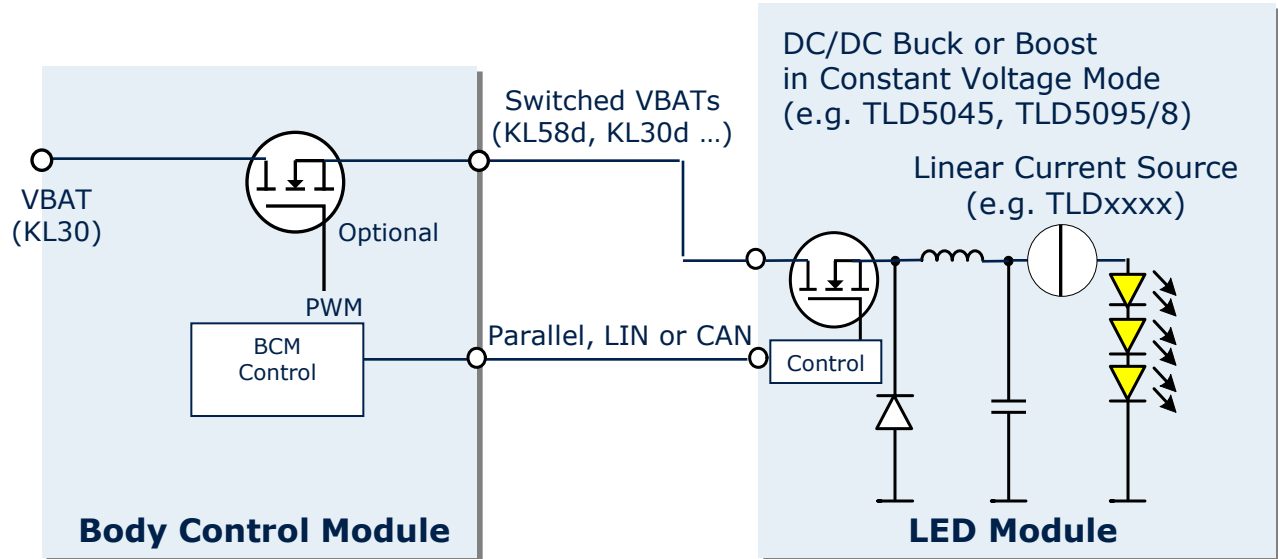
Generic LED Driving Concept IV

Exterior Light Module with DC/DC and Current Source



Applications:

- Low Beam
- High Beam
- DRL
- Fog Light

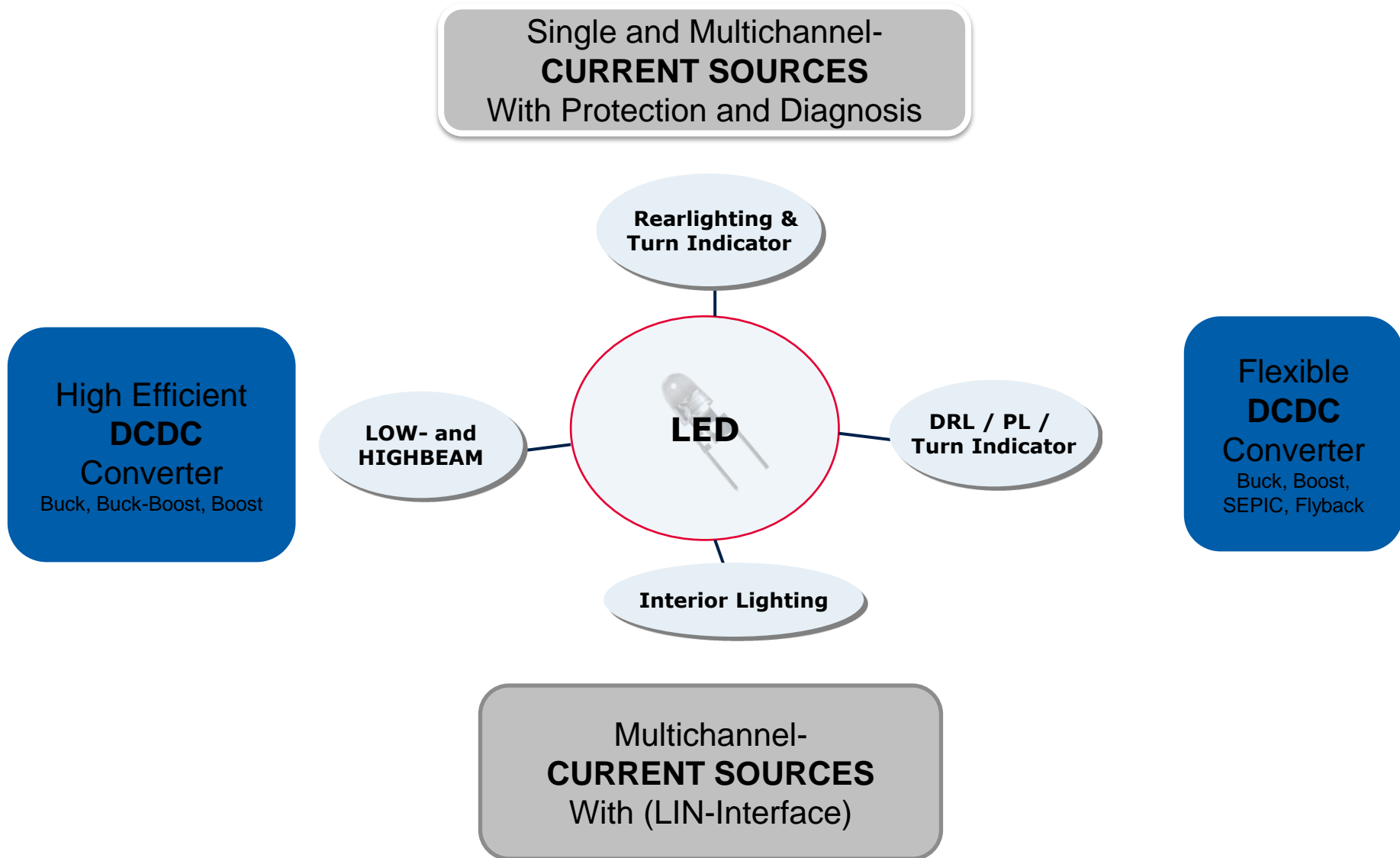


- Direct or Networked Control

- One DC/DC for multiple Linear Current Sources
- Boost Voltage adopted to LED Fwd Voltage
- High Efficiency / Low Power Loss
- High Power LED capable
- Extended LED lifetime
- Diagnosis and PWM Capability on Remote Module
- Usage of LED Nominal Current

Applications versus Concepts

Infineon® Auto LED Driver Family



Infineon offers a comprehensive set of LED driver families for Automotive Lighting Solutions



Infineon® Auto LED Driver

Automotive LED driver

Infineon® Basic LED Driver

Low/medium current LED driver

Infineon® Power LED Driver

High current LED driver

Infineon® LIN LED Driver

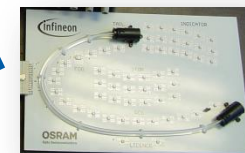
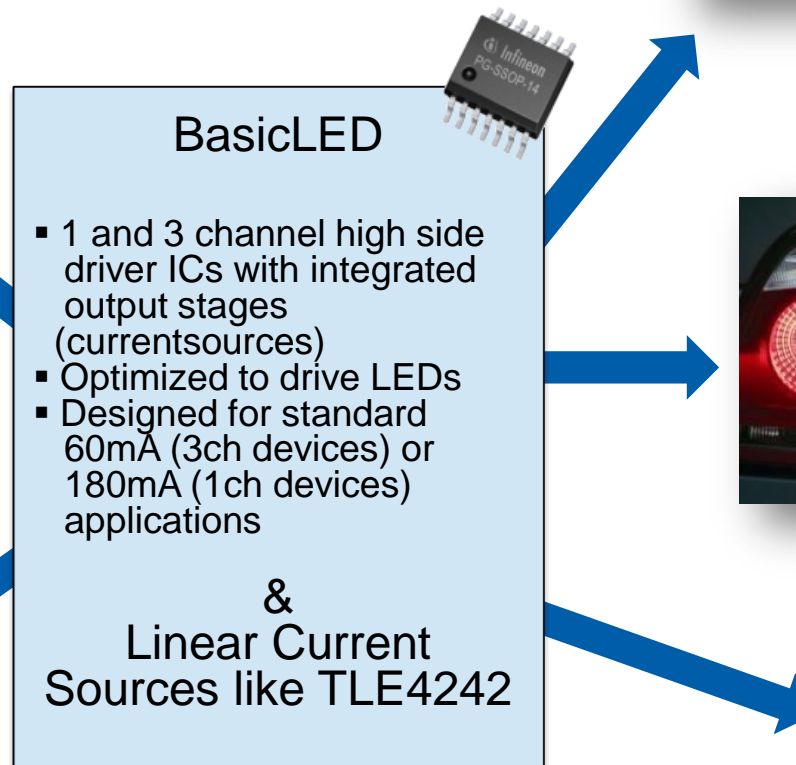
LIN controlled LED driver

Infineon® SPOC Driver

SPI controlled BULB/LED driver

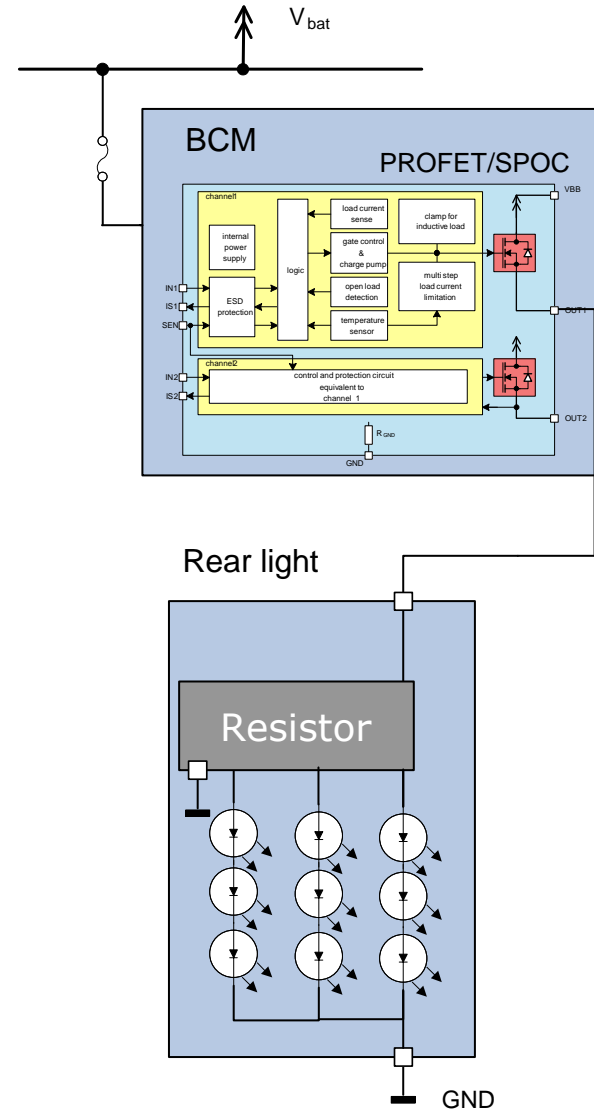
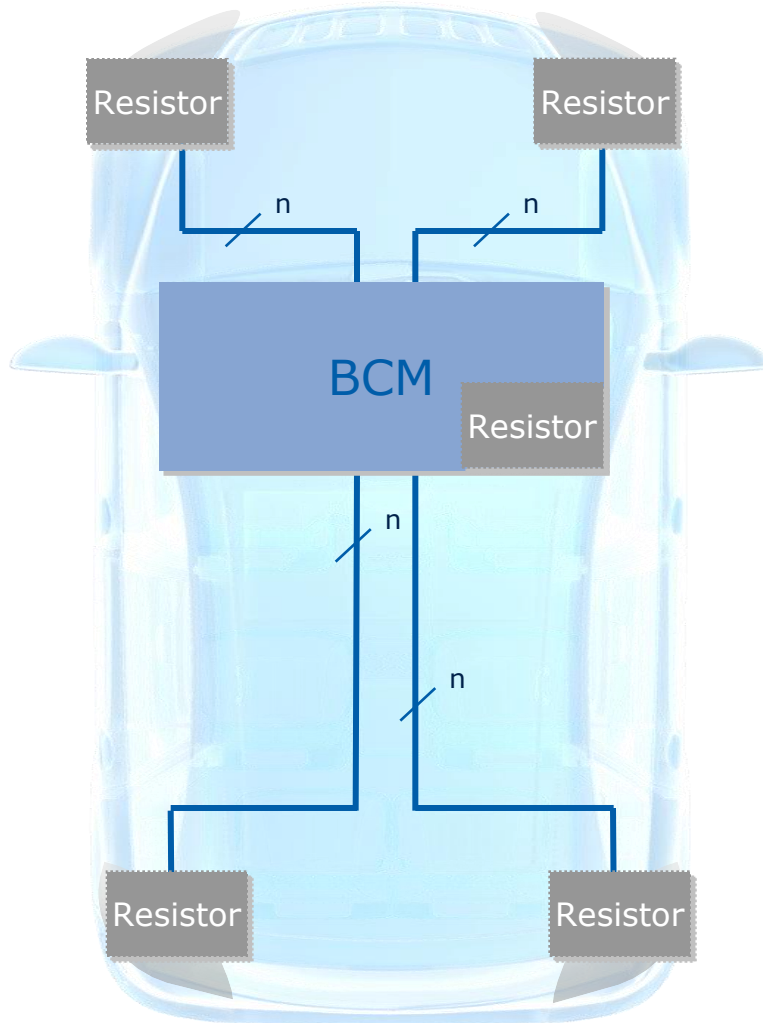
Basic LED Driver

Infineon is driving new LED solutions in...
Rear Lighting

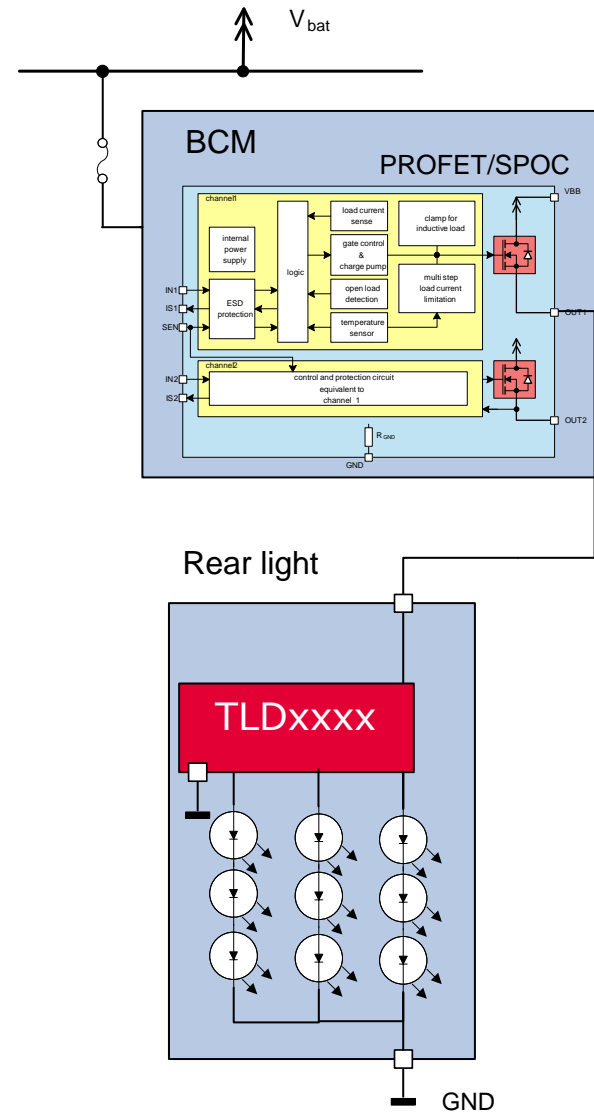
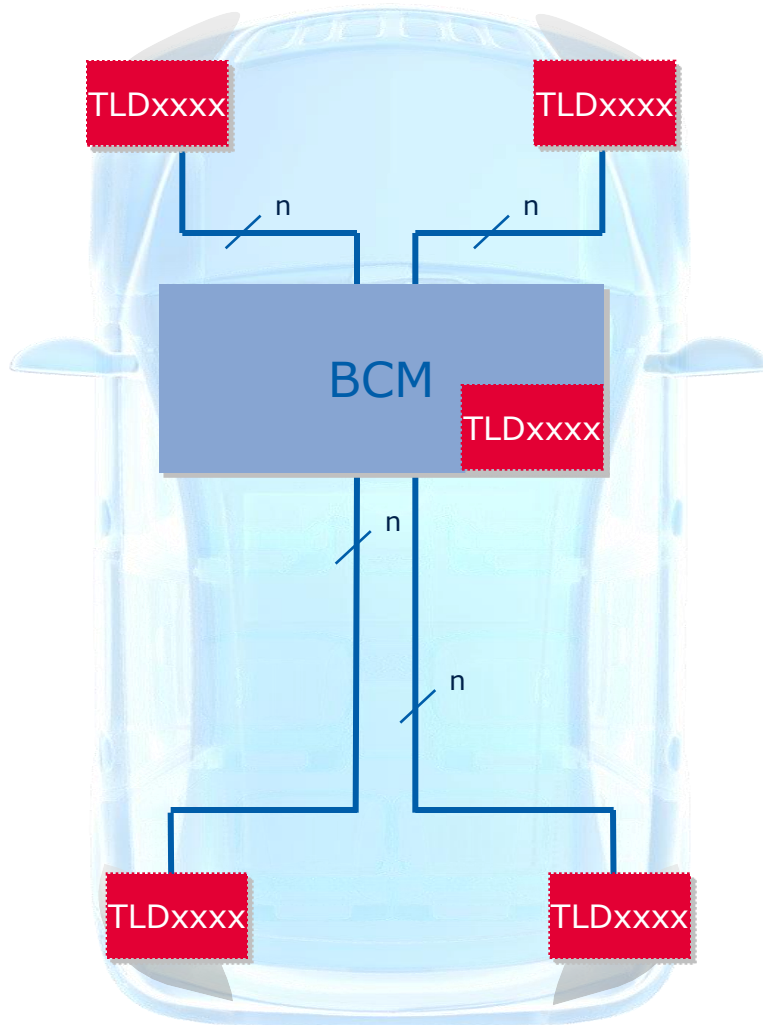


Source: Internet

Our major target application is exterior and interior LED lighting in Automotive



Our major target application is exterior and interior LED lighting in Automotive



Infineon® Basic LED Driver

A modular & flexible family setup



Now Productive

| Inputs Output | | | | | | | | |
|------------------|----------------------------------|-------------------------------|----------------|--------------------|-------------------------|-------------------------|------------------------------------|---|
| 3 IN 3 OUT | TLD2310 | | | | TLD2311 OL & SC | TLD2314 OL & SC, DEN | TLD2326 Matrix, OL&SC | |
| 1 IN 3 OUT | TLD1310 | TLD1312 PWMI | TLD1311 N-1 | TLD1313 OL & SC | TLD1314 OL & SC, DEN | TLD1315 PWMI, N-1 | TLD1326 Matrix, N-1&PWMI | |
| 1 IN 1 OUT | TLD1120 | | | | TLD1121 OL & SC | TLD1124 OL & SC, DEN | TLD1125 PWMI, OL & SC | |
| | parallel outputs 1ch/180mA | single outputs 3ch/60mA | + PWMI | + N-1 | + OL & SC | + OL & SC + DEN | + PWMI + N-1 or + OL & SC | + Matrix + N-1 & PWMI or + OL & SC |

Features

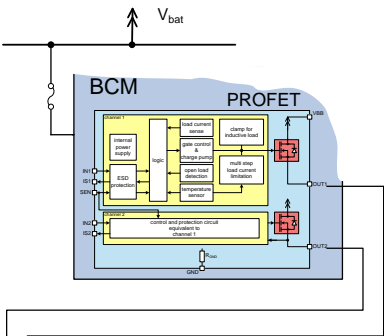
Infineon® Basic LED Driver Family



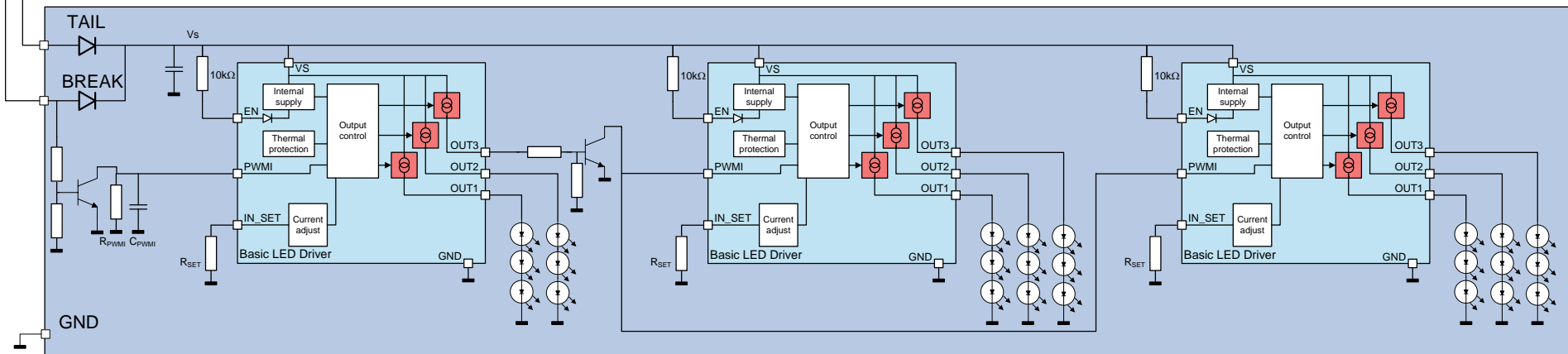
TLD1312EL – additional PWMI feature

■ 1 IN/SET - 60mA/ch – 3ch IC – PWMI feature

- Global ON-/OFF-state and brightness control via PWM on VS and EN
- PWM frequency for tail light defined via RC network at PWMI → PWM operation
- During brake event PWM dimming engine changes to 100% duty cycle



Application Example



Infineon® Basic LED Driver Family



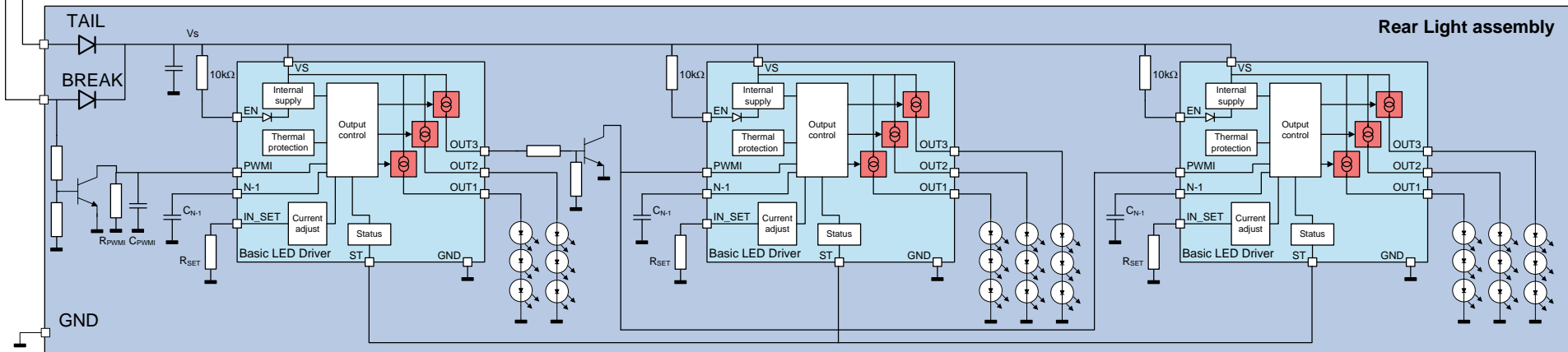
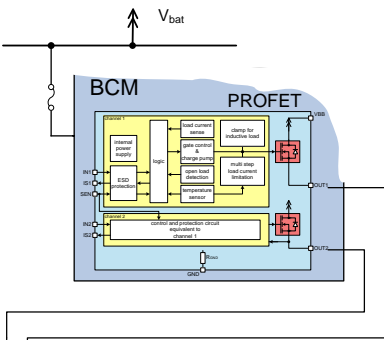
TLD1315EL – additional N-1 detection + PWMI feature

■ 1 IN/SET - 60mA/ch - 3ch IC - N-1 detection - PWMI feature



- Global ON-/OFF-state and brightness control via PWM on VS and EN
- PWMI and N-1 feature combined

Application Example

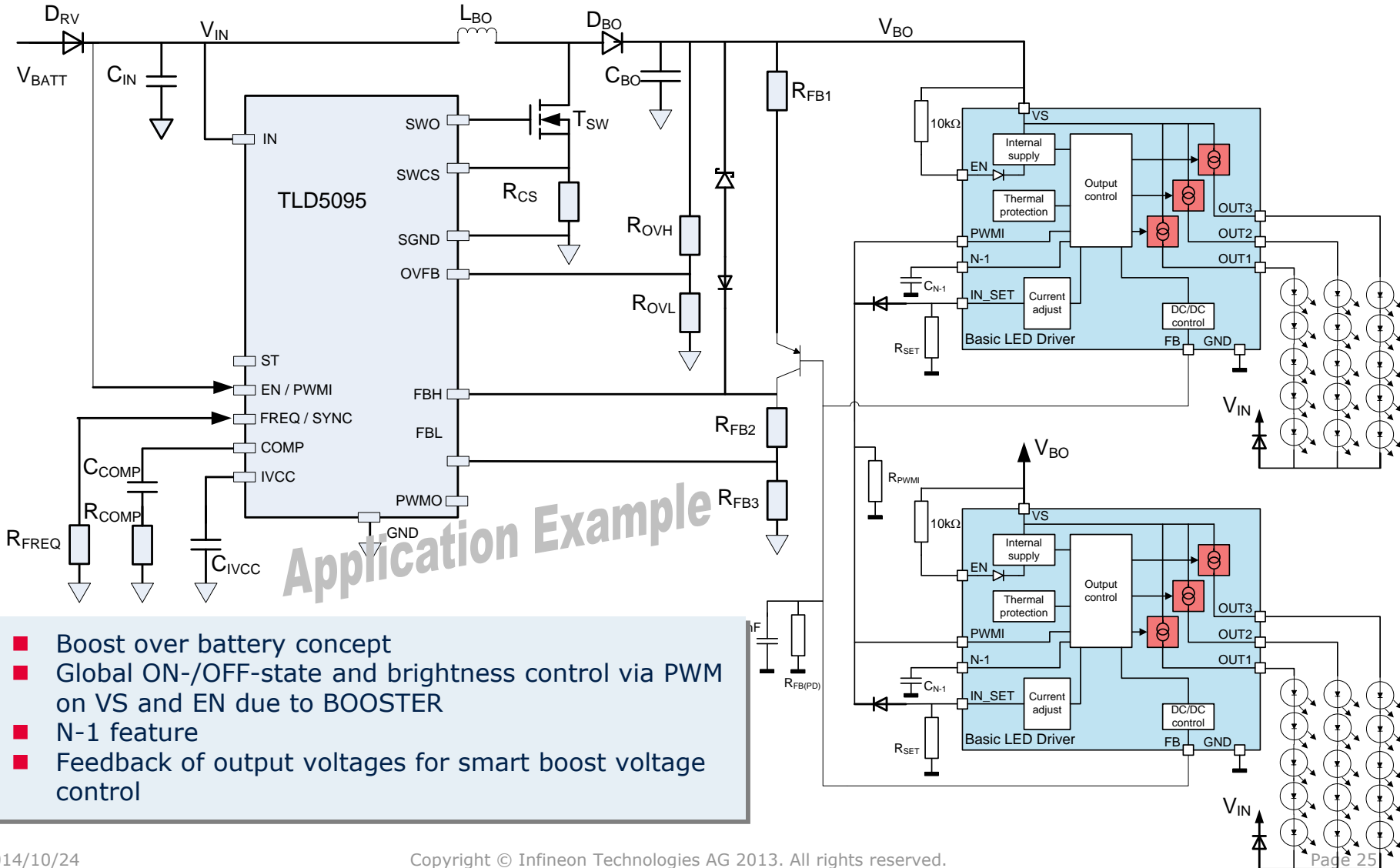


Infineon® Basic LED Driver Family



TLD1326EL – additional N-1 detection + Matrix feature (1)

- 1 IN/SET - 120mA/ch – 3ch IC – N-1 feature – Matrix Boost



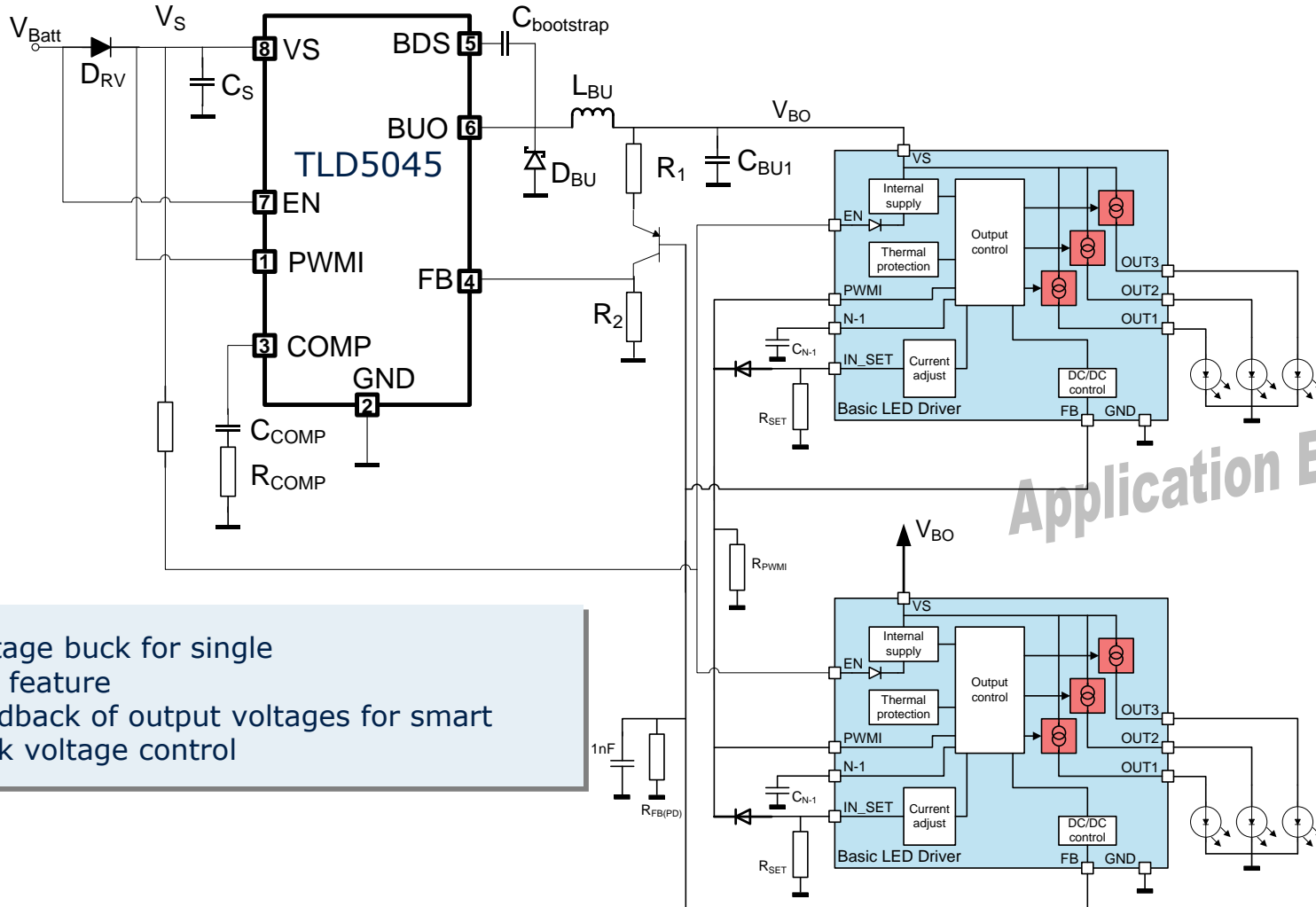
- Boost over battery concept
- Global ON-/OFF-state and brightness control via PWM on VS and EN due to BOOSTER
- N-1 feature
- Feedback of output voltages for smart boost voltage control

Infineon® Basic LED Driver Family



TLD1326EL – additional N-1 detection + Matrix feature (2)

■ 1 IN/SET - 120mA/ch – 3ch IC – N-1 feature – Matrix Buck



Application Example

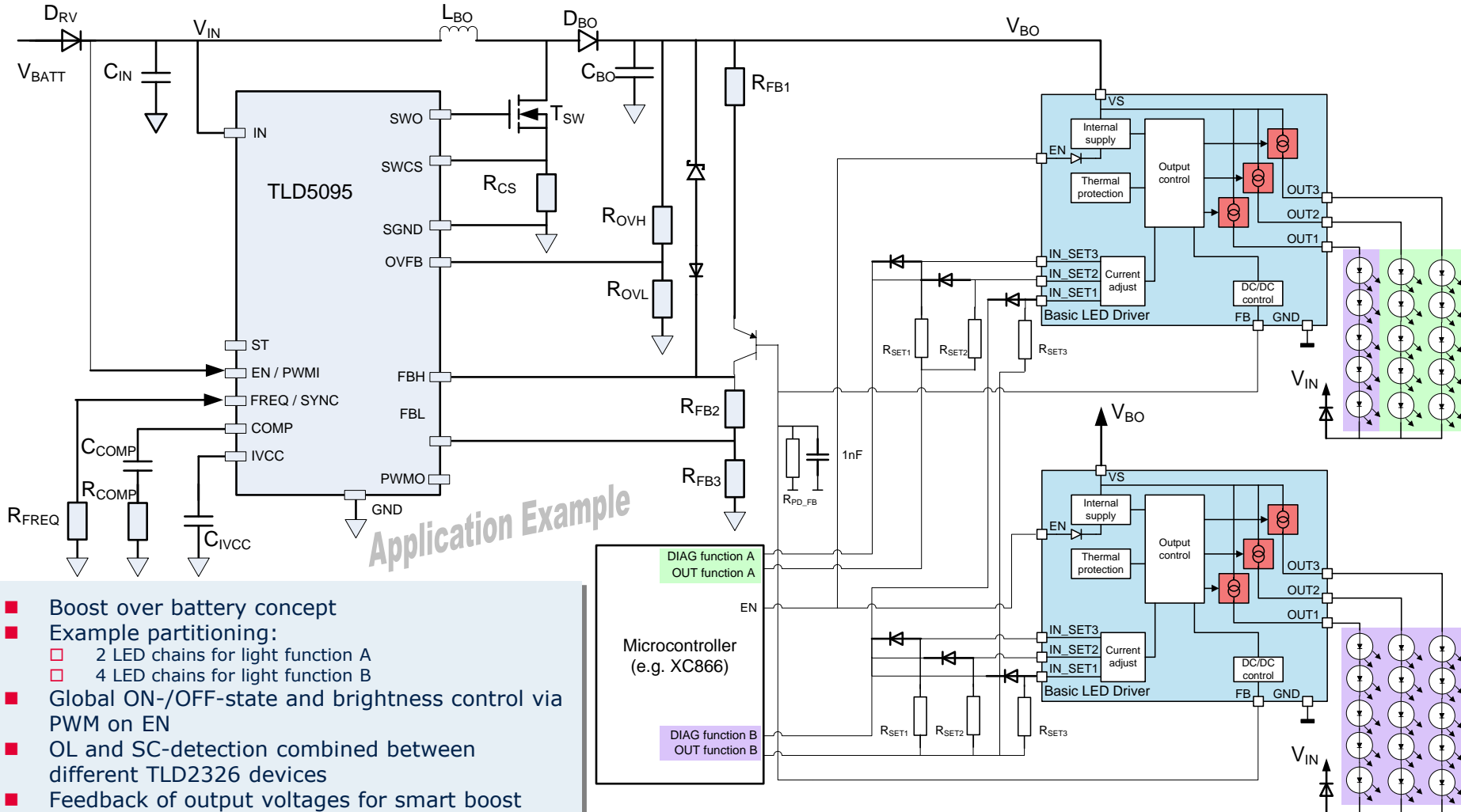
- Voltage buck for single
- N-1 feature
- Feedback of output voltages for smart buck voltage control

Infineon® Basic LED Driver Family



TLD2326EL – similar to TLD1326 but with 3 inputs

■ 3 IN/SET - 120mA/ch – 3ch IC – OL and SC det. – Matrix Boost



Application Example

- Boost over battery concept
- Example partitioning:
 - 2 LED chains for light function A
 - 4 LED chains for light function B
- Global ON-/OFF-state and brightness control via PWM on EN
- OL and SC-detection combined between different TLD2326 devices
- Feedback of output voltages for smart boost voltage control

Power LED Driver

■ Infineon is driving new LED solutions in...

■ Front Lighting



Source: Internet


Infineon[®] Power LED - Portfolio

Topology

BOOST

BUCK / BOOST

BUCK




TLD5095 available

TLD5097 development

TLD5098* available

Controller Concept
 I_{out} variable
 f_{sw} up to 500kHz
 Digital Dimming
 Analog Dimming*
 Short to GND*
 V_{OUT} up to 60V*



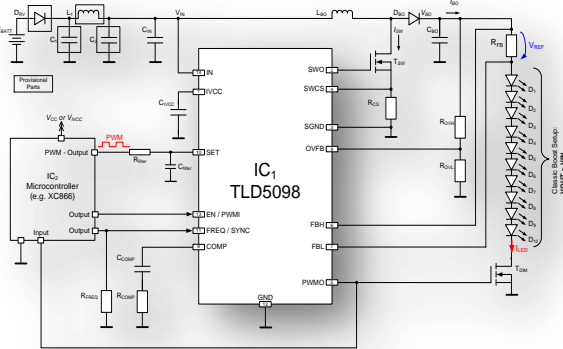
TLD5045

Full Integration
 I_{OUT} up to 700mA
 f_{SW} up to 300kHz
 Digital Dimming
 Analog Dimming
available Auto PWM
 Status Pin

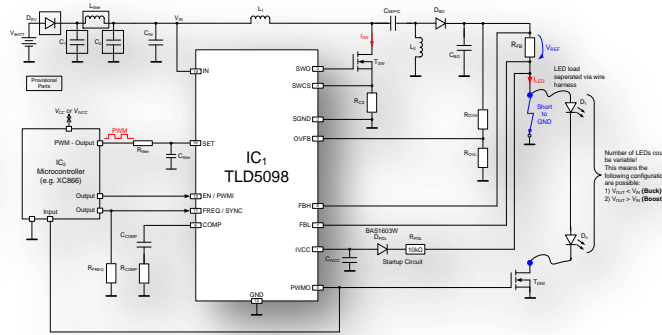
Products

TLD509x the "all rounder"

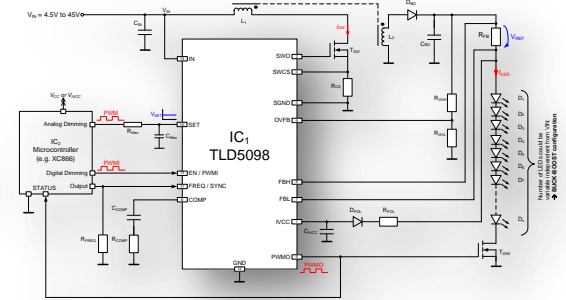
BOOST to GND



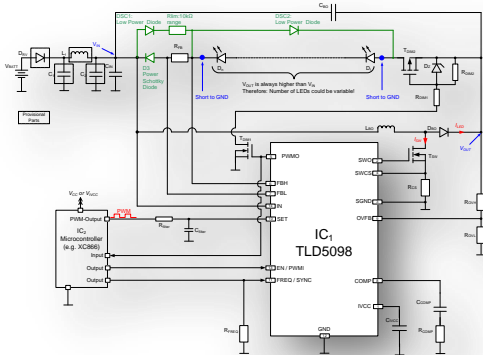
SEPIC



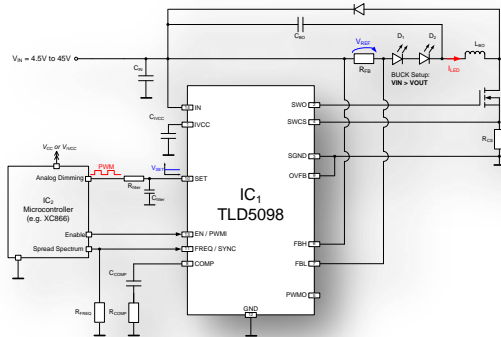
FLYBACK



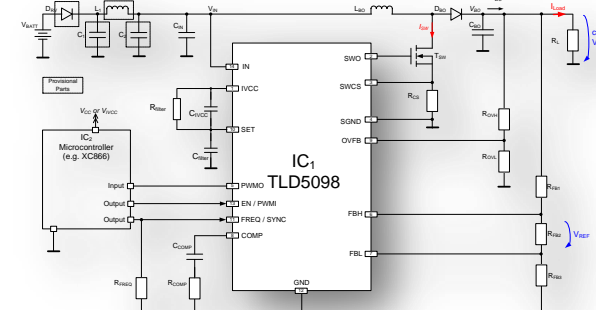
Boost to Battery



Buck

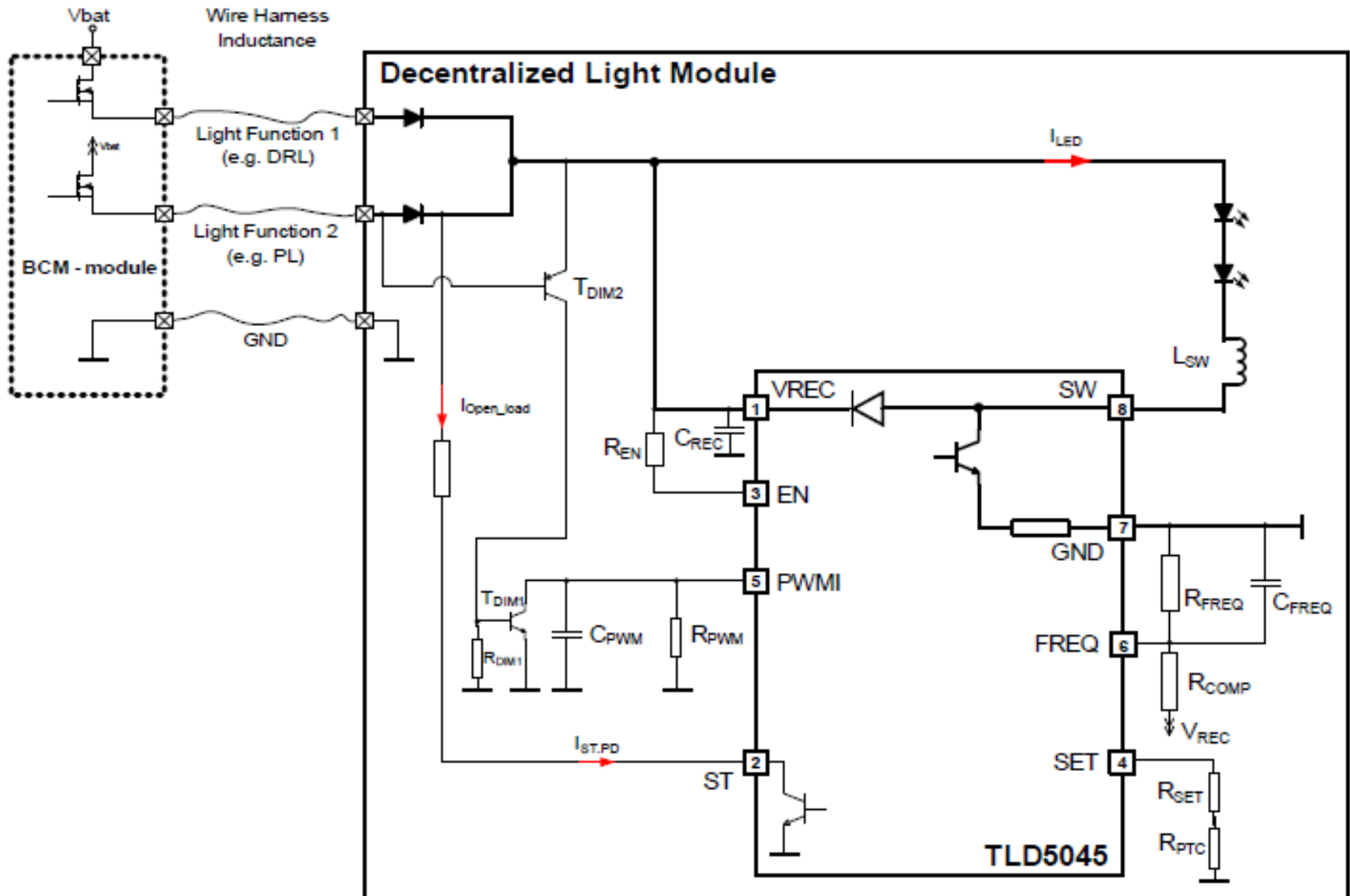


Constant Voltage Supply



TLD5045 on a Decentralized Light Module (DLM)

Imitating Bulb behavior



LIN LED Driver

Infineon is driving new LED solutions in...
Ambient Lighting



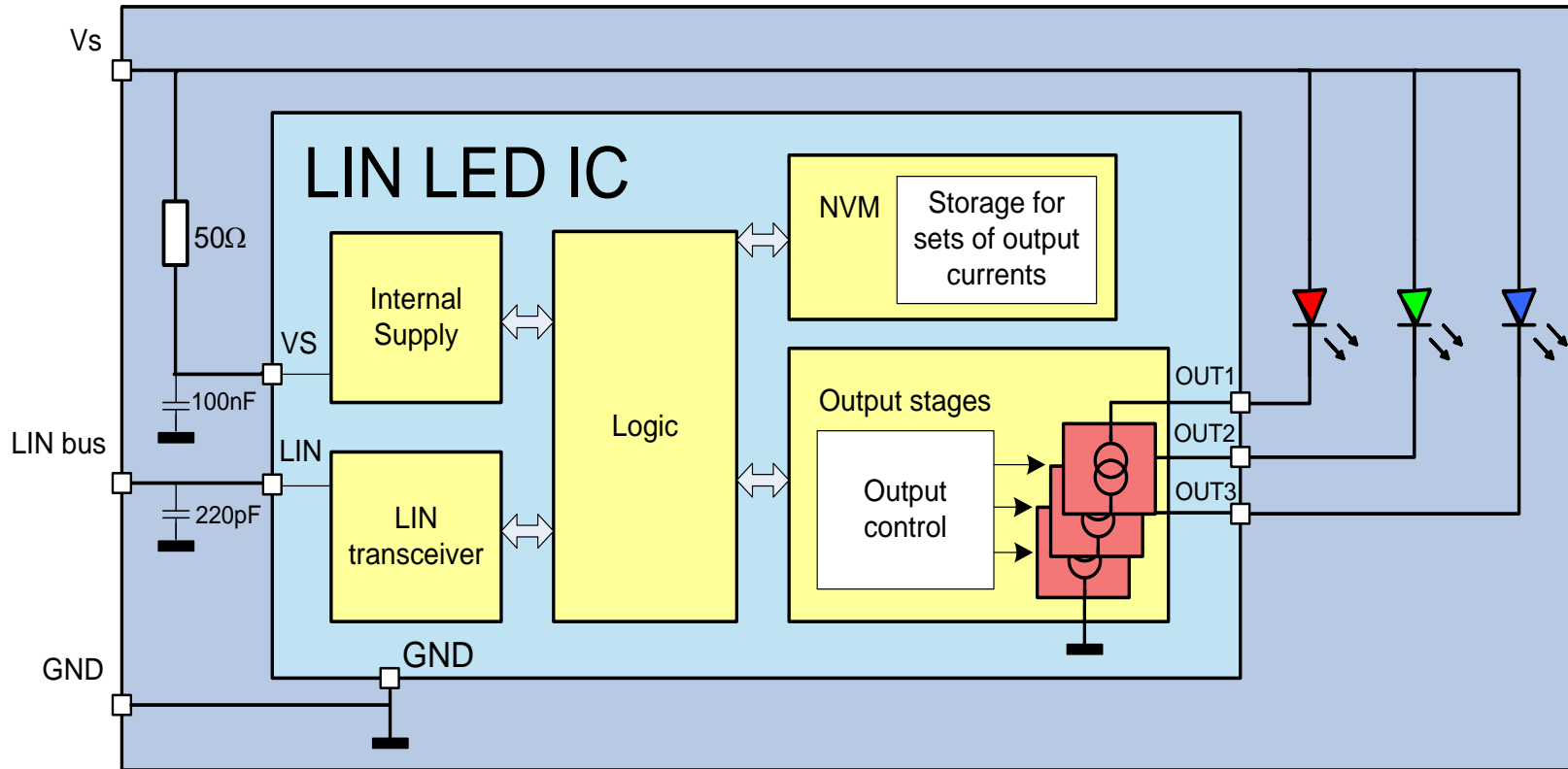
LINLED

- 3 channel lowside current sources
- Configuration and diagnostic via LIN-transceiver
- Non volatile memory for 4 output currents programmable (12, 24, 36, 48mA)
- 16 intensity settings for color point definition
- Device node ID
- Easy programmable
- Integrated intensity generation unit for
- Low power consumption in sleep mode



Smart LED module with Infineon® LIN LED Driver

→ Application diagram



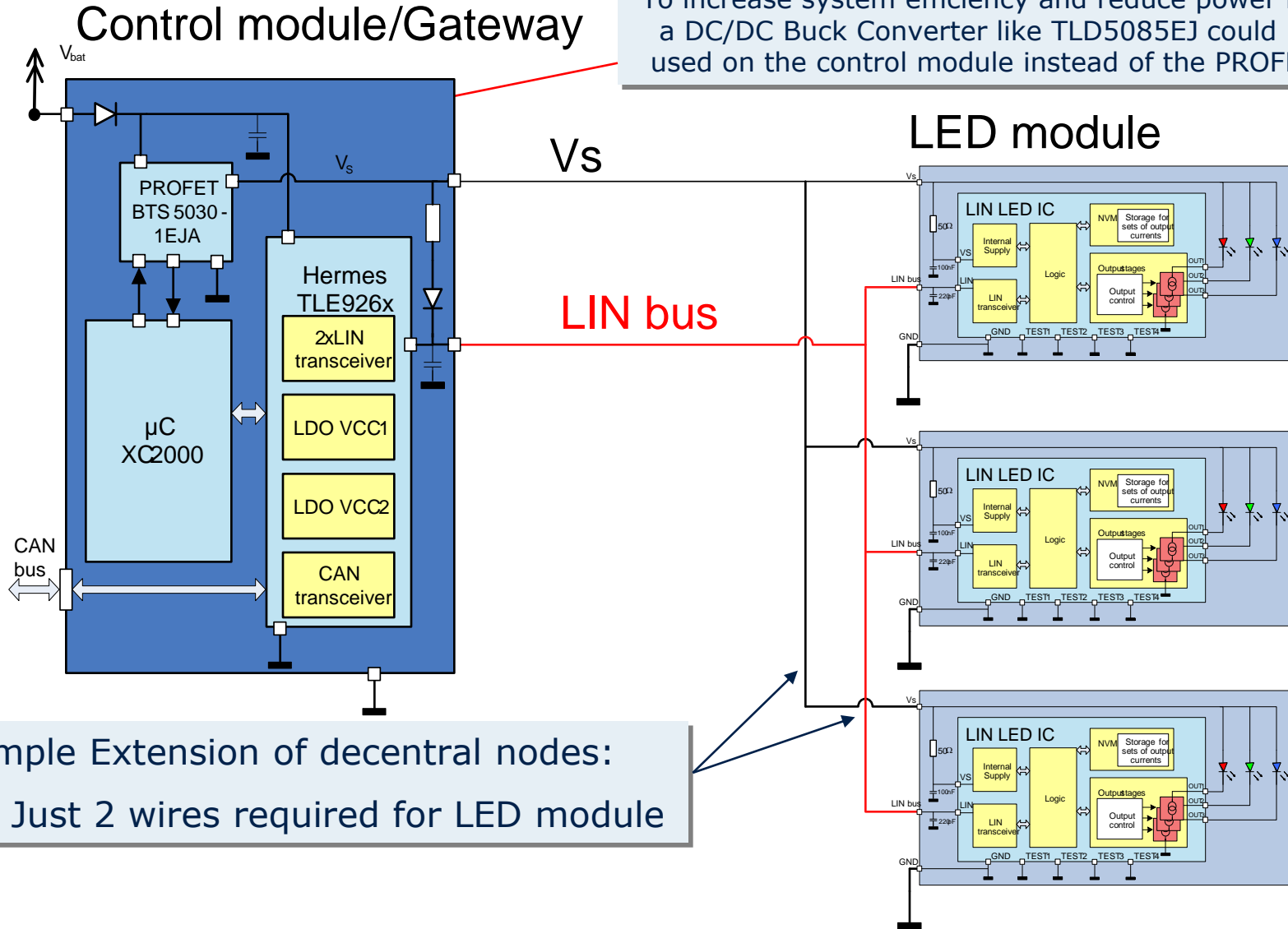
LED Module with 3 connections only!
Only 2 capacitors and 1 resistor required!

Smart LED module with Infineon® LIN LED Driver

→ System diagram



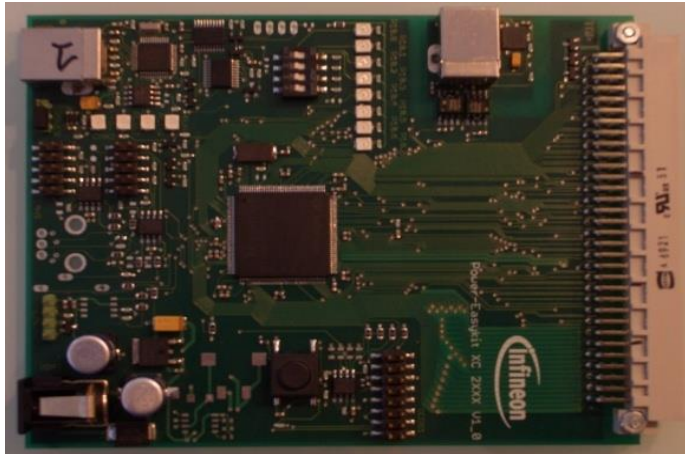
To increase system efficiency and reduce power loss a DC/DC Buck Converter like TLD5085EJ could be used on the control module instead of the PROFET.



Simple Extension of decentral nodes:
 → Just 2 wires required for LED module

OEM's pursue a platform approach for BCM's

One BCM design/PCB



Consequence:

Even in the next decade the by far biggest part of the BCM market will continue with a hybrid (bulb + LED) BCM design which requires today's driver concepts (PROFET, SPOC)



Low end
Car model

No LED

Mid range
Car model

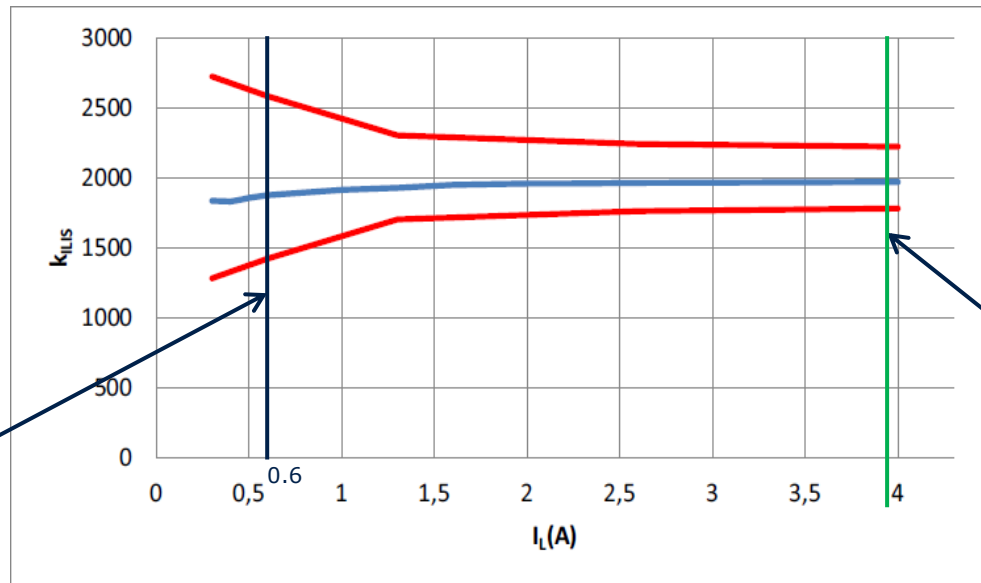
LED as option*

High end
Car model

LED only*

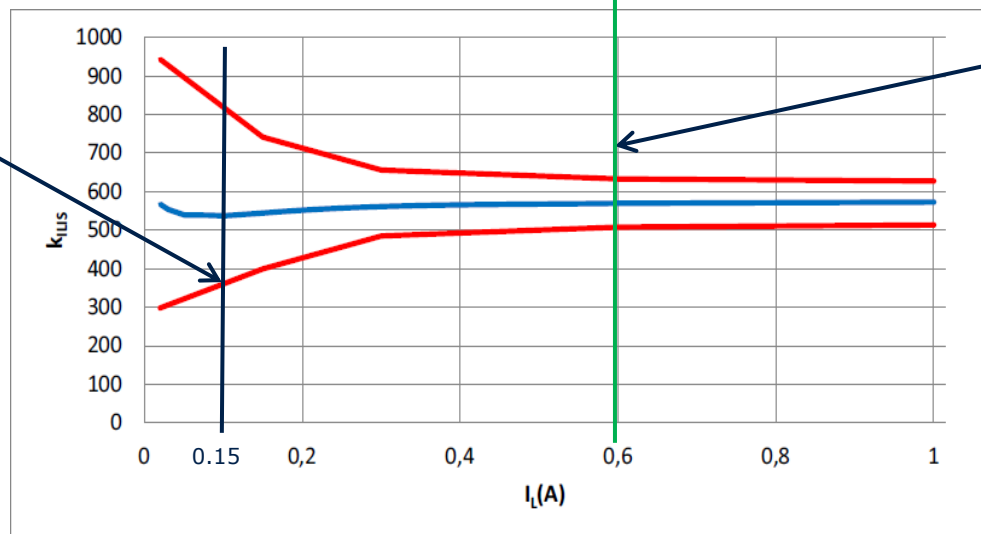
*for certain loads

Kilis accuracy: Lamp vs. LED



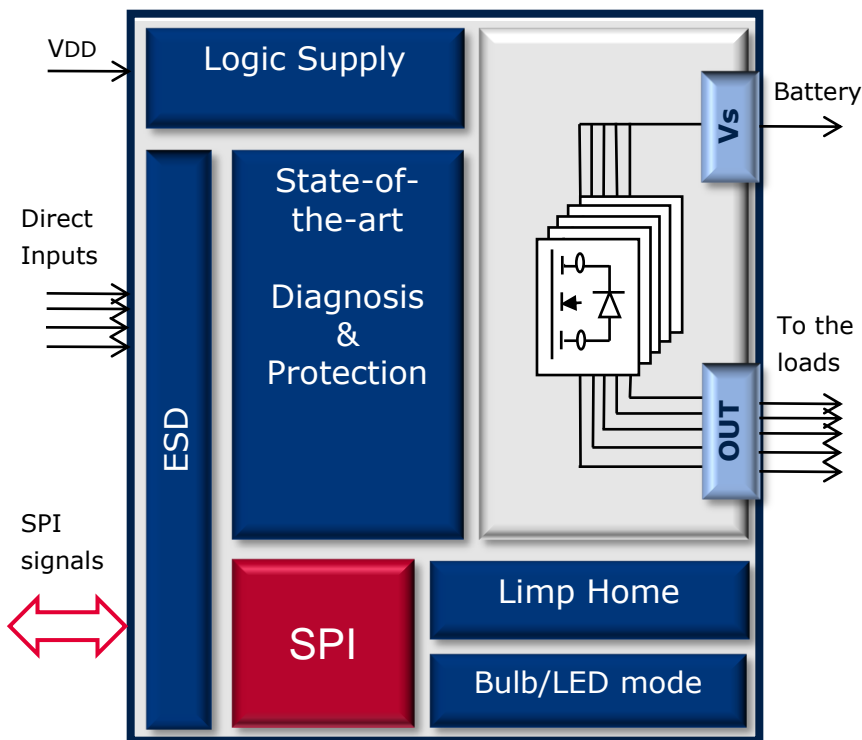
30%

11%



What is SPOC™ ?

SPOC = **S**PI **P**ower **C**ontroller

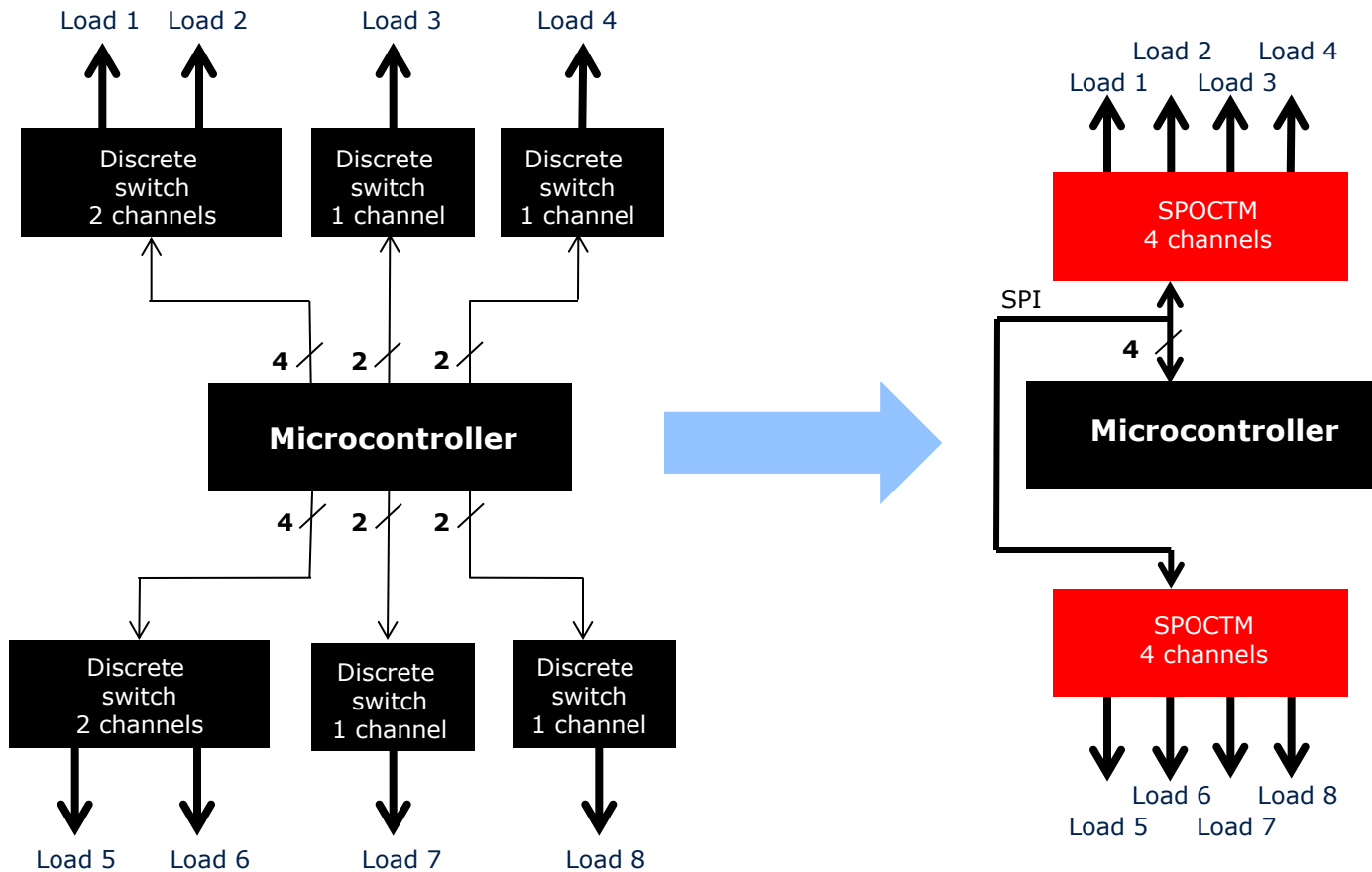


Simplified block diagramm

- SPOC stands for integrated Smart high-side switches, with control and diagnostics via SPI
- SPOC™ reduces costs on system level and brings new functionalities
 - ❑ Less I/O use from the MCU
 - ❑ Smaller PCB area
 - ❑ Diagnostics via SPI
 - ❑ Reduced Bill Of Material
 - ❑ Pre-tested “System on a chip”
 - ❑ Added logic features, e.g. limp home, LED mode

The control by SPI

Reducing the number of required GPIOs

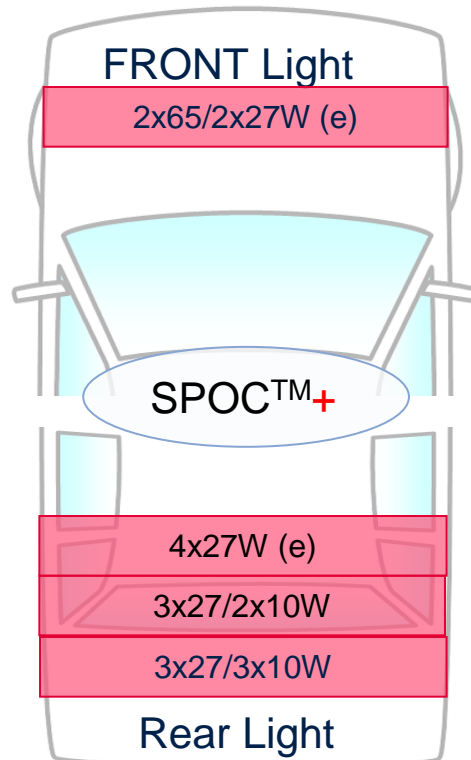


Discrete solution
16 GPIOs : 8 channel control + 8 diagnostic enable/select

SPOCTM solution
4 GPIOs : SPI pins

SPOC™+ fits all loads

Example : lighting



(e): optional external drive capability

- 6 devices in the portfolio
 - **PIN-PIN compatible**
 - **Same package**
 - **Same technology**
 - **Same diagnostics**
 - **Same SPI**
 - **Same Protection**
- Optional **external drive capability** for the 4-channel devices
- Optional **Lead Tip Inspection** devices
- **Small form factor** Exposed Pad package

4-channel products

| Product Name Without LTI | Product Name With LTI | "large" channels | "medium" channels | "small" channels | Ext.driver |
|--------------------------|-----------------------|------------------|-------------------|------------------|------------|
| BTS54220-LBA | BTS54220- LBB | 2x65W | 2x27W | 0 | no |
| BTS54220-LBE | BTS54220- LBF | 2x65W | 2x27W | 0 | yes |
| BTS54040-LBA | BTS54040- LBB | 0 | 4x27W | 0 | no |
| BTS54040-LBE | BTS54040- LBF | 0 | 4x27W | 0 | yes |

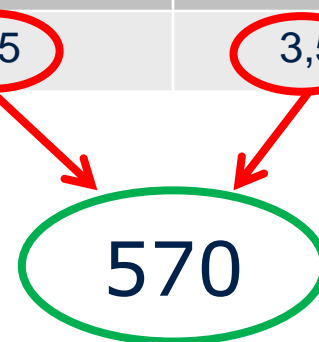
5 and 6-channels products

| Product Name Without LTI | Product Name With LTI | "large" channels | "medium" channels | "small" channels | Ext.driver |
|--------------------------|-----------------------|------------------|-------------------|------------------|------------|
| BTS55032-LBA | BTS55032- LBB | 0 | 3x27W | 2x10W | no |
| BTS56033-LBA | BTS56033- LBB | 0 | 3x27W | 3x10W | no |

SPOCTM+ channel overview

Main characteristics

| Feature | 65 W | 27 W (BTS54220) | 27 W (others) | 10 W |
|--------------------------|-------|--------------------|------------------|--------|
| RdsON | 9 mΩ | 27 mΩ | 39 mΩ | 110 mΩ |
| Max RdsON @ 150°C | 18 mΩ | 55 mΩ | 78 mΩ | 220 mΩ |
| Current limitation (min) | 66 A | 25 (32*) A | 25 A | 9 A |
| KILIS (typical) | 4500 | 2000 | 2000 | 1000 |
| LED mode available | No | Yes | Yes | No |
| LED mode factor | - | 3,5 | 3,5 | - |



Agenda

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- Infineon LED Drivers

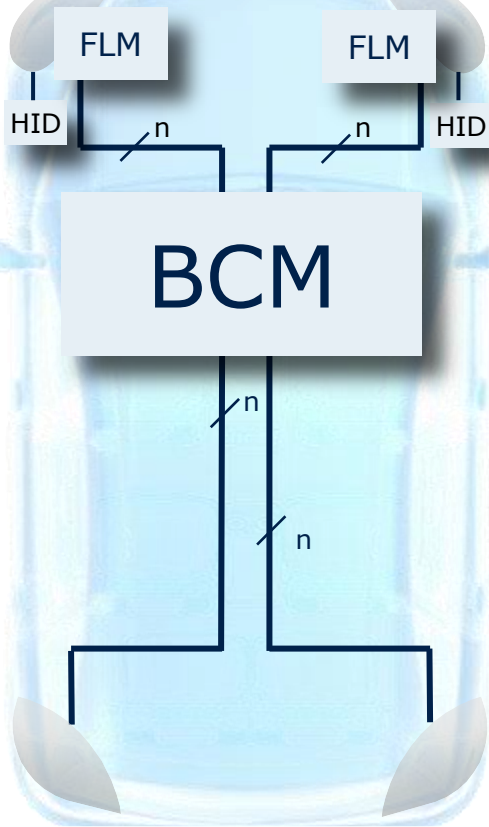
- **LED Lighting Architecture and Infineon's solutions**

- Future Trend LED Lighting

- Summary

The transition to LED will influence the Body Architecture for external lighting

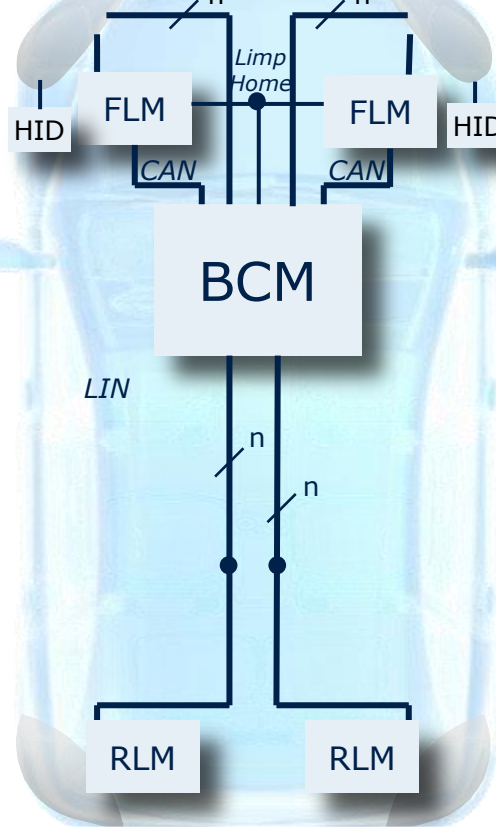
Centralized Architecture Today



LED as an option

e.g.
Front: HID + LED DTRL + bulb
turn indicator
Rear: bulb

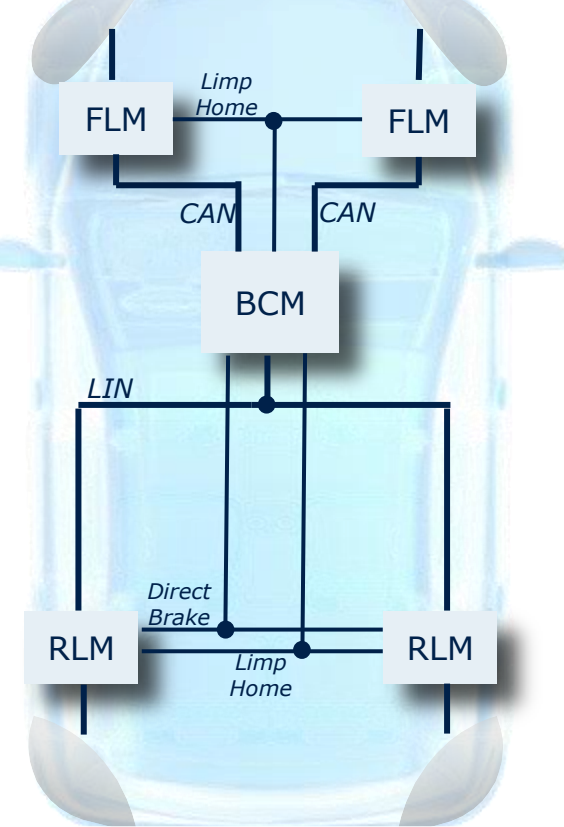
Partially Decentralized Architecture > 2012



LED-as an option

Front: HID + LED DTRL + bulb
turn indicator
Rear: Bulb+LED

Fully Decentralized Architecture > 2020

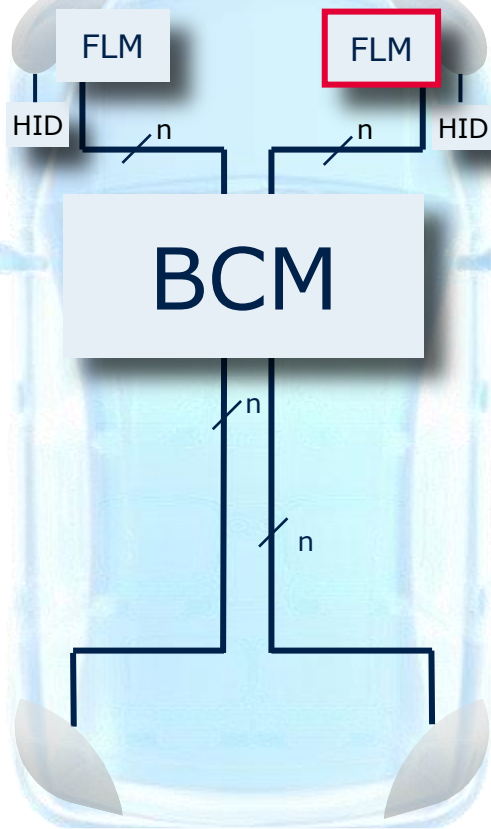


LED-only

Front: all functions in LED
Rear: all functions in LED

The transition to LED will influence the Body Architecture for external lighting

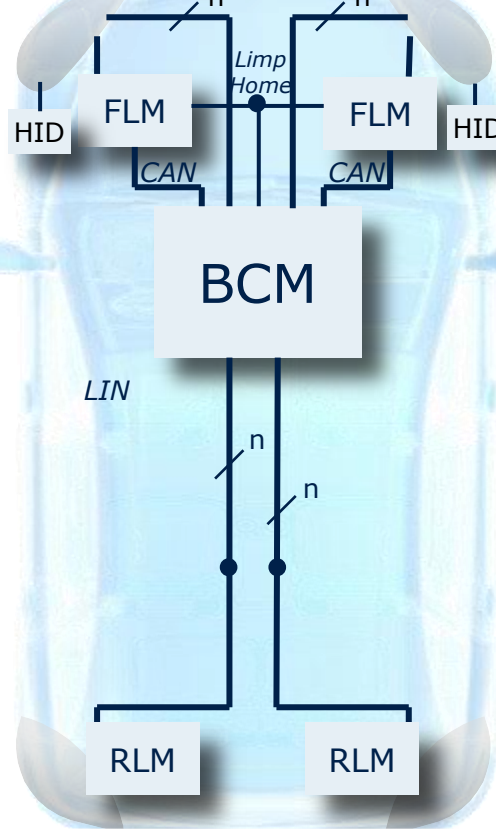
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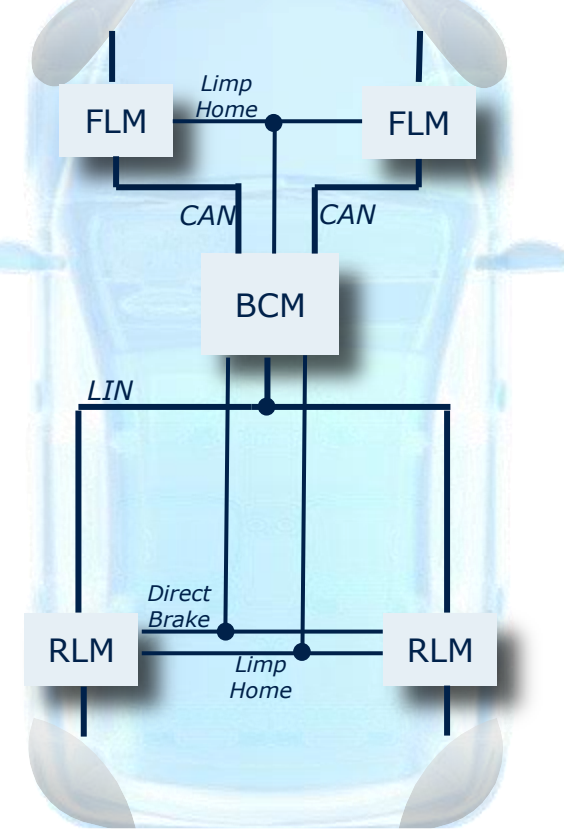
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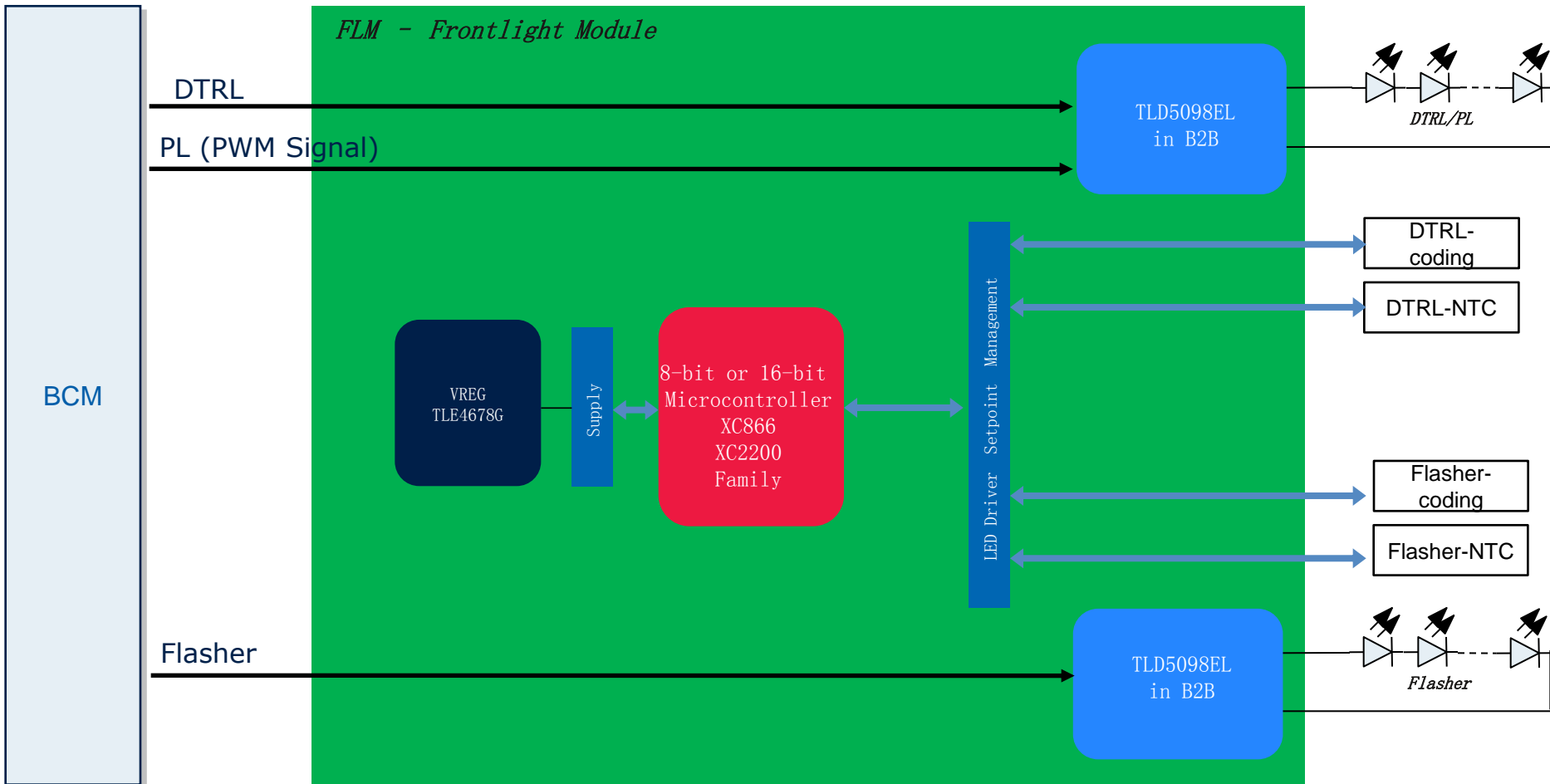
Fully Decentralized Architecture > 2020



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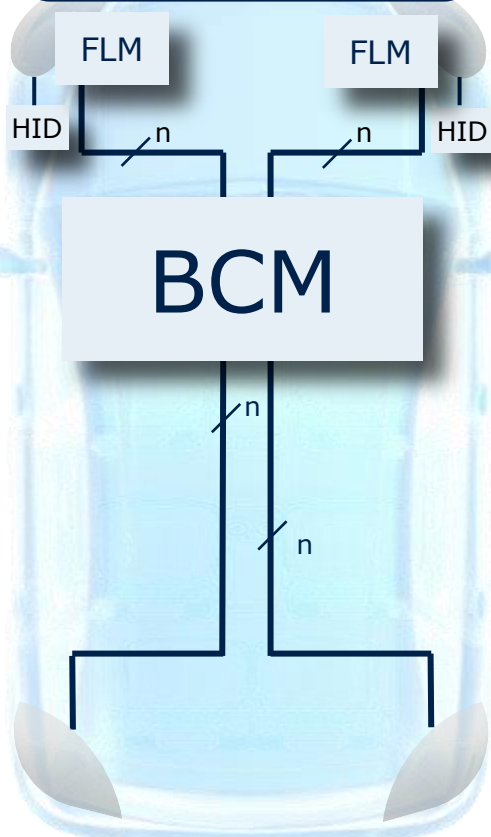
FLM used in central architecture today



**one switched supply line for each channel mandatory!
Parallel Interface!**

The transition to LED will influence the Body Architecture for external lighting

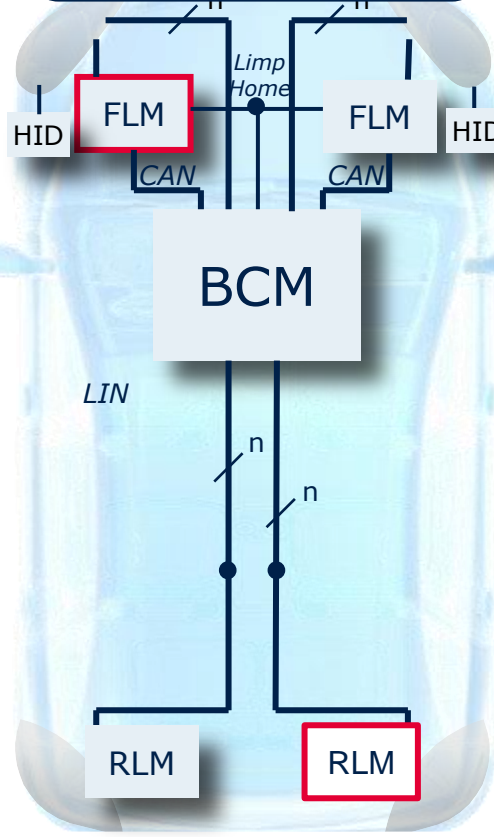
Centralized Architecture Today



LED as an option

e.g.
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turn indicator
Rear: bulb

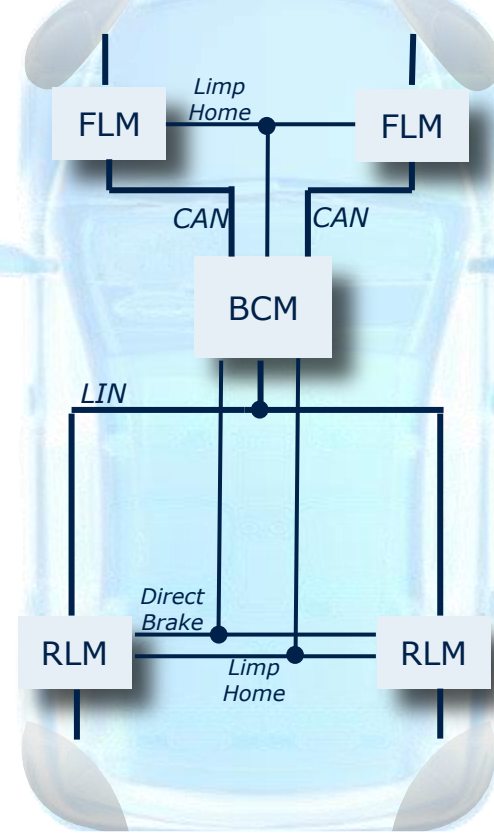
Partially Decentralized Architecture > 2012



LED-as an option

Front: HID + LED DTRL turn indicator + bulb
Rear: Bulb + LED

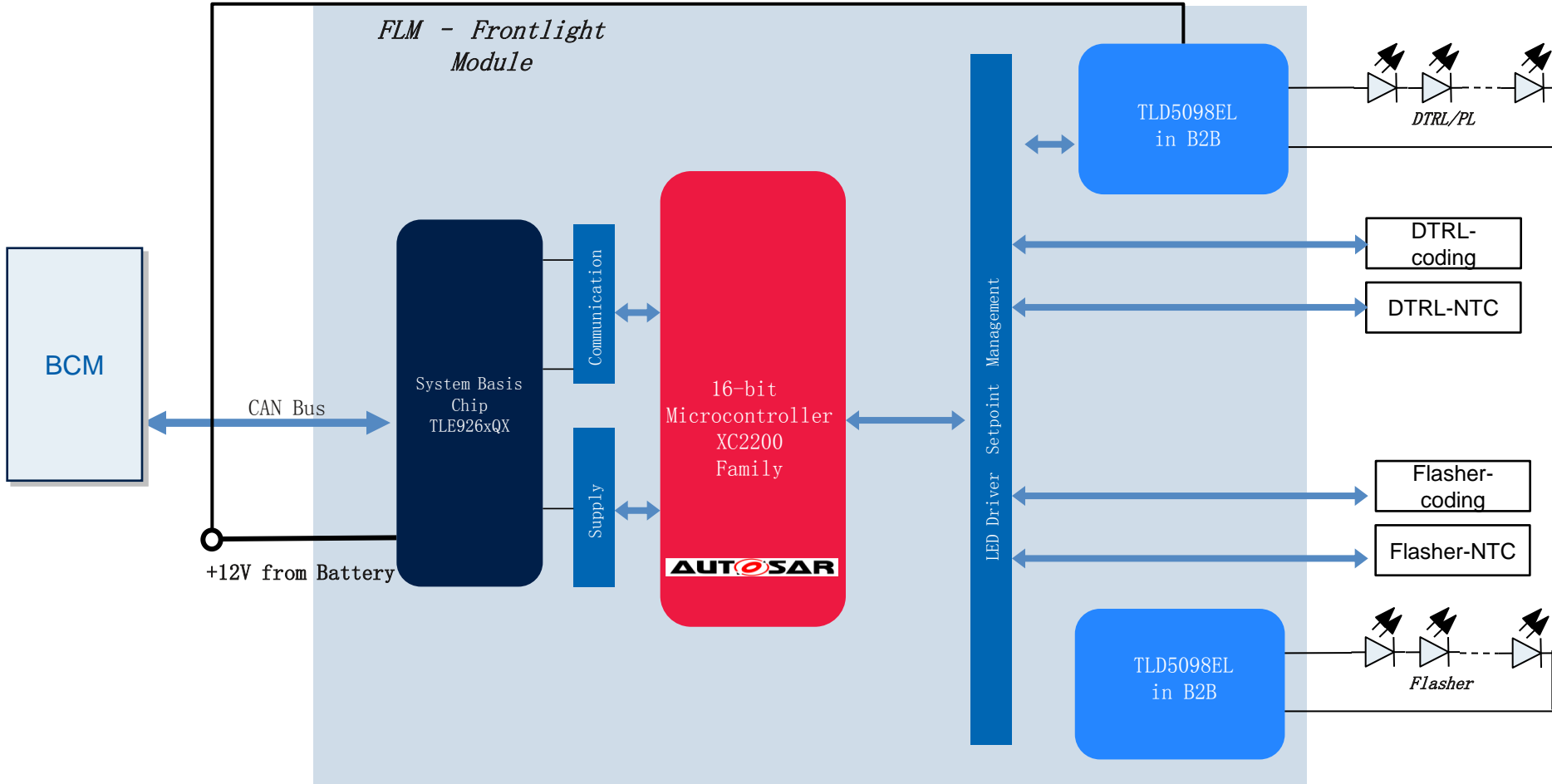
Fully Decentralized Architecture > 2020



LED-only

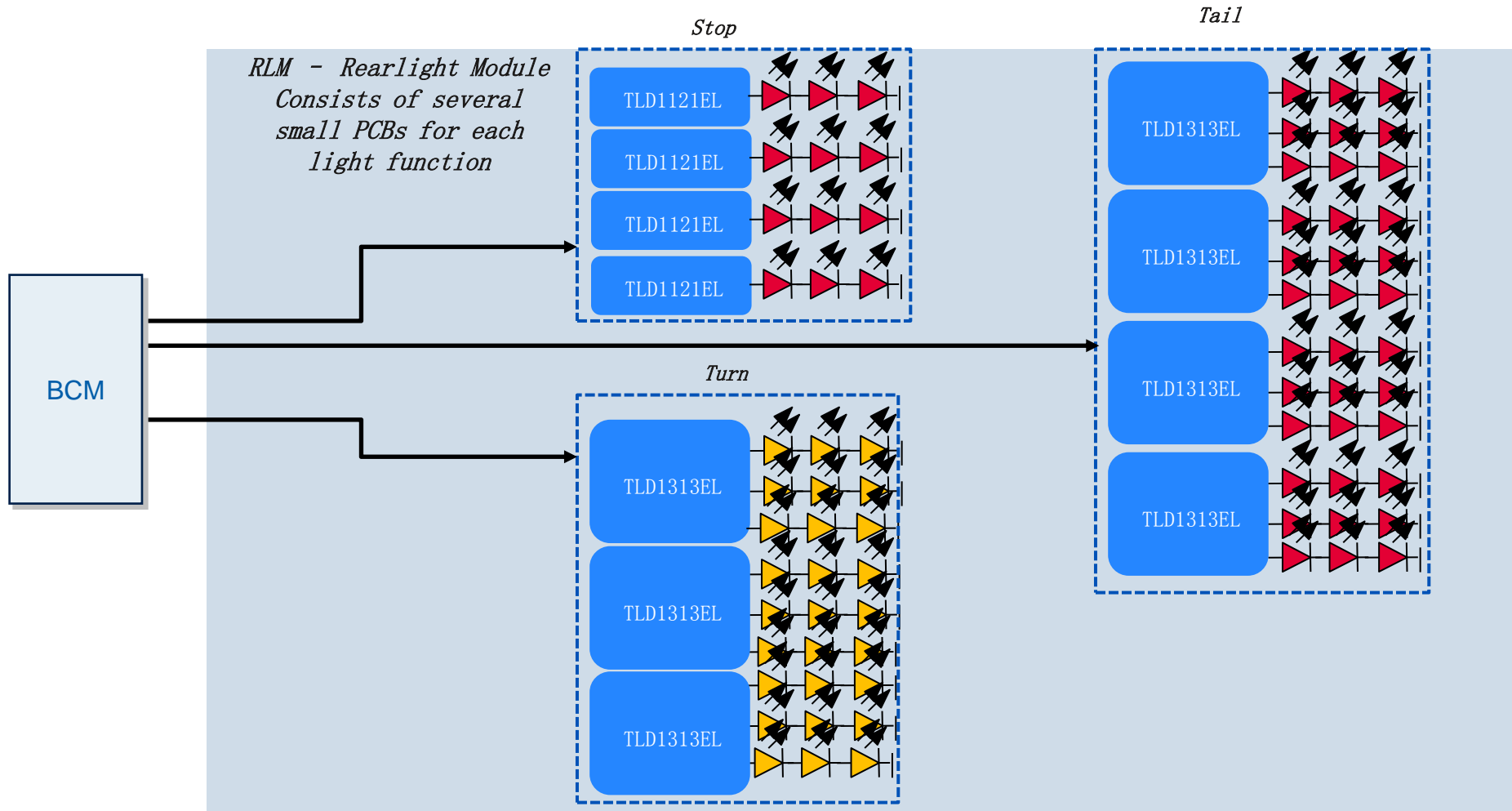
Front: all functions in LED
Rear: all functions in LED

FLM used in partially decentral architecture today



CAN Communication between BCM and FLM

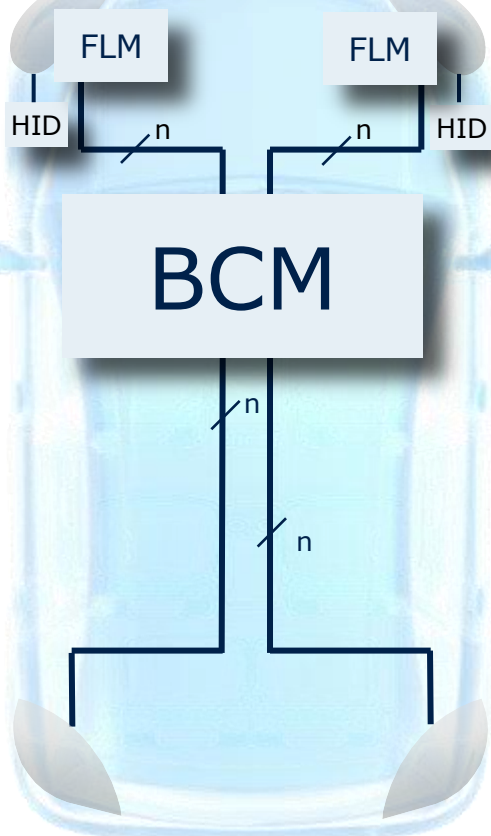
RLM used in partially decentral architecture today



**One switched supply line per light function
Each light functions uses several Basic LED driver**

The transition to LED will influence the Body Architecture for external lighting

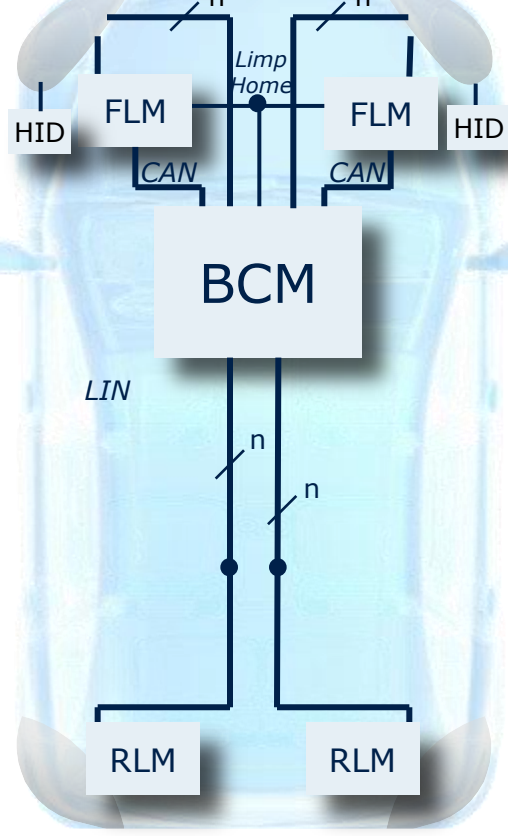
Centralized Architecture Today



LED as an option

e.g.
 Front: HID + LED DTRL + bulb
 turn indicator
 Rear: bulb

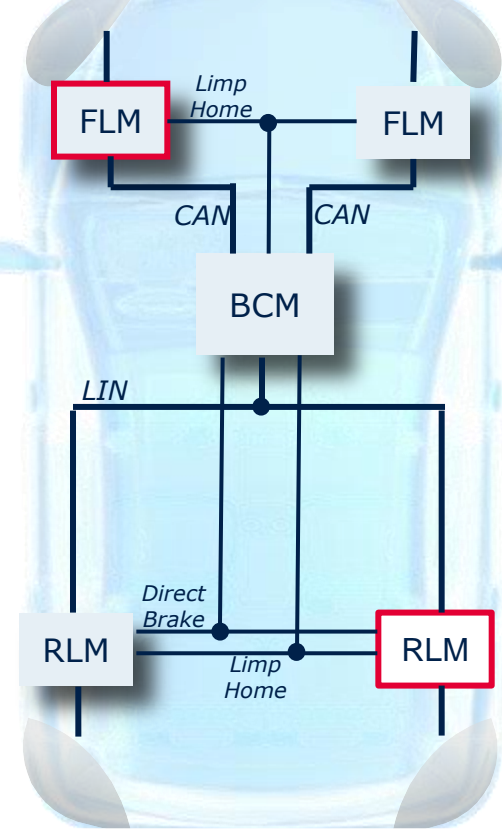
Partially Decentralized Architecture > 2012



LED-as an option

Front: HID + LED DTRL turn
 indicator + bulb
 Rear: Bulb + LED

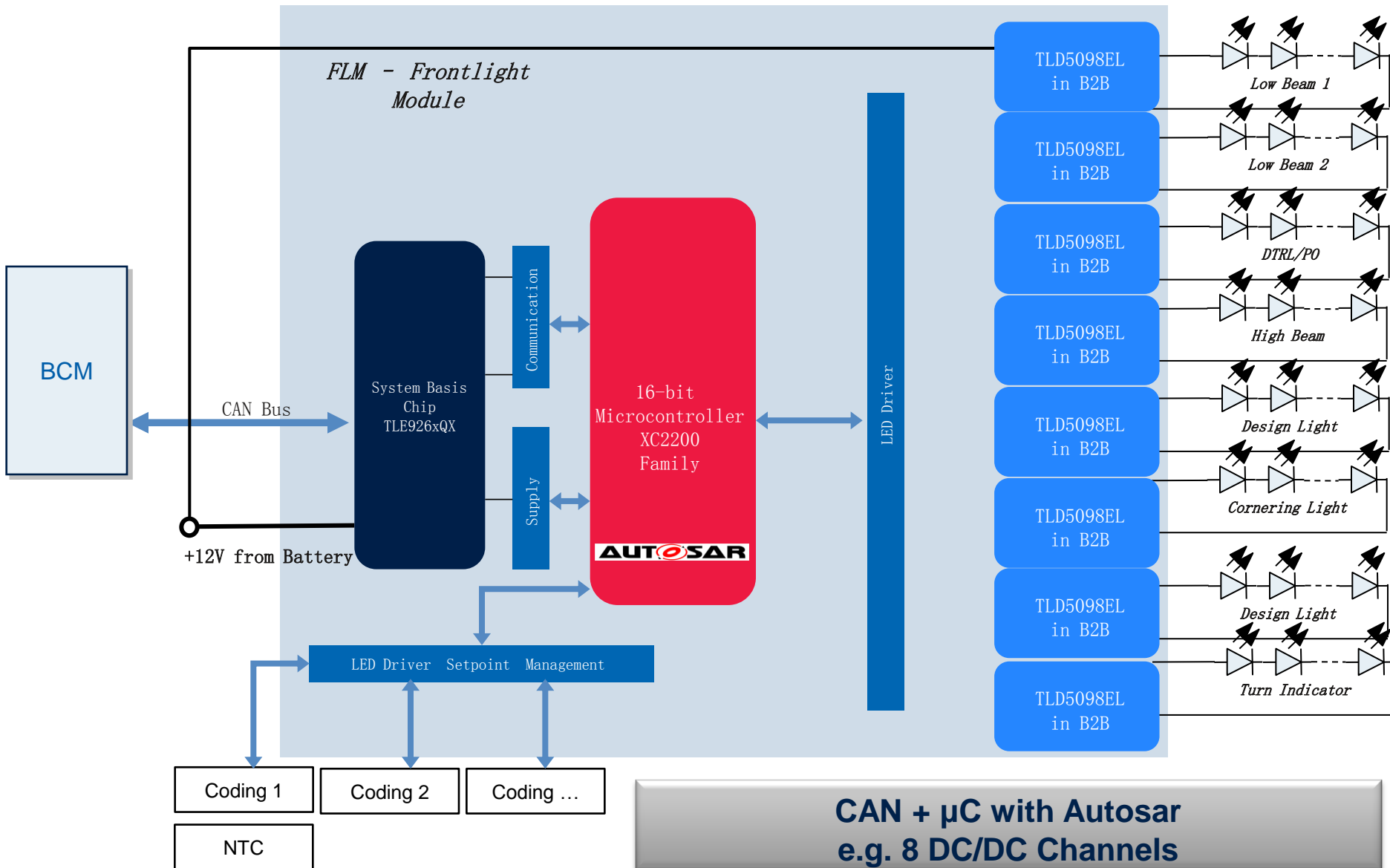
Fully Decentralized Architecture > 2020



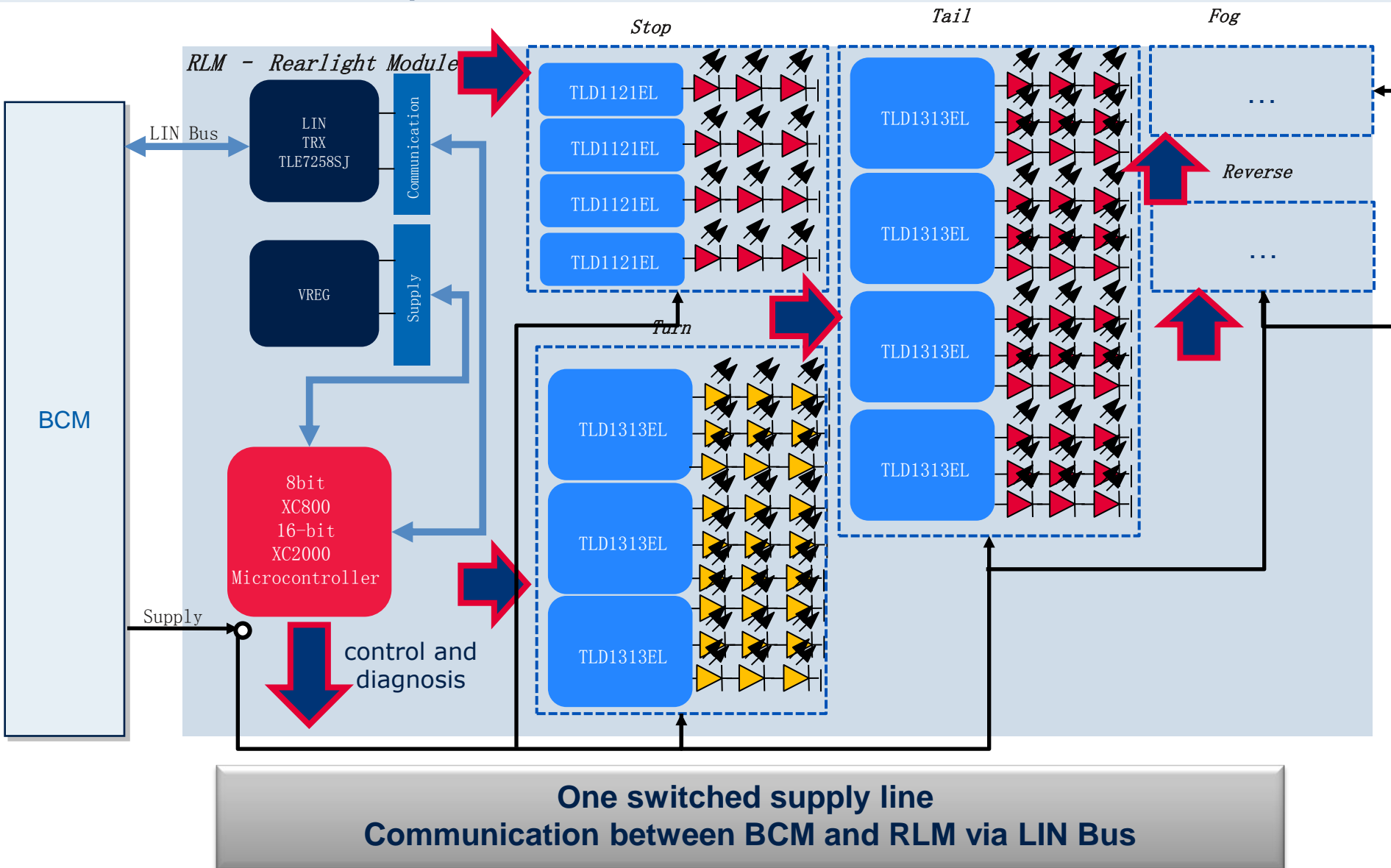
LED-only

Front: all functions in LED
 Rear: all functions in LED

FLM used in fully decentral architecture



RLM used in fully decentral architecture



Agenda

- Introduction
- Infineon LED Drivers
- LED Lighting Architecture and Infineon's solutions
- **Future Trend LED Lighting**
- Summary

Future Trend LED Lighting



Source: AUDI AG



Source: AUDI AG

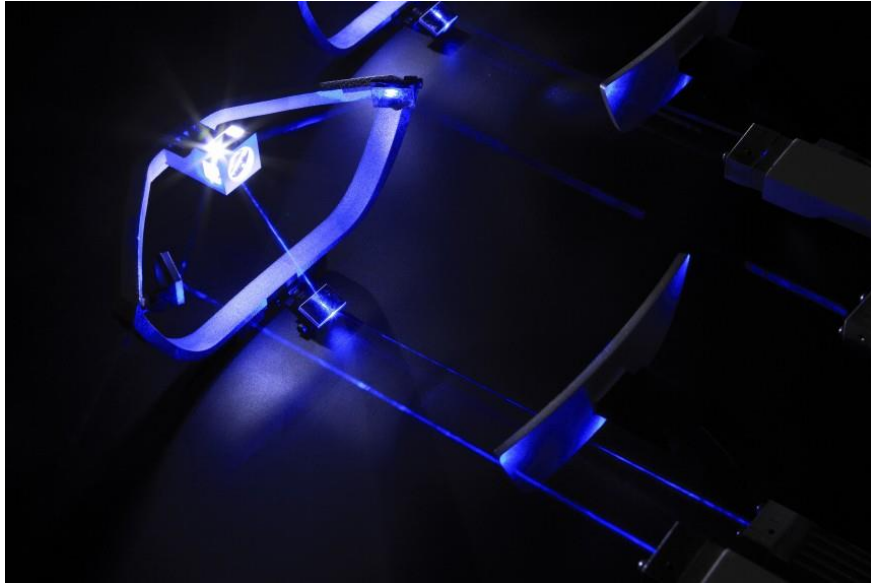


Source: AUDI AG

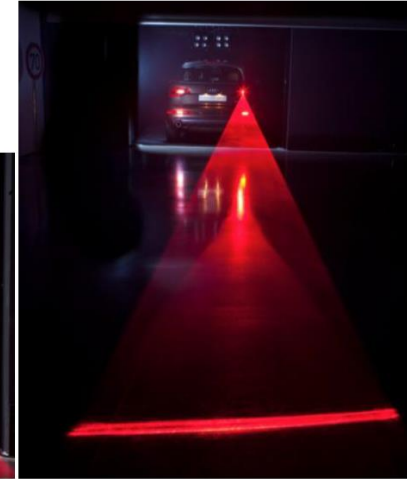


Source: AUDI AG /
R8

Future Trend Laserdiode



Source: BMW



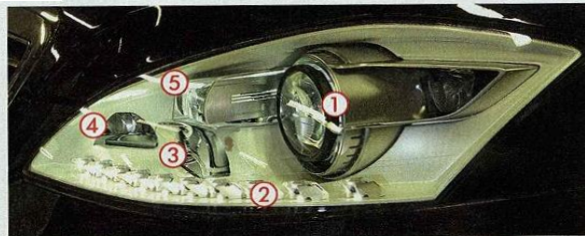
Source: AUDI AG

- Blue or UV lasers are used in combination with phosphor to convert blue into white light
- Some video projectors use laser light already, they have 5000cd, for **ATV 65000cd are required!**
 - still a long way to go!
- Luminance can be 5x higher than for LED
- Headlamps with only 10mm height should be possible with lasers new design possibilities and less size requirements!

Disadvantages:

- Drift of efficiency and color over (junction) temperature
- Lifetime in the moment 3000...10000h
- Efficiency today only 40lm/W, LED 100lm/W
- High cost

Future Trend Pixel Light



Im Mercedes-Scheinwerfer gibt es fünf Lichtquellen ① Abblend- und Fernlicht ② Blinker und Tagfahrlicht ③ zusätzlicher Fernlichtspot ④ Abbiegelicht ⑤ Basislicht



Volles Fernlicht, die 96 LED im Mercedes-Scheinwerfer leuchten bis zu 300 Meter weit



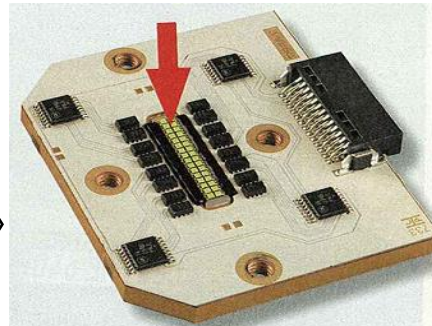
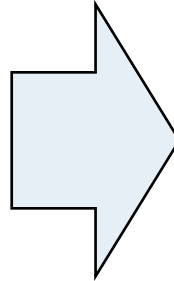
Typische Abblendlicht-Verteilung, die beim Prototyp noch einzelne Pixel zeigt



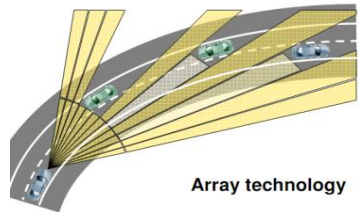
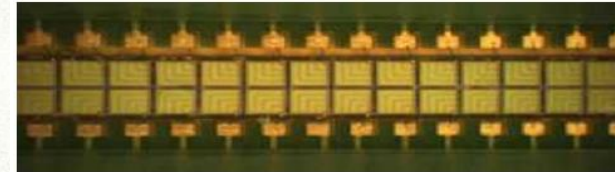
Eine Kamera erkennt entgegenkommende Autos, die durch Abschalten einzelner LED aus dem Lichtkegel ausgeblendet werden



Gefahrenquellen am Straßenrand wie Wildtiere sollen mit einzelnen Pixelspots gezielt angeleuchtet werden



Das Leuchtmittel der Zukunft sieht ungewöhnlich aus. Audi setzt im Prototyp auf 32 LED (Pfeil), die mit nur einem Millimeter Kantenlänge sehr klein ausfallen, aber schon heute fast so hell strahlen wie Xenon-Brenner



Array technology



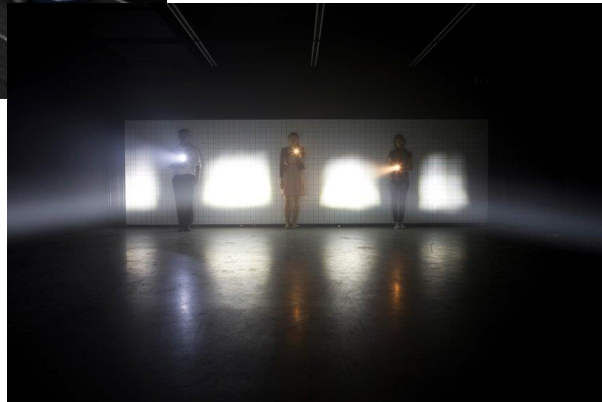
Glare-free high beam - oncoming traffic

Source: Internet

New Advanced Headlight Glare-Free High Beam



Masking other cars



*Illuminating Obstacles
On The Road*

*AUDI A8 Matrix Beam
MY2014*

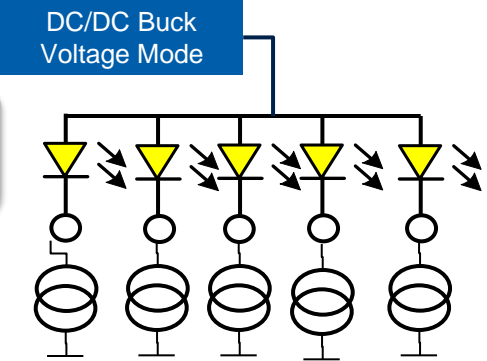


- [2014 奥迪 Audi A8 矩阵大灯解析 Matrix LED headlights](#)

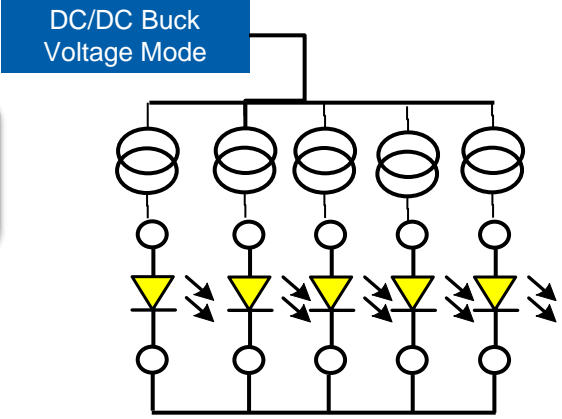
Pixel Light

3 Realization Methods/Topologies are seen at the moment

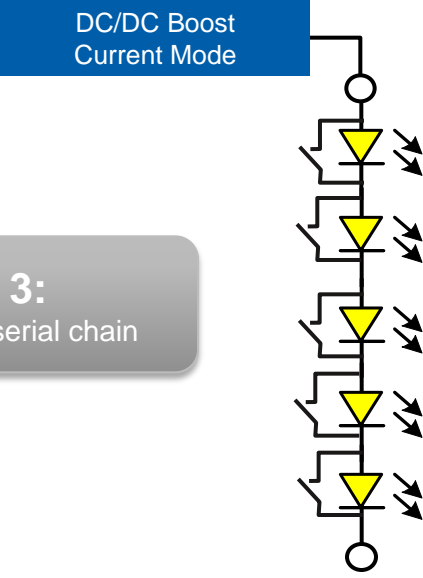
Solution 1:
Common Anode LED
Modules



Solution 2:
discrete LEDs
(usually common
Cathode)



Solution 3:
discrete LEDs in a serial chain



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'Enforcers' of the transition towards LED:

- Greater Styling and Branding Opportunities
- New light functions like pixellight or wiping indicators
- Decreased Fuel Consumption / CO₂ Emission Discussion
- Smaller Packaging
- Safety Considerations
- Increased Lifetime

'Preventers' of a fast transition towards LED:

- High Cost
- Platform approach of OEM's
- Still many technical challenges to be overcome
 - Binning and consistency of LED light emission
 - Complex heat dissipating assembly
 - Repair replacement costs
- Slow Pace of Regulatory Change

The benefit of smart LED driver

- **Achieve Constant Brightness Independent from the Battery Voltage**
- **Prevent the LED from Damage in case of Overvoltage Condition**
- **Detect and diagnose open loads**
- **Save system costs and PCB area by integrating features**
- **Protect against short circuits**
- **Improve the Electromagnetic Compatibility (EMC) with a Linear Constant Current Source**

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