Infineon® Auto LED Lighting

Product & Application Overview

Automotive - Body Power

http://www.infineon.com/automotive-leddrivers

Overview

LED Trends

LED Driving Concepts

Influence on the Light Architecture

Detailed Product Description

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The Drivers for the Automotive LED Market

Today – Design & Functionality

Tomorrow – Design & Functionality & Energy Efficiency

Overview

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Detailed Product Description

Generic LED Driving Concept I
Exterior Light Module with Simple Series Resistor

Applications:

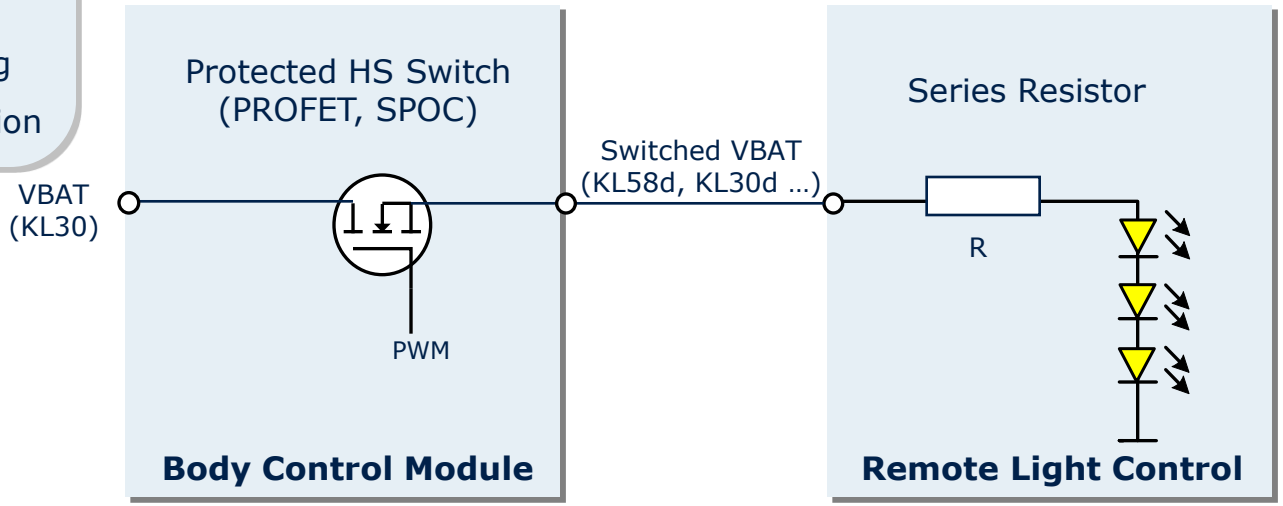
Rear Lighting

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:

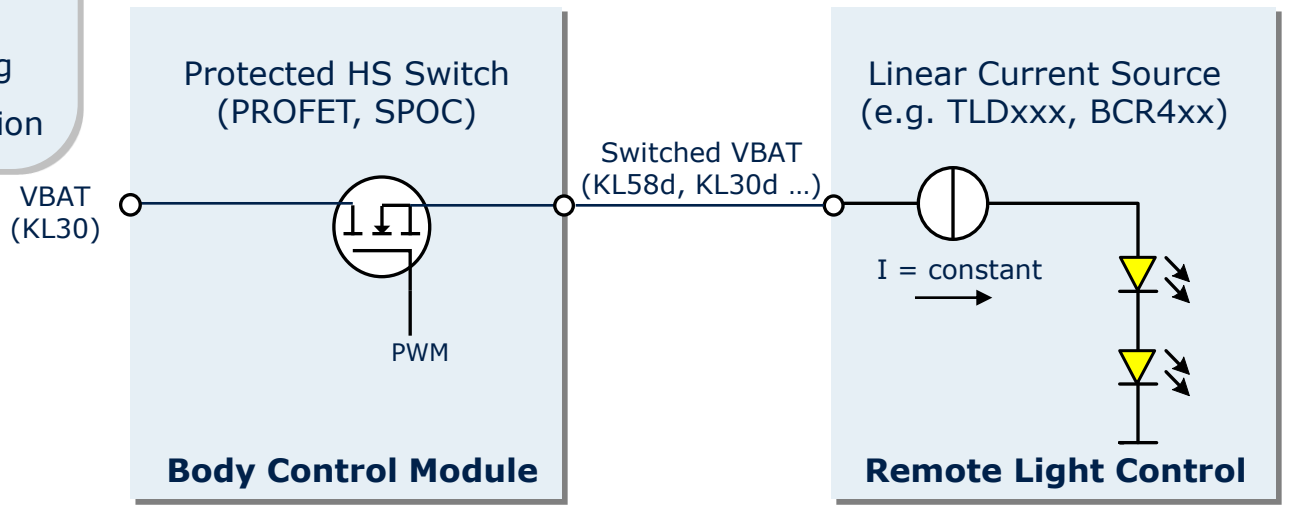
Rear Lighting

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

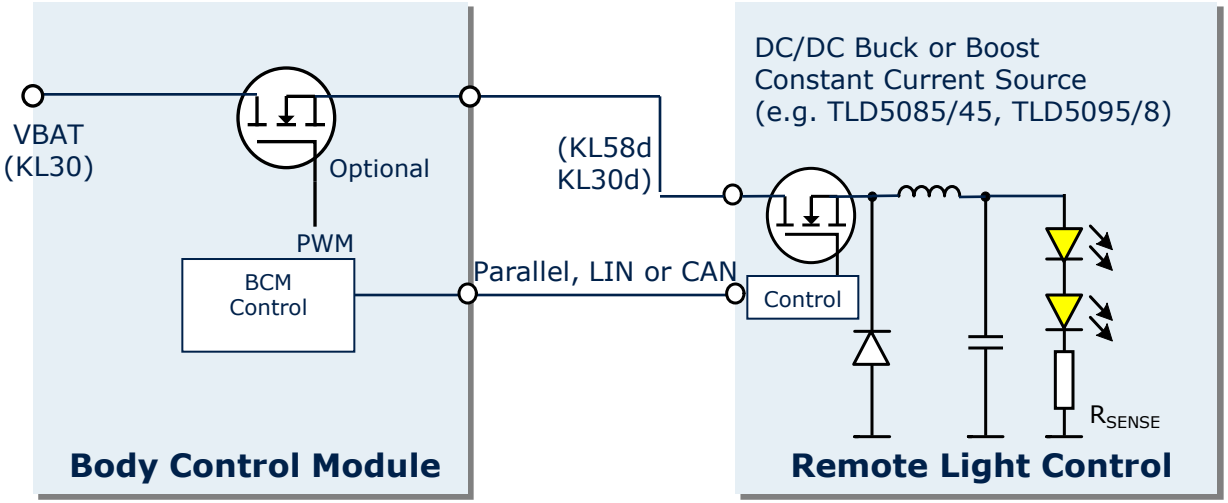
Applications:

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

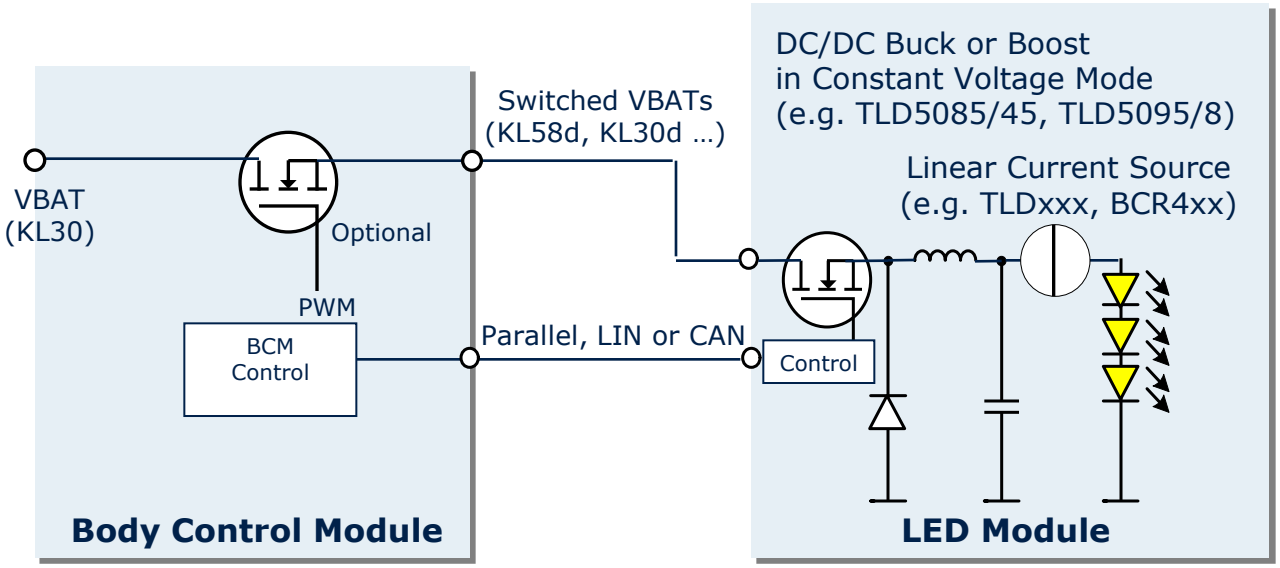
Applications:

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

Overview

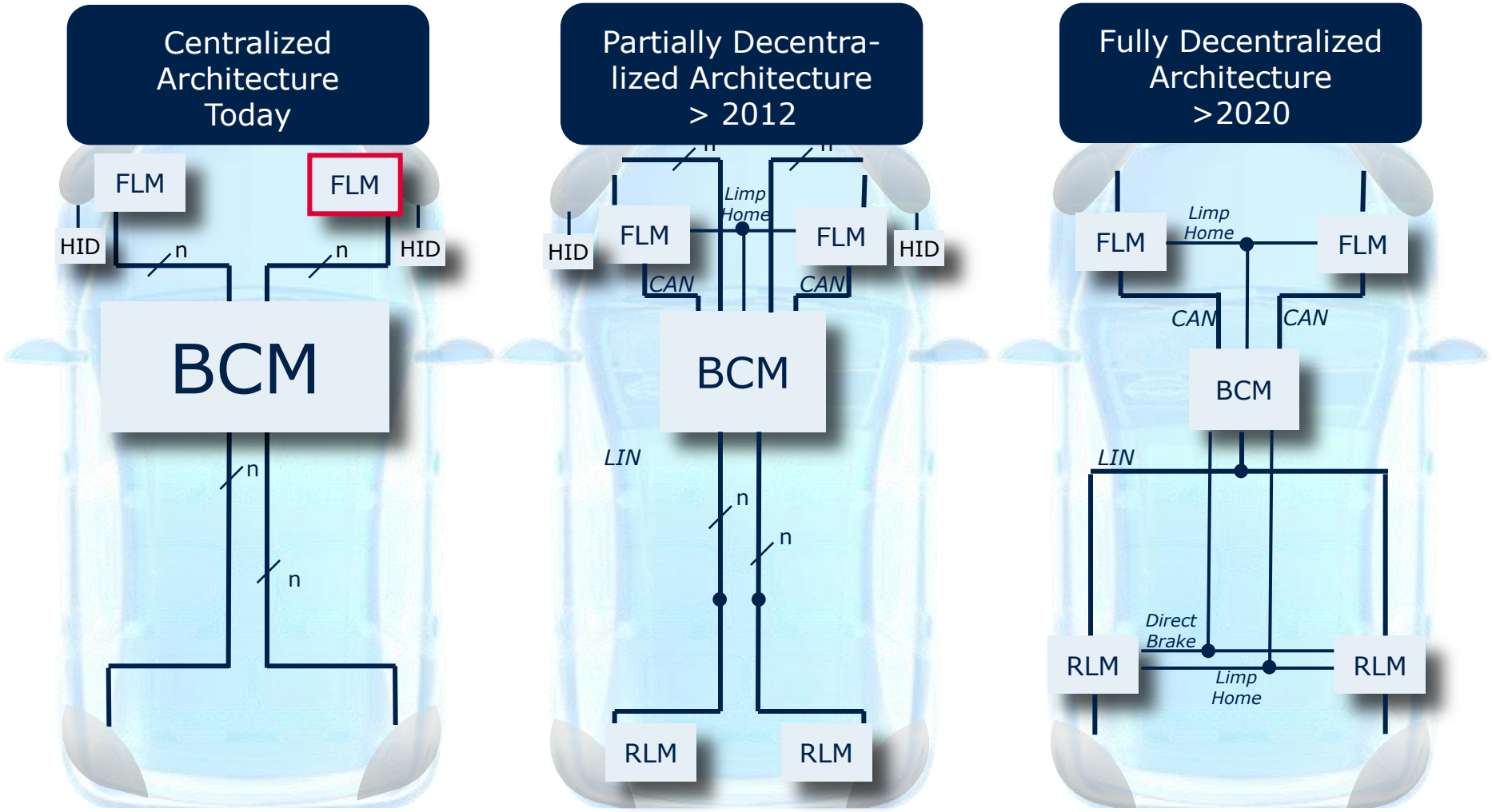
LED Trends

LED Driving Concepts

Influence on the Light Architecture

Detailed Product Description

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

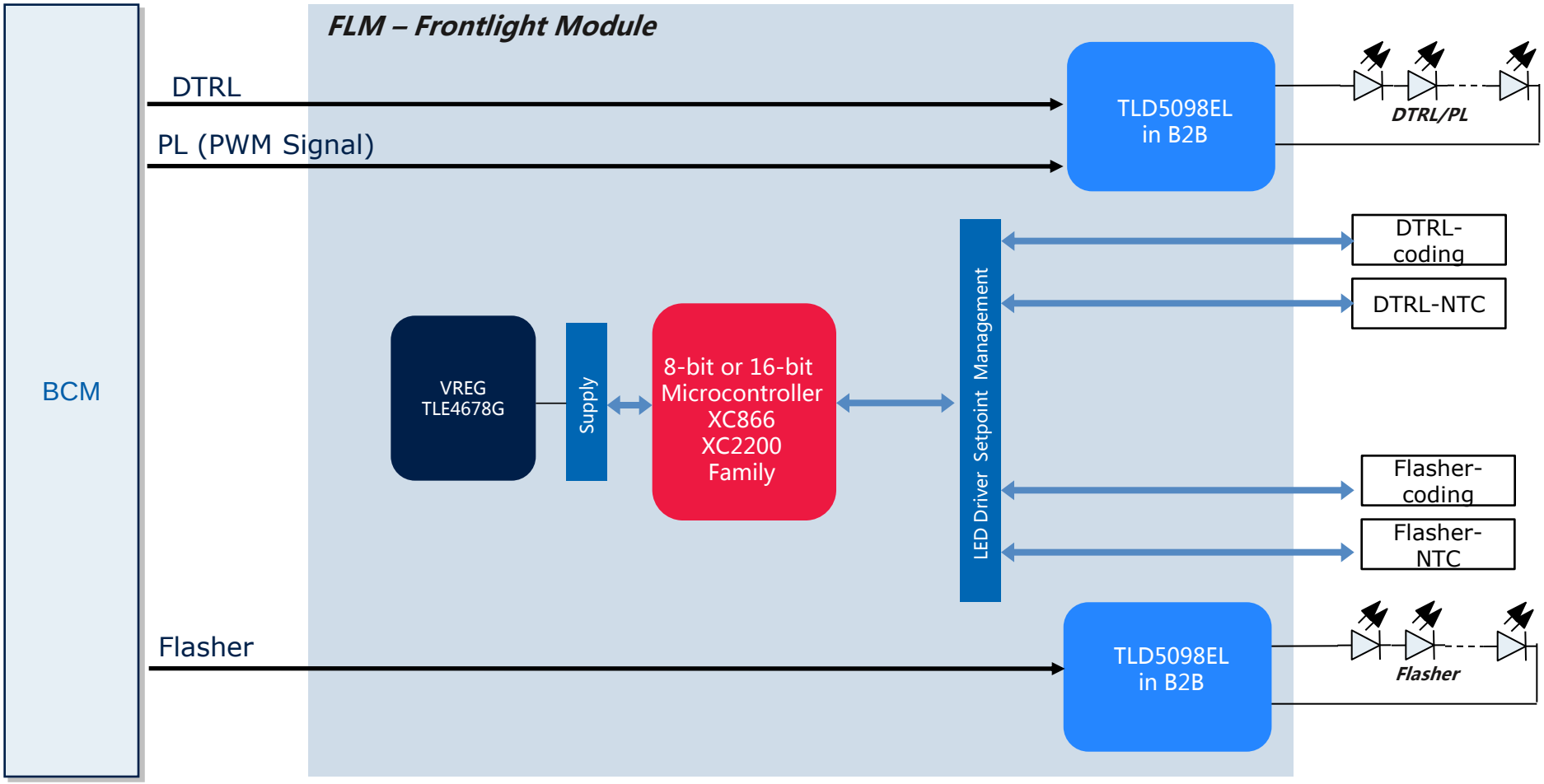


LED as an option
e.g.
Front: HID + LED DTRL + bulb
turn indicator
Rear: bulb

LED-as an option
Front: HID + LED DTRL + bulb
turn indicator
Rear: Bulb+LED

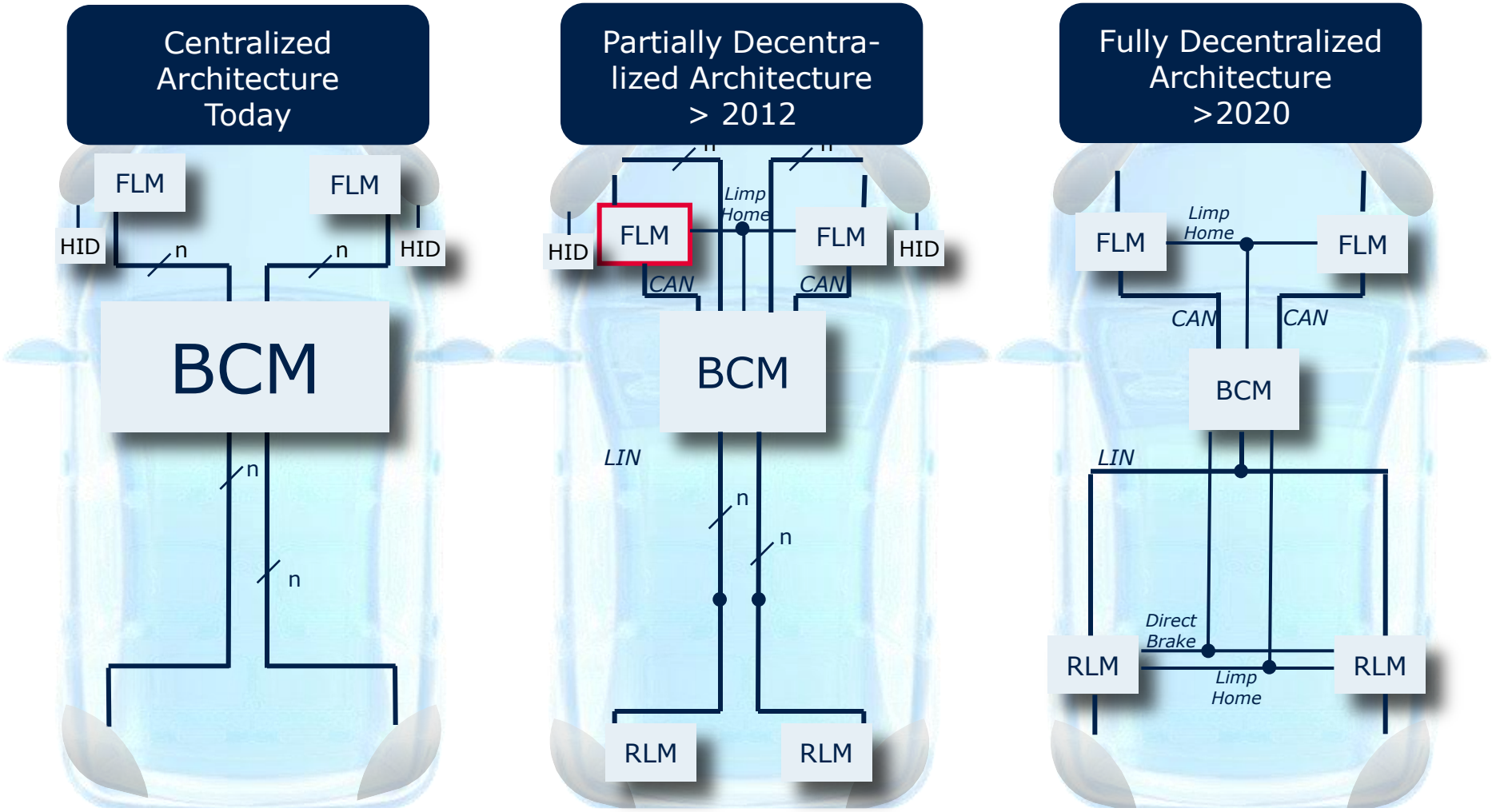
LED-only
Front: all functions in LED
Rear: all functions in LED

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



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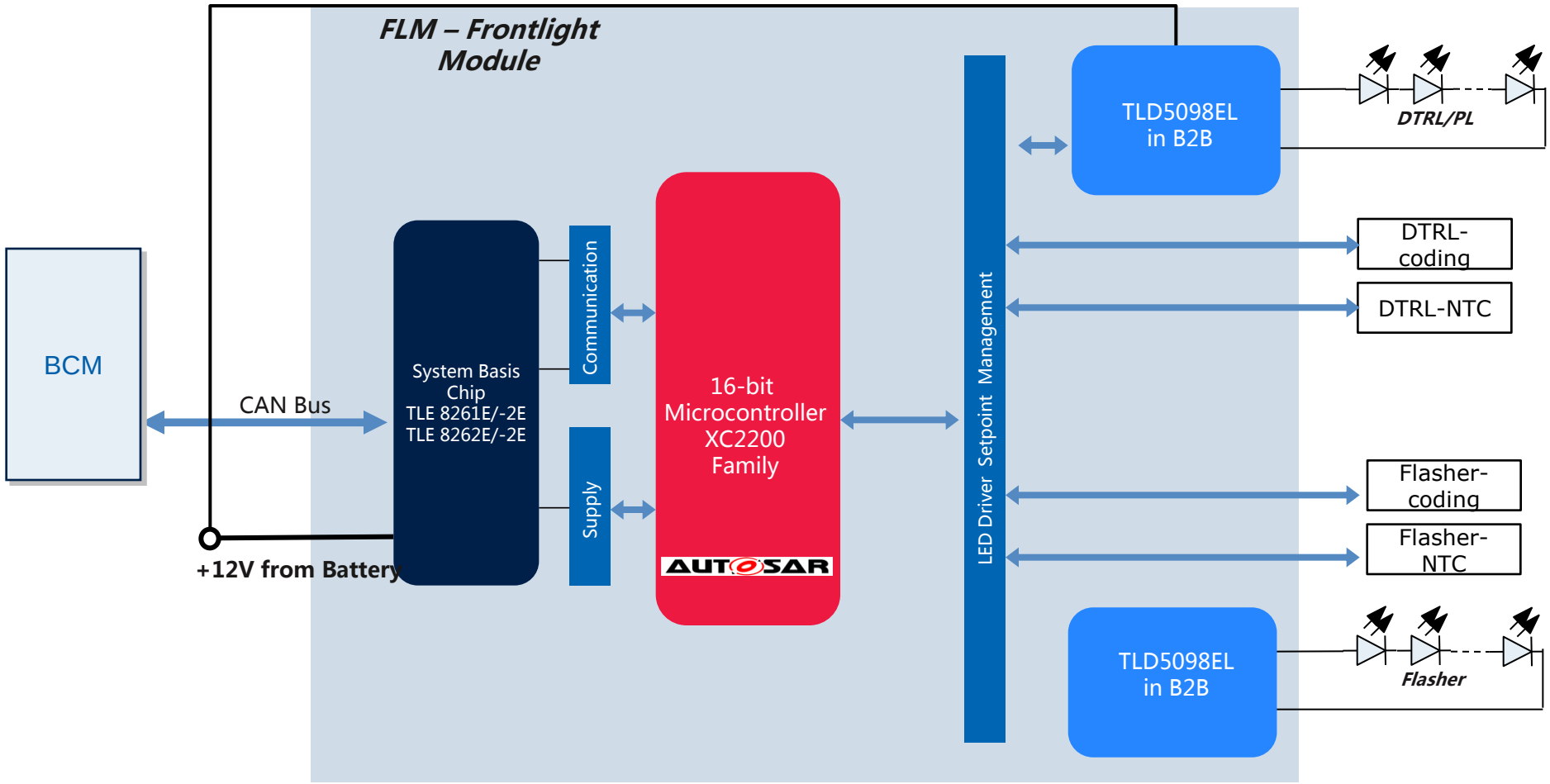
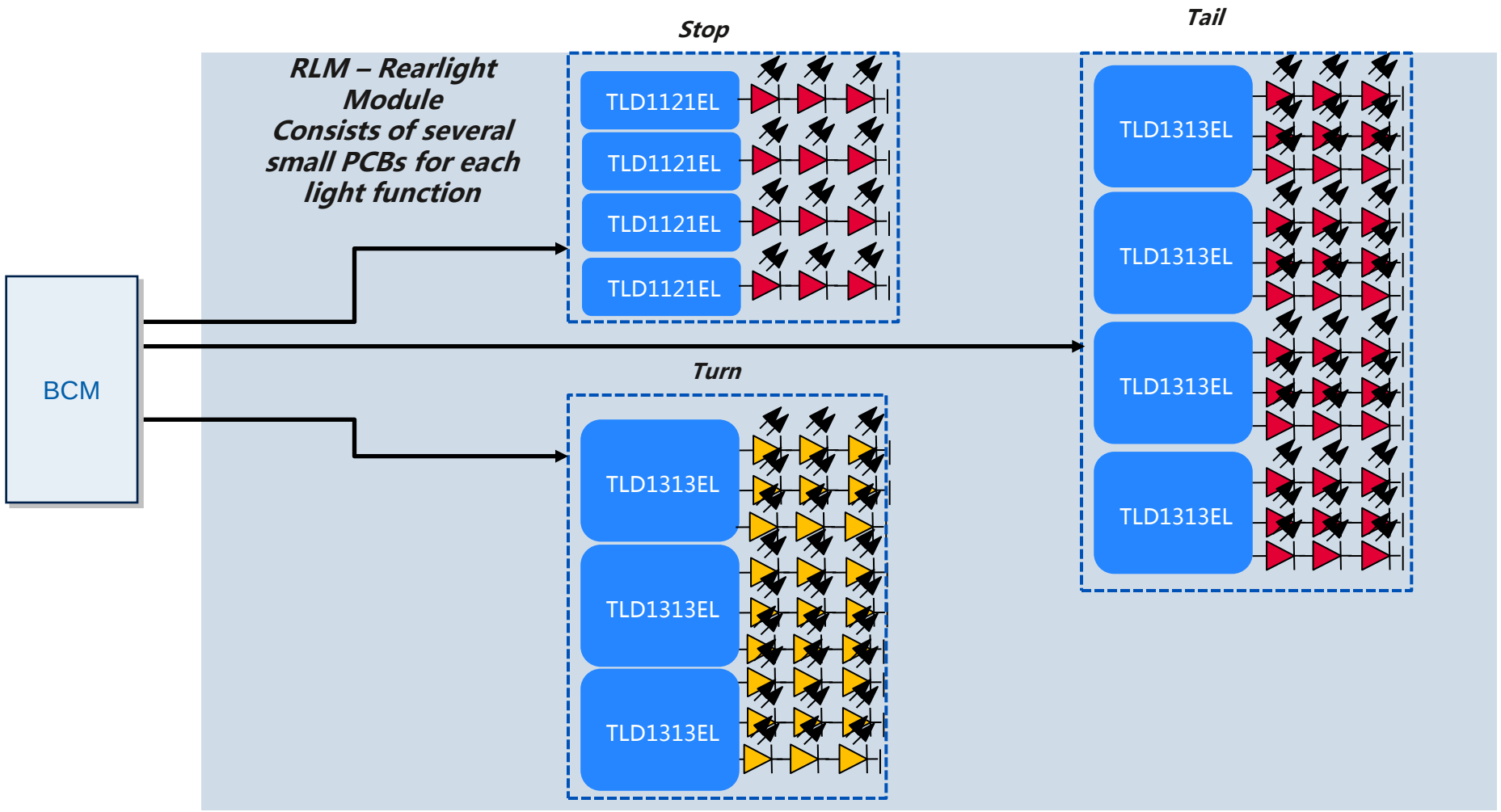
FLM used in partially decentral architecture today



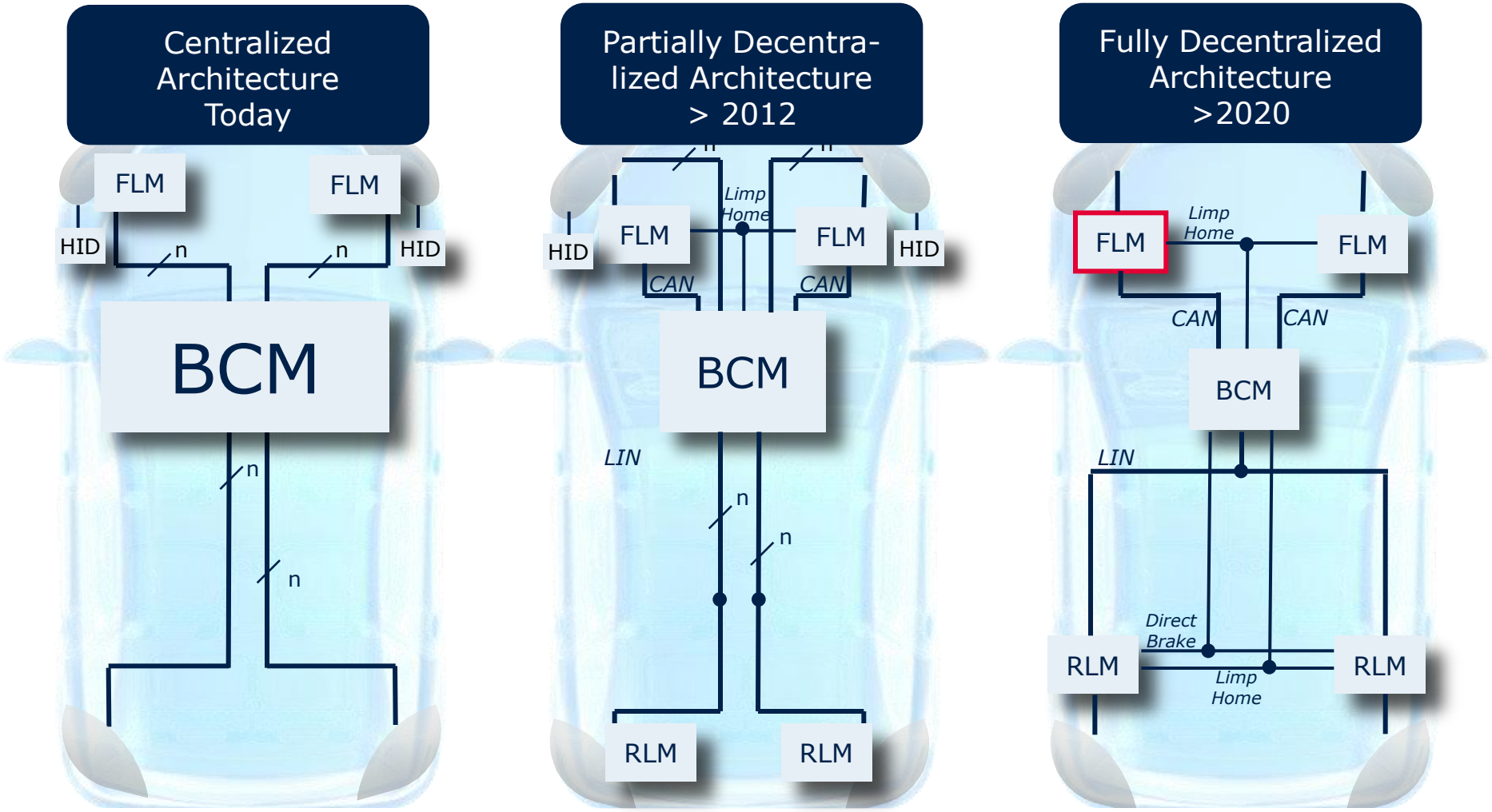
CAN Communication between BCM and FLM

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



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LED-as an option
Front: HID + LED DTRL turn indicator + bulb
Rear: Bulb + LED

LED-only
Front: all functions in LED
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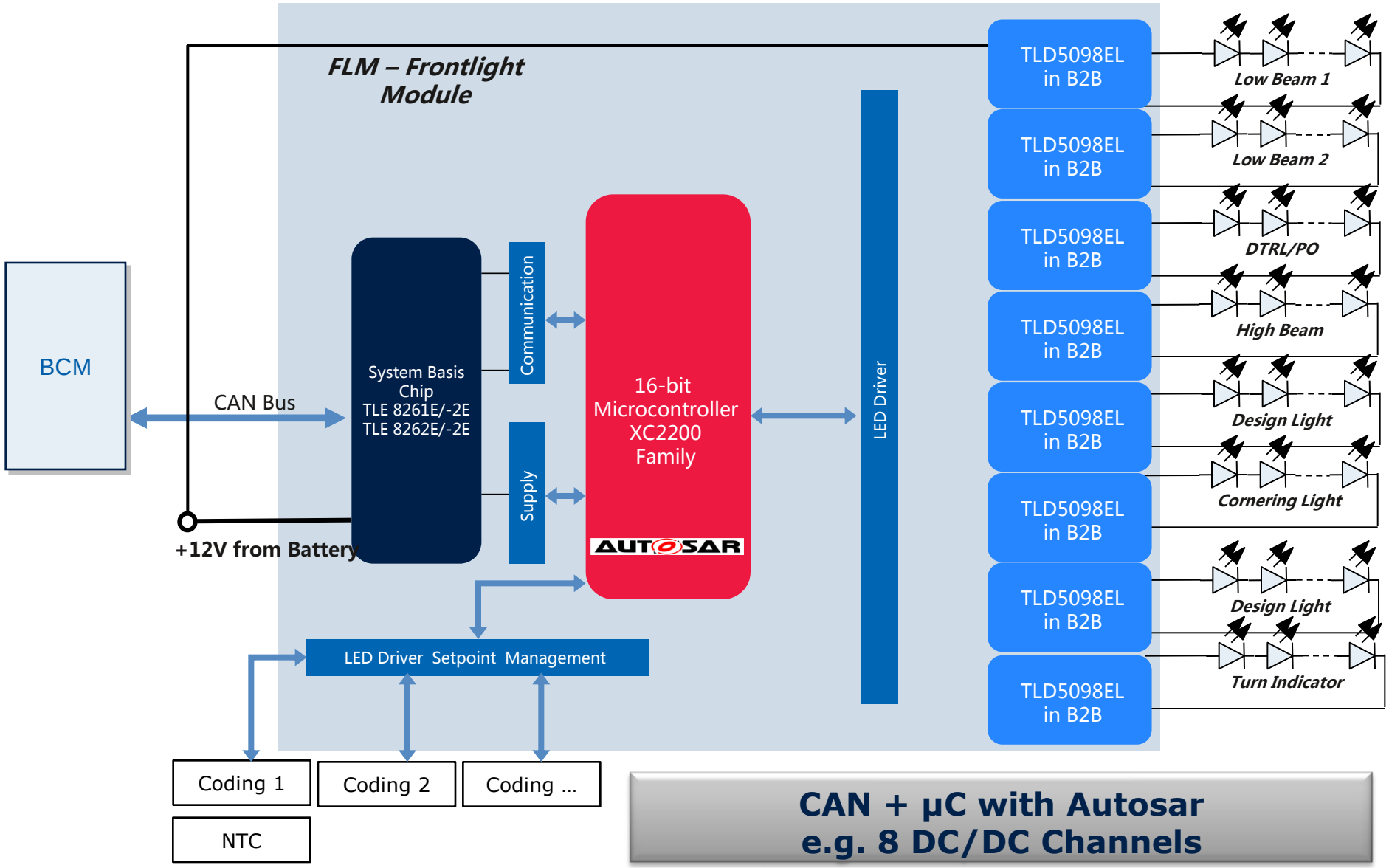
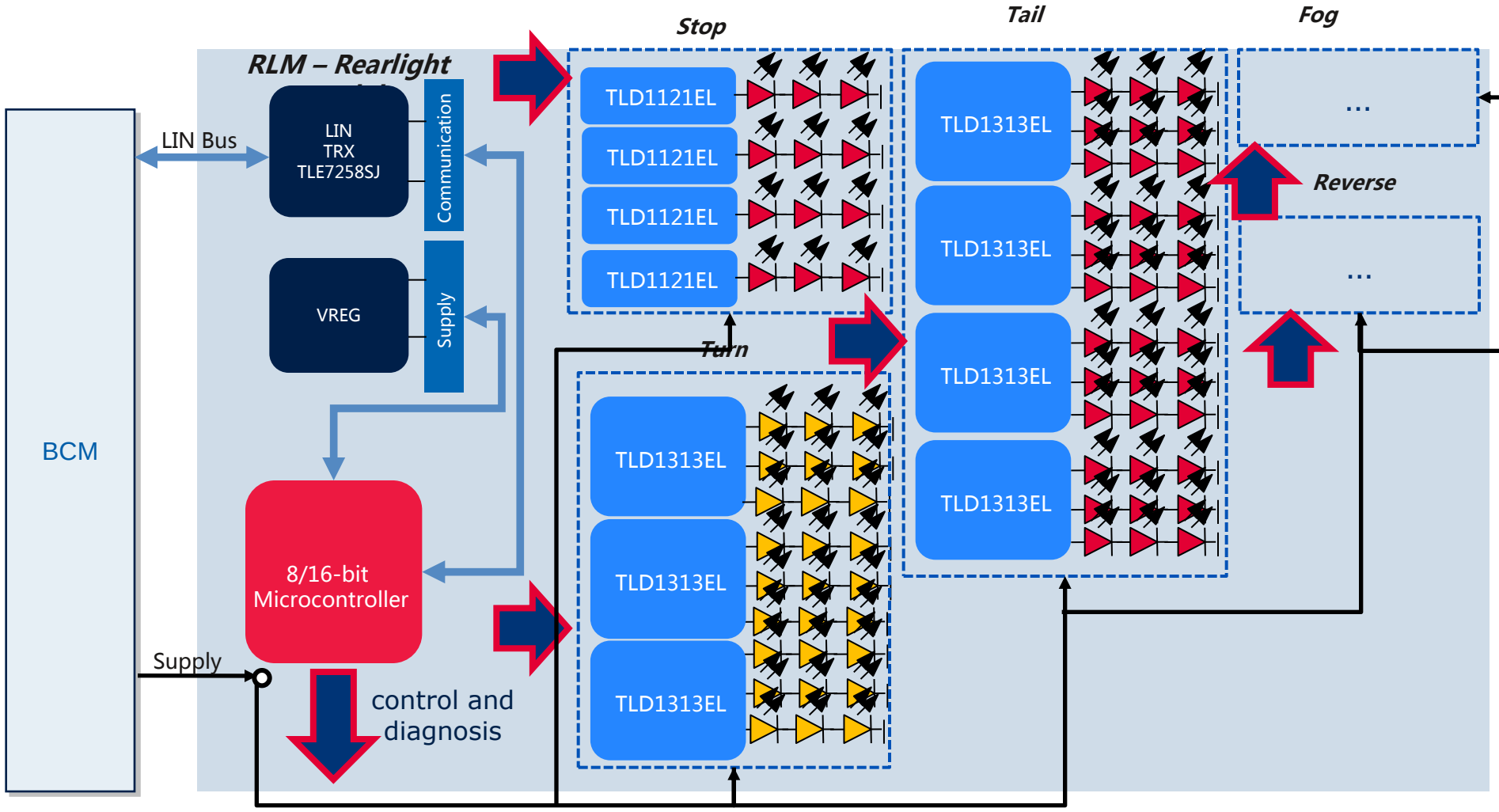
FLM used in fully decentral architecture



CAN + µC with Autosar
e.g. 8 DC/DC Channels

RLM used in fully decentral architecture



One switched supply line
Communication between BCM and RLM via LIN Bus

Overview

LED Trends

LED Driving Concepts

Influence on the Light Architecture

Detailed Product Description

Target Applications for Infineon® Auto LED Driver

Frontlighting

DTRL with discrete LEDs

DTRL with Lightguide

Energy Efficient DTRL with one LED

Full LED headlamp

Glare Free High Beam

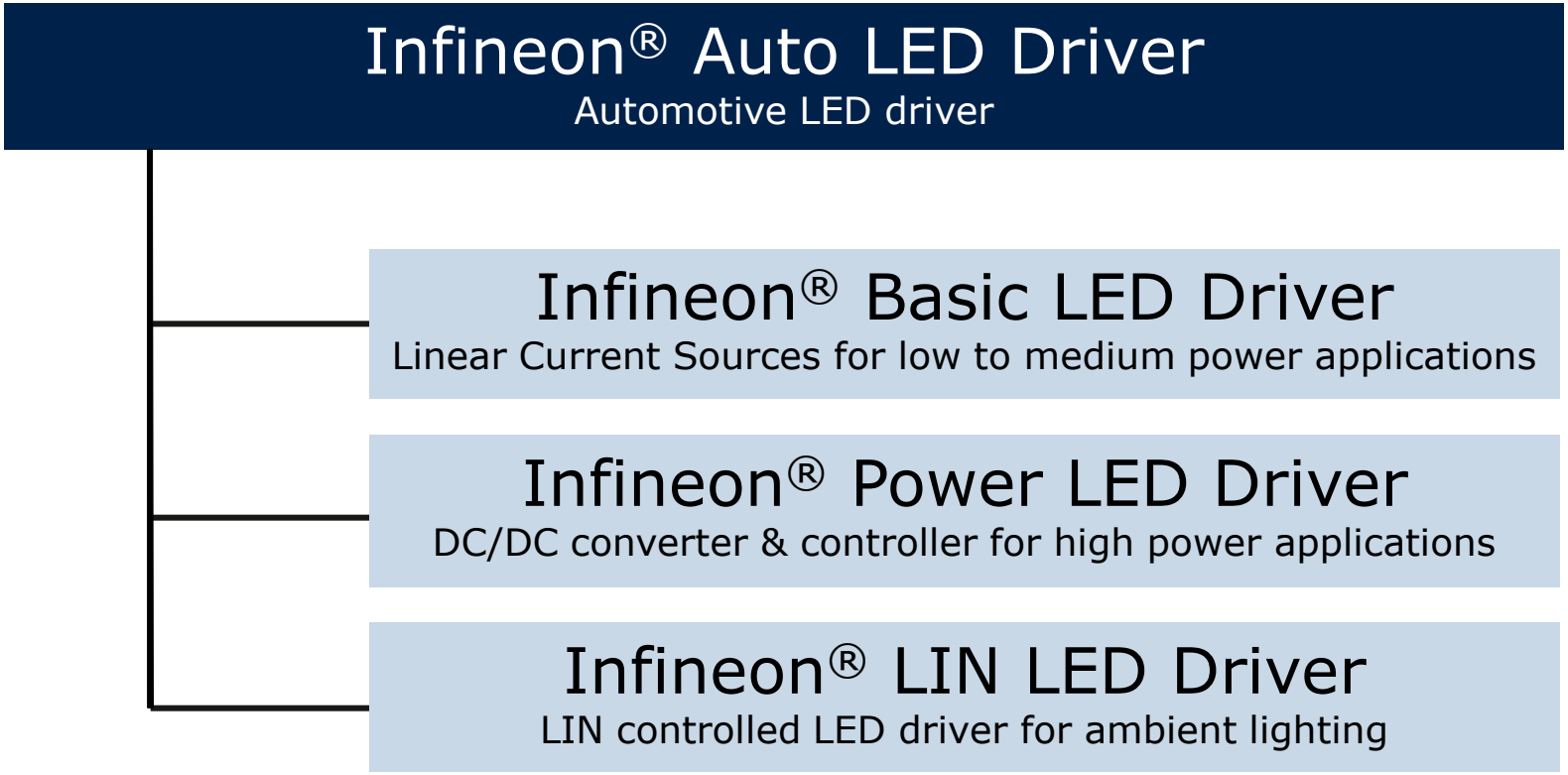
Rearlighting

with discrete LEDs

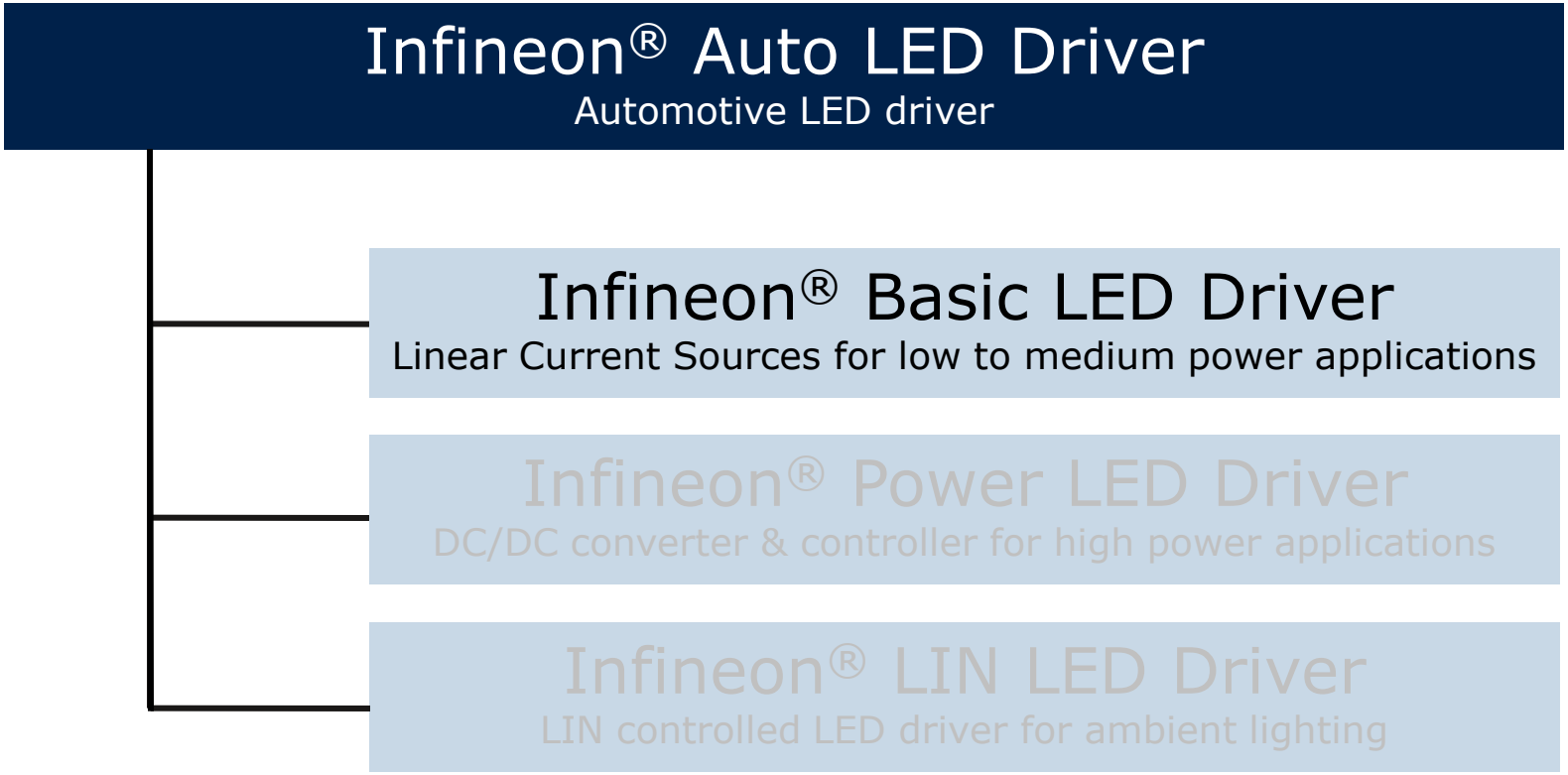
With Lightguide

Multicolor Ambient Lighting

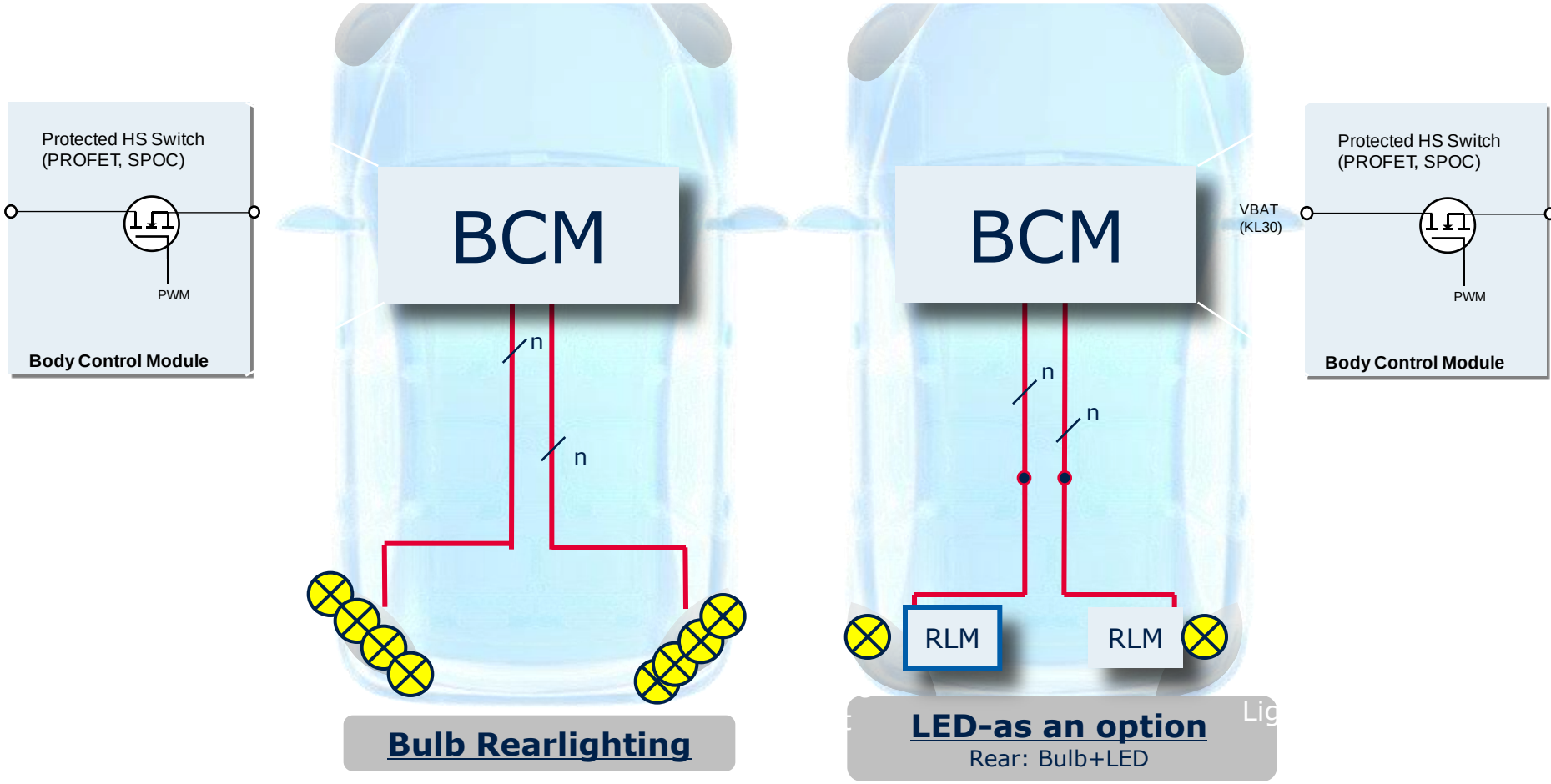
Infineon offers a comprehensive set of LED driver families for Automotive Lighting Solutions



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

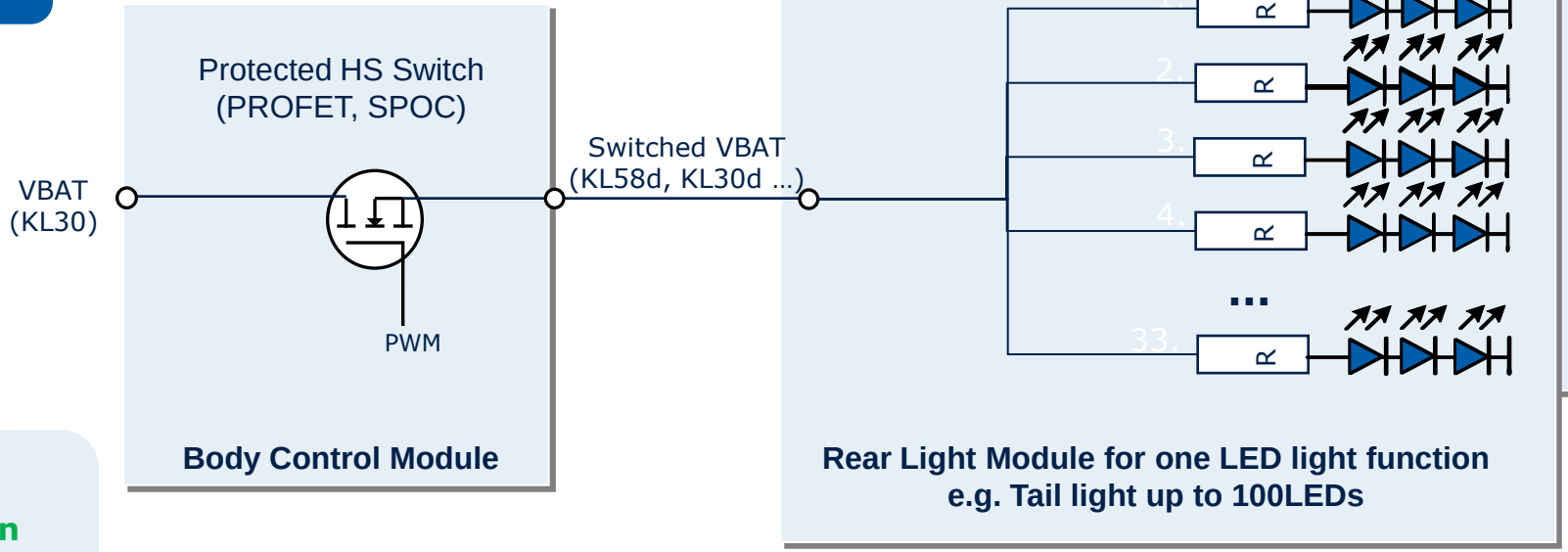


The transition to LED will influence the Body Architecture for external lighting

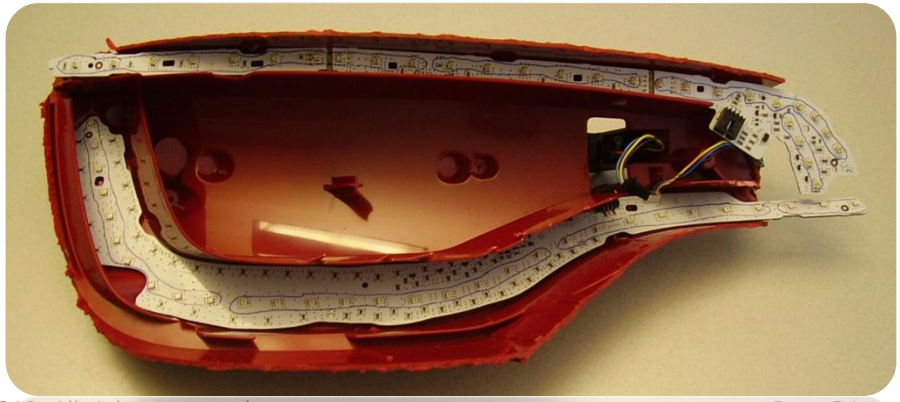


A simple LED **r**ear **l**ight **m**odule includes LEDs and serial resistors

Solution 1.
Serial resistor

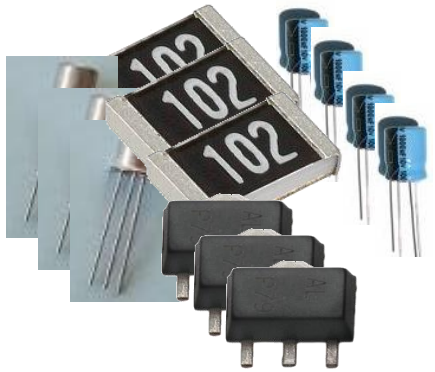


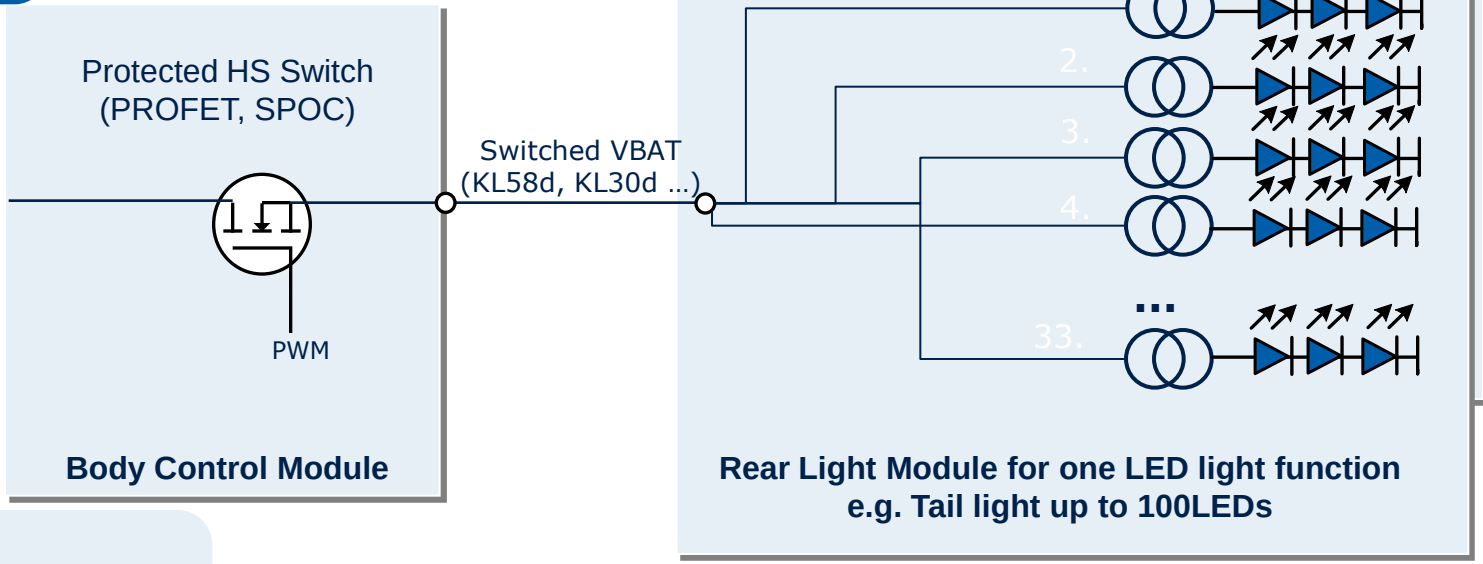
+Cheap
+Easy Design
- No Protection
- No Diagnostic



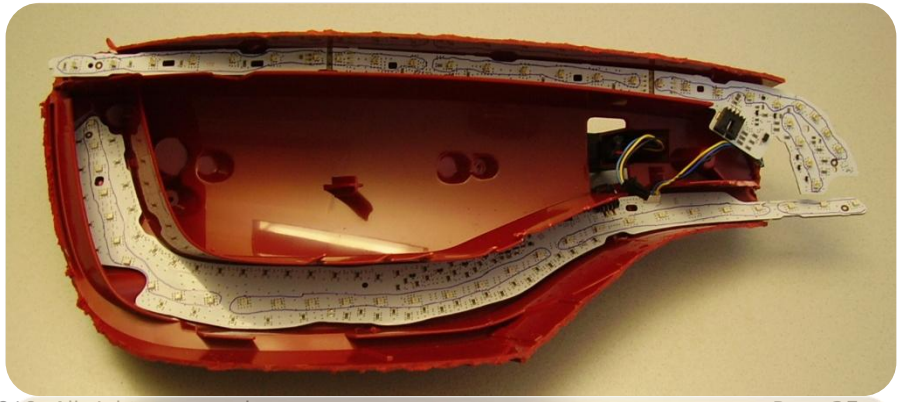
An advanced LED **r**ear **l**ight **m**odule includes LEDs and linear current sources

Solution 2.
Discrete linear current source with diagnostic



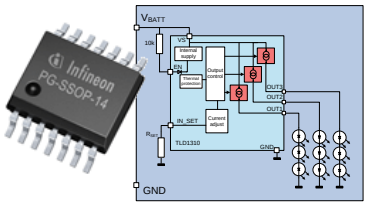


+Protection
+Diagnostic
- Increased Design Effort
- Huge number of components



The best LED **r**ear **l**ight **m**odule includes LEDs and Infineon® Basic LED Driver

Solution 3.
Infineon® Basic LED Driver



Protected HS Switch
(PROFET, SPOC)

PWM

Switched VBAT
(KL58d, KL30d …)

Body Control Module

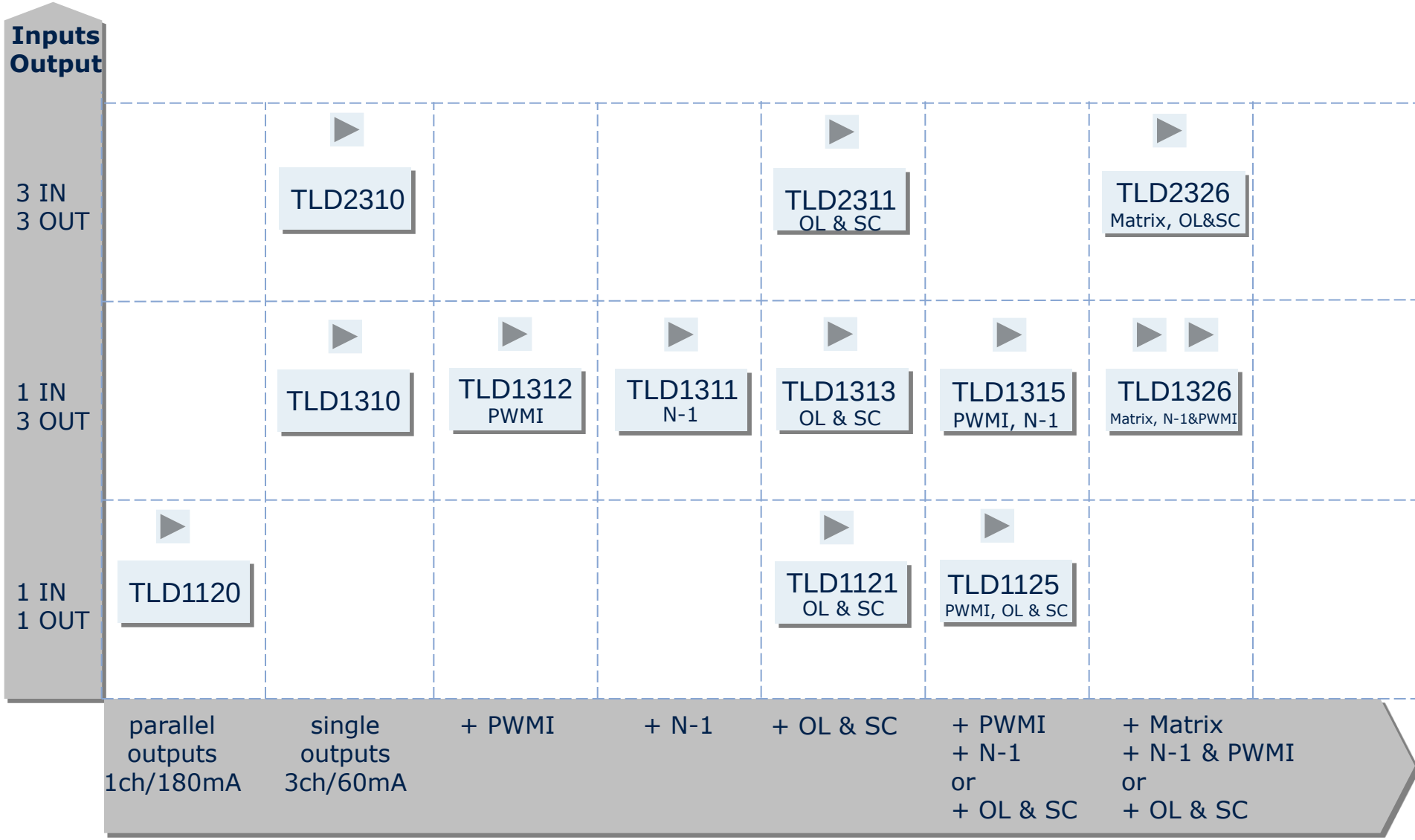
TLD1313EL
TLD1313EL
TLD1313EL
TLD1313EL
TLD1313EL
TLD1313EL
TLD1313EL

Rear Light Module for one LED light function
e.g. Tail light up to 100LEDs

+Protection
+Diagnostic
+Easy Design
+Minimum component Count

Infineon® Basic LED Driver

A modular & flexible family setup



Infineon® Basic LED Driver

Device Nomenclature

TLDabcd

a - IN_SET:

1: 1 IN_SET pin

2: 3 IN_SET pin

b - Number of channels

c - Output current class:

1: 60mA class

2: 180mA class

d - Features:

0: Basic

1: N-1 or OL & SC detection

2: PWMI

3: OL & SC

5: PWMI + N-1 or OL & SC

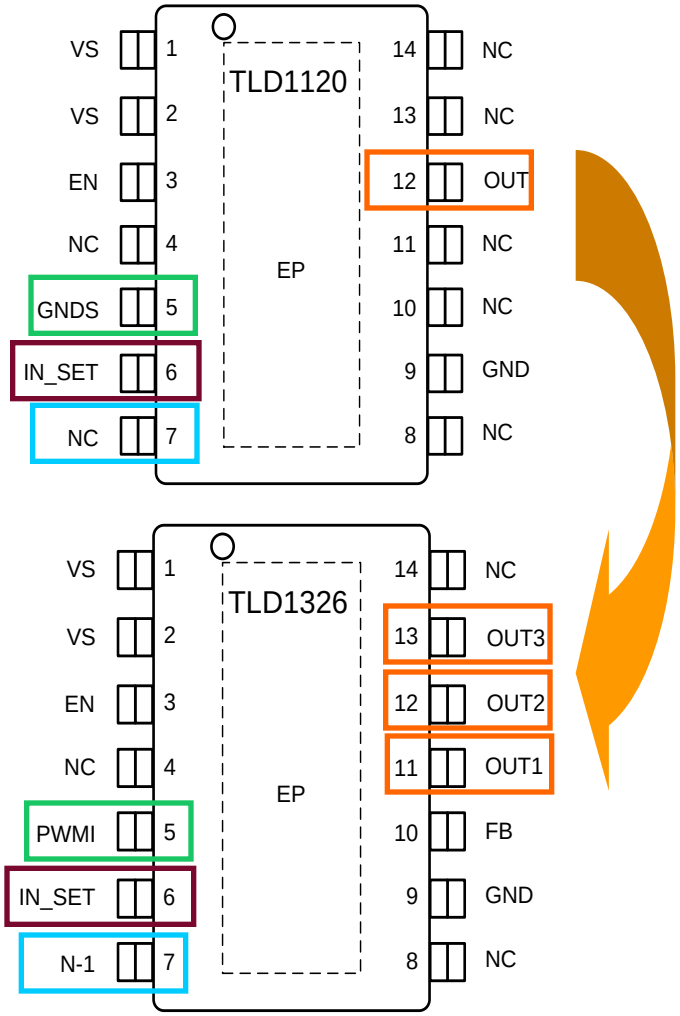
6: PWMI + N-1 or OL & SC + Matrix

The Infineon® Basic LED Driver Family offers Maximum Design Flexibility by Cross-Device Feature & Pin-Out Compatibility

confidential

Pin Compatibility

PG-SSOP14EP



Identical Feature Set

- All members of the family provide the same features on the Supply / EN pin (+ identical pin-out)
- Family members with / without PWMI functionality can use the same PCB design
- Same IN_SET behavior / pin-out for all devices in the family
- Family members with / without N-1 or OL functionality can use the same PCB design
- 1 channel / 3 channel devices can use the same PCB design (using 0Ohm resistor)

→ If you know 1 device, you know the whole family!

Further individual Automotive LED Driver
Product Portfolio of Linear Current Sources

	Current		Open Load Detection	PWM/Enable	Hi/Low Current Switch	Package
	mA	adj.				
BCR40xU	$10\text{-}50_{typ}$	✓				**SC-74**
BCR420U	150_{typ}	✓				**SC-74**
BCR421U	150_{typ}	✓		✓		**SC-74**
TLD1211SJ	85_{typ}	✓		✓		**DSO-8**
TLE4241GM	70_{max}	✓	✓	✓	✓	**DSO-8**
TLE4242EJ	250_{typ}	✓	✓	✓		**DSO-8 EP**
TLE4242G	450_{typ}	✓	✓	✓		**TO-263**
TLD1211SJ + ext NPN	<2500	✓		✓		**DSO-8**

TLE4242EJ

TLE4242G in DSO8 Exposed Pad Package

Applications

- Automotive LED Rear & Interior Lighting

In development
ES May 2013
QS August 2013
SOP September 2013

Key Features

- **Identical Feature-Set to TLE4242G but reduced thermal performance due to increased Rth of the package**
- **still ~20% better thermal performance than TI TL4242**
- Adjustable constant current up to 500 mA (±5%)
- Wide input voltage range up to 42 V
- Open load detection
- Over temperature protection
- Short circuit proof
- Reverse polarity protection
- Temp. range: -40 ° C to 150 ° C

TLE4242EJ

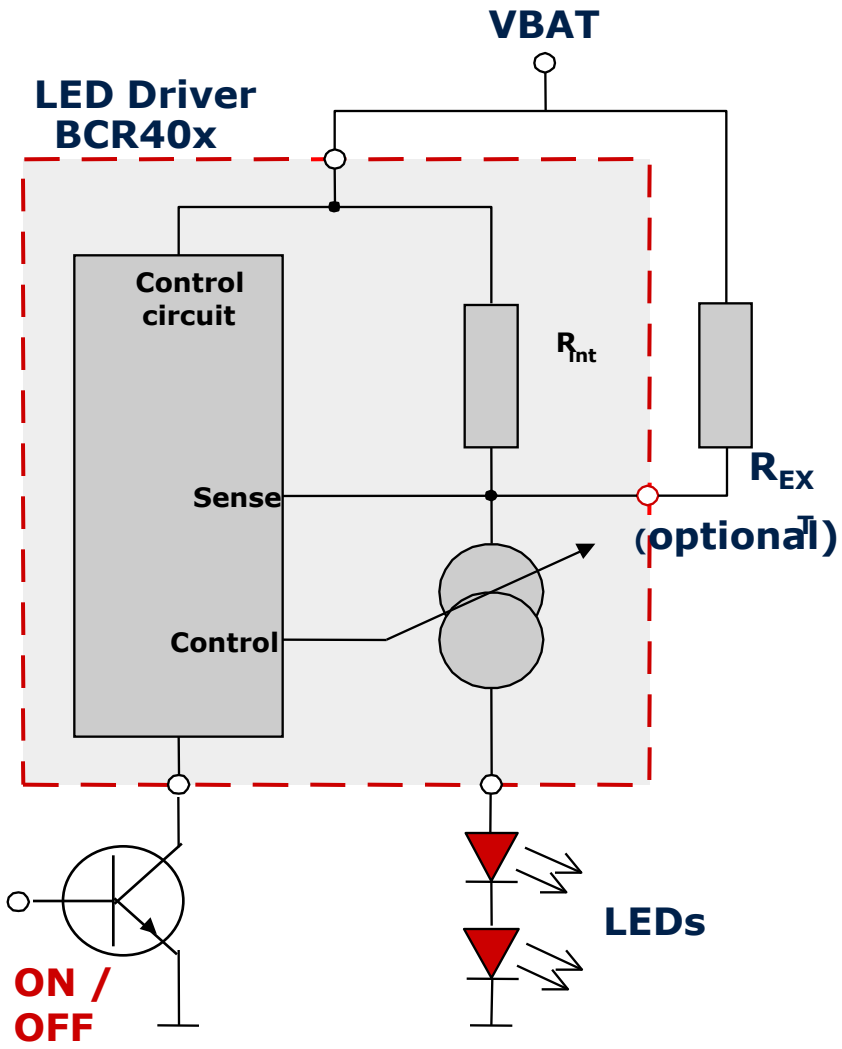
PG-DSO-8 (Exposed Pad)

BCR40x – Low cost linear LED-drivers

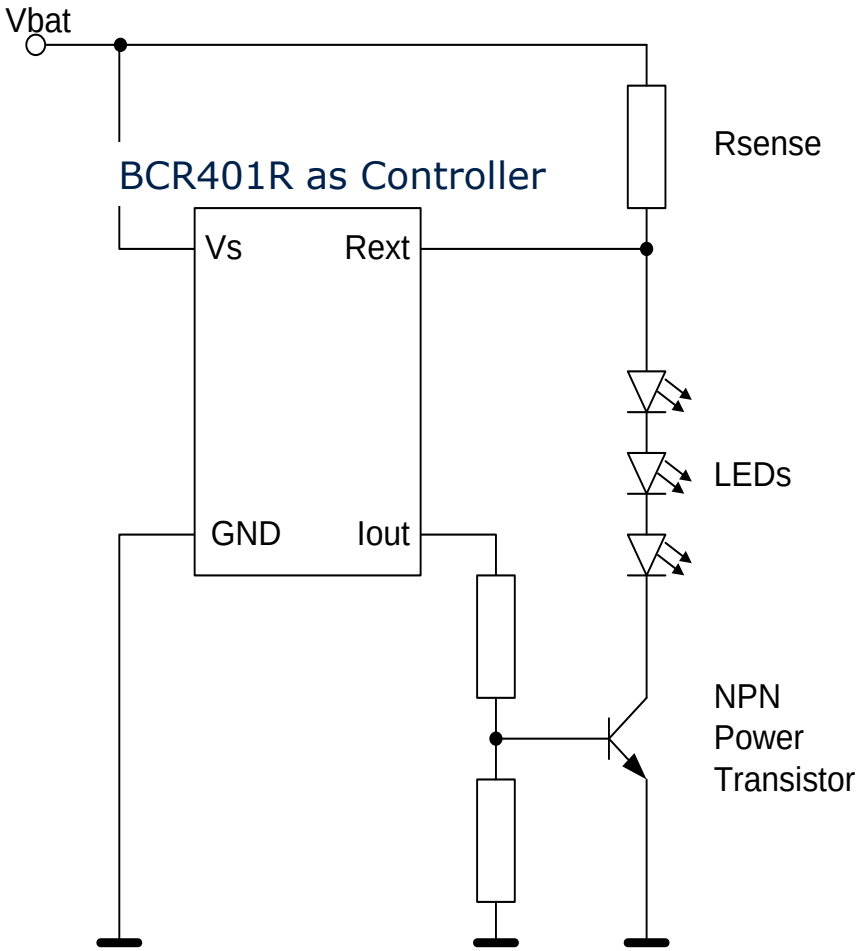
Available

Key Features

- Low Cost Technology & Package
- Output current adjustable by usage of external resistor from 10mA to 60mA
- Suitable for Pulse Width Modulation (PWM)
- Negative temperature coefficient (LED protection @ High Temperatures)
- Available in several package options: SOT143R, SOT343, SC74
- Operates in conjunction with our PROFET™ on the BCM



Driving high current LED's using BCR401R Application Note – AN101



Features

High LED currents from 65mA up to 700mA,for 0.5W to 4W LEDs

Benefits

Reasonable overall system cost

Stable light emission

Suitable for Pulse Width Modulation (PWM)→ possibility of LED dimming

Negative temperature coefficient

- Serves as protection for LEDs at
- Higher temperatures

Recommended Power Transistors:

- BCX68-25 (in SOT89 package) or
- BC817SU (in SC74 package)

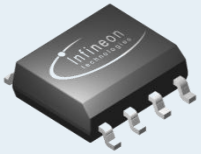
Product Overview BCR40x family
Low current linear mode LED drivers

Product type	Package	Topology	Input voltage min [V]	Input voltage max [V]	Output current [mA]	Inhibit	PWM	Open load detection
BCR420U	PG-SC74-6	Linear	4.5	40	150			
BRC421U	PG-SC74-6	Linear	4.5	40	150	✓	✓	
BCR401U	PG-SC74-6	Linear	4.5	40	10			
BCR402U	PG-SC74-6	Linear	4.5	40	20			
BCR405U	PG-SC74-6	Linear	4.5	40	50			

TLD1211SJ – new linear LED Driver

Key Features

- Max. Output current 85mA
- Temperature dependent current reduction
- External Transistor Option
  LED currents up to 2.5A
- Improved precision of Iout:
  +/- 10% in whole operating range
  (V supply; Tj)
- Over voltage protection
- Enable input for PWM operation
- DSO-8 package
- Automotive Qualified



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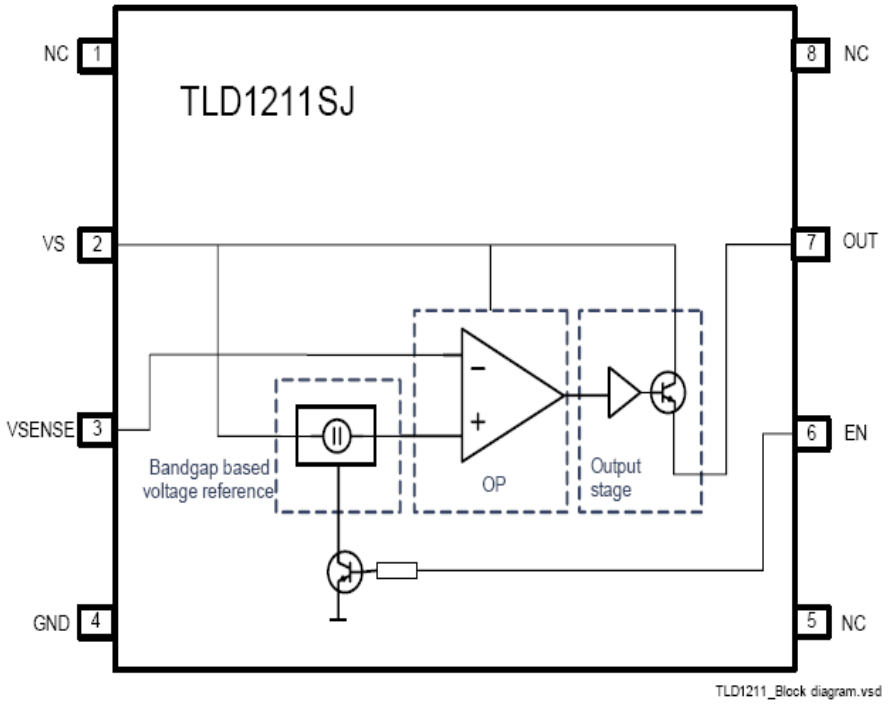


STATUS

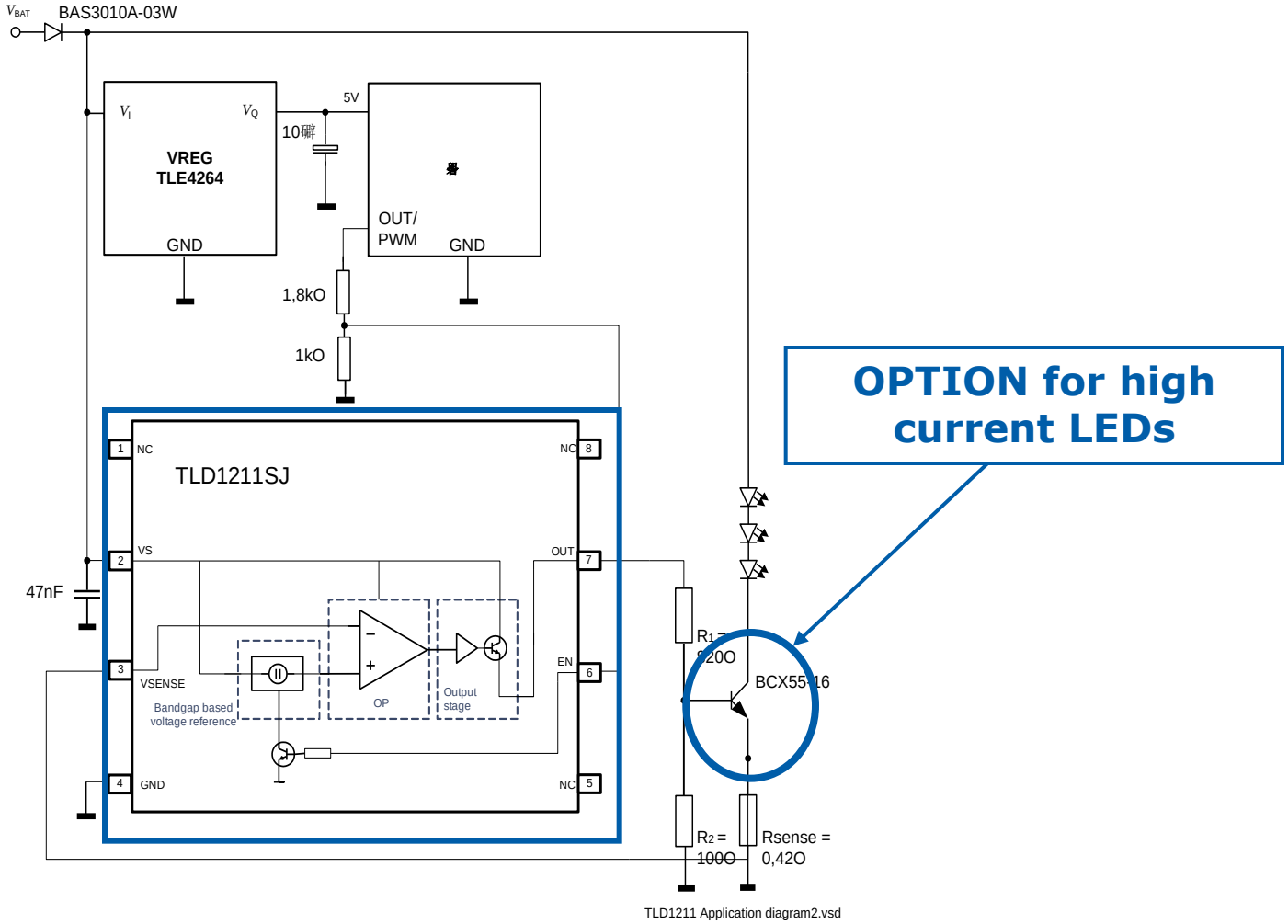
- Available

RoHS

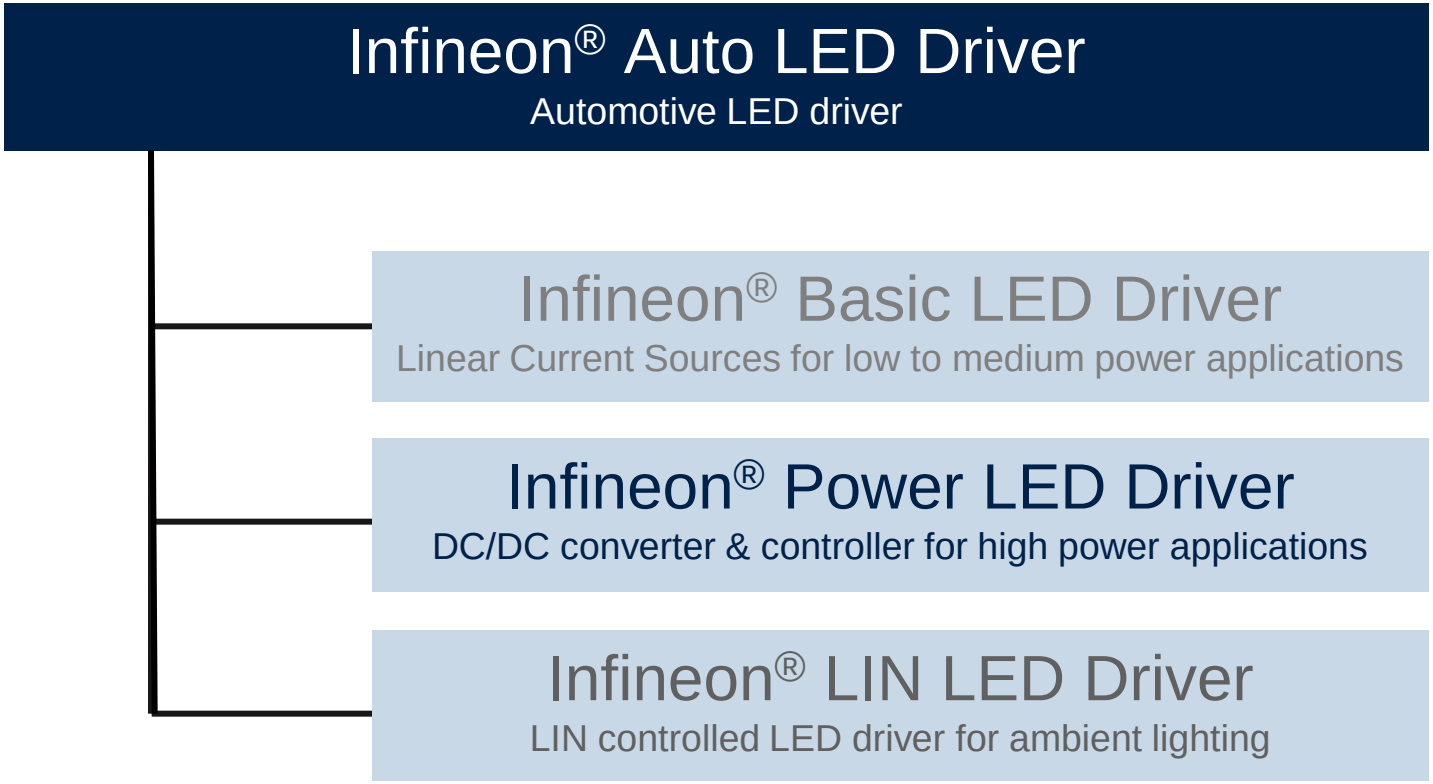
AEC Qualified

TLD1211SJ - Application example

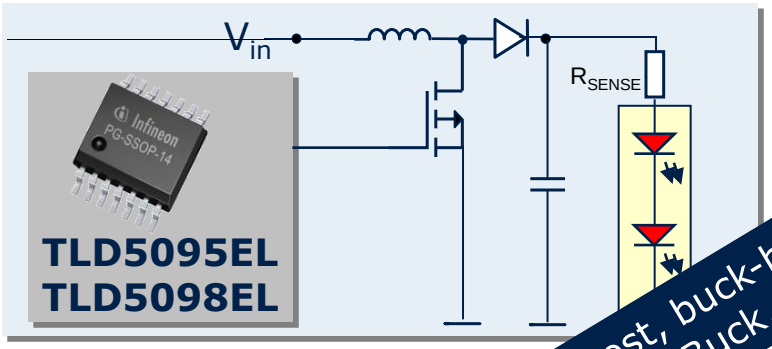
- In application where medium / high current LED are required, it is possible to use the TLD1211SJ as driver for an external NPN transistor



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



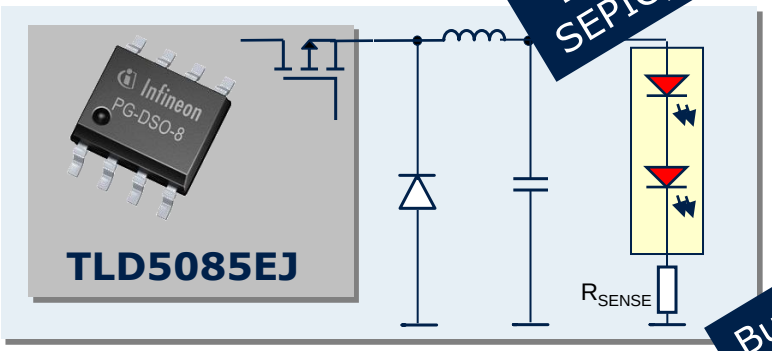
Infineon® Power LED Driver
Cover the Full Range of Integration Steps



Boost, buck-boost, SEPIC, Buck, Flyback

Smart DC/DC Controller IC

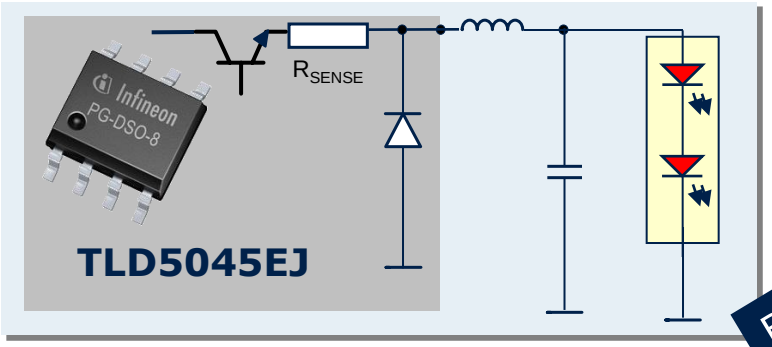
- Driver stages for external switching transistors implemented



Buck

Smart DC/DC Driver IC

- Switching transistors integrated



Buck

Integrated Smart DC/DC Driver IC

- Switching transistors + freewheeling diode + sense resistor integrated

Infineon® Power LED Driver
TLD 5095EL – LED Boost, Buck-Boost, Sepic Controller

Applications

- Specially designed for Automotive exterior lighting

Key Features

- **Wide Input Voltage Range from 4.75 V to 45 V**
- **Drives LEDs in Boost (B2G), Buck-Boost (B2B) and SEPIC Topology (max. 45V), Buck, Flyback**
- **Flexible Switching Frequency Range: 100 kHz to 500 kHz (for EMC optimization)**
- **Integrated Gate Driver for PWM Dimming**
- Open Circuit Diagnostic Output
- Synchronization with external clock
- Internal Soft Start
- Output Overvoltage Protection
- Over Temperature Shutdown
- Constant Current or Constant Voltage Regulation
- Very Low Shutdown Current: IQ< 10 µA

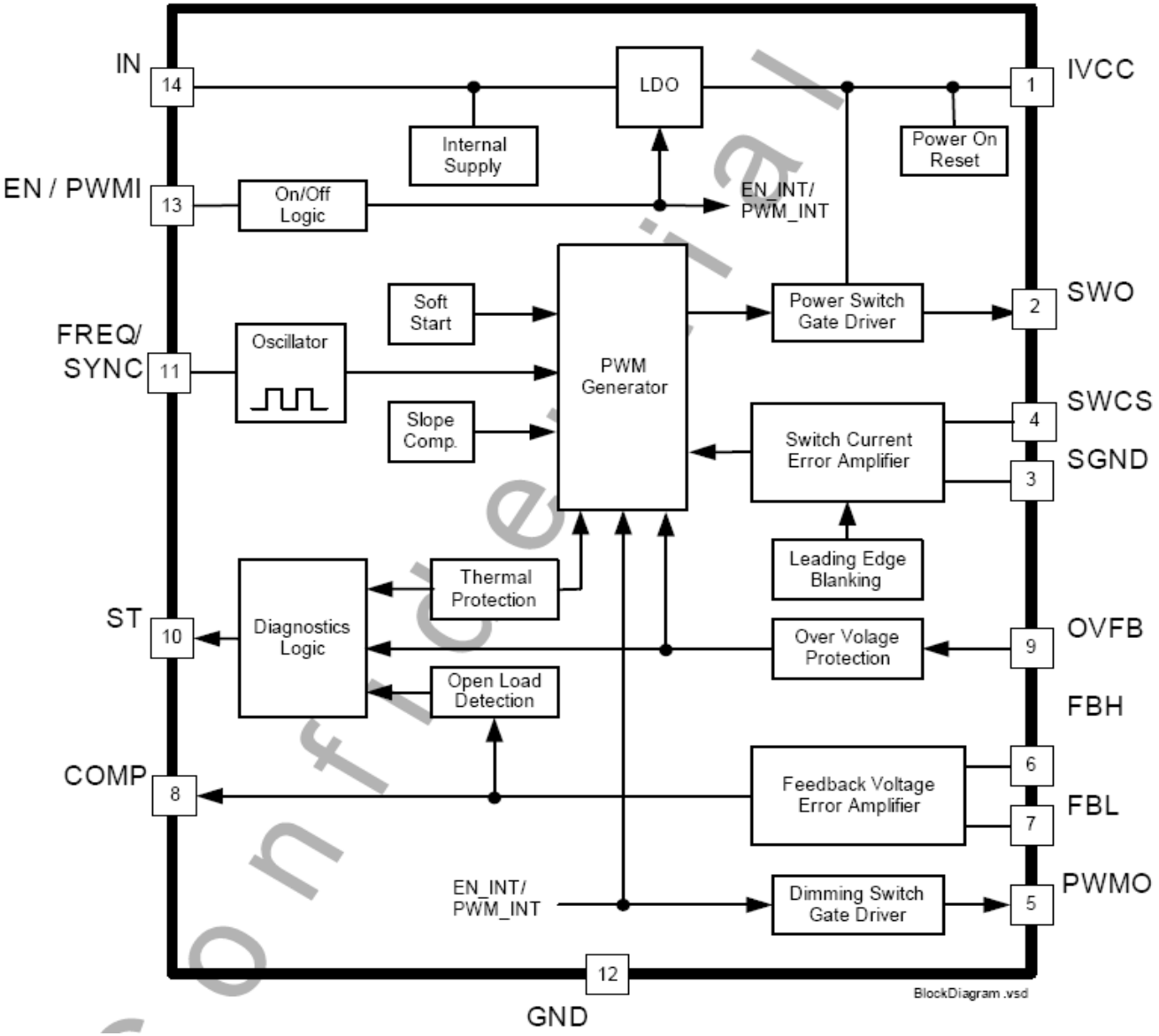
TLD 5095EL

SO-8 BODY SIZE

PG-SSOP-14 (150mil)

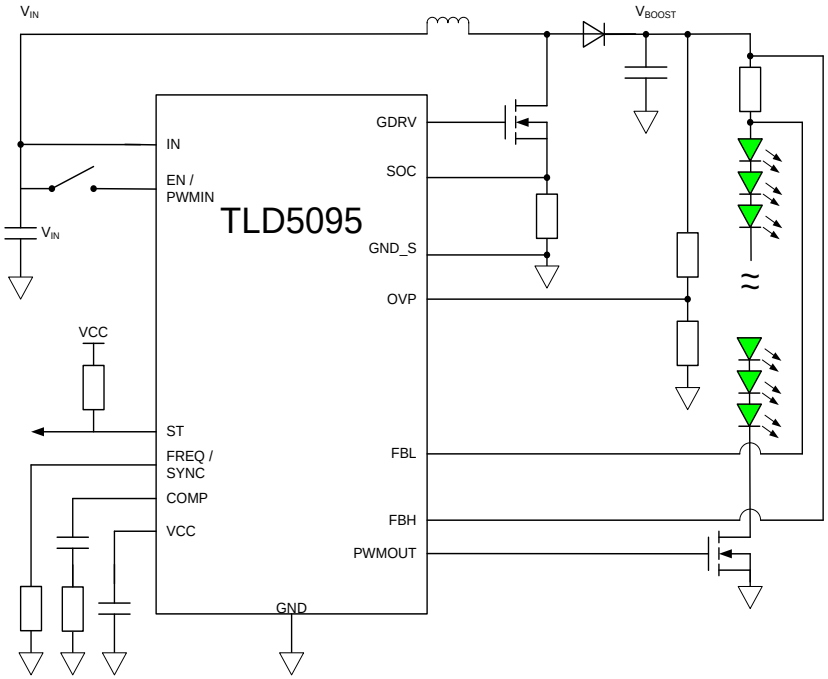
Available

TLD 5095EL
Block Diagram

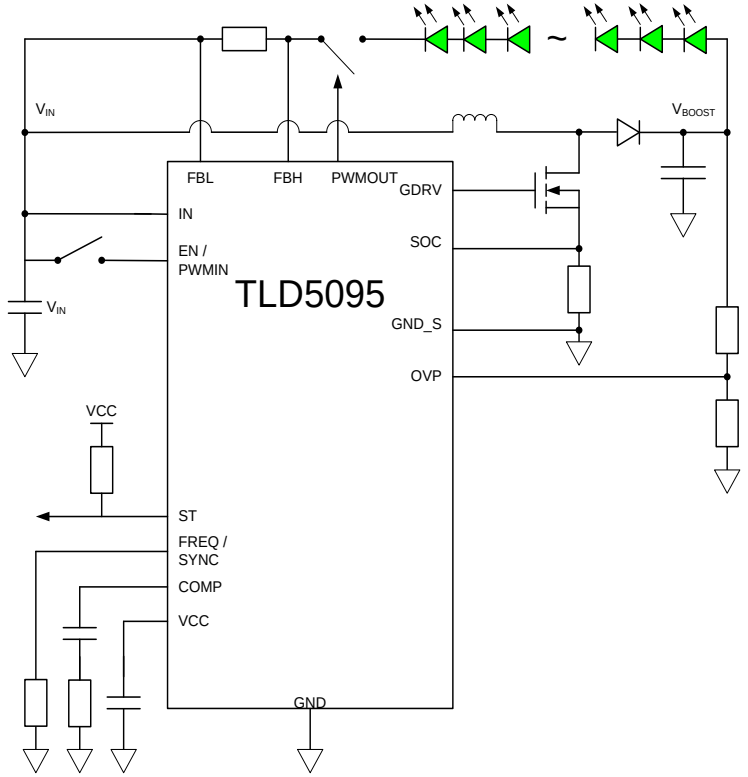


TLD 5095EL
Application options

GND Return



Vbat Return



Infineon® Power LED Driver
TLD 5098EL – LED Boost, Buck-Boost, Sepic Controller

Applications

- Specially designed for Automotive Front Lighting

Key Features

- **Wide Input Voltage Range from 4.5 V to 45 V**
- **Drives LEDs in Boost (B2G), Buck-Boost (B2B) and SEPIC Topology (max. 60V), Buck, Flyback**
- **Flexible Switching Frequency Range: 100 kHz to 500 kHz (for EMC optimization)**
- **Analog Dimming feature to adjust average LED current**
- **Integrated Gate Driver for PWM Dimming**
- Open Circuit Detection and Shutdown
- Short to GND Detection and Shutdown
- Output Overvoltage Protection
- Device Over Temperature Protection
- Synchronization with external clock
- Very Low Shutdown Current: IQ< 10 µA

TLD 5098EL

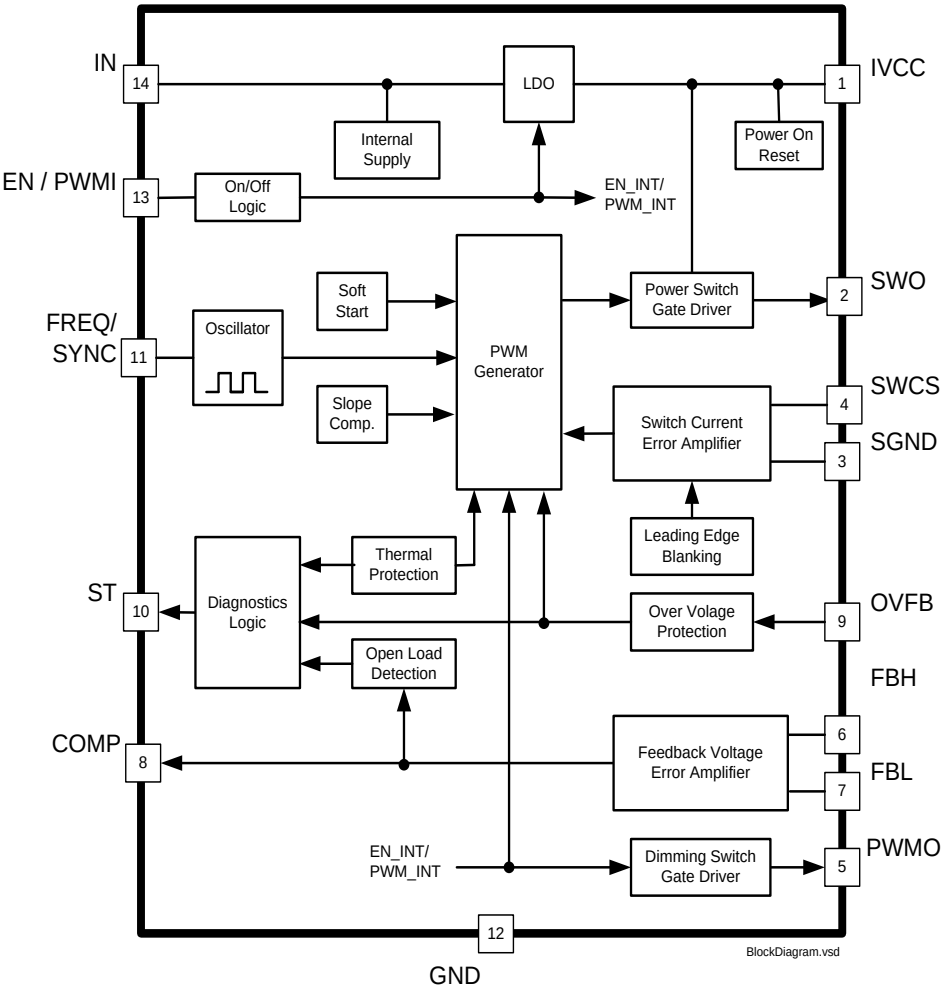
SO-8 BODY SIZE

PG-SSOP-14 (150mil)

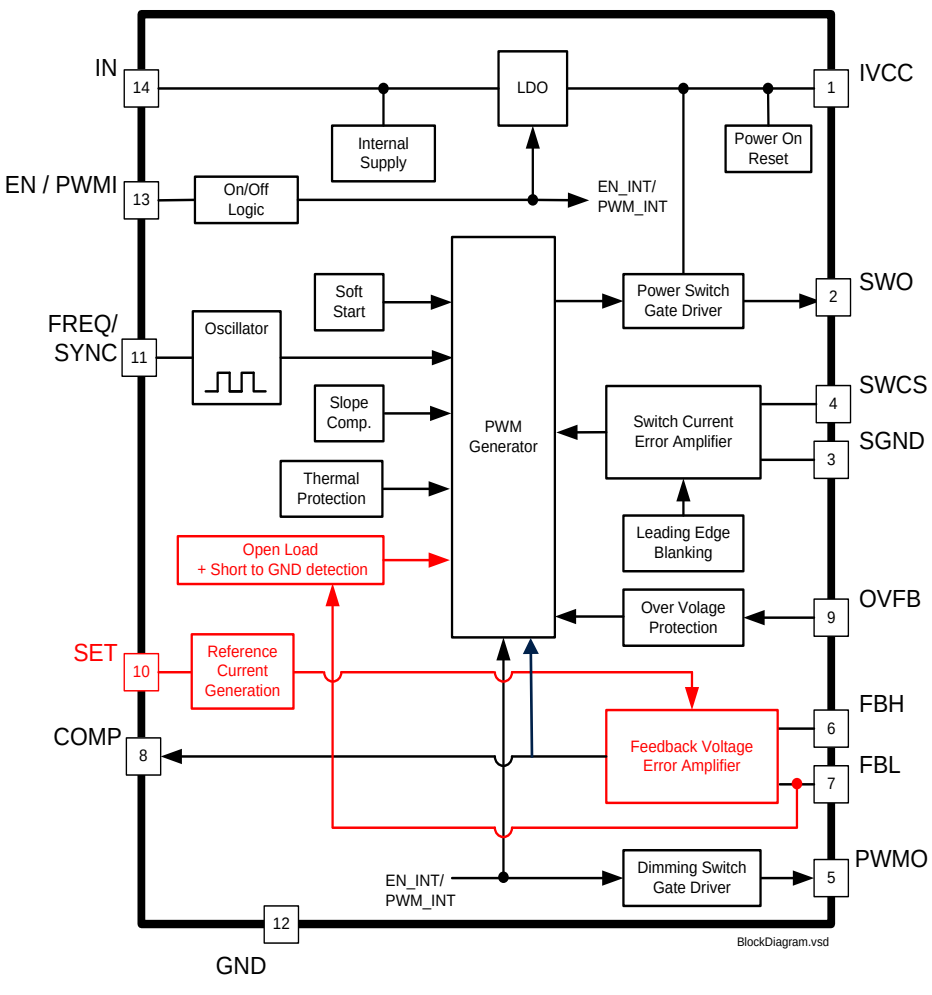
Available

TLD5098EL
Block Diagram

TLD5095EL

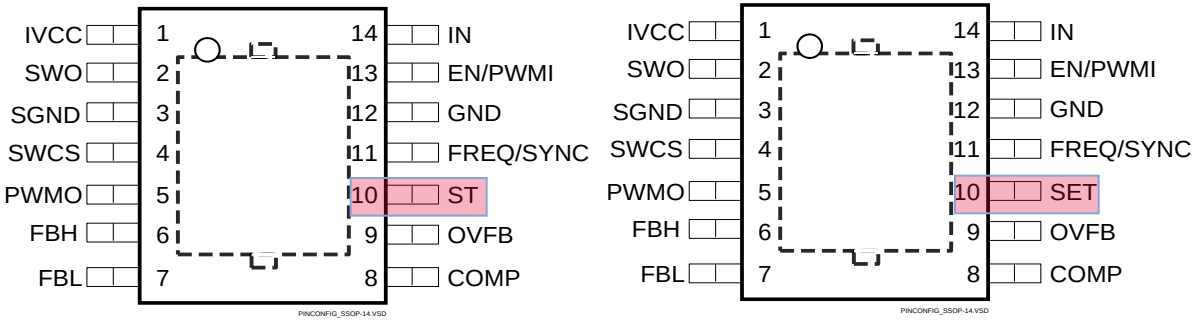


TLD5098EL

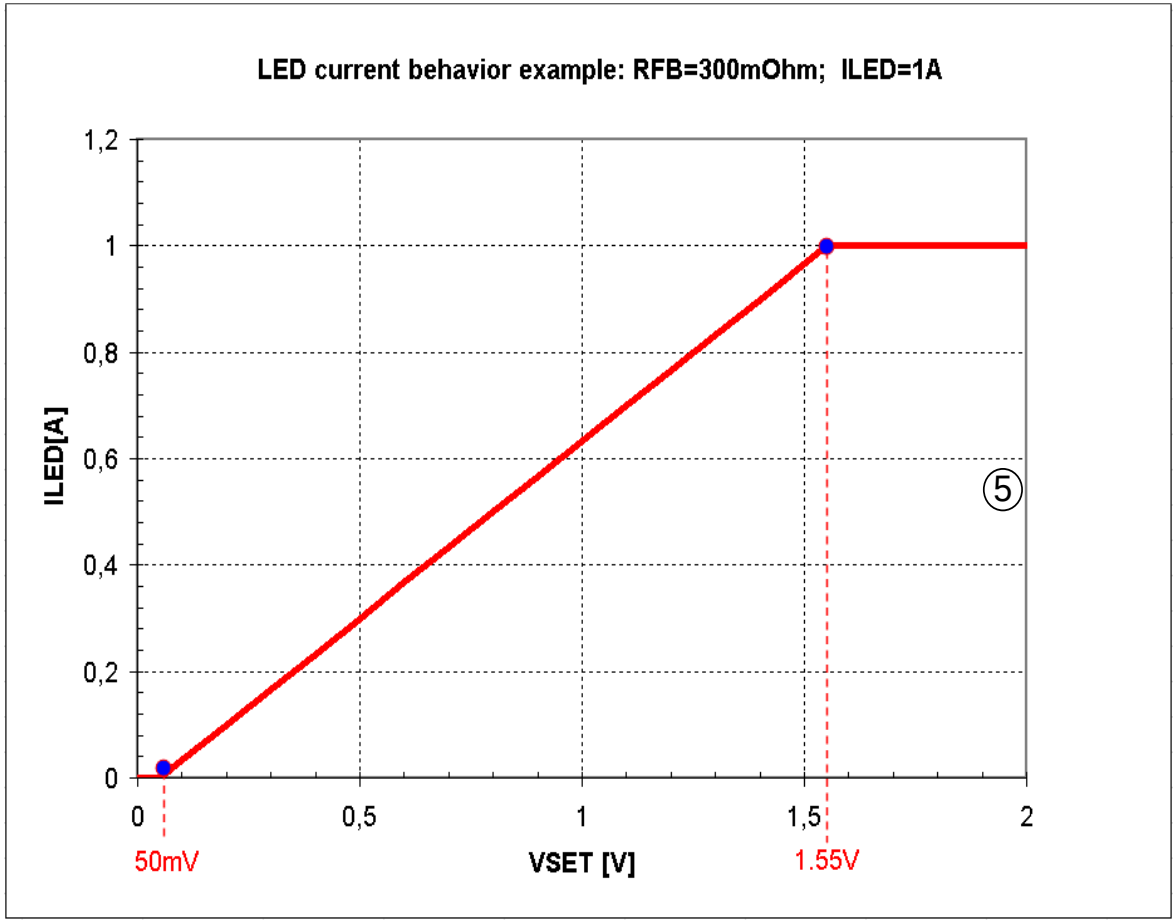


TLD5095EL vs TLD5098EL

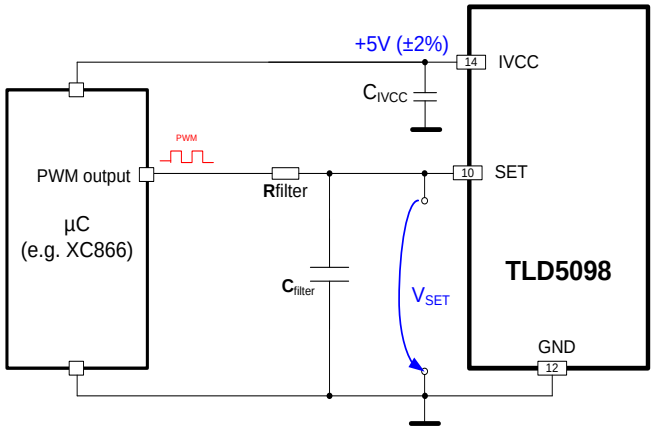
	TLD5095EL	TLD5098EL
Analog Dimming	NO	YES
SEPIC	YES	YES
Boost to Vbat (B2B)	YES	YES
Boost to GND (B2G)	YES	YES
Short to GND Protection	SEPIC – YES B2G, B2B - possible with external components but not optimized due to softstart and diagnosis function	YES (all configurations with external components)
Vout,max=60V	YES (only Boost to Vbat)	YES (all configurations)
Status Pin	YES	NO But, µC can observe the PWMO and IVCC signal to check fault conditions



TLD5098EL
analog dimming feature



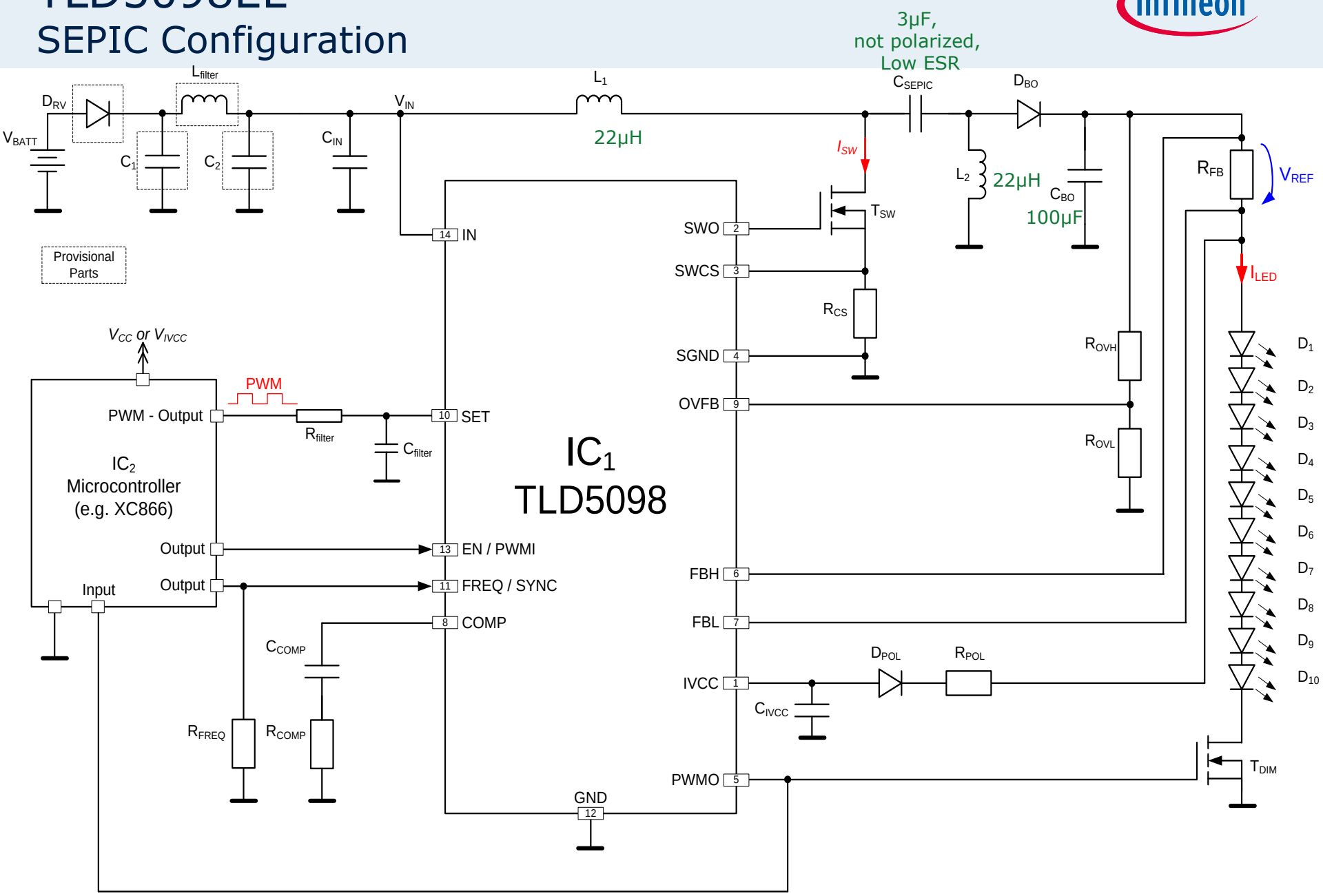
- The peak current can be set in a speficied range
- Current setting via uC or passive circuitry



Summary for the SEPIC Configuration:

- Simple concept of PWM dimming (direct drive of MOSFET)
- Low input current ripple
  - The EMC filter circuit on the input can be reduced or removed
- BUCK and BOOST Operation possible
- Short to GND protected due to configuration
- Vboost,max= 60V
- For a cost and area effective system a SEPIC coupled coil (e.g. MSD1278, coilcraft = two coils in one package) is recommended.
- In case of a load dump pulse the Booster is protecting the application (over voltage protection)

TLD5098EL
SEPIC Configuration



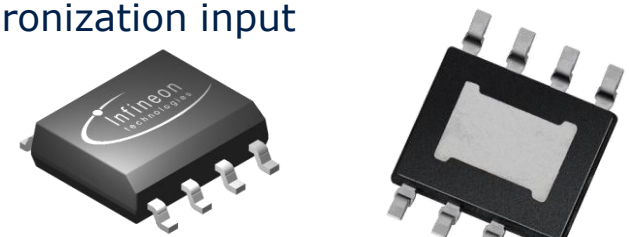
Infineon® Power LED Driver
TLD5085EJ – LED buck converter

Applications

- Well suited for Automotive interior & exterior light solutions

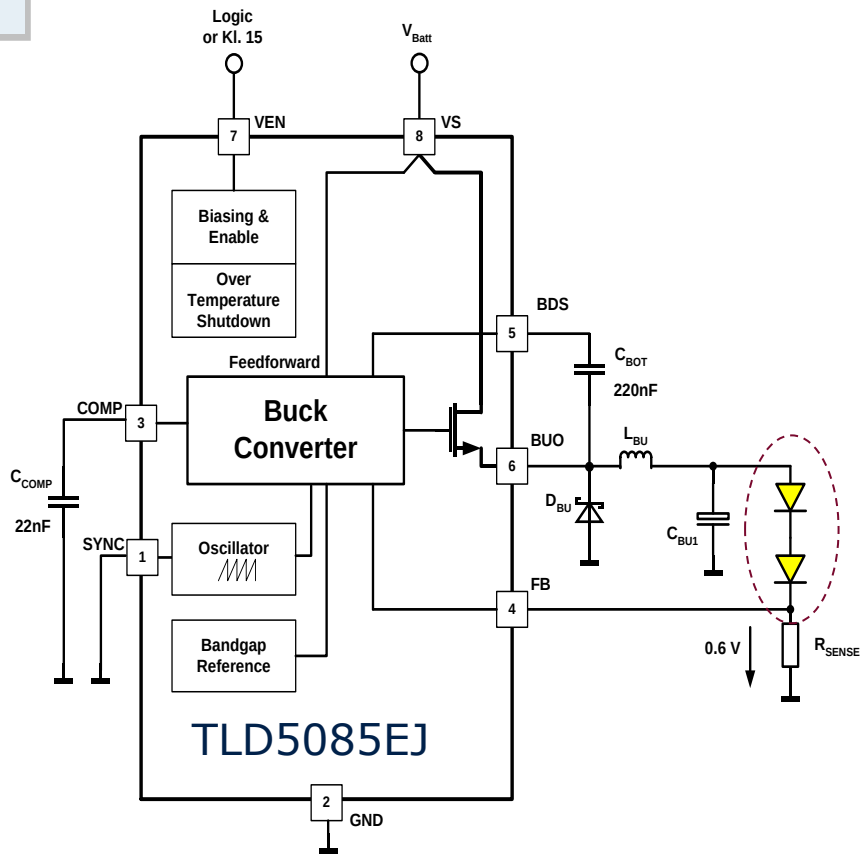
Key Features

- **Max. 1.8A load current capability**
- **Wide operating voltage range: 4.5V to 40V**
- **PWM capability for LED dimming**
- **Very small PG-DSO-8 exposed pad package**
- Enable input: Low shutdown quiescent current <2µA
- 370 kHz switching frequency
- Synchronization input



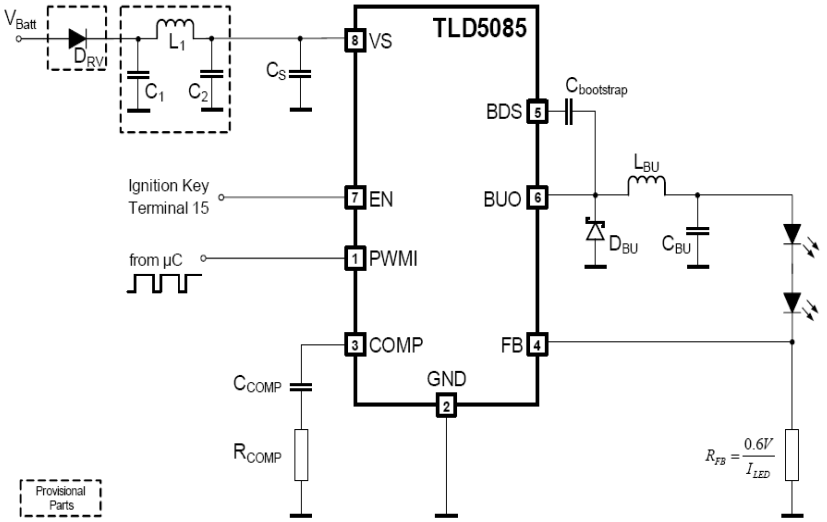
TLD 5085EJ
PG-DSO-8 EP

Available

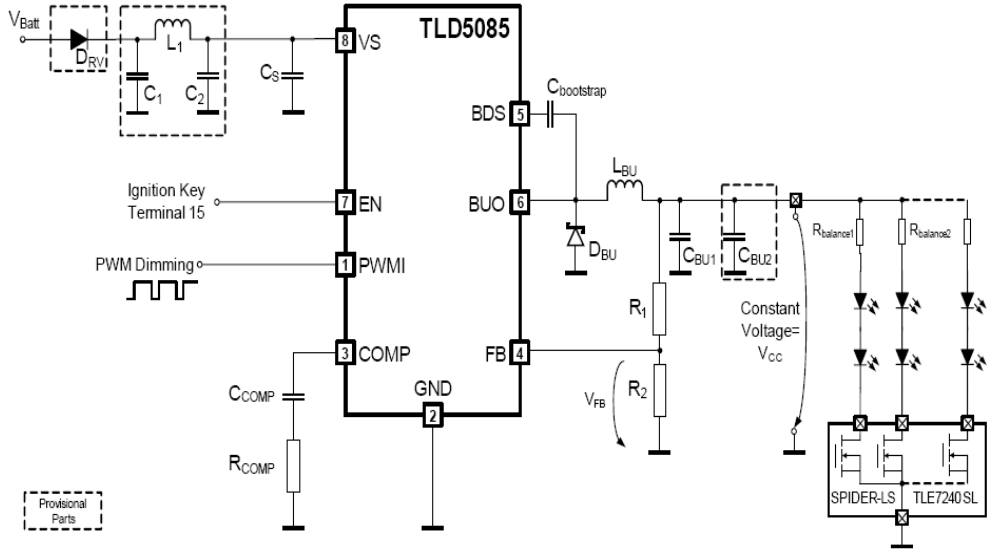


TLD5085EJ (BUCK)
Constant current / constant voltage mode

- Constant current mode:



- Constant voltage mode:



Infineon® Power LED Driver
TLD5045EJ – LED buck converter

Key Features

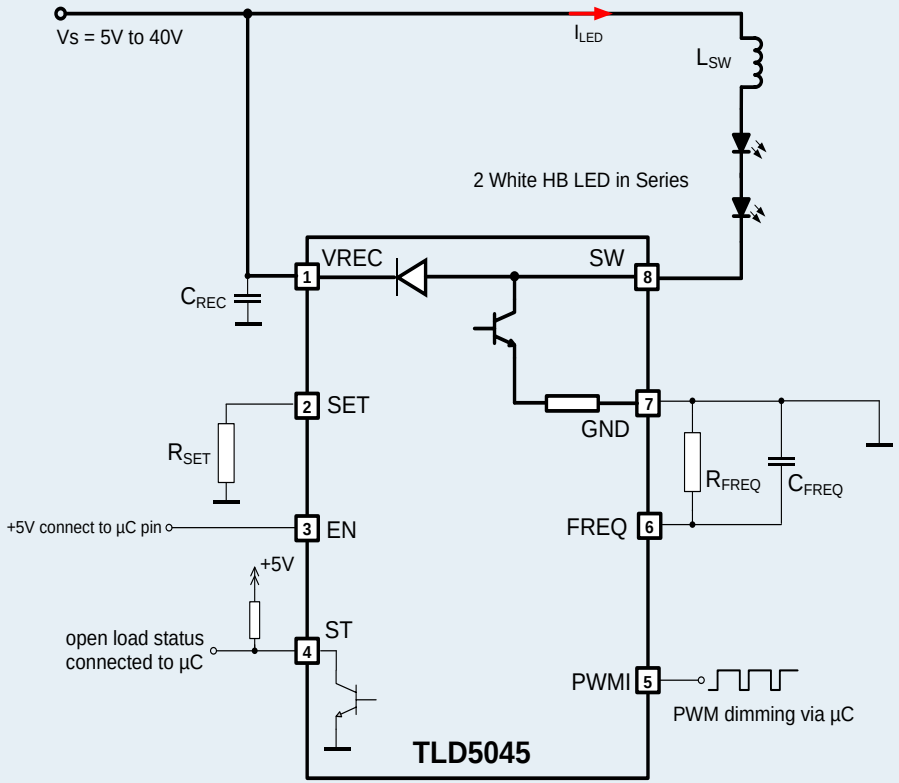
- DC/DC Buck Converter for 1-3 High power LEDs in Automotive applications
- Maximum Output current: 700mA
- Wide input voltage range: 5V … 40V
- Very low quiescent current: <2µA
- High Integration
  - Power switch
  - Sense resistor
  - Fast freewheeling diode
  - PWM dimming engine
    (frequency & duty cycle adjustable externally)
  - Over temperature protection
  - Peak current regulation
  - OL detection via status pin
- Switching frequency adjustable with external RC network (typ. 300kHz)
- Analog dimming via external resistor (Rref) possible
- LED temperature monitoring via PTC possible

Available

PG-DSO-8 (150mil)

AEC Qualified

RoHS

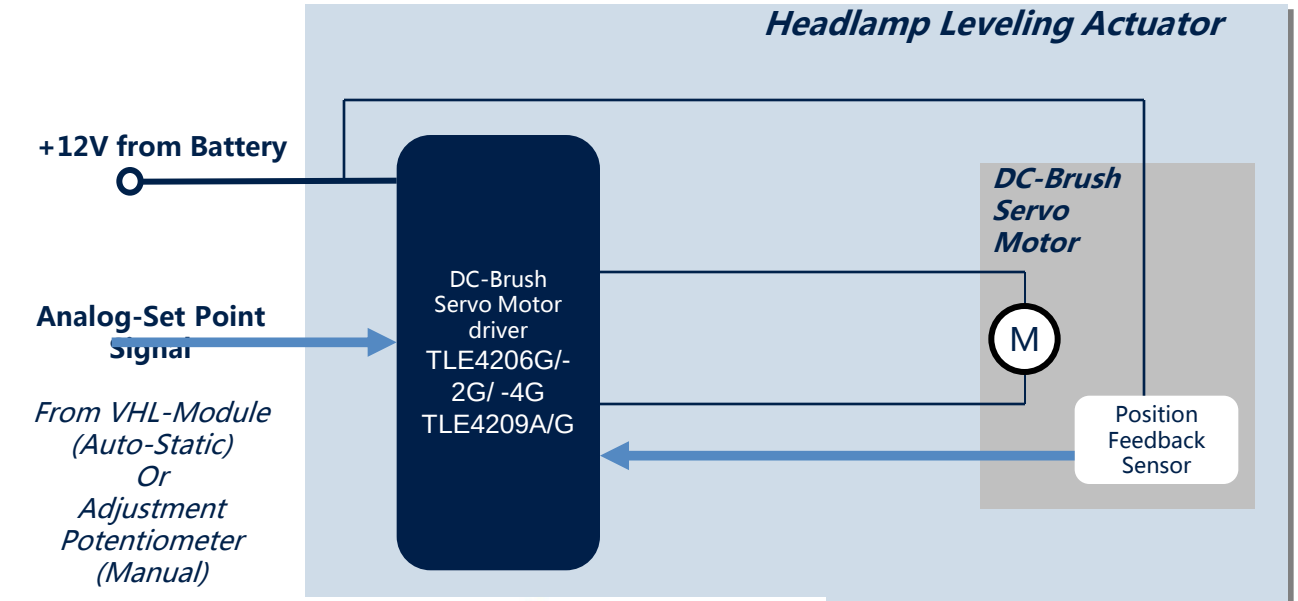


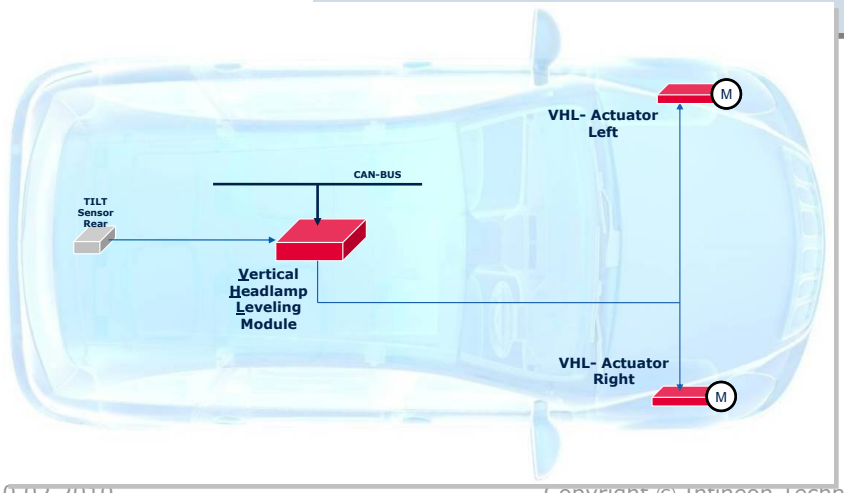
TLD5085EJ vs TLD5045EJ

	TLD5045EJ	TLD5085EJ
Topology	Buck	Buck
Package	DSO-8 ePad	DSP-8 ePad
Max. Load current	700mA	1.8A
Integrated Power Stage	YES	YES
Integrated freewheeling diode	YES	NO
Status Pin	YES	NO
Integrated Open Load Transistor	YES	NO
PWM dimming	YES	YES
Auto PWM for stand alone application	YES	NO
Analog Dimming	YES	NO
Sleep mode (low current consumption)	YES	YES
Switching Frequency	Typ.300kHz, adjustable	Typ. 360kHz, fixed

Headlamp Leveling Actuator
Auto-Static / Manual

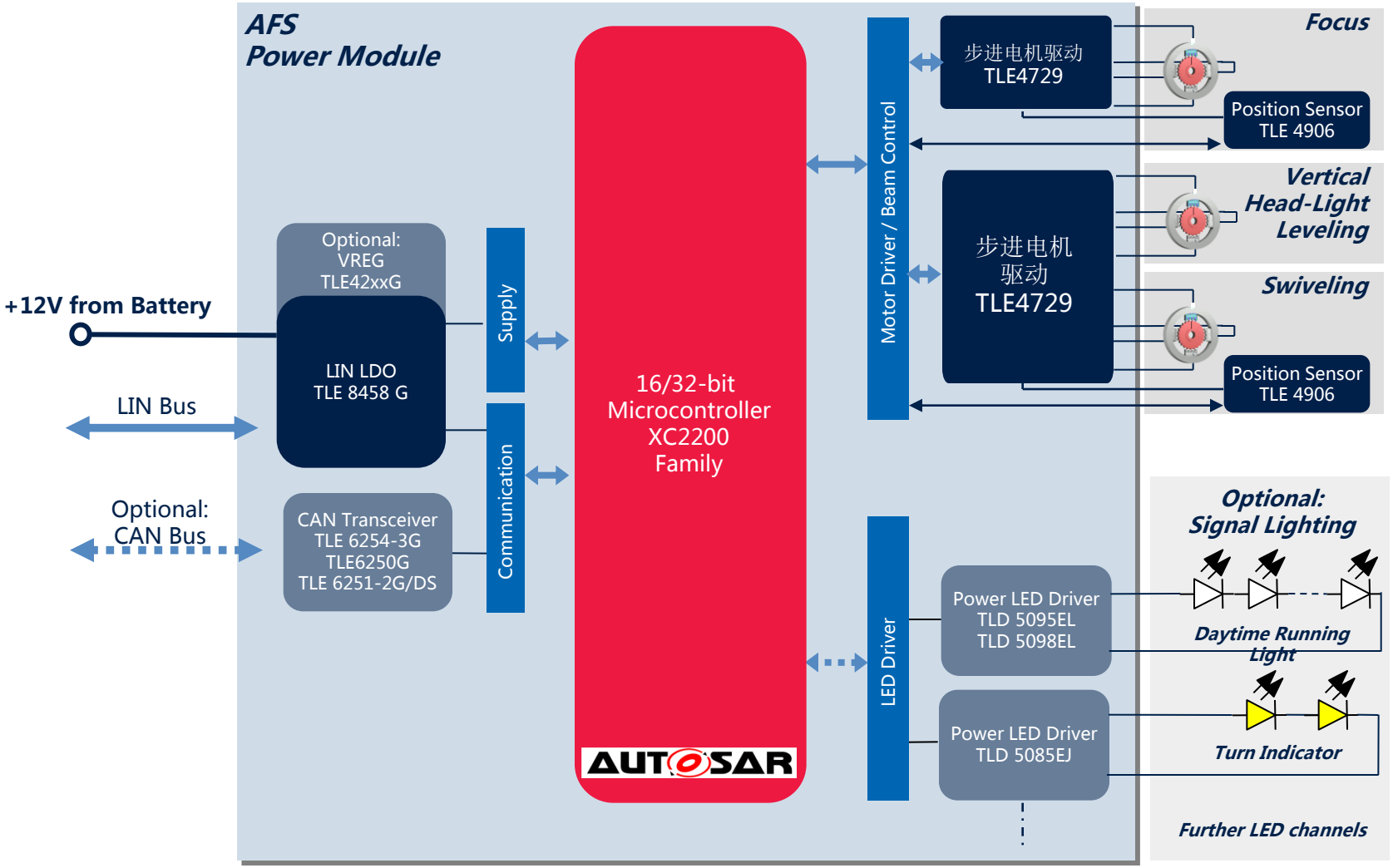
Barth Martin (IFAG ATV BP AE)

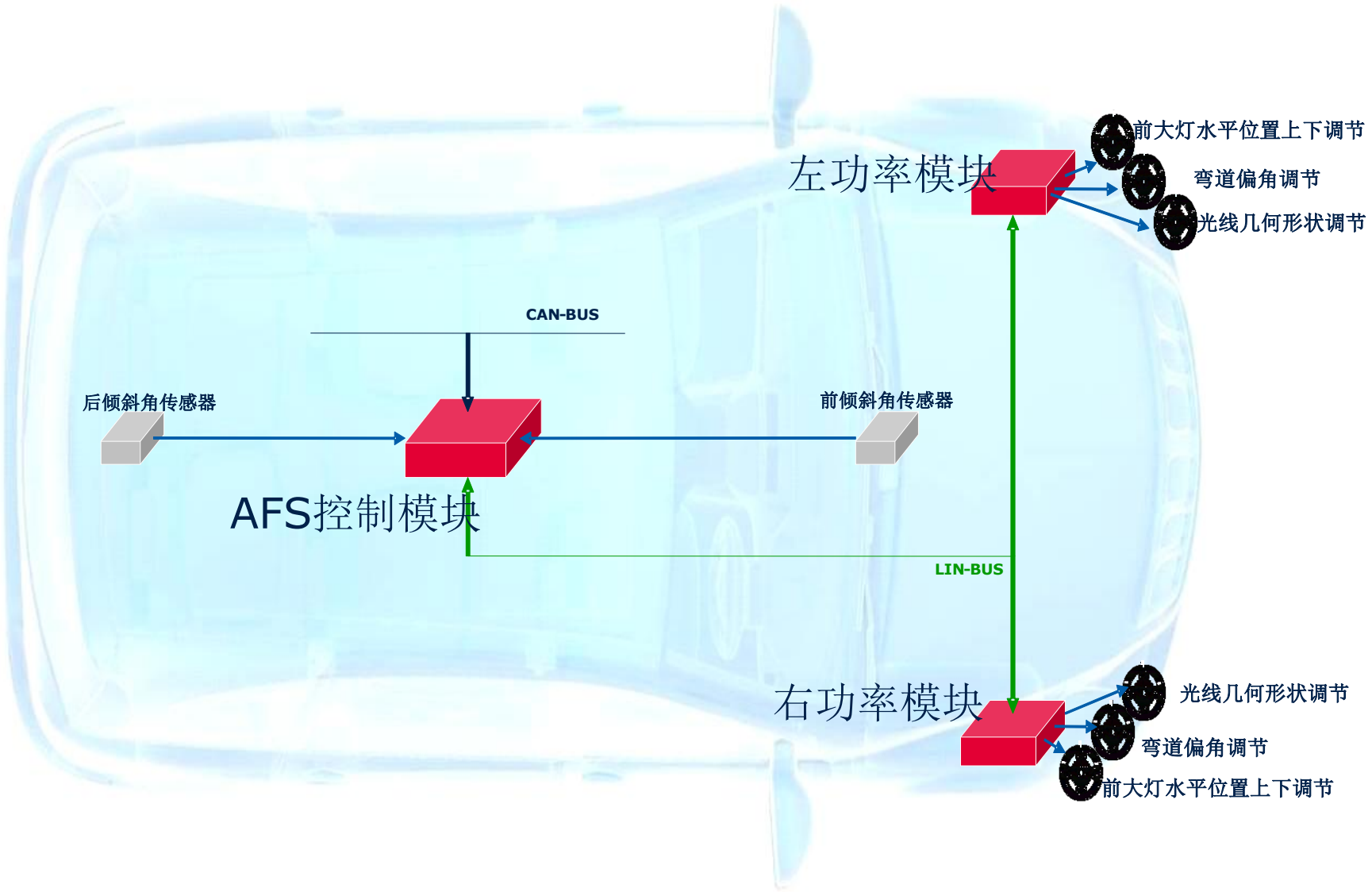




AFS Power Modules

Barth Martin (IFAG ATV BP AE)

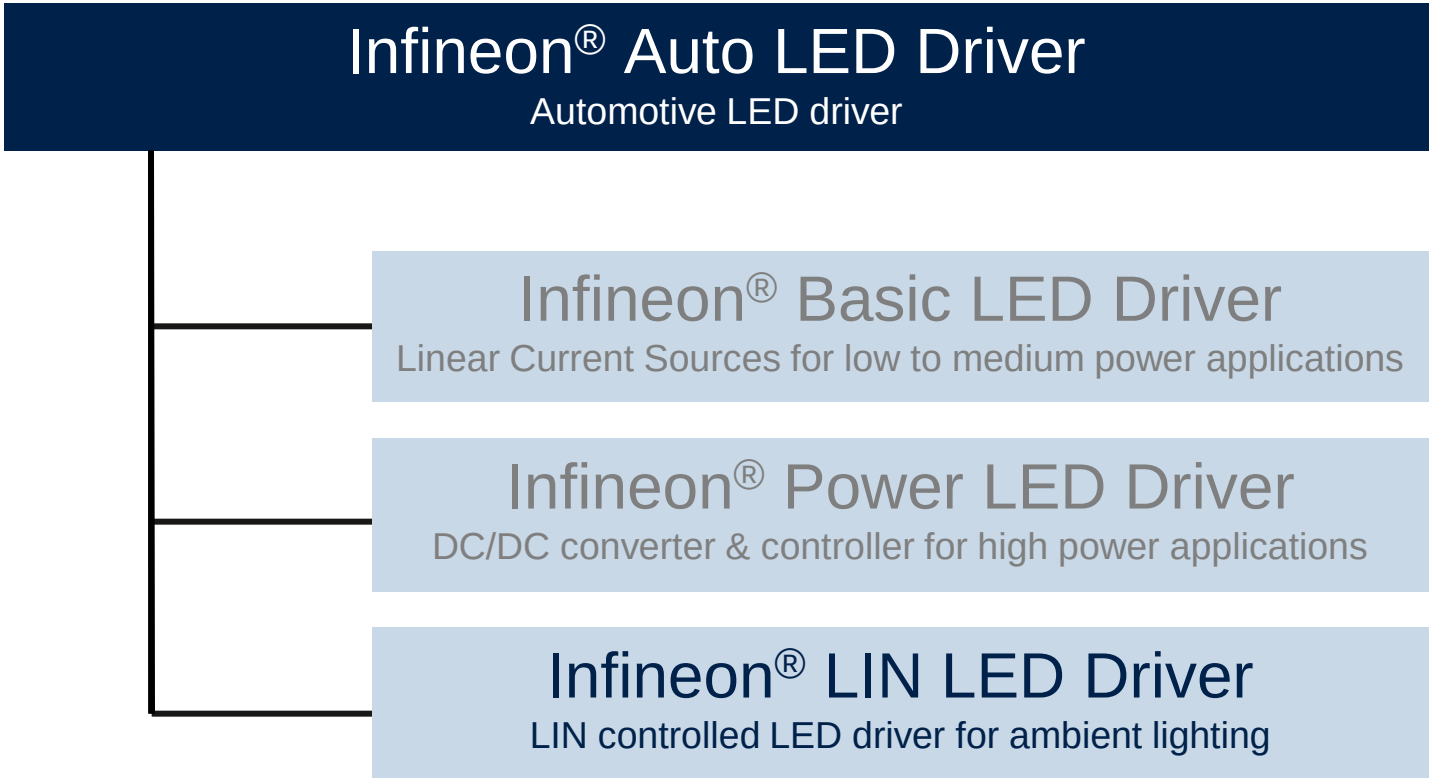




Available Support Material

- Demoboards (overview at website)
- Application Boards (overview at website)
- P-Spice Model for TLD5098EL, TLD5095EL, TLD5085EJ, TLD5045EJ available at www.infineon.com/power-led
- Application Note for TLD5095EL, TLD5098EL available at www.infineon.com/power-led
- Excel Calculation Tool for TLD5095EL, TLD5098EL available on request please contact Dieter Parth

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



Infineon® LINLED motivation

What is the idea and motivation of the Infineon LINLED drivers?

Enable individual car interior design…

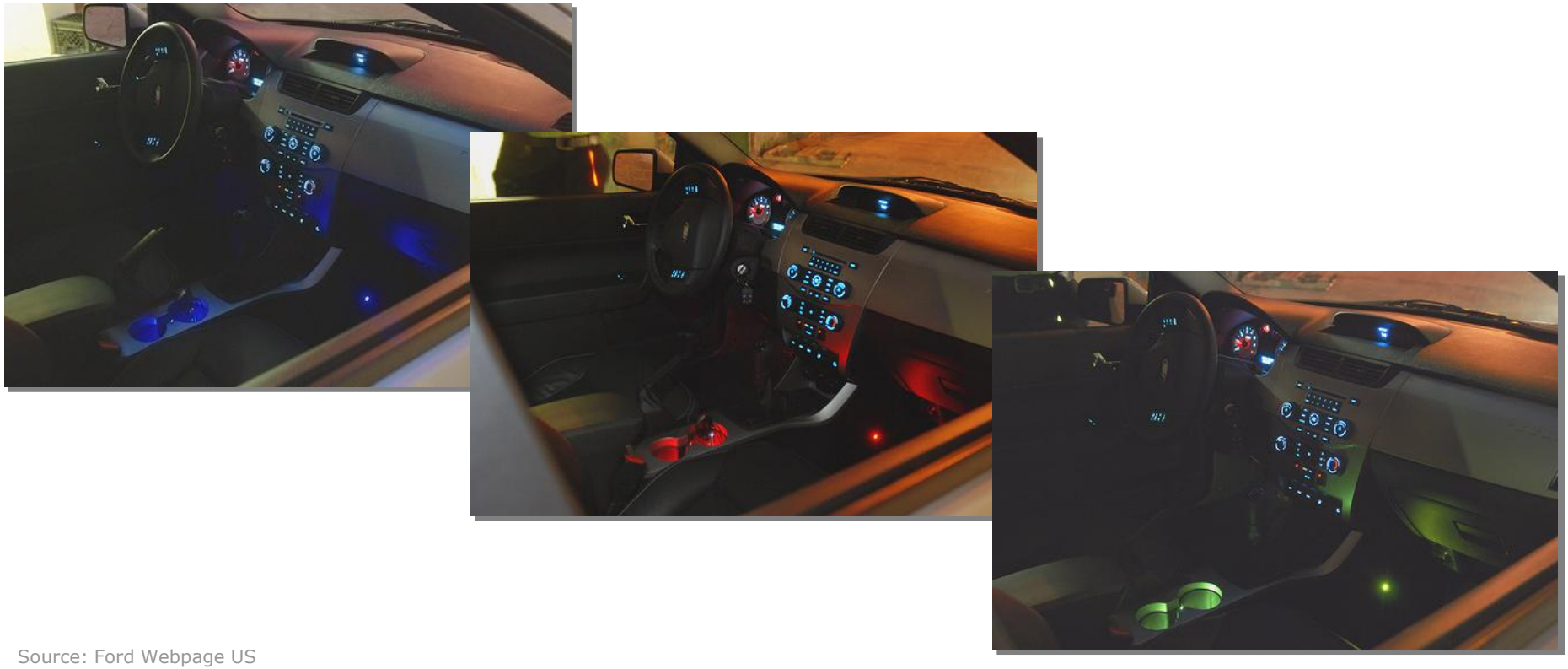
- by decentralized ambient lighting!
- by smart Color and Light Management!

- allows the car driver to adjust color and light settings individually!

Colored Ambient Lighting is already in mass production, e.g. with Ford “MyColor” Technology

Color-controllable LED-based lighting

- Digitally controlled RGB LEDs
- Example: Ford Mustang “MyColor” color-changing instrument panel
- Example: Ford Focus & Mustang MY08 - Ambient Lighting Option



Source: Ford Webpage US

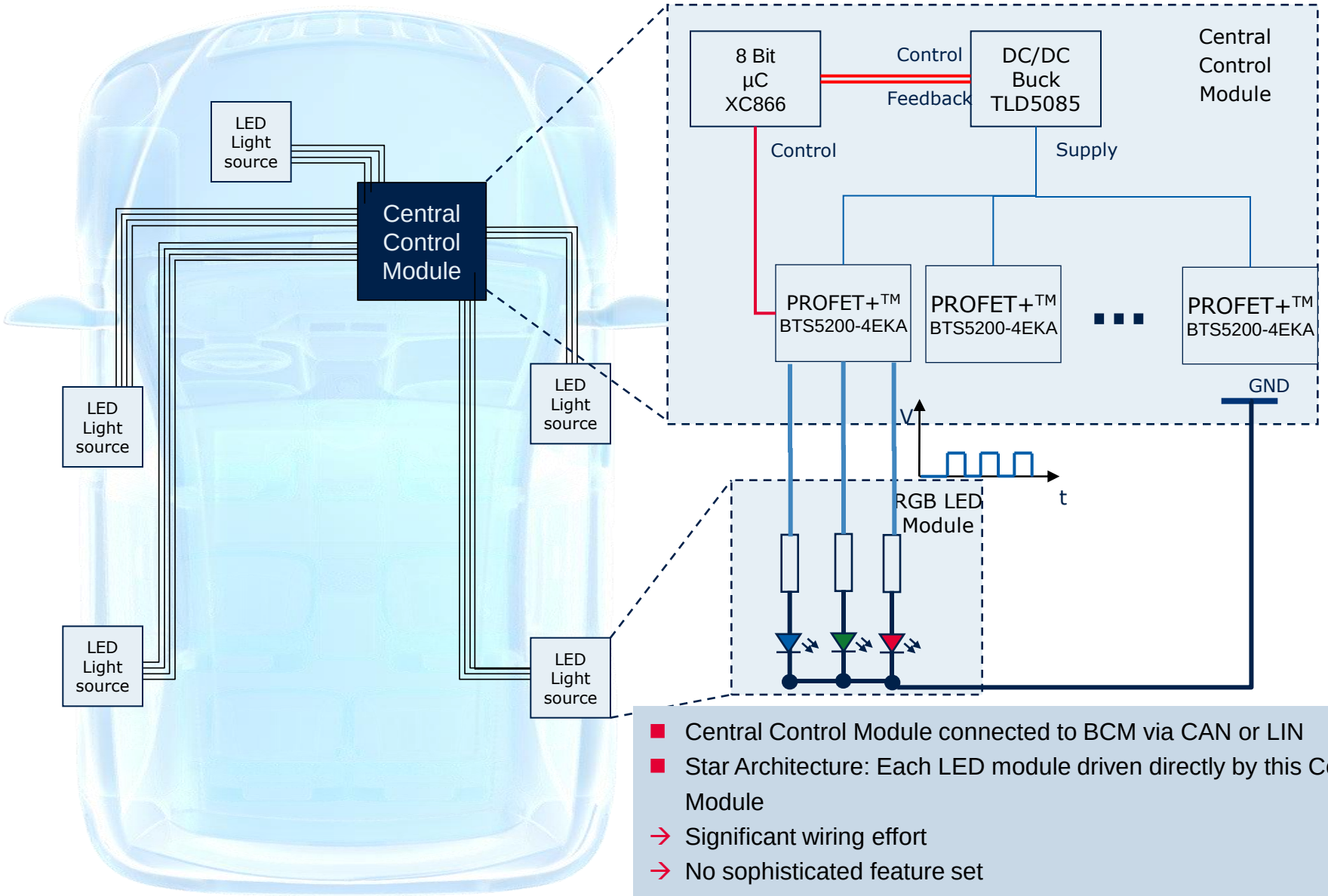
Colored Ambient Lighting already in mass production - Audi

Audi A8 – MY 2010

- Three colors – polar, ivory, rubin
- More than 20 ambient light spots

Source: fourtitude.com
Audi.de

Interior Lighting - Centralized Control
Existing solutions need complex control electronics



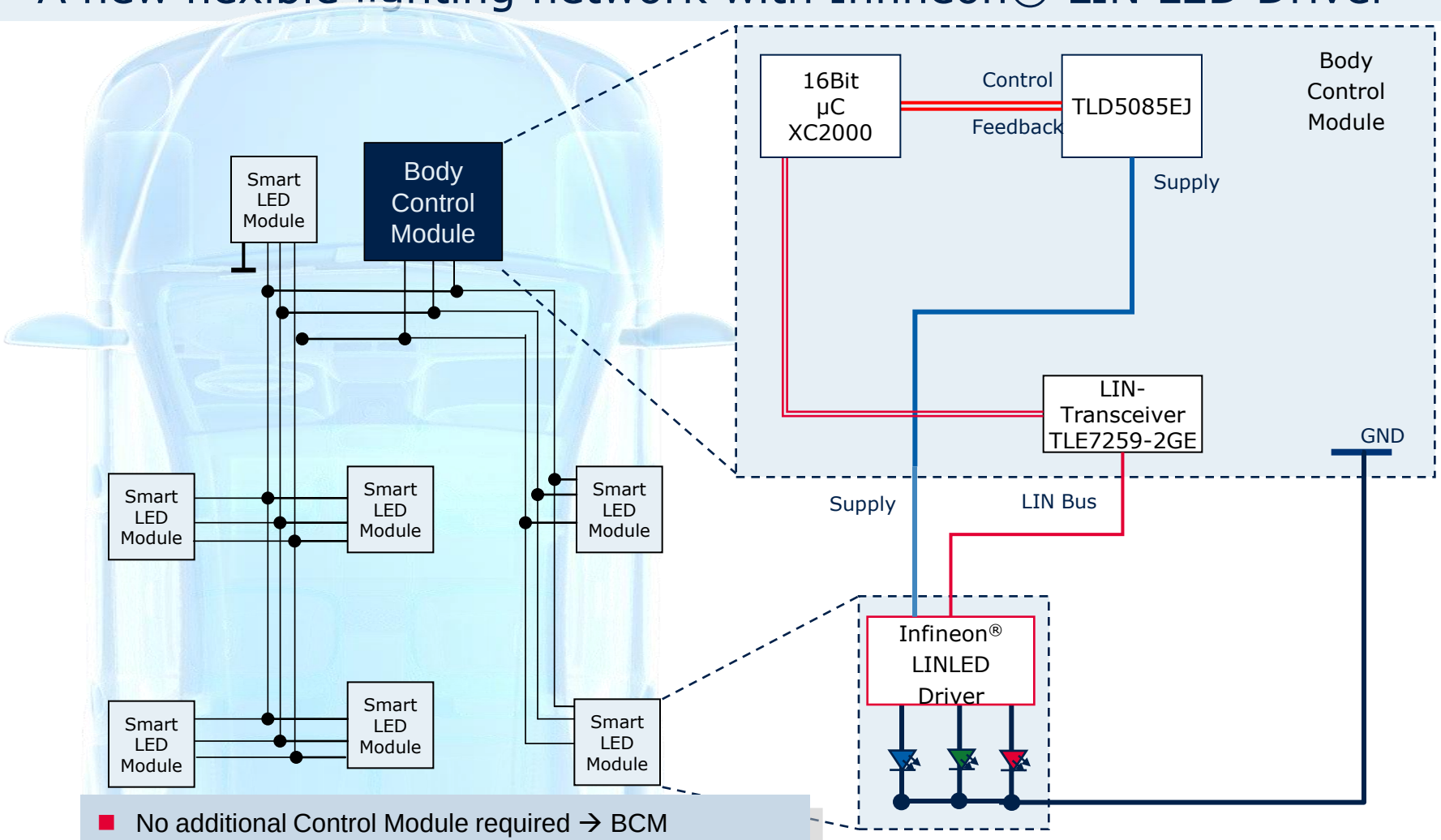
- Central Control Module connected to BCM via CAN or LIN
- Star Architecture: Each LED module driven directly by this Control Module

→ Significant wiring effort

→ No sophisticated feature set

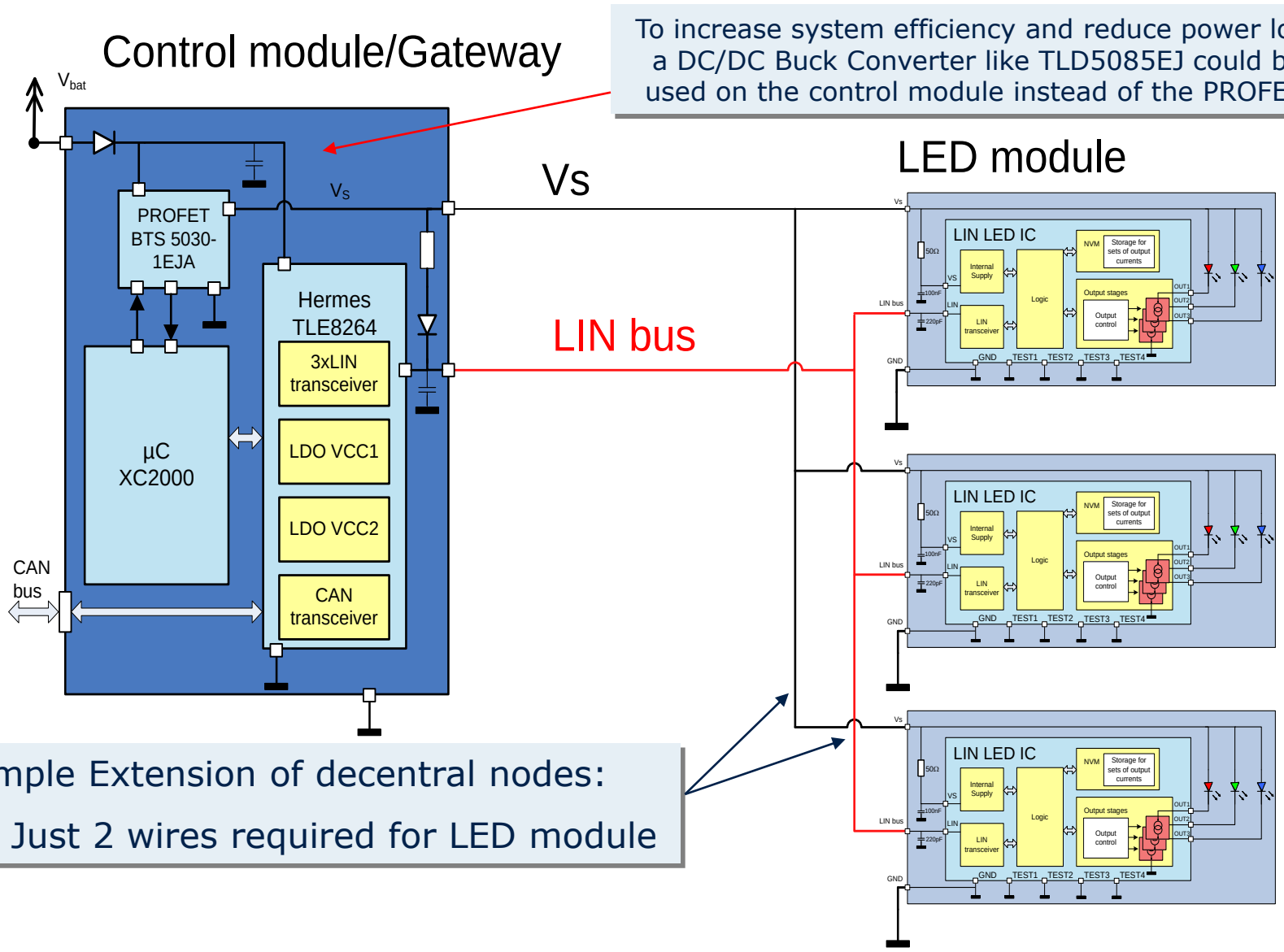
→ Smart central control unit required

Interior Lighting - Decentralized Control
A new flexible lighting network with Infineon® LIN LED Driver

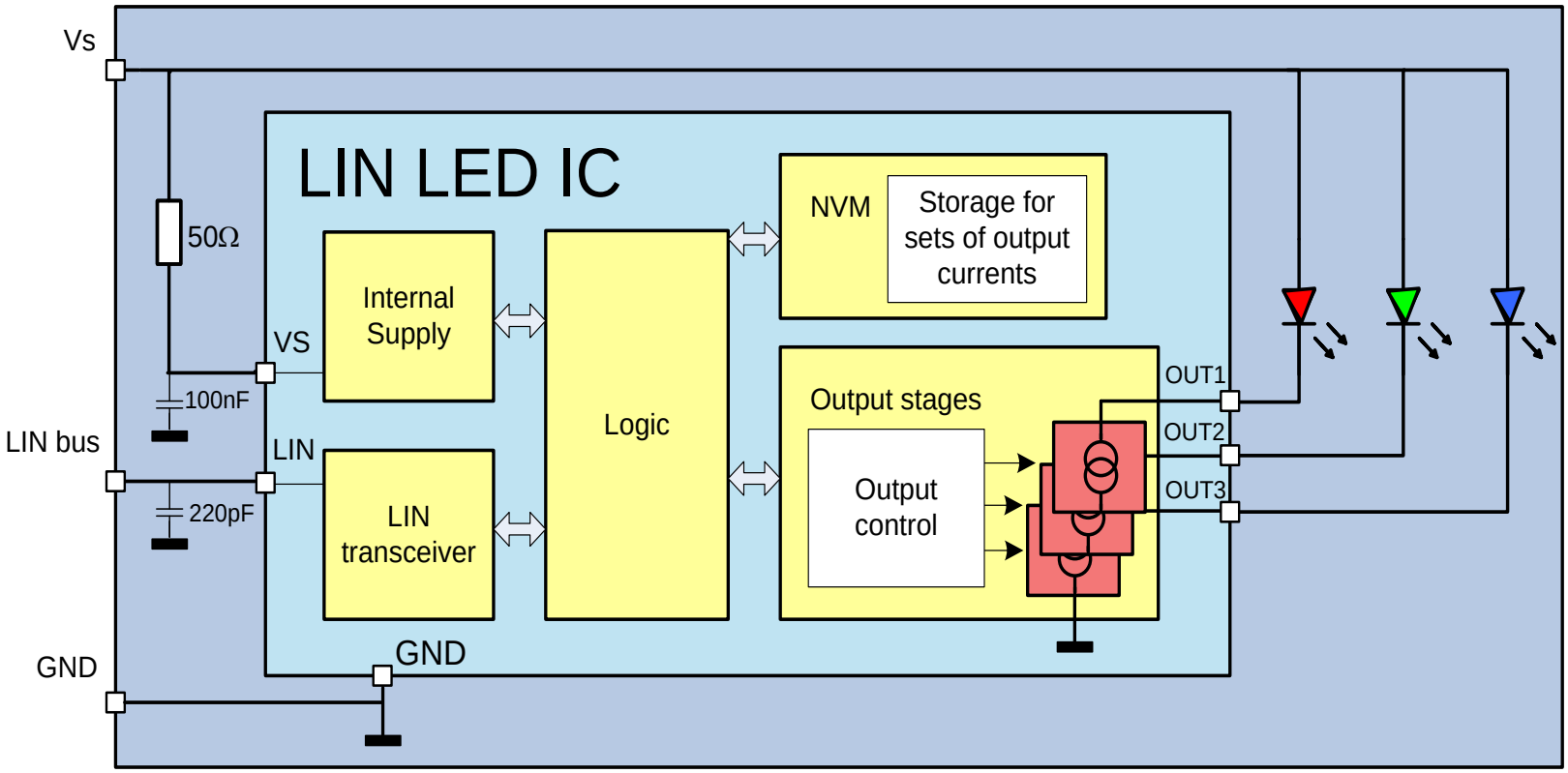


- No additional Control Module required → BCM
- RGB-modules in parallel
- → Simple extension
- → Reduced wiring effort
- → Ready to mount shipped LED modules
- → Smart LED module with sophisticated feature set

Smart LED module with Infineon® LIN LED Driver
→ System diagram



Smart LED module with Infineon® LIN LED Driver
→ Application diagram



LED Module with 3 connections only!

Only 2 capacitors and 1 resistor required!

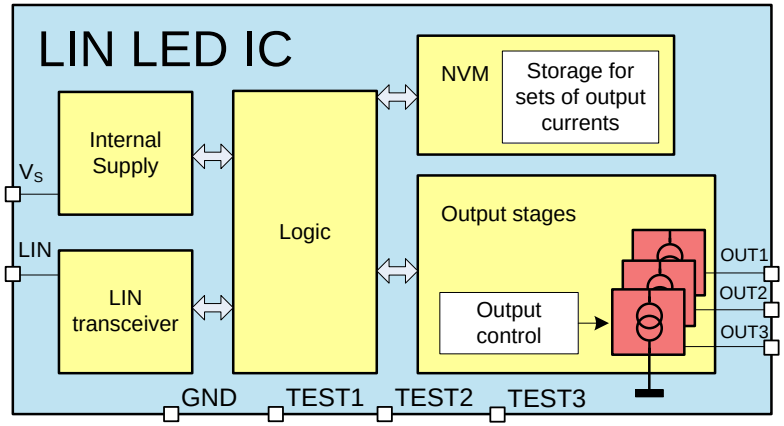
Smart LED module – decentralized control with Infineon® LIN LED Driver IC

available

- 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
  - Theater dimming effects, 16 selectable times, 12 bit res.
  - Smooth color transitions, 8 selectable times, 10 bit res.
- Low power consumption in sleep mode
- Overload protection
- Undervoltage detection

RoHS

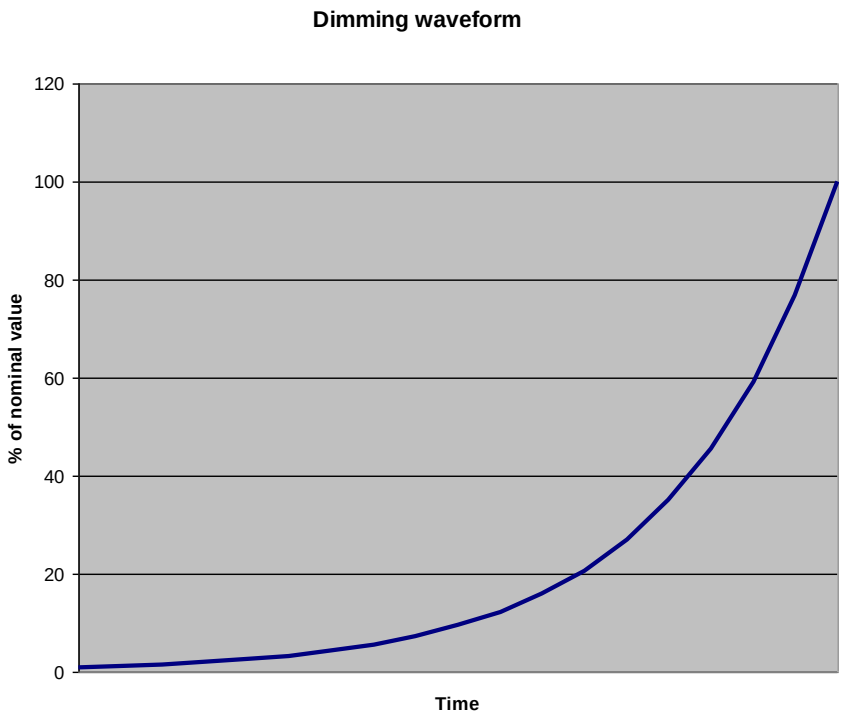
Special IFX Solution for RGB-LED control → NO PWM! → **Variable OFF-time Generator!**



Demo Board available!

Infineon® LIN LED Driver – nonlinear theater dimming function includes dimming between intensities

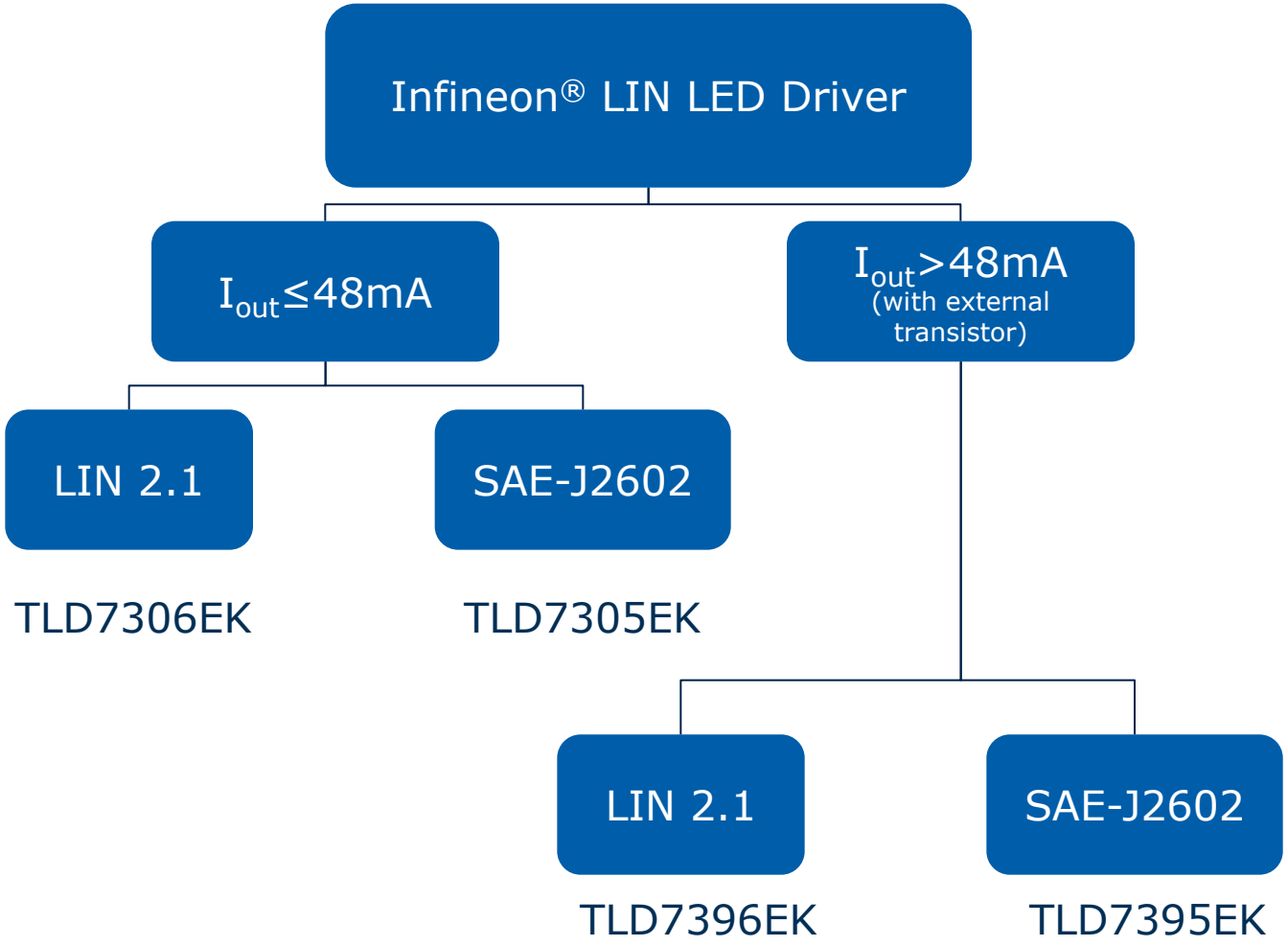
- Smooth dimming possible without "flickering" at low intensities
- Interpolated exponential curve
- Theater dimming resolution 12 bit
- Dimming between intensity levels possible via LIN message
- Dimming time between intensity levels is always constant
  - Example: Dimming from 3% intensity to 0% intensity within 1.7 s without flickering possible!
- Dimming time adoption from 0.3s to 4.6s possible via LIN message



Special IFX Solution for RGB-LED control → NO PWM!

The integrated dimming generation unit has a high internal resolution to enable smooth theater dimming

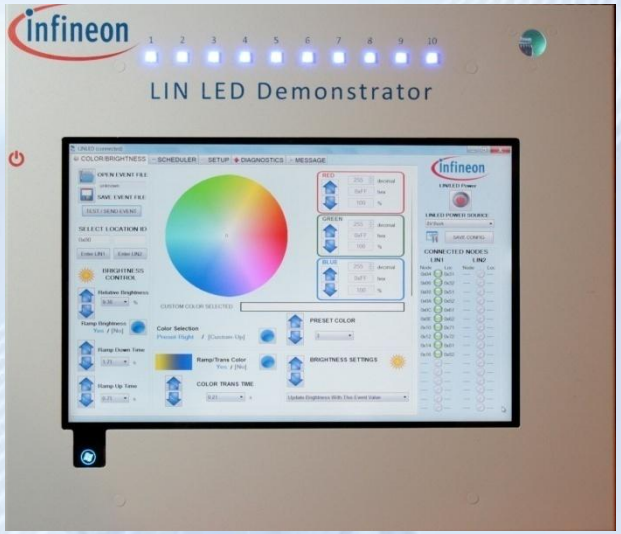
Infineon® LINLED Driver Family



How to support the customers?

Both can be ordered via ISAR

LIN LED System Demonstrator



Benefits

- Evaluate color and brightness in car interiors
- Experiment with color and trim combinations
- Adjust brightness levels depending on location
- Create lighting effects for unique experience

LIN LED Engineering Development Kit

Benefits

- Diagnose LIN and IC faults
- Calibrate and save up to 16 colors in LIN LED IC

LINLED Application Note

- LINLED application note
  - Available at www.infineon.com/LINLED

- LINLED e-learnings
  - Available at www.infineon.com/LINLED

Infineon® LIN LED Driver - Simple Device Handling

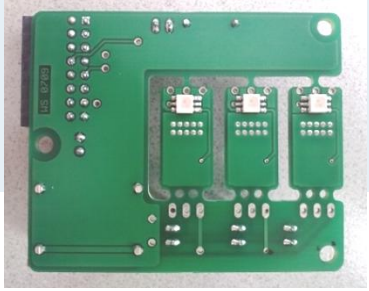
- Mount device and RGB LED onto substrate

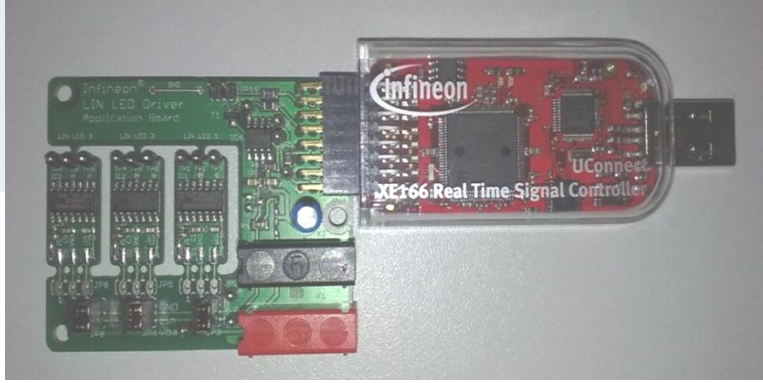
- Color point calibration at TIER1
  a. Iterative sending "Write_Intensity_Set" to LIN LED IC until correct color point is found
  b. Store set of output currents to NVM

- Shipment of completely programmed module

- LIN master addresses LED modules according device node ID
  a. Desired color
  b. Desired intensity

LIN LED Demoboard





- Demoboard Supports
  - Tests of all device functions
  - NVM programming
  - Graphical User Interface (limited functionality)

Individual/custom intensity setting for each output

Select preset color points stored in NVM (16 diff. color points)

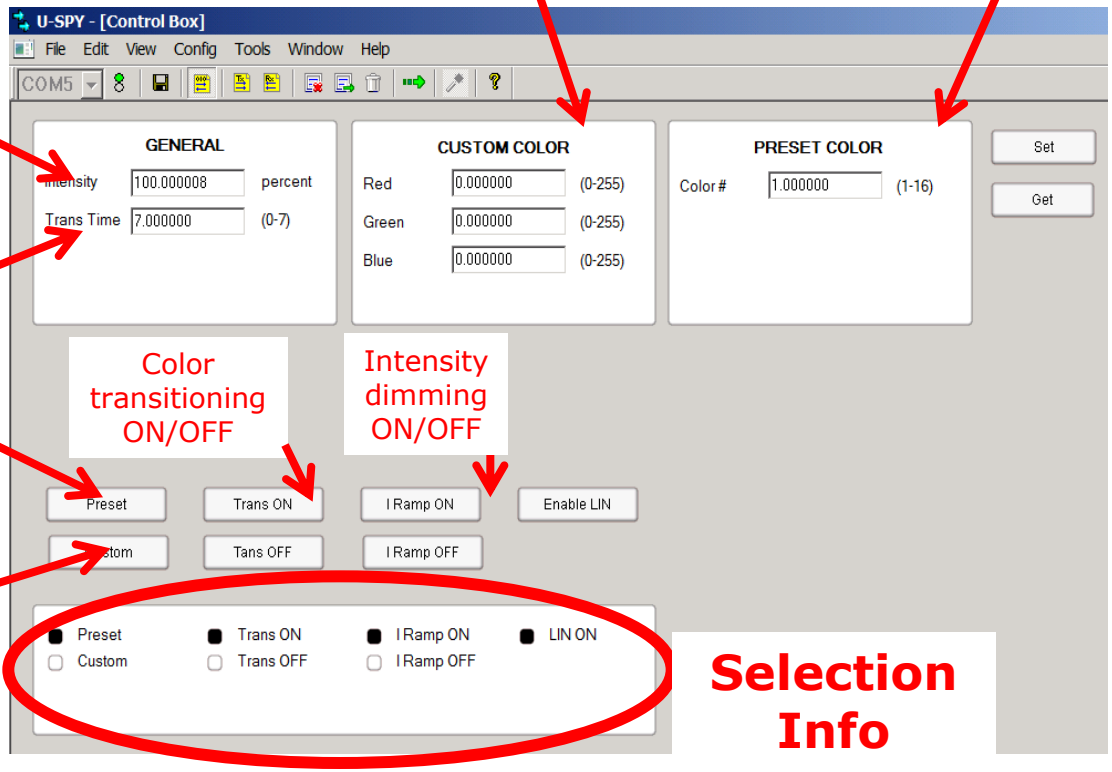
Use new settings

Intensity setting

Transition time (8 values)

Use preset color points

Use custom color points



Selection Info

For internal use only

ENERGY EFFICIENCY
MOBILITY
SECURITY

Innovative semiconductor solutions for energy efficiency, mobility and security.