

LITIX™

Infineon® Automotive LED Solution

2015/10/22

www.infineon.com/litix



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- 6 – LITIX™ Power FLEX

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LED Front and Rear Lighting Driven by Innovation in Design & Functionality



Design is King ...
LED as part of the OEM design language



**Full LED
Headlamps +
Rear Light**



**Dynamic &
decorative
light functions**



**Pixel Light,
Glare Free
High Beam**



Laser Light

LEDs enabling new light functions and help
to underline innovation power of a car brand

Pictures: Internet

Full LED Headlamps and Rear Lights make high demands on LED Driver solutions



- > **Front Light:**
two contradictory trends are visible
 - High End Full LED headlamps
 - with high LED channel count (up to 12)
 - additional functions like glare free high beam, animation, assist systems => High efficient and flexible Driver solution required
 - Low Cost Full Head Lamps
 - For Middle class cars like Seat Leon or VW Polo
 - Cost level of Halogen as target
 - Energy Saving with some importance => cost is king
- > **Rear light:**
"completely" driven by Design
 - Higher LED count or/and high power LEDs to realize uniformity designs
 - OLED to give additional design possibilities in the future
 - Animation and not only for wiping indicator => DC/DC come into discussions especially for OLED designs



Dynamic and decorative Light Functions will enter Front and Rear Lighting

> **Dynamic Indicator**

- Introduced with Audi A8 and R8 now more and more OEM seem to think about introducing it (e.g. Ford Mondeo, Mercedes AMG GT)



> **Welcome Function**

- Additional animated light functions for front (e.g. DRL, turn indicator, ...) and rear lighting (turn indicator, tail, CHMSL, ...)
- First solutions already introduced, e.g. Mercedes (SOP 2014): Multi function light guide for DRL, position and turn indicator with a blue light as welcome function



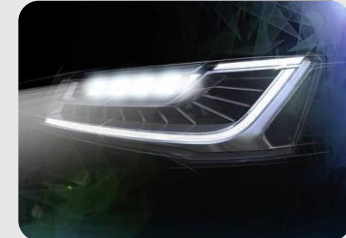
> **Signature Lighting**

- Illuminated Mercedes Star for C-, E-, GL-, M- and CLS-Class
- Mercedes-Benz Accessories



High end LED Headlamps Various Solutions in Place

- > **Different Solutions fighting for innovation leadership**
- > **Matrix-/Pixellighting**
 - Audi Matrix beam
 - A8 in 2013
 - A6, A7 in 2014
 - New TT
 - New A3 (press information)
 - Mercedes Multibeam CLS & further models
 - Opel Matrix Headlamp
 - Mazda Matrix Headlamp announced (internet)
 - Several funding projects looking into pixel counts of >1.000pixel per headlamp
- > **Laser based solutions**
 - Audi R8
 - Audi Laser Matrix announced (internet)
 - BMW i8, 7series



Laser based Solutions are highlighted in the Medias as top automotive (Lighting) Innovations

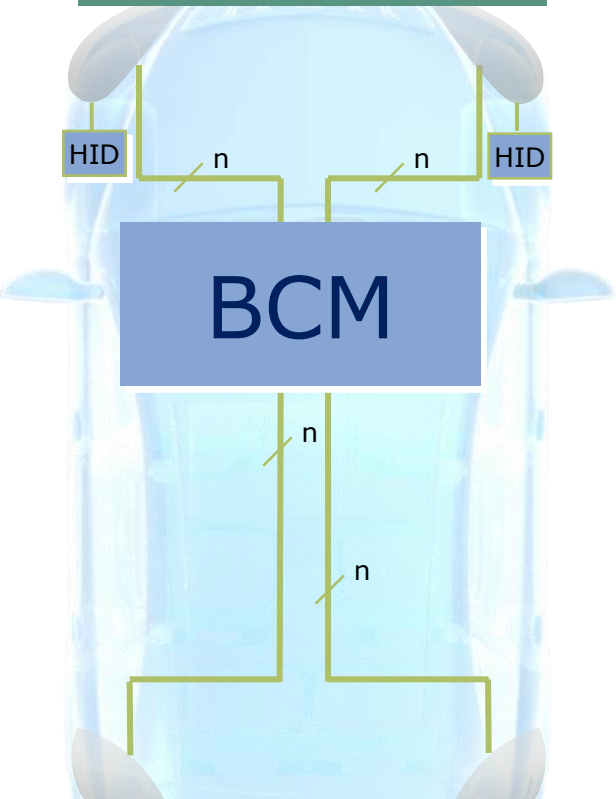
> Laser based solutions, e.g.

- **BMW i8**
 - Low-/High beam in classic LED technology (outside)
 - Inner light function is Laser as additional high beam in combination with an additional LED beam for the near field (e.g. for driving within city limits)
 - Very flat front light in combination of 600m range for the high beam.
- 7series MY16, with Laser as option
- **Audi R8**
 - Active only above 60km/h
 - Advanced high beam assistant system
- **Today a niche market with many open questions, but with BMW 7series option it is trickling down into additional car models**



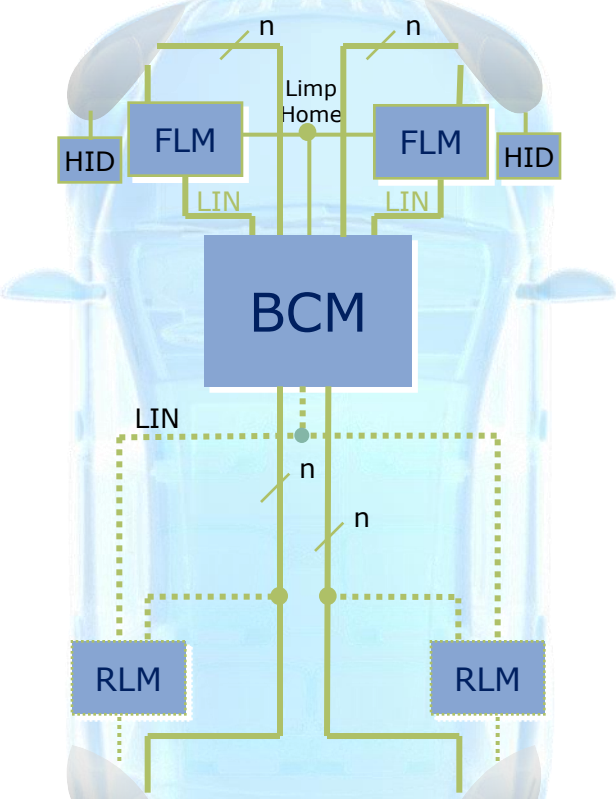
IFX offers a broad Range of Products to serve the various needs of Automotive Lighting/BCM Applications

Centralized Architecture Today



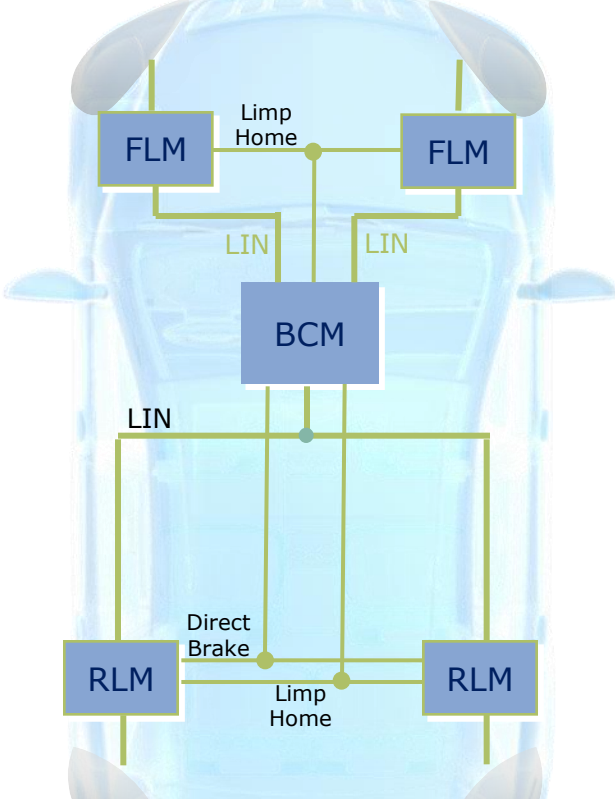
LED as an option
For **Certain** Car Models of One Platform

Partially Decentralized Architecture > 2012*



LED - only
For **Certain** Car Models of One Platform

Fully Decentralized Architecture > 2020*



LED - only
For **All** Car Models of One Platform

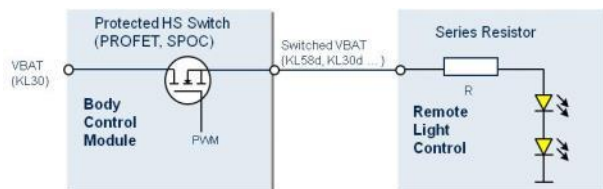
*) First platforms

LED Driving Concepts

Concept

Applications

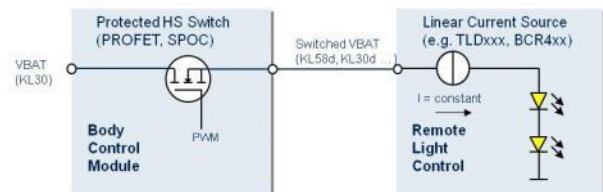
Characteristics



Resistor

- › Rear Lighting
- › Interior Lighting
- › Ambient Lighting
- › Front Signal Lighting
- › Dual Bulb/LED operation
- › 1 to 4 W typically

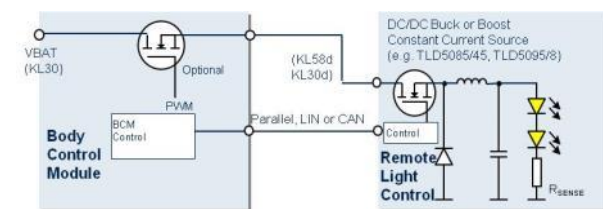
- › Supports Dual Bulb/LED Operation
- › Protection against Shorts and Transients
- › Diagnosis and PWM control on BCM
- › Medium Power Dissipation
- › Reduced LED lifetime Due To Current Peaks
- › No Intrinsic Overvoltage Protection
- › Usable LED Current Lower Than Nominal Current



Linear Current Source

- › Rear Lighting
- › Interior Lighting
- › Ambient Lighting
- › Front Signal Lighting
- › Dual Bulb/LED operation
- › 1 to 4 W typically

- › 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



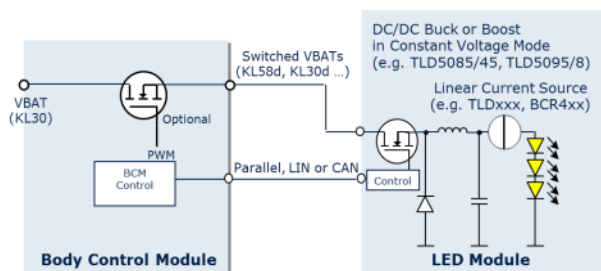
DCDC Controller & Converter

- › Low Beam
- › High Beam
- › DRL
- › Fog Light
- › 4 to 60 W typically

- › 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

LED Driving Concepts

Concept



DC/DC + Linear Current Source in Matrix configuration

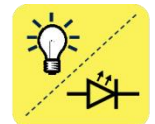
Applications

- > Low Beam
- > High Beam
- > DRL
- > Fog Light
- > Rear Lighting
- > Front Signal Lighting
- > 1 to 60 W typically

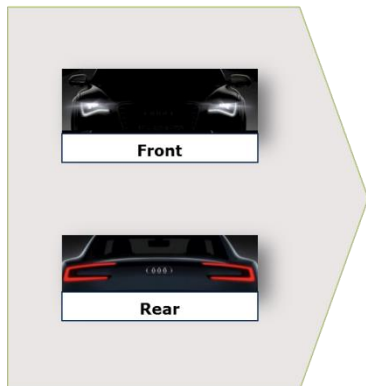
Characteristics

- > 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

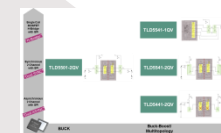
Automotive Lighting smartly driven by Infineon since more than 20 Years



Lighting Today



Lighting Future



2016

Front light

Most flexible & efficient multi-topology DC/DC Controller family

LITIX™ Power Flex



2014

Rear/Tail light

1st integrated LED driver on the road with diagnosis

LITIX™ Basic



Courtesy: AUDI

2013

Matrix/Pixel

1st Matrix beam headlight system on the road with LITIX™ Power



2011

Front Lighting

1st generation of DC/DC LED Driver on the road

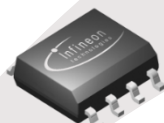
LITIX™ Power



2008

Bulb/LED support

1st Integrated Smart Hi-Side switch with dedicated LED mode
SPOC™ family



2002

Introducing LED

1st Infineon LED driver on the road in LED exterior lighting systems

LITIX™ - Auto LED Driver (LITIX™ brand introduced in 2015)



1993

Protected Bulb Switching

1st "Smart" Hi-Side switch on the road
PROFET™ family



Frontend Technologies used for Lighting Applications						
SPT	Bipolar CMOS DMOS	SPT4	SPT5	SPT6	SPT7	SPT9
Smart	Common Drain	SSMART	Smart5	Smart6	Smart7	
DOPL	Bipolar	DOPL3	DOPL4	Supply1		
... PFET, SFET (MOSFET)						

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LITIX™ Infineon® Automotive LED driver

LITIX™ **Linear**

Linear Current Sources for low to high power applications

LITIX™ **Basic**

Linear Current Sources family with flexible feature set

LITIX™ **Power**

DC/DC converter & controller for high power applications

LITIX™ **Power Flex**

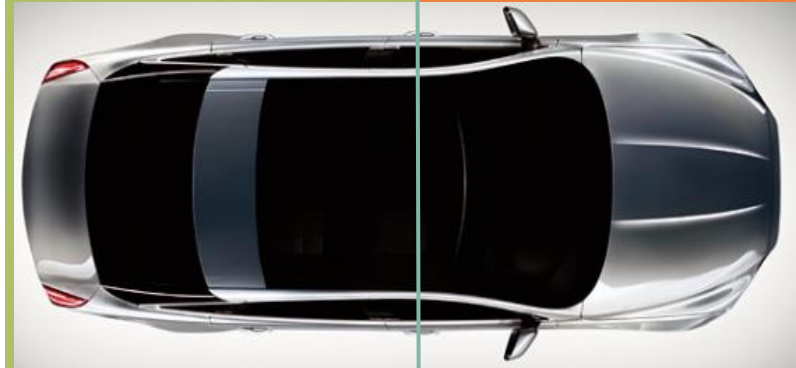
DC/DC controller for highest flexibility / power applications

REAR LED

Linear Current Drivers
(DCDC for OLED)

Front LED

DCDC Controllers
(Linear Current Drivers for Low Cost)



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



LITIX™

Infineon® Automotive LED driver

LITIX™ **Linear**

Linear Current Sources for low to high power applications

LITIX™ **Basic**

Linear Current Sources family with flexible feature set

LITIX™ **Power**

DC/DC converter & controller for high power applications

LITIX™ **Power Flex**

DC/DC controller for highest flexibility / power applications

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LITIX™ Linear – TLD1211SJ

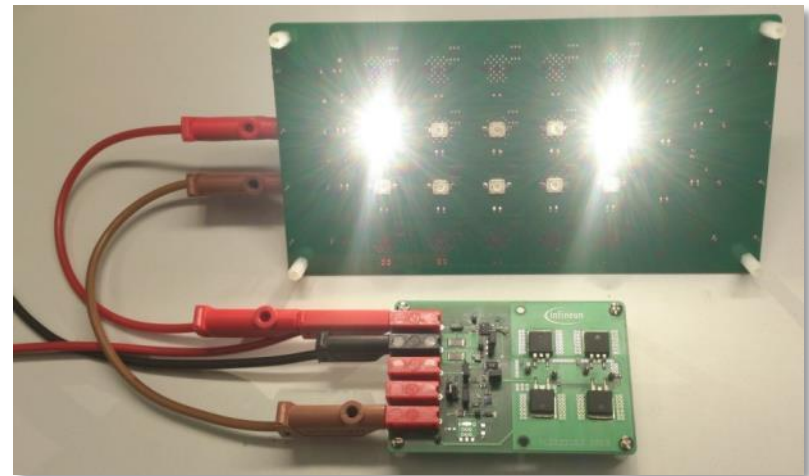
High Current Applications PRO/CON



PRO	CON
Simple circuitry	Power efficiency
Standard components	Supply voltage range
No significant EMC radiations compared to DCDC converter solutions	
LED over-temperature protection	

Target Applications

- › Low cost Front Lighting
 - Low- / High Beam
 - Fog
 - DTRL
 - ...



LITIX™ Linear – established Current Sources for low, mid and high Power Application



LITIX™ Linear

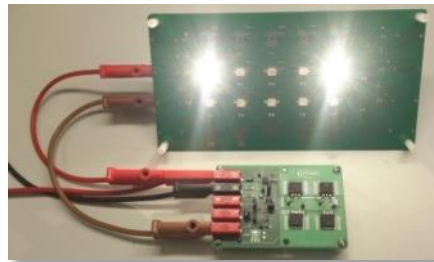
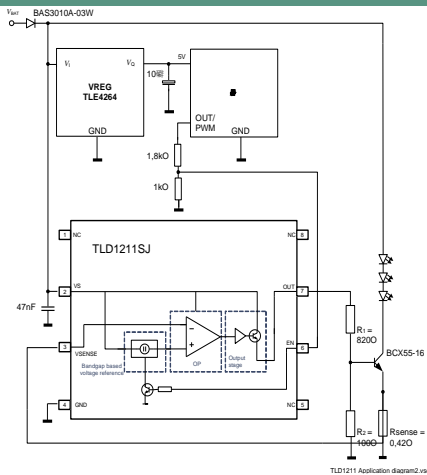
	Current		Open Load Detection	PWM/Enable	Hi/Low Current Switch	Package
	mA	adj.				
BCR40xU	10-50 _{typ}	✓				SC-74
BCR420U	150 _{typ}	✓				SC-74
BCR421U	150 _{typ}	✓		✓		SC-74
TLD1211SJ	85 _{typ}	✓		✓		DSO-8
TLE4241GM	70 _{max}	✓	✓	✓	✓	DSO-8
TLE4242EJ	250 _{typ}	✓	✓	✓		DSO-8 EP
TLE4242G	450 _{typ}	✓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

Well established in the Market



Picture Source: Internet

TLD1211EJ for low cost front light



OPTION for high current LEDs

Key Features & Benefits

- › Stable and reliable LED brightness by precise current control
- › Improved system reliability by significant component reduction (from discrete to integrated) on board level
- › Linear current sources for low (10mA), mid (up to 500mA) and high power application (with TLD1211SJ + ext. Transistor up to 2.5A)
- › built in protection and for some devices diagnostic features

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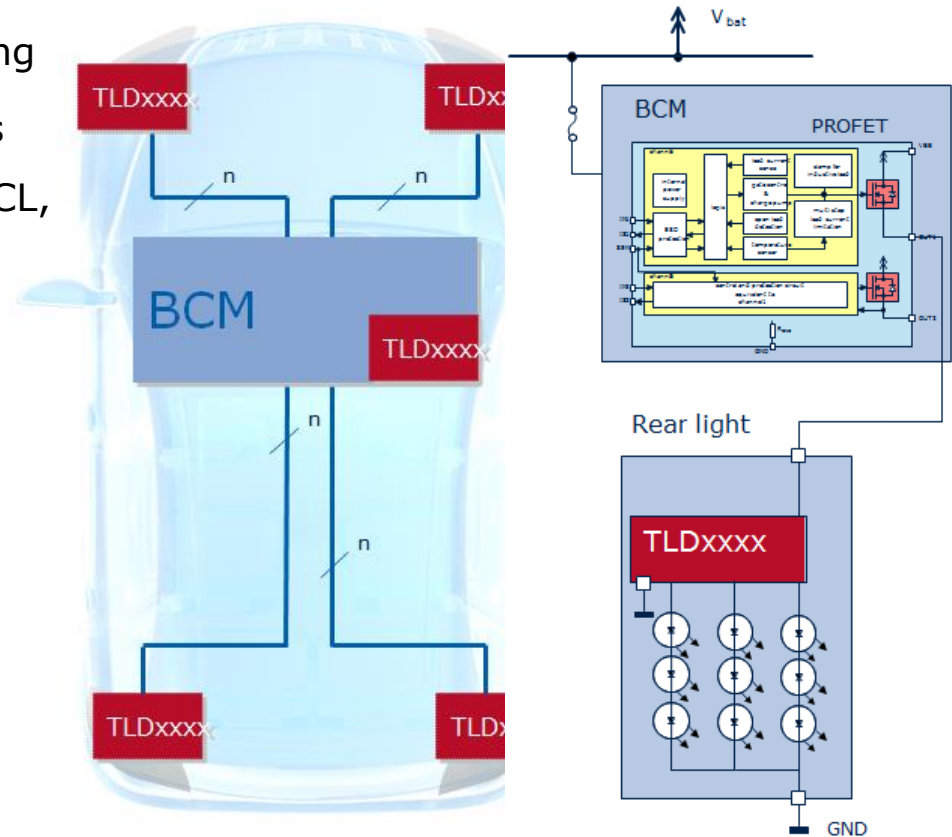
5 – LITIX™ Power

6 – LITIX™ Power FLEX

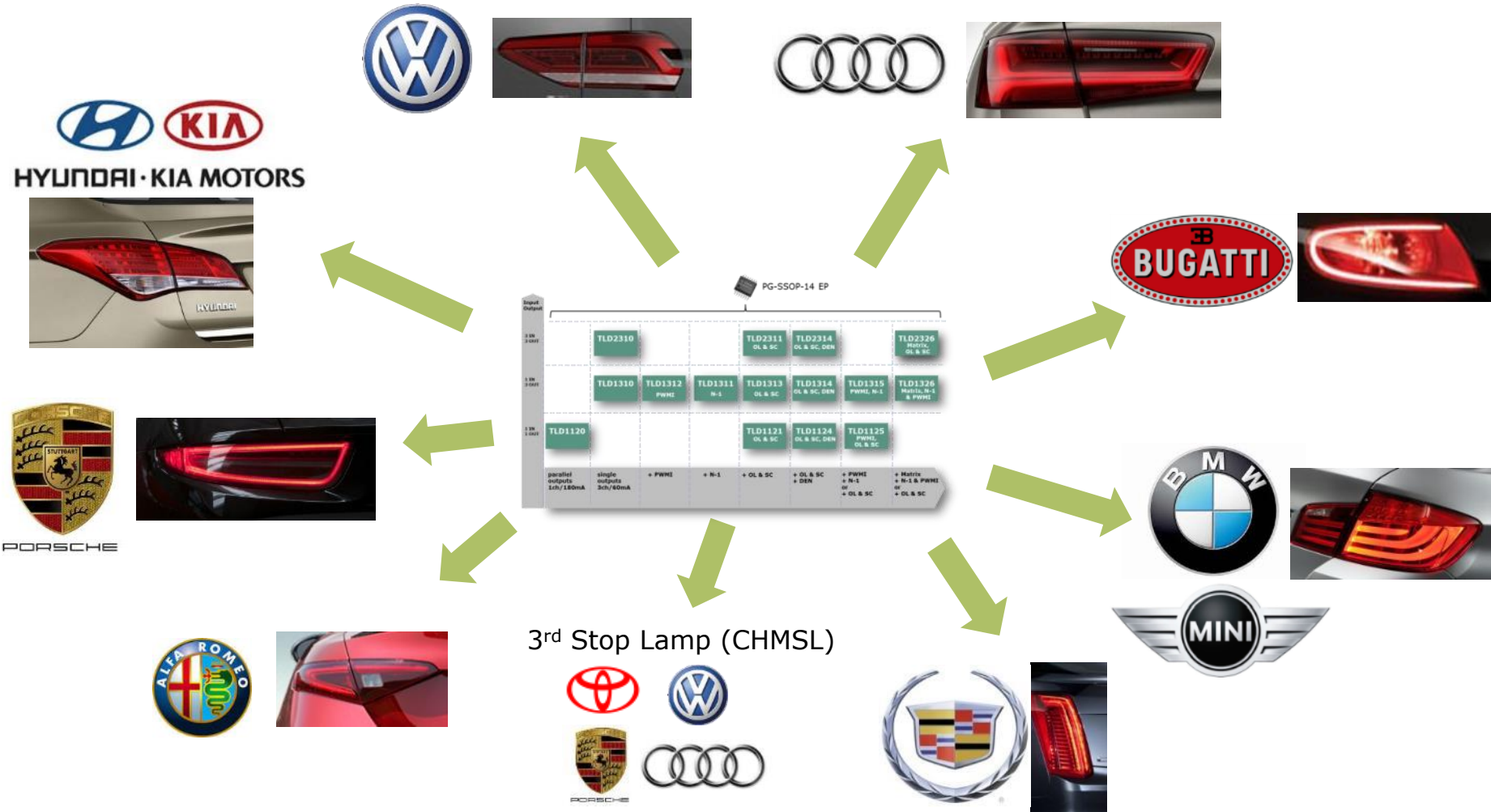
LITIX™ Basic major target application is Automotive exterior and interior LED lighting



- › Automotive exterior and interior LED lighting
 - Low to medium power LED applications
 - e.g. position, turn, tail, stop, CHMSL, RCL, reverse, fog, dome



The LITIX™ Basic is very well received in the Market since its Launch in early 2014



3rd Stop Lamp (CHMSL)



Depending on OEM and car model 4 to more than 40 LITIX™ Basic per car for Rear light applications

Beside Rear Light we see also some other Applications for LITIX™ Basic – DI/DW Selection



- › Status Lamp for onboard charger
- › Device: TLD2310EL
- › Status: 1 Design-win & several design-in



- › Trunk light
- › Device: TLD1120EL
- › Status: Design-win



- › Dome light
- › Device: TLD1121EL
- › Status: Design-win



- › 1 light function on BCM/Light Module:
- › Device: TLD1120EL
- › Status: Design-win



- › Dynamic turn indicator - front
- › Device: TLD2314EL
- › Status: 1 Design-win and 1 Design-in



- › Dashboard illumination
- › Device: TLD2314EL
- › Status: Design-in



- › Door Pocket LED
- › Device: TLD1xxEL
- › Status: Design-in



- › Door Handle LED
- › Device: TLD1125EL/2311EL
- › Status: Design-in

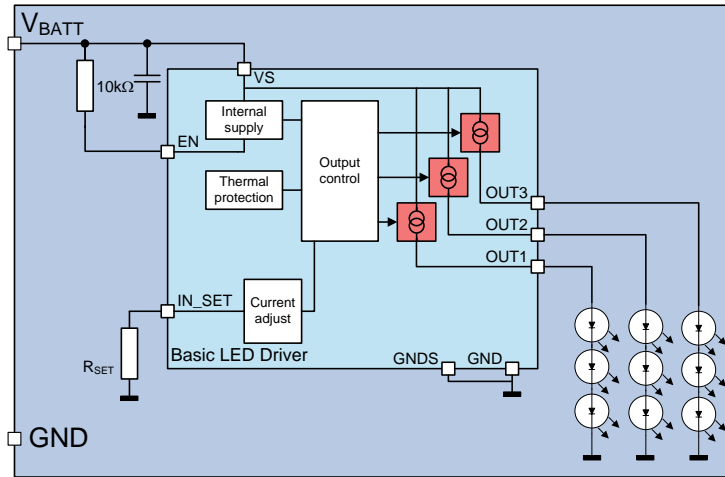


LITIX™ Basic

15 linear current sources with scalable feature set



Block diagram



Example TLD1310EL

Feature Set

Basic features

- › 1 to 3 output channels; typ. 60 to 180mA
- › Output current adjustable (ext. low power R_{set})
- › Wide supply voltage range 5.5...40V
- › Over Load and Over Temperature protection
- › PWM via external PWM signal via EN or VS

Optional features

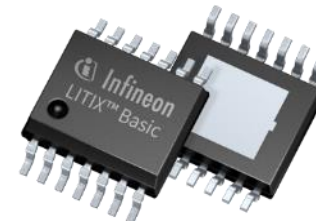
- › N-1 or Open Load and Short Circuit detection
- › Diagnosis enable feature
- › Integrated PWM dimming engine to provide two LED brightness levels only with RC-network
- › Matrix setup with DC/DC buck or boost converter – Infineon® Dynamic Overhead Control

System Benefits

- › Scalable feature set for dimming and diagnosis
- › Pin-to-pin footprint compatibility
- › Reduced system complexity
- › Reduced effort for design adaptations
- › Increased lifetime for LED and driver by integrated protection

Package

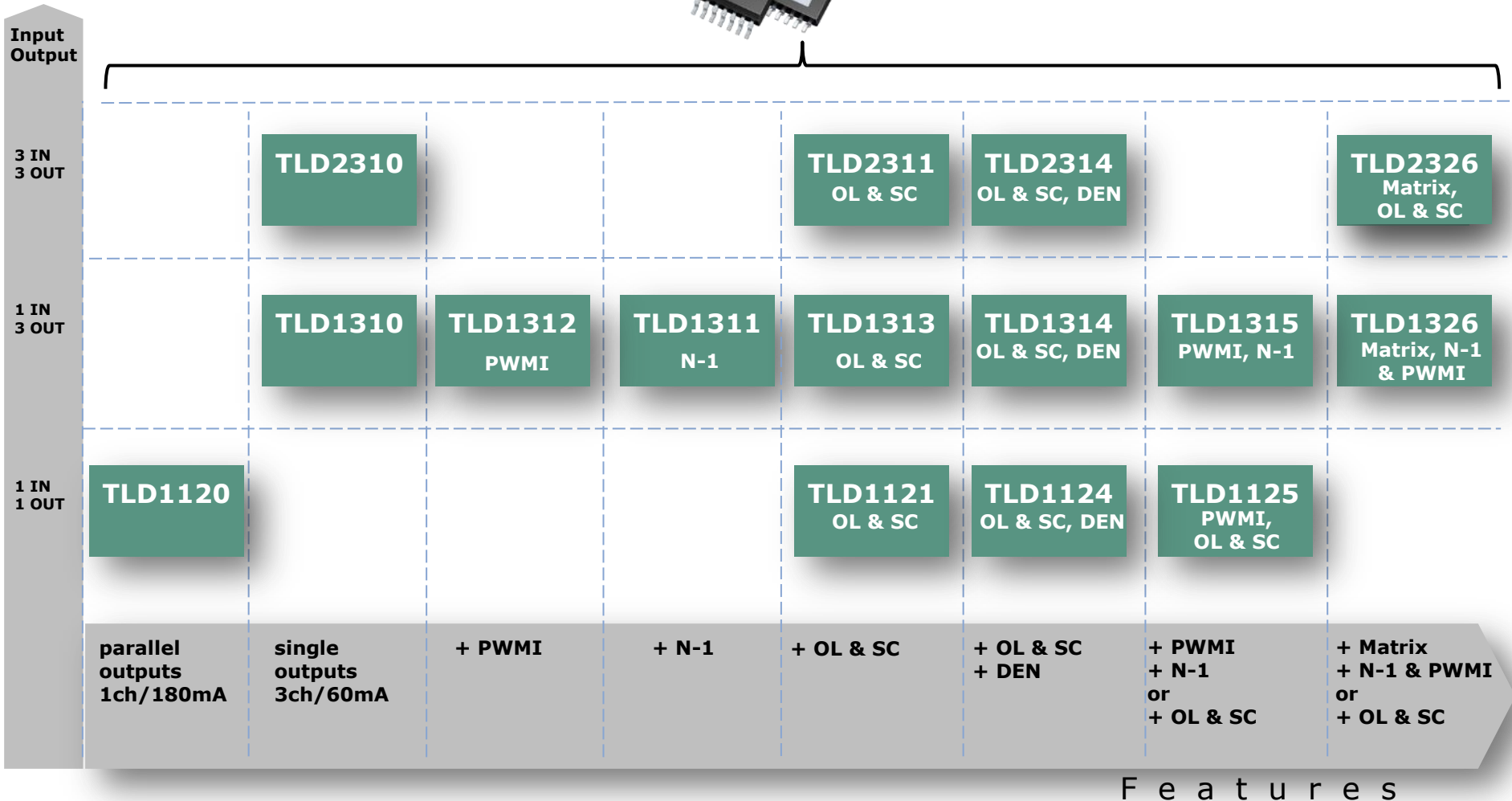
- › PG-SSOP14 Exposed Pad



LITIX™ Basic – a modular Family Concept scaled by Features and Channels



PG-SSOP-14 EP

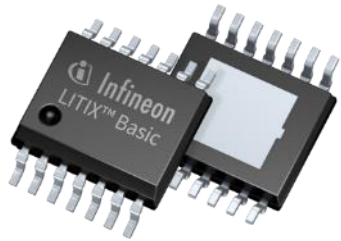


LITIX™ Basic - Maximum Design Flexibility

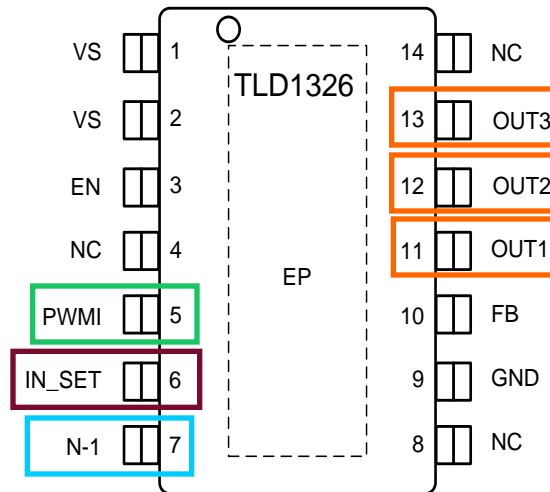
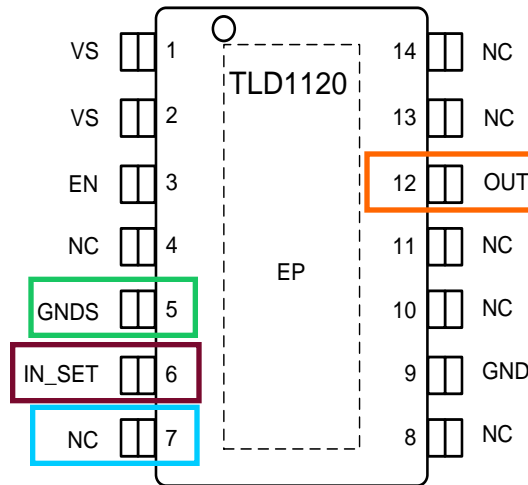
by Cross-Device Feature & Pin-Out Compatibility



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 00hm resistor)

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

Reliable Control of low to medium Power LEDs by IFXs LITIX™ Basic

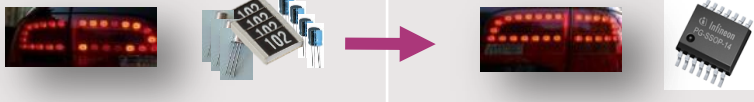


Driving low to medium Power LEDs



Discrete

Integration



- resistors
- OP amps
- zener diodes

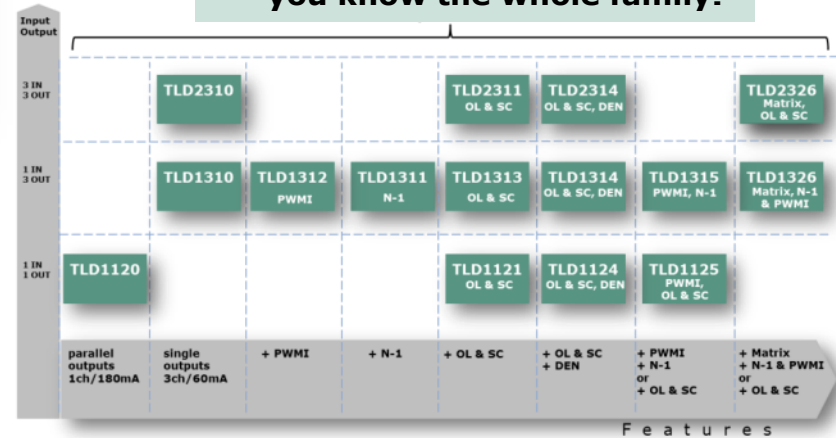
- LITIX™ Basic

Customer Benefits

- › Stable and reliable LED brightness by precise current control
- › Improved system reliability by significant component reduction (from discrete to integrated) on board level
- › Improved system protection (e.g. against ISO pulses)
- › Enabling energy optimized system solution (DCDC control)
- › Design flexibility
- › Ease of design by identical feature set

LITIX™ Basic

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



Product USPs

- › Footprint compatibility of whole family ranging from 1 to 3ch and 60 to 180mA
- › Modular feature scaling
- › Diagnostics optimized for automotive LED requirements
- › PWM via external PWM signal and optional via integrated PWM engine
- › Feedback pin for optimized DCDC control

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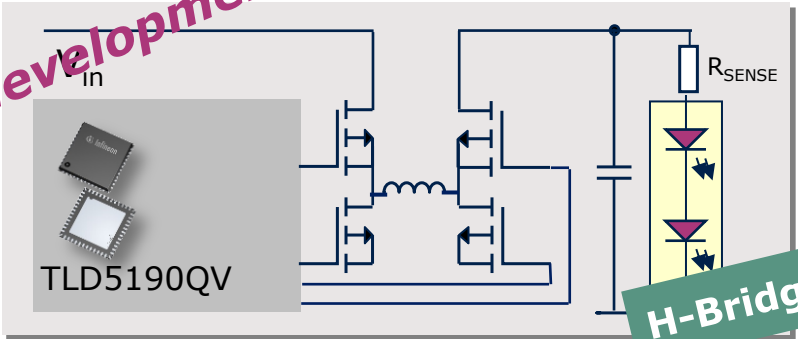
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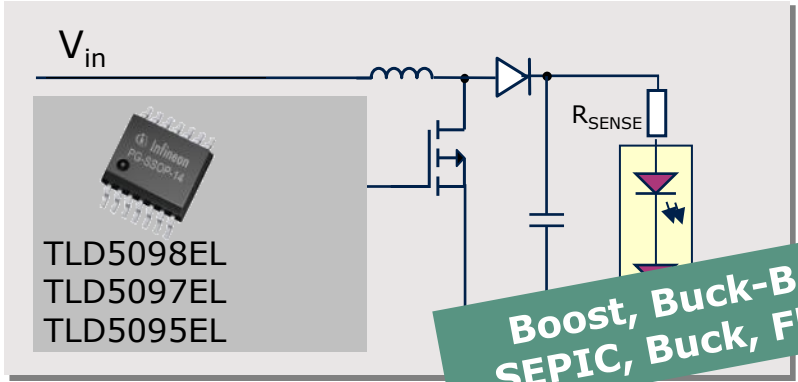
In development



TLD5190QV

H-Bridge

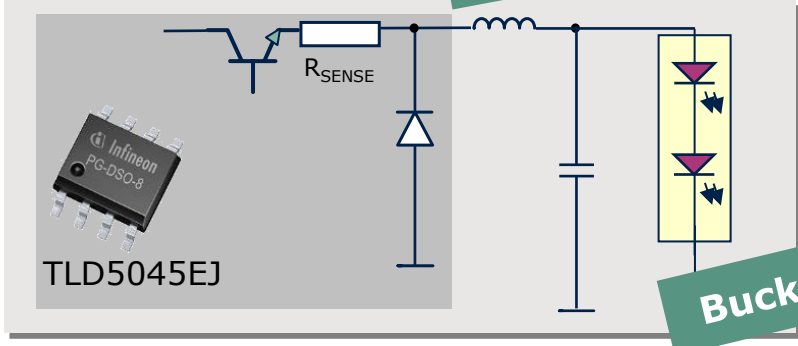
H-Bridge DC/DC Driver IC
Highest efficiency H-Bridge with external power stages
+ IOUIMON
+ Spread Spectrum



TLD5098EL
TLD5097EL
TLD5095EL

Boost, Buck-Boost, SEPIC, Buck, Flyback

Smart DC/DC Controller IC
Driver stages for external switching transistors implemented



TLD5045EJ

Buck

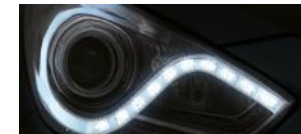
Integrated **Smart DC/DC Driver IC**
Integrated Switching transistor (700mA)
+ freewheeling diode
+ sense resistor integrated

- › Infineon is driving new LED solutions in...
- › **Front Lighting**



TLD5098

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



Picture Source: Internet

LITIX™ Power

TLD5045EJ - Success Story



DC/DC Buck Converter

- › for 1-3 High power LED
- › Maximum Output current: **700mA**
- › Wide input voltage range: **5V ... 40V**
- › Very low quiescent current: $<2\mu\text{A}$
- › High Integration
 - Power switch
 - Sense resistor
 - **Fast freewheeling diode**
 - **PWM dimming engine**
 - 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

Illuminated Mercedes Star for C-, E-, GL-, M- and CLS-Class Mercedes-Benz Accessoires

		TLD5095EL	TLD5097EL	TLD5098EL
Topology	BOOST	YES ✓	YES ✓	YES ✓
	BUCK	YES ✓	YES ✓	YES ✓
	BUCK-BOOST	YES ✓	YES ✓	YES ✓
Operating Voltage	MIN	4.75V	4.5V	4.5V
	MAX	45V	45V	45V
Integration		Controller (2 Gate Drive)	Controller (1 Gate Drive)	Controller (2 Gate Drive)
MAX LED Current		scaleable	scaleable	scaleable
MAX Output Voltage		45V	61V	61V
LED current accuracy		±6.6%	±3.3%	±3.3%
Operating Temperature	MIN	-40°C	-40°C	-40°C
	MAX	150°C	150°C	150°C
LED current Dimming	Digital (PWM)	YES, with dedicated PWM Gatedriver	YES ✓	YES, with dedicated PWM Gatedriver
	Analog	NO ⚠	YES ✓	YES ✓
Switching Frequency	MIN	100kHz	100kHz	100kHz
	MAX	500kHz	500kHz	500kHz
OPEN/ VOUTOV		YES ✓	YES ✓	YES ✓
Protection	SHORT of OUT	NO ⚠	NO ⚠	YES ✓
	IC Overtemperature	YES ✓	YES ✓	YES ✓
STATUS PIN		YES ✓	YES ✓	NO, but µC can monitor alternative Pins
ATV Grade/ AEC Qualified				
Package		PG-SSOP-14 ePad (Body: 5mm x4mm)	PG-SSOP-14 ePad (Body: 5mm x4mm)	PG-SSOP-14 ePad (Body: 5mm x4mm)
Pinning				

LITIX™ Power - TLD5095EL

LED Boost, Buck-Boost, Sepic Controller



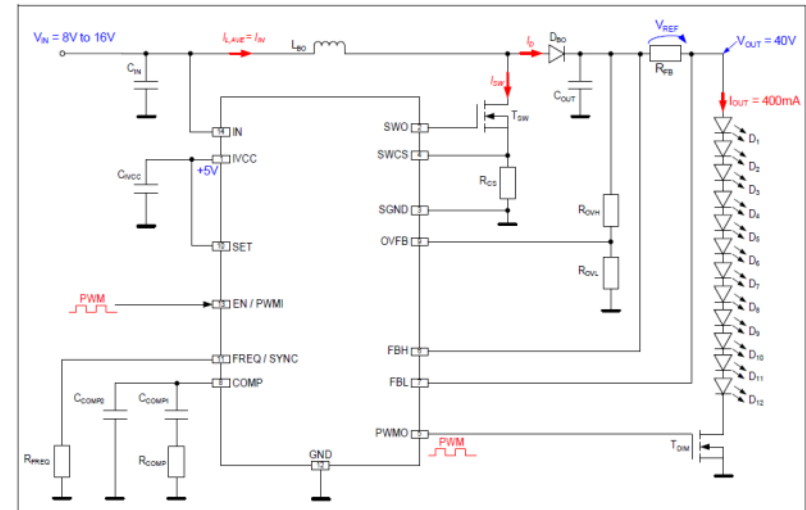
Key Features

- › 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: $I_Q < 10 \mu\text{A}$

Target Applications

- › Specially designed for Automotive exterior lighting

TLD5095EL



Package

- › PG-SSOP-14



LITIX™ Power - TLD5097EL

LED Boost, Buck-Boost, Sepic Controller



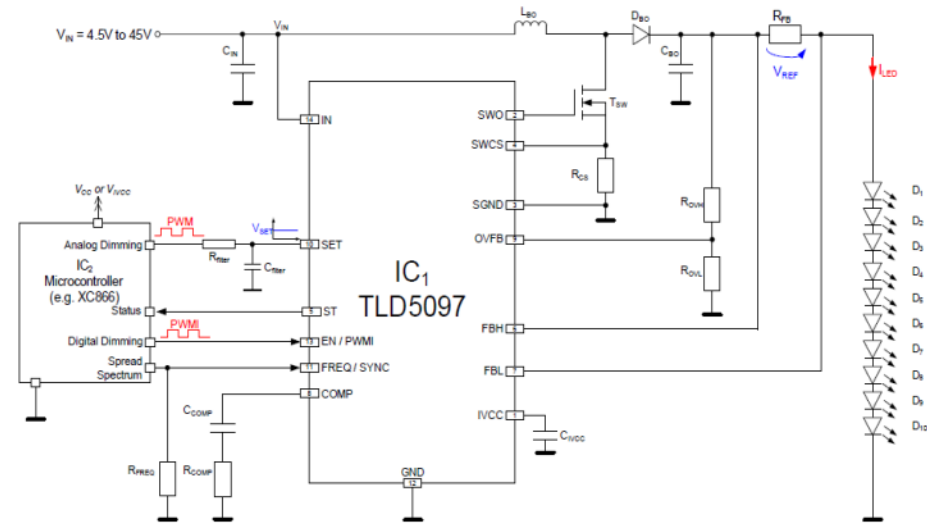
Feature Set

- > Wide Input Voltage Range from 4.5 V to 45 V
- > Constant Current or Constant Voltage Regulation
- > Drives LEDs in Boost, Buck, Buck-Boost, SEPIC and Flyback Topology
- > Very Low Shutdown Current: $I_{q_OFF} < 10 \mu A$
- > Flexible Switching Frequency Range, 100 kHz to 500 kHz
- > Synchronization with external clock source
- > PWM Dimming
- > Analog Dimming feature to adjust average LED current
- > Internal 5 V Low Drop Out Voltage Regulator
- > Open Circuit Detection
- > Output Overvoltage Protection
- > Internal Soft Start
- > Over Temperature Shutdown
- > Wide LED current range via simple adaptation of external components
- > High Side Current Sense

System Benefits

- > Flexibility (topologies to address different LED architectures/applications)
- > Good EMC performance
- > Increased LED current accuracy
- > Automotive Grade

TLD5097EL



Package

- > PG-SSOP-14



LITIX™ Power - TLD5098EL

Boost, Buck-Boost, Sepic Controller



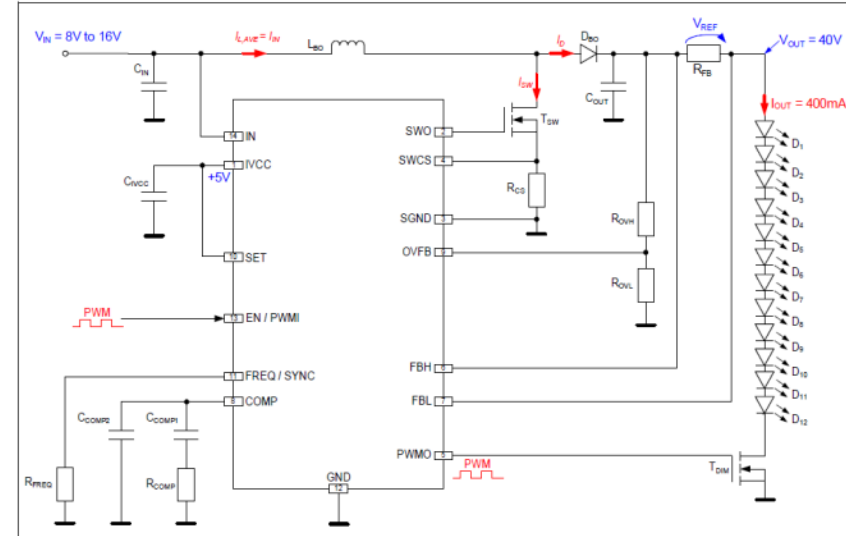
Key Features

- › 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: $I_Q < 10 \mu\text{A}$

Target Applications

- Specially designed for Automotive exterior lighting
- › High & Low Beam
 - › DTRL
 - › Fog
 - › ...

TLD5098EL



Package

- › PG-SSOP-14



LITIX™ Power TLD5045EJ

High integrated LED Buck Converter



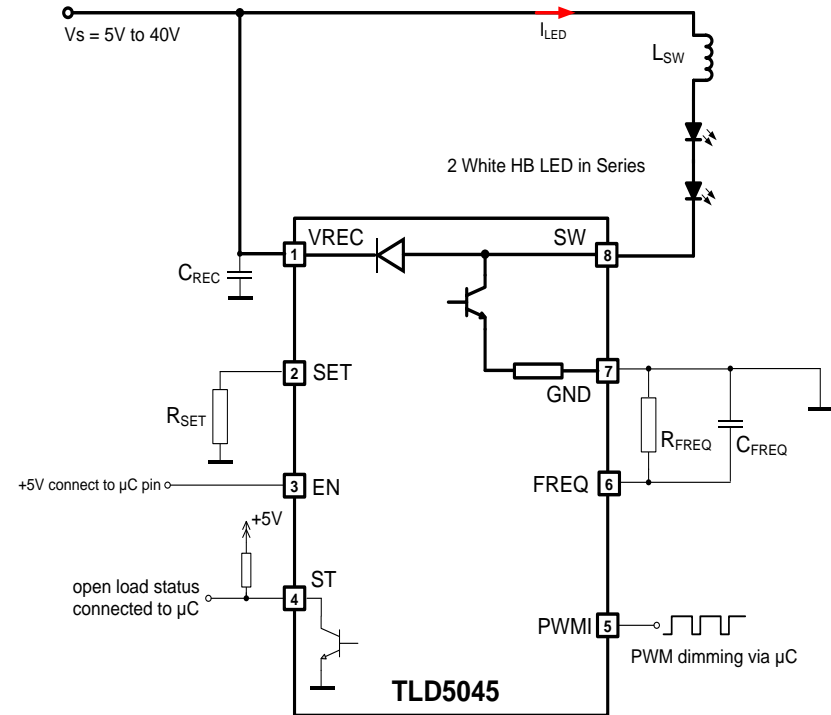
Key Features

- > DC/DC Buck Converter for 1-3 High power
- > Maximum Output current: 700mA
- > Wide input voltage range: 5V ... 40V
- > 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
- > Analog dimming via external resistor (Rref) possible
- > LED temperature monitoring via PTC possible

Target Applications

Specially designed for Automotive exterior lighting

TLD5045EJ



Package

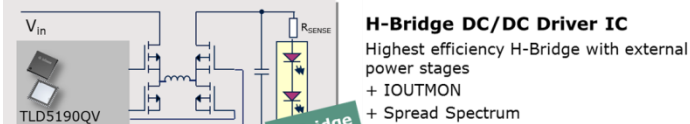
- > PG-DSO-8



LITIX™ Power DCDC Family is well established in Automotive LED Lighting Applications



TLD50xx Family

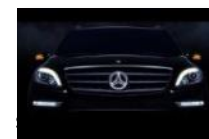


H-Bridge

Boost, Buck-Boost, SEPIC, Buck, Flyback

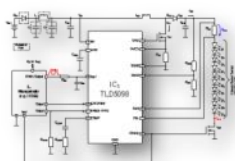
Buck

Well established in the Market

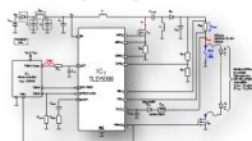


The Topology "allrounder"

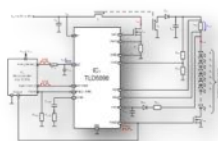
BOOST to GND



SEPIC

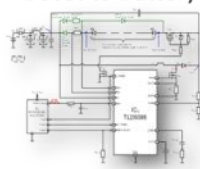


FLYBACK



TLD509x

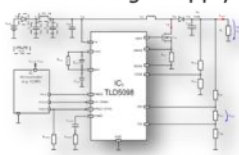
Boost to Battery



Buck



Constant Voltage Supply



Key Features & Benefits

- > TLD5190QV: 1ch DC/DC for seamless Buck-Boost & high power applications
- > TLD509xEL: Multitopology 1ch DC/DC controller Family
- > wide LED current range via simple adaptation of external components
- > good EMC performance
- > built in protection and diagnostic features
- > constant Current or Constant Voltage Regulation
- > PWM dimming
- > analog dimming for TLD5097/98EL, TLD51901QV
- > TLD5045EJ: High integrated (power stage, free wheeling diode, current sense resistor) Buck converter for up to 700mA

Available Appboards

Sales Name of Demoboard	SP Number	Description
APPBOARD TLD5098EL VER1	SP000954242	Constant Voltage Mode
APPBOARD TLD5098EL VER2	SP000954244	Boost to Ground Configuration w/ short to ground protection
APPBOARD TLD5098EL VER3	SP000954246	Boost to Battery Configuration
APPBOARD TLD5098EL VER4	SP000954248	SEPIC Configuration
APPBOARD TLD5098EL V5	SP000984908	Boost to Ground Configuration w/ short to ground protection & EMC filter
APPBOARD TLD5098EL V6	SP000984910	Boost to Battery Configuration with EMC filter
APPBOARD TLD5098EL V7	SP000984912	SEPIC Configuration with EMC filter
BOARD TLD5097 B2B	SP001157588	Boost to Battery Configuration
BOARD TLD5097 B2G	SP001157586	Boost to Ground Configuration
BOARD TLD5097 SEPIC	SP001157590	SEPIC Configuration



<http://www.infineon.com/litix-power-appboards>

Available Demoboards

Sales Name of Demoboard	SP Number	Description
Demoboard TLD5045EJ	SP000924382	Buck mode
Demoboard TLD5095EL Ver1	SP000760364	Boost to GND (default), Sepic & Constant Voltage Mode possible
Demoboard TLD5095EL Ver2	SP000845642	Boost to Battery (default), Constant Voltage Mode possible



<http://www.infineon.com/litix-power-demoboards>

Other design in support material

- › Data Sheets & Application Note
- › Simulation Models
- › EMC Test Reports
- › Excel Calculation Tool for TLD509xEL available on request

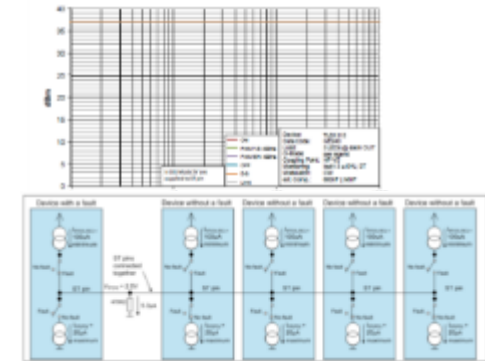


Figure 15 Showing an ST diagnostic pin between multiple devices

Thank you very much for your attention

For more information, please visit:

www.infineon.com/litix

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