

# NXP SEMICONDUCTORS

## FUNCTIONAL SAFETY CONSIDERATIONS AND SOLUTIONS FOR MATRIX HEADLIGHTING

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SECURE CONNECTIONS  
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## AGENDA

- Advances in Automotive LED Lighting
- Electronic LED Lighting Architectures
- NXP Multichannel LED Drivers
- NXP Matrix LED Controller
- Functional Safety Support & Tools
- Summary

# AUTOMOTIVE LED LIGHTING TRENDS



# AUTOMOTIVE LED LIGHTING

## EMERGING MARKET DRIVEN BY DESIGN, EFFICIENCY AND INNOVATION

### Growth Drivers

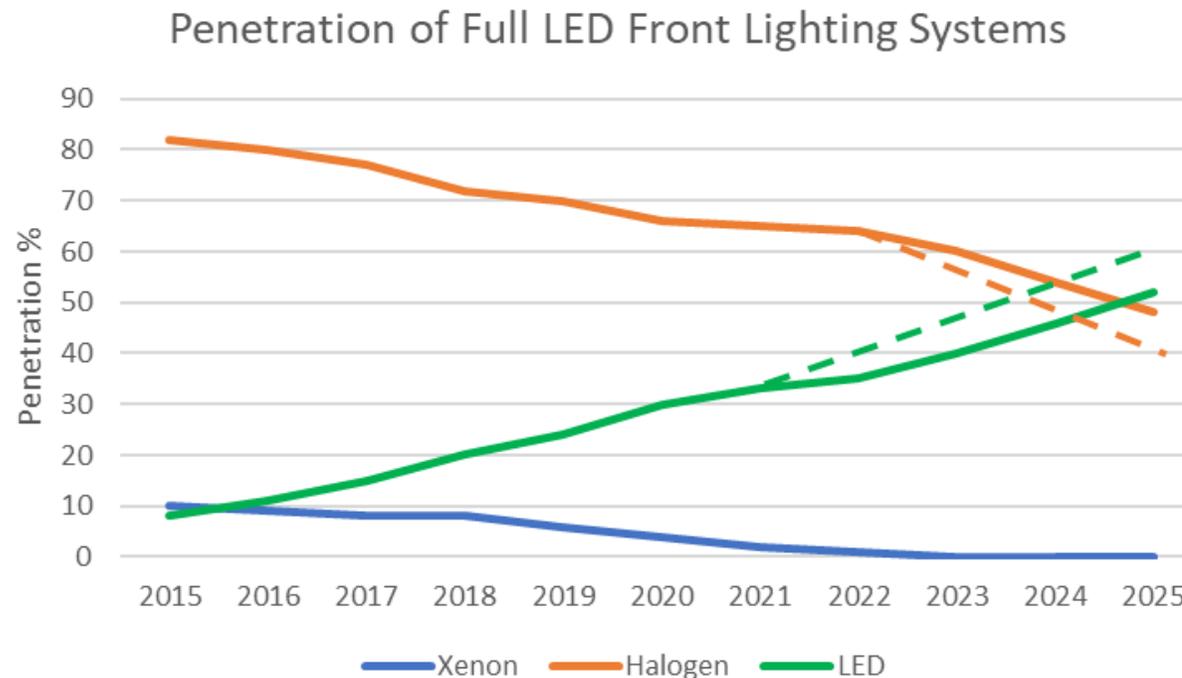
#### Styling

#### Improved efficiency

| Energy Consumption*        | DRL – LED                        | DRL – Bulb                      |
|----------------------------|----------------------------------|---------------------------------|
| Energy Consumption         | 2 x 11.4W                        | 45.8W                           |
| CO <sub>2</sub> – Emission | <b>0.58g</b> CO <sub>2</sub> /km | <b>1.2g</b> CO <sub>2</sub> /km |

50% reduction in CO<sub>2</sub> emissions by using LEDs\*

#### Advanced lighting options (ADAS-ADB)



Source: Driving Vision News 2019

\* Source: University Of Michigan Transportation Res. Inst.

# ADVANCES IN AUTOMOTIVE LED LIGHTING

## TRENDS AND APPLICATIONS REQUIREMENTS

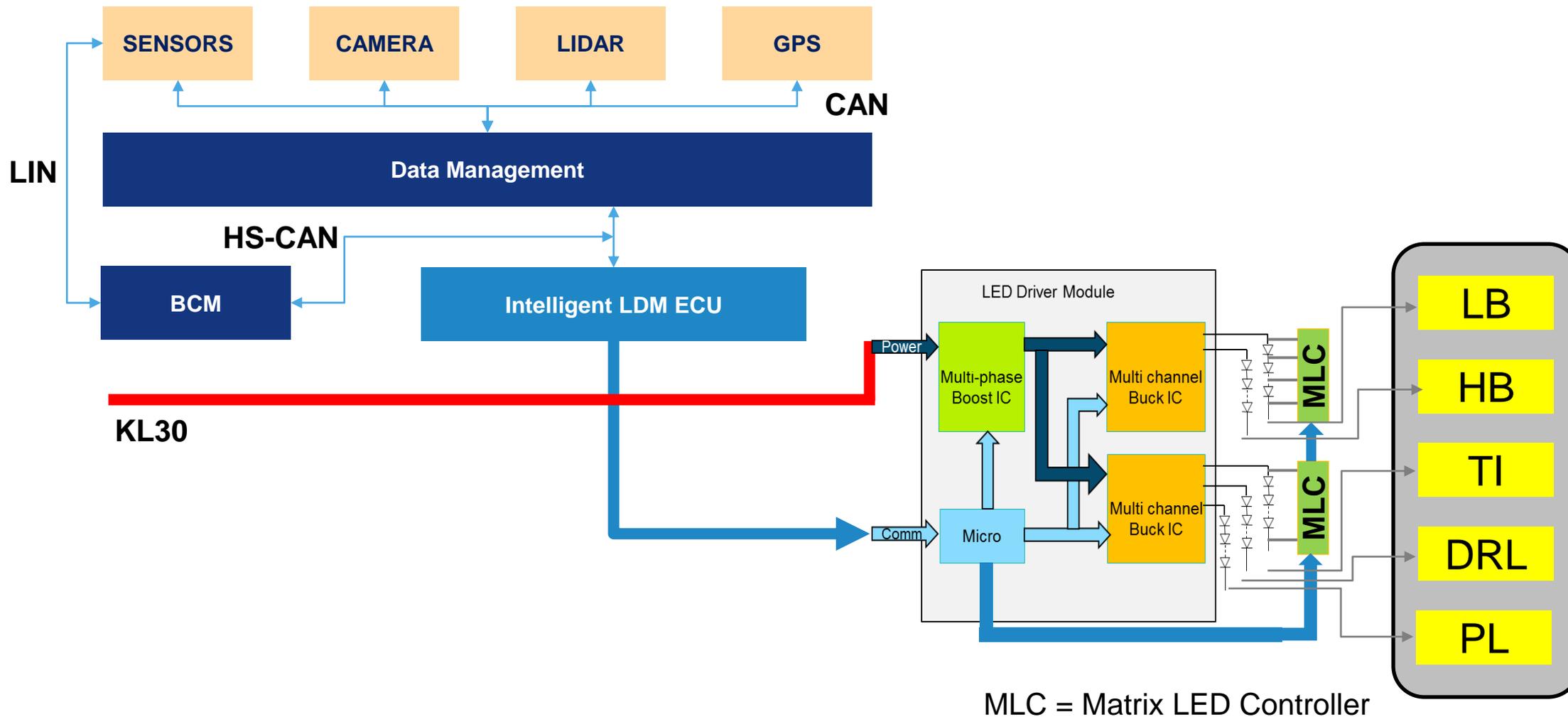
### Advances in Intelligent Automotive Exterior Lighting

|                     | Single Channel   | Multi Channel   | Matrix/Pixel   |
|---------------------|--|---|--|
| <b>Application</b>  | Daytime Running Lights, Fog                                  | Full LED Headlights, Advanced Tail Lights                                     | Advanced Dynamic Beam, Dynamic Turn Indicator, Matrix Lighting |
| <b>Requirements</b> | Wide range of requirements – light guide to LED string       | Increased functionality & diagnostics   | Increased signal processing and focus on network interface     |
| <b>Challenges</b>   | Low cost solution, wide operating range & core functionality | Flexible & scalable system solution, thermal management and system efficiency | Efficient flexible system with advanced functionality          |

# AUTOMOTIVE LED LIGHTING ARCHITECTURES



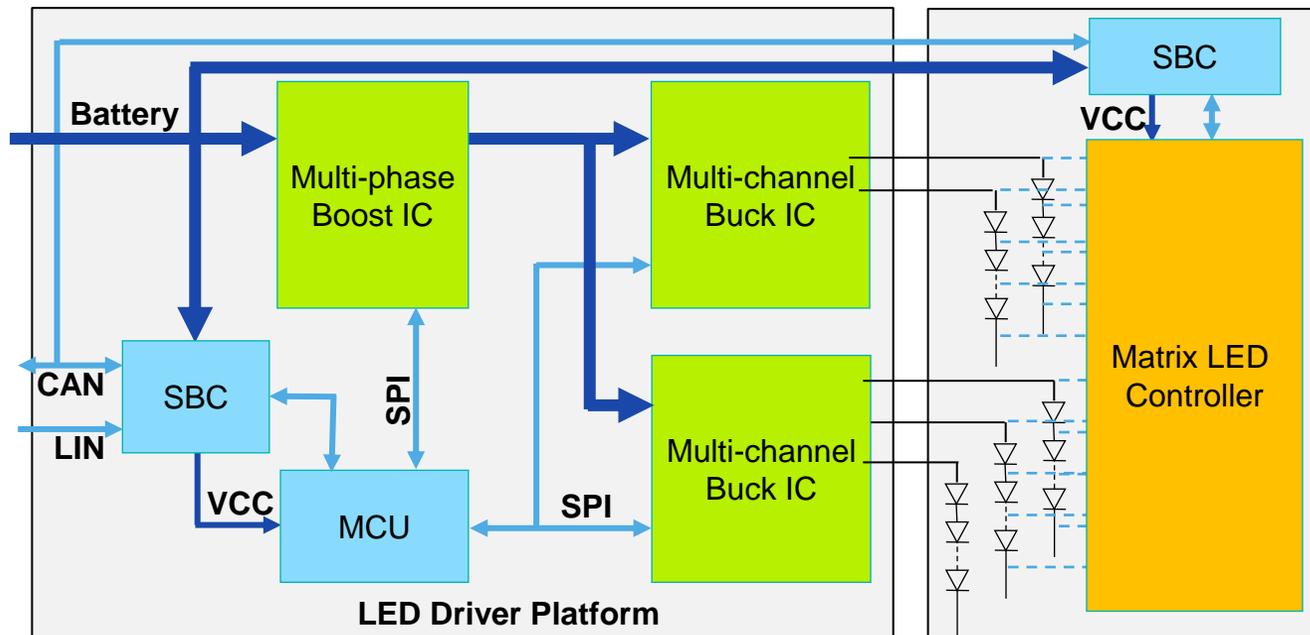
# TYPICAL SYSTEM ARCHITECTURE FOR ADVANCED DYNAMIC BEAM



# AUTOMOTIVE LED DRIVER ARCHITECTURES WITH ADVANCED MATRIX FUNCTIONALITY

Requirements for LED driver platform:

- Flexibility
- Scalability
- Re-usability
- High-efficiency



Most current platforms adopt a DC/DC converter solution with Boost followed by multi-channel Buck LED driver architecture.

The dynamic LED functionality is achieved by a Matrix LED Controller in parallel to the LEDs

# NXP MULTICHANNEL LED DRIVERS



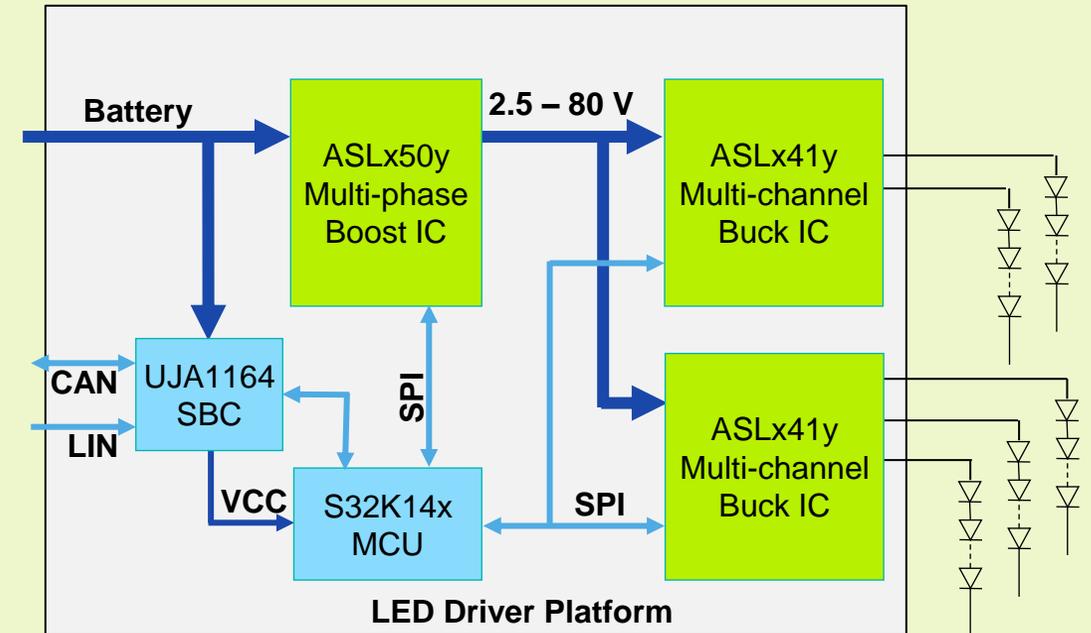
# NXP MULTI CHANNEL AUTOMOTIVE LED DRIVERS: KEY FEATURES

## *COST EFFECTIVE ARCHITECTURE FOR MULTI-CHANNEL LED PLATFORM*

### Key Benefits to Customer

- **Provides flexibility using a common architecture**
  - Drives all LED string configurations
  - SPI Interface for configurability, control and diagnostics
- **Enables scalability with a common architecture**
  - Drives 2 to 12+ LED channels and 30 to 140 W output power
- **Multi-phase boost stage**
- **2 output voltages** from boost stage
- **Drive >1.5 A LED current** per channel
- **External FETs**
- **>87% overall system efficiency**

### *Boost Followed by Buck with External FETs*



# ASL1500/2500/4500 – BOOST CONVERTER

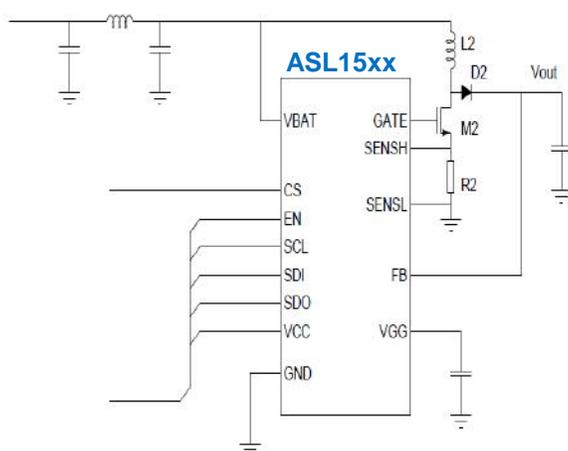
## MULTIPHASE BOOST CONVERTER IC WITH INTEGRATED SPI

- Highly integrated boost converter
- 2 independently controlled output voltages with 3% accuracy
- 5-V SPI interface for control & diagnostic
- Adjustable DC/DC converter frequency
- Optimize cost, efficiency, EMC and LED ripple current

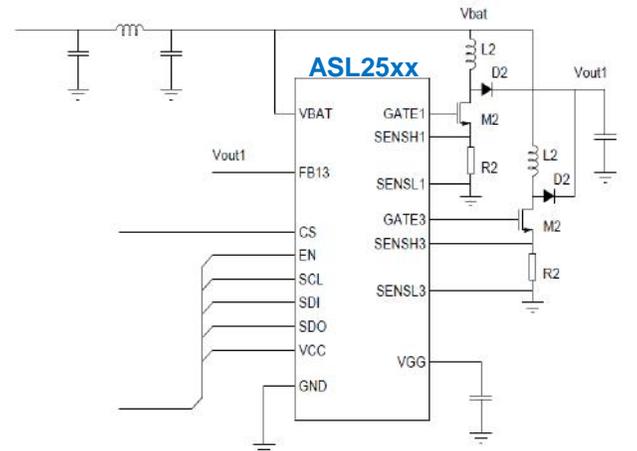
### Boost Converter Portfolio

- ASL1500SHN: 1-phase Boost Converter
- ASL2500SHN: 2-phase Boost Converter
- ASL4500/1SHN: 4-phase Boost Converter
- ASL1507SHN: 1-phase Boost Converter with Limp Home Mode
- ASL2507SHN: 2-phase Boost Converter with Limp Home Mode

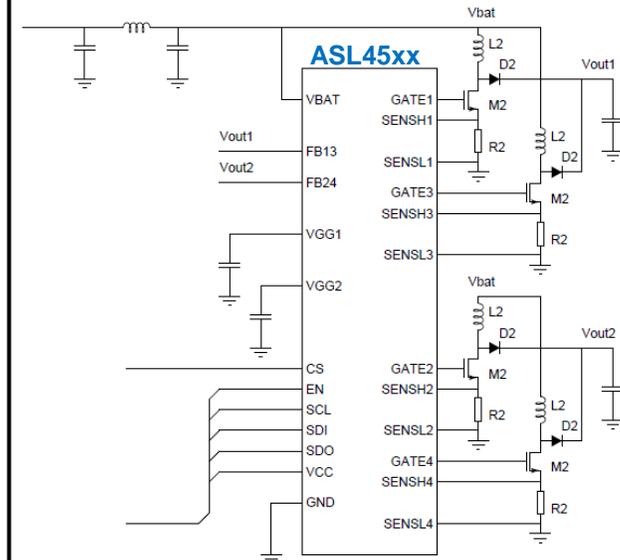
#### ASL15xx: 1 Phase Boost Converter



#### ASL25xx: 2 Phase Boost Converter



#### ASL45xx: 4 Phase Boost Converter



# ASL2416SHN/3416SHN – BUCK CONVERTER

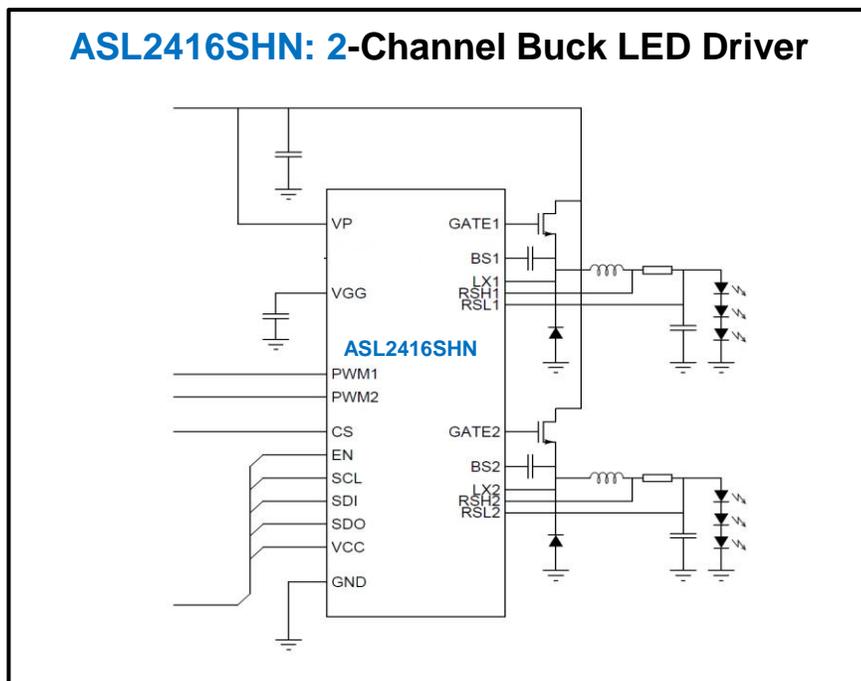
## MULTI-CHANNEL BUCK MODE LED DRIVERS WITH INTEGRATED SPI

- A programmable hysteretic constant current buck converter
- 5-V SPI interface for control & diagnostics
- Programmable LED current 120 mA to >1.5 A with 5% accuracy
- PWM dimming from 0 to 100%, 0.1% resolution
- LED open and short-to-ground fault detection.

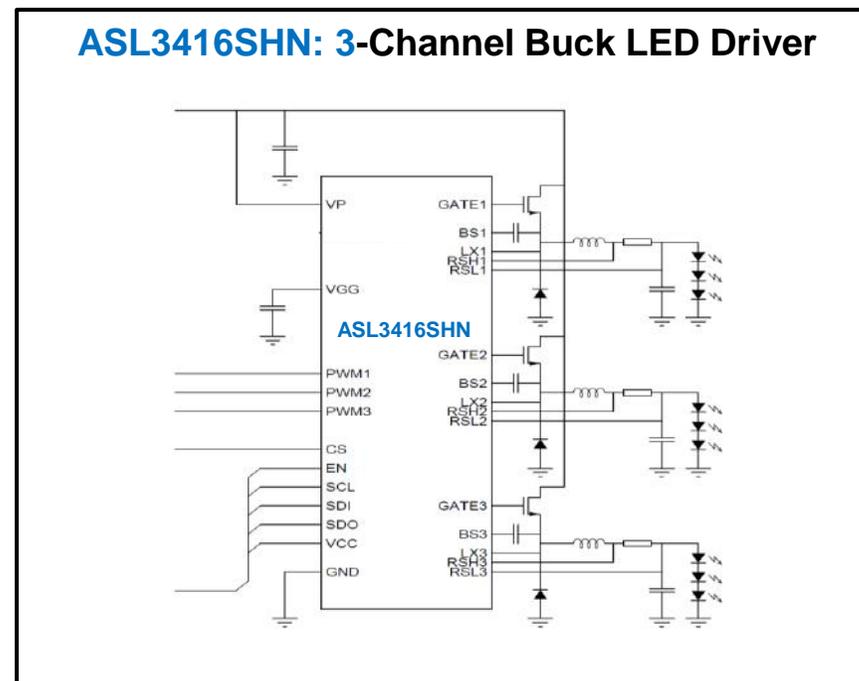
### Buck LED Driver Portfolio

- ASL2416SHN: 2-Channel Buck LED Driver
- ASL3416SHN: 3-Channel Buck LED Driver
- ASL2417SHN: 2-Channel Buck LED Driver with Limp Home Mode
- ASL3417SHN: 3-Channel Buck LED Driver with Limp Home Mode

#### ASL2416SHN: 2-Channel Buck LED Driver

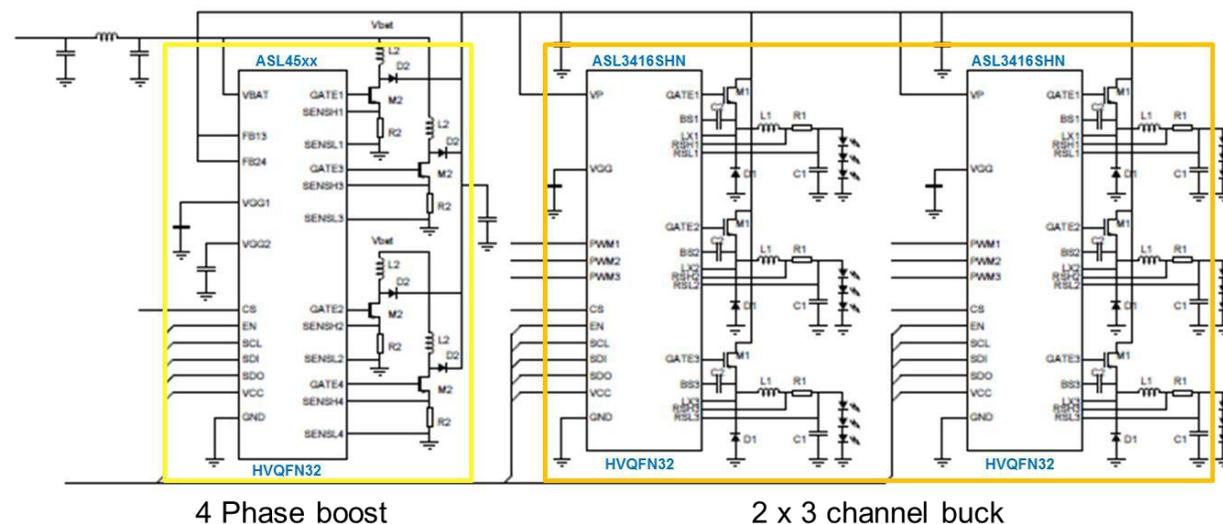
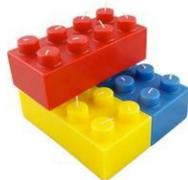
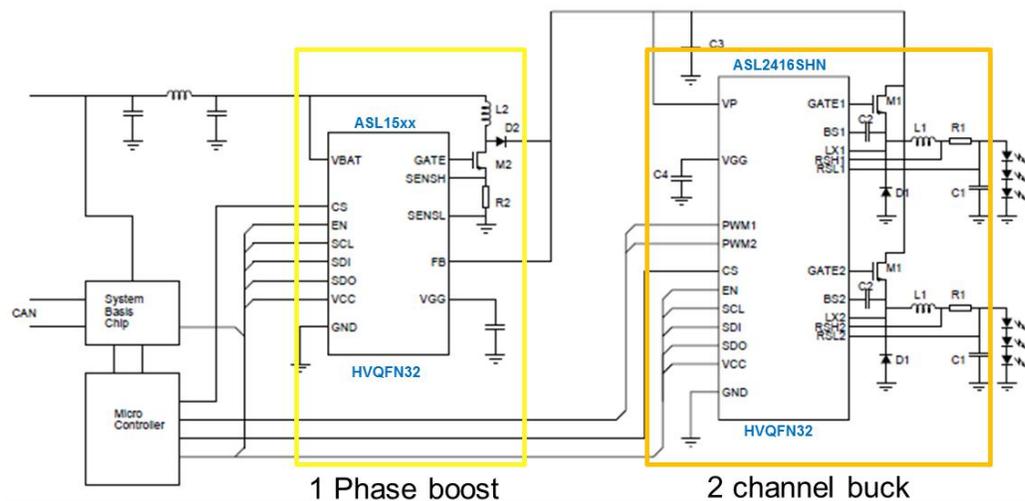


#### ASL3416SHN: 3-Channel Buck LED Driver



# NXP'S SCALABLE MULTI-CHANNEL ARCHITECTURE

## TYPICAL SCHEMATIC FOR 2-CHANNEL SYSTEM – EASILY SCALABLE TO 6-CHANNEL SYSTEM



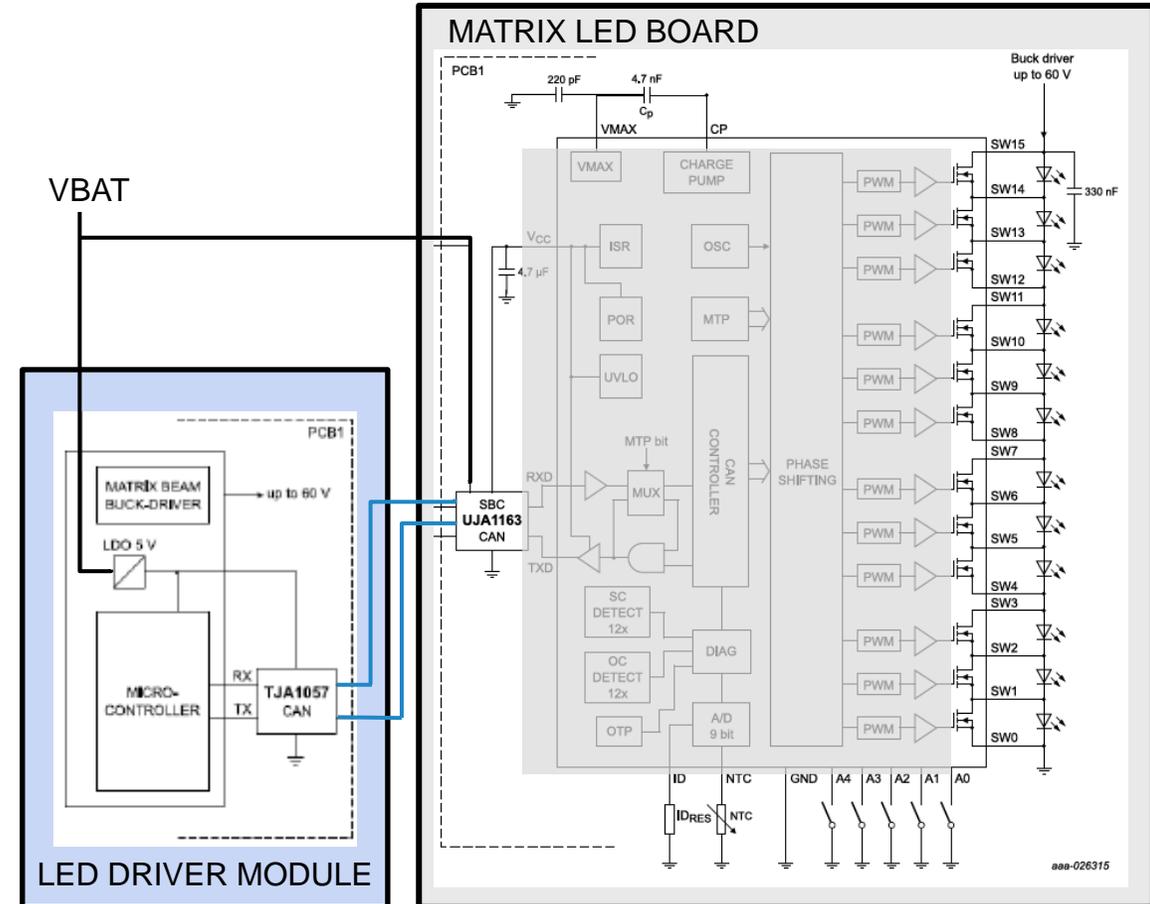
# NXP MATRIX LED CONTROLLER



# NXP MATRIX LED CONTROLLER (MLC): ASL5X15 / ASL5X08

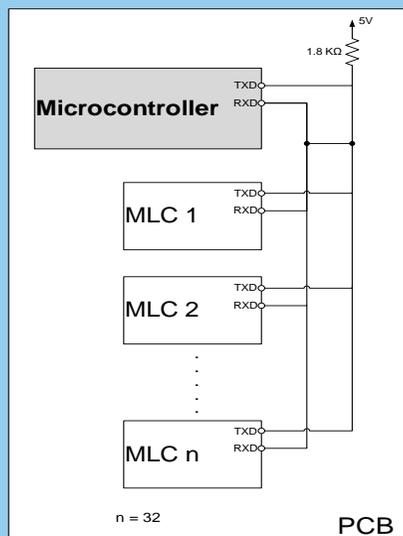
## KEY FEATURES AND BLOCK DIAGRAM

- **12 switches**, 4 floating blocks of 3 switches (individual or segments)
- **Low Rdson 1.5A max. per Switch** (in parallel up to 6.0A)
- **12-bit resolution PWM** at 244 Hz/488 Hz allowing smooth dimming
- **SMART & Direct PWM** options available
- **Phase shifted of PWM** to avoid large peak currents when switching
- Single LED open/short detection and diagnostics with bypass feature
- Direct NTC and PCB binning resistor input
- **CAN interface** (optionally CAN FD available)
- Integrated **200 MHz Oscillator**
- **Limp Home Mode** in case of communication failure
- 5 Address pins enabling up to 32 MLCs
- **Small package outline HVQFN36** (6x6 mm<sup>2</sup>) with wettable flanks

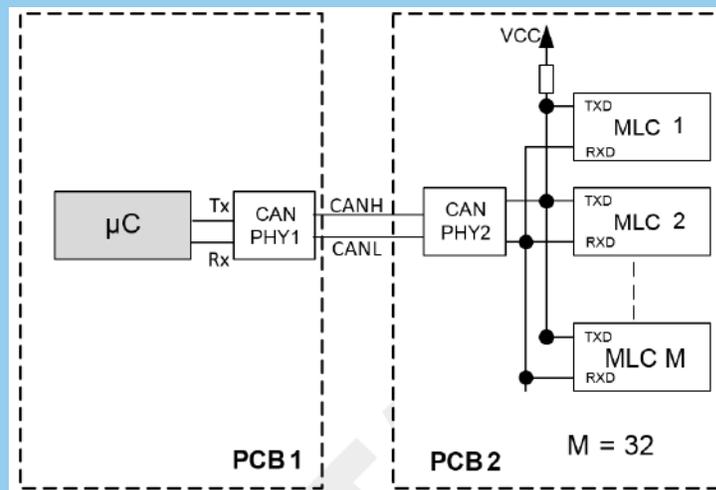


# COMMUNICATION INTERFACE CONFIGURATION OPTIONS

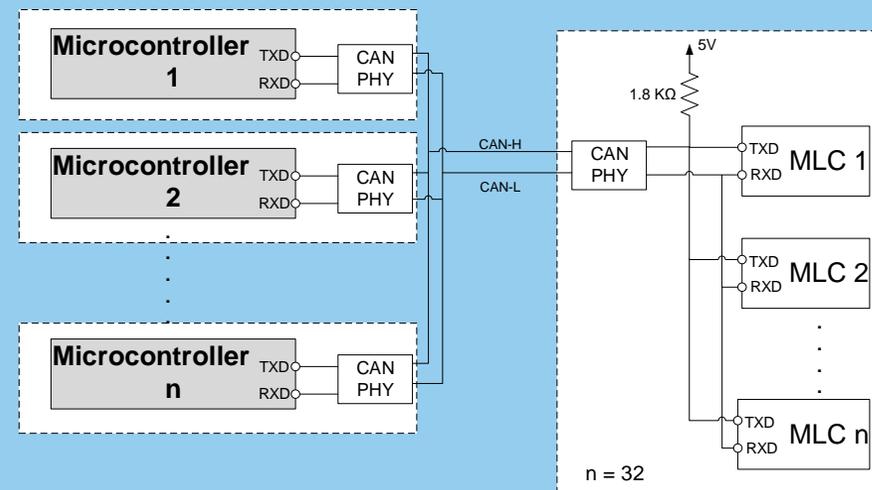
## FLEXIBLE FOR ON BOARD OR OFF BOARD MICROCONTROLLER



On-Board Configuration



Off-Board Configuration

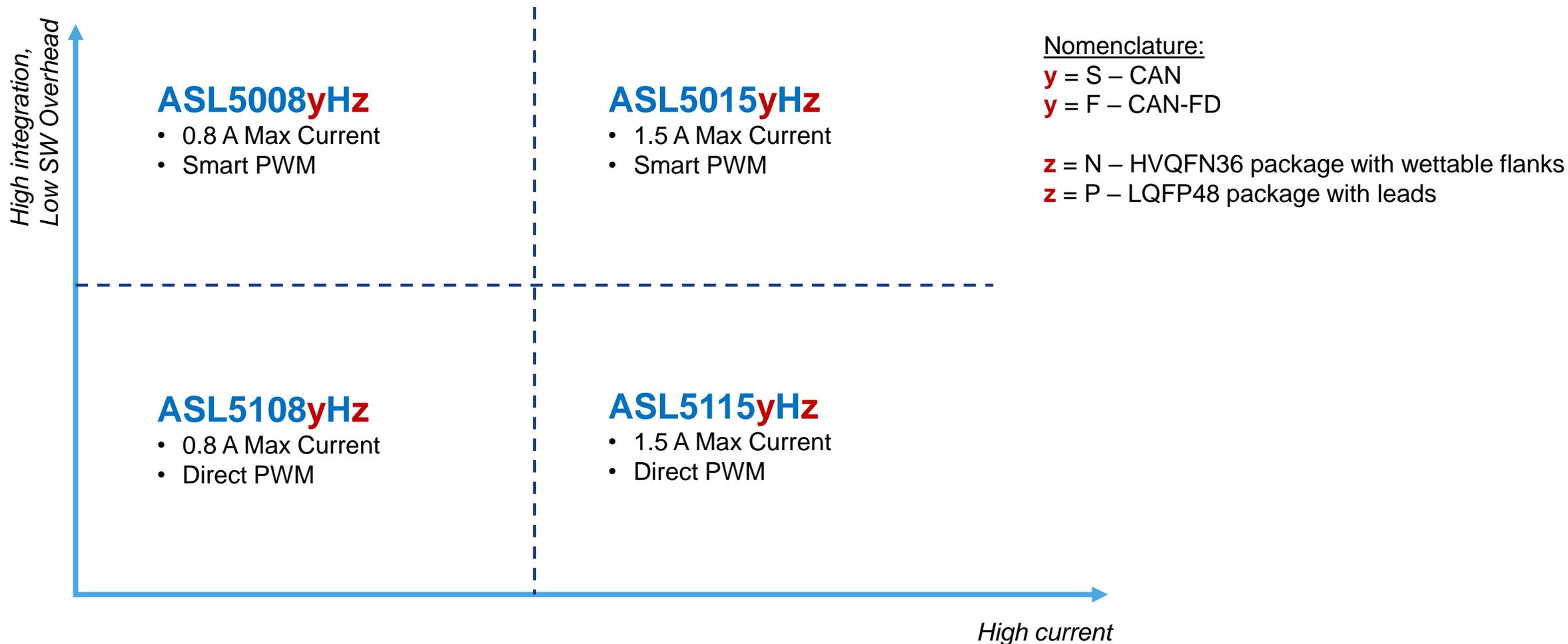


Multi-MCU Configuration

The standard CAN interface allows flexible configurations and robust communication between boards

# NXP MLC SOLUTIONS FOR DIFFERENT ADB APPLICATIONS

## PRODUCT MATRIX ADDRESSING WIDE RANGE OF USE CASES



# FUNCTIONAL SAFETY SUPPORT & TOOLS

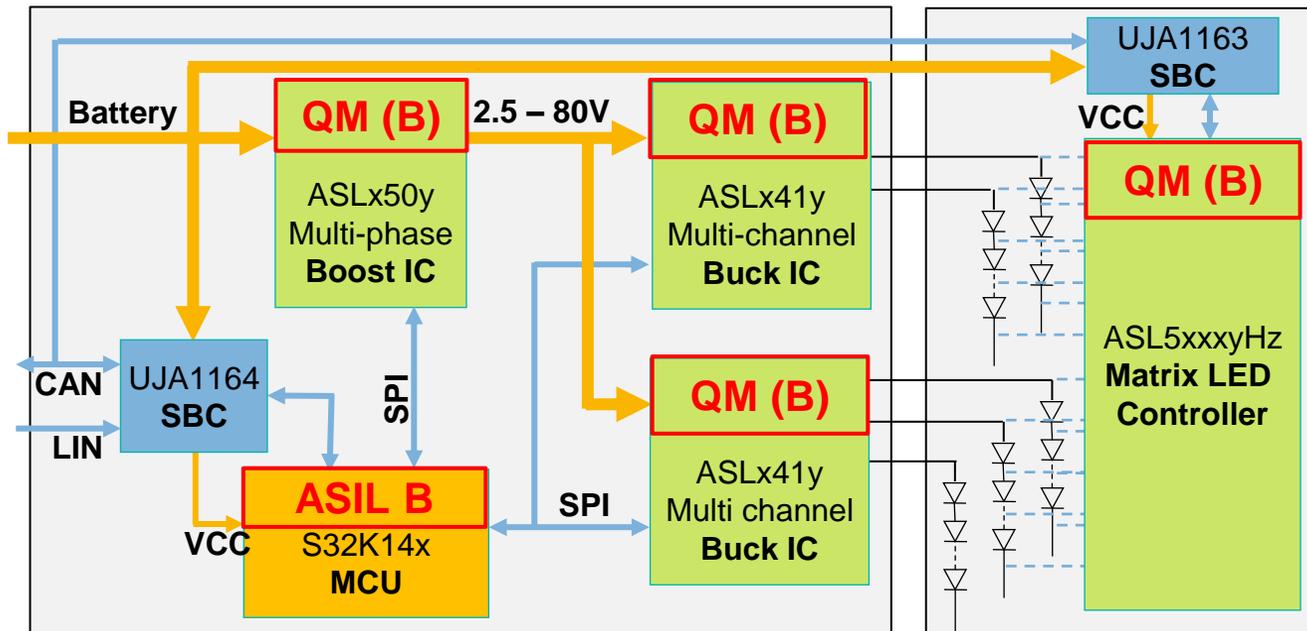


# FUNCTIONAL SAFETY REQUIREMENTS IN LIGHTING

## ASIL assessment by Car OEMs on lighting functions:

- Low beam (with or without Matrix function) → ASIL B
- Turn Indicator → ASIL B
- High Beam with ADB functionality → Foreseen as potentially ASIL A/B
- High Beam without ADB functionality and other functions → QM (Quality Managed)

## Typical ASIL allocation by Tier 1s for a Lighting Electronic System:



QM devices can be used to support ASIL B if:

1. The device was developed following system level assumptions for ASIL B
2. The device has all the documentation to support the tier 1's analysis at system level

# FUNCTIONAL SAFETY REQUIREMENTS IN LIGHTING

FMEDA

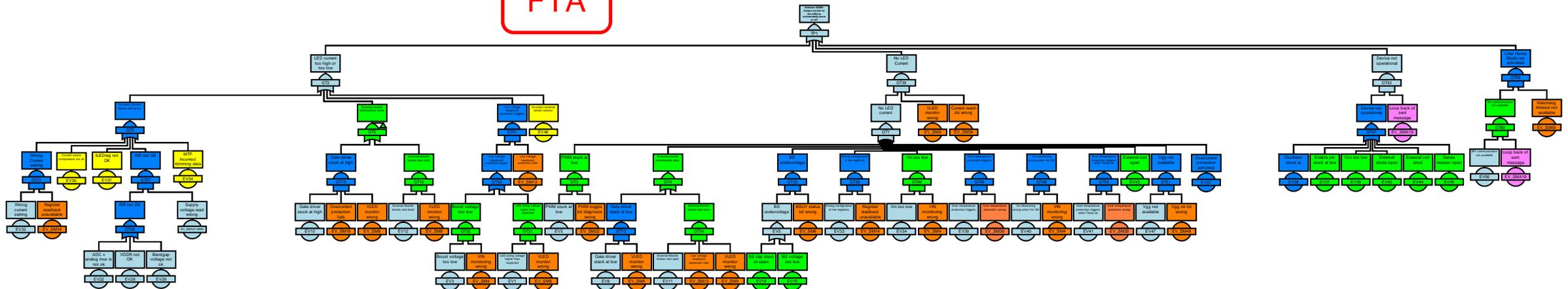
## Documentation for QM devices supporting ASIL B at system level:

- FMEDA
- FTA
- DFA
- Safety Application notes \*
- FIT rate calculation report \*

\* Available in DocStore for LED drivers and MLC

| SPFM = 93,22% |  |   |                           |                   |                             |  |                               |  |  |
|---------------|--|---|---------------------------|-------------------|-----------------------------|--|-------------------------------|--|--|
| ID            | Failure mode   | Failure mode that has the potential to violate the safety goal in absence of safety mechanisms? | Failure rate distribution | Failure mode rate | Applicable Safety mechanism | Safety Mechanism(s) allowing to prevent the failure mode from violating the safety goals | #EOL ZONE                     | Failure mode coverage wrt. violation of safety goals | Residual of single point fault failure rate(FIT) |
| 0.078         | Voltage reference too high   | Yes   | 25.0%                     | 0.004             | SME + SPMA21                | Input voltage measurement on VIN voltage   | 0.0.0.1<br>0.0.0.1<br>0.0.0.1 | SDC  | 0.0004   |
| 0.078         | Voltage reference too low  | Yes   | 25.0%                     | 0.004             | SME + SPMA21                | Input voltage measurement on VIN voltage   | 0.0.0.1<br>0.0.0.1<br>0.0.0.1 | SDC  | 0.0004   |
| 0.078         | Voltage reference oscillation outside reference range (inrush)     | No  | 25.0%                     | 0.004             |                             | #N/A   | #N/A                          | #N/A   | 0.0000   |
| 0.076         | Voltage reference oscillation outside reference range (inrush)     | No  | 25.0%                     | 0.004             |                             | #N/A   | #N/A                          | #N/A   | 0.0000   |
| 0.174         | AOC output data stuck at full scale value                          | Yes   | 20.0%                     | 0.025             | SPMA20                      | Loop back of low SPI messages (External SPI)   | 0.0.0.1<br>0.0.0.1            | SDC  | 0.0025   |
| 0.174         | AOC output data stuck at 0 value                                   | Yes   | 20.0%                     | 0.025             | SME + SPMA21                | Input voltage measurement on VIN voltage   | 0.0.0.1<br>0.0.0.1<br>0.0.0.1 | SDC  | 0.0025   |
| 0.174         | Wrong Conversion   | Yes   | 20.0%                     | 0.025             | SME + SPMA21                | Input voltage measurement on VIN voltage   | 0.0.0.1<br>0.0.0.1<br>0.0.0.1 | SDC  | 0.0025   |
| 0.174         | Conversion inaccurate (offset)                                     | Yes   | 20.0%                     | 0.025             | SME + SPMA21                | Input voltage measurement on VIN voltage   | 0.0.0.1<br>0.0.0.1<br>0.0.0.1 | SDC  | 0.0025   |
| 0.174         | Conversion rate too long   | No  | 20.0%                     | 0.025             |                             | #N/A   | #N/A                          | #N/A   | 0.0000   |
| 0.026         | Regulated Output in overvoltage                                    | Yes   | 16.7%                     | 0.018             | SME + SPMA21                | Input voltage measurement on VIN voltage   | 0.0.0.1<br>0.0.0.1<br>0.0.0.1 | SDC  | 0.0018   |
| 0.026         | Regulated Output in undervoltage                                   | Yes   | 16.7%                     | 0.018             | SME + SPMA21                | Input voltage measurement on VIN voltage   | 0.0.0.1<br>0.0.0.1<br>0.0.0.1 | SDC  | 0.0018   |
| 0.026         | Regulated Output affected by ripple                                | No  | 16.7%                     | 0.018             |                             | #N/A   | #N/A                          | #N/A   | 0.0000   |
| 0.026         | Incorrect start-up time  | No  | 16.7%                     | 0.018             |                             | #N/A   | #N/A                          | #N/A   | 0.0000   |
| 0.026         | Regulated Output Oscillation outside regulation range (load shift) | No  | 16.7%                     | 0.018             |                             | #N/A   | #N/A                          | #N/A   | 0.0000   |
| 0.026         | Regulated Output Oscillation inside regulation range (load shift)  | No  | 16.7%                     | 0.018             |                             | #N/A   | #N/A                          | #N/A   | 0.0000   |

FTA



# COMPLETE SYSTEM SOLUTION FROM NXP ENABLING DESIGN OF ADVANCED SOLUTIONS

- Reference design based on
  - 6-channel / 120W LED driver board
  - Matrix LED driver board
  - S32K MCU, SBC, LEDs
- Basic SW drivers to run front lighting scenarios
- Full documentation and SW support available

## Multichannel LED Driver Evaluation Board

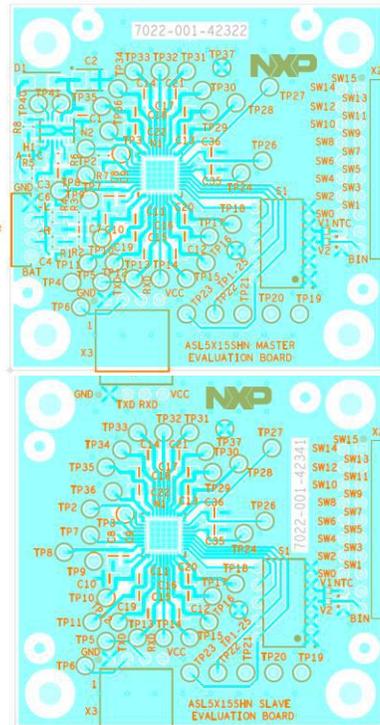
1 x ASL4500SHN  
2 x ASL3416SHN



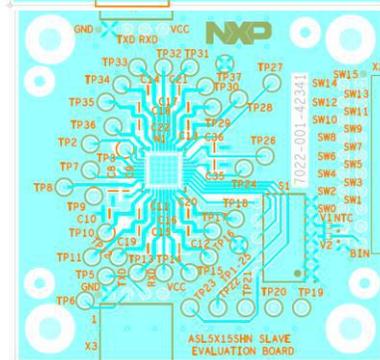
S32K (Micro) + UJA1169 (SBC)



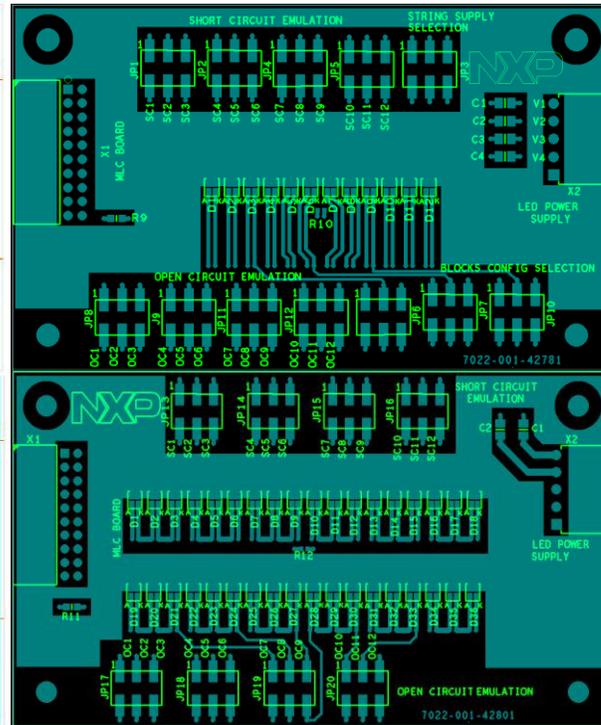
Primary MLC Board



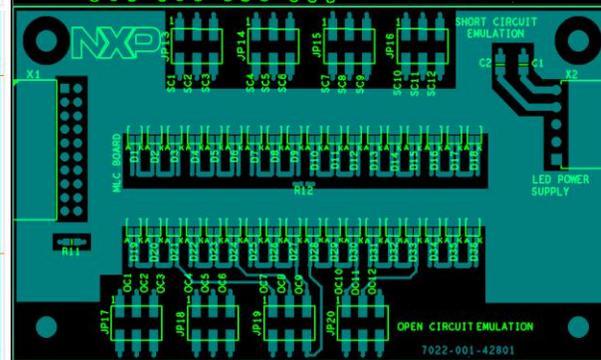
Secondary MLC Board



LED Board 1



LED Board 2



# SUMMARY

## SUMMARY

- We have seen major advances in new automotive lighting functionality to improve road safety
- To enable these advances, lighting electronics have also needed to develop new architectures
- To meet the new advanced requirements electronic platforms need to be fully flexible and scalable
- NXP total solution includes LED Drivers, Matrix LED Controller, SBC, and Microcontroller
  - High integration for low system cost and a highly flexible/scalable solution suitable for platform designs



For more information on **NXP Automotive Lighting LED Driver ICs**, please visit [https://www.nxp.com/products/power-management/lighting-driver-and-controller-ics/automotive-lighting-led-driver-ics:MC\\_71502](https://www.nxp.com/products/power-management/lighting-driver-and-controller-ics/automotive-lighting-led-driver-ics:MC_71502)

# Q&A

**THANK YOU**

