KEEPING YOU INFORMED – LCD AND LED AUTOMOTIVE DASHBOARD DISPLAYS

SECURE CONNECTED & AUTOMATED VEHICLES INSTRUMENT CLUSTERS & INFOTAINMENT

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FTF-AUT-N1918
LONE STAR BALLROOM E - LEVEL 3
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AGENGA

- Overview

- LCD Display Drivers

- LED Controller

- Summary

Abstract – A modern car is more than just transport, it provides comfortable heating and cooling, navigation systems, entertainment systems, and a lot of data about the car's health and performance. Including how well you are conserving fuel or when to seek service. All of this is a challenge to present to the driver and passengers, without distraction to driving, under all conditions from bright daylight to the dark of night, in any temperature. We talk about both Liquid Crystal Display (LCD) and Light Emitting Diode (LED) component solutions that keep your dashboard simple, readable, and helpful.

Interface Products – Front Seat Infotainment
System peripherals

LED Controllers

Capacitive Touch Sensors

Temperature Sensors

Real Time Clocks

LCD Drivers

Voltage Level translators

I^{2}C-SPI - UART Bridges
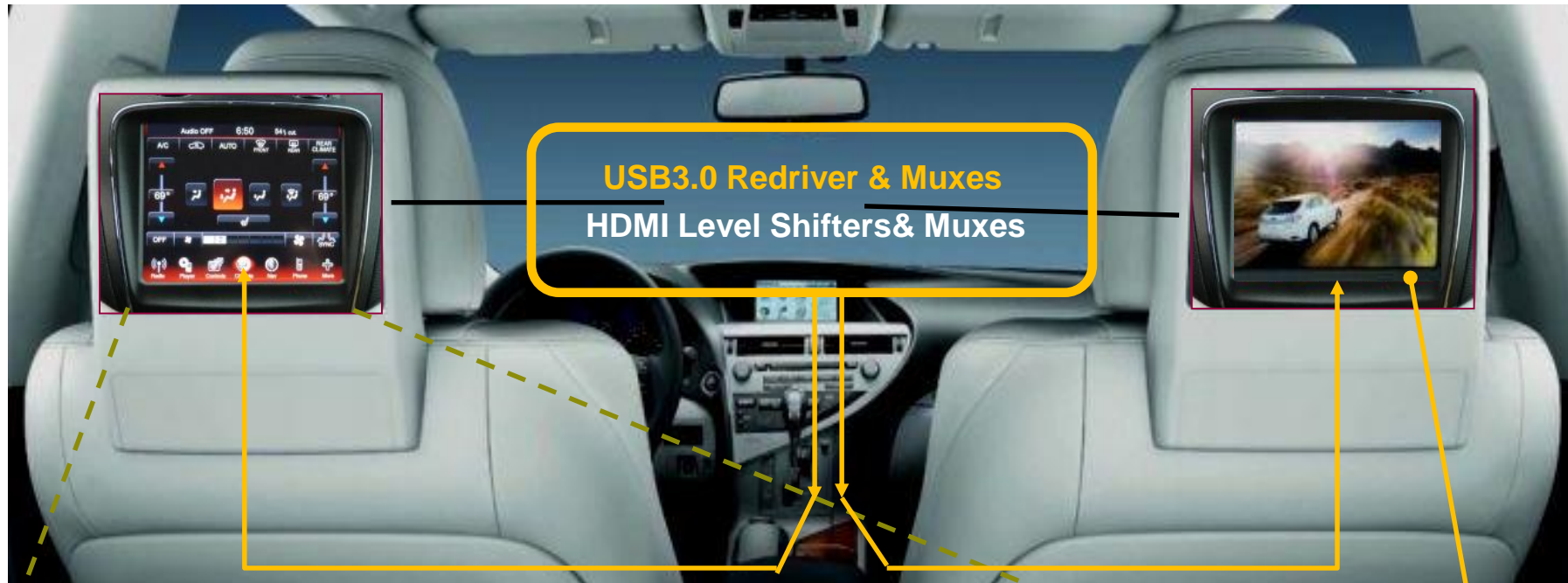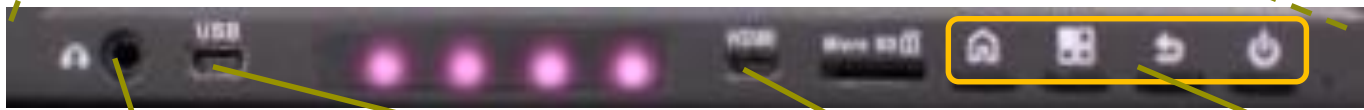
I^{2}C I/O Expanders

Audio Jack & Analog Switch

I^{2}C BUS Multiplexers

NXP

Interface Products – Rear Seat Infotainment

USB3.0 Redriver & Muxes

HDMI Level Shifters& Muxes

Audio Jack & Analog Switch
(Multi Standard Support)

USB3.0 Redrivers
(Drive Longer Cables)
USB3.0 2:1 Switches
(Drive multiple rear seat output w/ single USB3.0 source on processor)

DP++ to HDMI Level Shifter
(For Protocol flexibility)
HDMI 2:1 Switches
(MUX rear screen between an ext user source and internal video player)

Touch Switches
(High Reliability Touch Switches)

LED Controller Temperature sensor
(LCD Backlight)

DP to LVDS Adapter
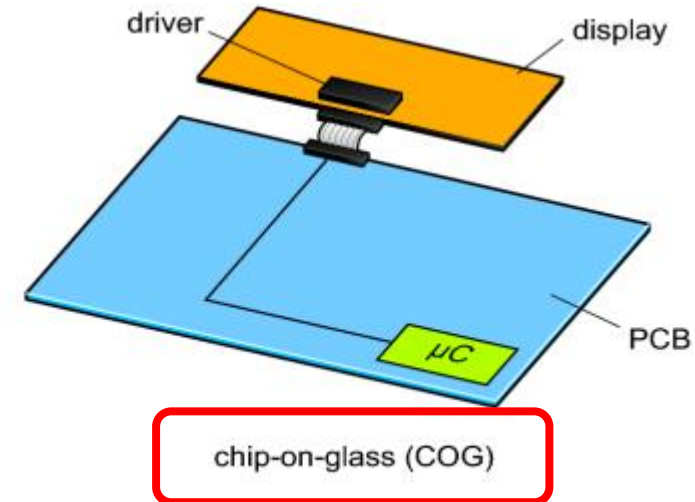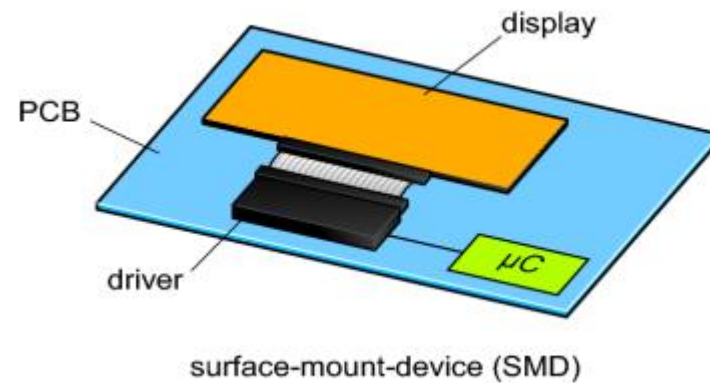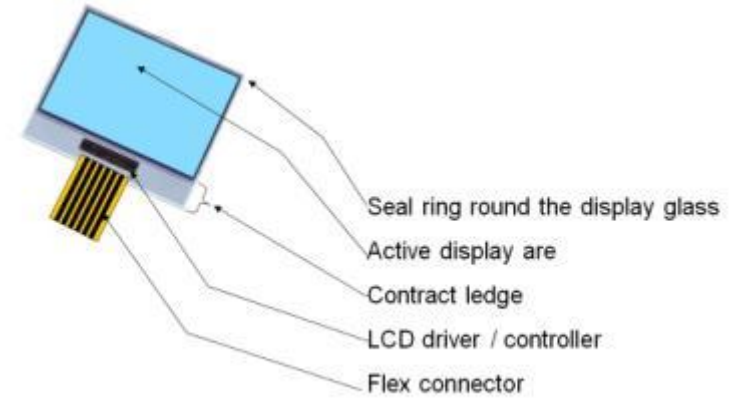(Enables migration to processors supporting DisplayPort)

LCD DRIVERS

Chip-on-Glass (COG) vs Surface Mount Device (SMD)

- GOC cost-saving and easy way to design with LCD Drivers
- Advantages
  - The driver is directly placed on the glass
  - No package is needed (cost saving)
  - Easier PCB design
  - Less board space needed on the PCB
  - Driver is handled by the module maker

Seal ring round the display glass
Active display are
Contract ledge
LCD driver / controller
Flex connector

surface-mount-device (SMD)

chip-on-glass (COG)

aaa-002681

NXP New LCD Driver Trends

- Higher Frame Frequency
  - Standard TN displays require frame frequency of 64Hz
  - High-contrast, true black background Vertical Alignment displays require frame frequency to be 2x to 3x higher
- On-Chip Charge Pump
  - Eliminate the need for external components
  - Ability to generate high VLCD voltage, even in systems with only 3.3V supply
  - In battery operated systems, the supply voltage may vary from 3.3V to 1.8V, but the charge pump allows the user to maintain a stable VLCD voltage
  - Ability to regulate VLCD internally and do temperature compensation
- Higher VLCD Voltage
  - For Vertical Alignment display applications (with true black background)
- Integrated Temperature Sensor
  - For temperature-compensated VLCD
  - With digital readout
- Temperature Compensated VLCD
  - Ability to adjust and maintain optimal contrast with varying liquid crystal viscosity due to temperature fluctuations
- Improved Power-on Reset (POR) Circuitry
  - Improved system ESD performance
  - Up to ±15kV air discharge and ±8kV contact discharge
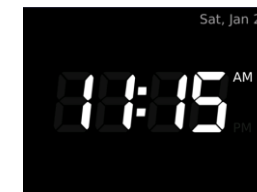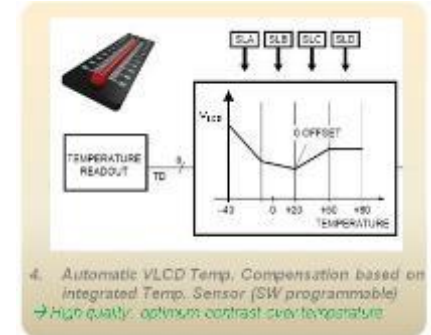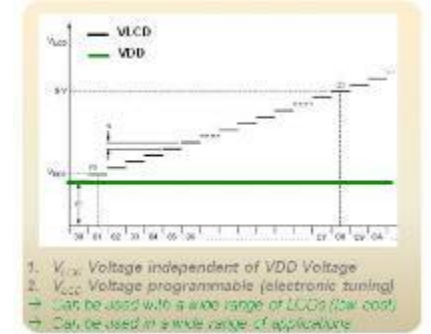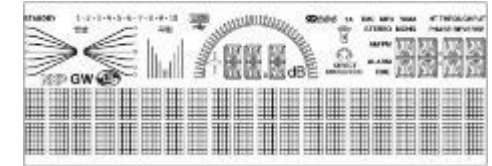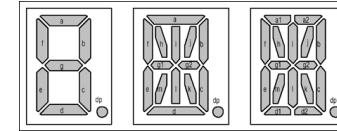
NXP LCD Drivers – Key Values at a Glance

High quality & reliability

Automotive grade

High temperature

Comprehensive testing production and screening

High ESD/EMC performance

Collaboration with leading module maker

Collaboration with leading automotive Tier-1 suppliers

Operations Excellence
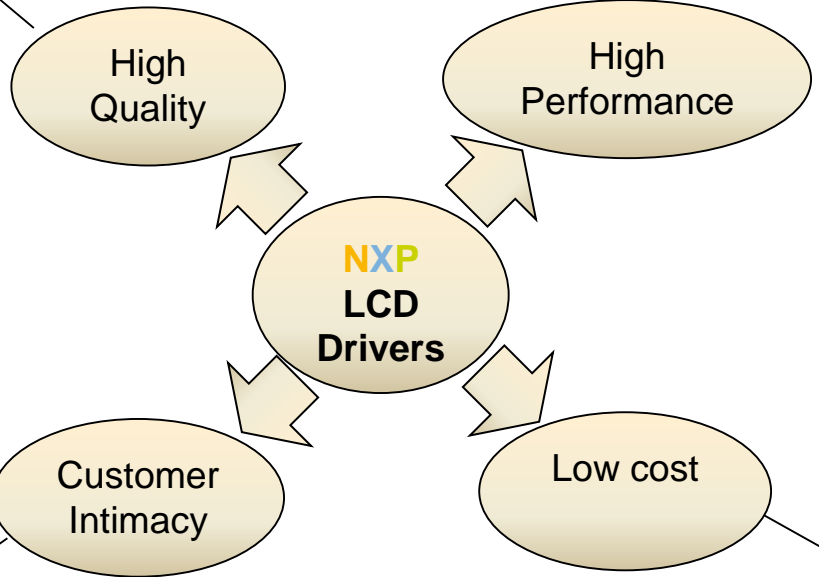
Vertical Alignment Displays

Pioneered the Chip-On-Glass Technology

New "Economy" line of COG LCD drivers

New low-cost but highly reliable LCD drivers in TSSOP48 and TSSOP56

High Quality

High Performance

NXP LCD Drivers

Customer Intimacy

Low cost

COG
LCD DRIVERS

COG LCD Segment Drivers for Automotive Applications

Performance (vertical axis)

New generation

Industry-standard products

High quality and **highly performing** drivers with integrated **charge pump**, perfectly suitable to drive **VA displays**
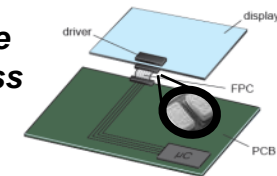
PCA8539

PCA8538

PCA8530

PC8576 Family

PC8533 Family

PC8532 Family

New line compatible with their predecessors but with **enhanced EMC,** up to **105ºC,** and suited to drive the **VA displays**

Resolution (horizontal axis)

| 4 x 40 = 160 | 4 x 80 = 320 | 4 x 102 = 408 | 4 x 160 = 640 | 9 x 102 = 918 | 18 x 100 = 1800 |

PCA8530 Up to 4 x 102 LCD Segment Driver

NEW! The most performing mux 1:4 display driver in the market!

Key Features

- 4 x 102 segment driver *(408 dots or segments)*
- Programmable Multiplex Rate *(1:1, 1:2, 1:4)*
- n-line inversion *(includes line and frame inversion)*
- On-chip **Charge pump** with integrated capacitors for the V_{LCD} internal generation up to **12 V**
- Temperature readout and device status readout for **diagnostics**
- Temperature compensated VLCD voltage (with programmable temperature regions and programmable slopes)
- Programmable frame frequency 45Hz to **300Hz**
- I²C-bus and SPI-bus Interface
- Up to 4 chips can be cascaded with internal or external V_{LCD} to drive bigger display
- Extended temperature range up to **+105°C**
- **AEC-Q100** grade 2 compliant

Mux 1:4 LCD driver with integrated charge pump and temperature sensor

- High and stable display contrast over temperature
- Compensation for slow switching times at cold temperatures
- Can drive big segments
- Can be used in combination with high-res ITO for cost optimization
- High resistance to EMI
- High precision of V_{LCD} and frame frequency
- Highly featured

PCA8530 Up to 4 x 102 LCD Segment Driver

- Accurate VLCD temperature compensation
  - High and stable display contrast across the temperature
 - Compensation for degradation of switching times at cold temperatures
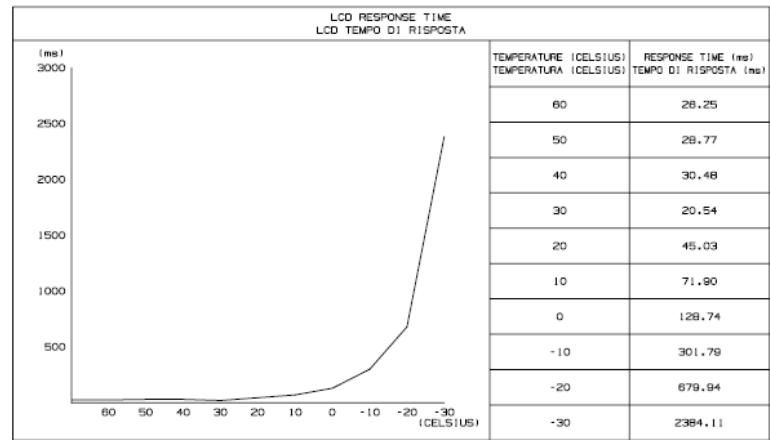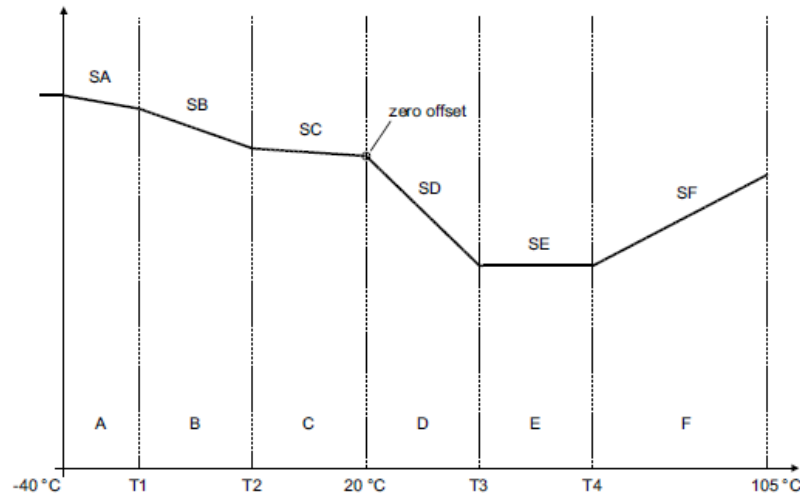
T1T[2:0] to T4T[2:0]	Temperature region 1 and 2		Temperature region 3 and 4	
	T1, T2 (°C)	Corresponding TD value[1]	T3, T4 (°C)	Corresponding TD value[1]
000	−34	10	+29	110
001	−27	20	+38	124
010	−21	30	+47	138
011	−15	40	+55	152
100	−9	50	+64	166
101	−2	60	+73	180
110	+4	70	+82	194
111	+10	80	+91	208

| TSA[2:0] to TSF[2:0] value	Slope factor (mV/°C)	Temperature coefficients SA to SF[1]
000	0	0.000
001	−6	−0.125
010	−12	−0.250
011	−24	−0.500
100	−60	−1.250
101	+6	+0.125
110	+12	+0.250
111	+24	+0.500

PCA8530 Up to 4 x 102 LCD Segment Driver

- High Driving Capability
  - 4 bumps per each COM output → 180um pitch
  - Dual set of backplanes
  - Ro(BP) = 1 kΩ; Ro(SEG) = 2.5 kΩ
  - Can drive big segments
  - Can be used in combination with high-res ITO → low cost

PCA8530DUG
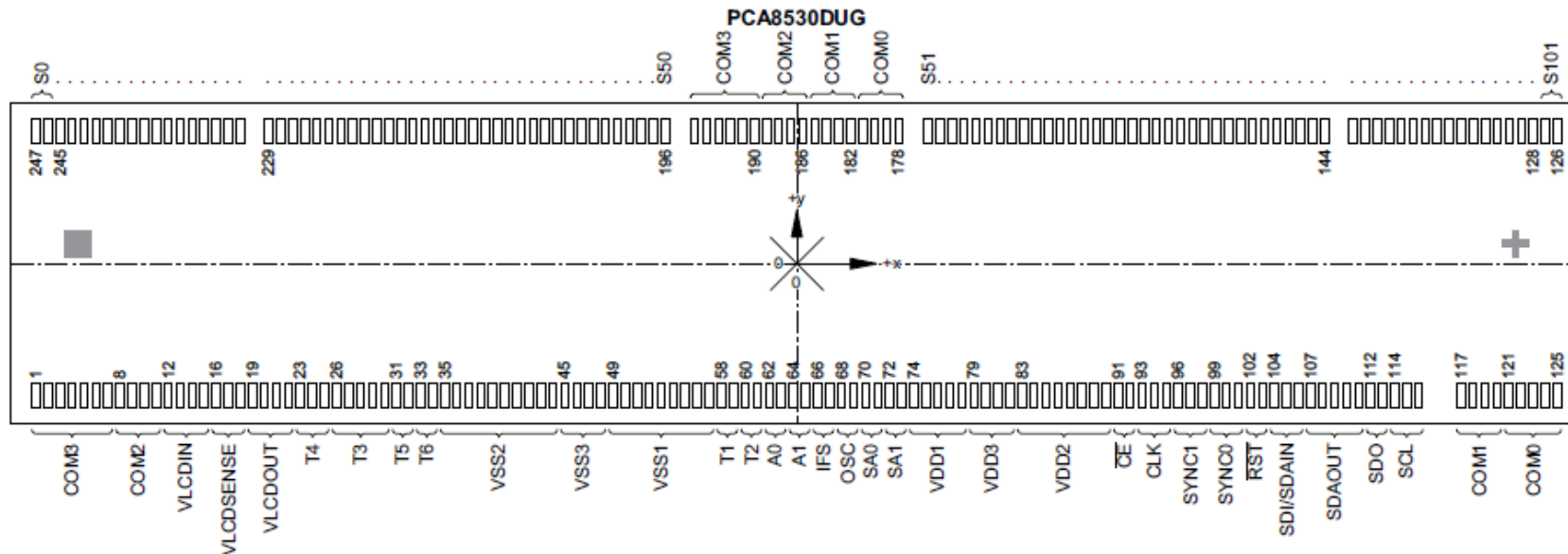
PCA8530 Up to 4 x 102 LCD Segment Driver

- ## High resistance to EMI

  - Allow a wide VSS connection

  - Fewer connections, fewer external components

  - EMC detection bits
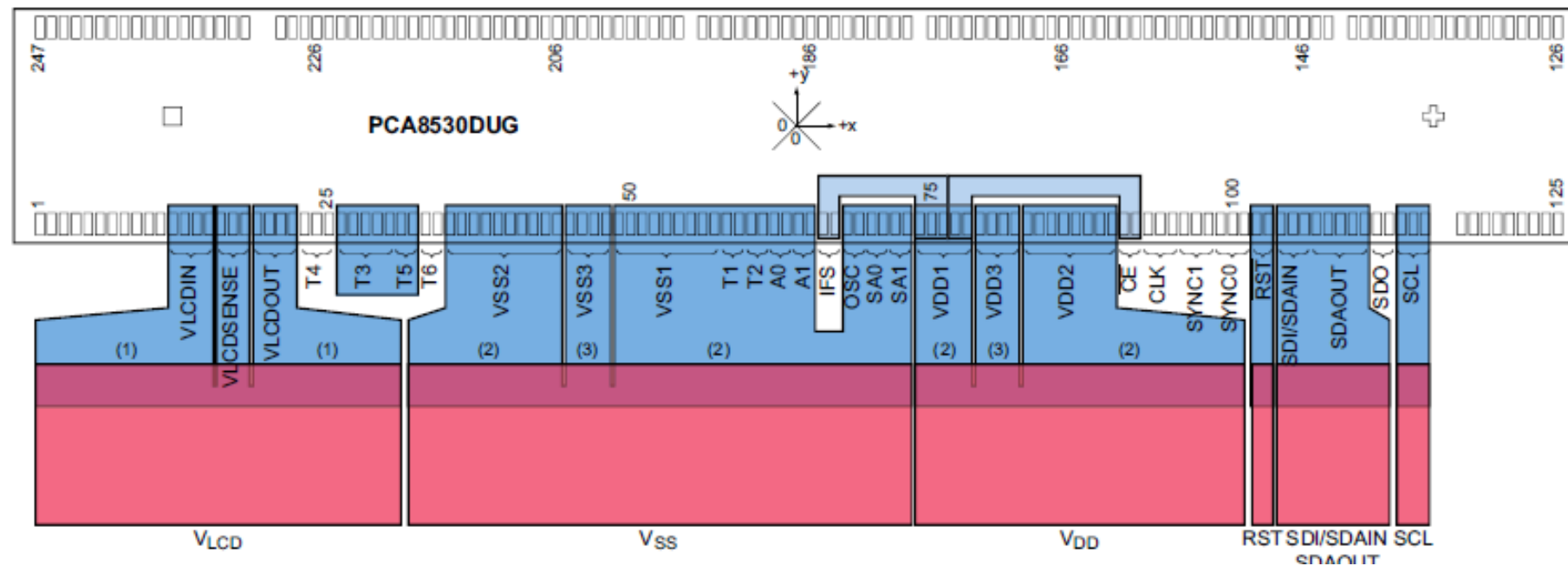
PCA8530 Up to 4 x 102 LCD Segment Driver

- ## High precision

  - VLCD accuracy: ± 60 mV at 8 V, RT
  - Frame frequency accuracy: ± 3 Hz at 80 Hz, RT

- ## Highly featured

  - Programmable FF: 45Hz to 300Hz
  - Programmable VLCD: 4V to 12V
  - Diagnostic function
  - Temperature readout
  - Multiple reset capabilities
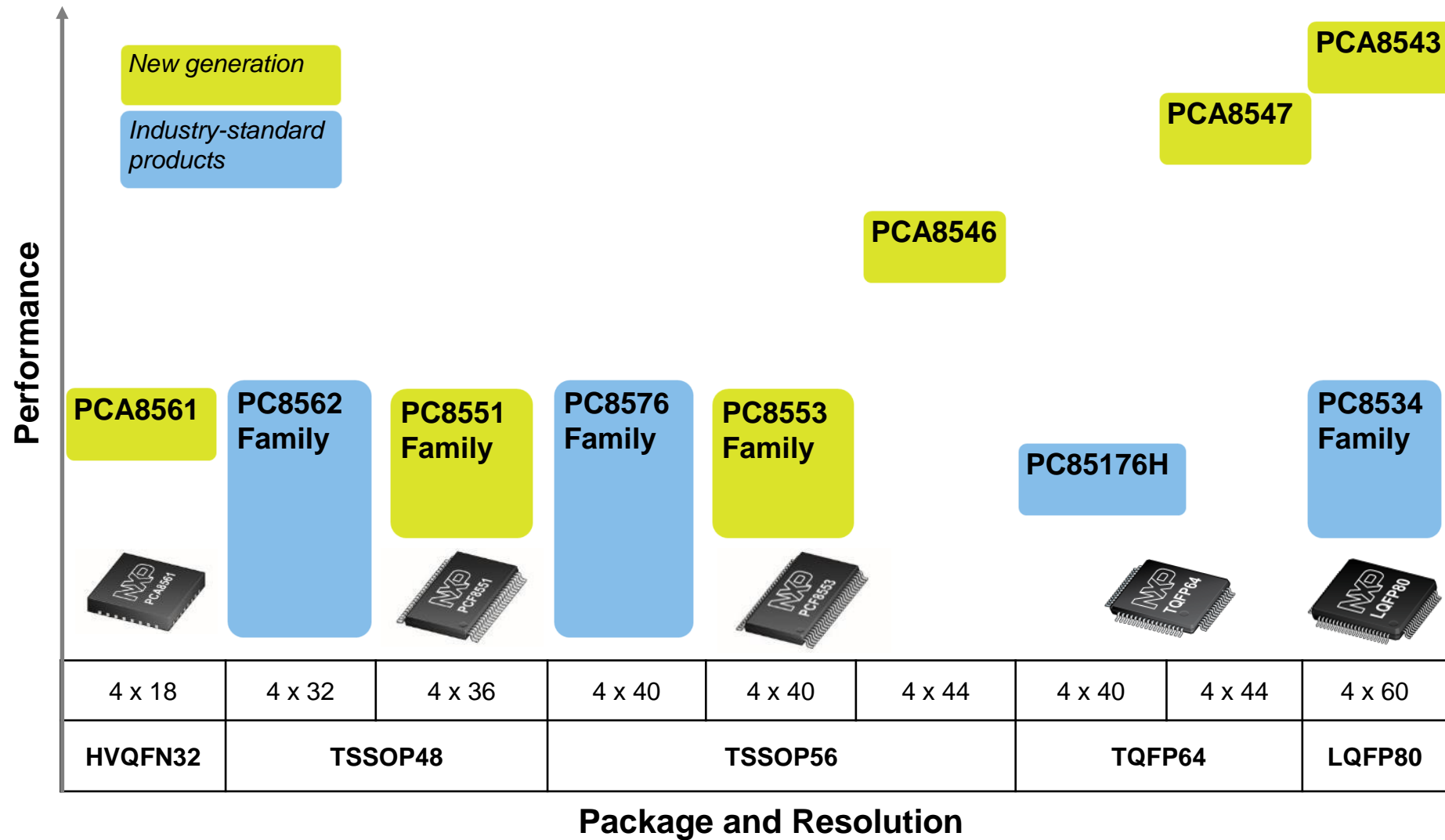 - …

Bit	Symbol	Value	Description
-	R/W̄	1	fixed value
-	RS[1:0]	00	fixed value
Temperature readout if SO = 0 (see Table 11)			
7 to 0	TD[7:0]	00000000 to 11111111	**temperature readout** (see Section 8.10.4.1 on page 40)
Device status readout if SO = 1 (see Table 11)			
7	SR7		**display status** (see Table 22 on page 21)
		0	display is disabled
		1	display is enabled
6	SR6		**charge pump switching status** (status of bit CPE, see Table 14 on page 15)
		0	charge pump disabled
		1	charge pump enabled
5	SR5		**charge pump charge status**
		0	charge pump has not reached programmed value
		1	charge pump has reached programmed value
4	SR4		**reset status flag**
		0	**no reset** has occurred since the reset status flag was cleared last time
		1	**reset** has occurred since the reset status flag was cleared last time[1]
3 to 0	SR[3:0]		**EMC detection**
		01SA1SA0	pre-defined code for EMC detection when I²C interface is used
		0101	pre-defined code for EMC detection when SPI interface is used

NXP

CASED
LCD DRIVERS

Cased LCD Segment Drivers – Mux 1:4

Performance (y-axis)

New generation

Industry-standard products

PCA8561	PC8562 Family	PC8551 Family	PC8576 Family	PC8553 Family	PCA8546	PC85176H	PCA8547	PCA8543 / PC8534 Family

| 4 x 18	4 x 32	4 x 36	4 x 40	4 x 40	4 x 44	4 x 40	4 x 44	4 x 60
HVQFN32	TSSOP48		TSSOP56			TQFP64		LQFP80

Package and Resolution

PCA8561
4 x 18 LCD segment driver in HVQFN32 package

Small-footprint, high-quality, low-power, & low-cost

Main features	PCA8561
Resolution (max)	4 x 18 = 72 segments
VDD range [V]	1.8V ÷ 5.5V
VLCD external [V]	1.8V ÷ 5.5V
Mux rates	1:1, 1:2, 1:3, 1:4
Bias configuration	static,1/2, 1/3
Oscillator	Internal or external selectable through command
Frame Freq.	32 Hz ÷ 256 Hz programmable
Reset	Input reset pin (RST); software reset command; POR circuit with POR enable input pin (PORE)
Interface	PCA8561AHN: 2-lines I^2C PCA8561BHN: 3-lines SPI
Others	A0,A1 pins for I^2C slave address selection
Operating Temp Range	-40°C to +105°C
Package	HVQFN32 (with wettable flanks)
ESD	HBM ± 3.5 kV
Qualification	AEC-Q100 grade 2
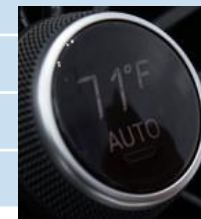
A stand-alone LCD driver per each display avoid any routing and mechanical issues

The TSSOP package is to big to be mounted inside the knob of a climate control

Small passive displays in the clusters in combination with the big TFT display in the center. The MCU is advanced for TFT controller and does not encompass any LCD driver.

PCA8561
4 x 18 LCD segment driver in HVQFN32 package

- Package Details HVQFN32 (DFN5050-32; outline: SOT617-3)

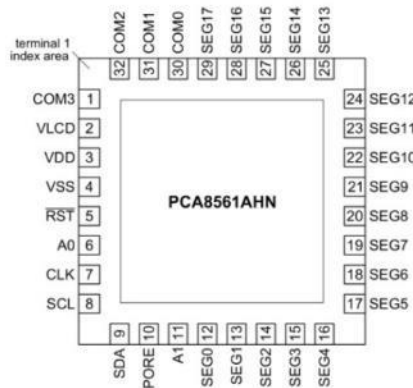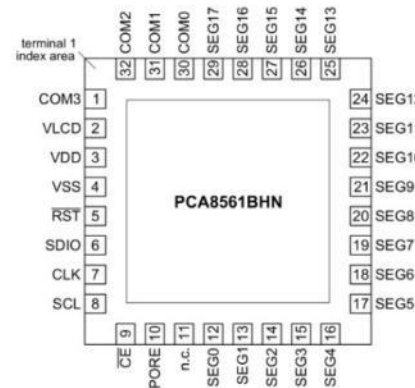| Parameter	Value
Width	5.0 mm
Length	5.0 mm
Height	0.85 mm
Pitch	0.5 mm
Soldering	wettable flanks

Wettable flanks:
The exposed edge of each terminal contains a small plated cavity, ensuring the solder flows into it and adheres to the side of the terminal. Non-wetting of the sides can be detected easily, allowing a **cost-effective optical inspection process.**
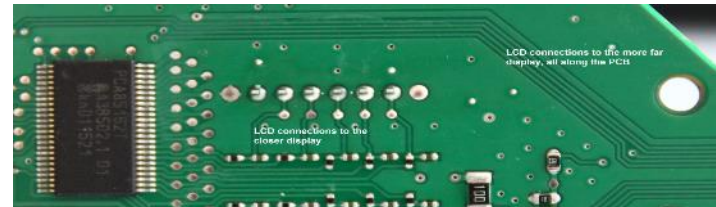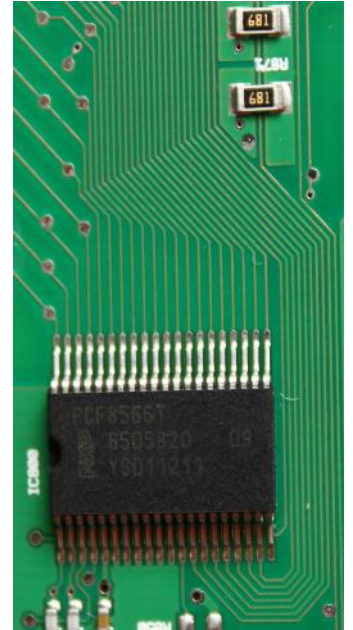
PCA8561
4 x 18 LCD segment driver in HVQFN32 package

- Key applications
  - Car climate control unit
  - Small passive displays in a car instrument cluster
  - Consumer healthcare / battery operated devices
- Key benefits
  - Reduce the PCB area
  - Sustain high operating temperatures
  - High EMC robustness
  - Easy visual inspection
  - Ultra low-power

PCA8553DTT OM13506 Demo Board (Hardware)

Current measurement
- Allows to show the low power consumption
- Useful for LCD driver behavior understanding (consumption vs configuration)

PCF8553DTT
- TSSOP56 package
- Up to 160 segments (4x40)
- Low power consumption

Passive display
- 120 segments (3x40)
- VLCD: 5V
- Mux: 1:3
- Bias: 1/3

USB connection
- Allows interconnection between the PC and the demo board
- HID Class: drivers are not needed

MCU based
- LPC1549 - 32bit ARM microcontroller
- Acts as a bridge between the LCD driver and the PC
- Schematics and PCB available on NXP web site

Interconnection bridge
- Allows to test the user custom application using the LCD driver mounted in the demo boar
- Jumpers allow flexibility
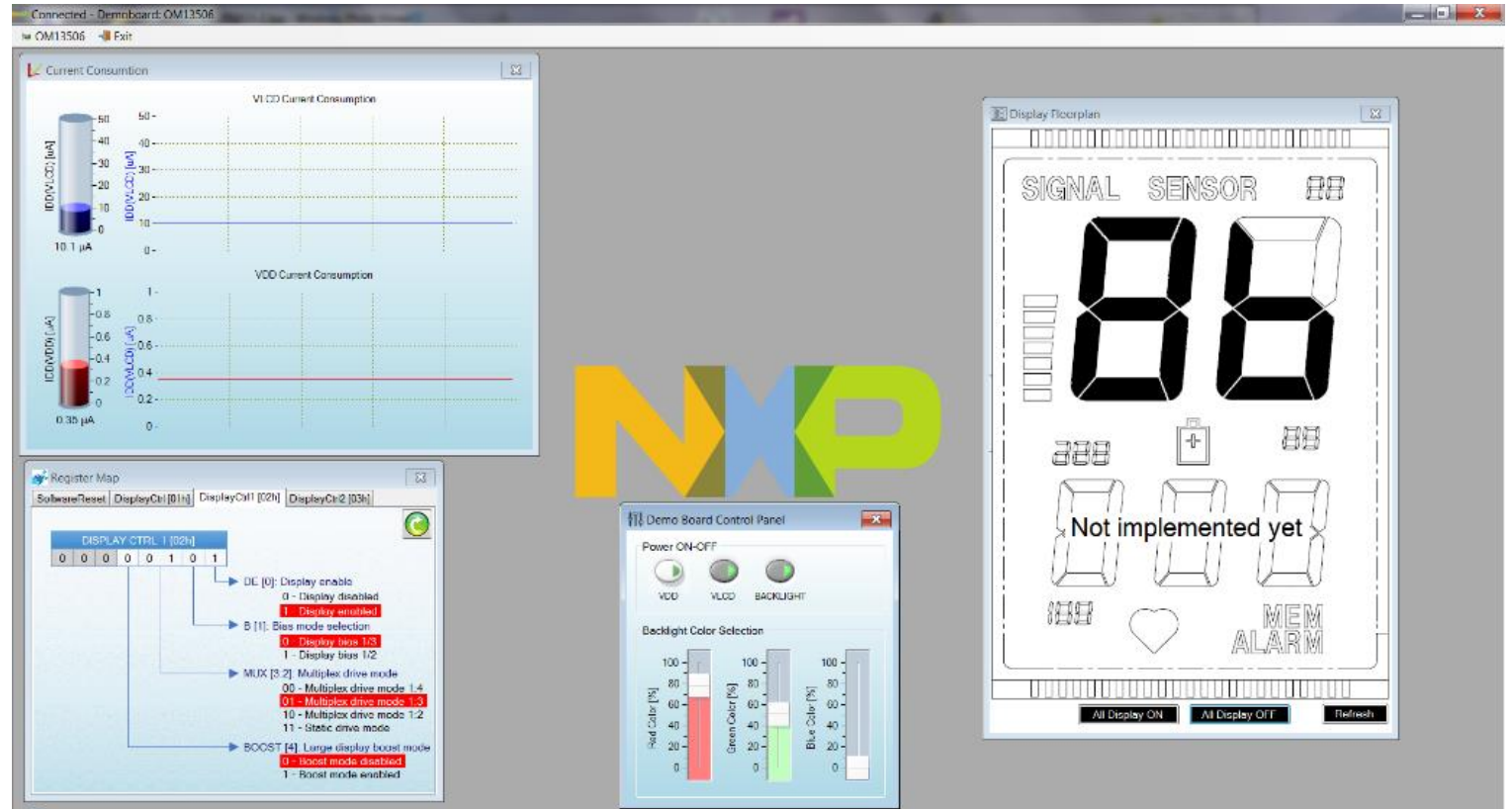- Main signals available (VDD, VLCD, CLK, SCL, SDA, etc.)

RGB backlight
- PWM driven
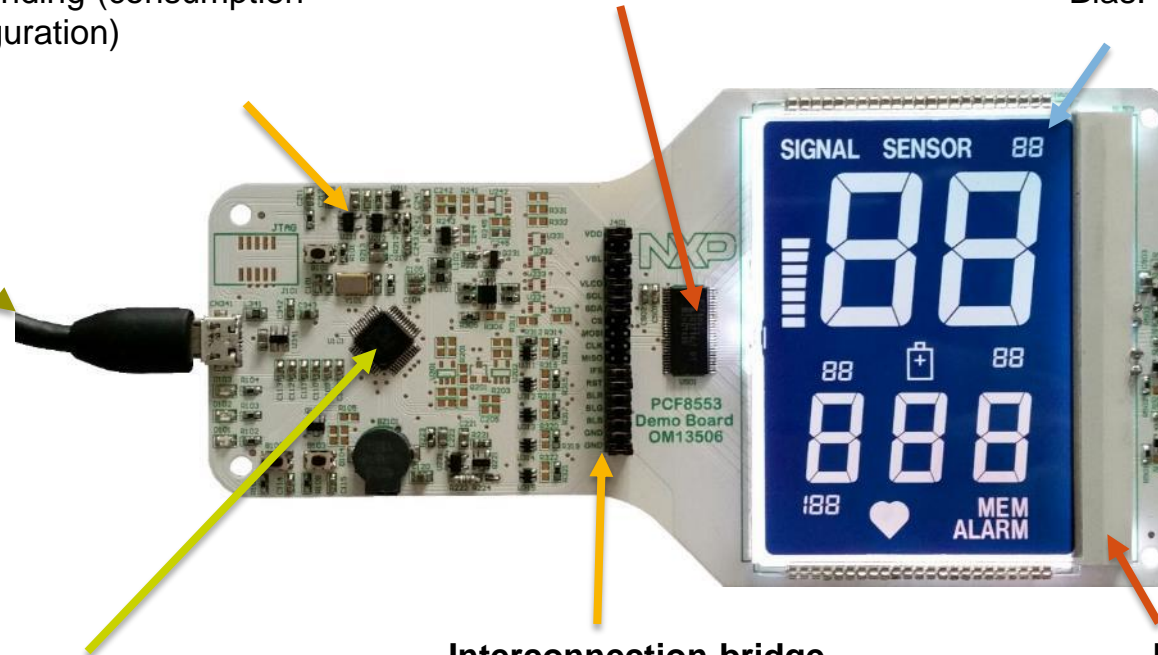
PCA8553DTT OM13506 Demo Board (Software)

- Graphical User Interface (GUI) for Windows

- User friendly

- Easy to use

- Plug & Play design

- Four sections available:
  - Current consumption
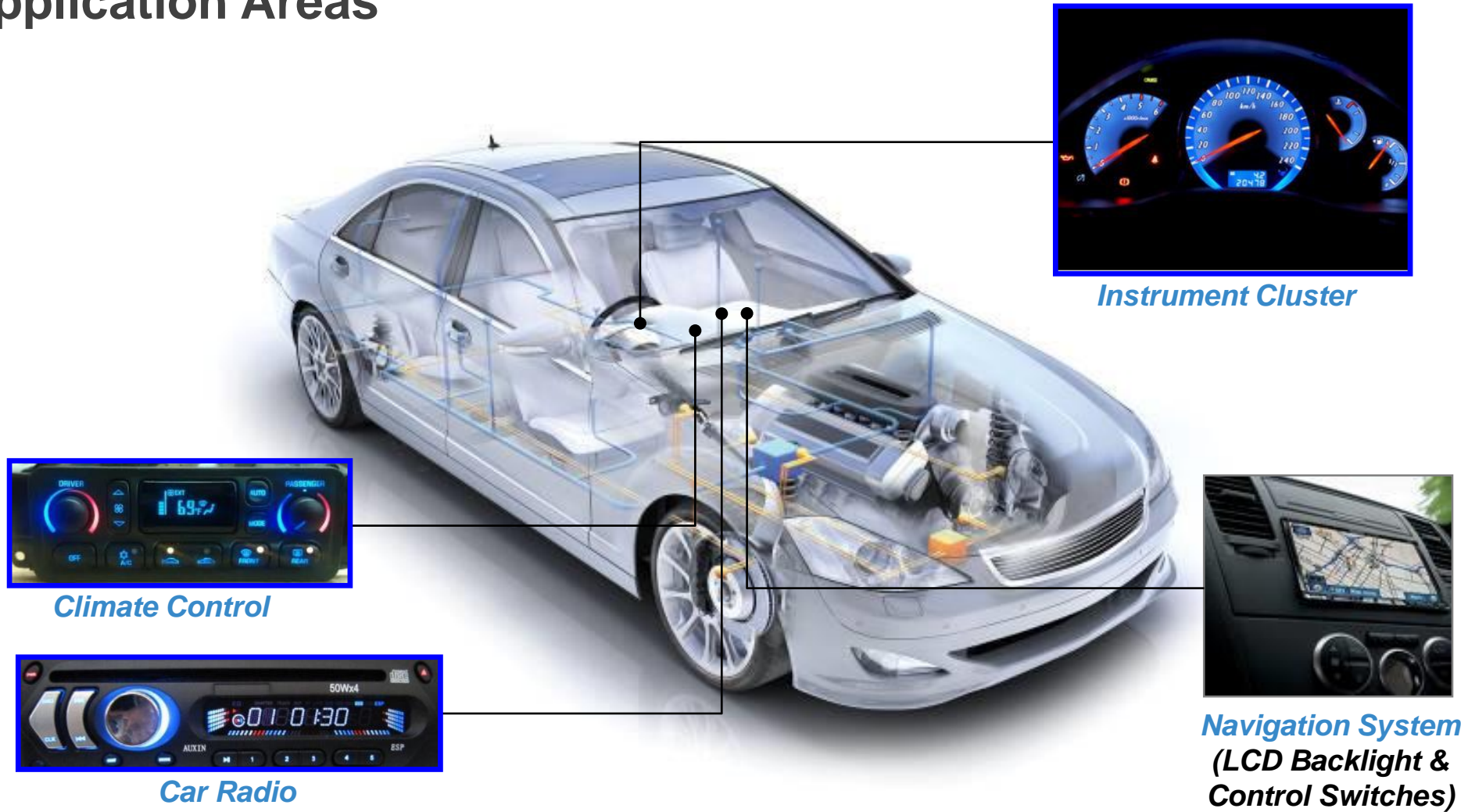 - Display floorplan
  - Power supply control
 - Register map

LED CONTROLLERS

NXP LED Controller for Automotive
Focus Application Areas

Instrument Cluster

Climate Control

Car Radio

Navigation System
(LCD Backlight &
Control Switches)

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NXP LED Controller for Automotive
Value proposition (1/2)

Fully integrated LED Control with Color Mixing and Dimming

Comparison discrete vs. fully integrated LED Control

(i) Discrete

(ii) Fully Integrated
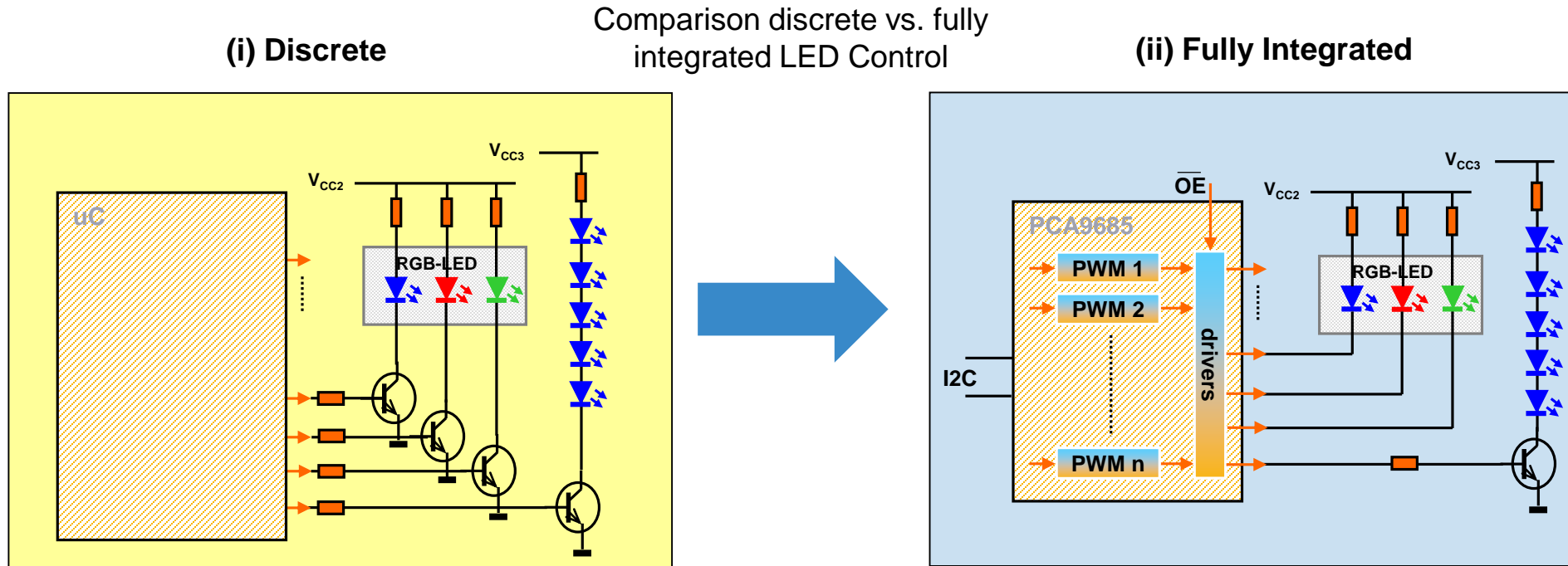
- *Reduced Bill of Material by integration of up to 16-PWM channels into one single controller*
- *Add value by smart color mixing and global dimming capability*

NXP LED Controller for Automotive
Value proposition (2/2)

Voltage Source or Constant Current Devices

Comparison Voltage Source vs.
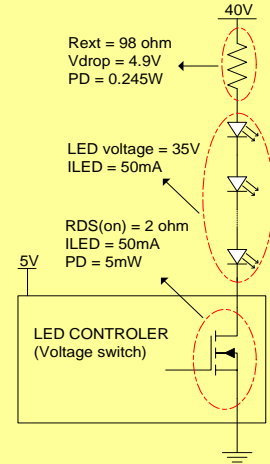Constant Current LED Control

(i) Voltage Source

(ii) Constant Current

Voltage Source

Advantages

▸ Less power dissipation in driver (less heat on the IC)

Considerations

▸ LED current varies with changes of supply voltage and LED voltage

▸ Need one resistor per channel to limit current

40V

Rext = 98 ohm
Vdrop = 4.9V
PD = 0.245W

LED voltage = 35V
ILED = 50mA

RDS(on) = 2 ohm
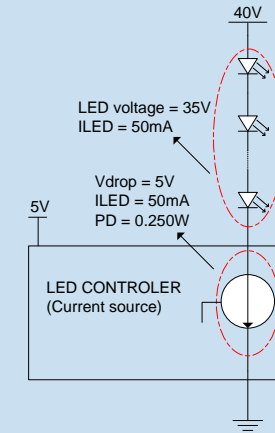ILED = 50mA
PD = 5mW

5V

LED CONTROLER
(Voltage switch)

Constant Current

Advantages

▸ LED current is independent of changes in supply voltage and LED forward voltage

▸ One resistor sets LED current for all channels

Considerations

▸ Higher power dissipation in driver (more heat on IC)

40V

LED voltage = 35V
ILED = 50mA

Vdrop = 5V
ILED = 50mA
PD = 0.250W

5V

LED CONTROLER
(Current source)

- *Voltage source: low power consumption and low heat generation but instead varying LED brightness with varying supply voltage and need for external resistor*
- *Constant Current: higher power consumption and higher heat generation but instead constant LED brightness and no need for external resistors*
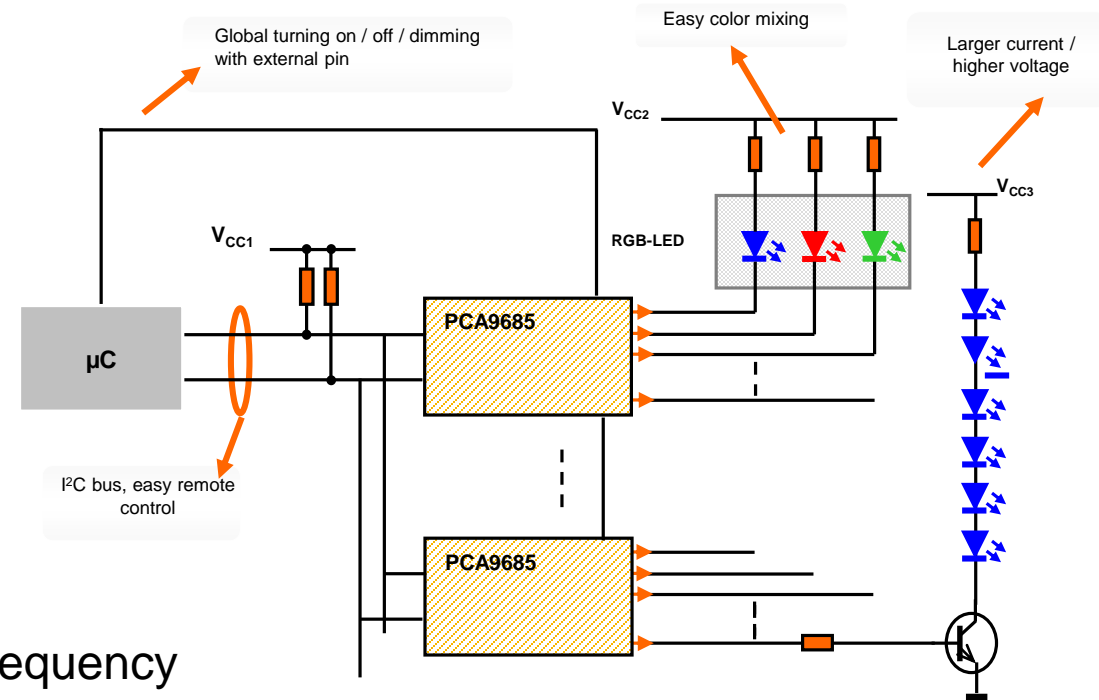
NXP

Voltage Source PWM LED Controller
➔ For cluster backlight, push button and tell tale illumination

- **PCA9635PW/Q900**
  - 16 + 1 PWM channels (16 individual, one global)
  - 8-bit PWM resolution (256 steps); 96kHz PWM frequency
  - *25mA output sink current; 5V compliant*
  - -40°C, .. , +85°C; TSSOP28 package
  - *AEC-Q100 automotive compliant qualification*

- **PCA9685PW/Q900**
  - 16 PWM channels, one global Output Enable
  - 12-bit PWM resolution (4096 steps); 40Hz-1000Hz PWM frequency
  - *25mA output sink current; 5V compliant*
  - -40°C, .. , +85°C; TSSOP28 package
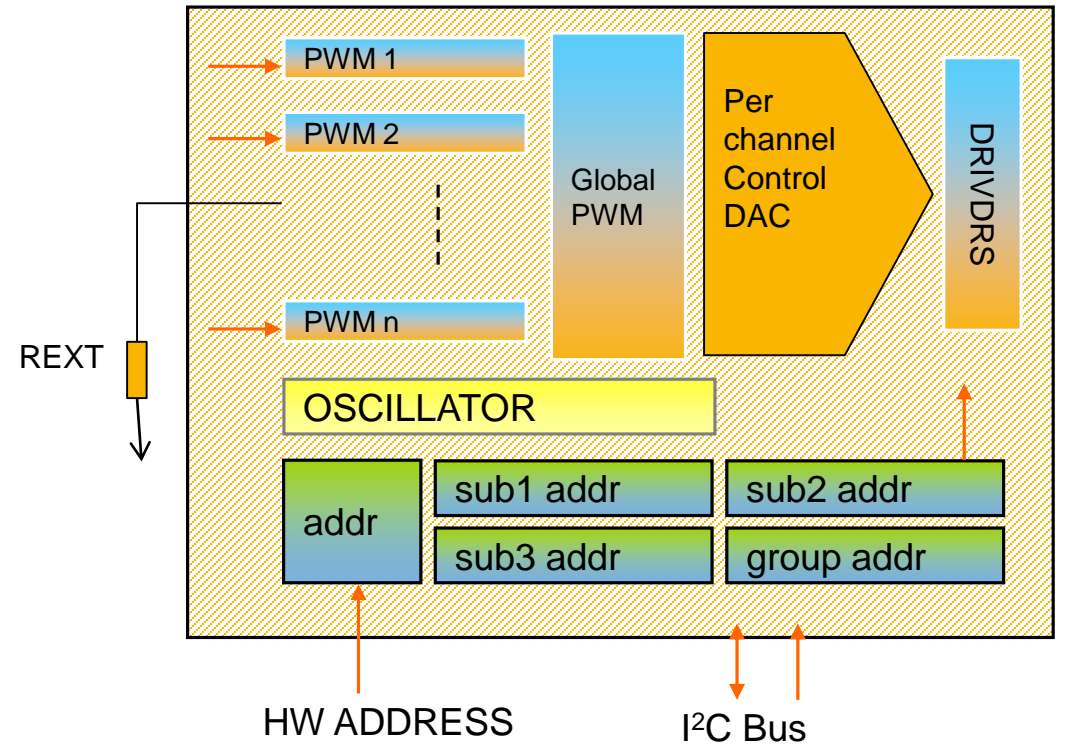 - *AEC-Q100 automotive compliant qualification*

Automotive AEC-Q100 Qualified

Constant Current PWM LED Controller
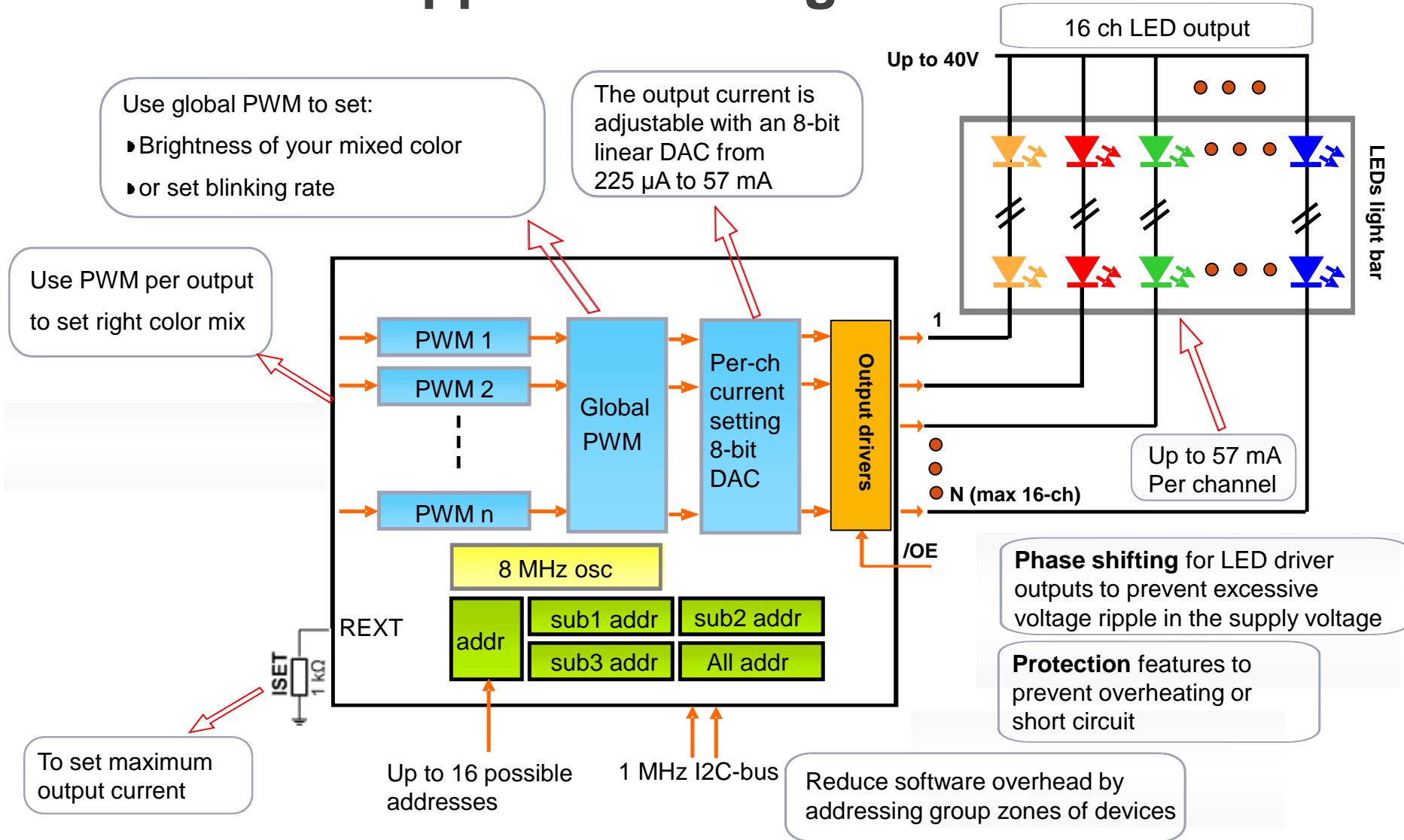➔ **For cluster backlight, push button and tell tale illumination**

- **PCA9955BTW/Q900**
  - *57-mA Constant current LED drivers @ 20V*
  - External resistor to set the overall output current
  - Output to output accuracy + 4%
  - Chip to chip output accuracy + 6%
  - 8-bit programmable output to output delay
  - Per channel 8-bit DAC to set individual output current
  - Per channel 8-bit PWM to dim LED in 256 steps
  - Global 8-bit PWM to dim or blink in 256 steps
  - Gradation control for LED output for up to 4 zones
  - 3 HW ADDR pins to allow up to 125 devices per bus
  - 4 programmable sub calls address groups for cluster control
  - LED open/short, over-temp, over current detection
  - Fast-mode Plus (1 MHz) I2C-bus interface
  - Thermally enhanced package HTSSOP28
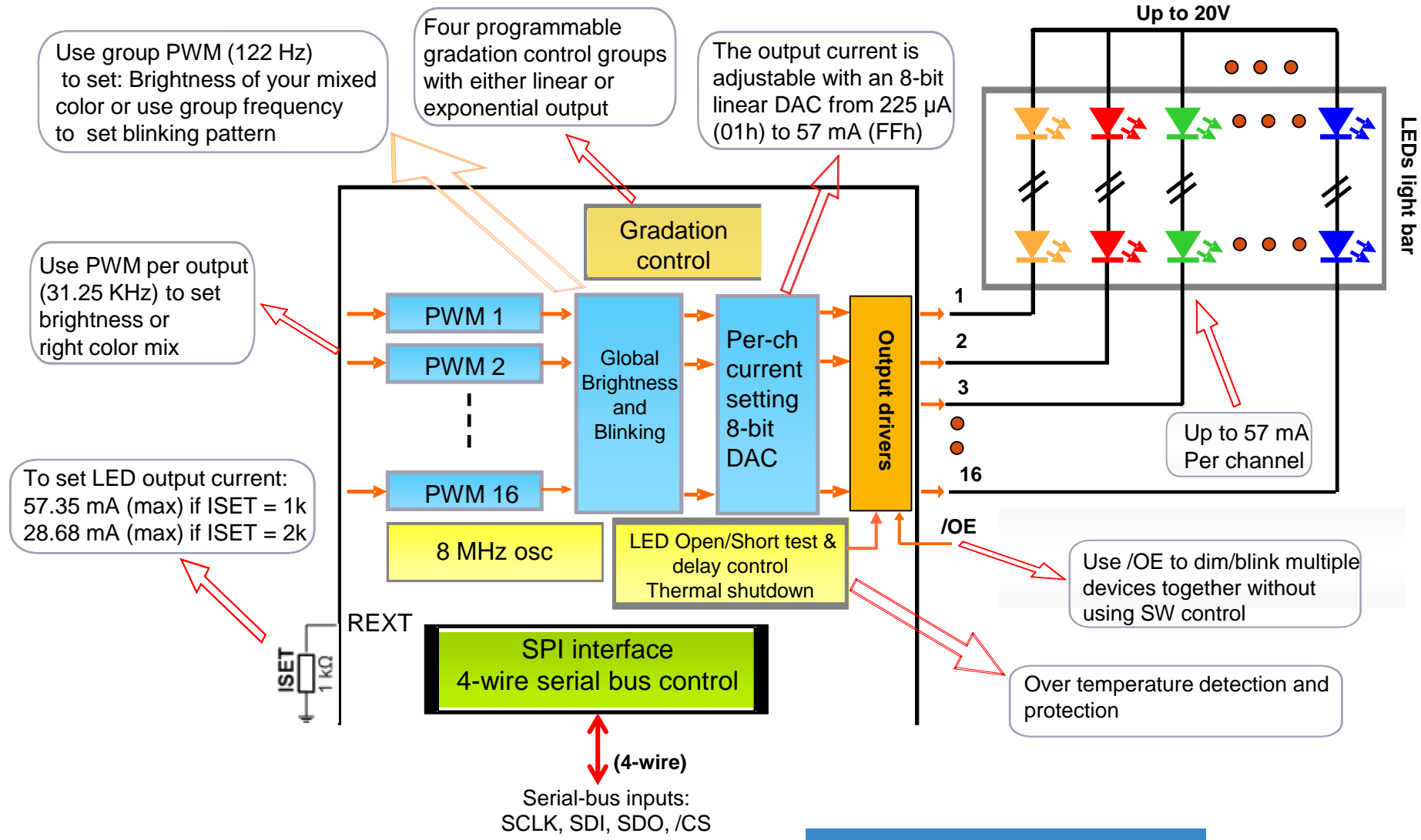 - *AEC-Q100 automotive compliant qualification*

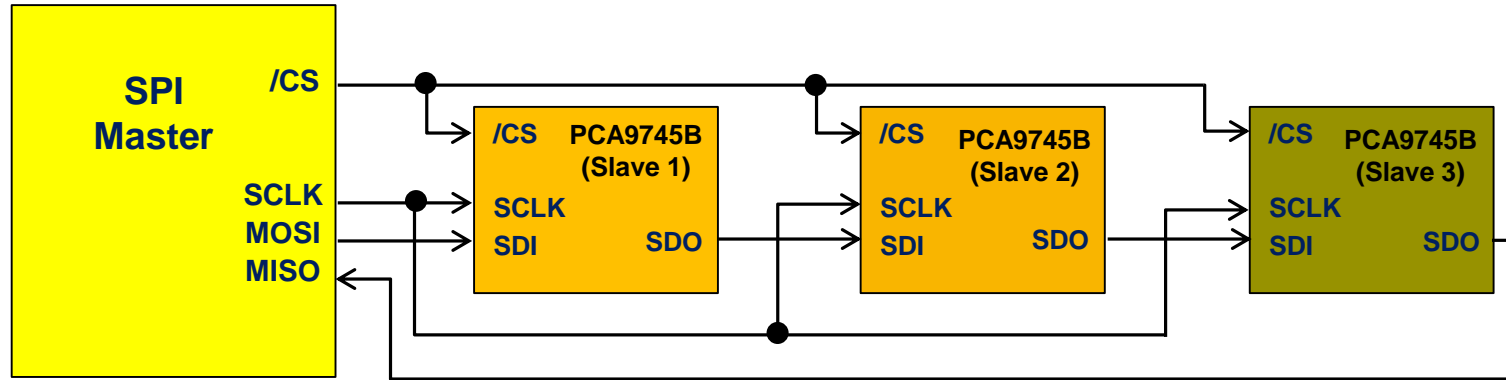**Automotive AEC-Q100 Qualified**

PCA9955BTW/Q900 Application Diagram

16 ch LED output

Up to 40V

LEDs light bar

Use global PWM to set:
- Brightness of your mixed color
- or set blinking rate

The output current is adjustable with an 8-bit linear DAC from 225 μA to 57 mA

Use PWM per output to set right color mix

PWM 1

PWM 2

PWM n

Global PWM

Per-ch current setting 8-bit DAC

Output drivers

1

N (max 16-ch)

/OE

8 MHz osc

REXT

ISET 1 KΩ

addr

sub1 addr

sub2 addr

sub3 addr

All addr

To set maximum output current

Up to 16 possible addresses

1 MHz I2C-bus

Up to 57 mA Per channel

Phase shifting for LED driver outputs to prevent excessive voltage ripple in the supply voltage

Protection features to prevent overheating or short circuit

Reduce software overhead by addressing group zones of devices

NXP

PCA9745B SPI Daisy-chain LED Driver Block Diagram

Use group PWM (122 Hz) to set: Brightness of your mixed color or use group frequency to set blinking pattern

Four programmable gradation control groups with either linear or exponential output

The output current is adjustable with an 8-bit linear DAC from 225 µA (01h) to 57 mA (FFh)

Up to 20V

LEDs light bar

Gradation control

Use PWM per output (31.25 KHz) to set brightness or right color mix

PWM 1
PWM 2
PWM 16

Global Brightness and Blinking

Per-ch current setting 8-bit DAC

Output drivers

1
2
3
16

/OE

Up to 57 mA Per channel

To set LED output current:
57.35 mA (max) if ISET = 1k
28.68 mA (max) if ISET = 2k

8 MHz osc

LED Open/Short test & delay control Thermal shutdown

Use /OE to dim/blink multiple devices together without using SW control

REXT

ISET 1 kΩ

SPI interface
4-wire serial bus control

Over temperature detection and protection

(4-wire)
Serial-bus inputs:
SCLK, SDI, SDO, /CS

Sampling

(AUTOMOTIVE QUALIFICATION IN PROGRESS)

PCA9745B SPI Daisy-chain Connection

SPI Data Format

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
MSB	Register Address					LSB	R / W	MSB	Data						LSB

- SPI Master send 16-bit (clocks with address and data) x 3 (number of slaves) to access all slave devices at the same time
- Only one byte data can be read/write from/to all slave devices
- No slave address required

Sampling

SUMMARY

NXP Secure Interface & Power Solutions
Automotive Qualified Devices & Targeted Devices

- **Continuously expanding automotive portfolio by post qualification of existing products**
- **Portfolio of more than 700 products and more than 10'000 customers world-wide**
- **More than 25 years experience in delivering into automotive industry**

DP-LVDS Bridge
- Infotainment

Why NXP?
- Wide operating temperature range
- Low BOM Count
- Field FW Upgrade
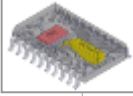
REALTIME CLOCKS
- Tachographs
- Black boxes
- Battery Mgmt Units
- Navigation Systems
- Car Radios

Why NXP?
- up to 125ºC op. Temp.
- Ultra low power (< 1 µ A)
- Temp. compensation
- integrated quartz crystal
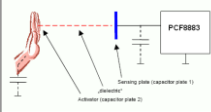
CAPACITIVE SENSORS
- Passive Key-less Entry Systems (PKE)
- Replacement of rotary knobs, push buttons, sliders in car radios or climate control units

Why NXP?
- Configurable as touch or proximity sensor
- self-calibrating
- Low power consumption

Analog Switches
- Multiplexing and Demultiplexing high-speed signals

Why NXP?
- Speeds up to 12GHz
- Broad portfolio

LED CONTROLLERS
- Instrument clusters
- Dash boards
- Gauges / Tell Tales
- Car radios
- Climate Controls

Why NXP?
- Low power (<1µA)
- Wide Vdd range
- Dimming & color mixing
- No external components

TEMPERATURE SENSORS
- Multimedia systems
- Infotainment /cluster displays
- Body Control Unit
- Climate Control Unit
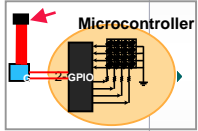
Why NXP?
- High accuracy
- Wide temperature range

IO EXPANDERS (GPIOs)
- Body Control Units
- Instrument Clusters
- Car radios

Why NXP?
- Large portfolio
- NXP (Philips) has invented the I2C bus

Microcontroller

Comparators
- Battery Level Detection
- Battery Thermal Protection
- Audio Line Plug-in Detection
- Portable Headset Detection
- Reset Command to MCU

Why NXP?
- Ultra-low current consumption

LCD DRIVERS
- Instrument clusters
- Climate controls
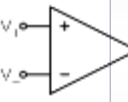- Tachographs
- Car radios
- Key fobs

Why NXP?
- up to 105ºC op. Temp.
- up to 16.0V VLCD
- Frame Freq. calibration
- On-chip Charge Pump
- On-chip Temp. Sensor

Load Switches
- Power Sequencing & Saving
- Protection & Control
- *Power Delivery & Charging*

Why NXP?
- Low & flat R_{ON}
- Low power consumption

LEVEL SHIFTERS
- Processor Interface in Infotainment Systems

Why NXP?
- market leader in GTL devices used for processor to chipset interface
- wide portfolio of 2-bit, 4-bit, 8-bit and 16-bit devices

Conclusion & Summary

- For more information about NXP LED and LCD products, as well as the entire NXP I^{2}C product portfolio, visit www.nxp.com/i2c

SECURE CONNECTIONS
FOR A SMARTER WORLD

ATTRIBUTION STATEMENT