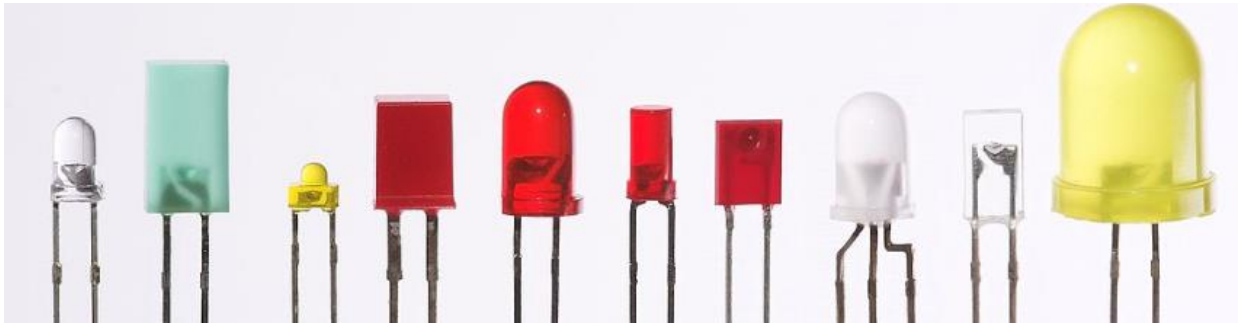
# OFFERING SOLUTIONS FOR LED STATUS INDICATION AND COLOR MIXING

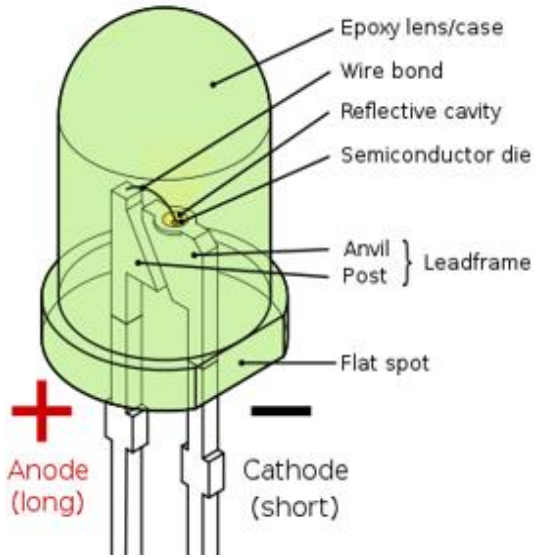
MARCH 25, 2020




SECURE CONNECTIONS FOR A SMARTER WORLD

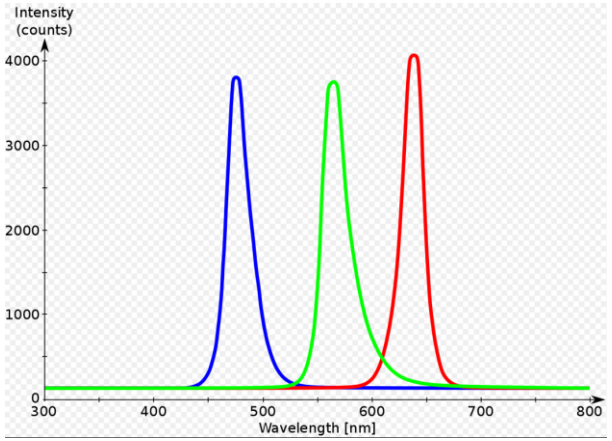
# LED

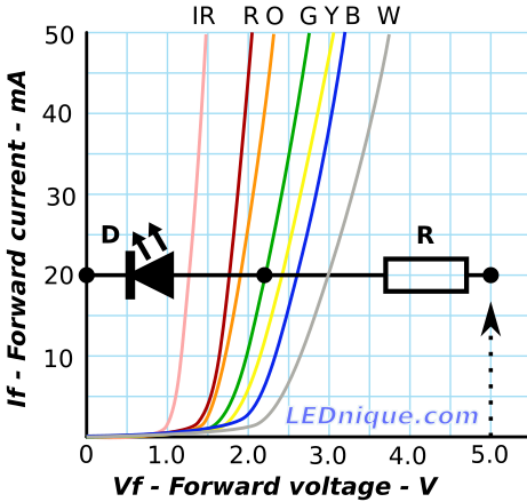


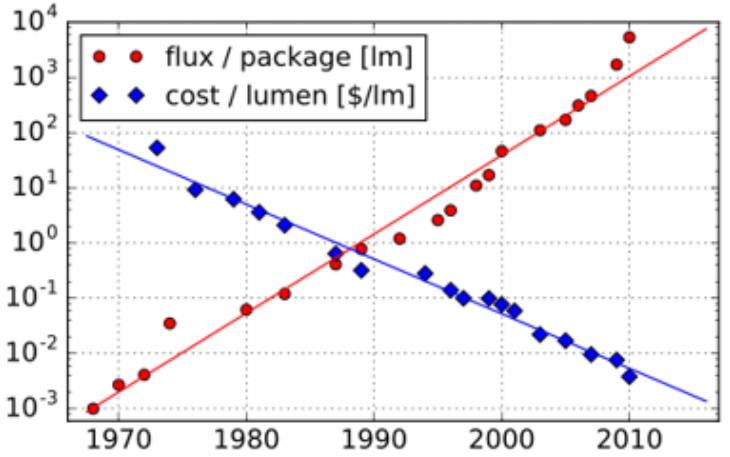



Illumination vs Indication

A light emitting diode (LED) is a two lead semiconductor light source. Electrons are able to recombine with electron holes within the device, releasing energy in the form of photons.




https://en.wikipedia.org/wiki/Light-emitting_diode

# LED Controllers Use Cases

**Examples:**

- Indication – off/on
- Status LED – off, dim/blink 1, dim/blink 2 and on
- Fade-in and fade-out for breath light – in sleep mode
- Fun lighting – RGB color mixing
- Information – smart assistant RGB LED circle
- VR headsets – position indication
- Keypad backlights for cellular phones or handheld devices

# LED Controllers – Major Selection - Type

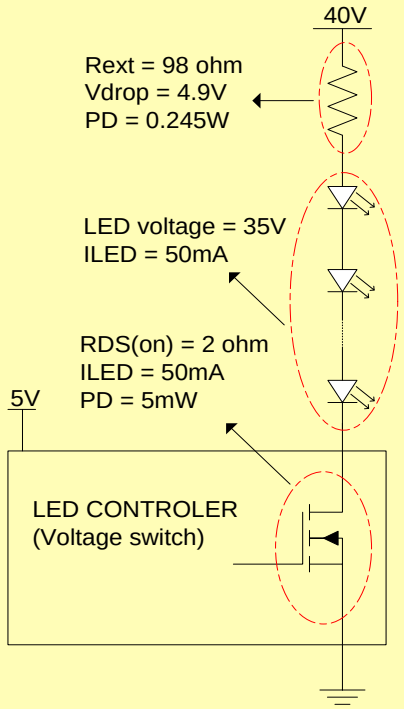
## Voltage Source

**Advantages**

- Less power dissipation in driver (less heat on the IC) since it is dropped across resistor
- Different supply voltage per channel allowed

**Considerations**

- LED current varies with changes of supply voltage and LED voltage
- Need one resistor per channel to limit current



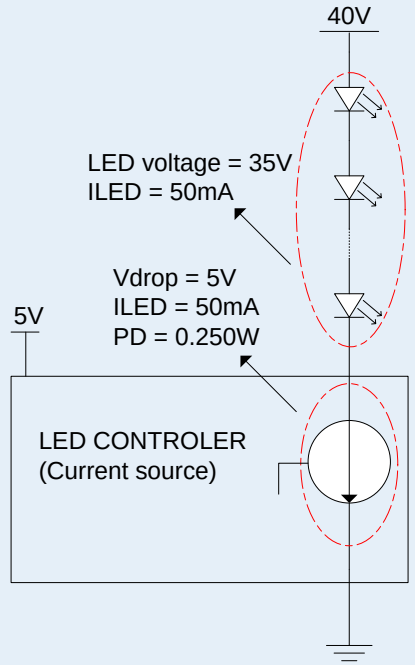

## Constant Current

**Advantages**

- LED current is independent of changes in supply voltage and LED forward voltage
- One resistor sets LED current for all channels

**Considerations**

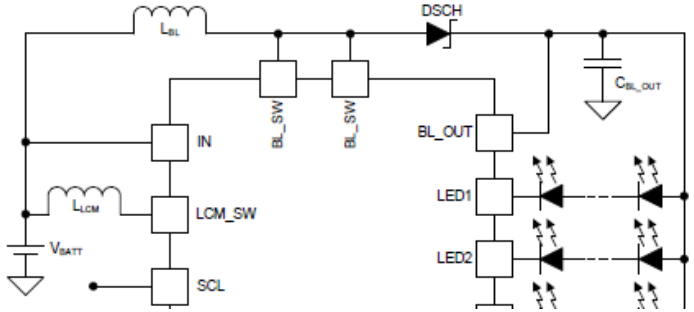
- Higher power dissipation in driver (more heat on IC)
- Need to adjust supply voltage for < 2V across IC



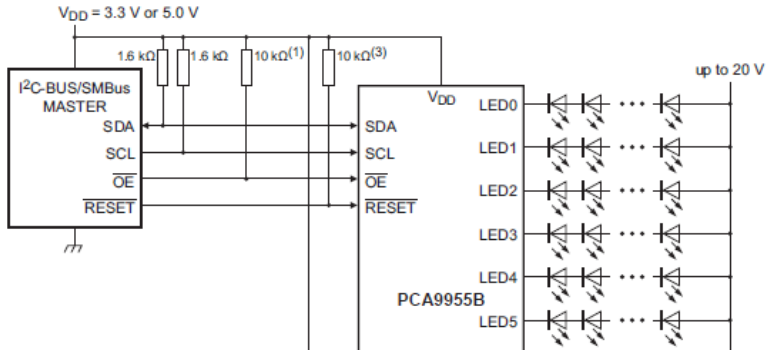
# LED Controllers – Selection Parameters - Voltage

- **Number of LEDs per channel**
  - One LED per channel requires a VLED just above VF and the drop across the on-chip transistor
  - LEDs in series connected to a single channel require high VLED
- **Booster or no Booster**
  - In case of high VLED is required, a booster must be implemented, which could be external or internal in the LED driver
  - In case of low VLED and a battery-operated devices, a charge pump is typically implemented

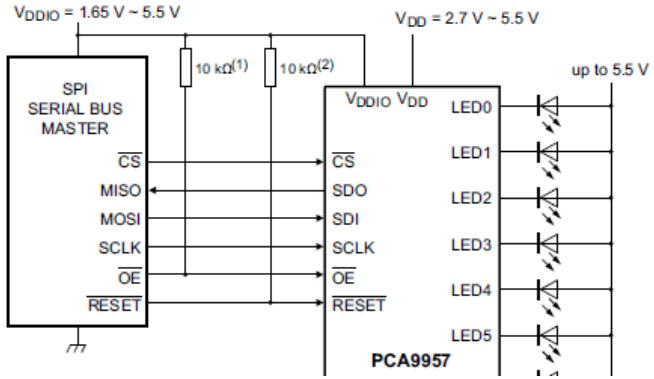
**Several LEDs in series**
**LED driver with booster integrated**




**Several LEDs in series**
**LED driver without booster integrated**

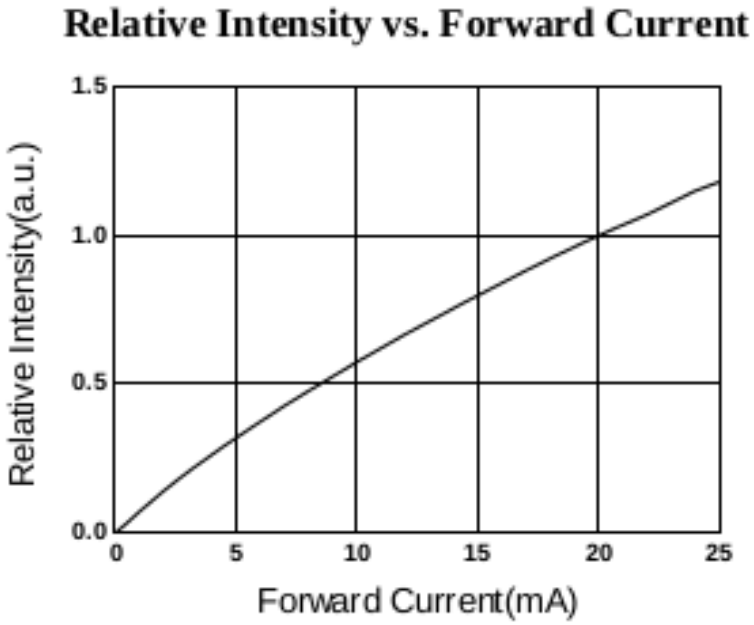



**1 LED per channel VLED = 5V**



# LED Controllers – Selection Parameters - Current

- **Current Per Channel:**
  - The amount of current flowing through the LED determines how bright it is
  - Excessive current will burn the LED
  - The relative intensity vs current curve is defined in the LED datasheet
  - Typically the LED current is a fixed requirement
  - LED color can change with current change
  - To ensure same color, use PWM (duty cycle) for dimming



# LED Controllers – Selection Parameters - Other

- **Many Other Selection Criteria:**
  - Number of channel (1 to 24 or higher – some in multiples of three)
  - Programming current resolution (external resistor and/or internal DAC)
  - PWM resolution (8 bit 256 steps – some 12 to 14 bits for lack of LED binning)
  - Interface ($I^2C$-bus, SPI, HW pin)
  - Diagnostics functions (open/short detection, thermal overload)
  - Package (TSSOP leaded (with heat sink) to QFN (with center pad)

# LED Controllers

40 V

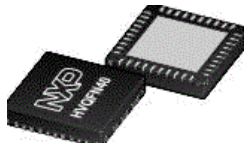
20 V

5 V

PCA955x (2/4/8/16) – blinker
PCA953x (2/4/8/16) – dimmer
PCA963x (4/8/16) – RGB
PCA9685 (16) – 12-bit RGB



PCA9957HN (24)




PCA99552TW (16)
PCA99555TW (16)

PCA9956BTW (24)
PCA9955BTW (16)
PCA9745BTW (16)


PCA9626B (24)
PCA9622B (16)
PCA9624B (8)


25 mA

32 mA

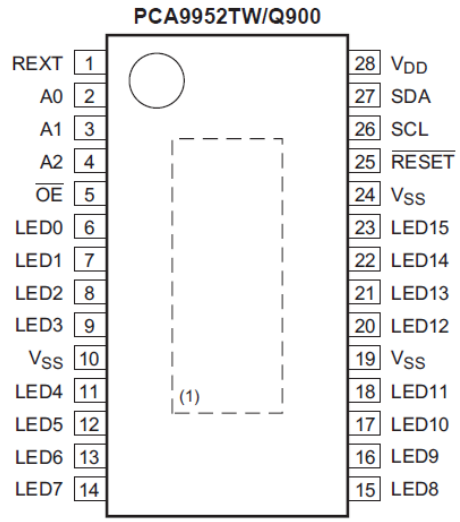
57 mA

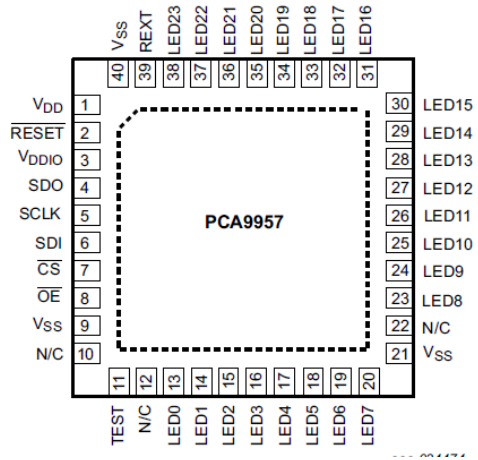
100 mA

**Legend:**
Voltage Source
Constant Current

# Overview of Constant Current Drivers

| | x52 | x55 | x55B | x45B | x56B | x57 |
|---|---|---|---|---|---|---|
| Interface | I²C | I²C | I²C | SPI | I²C | SPI |
| Supply voltage range (V) | 3.0 ~ 5.5 | 3.0 ~ 5.5 | 3.0 ~ 5.5 | 3.0 ~ 5.5 | 3.0 ~ 5.5 | 2.7 ~ 5.5 |
| Temp range (°C) | -40 ~ +85 | -40 ~ +85 | -40 ~ +105 | -40 ~ +105 | -40 ~ +85 | -40 ~ +85 |
| Number of channels | 16 | 16 | 16 | 16 | 24 | 24 |
| Max LED voltage (V) | 40 | 40 | 20 | 20 | 20 | 5 |
| Max output drive current (mA) | 57 | 57 | 57 | 57 | 57 | 32 |
| External resistor to set the overall output current | Yes | Yes | Yes | Yes | Yes | Yes |
| Output to output accuracy | ±6% | ±6% | ±4% | ±4% | ±4% | ±4% |
| Chip to chip output accuracy | ±8% | ±8% | ±6% | ±6% | ±6% | ±6% |
| 8-bit programmable output to output delay | Yes | Yes | Yes | Yes | Yes | Yes |
| Per channel 8-bit DAC - individual output current | Yes | Yes | Yes | Yes | Yes | Yes |
| Per channel 8-bit PWM to dim LED in 256 steps | Yes | Yes | Yes | Yes | Yes | Yes |
| Global 8-bit PWM to dim or blink in 256 steps | Yes | Yes | Yes | Yes | Yes | Yes |
| LED open/short, over-temp, over current detection | Yes | Yes | Yes | Yes | Yes | Yes |
| Thermally enhanced package | HTSSOP | HTSSOP | HTSSOP | HTSSOP | HTSSOP | QFN |
| Number of address pins | 3 | 4 | 3 | NA | 3 | NA |
| /OE pin | Yes | No | Yes | Yes | Yes | Yes |
| AEC-Q100 automotive compliant versions available | Yes | Yes | No | Yes | No | No |



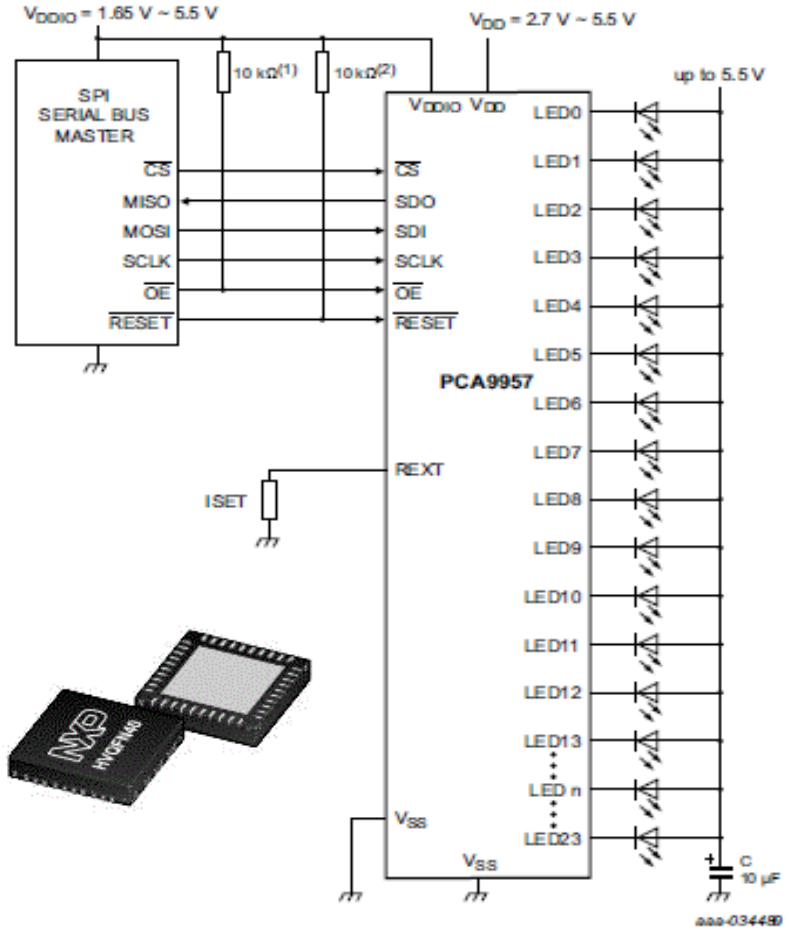
# PCA9957HN: 24-Ch, 5.5 V/32 mA LED Controller

## Features

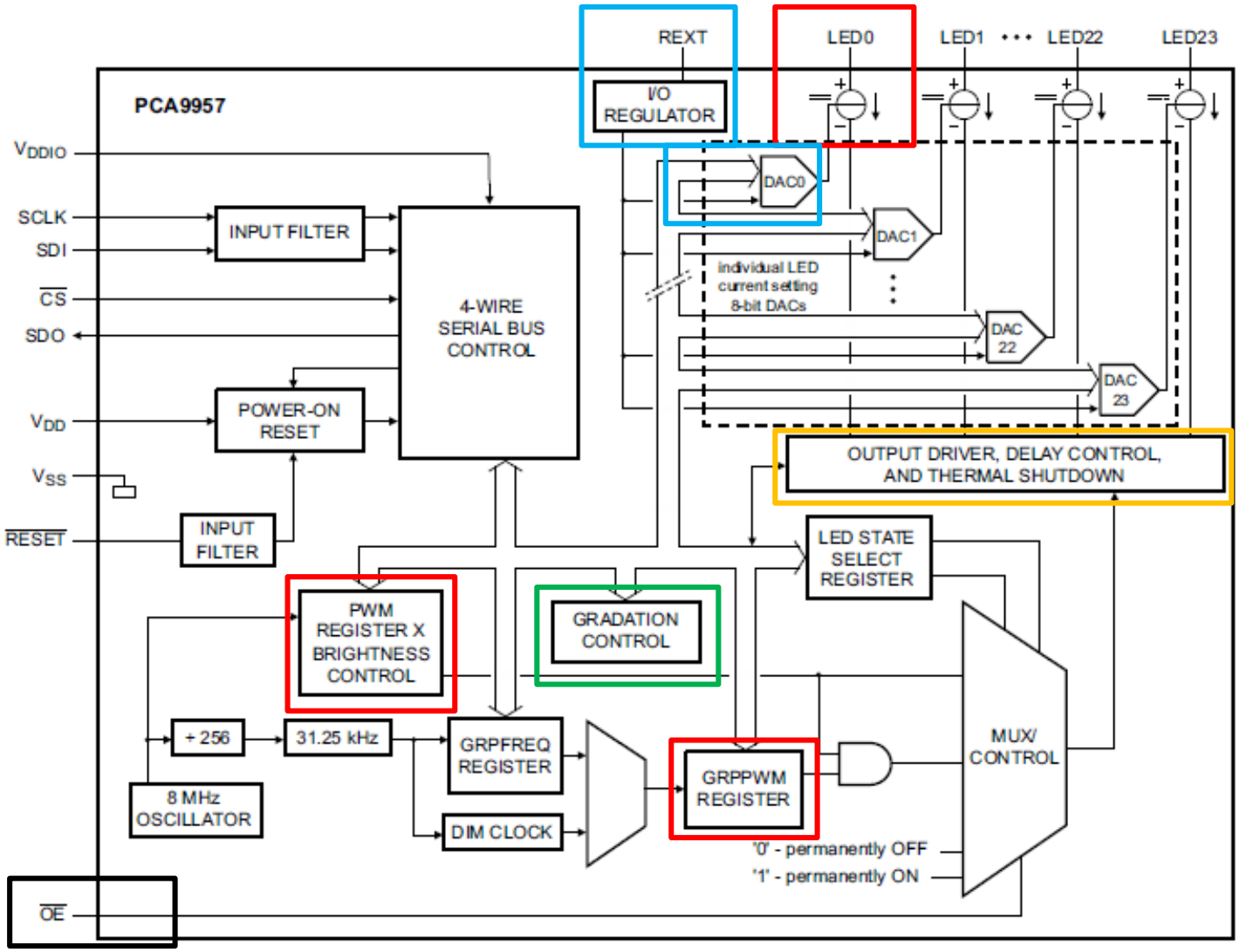
- Daisy-chain SPI 4-wire 10 MHz
- Absolute channel-to-channel accuracy ±4% (max)
- 140°C over-temperature protection
- 256-step group brightness and blinking control from 0% to 99.6%
- IREFx registers to set current gain
- Programmable LED output delay to reduce EMI and surge currents

## Differentiation

- 2.7 V to 5.5 V supply range with VDDIO down to 1.8 V
- Max CC output 32 mA/Channel
- Down to 0.4 V (min) voltage drop at LED outputs → low power
- Six gradation control groups for all channels
- 40-pin 5 mm x 5 mm SOT169-5 HVQFN package saves space



# PCA9957HN Block Diagram




**LED – 256 steps dim**

**Group – 256 steps dim or 15 Hz to 16.8 sec blink with adjustable duty cycle**

**Each LED can be Off, On, Individual PWM or Individual + Group PWM**

**DAC – 256 steps**

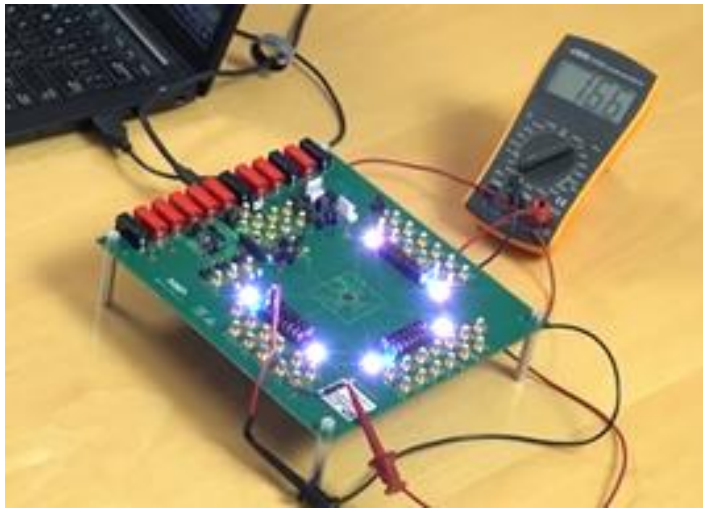
**Six Gradation Controls – ramp up/down**

**Over Temp Shut Down**

**OE control – external dim/blink multiple devices**

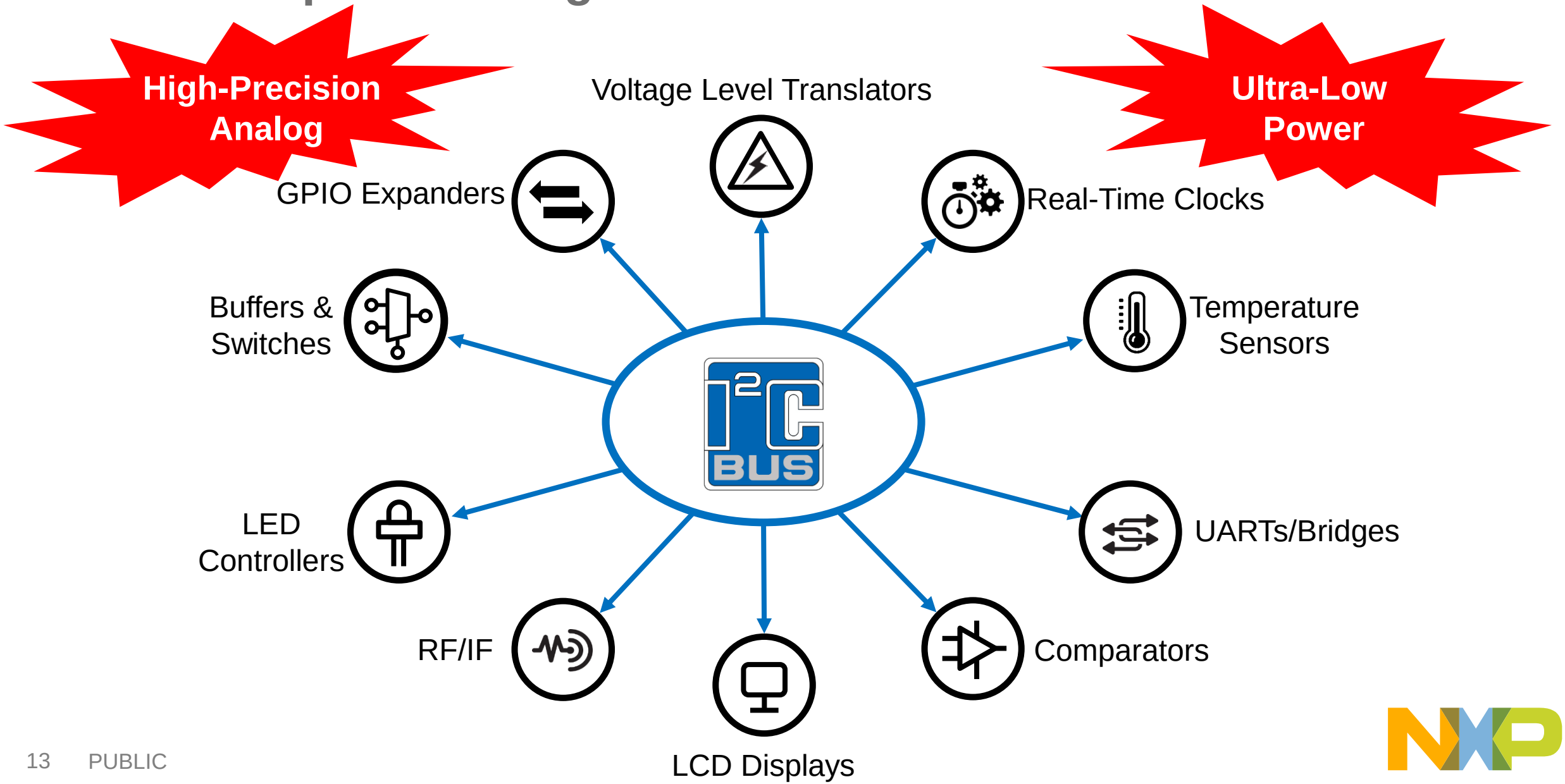
# PCA9957HN Evaluation Board

## OMPCA9957LEDEV



# QUESTIONS AND ANSWERS

# General Purpose Analog Offers "*Solutions Around The Core*"



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# LED Controllers Portfolio Overview

| Part | Output | | | | | Function | | | Qualification |
|---|---|---|---|---|---|---|---|---|---|
| | # Channels | VS | CC | $V_{LED}$ | IDD | Control I/F | PWM | Function | Consumer / Industrial |
| PCA9550,3,1,2 | 2, 4, 8, 16 | ● | - | 5 V | 25 mA | 400 kHz Fm | 2x 8-bit | Blinker | Consumer / Industrial |
| PCA9530,3,1,2 | 2, 4, 8, 16 | ● | - | 5 V | 25 mA | 400 kHz Fm | 2x 8-bit | Dimmer | Consumer / Industrial |
| PCA9624,2,6 | 8, 16, 24 | ● | - | 40 V | 100 mA | 1 MHZ Fm+ | 8-bit indiv / global | RGB - Mixer | Consumer / Industrial |
| PCA9632,3,4,5 | 4, 4, 8, 16 | ● | - | 5 V | 25 mA | 1 MHZ Fm+ | 8 bit indiv / global | RGB - Mixer | Consumer / Industrial |
| PCA9635 | 16 | ● | - | 5 V | 25 mA | 1 MHZ Fm+ | 8 bit indiv | RGB - Mixer | Consumer / Industrial Automotive |
| PCA9685 | 16 | ● | - | 5 V | 25 mA | 1 MHZ Fm+ | 12 bit indiv | RGB - Mixer | Consumer / Industrial Automotive |
| PCA9952 | 16 | - | ● | 40 V | 57 mA | 1 MHZ Fm+ | 8-bit indiv / global | RGB - Mixer | Consumer / Industrial Automotive |
| PCA9955 | 16 | - | ● | 40 V | 57 mA | 1 MHZ Fm+ | 8-bit indiv / global | RGB - Mixer | Consumer / Industrial Automotive |
| PCA9955B | 16 | - | ● | 20 V | 57 mA | 1 MHZ Fm+ | 8-bit indiv / global | RGB - Mixer | Consumer / Industrial Automotive |
| PCA9956B | 24 | - | ● | 20 V | 57 mA | 1 MHZ Fm+ | 8-bit indiv / global | RGB - Mixer | Consumer / Industrial |
| PCA9745B | 16 | - | ● | 20 V | 57 mA | SPI Daisy | 8-bit indiv / global | RGB - Mixer | Consumer / Industrial Automotive |
| PCA9957 | 24 | - | ● | 5 V | 32 mA | SPI | 8-bit indiv / global | RGB - Mixer | Consumer / Industrial |
| PCA99xx | 24 | - | ● | 5 V | 65 mA | SPI | 8-bit indiv /global | RGB - Mixer | Consumer / Industrial Release in Q3 |

VS: Voltage Source; CC: Constant Current
PCA9952 has an Output Enable pin and the PCA9955 does not. The PCA9952 has 3 HW address pins compared to 4 on PCA9955.