

FOR ENERGY EFFICIENT INNOVATIONS

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NCL310xx
Intelligent LED Driver Family

June 2021

Mike Sandyck

Public Information

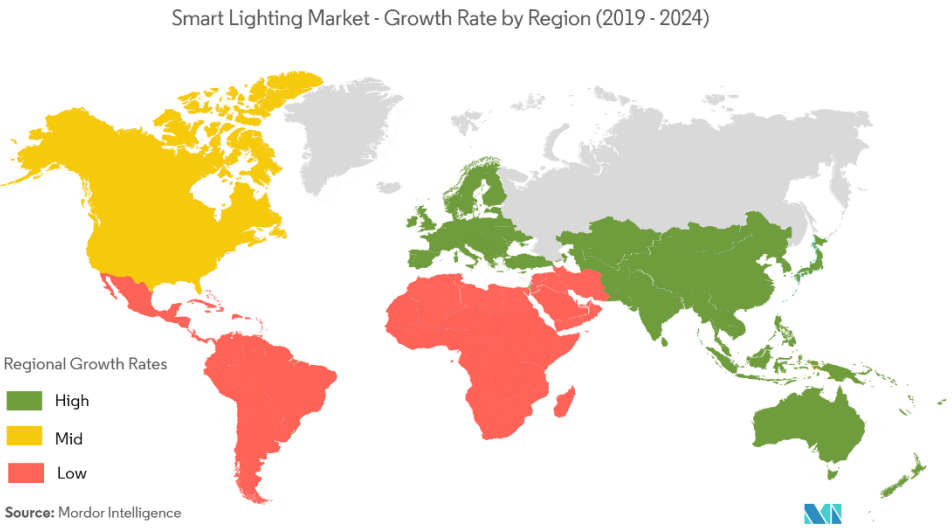
Connected Lighting – Fastest growing PoE segment

What is it?

- Smarter Building Management
- Efficient use of power
- Integration of sensors
  (room occupancy, temperature, humidity, CO/CO2, …)
- CAGR >27%
- Addressable with LED, PoE and KNX devices









Study Period:	2019-2025
Base Year:	2019
Fastest Growing Market:	Asia Pacific
Largest Market:	Europe
CAGR:	27.1 %

EATON wipro PHILIPS GE CREE

Public Information

NCL31000 - Intelligent LED Driver

Product Details

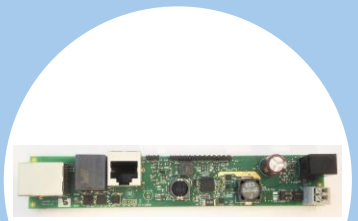
Public Information

What the NCL31000 Brings to Intelligent Lighting

Connectivity, Integration, Control, and Position Location

Connectivity

- Designed for PoE
- Visible Light Comms
- RF/MCU connectivity (SPI/I2C serial i/f)



Increased Integration

- Efficient LED driver
- 3.3V buck converter
- 2.5-24V adjustable buck
- Power metrology

Advanced Light Engine

- True dimming to dark
- Color Blending through multi channel capability
- Environmental settings

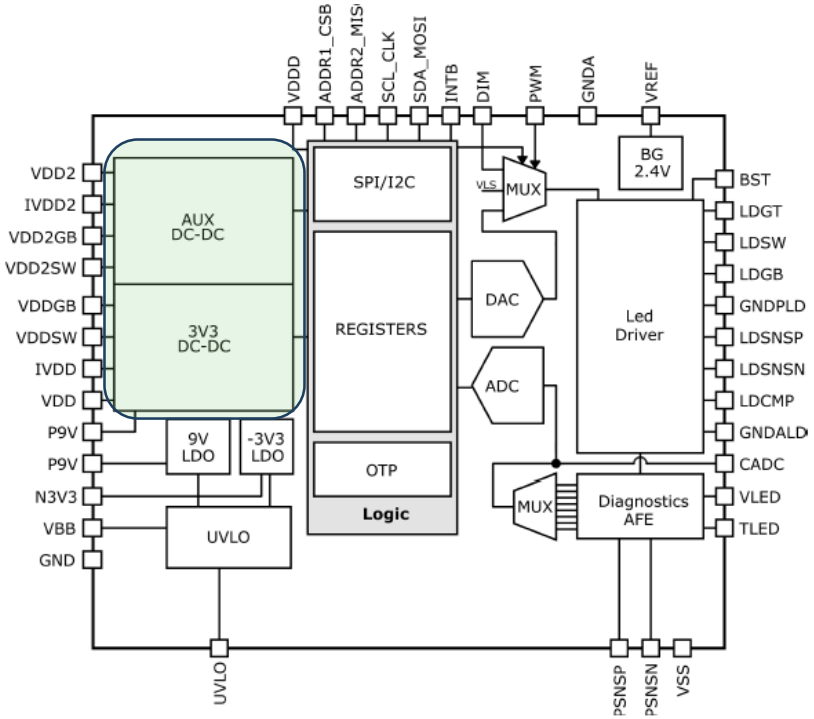
Indoor Positioning

- Accuracy within 30cm
- Enabled with VLC
- Communication with mobile phone

Public Information

NCL310xx VLC Family Summary

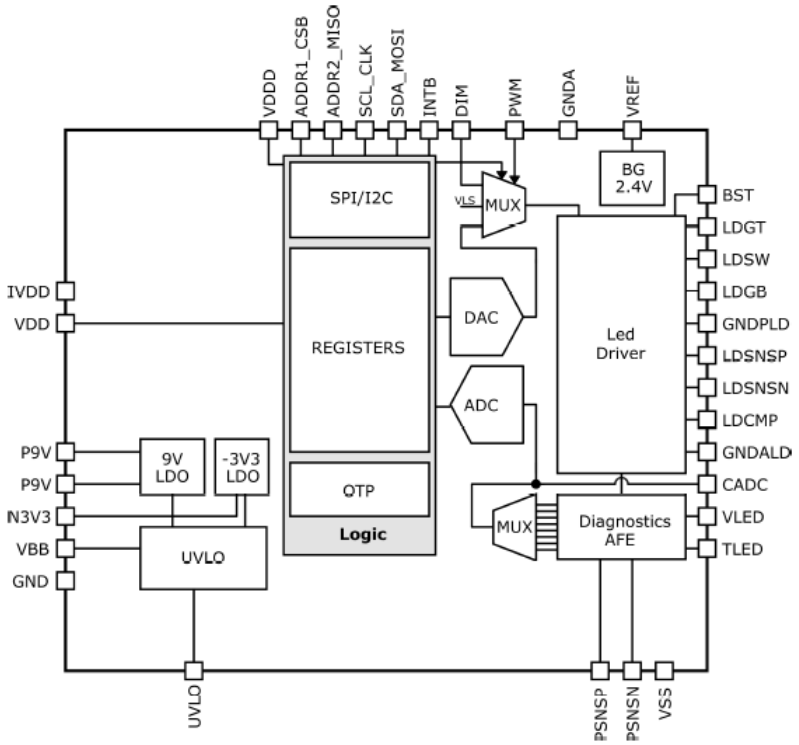
NCL31000:



Integrated DCDC's

Production/ON Target

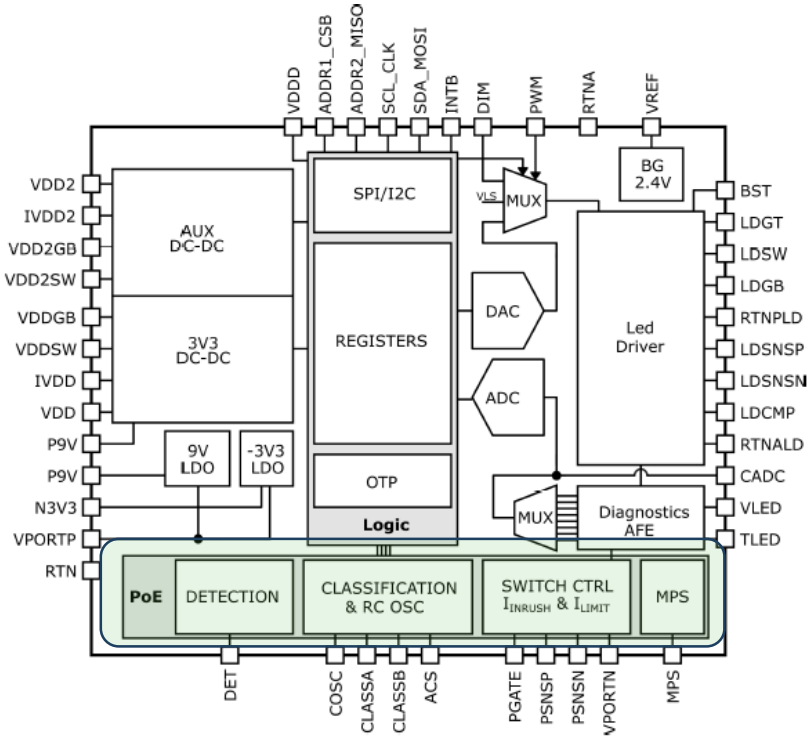
NCL31001:



DCDC's removed for
Multi Channel Applications

Production/ON Target

NCL31010:



Integrated IEEE802.bt PD (90W)

RTM: Dec 2021
Planned ON Target

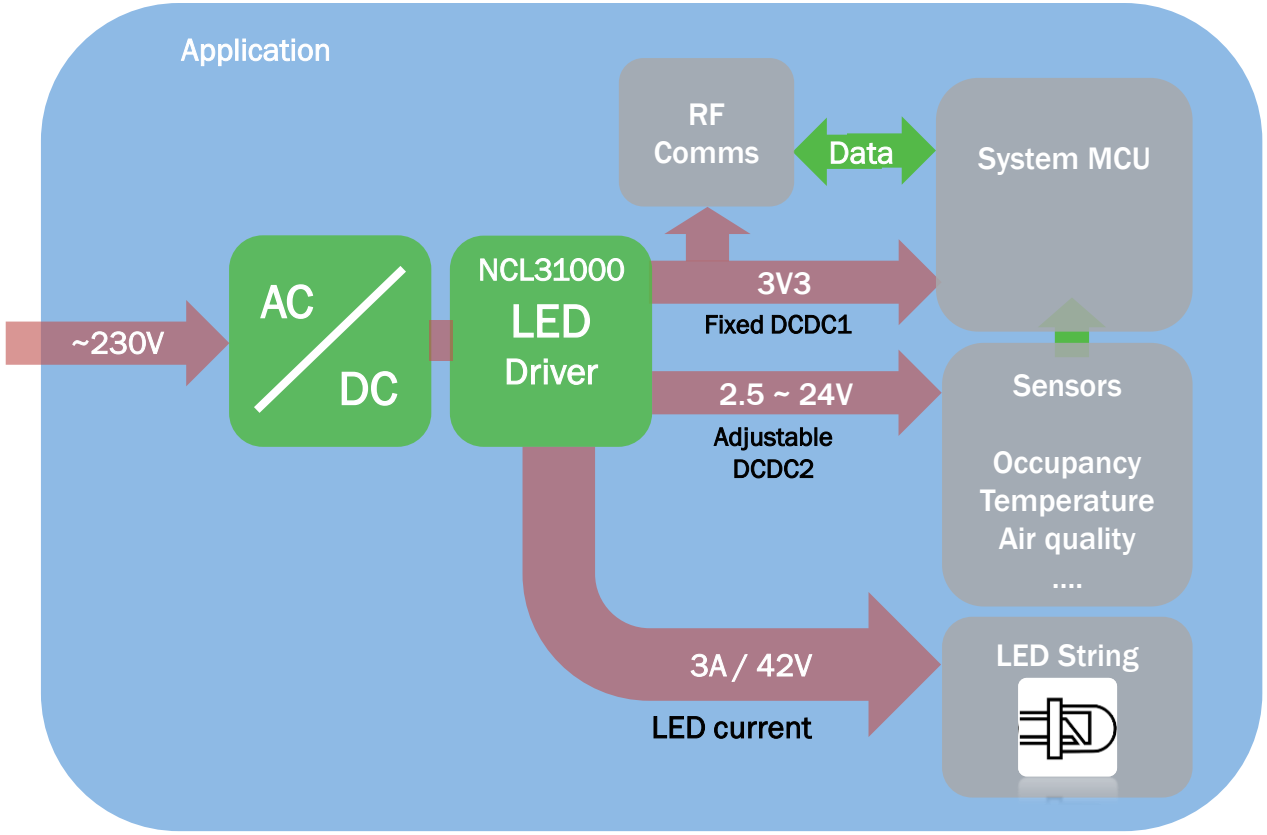
NCL310xx - Integrated LED Driver Family

Communication Interface, System Power, LED driver, and Metrology all in one IC

Part Number	PoE PD	Integrated DCDC1 DCDC2	I²C	SPI	Adjustable UVLO
NCL31000MNITWG		✓	✓		>100W LED Driver
NCL31000MNSTWG		✓		✓	>100W LED Driver
NCL31001MNITWG			✓		Multi Channel Enabler
NCL31001MNSTWG				✓	Multi Channel Enabler
*NCL31010MNITWG	✓	✓	✓		*PoE interface + LED Drive*
*NCL31010MNSTWG	✓	✓		✓	*PoE interface + LED Drive*

** RTM Dec 2021*

System Architecture Example



Dynamic max LED current is ~2.8A (3A DC)
Combined with 42Vout max => ~115W max lighting power

NCL31000

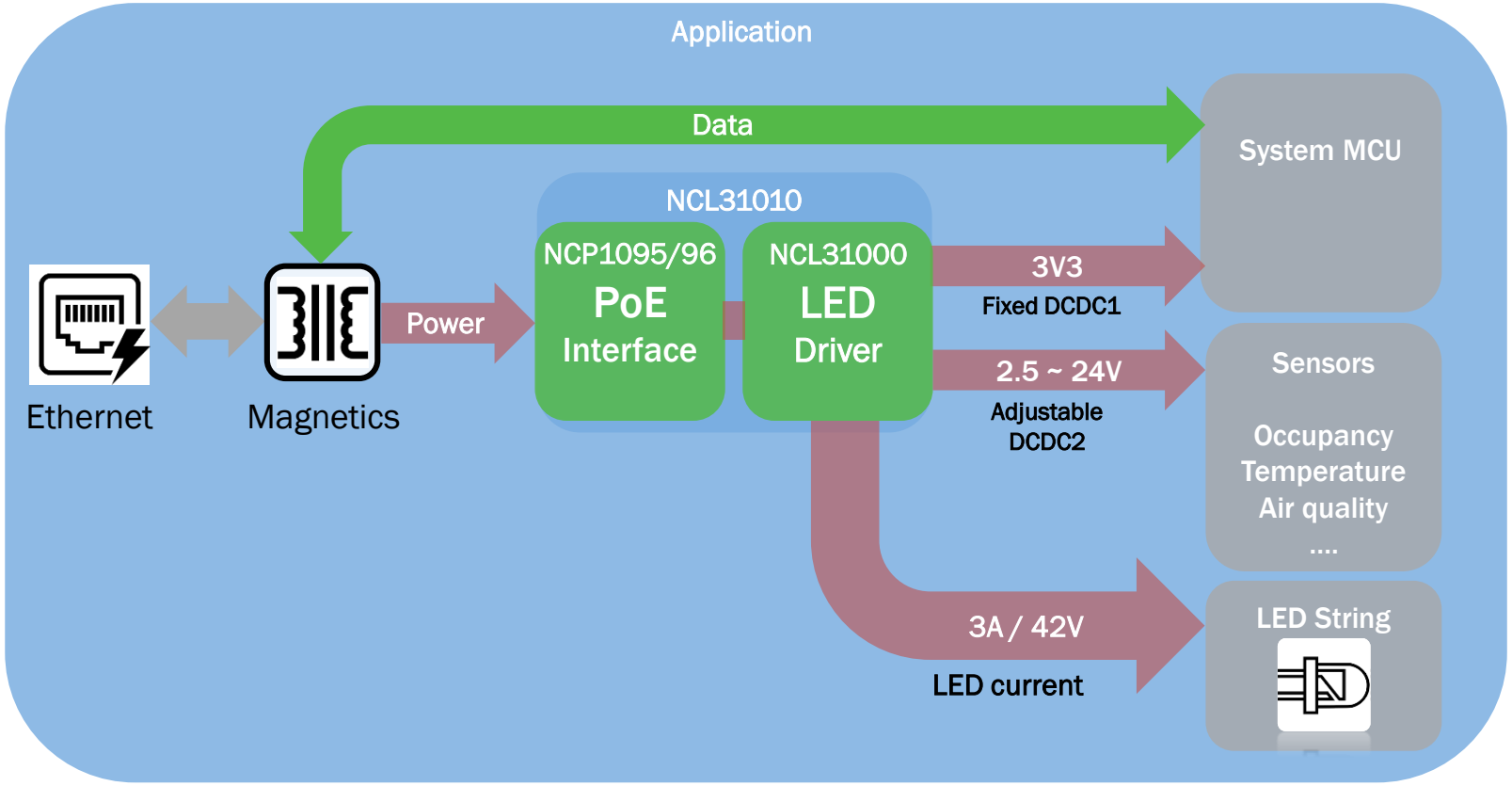
- Input voltage 24 ~ 57V
- LED Current : Up to 3A
- DCDC1: 3.3V fixed, 150mA max
- DCDC2: Adjustable, 2.5 ~ 24V

VDD2 Configurations

V_{OUT} (V)	I_{OUT} (mA)	R_{CS} (mΩ)	L (µH)
2.5	560	220	100
3.3	515		
5	510	200	
7.2	415		330
10	335	330	330
12	315		
15	285		
24	230	390	470

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PoE System Architecture



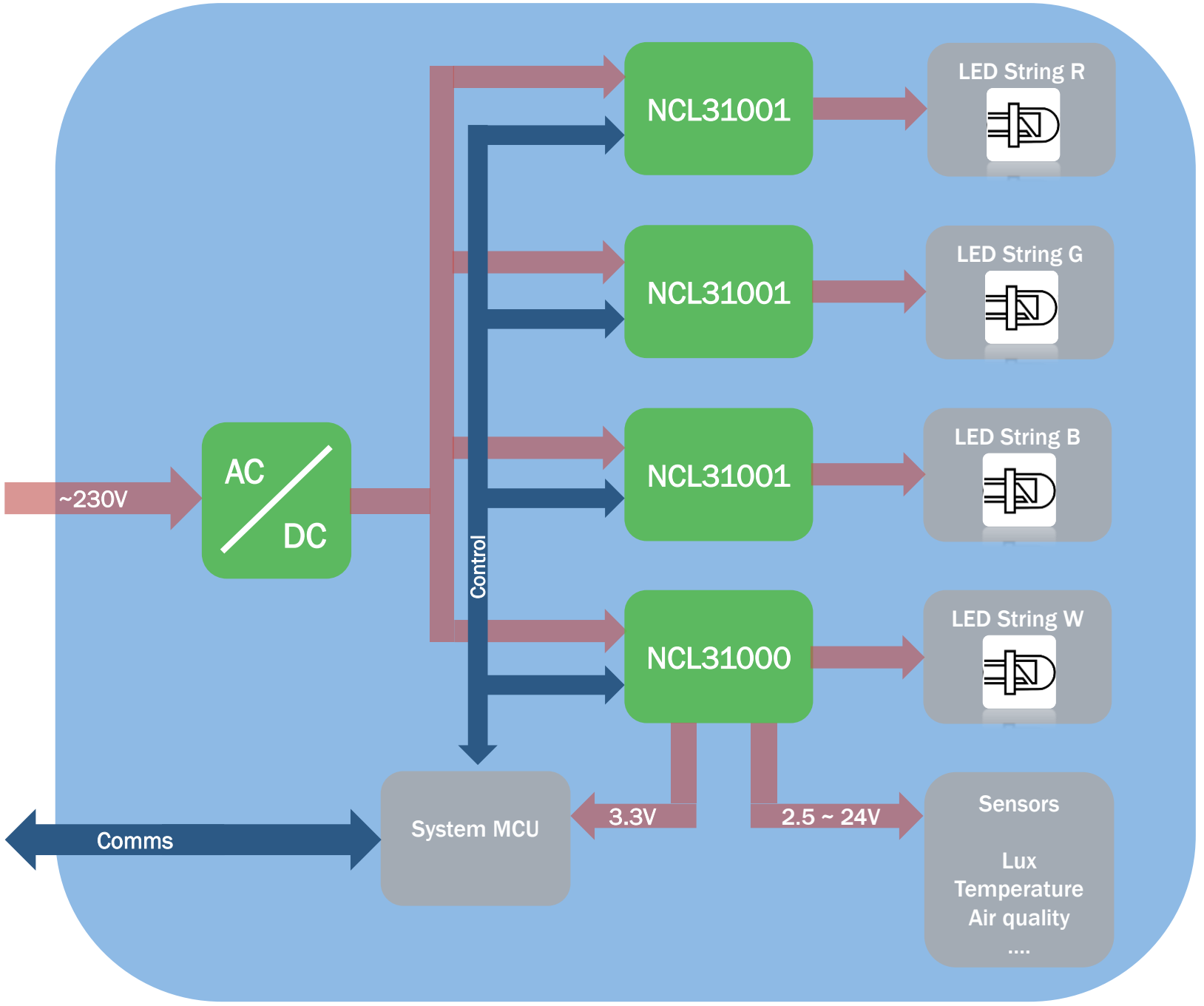
* NCP1095 >100W capability

Public Information

Multi Channel Example



Indoor Agriculture



NCL31000 - Intelligent LED Driver

Product Details

Public Information

NCL31000 - Integrated LED Driver

System Power, LED driver, and Metrology IC



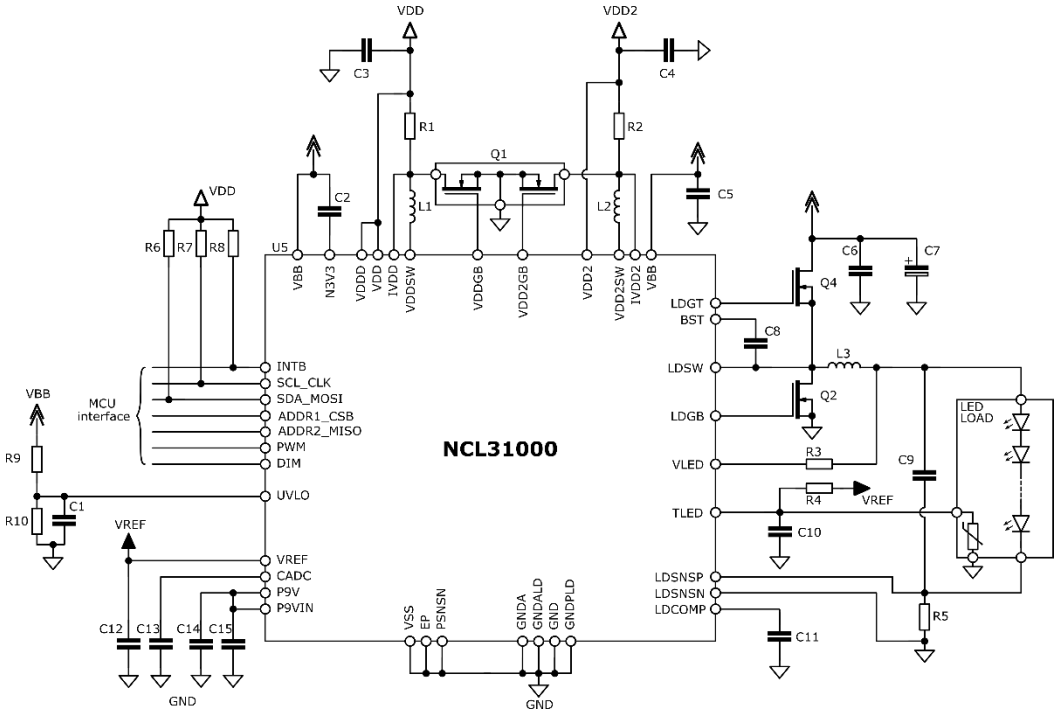
Unique Features & Benefits

- Input Voltage from 24V to 57V
- 97% efficient Buck Controller LED driver (power in to LED out)
- Integrated 3V3 Buck Converter (150mA) for companion MCU.
- Integrated Adjustable Buck Converter 2.5-24V
- **Visible Light Communication** capable, **Yellow-Dot ready,** up to 10kb/s
- **Linear, high bandwidth dimming to zero** (full range linearity 0.05% INL)
- **Versatile dimming through analog voltage, PWM, analog+PWM, …**
- **Digital Dimming over I2C/SPI (Warm Boot)**
- **Active Fault protection and diagnostics for LED shorts/opens,..**
  - Over/Under Voltage, Over Current, LED Temperature

Other Features & Specifications

- Capable to drive high-power LED luminaires up to 115W
- Embedded V/I measurements of the input and output stage, to calculate P_{IN}, P_{OUT} and system η
- Spread Spectrum to reduce conducted EMI (0~14% config)

Typical Application Schematic

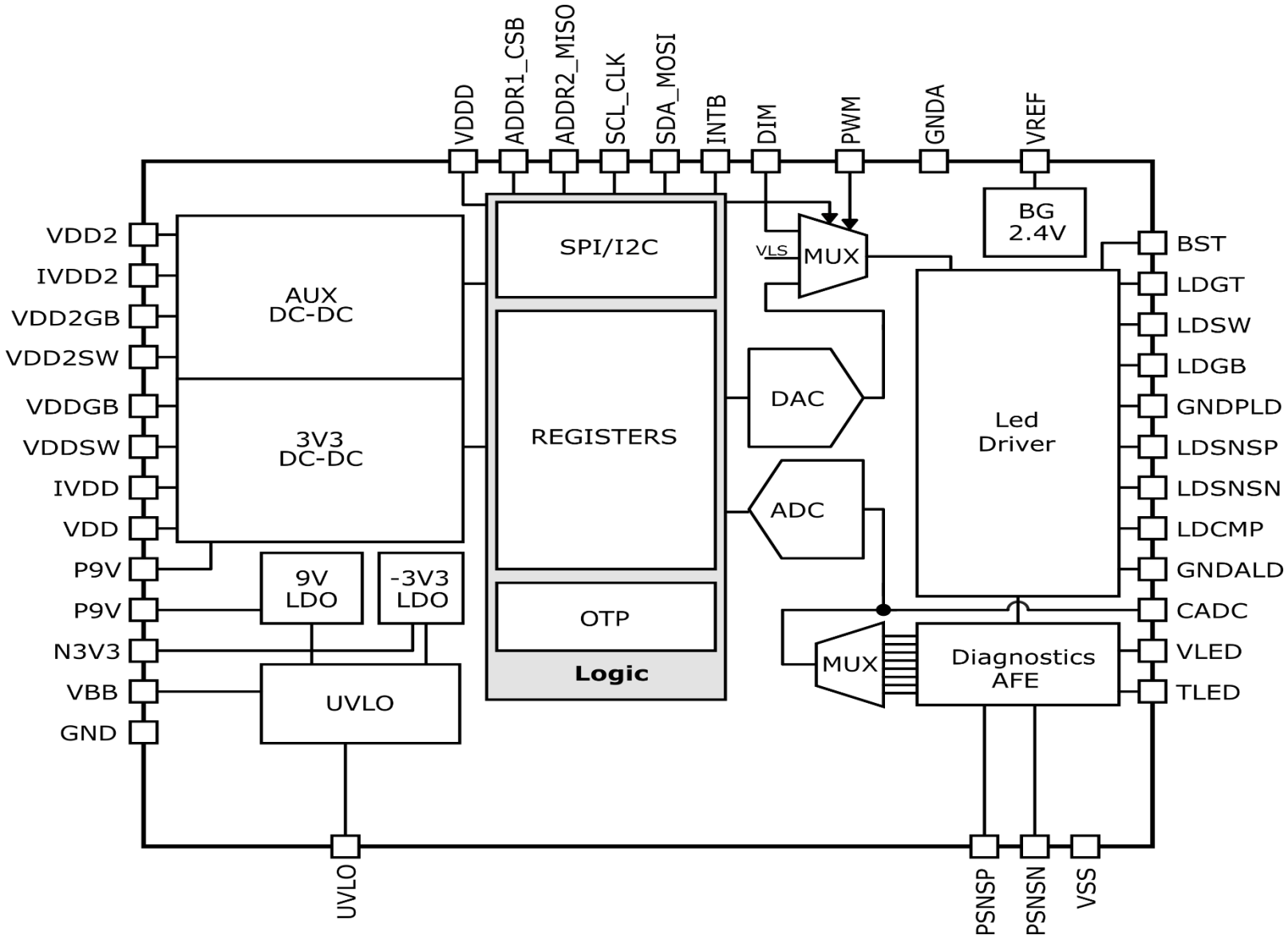


Ordering & Package Information

- Available in 48-pin QFN 7x7
- Industrial temperature range -40°C to +85°C
- NCL31000MNITWG I²C version, 2500pcs Reel
- NCL31000MNSTWG SPI version, 2500 pcs Reel

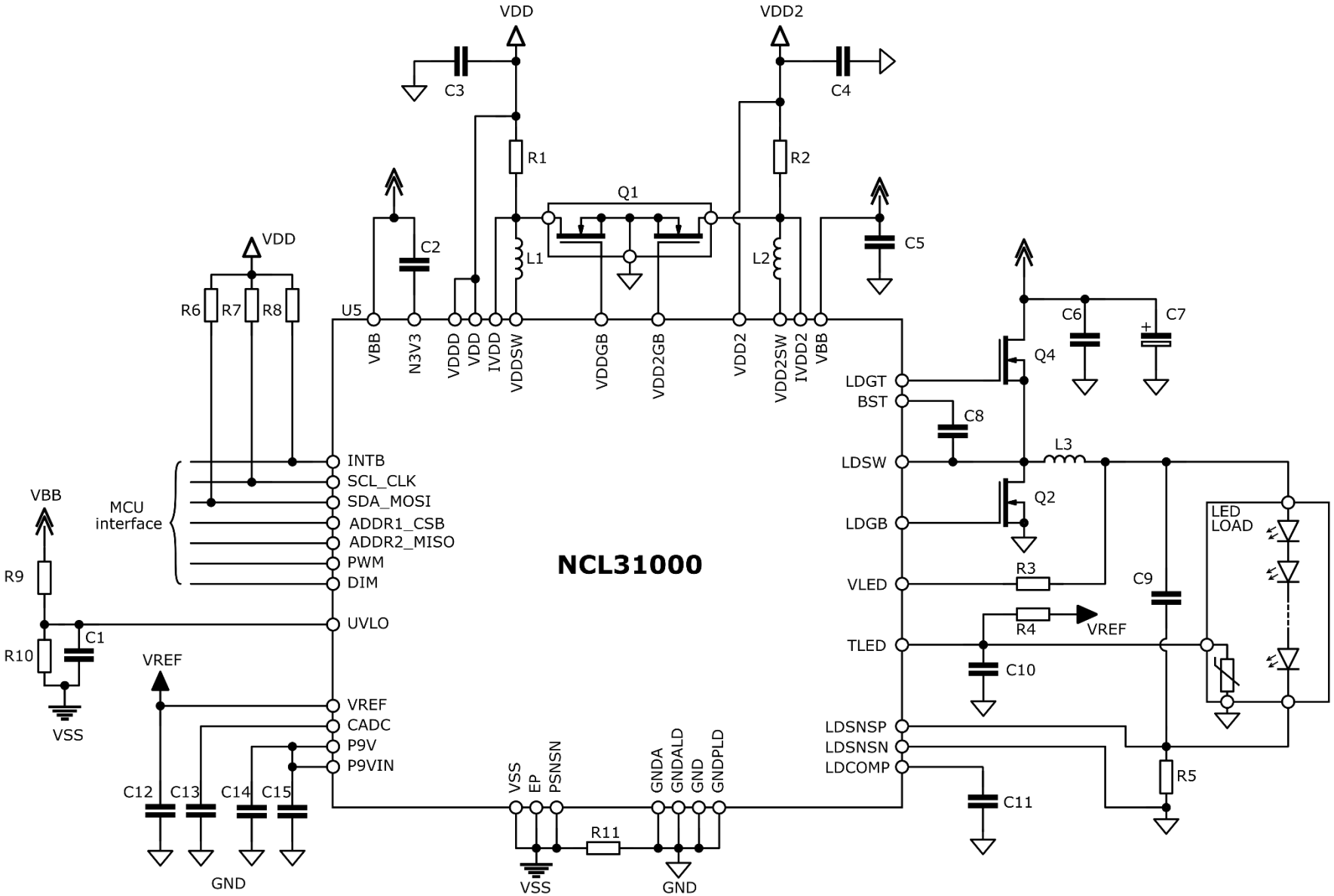
Public Information

NCL31000 Block Diagram



Public Information

NCL31000 Application Diagram



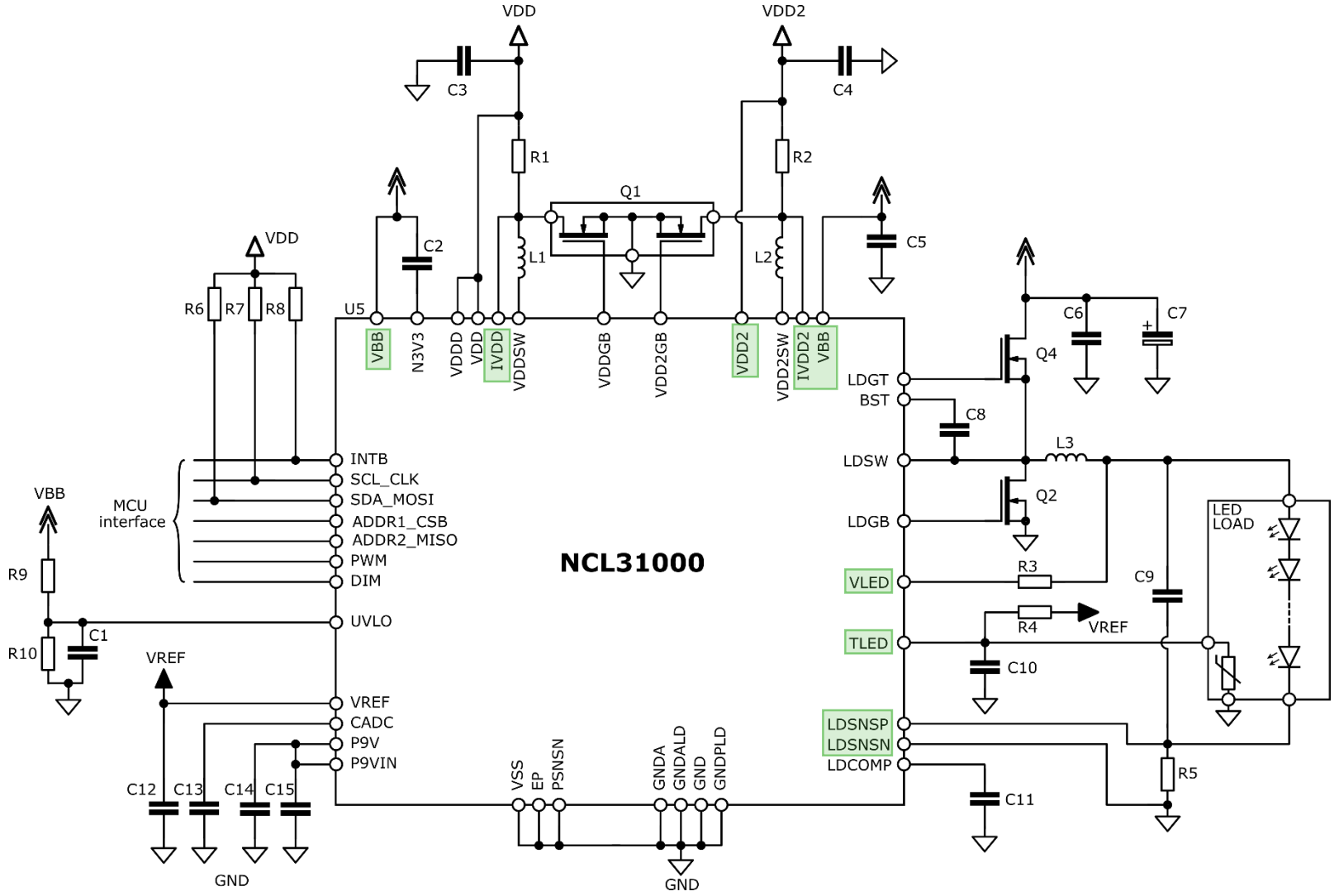
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NCL31000 Metrology

The NCL31000 Metrology incorporates a high accuracy 10-bit ADC that measures (100msec sample rate) the following system voltages, currents and temperatures:

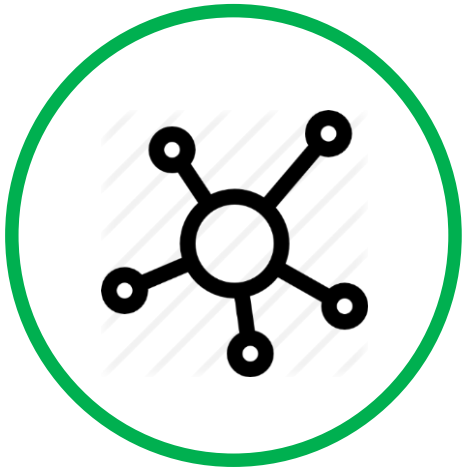
- VBB: Supply Voltage
- VDD: DCDC1 (3.3V) Voltage
- VDD2: DCDC2 (2.5V to 24V) Voltage
- VLED: LED Voltage
- ILED: LED Current
- IBB: Supply Current
- IVDD: DCDC1 (3.3V) Current
- IVDD2: DCDC2 (2.5V to 24V) Current
- TLED: LED Temp

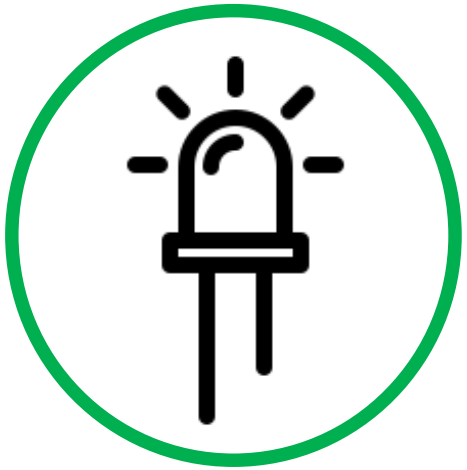
The Metrology measurements can be read out from internal 16-bit registers by the host MCU.

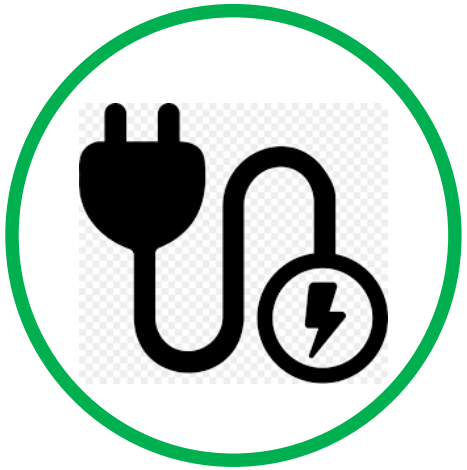


Public Information

NCL31000 Key Specifications







Advanced Light Engine

Connectivity

- IEEE 802.3bt Compliant
- 0.033% Linear Deep Dimming
- VLC enables YellowDot™
- I2C or SPI serial interface option

LED Driver

- 97% Efficiency
- Integrated 3.3V Buck
- Integrated adjustable 2.5-24V Buck
- Spread spectrum PWM to reduce EMI

Power Metering

- 1% Power Metering
- Voltage and Current Monitoring
- Temperature Protection
- Accurate voltage reference

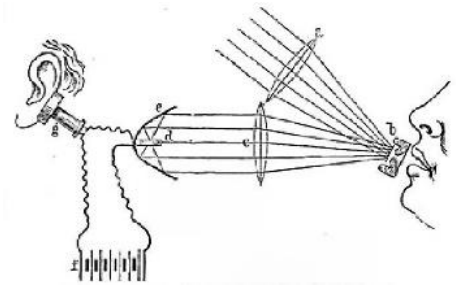
Public Information

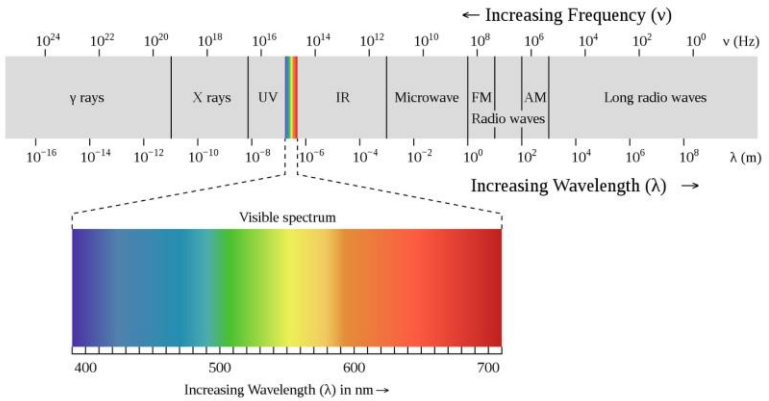
Visible Light Communication (VLC)

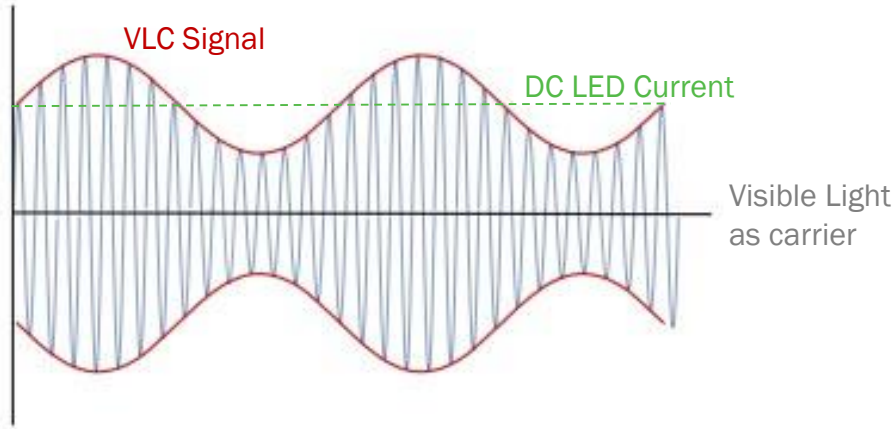
Background and Technology

Public Information

Visible Light Communication







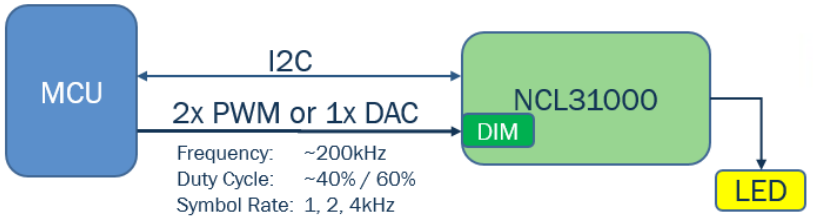
- Photophone work at Bell Labs during the 1880-ies predates radio
- **VLC is a data communication technology which uses visible light as a carrier, with low data rates (kb/s)**
- Lifi: 500 Mbit/s with a white LED over a distance of 5 metres (16 ft), and 100 Mbit/s over longer distance using five LEDs demonstrated in lab conditions

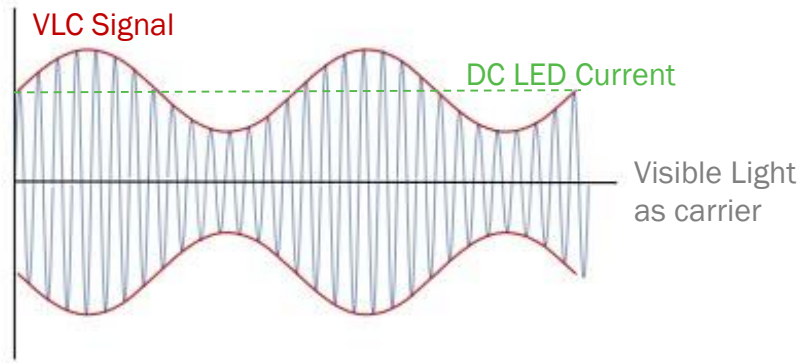
Public Information

VLC – Indoor Positioning



- The dimming function (MCU) is used to transmit the data
- Due to maintaining an average LED current it is imperceptible to the human eye
- The data is readable by an image sensor
- The data processing and for example position extrapolation happens in the receiver (smartphone, tablet, ..)
- Yellow Dot is a communication protocol that defines the VLC scheme for the PWM frequency, Duty Cycle and symbol rate.







Public Information

VLC – Advantages vs RF

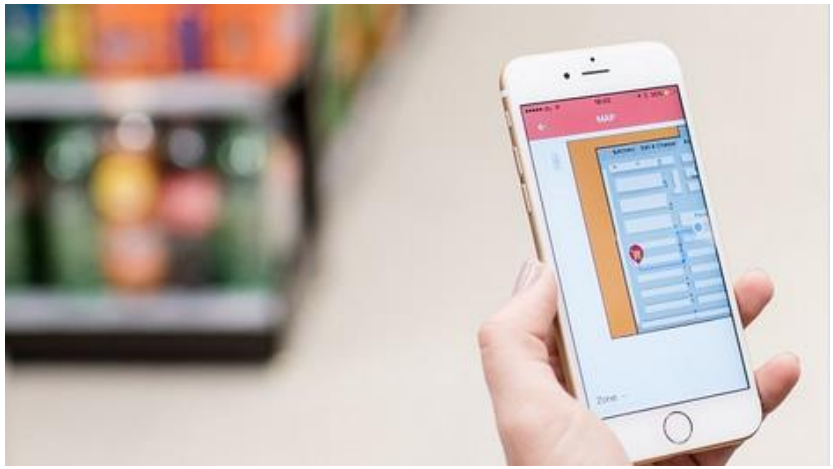


- Localized to the light source, does not disturb nearby or other applications (no interference)
- No influence of RF sources nearby
- Unlicensed transmission band
- More secure, inherently limited to line of sight
- No extra power amplifier and signal chain needed vs RF (saves power & design complexity)
- Better suited for EM sensitive area's: aircraft, hospitals, explosion risk area's, …
- Less intrusive comms method for bio-applications due to semitransparency of biological tissue in Near InfraRed (1000-700nm)

Public Information

What is YellowDot?

- YellowDot is an **indoor position location technology**
- **Each LED ballast has a unique identifier** that indicates the position within a building
- LED ballast signals through **visible light communication** (VLC) to a camera on a phone or tablet
- Phone's camera **detects the code** and **reveals the position**
- **Accuracy to within 30cm**; **BLE accuracy is 3 meters**
- Certification requires a range of tests; passing allows the use of the YellowDot trademark to a luminaire
- Has two defined data rates: 1kb/s and 2kb/s





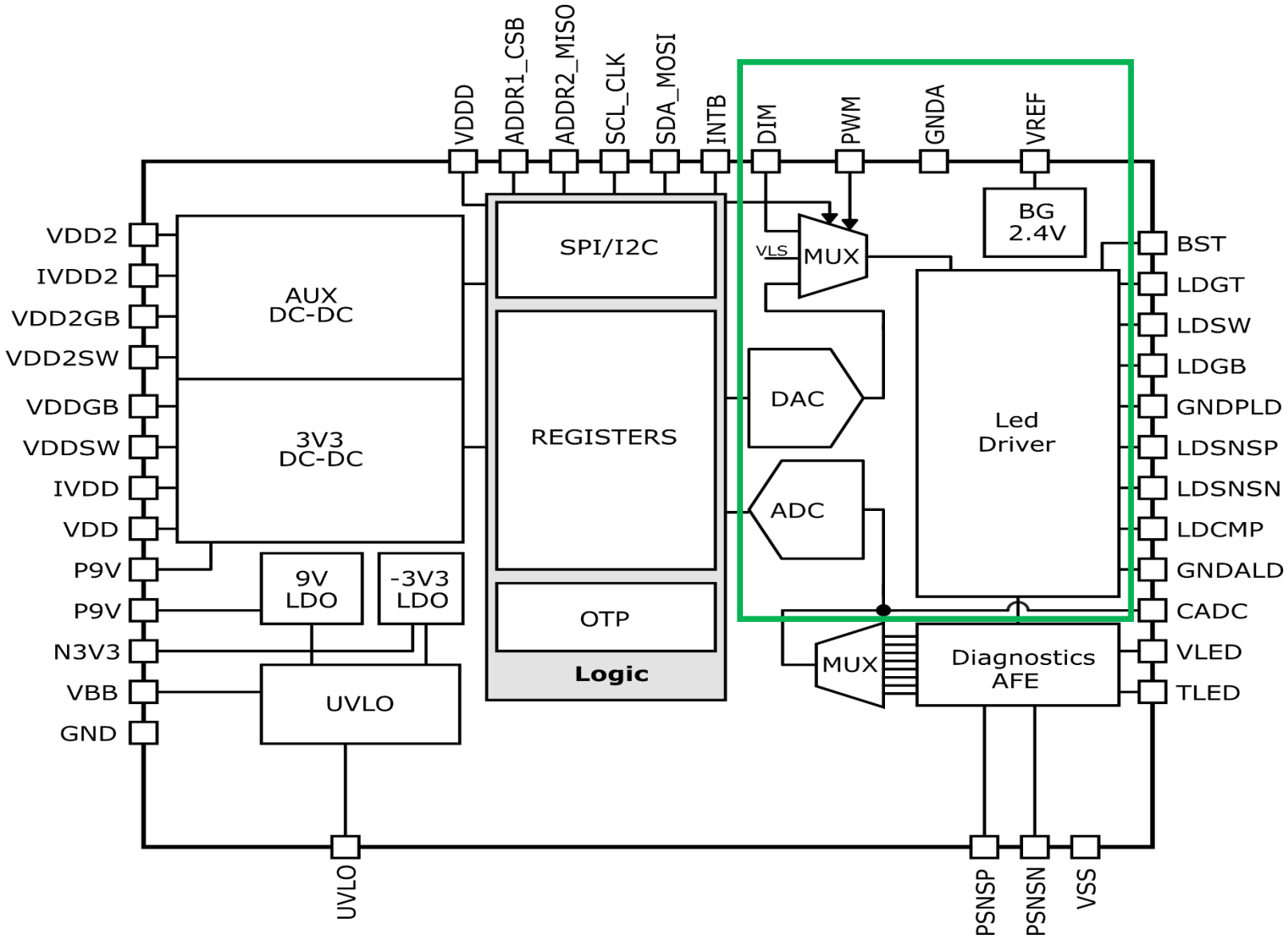
Public Information

Advanced Light Engine

Dim Control & VLC

Public Information

NCL31000 – Advanced Light Engine



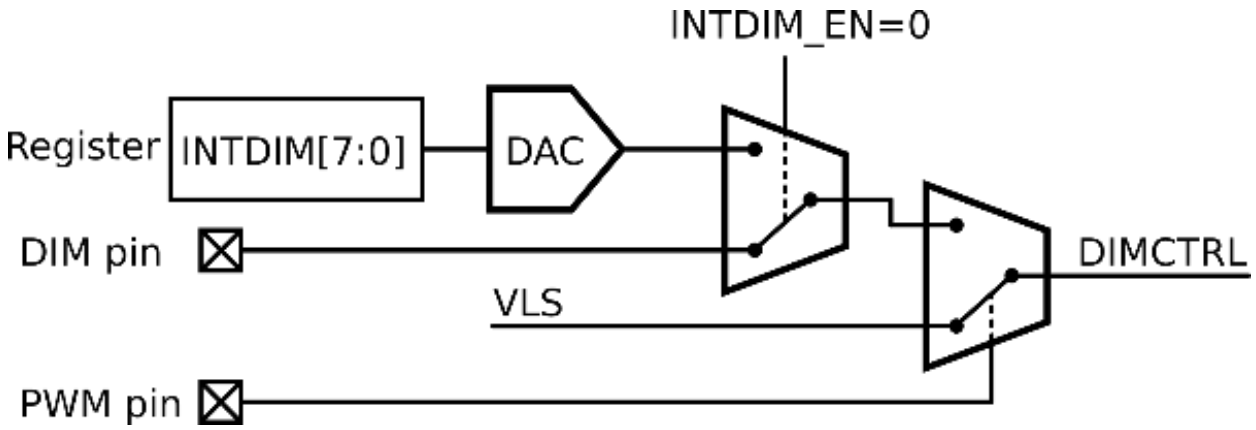
Public Information

Versatile Dim Control

DIMCTRL is the internal analog voltage which will determine the LED current.

The dimming level can be controlled through:

- External DIM pin:
  By default, this signal is routed to DIMCTRL
- VLS: internal reference voltage (200mV) for zero LED current
- DAC: internal DAC (register value)
- External PWM/Enable pin

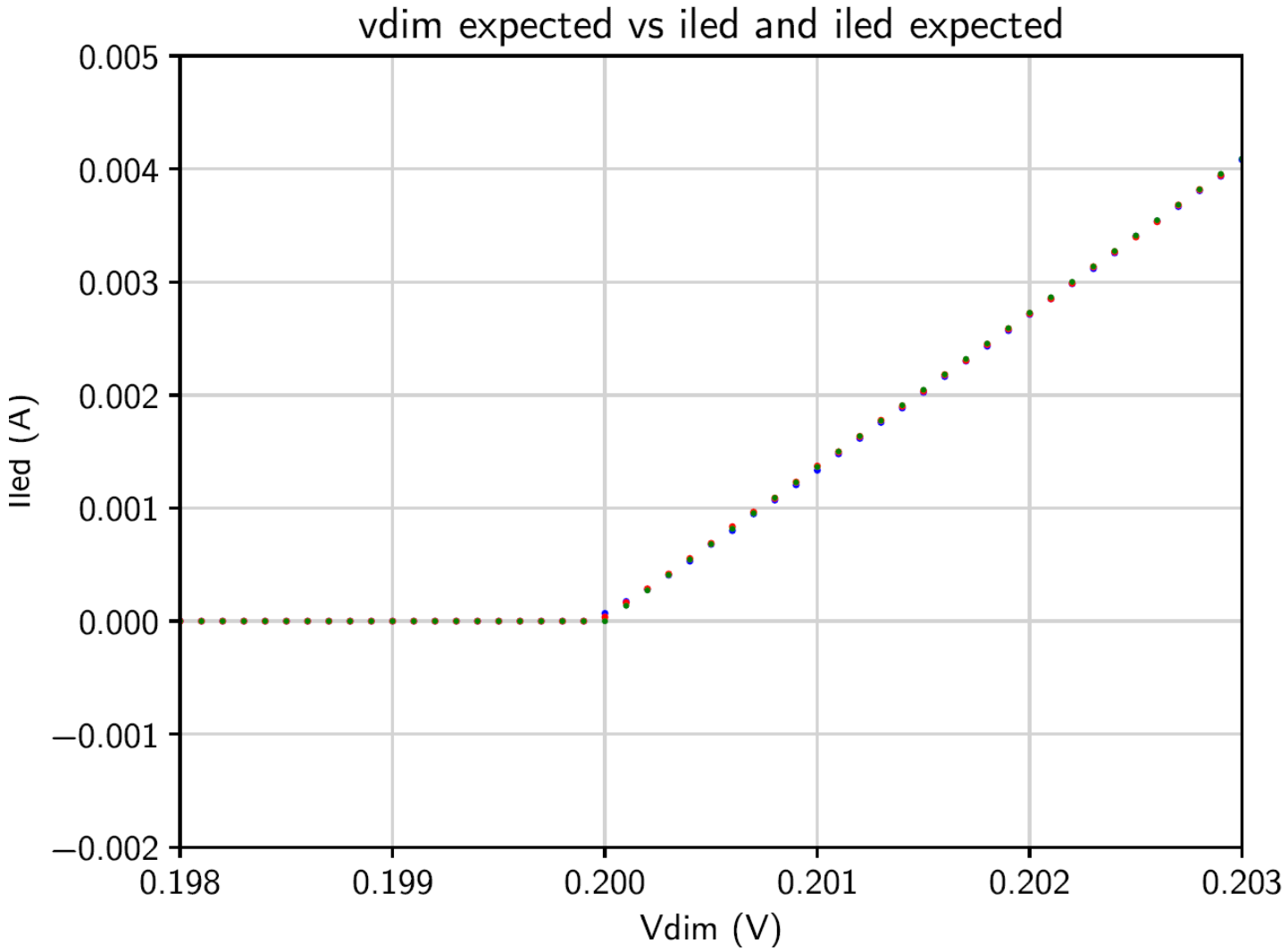


Public Information

NCL310xx Deep Dimming and Linearity

- Red = measured
- Blue = theoretical

- Ultra linear behavior extends down to the zero crossing point (200mV reference)
- Increasing Vdim by 1mV above zero point results in 1,35mA LED current
- … and climbs linearly with each increasing mV applied
- Likewise, reducing Vdim by less than 1mV below the 200mV zero reference, results in zero LED current
- The 200mV reference ensures that 0V on the Vdim pin keeps the LED current off, despite potential interference or induced noise



Public Information

NCL31001
Multi Channel Enabler

Public Information

NCL31001 - Integrated LED Driver

Enables multi-channel operation

Unique Features & Benefits

- Same features as NCL31000, no onboard DCDC convertors
- Multi-channel operation through the serial bus (I²C/SPI)
- Input Voltage from 24V to 57V
- 97% efficient Buck Controller LED driver
- **Visible Light Communication** capable, **Yellow-Dot ready,** up to 10kb/s
- **Linear, high bandwidth dimming to zero** (full range linearity 0.05% INL)
- **Deep dimming down to 1mA or 0.033% @ 3A full scale current**
- **Active Fault protection and diagnostics**

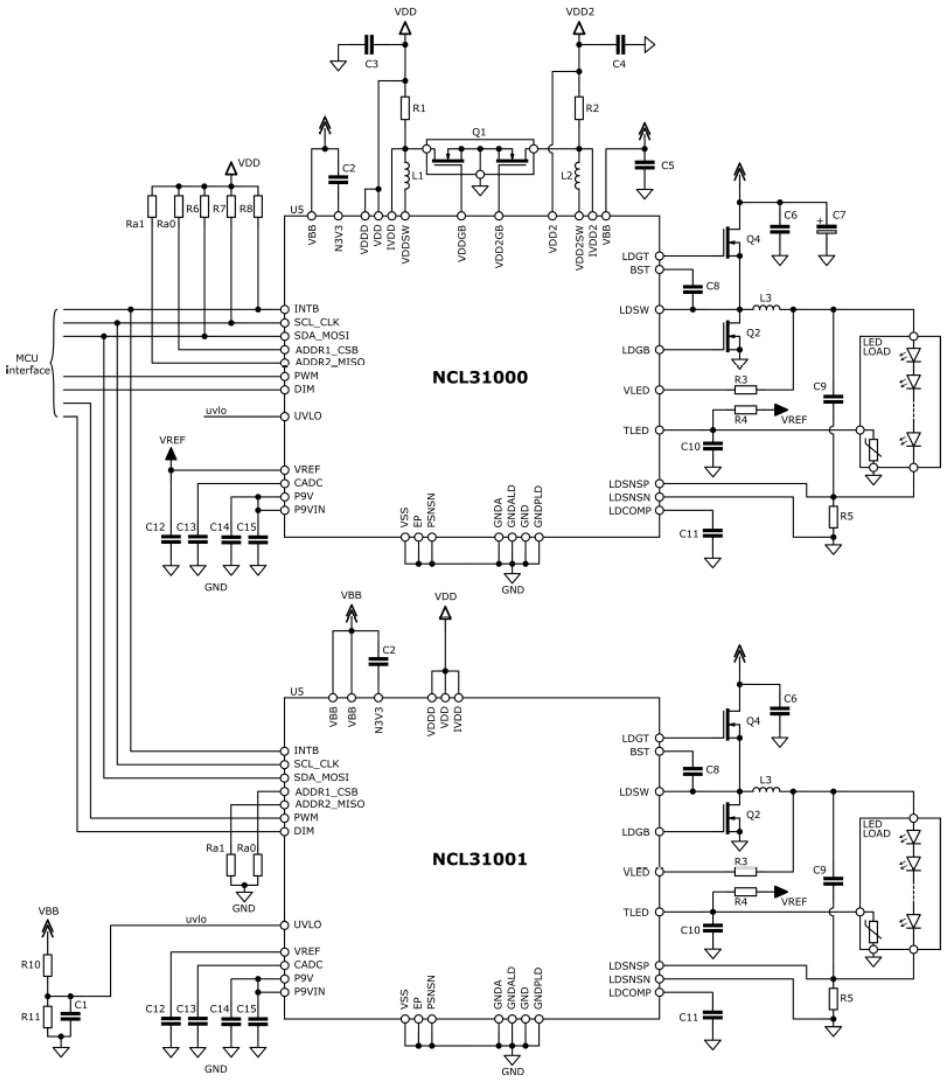
Other Features & Specifications

- Capable to drive high-power LED luminaires beyond 100W
- Embedded V/I measurements of the input and output stage
- Optional Spread Spectrum for conducted EMI reduction

Ordering & Package Information

- Available in 48-pin QFN 7x7, -40°C to +85°C temp range
- NCL31001MNITWG I²C version, 2500pcs Reel
- NCL31001MNSTWG SPI version, 2500 pcs Reel

Typical Application Schematic



Public Informa

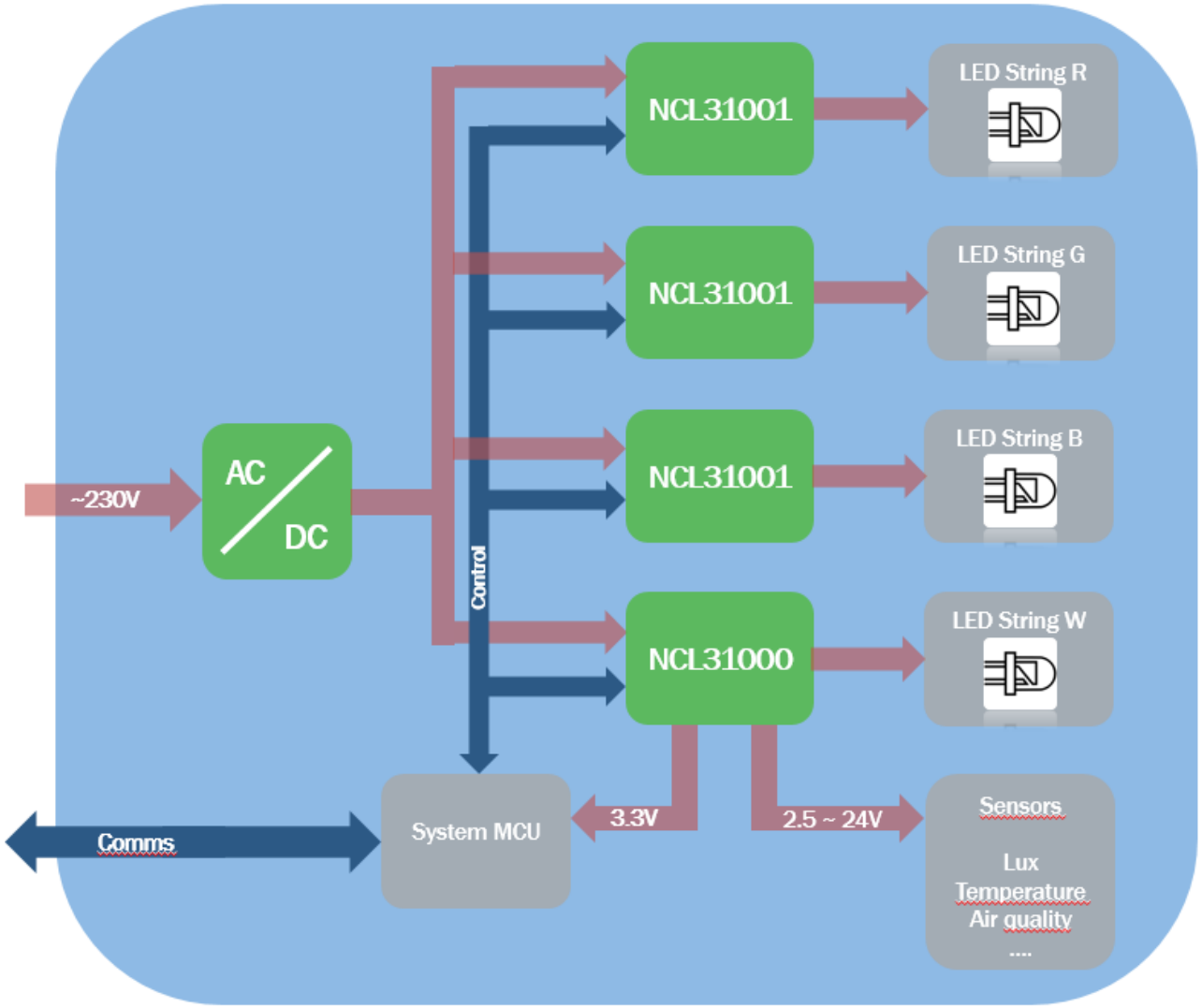
Multi Channel Operation

SPI or I²C serial control channels allow multiple channels to be driven by one microcontroller

The amount of channels is only limited by the (MCU) serial channel capabilities

If 128-step digital dimming is acceptable, large numbers of channels can be addressed through the I²C bus

In case of analog dimming, the limit will be the nr of PWM channels of the MCU



Public Information

ON Intelligent LED Driver Product Family

NCL31000 Family Key Features
Power Supply
High Input Voltage (24 ~ 57V)
Integrated 3.3V Buck (NCL31000 only)
Adjustable 2.5-24V Buck (NCL31000 only)
Accurate Voltage (2.4V+/-0.3%)
Buck LED Driver
Linearity (full range) 0.05% INL
Deep Dimming to 1mA = 0.066% of 1.5A or 0.033% of 3A
Efficiency (97%)
Spread Spectrum PWM
Connectivity
Serial Interface SPI or I2C
Protections/Diagnostics - LED Temperature, Over/Under Voltage and Over Current
Power Metrology Accuracy (1%)

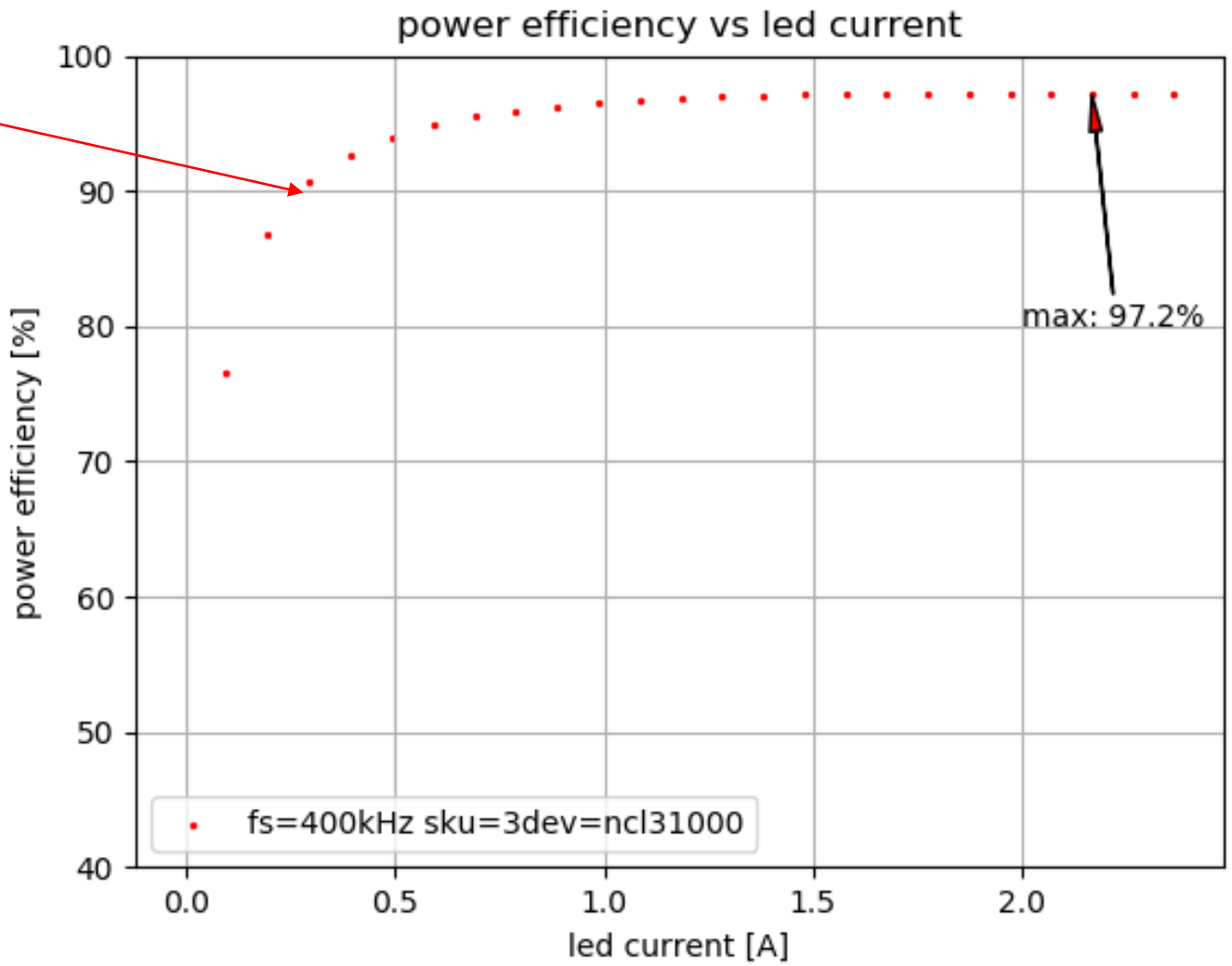
Public Information

Applications

Public Information

NCL31000 Application Efficiency

From ~300mA
LED current
>90% efficiency



Public Information

Strata Enabled Kit



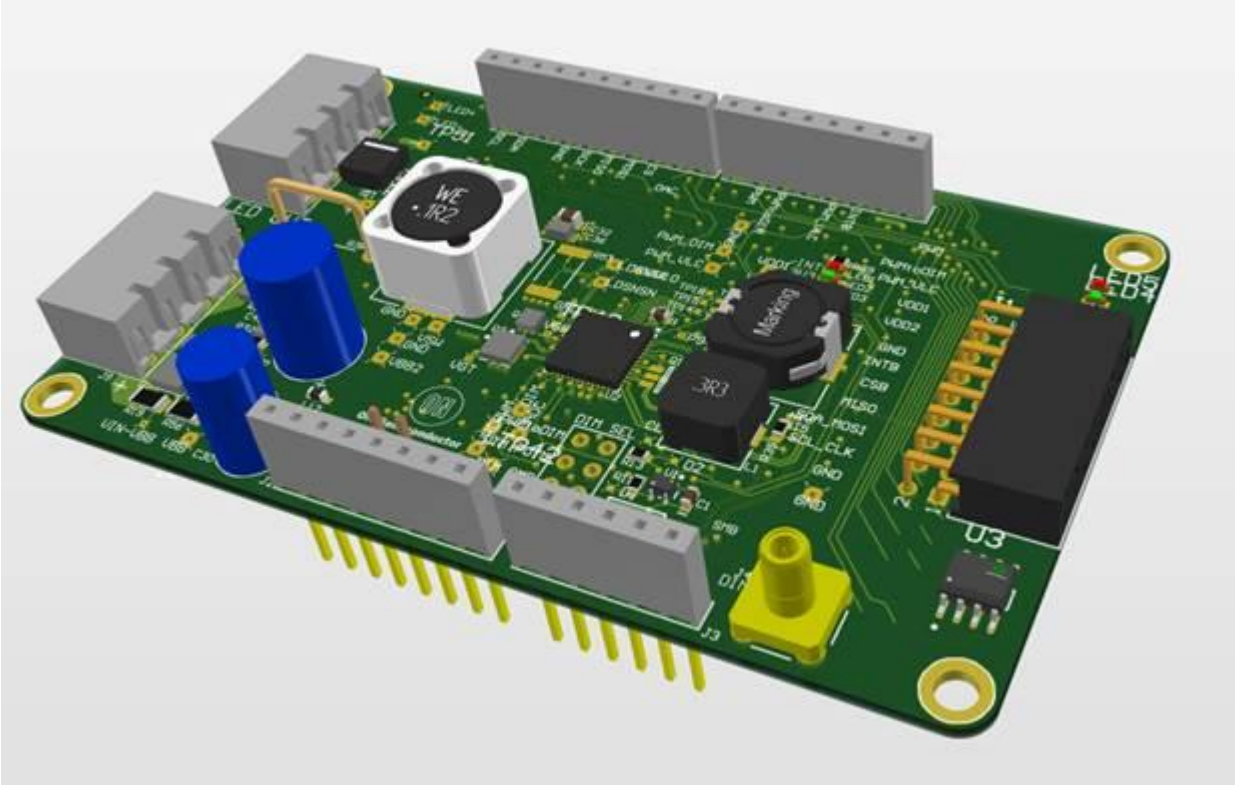
Under development
RTM end July



Public Information

NCL31000ASGEVB

- **Arduino Shield compatible evaluation board**
- VLC/Yellow Dot capable
- LED Power capability beyond 100W
- Input voltage up to 57V
- I2C/SPI for MCU daughter card
- Efficiency of total solution ~97%
  - Incl EMC, DC-DC's, Diagnostics etc



Public Information

Applications

- Outdoor Lighting
  - Connected Street Lighting
  - Architectural Lighting
- Indoor Lighting
  - Office Lighting
  - Industrial Lighting
  - Theater Lighting
  - Therapeutic Lighting
- Greenhouse Agriculture
  - Multi channel managed lighting
- Displays
  - Data to and from displays (e-ink price tags, LED displays)
  - Backlighting Pro & High end displays
- Automated Guided Vehicles
- Hazardous environments





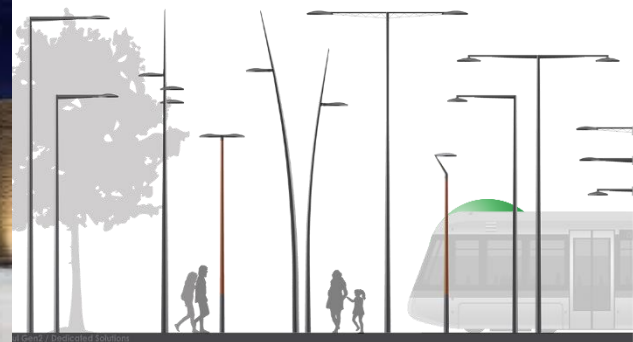






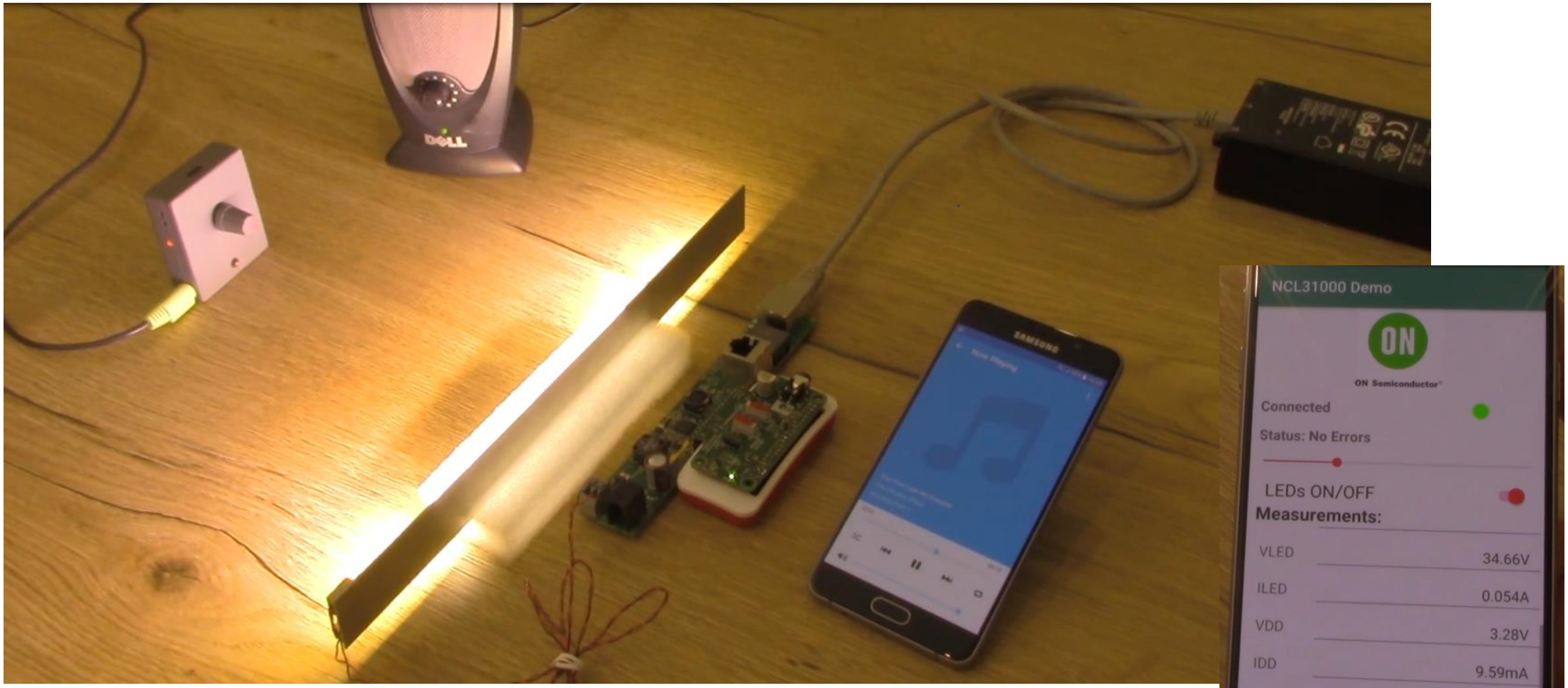




Visible Light Communication Demonstration

https://www.onsemi.com/video/ncl31000-smart-led-driver-and-visible-light-communication



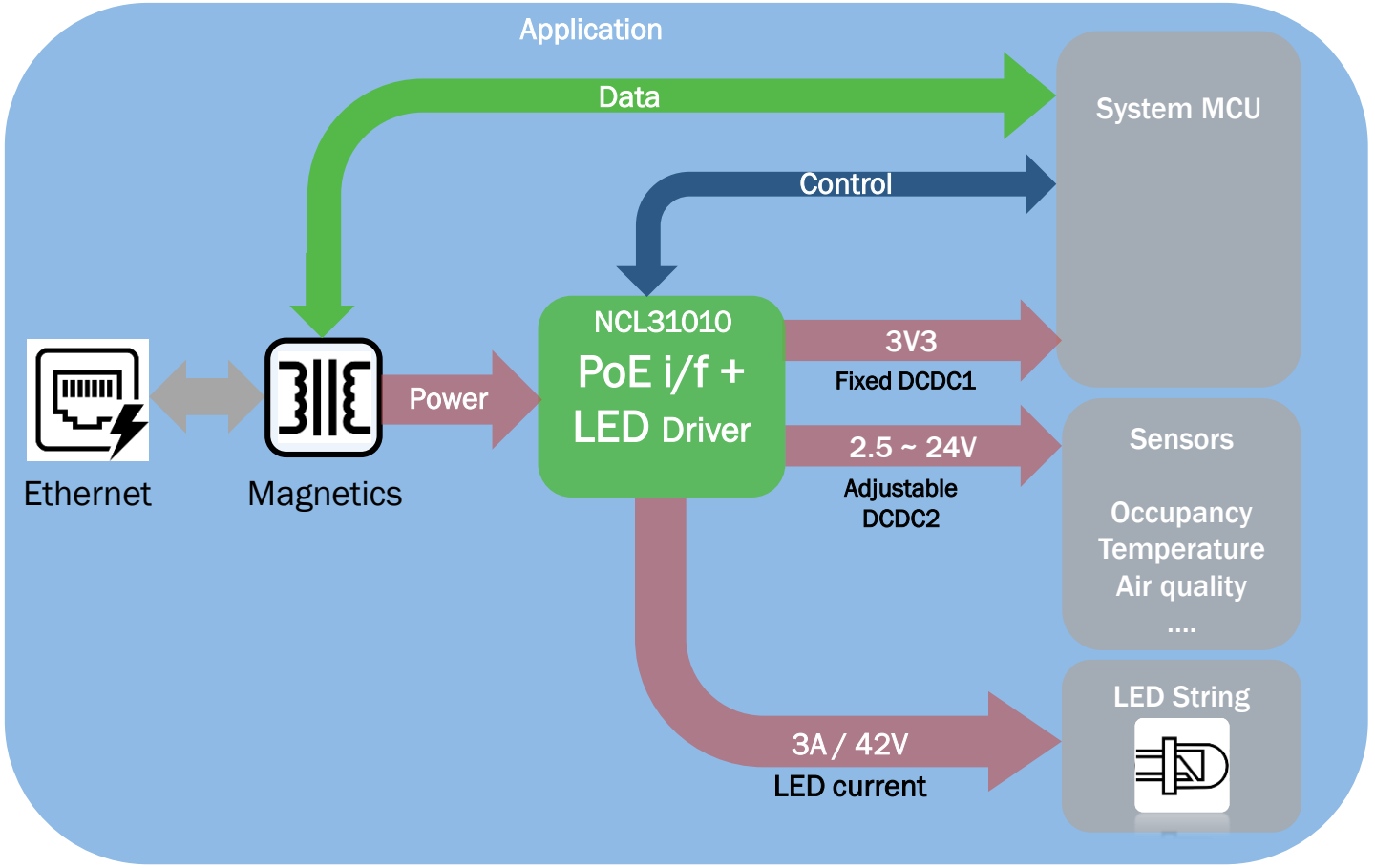
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NCL31010
Smart LED Driver with PoE Interface Controller

RTM Dec 2021

Confidential

Single IC PoE LED Driver System



Confidential

NCL31010 - Integrated LED Driver

PoE i/f, System Power, LED driver, and Metrology IC



Release To Market
Dec 2021

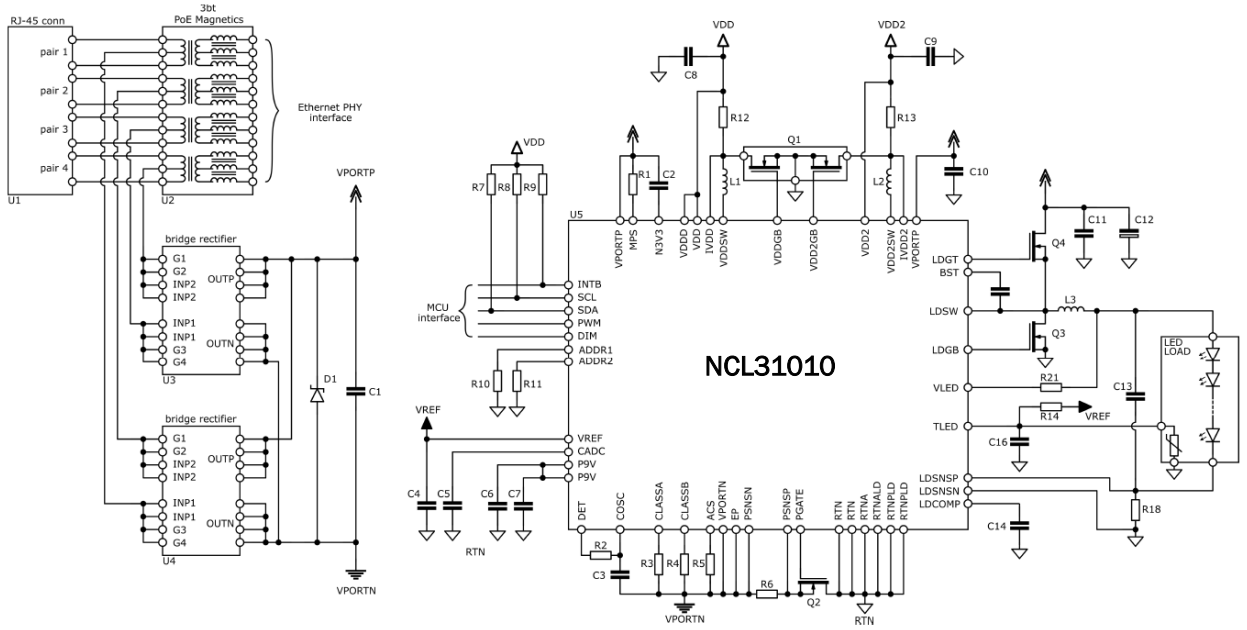
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- Integrated 3V3 Buck Converter (150mA) for companion MCU.
- Integrated Adjustable Buck Converter 2.5-24V
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    - Over/Under Voltage, Over Current, LED Temperature

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- Spread Spectrum to reduce conducted EMI (0~14% config)
- 48-pin QFN 7x7, Industrial temperature range -40°C to +85°C

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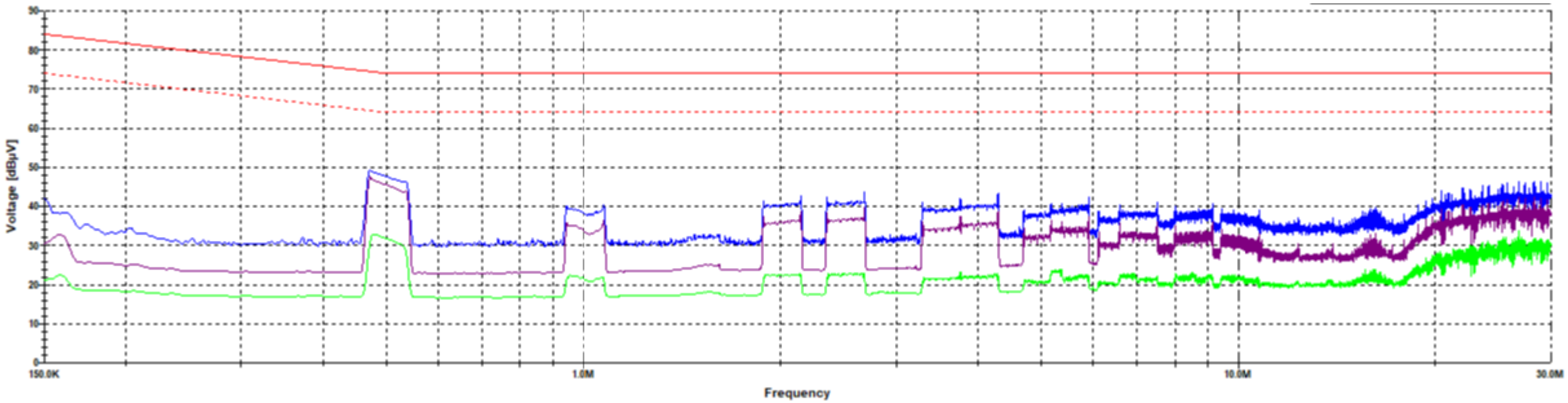


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- NCL31010MNITWG I²C version, 2500pcs Reel
- NCL31010MNSTWG SPI version, 2500 pcs Reel

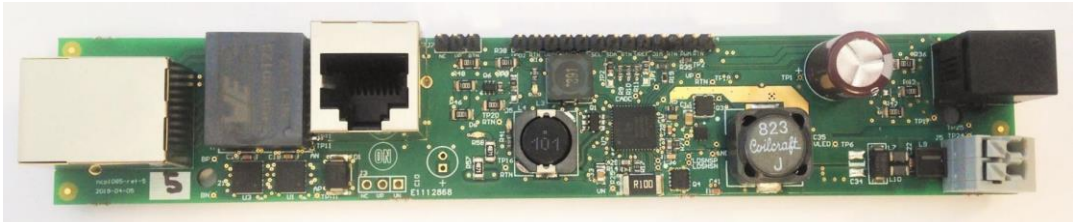
Confidential

Conducted Emissions



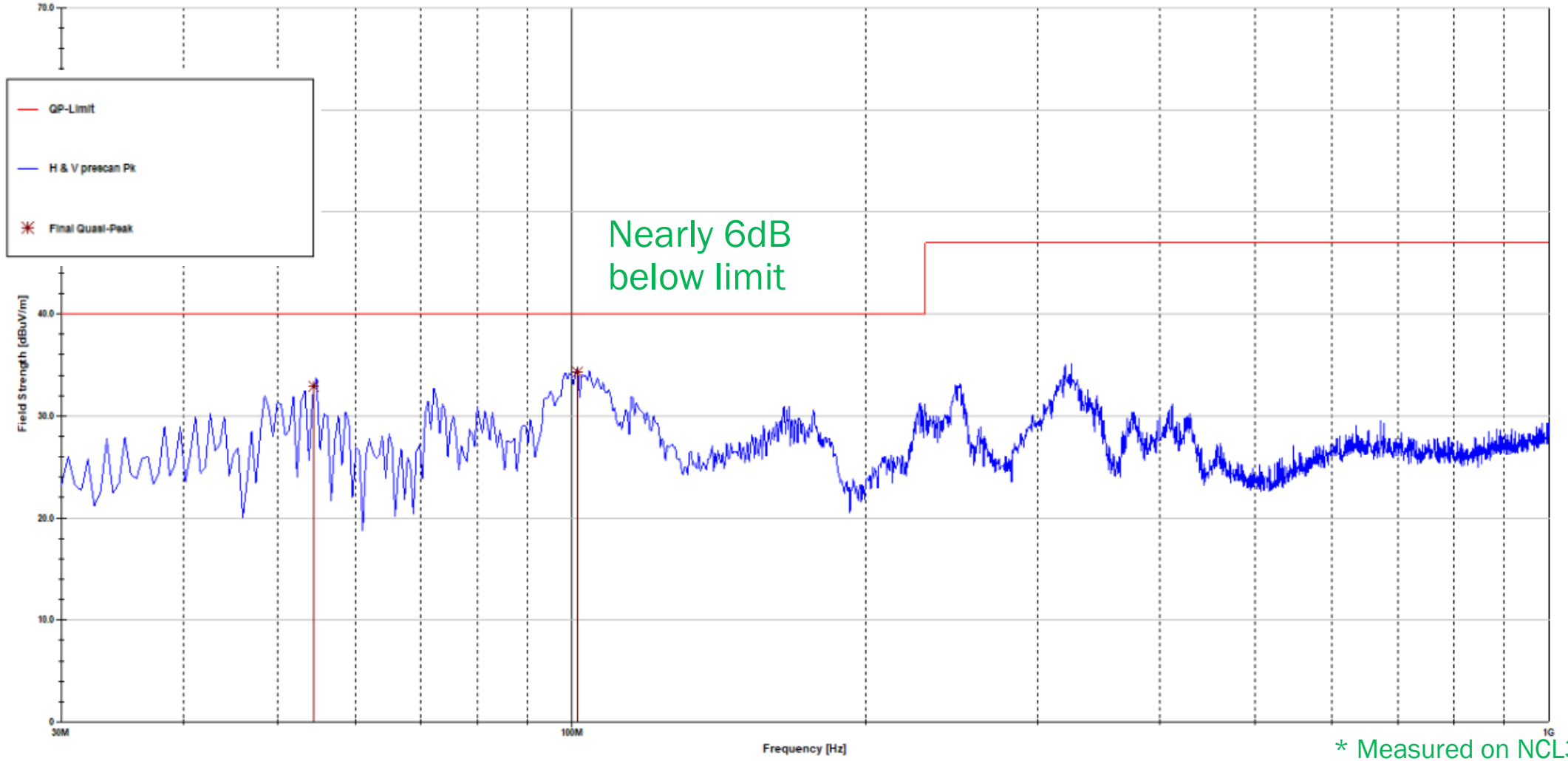
- CISPR15 / EN55015
- >14dB below limit!
- Not trivial to design: limit = 5µA flowing through the cable!

* Measured on NCL31010GEVB

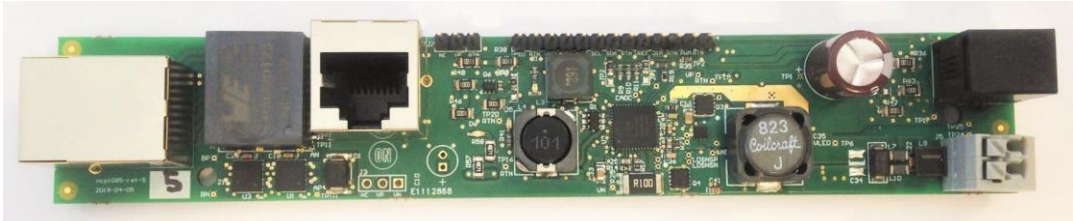


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Radiated Emissions



* Measured on NCL31010GEVB



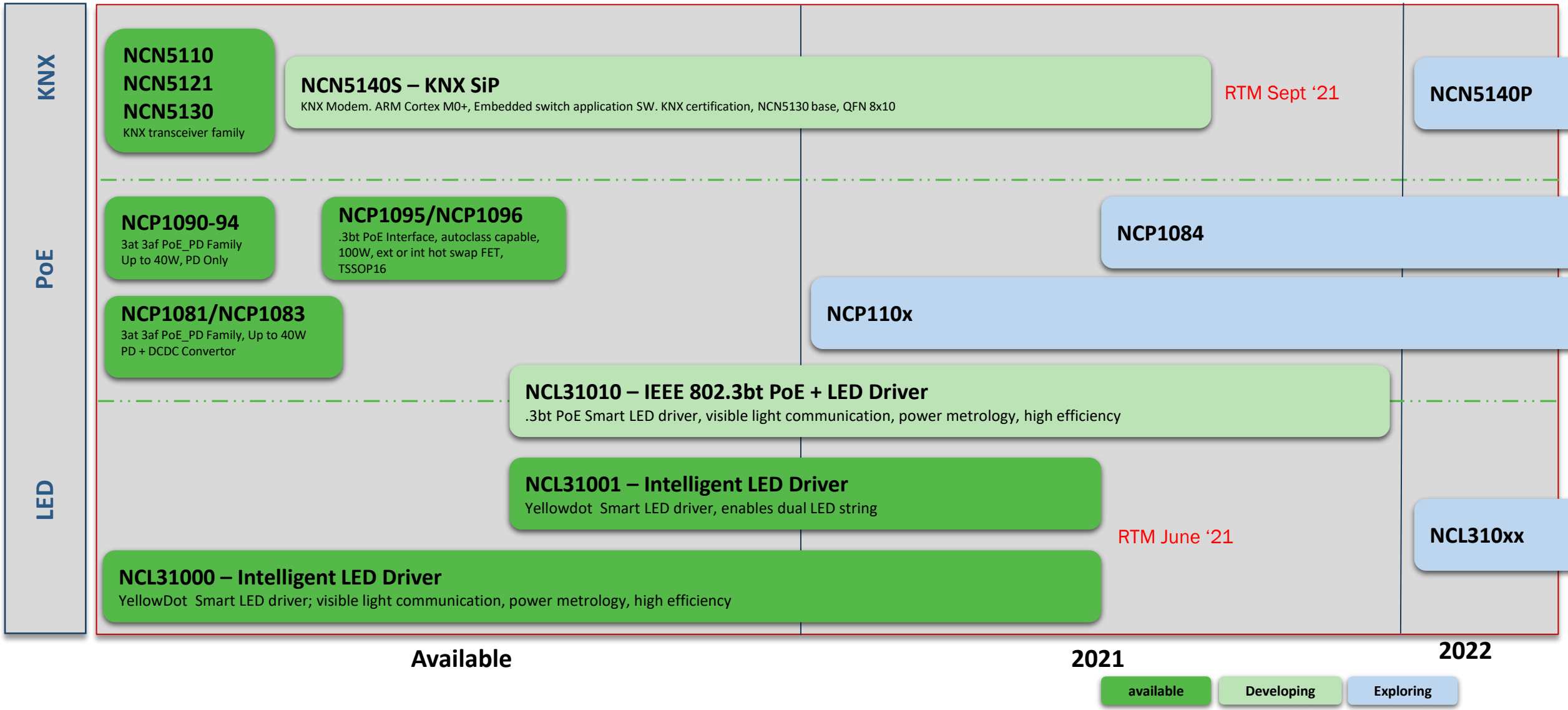
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Connected Lighting

Additional Information

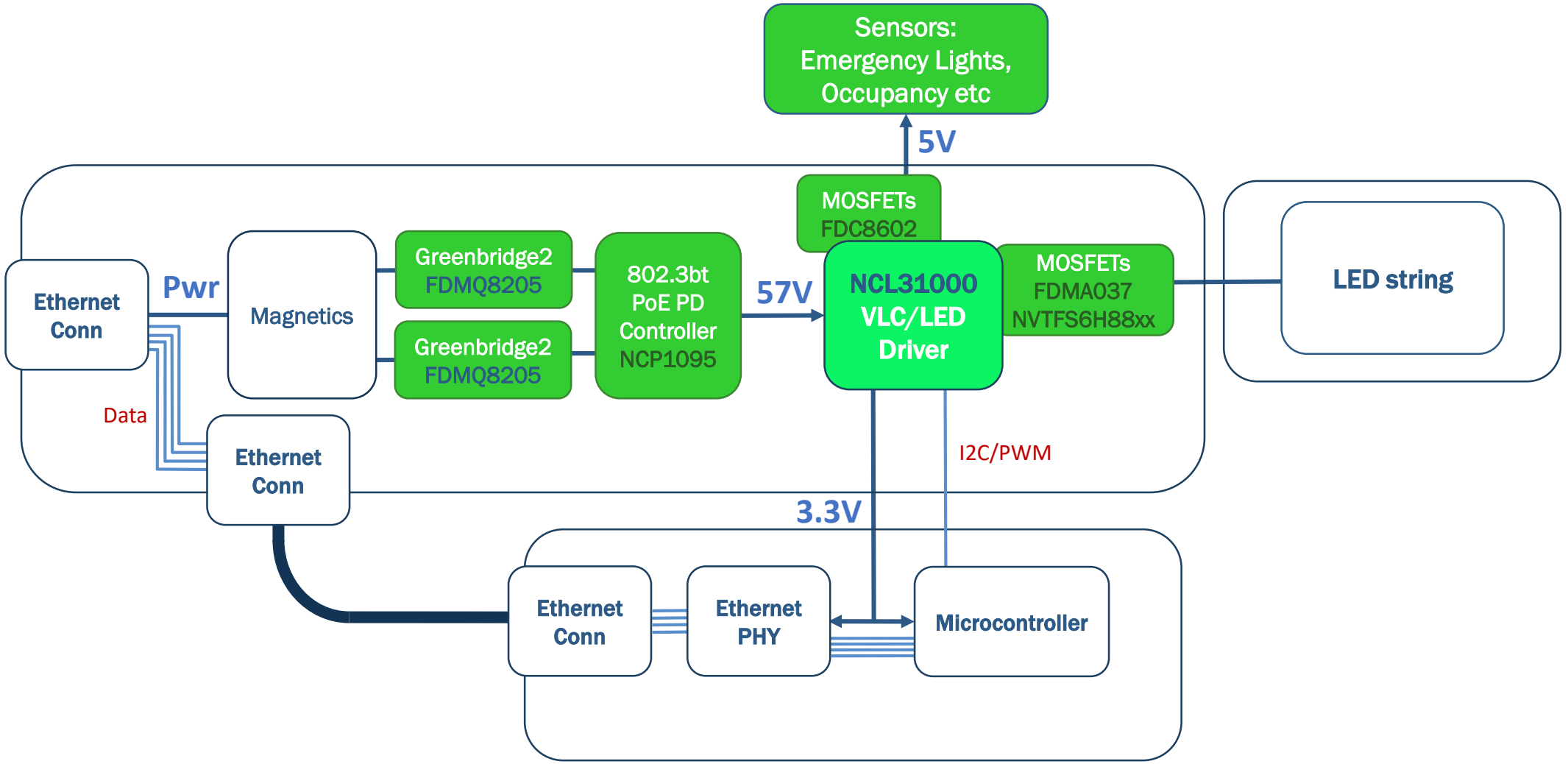
Public Information

Connected Light & Building Roadmap



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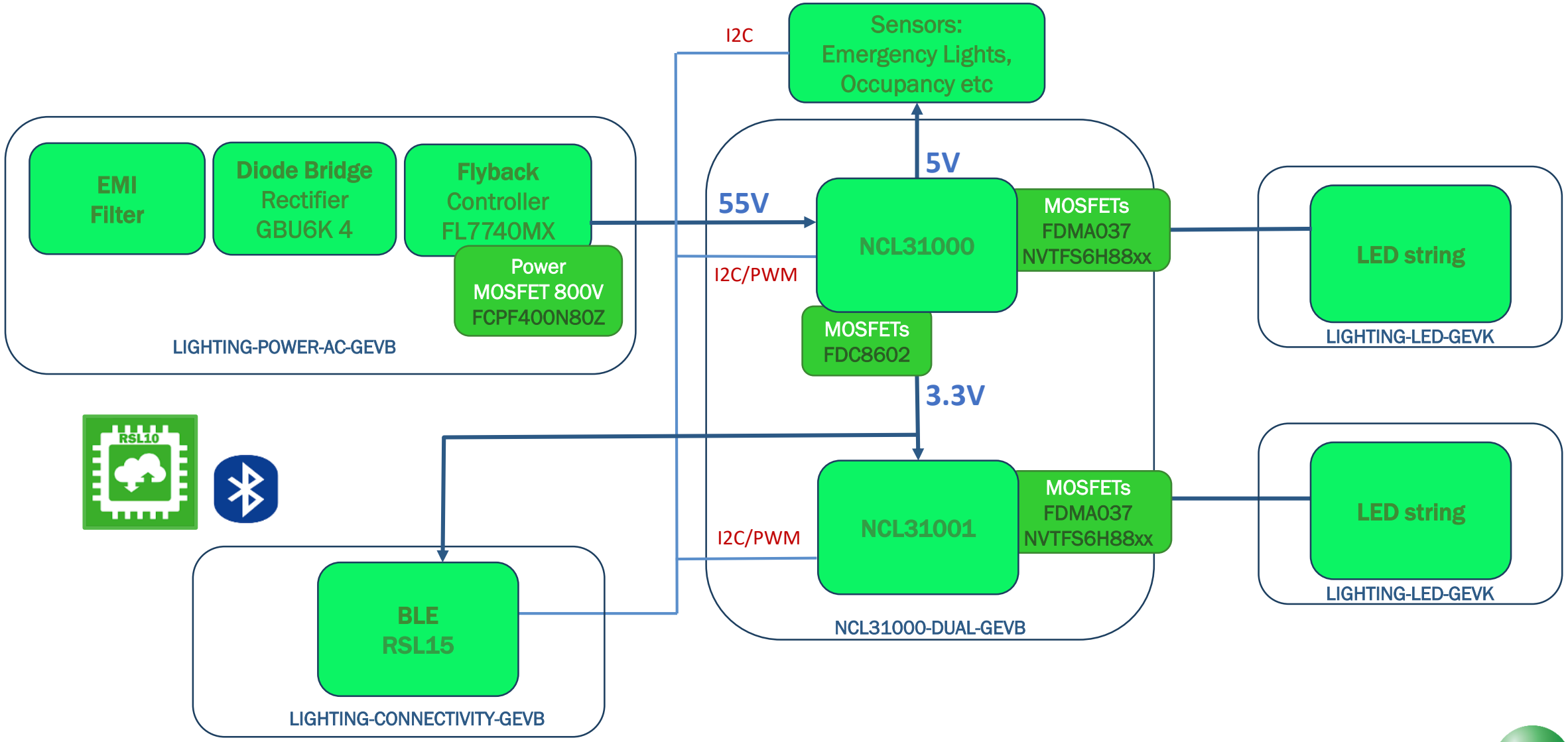
NCL31000 PoE System Diagram



Public Information

NCL3100x in the Smart Lighting Kit

Proposal



Public Information