DIGITAL WE DAYS 2024

ICLED – THE REVOLUTION OF LIGHTING CONTROL

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WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

INTRODUCTION

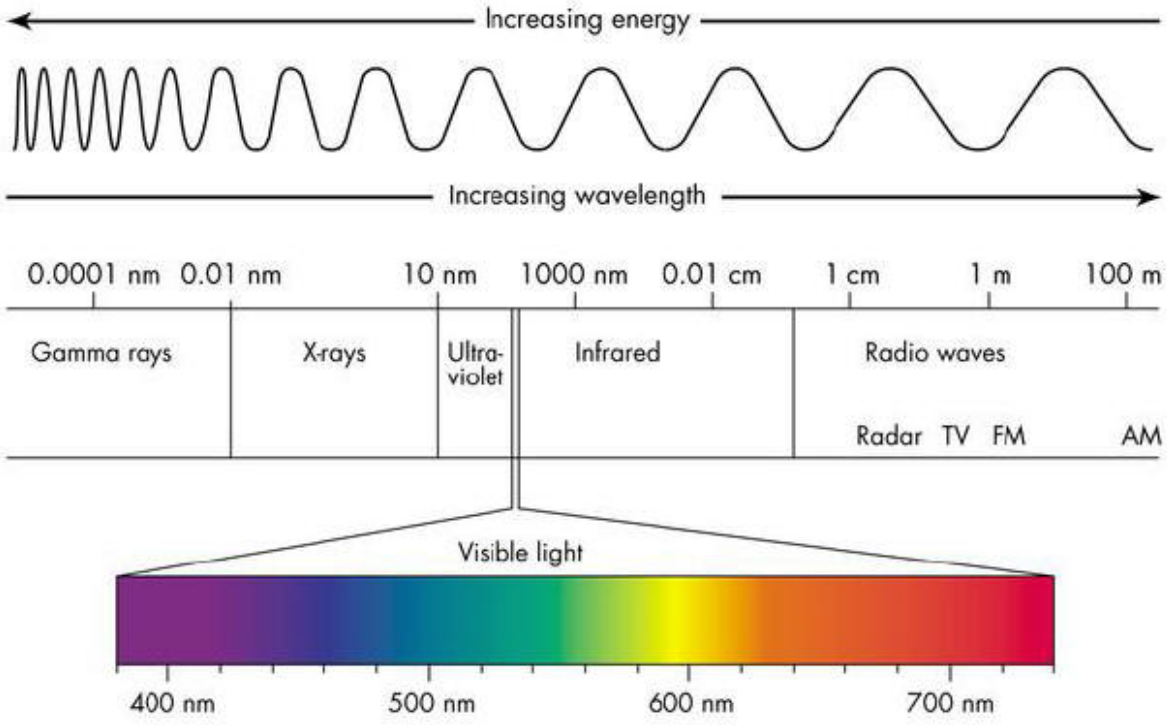
What is light?

- **Light** – Electromagnetic radiation

- **Described by:**
  - Wavelength (frequency)
  - Energy

- **Electromagnetic spectrum is divided into:**
  - Radiation – Gamma and X-Ray
  - Visible spectrum
  - Non visible – UV, IR
  - Radiofrequency

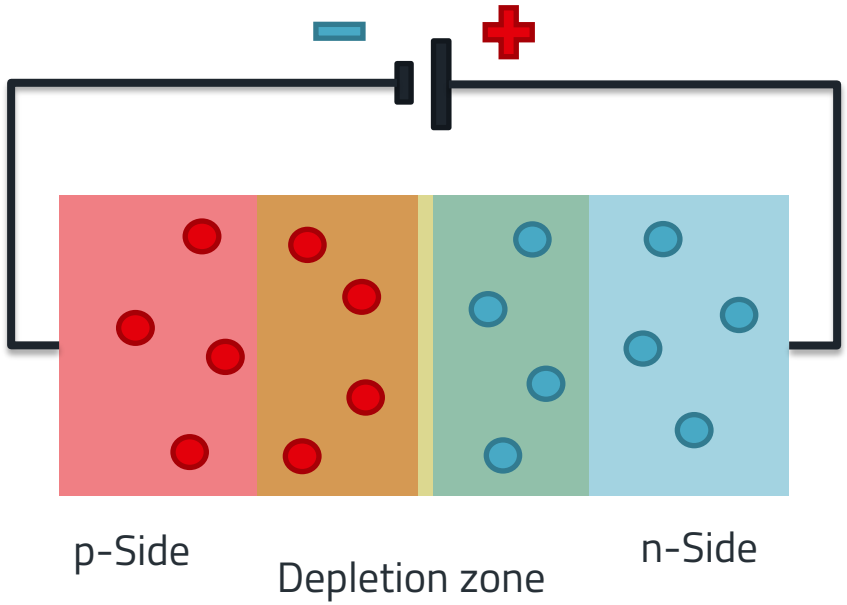
Emission's range of LED technology



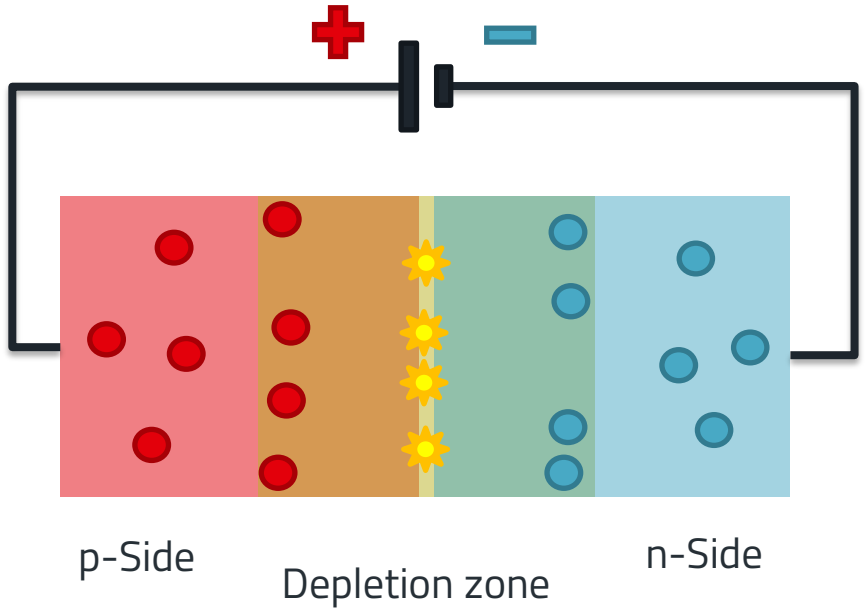
Electromagnetic Spectrum

INTRODUCTION

LED's working principle



Appliying Reverse-Bias: LED doesn't work!

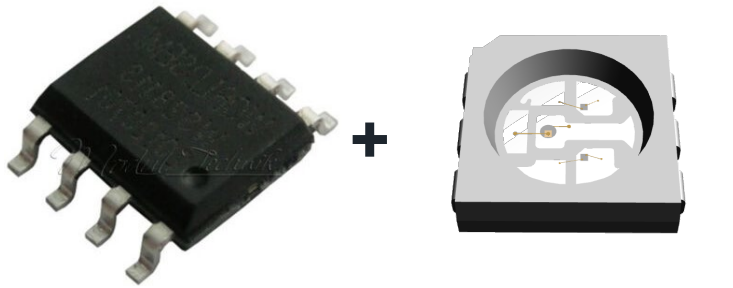


Appliying Forward-Bias: LED lights up!

INTRODUCTION

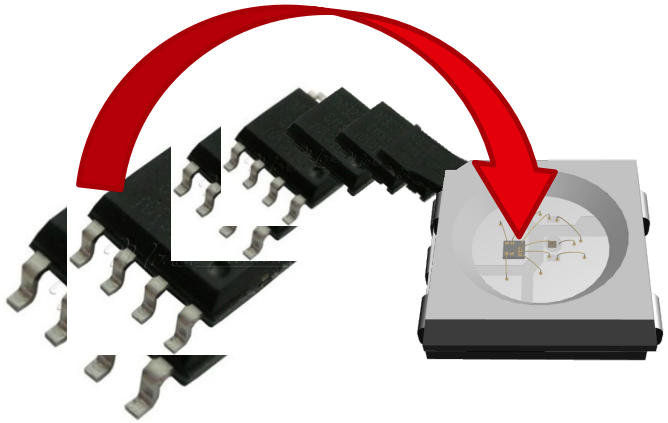
From analog to digital LEDs

Before

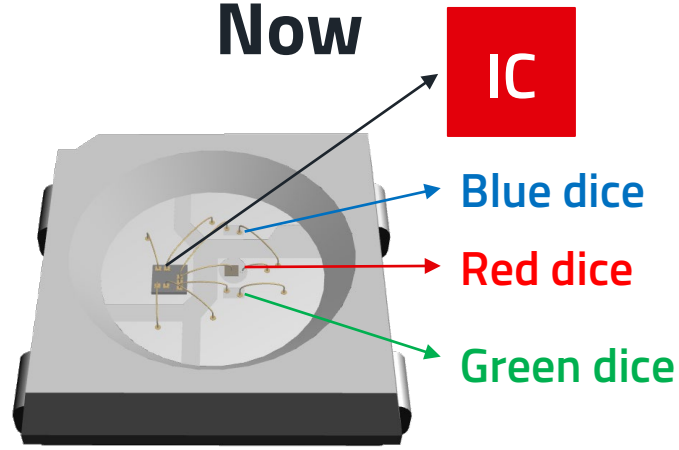


IC + RGB LED

Solution



Now



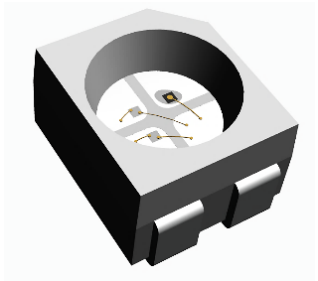
RGB LED with IC

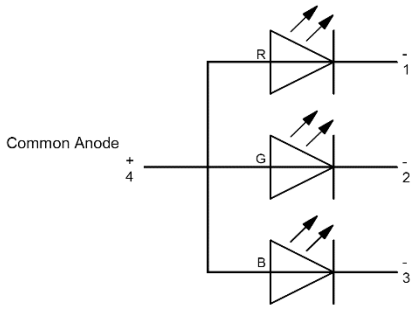
Intelligent LED Pixel LED Bus LED

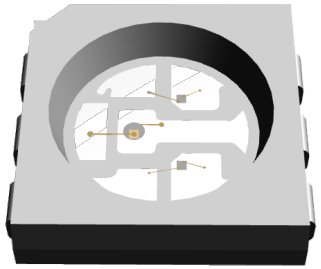
Addressable LED Smart LED Digital LED

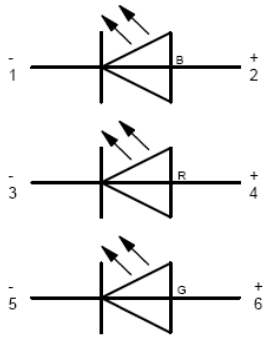
INTRODUCTION

From analog to digital LEDs

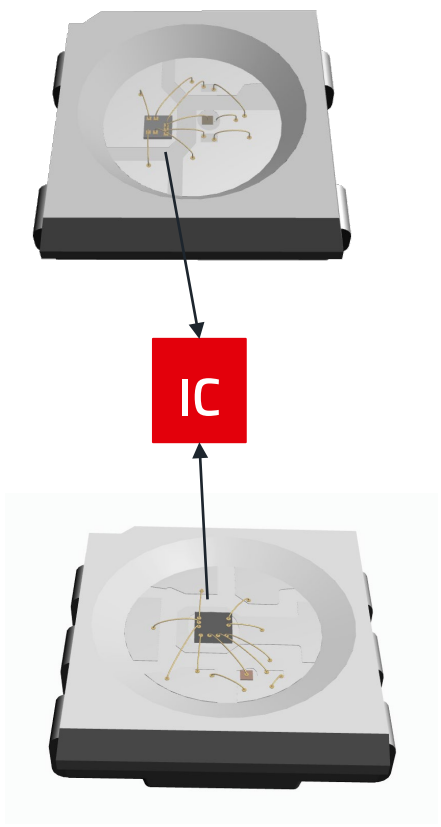


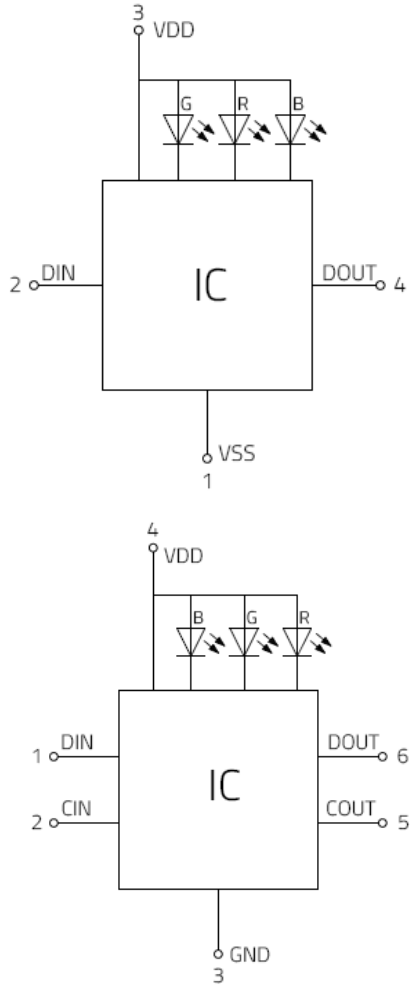






Visual appearance and schematic of analog LEDs



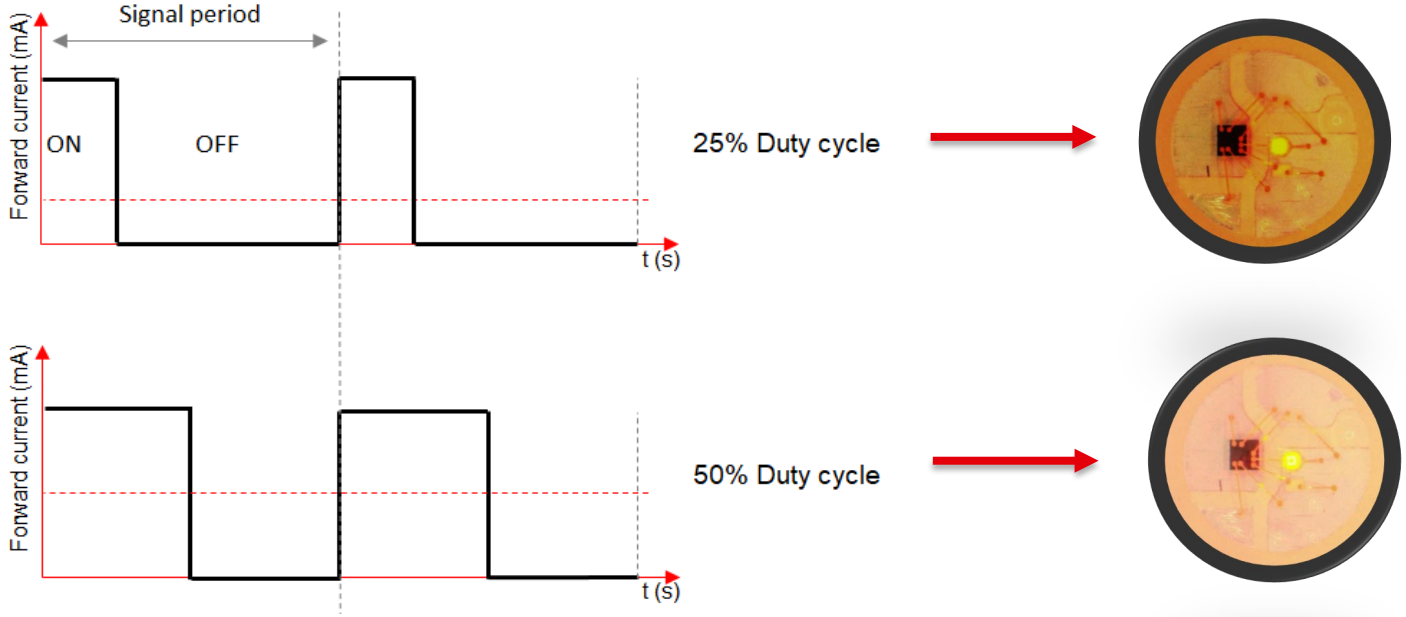


Visual appearance and schematic of IC LEDs

IC LED TECHNOLOGY

Working principle

- RGB LEDs are dimmed by means of pulse with modulation (PWM)
- The current flowing through each LED can be approximated as: $I_{F\,avg} \propto I_{F\,peak} \cdot D$
- Where D corresponds to the duty cycle of the PWM signal defined by: $D = \frac{t_{on}}{t_{on} + t_{off}} = \frac{t_{on}}{T}$



HIGHER DUTY CYCLE → BRIGHTER LED

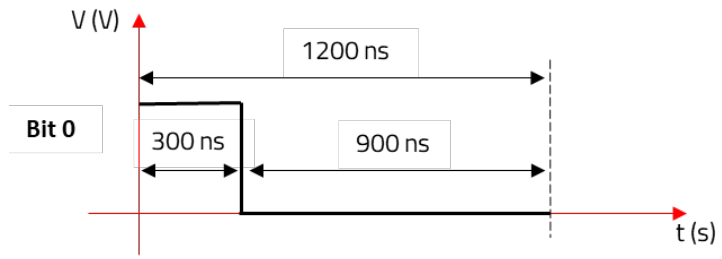
IC LED TECHNOLOGY

Single wire communication protocol

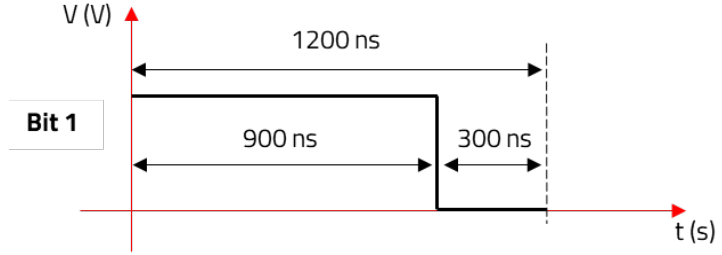
G7	G6	G5	G4	G3	G2	G1	G0	R7	R6	R5	R4	R3	R2	R1	R0	B7	B6	B5	B4	B3	B2	B1	B0

24-bit pattern to define the GRB data*

For bit recognition



Bit 0 timing diagram (typ.)



Bit 0 timing diagram (typ.)

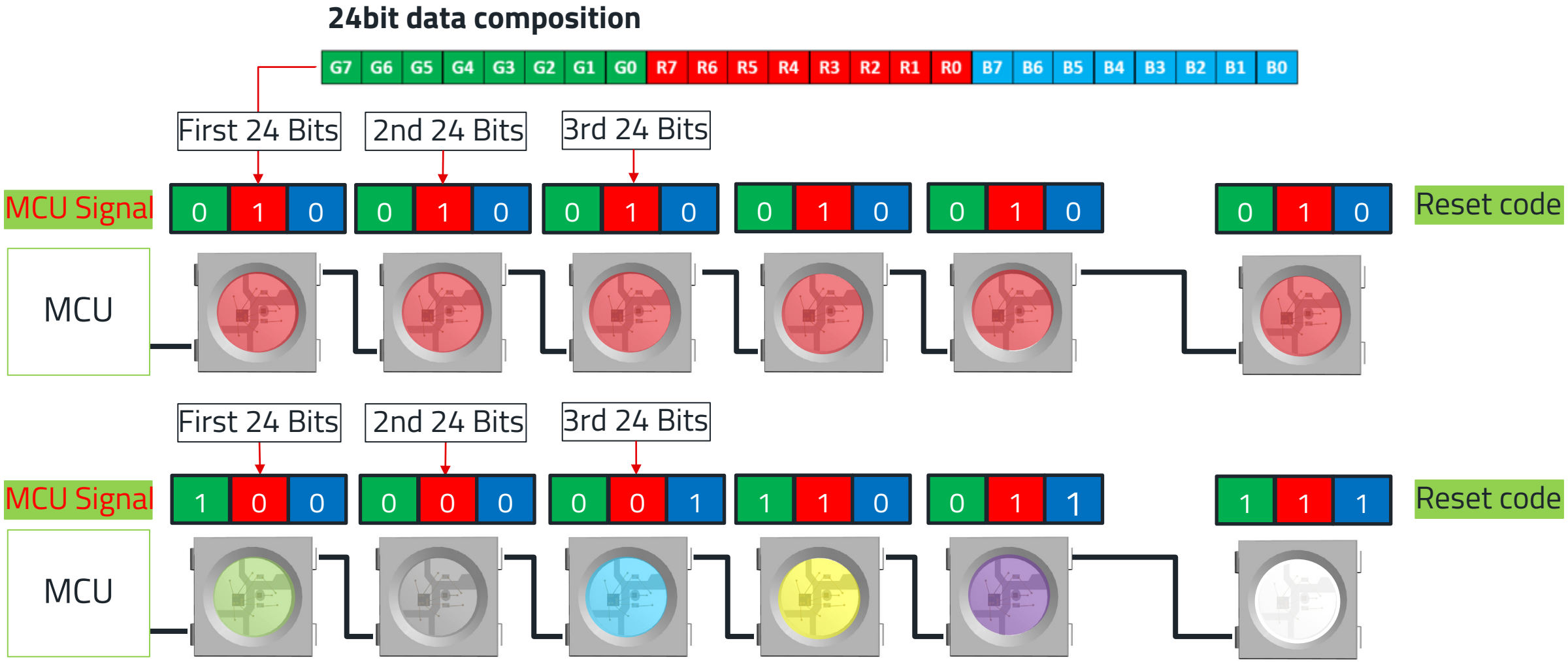
To start a new data line

Reset code timing diagram (typ.)

*Data is transferred with MSB first

IC LED TECHNOLOGY

Data transmission method



ADVANTAGES - IC LEDS FROM WE

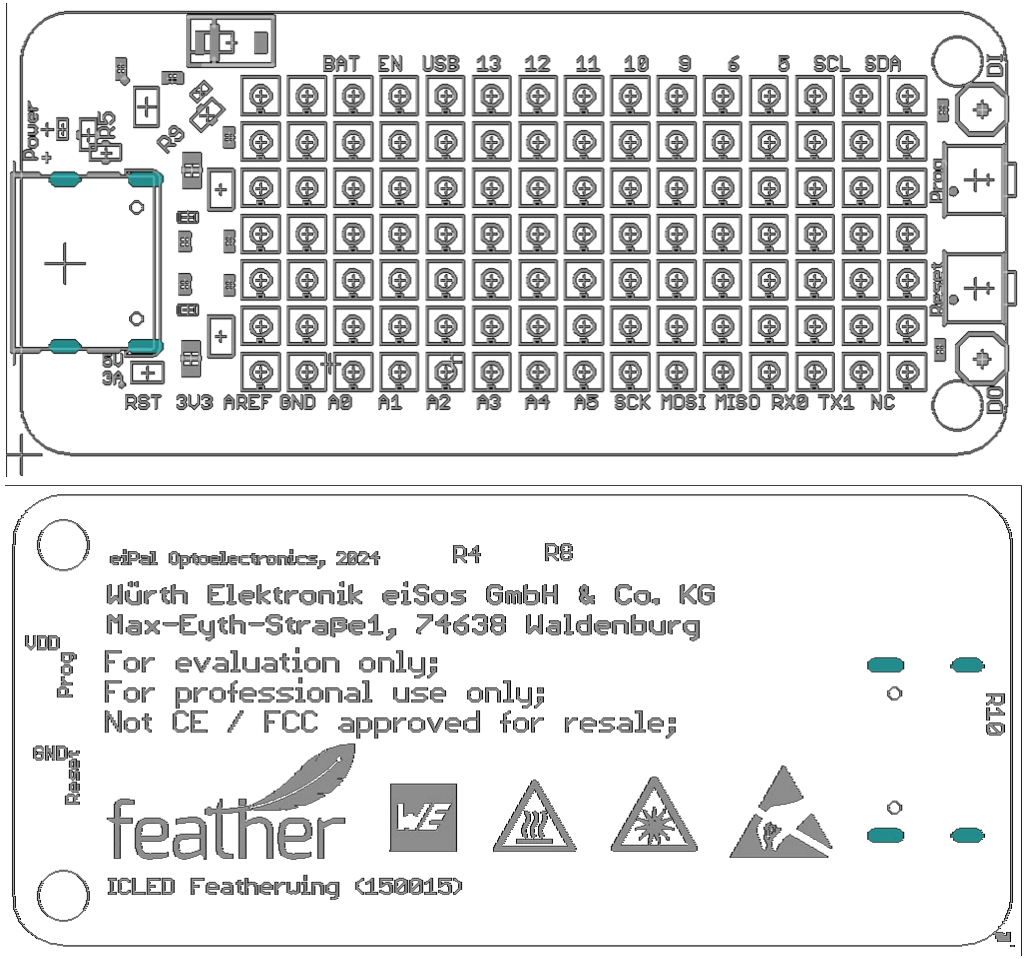
WE offer you the best solution!

- **MSL 3 / MSL 5a (IPx7) * Available for size 2121**
- **Improved solderability:**
  - Plating for Chip LEDs with Sn & Au
  - Plating for PLCC LEDs with Sn & Ag
- **Pure gold wire for high reliability**
- **Reliable LED performance: Requirement to overcome the LED market**
- **Delivery time: Between 8 and 14 weeks to customer**

APPLICATION – IC LED FEATHERWING

Board design

- High density LED display in the FeatherWing-standard
- 4-layer PCB for EMC-compliant design
  - Layer 2: Complete VSS (ground) area
  - Layer 15: Complete VDD area
  - Routing on top & bottom layer
- Power supply via USB-C: 5V @3A
- Combination of other FeatherWings possible
- Usable with 1.8V logic controllers outside FW-standard

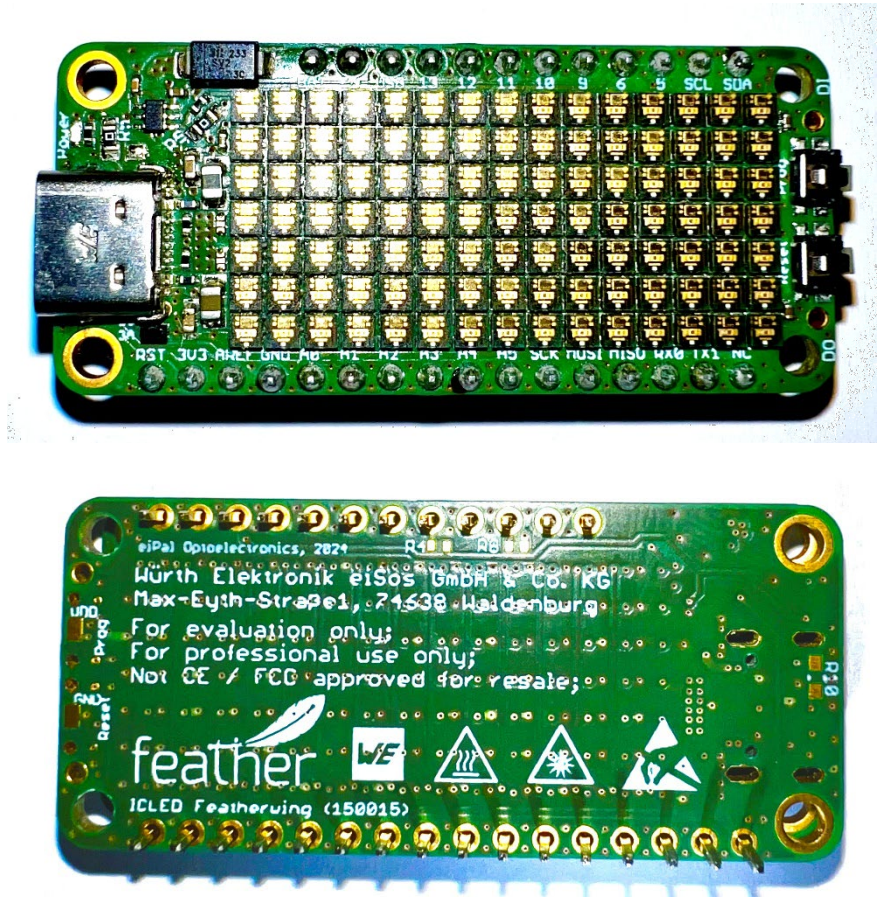


IC LED Featherwing design (Top and bottom side)

APPLICATION – IC LED FEATHERWING

Basic characteristics

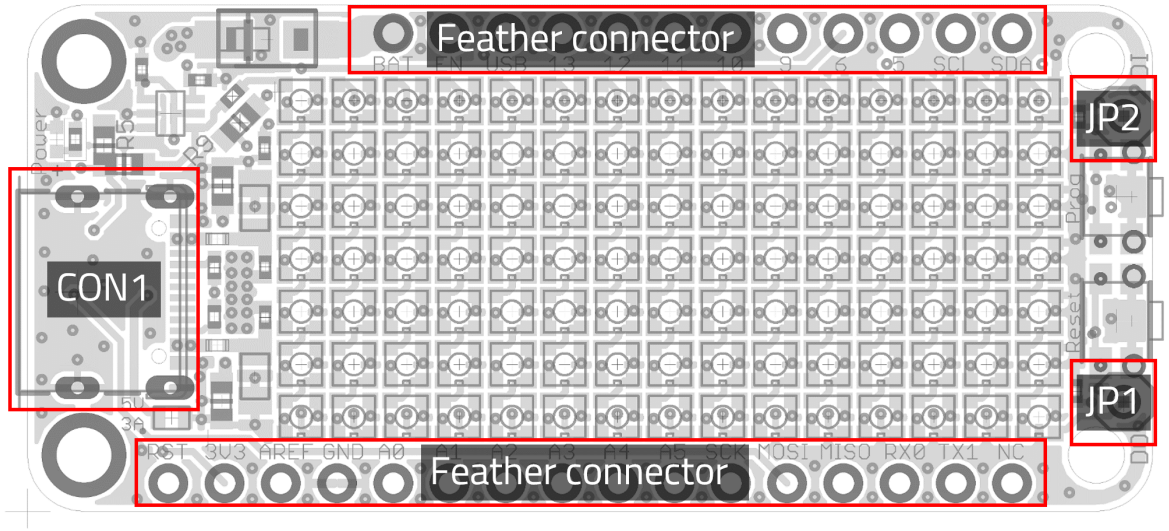
Properties	Value	Unit
Supply voltage	3.3 – 5	V
Logic level high (min)	1.65	V
Ouput logic level high (DOUT)	0.9 * VDD	V
Power consumption (max.)	8	W
Power consumption (with software limitation)	2.5	W
Emitting power density (max.)	16,000	cd/m²
Peak wavelenght (Red)	630	nm
Peak wavelenght (Green)	518	nm
Peak wavelenght (Blue)	465	nm
Sleep current (typ.)	90	mA
Frame rate (max.)	150	Hz

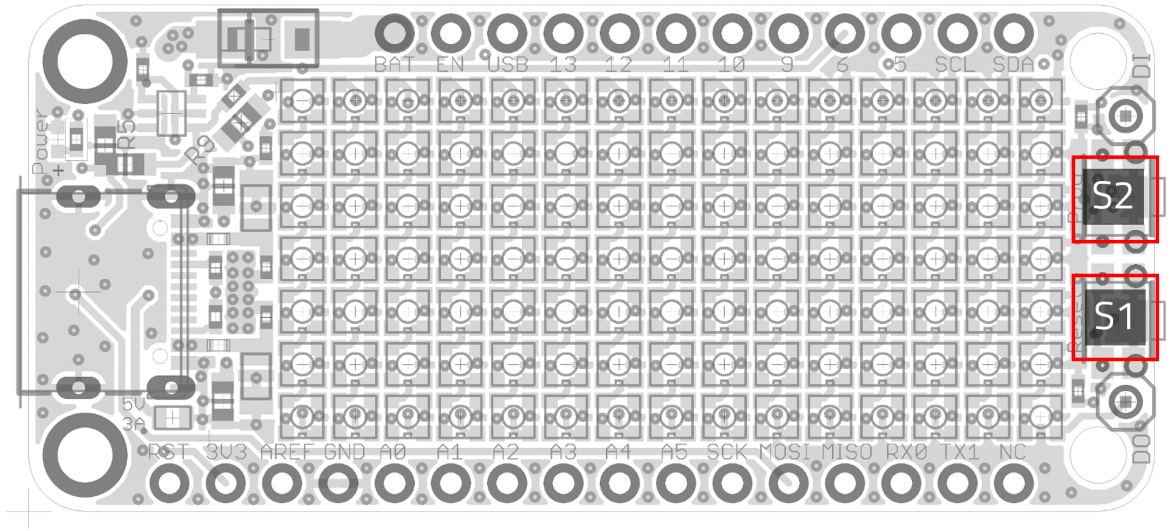


IC LED Featherwing (Top and bottom side)

APPLICATION – IC LED FEATHERWING

Hardware description





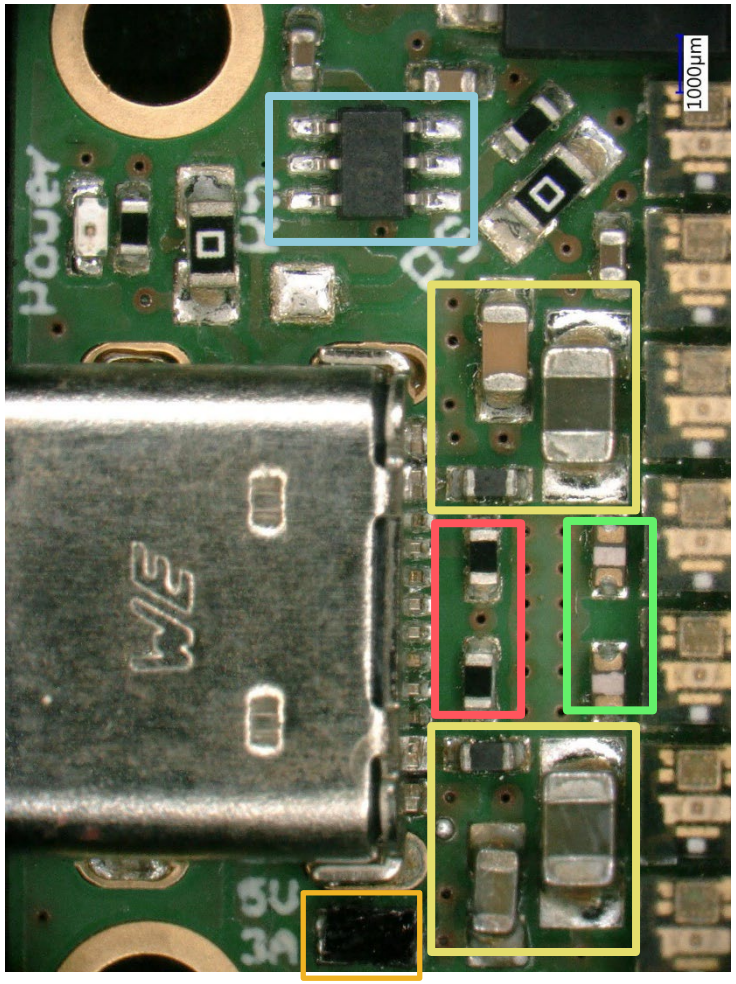
CON1:	USB-C connector (5V/3A)
JP1:	DOUT pin of IC LED 105
JP2:	DIN pin of IC LED 1

S1:	RESET pin of the Feather connector
S2:	Pin 5 of the Feather connector (interrupt pin)

SMD jumpers are located on the rear side

APPLICATION – IC LED FEATHERWING

Hardware description – More features



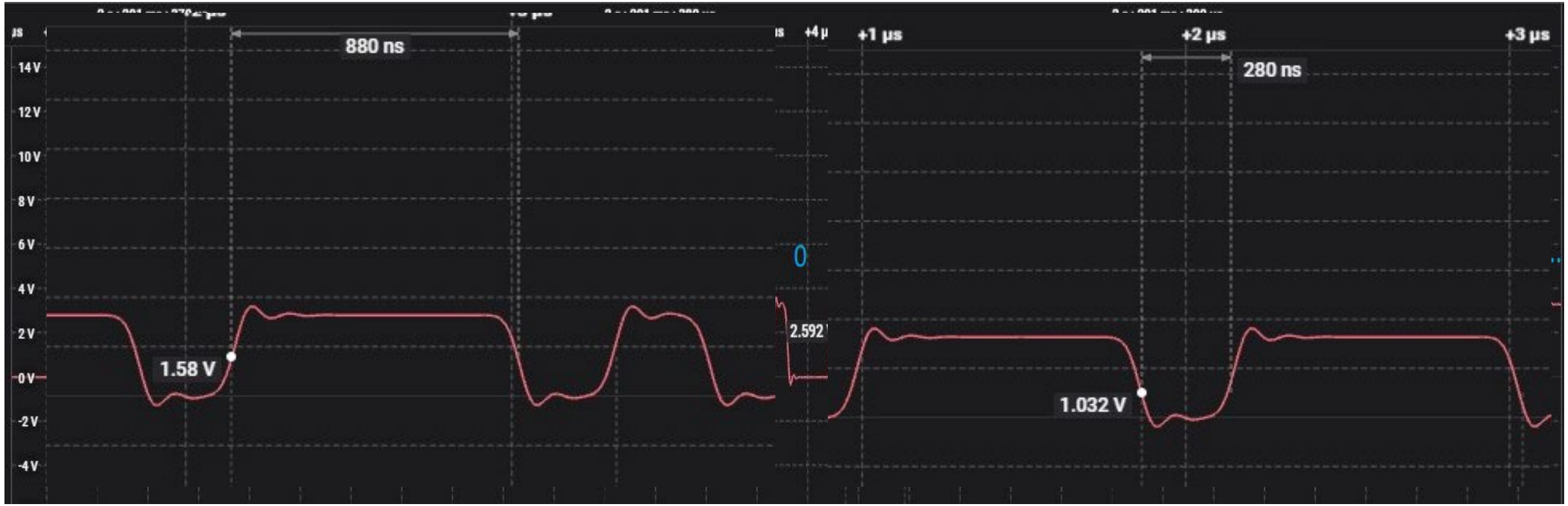
- Level-shifter for optimized logic-levels (V_{IH} between 1.65 V and 3.6 V)
- EMC-Filters added in both VDD lines of the USB-C connector
- 5.1 kΩ resistors to handle out up to 3 A from USB-C power source
- Fuses on each VDD line to avoid overheating and high currents
- TVS-Diode added for protection against transient voltage spikes

APPLICATION – IC LED FEATHERWING

Software description – Signal generation with DMA and SPI

Required signal is composed of four SPI bits-

1-bit: 1110 & 0-bit: 1000



Generated signal for T1H from MCU (Cortex M0)

Generated signal for PWM: 255 - 125

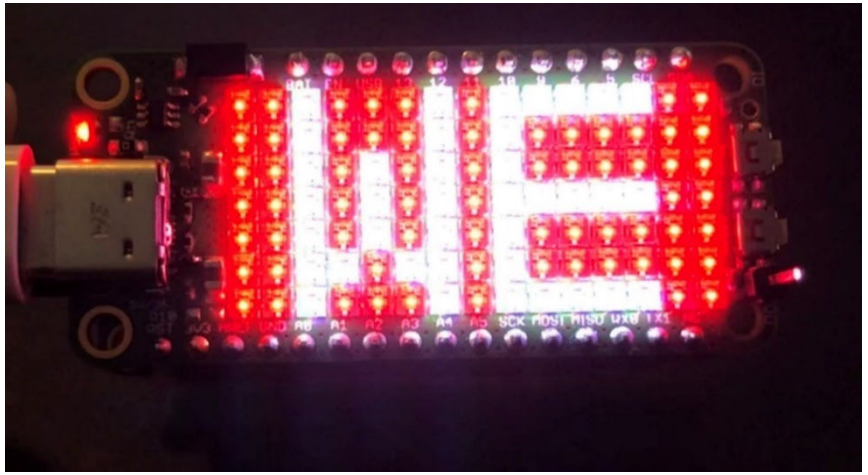
Generated signal for T1L from MCU (Cortex M0)

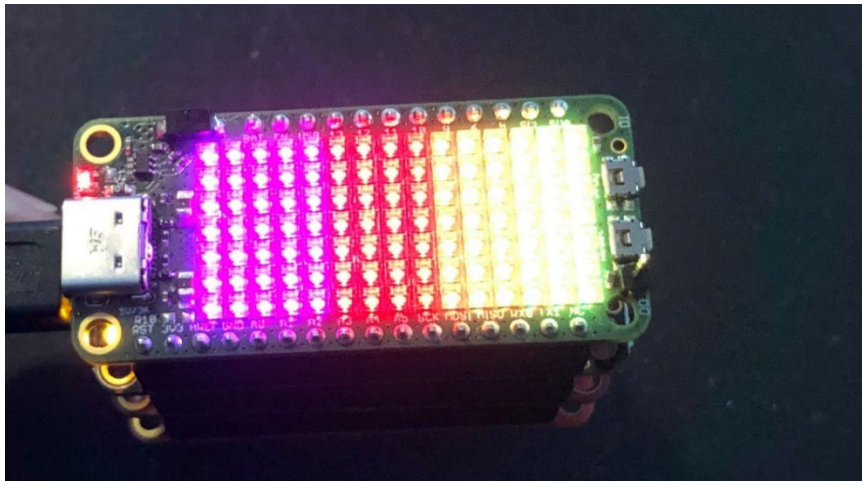
Signal measured with logic analyzer ”Logic Pro 8” from Saleae

APPLICATION – IC LED FEATHERWING

Software description

- C++ library (Visual Studio Code combined with ”PlatformIO” extension)
- Signal generation via DMA and SPI
- Framerate up to 150 Hz, arbitrarily adjustable
- HSV to RGB color system conversion implemented
- PWM-restriction to prevent from overheating
- Program-change via interrupt possible
- Letters, numbers and even animations implemented in library



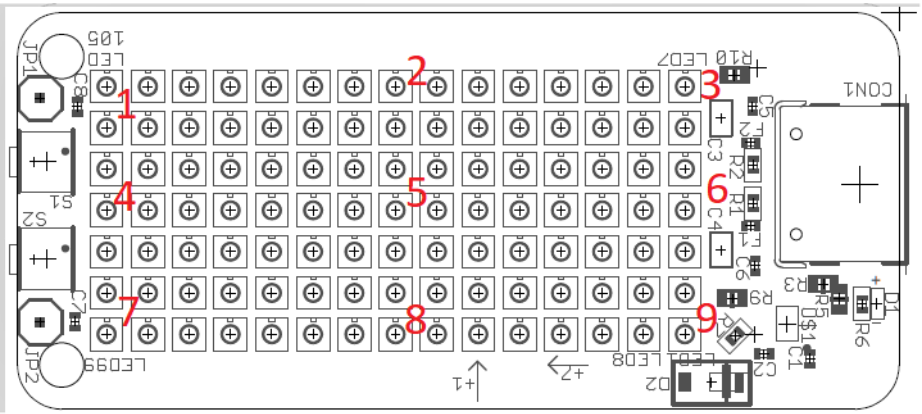


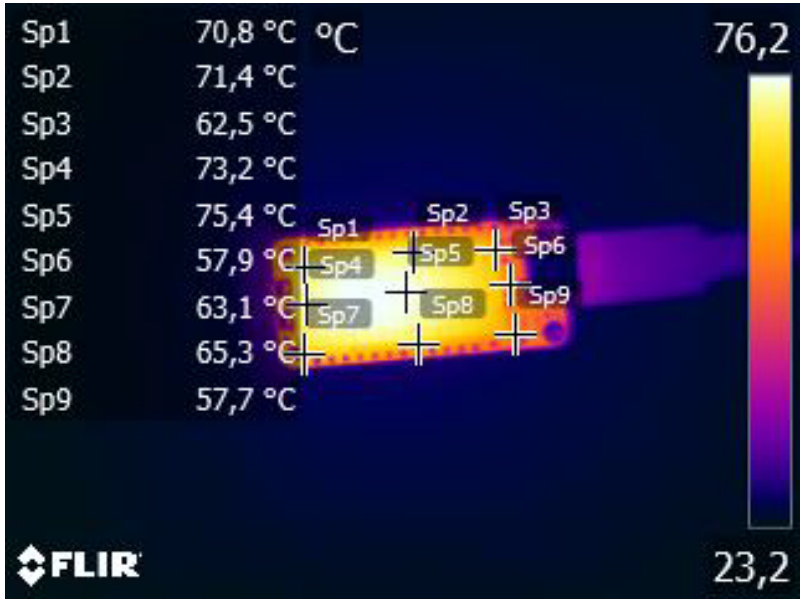
APPLICATION – IC LED FEATHERWING

Thermal safety – Implemented restrictions

- Temperature with Infrared-camera FLIR A325sc measured on 9 spots
- Featherwing's expected handling time <1s
- The Featherwing's maximum temperature is defined at: **85°C***
- Implemented restrictions:
  - Software → Maximum PWM is 210 (sum of RGB)
  - Hardware → Fuses shut down the board in case of overheating

*Touchable temperature limits according to IEC 62368-1 Edition 3



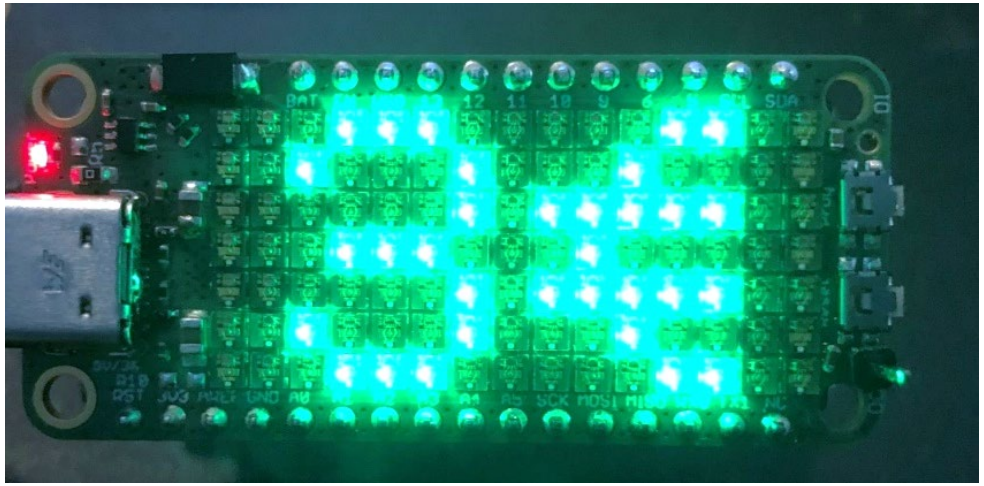


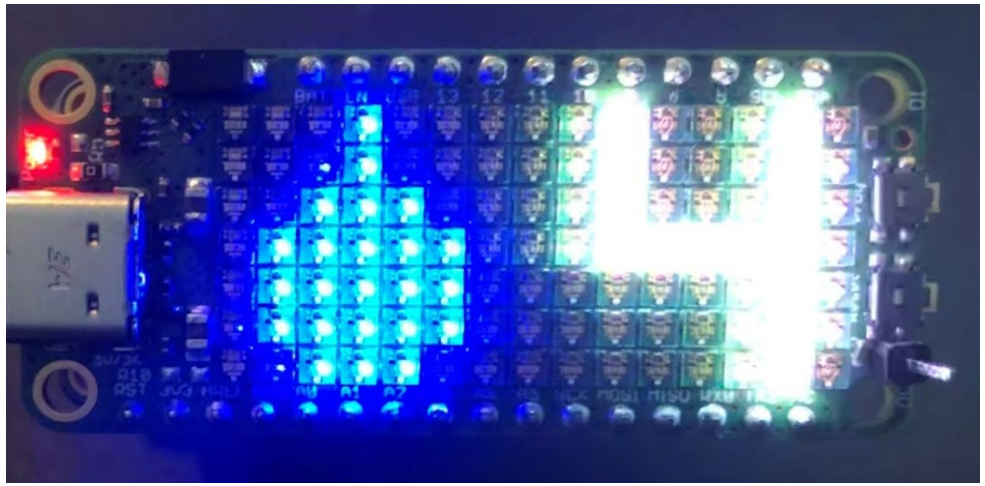
Temperature measurement with Software and Hardware restrictions

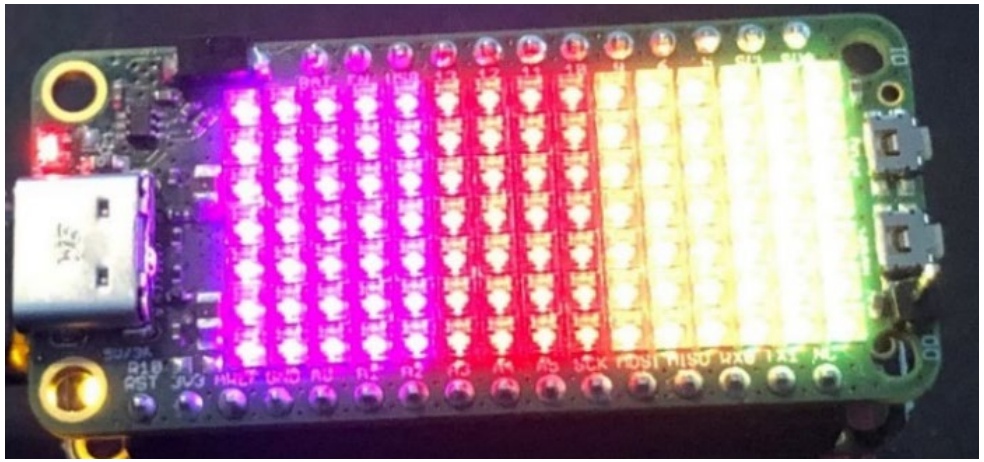
Highest Temperature: **75,4 °C**

APPLICATION – IC LED FEATHERWING

Use cases







APPLICATION – IC LED FEATHERWING

Live demonstration

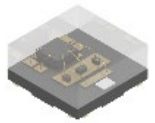
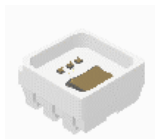
- Example functions:
  - init_show ()
  - showRainbow()
  - showPrice()
  - set emoji()

- Combination with FeatherWing sensor possible
  - Show: temperature, relative humidity and absolute pressure
  - Text rotates when the screen is turned around-3-axis acceleration sensor

```
624  #ifdef TEST116
625      //initial Test
626      strip.init_show();
627      strip.showRainbow(30, 5);
628      strip.showPrice("9", 2, 50, 0, 0, 50);
629      strip.showPrice("19.99", 12, 50, 0, 0, 50);
630      strip.fill(21,0,112,15);
631      uint16_t x = strip.set_string("DIGITAL DAYS 2024", 15, 60, 60, 60, 50);
632      strip.showRunLoop(100, x);
633      // show all emojis
634      x = strip.set_emoji(1, 4, 20, 20, 0, 75);
635      x = strip.set_emoji(2, x, 20, 20, 0, 75);
636      x = strip.set_emoji(3, x, 20, 20, 0, 75);
637      x = strip.set_emoji(4, x, 20, 20, 0, 75);
638      x = strip.set_emoji(5, x, 20, 20, 0, 75);
639      x = strip.set_emoji(6, x, 0, 20, 0, 75);
640      strip.showRunLoop(100, x);
641      strip.showTemperature(100, 50);
642      strip.showHumidity(100, 50);
643      strip.showBLEdata(50, 0, 50, 30);
644  #endif
645  }
```

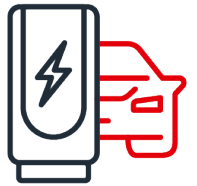
WÜRTH ELEKTRONIK'S IC LED CATALOG

Matchcode: WL-ICLED

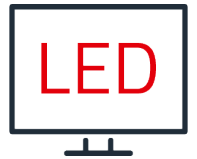
Matchcode	Picture	Size	WE Part Number	Packaging	Mounting technology
WI-ICLED		2020	1312020030000	Chip LED compact	SMT
		3210	1313210530000	Chip LED Side View	SMT
		2121	1312121320437	PLCC6 with bypass **IPx7**	SMT
		5050	1315050930002	PLCC4	SMT

APPLICATIONS

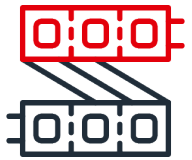
Home appliances



E-mobility



Full color LED Matrix



Decorative lighting

Smart lighting

Gaming peripherals

Wearables

Traffic displays

Industrial control systems

Questions

& Answers

We are here for you now!
Ask us directly via our chat or via E-Mail.

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