



Wenn Bits zu Strom werden – Elektronik am I/O-Port des Microcontrollers

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KNF-Kongress 2016

Agenda

- **I/O-Port**
- **Spannung**
- **Strom**
- **Ground**
- **Lange Leitung**
- **EMV**

I/O-Port

General Purpose Input Output (GPIO)

I/O-Port

sudo apt-get install rpi.gpio

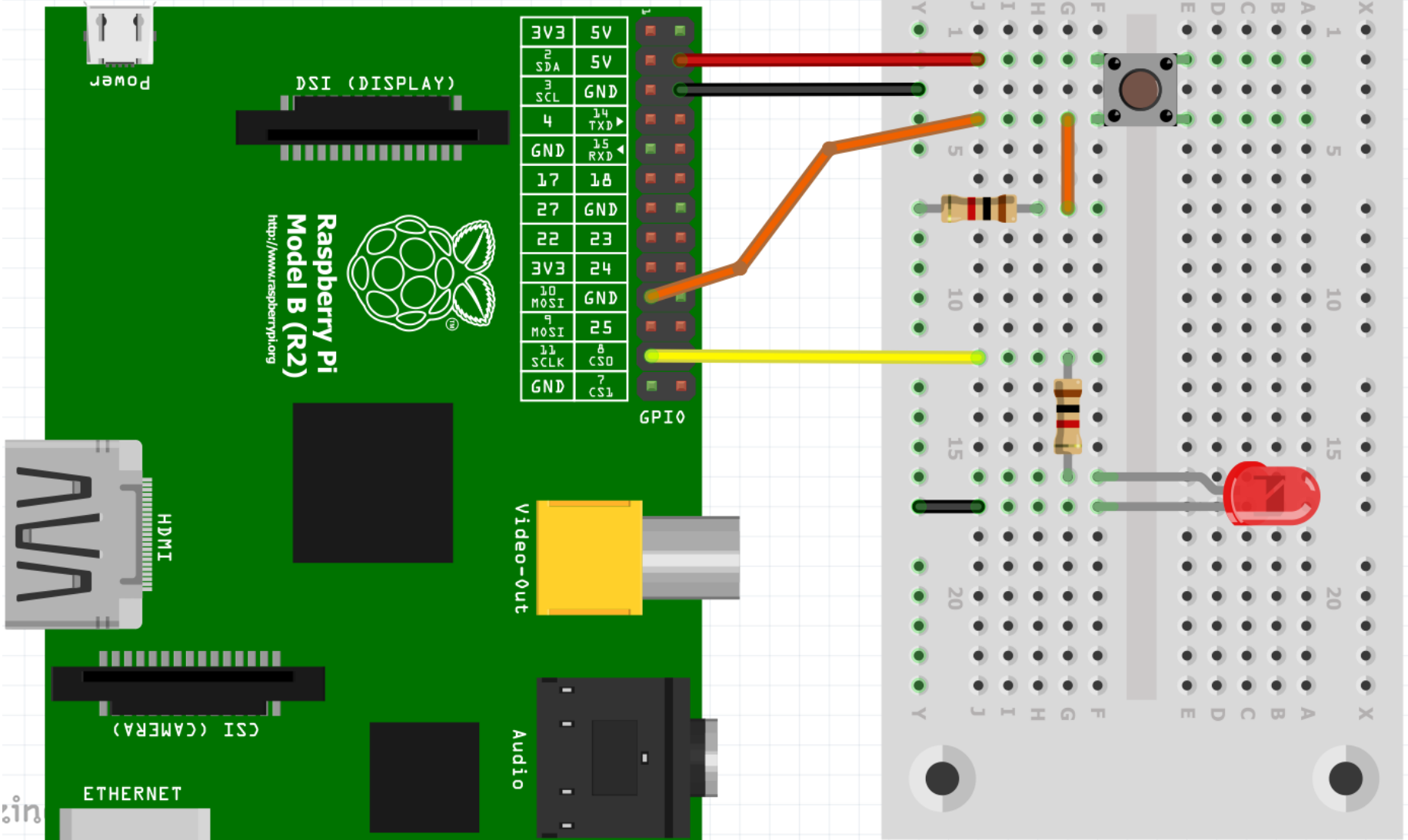
```
import RPi.GPIO as GPIO

# set up the GPIO channels
# one input and one output
GPIO.setup(10, GPIO.IN)
GPIO.setup(11, GPIO.OUT)

# input from pin 11
input_value = GPIO.input(10)

# output to pin 12
GPIO.output(11, GPIO.HIGH)
```

I/O-Port



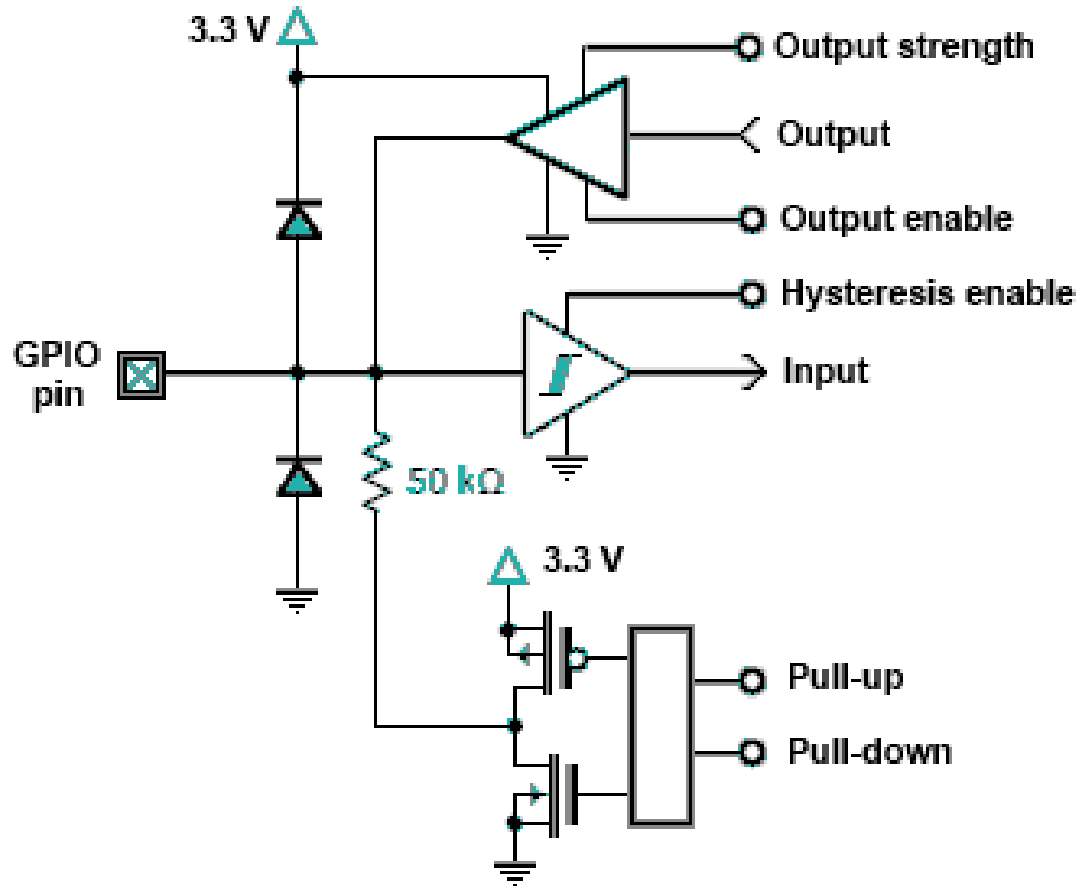
I/O-Port



Alternate Function				Alternate Function	
	3.3V PWR	1		2	5V PWR
I2C1 SDA	GPIO 2	3		4	5V PWR
I2C1 SCL	GPIO 3	5		6	GND
	GPIO 4	7		8	UART0 TX
	GND	9		10	UART0 RX
	GPIO 17	11		12	GPIO 18
	GPIO 27	13		14	GND
	GPIO 22	15		16	GPIO 23
	3.3V PWR	17		18	GPIO 24
SPI0 MOSI	GPIO 10	19		20	GND
SPI0 MISO	GPIO 9	21		22	GPIO 25
SPI0 SCLK	GPIO 11	23		24	GPIO 8
	GND	25		26	GPIO 7
	Reserved	27		28	Reserved
	GPIO 5	29		30	GND
	GPIO 6	31		32	GPIO 12
	GPIO 13	33		34	GND
SPI1 MISO	GPIO 19	35		36	GPIO 16
	GPIO 26	37		38	GPIO 20
	GND	39		40	GPIO 21
					SPI0 CS0
					SPI0 CS1
					SPI1 CS0
					SPI1 MOSI
					SPI1 SCLK

I/O-Port

Equivalent Circuit for Raspberry Pi GPIO pins



GPIO
USART (Serial)

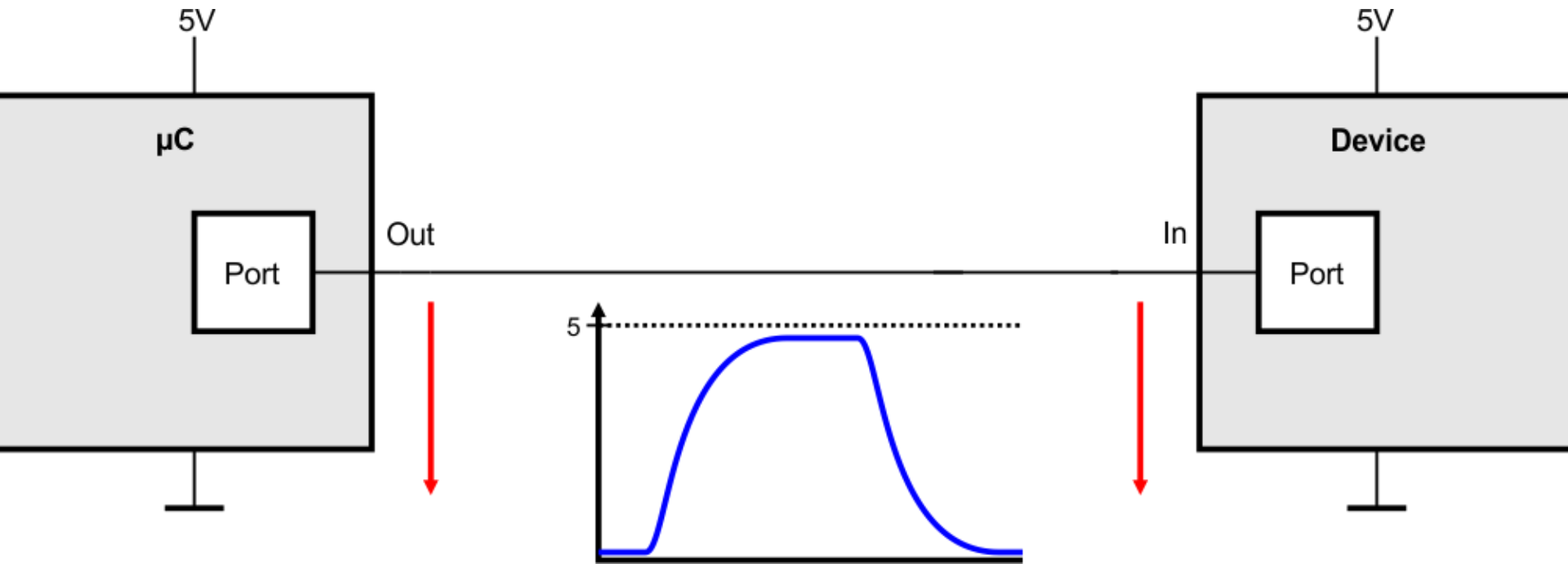
SPI

I²C

PWM

...

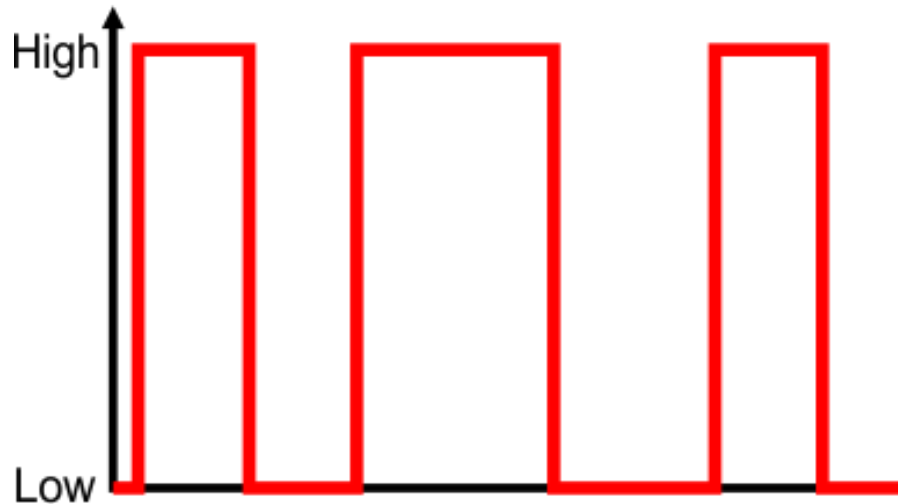
I/O-Port



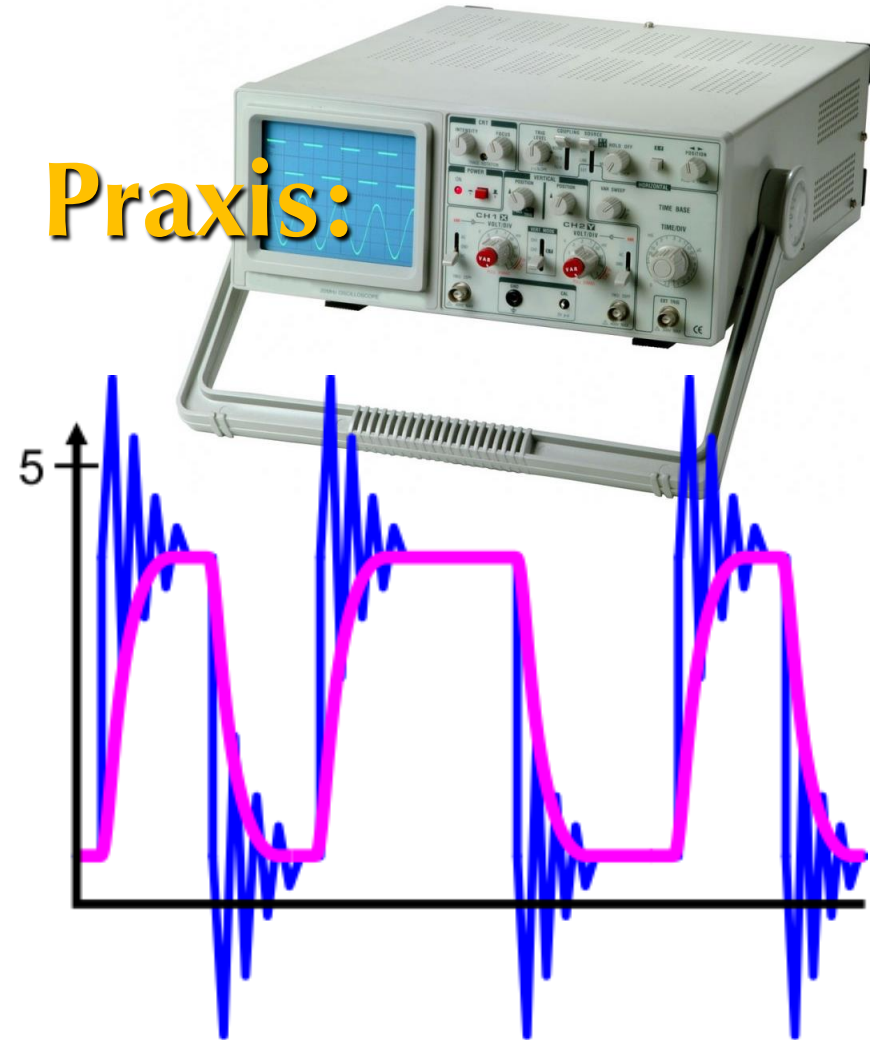
Spannung

Spannung: Praxis

Theorie:



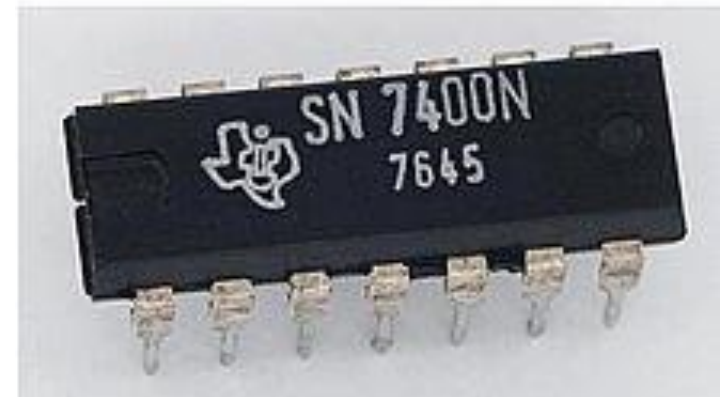
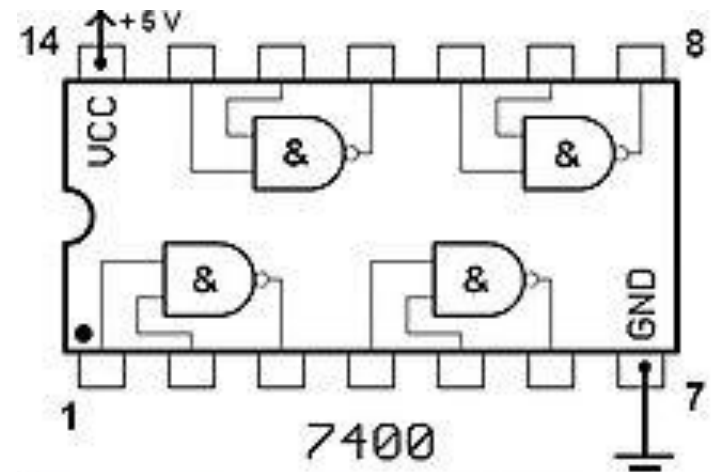
Praxis:



Spannung: TTL

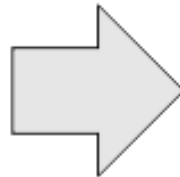
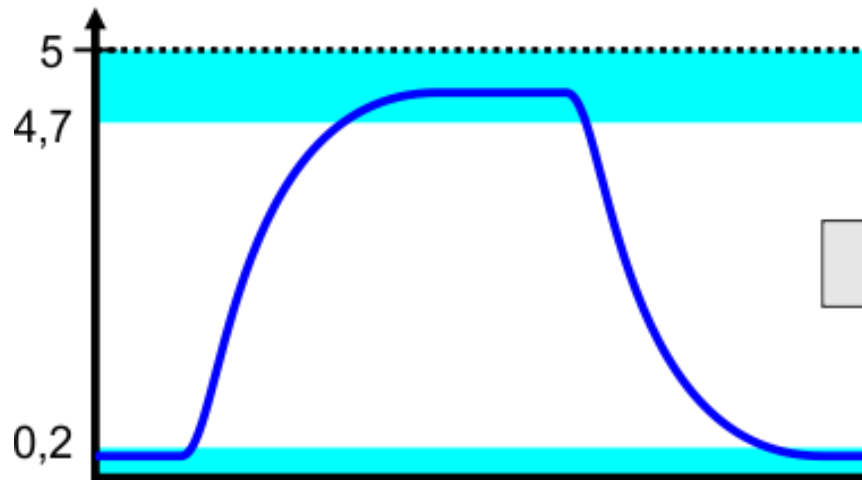
Anno 1961...

Transistor-
Transistor-
Logic (TTL)

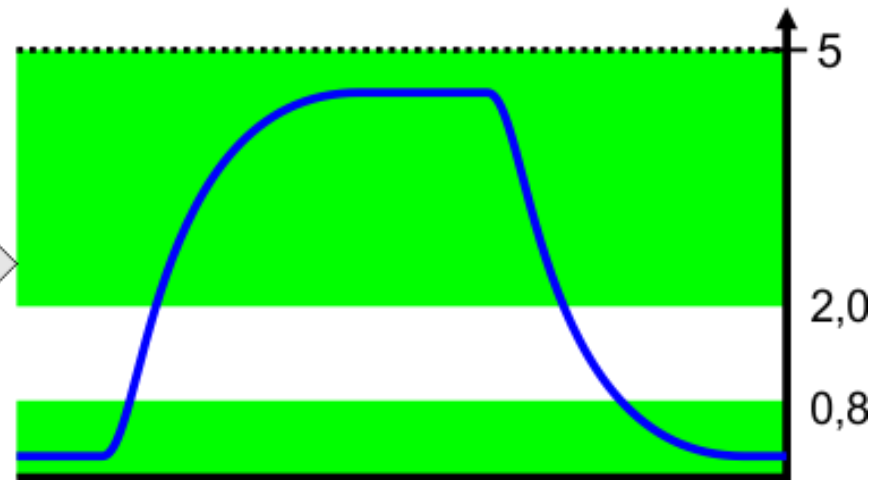


Spannung: TTL (5V)

TTL (5V) Out



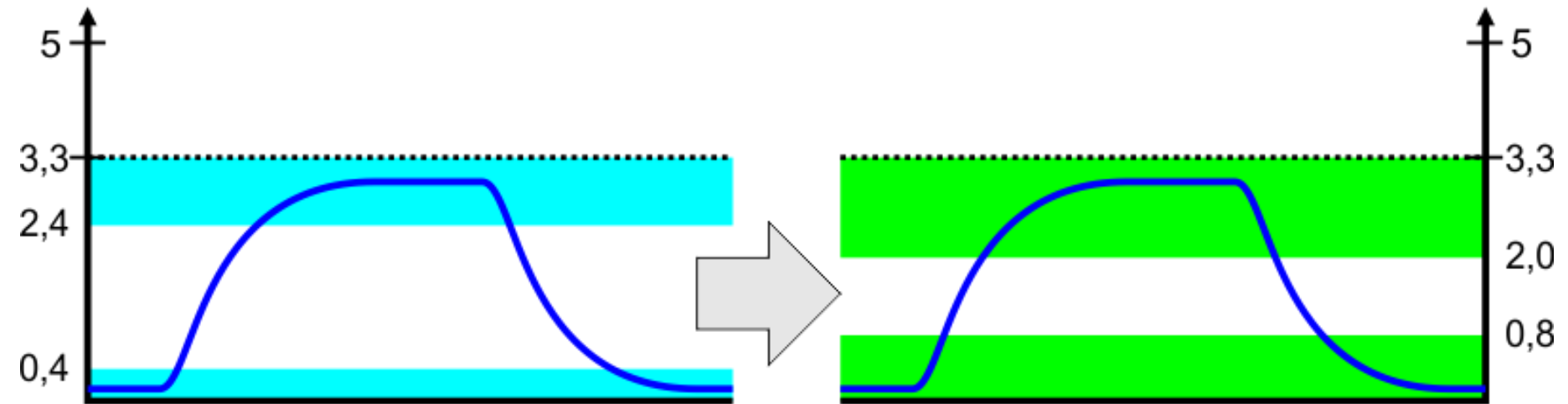
TTL (5V) In



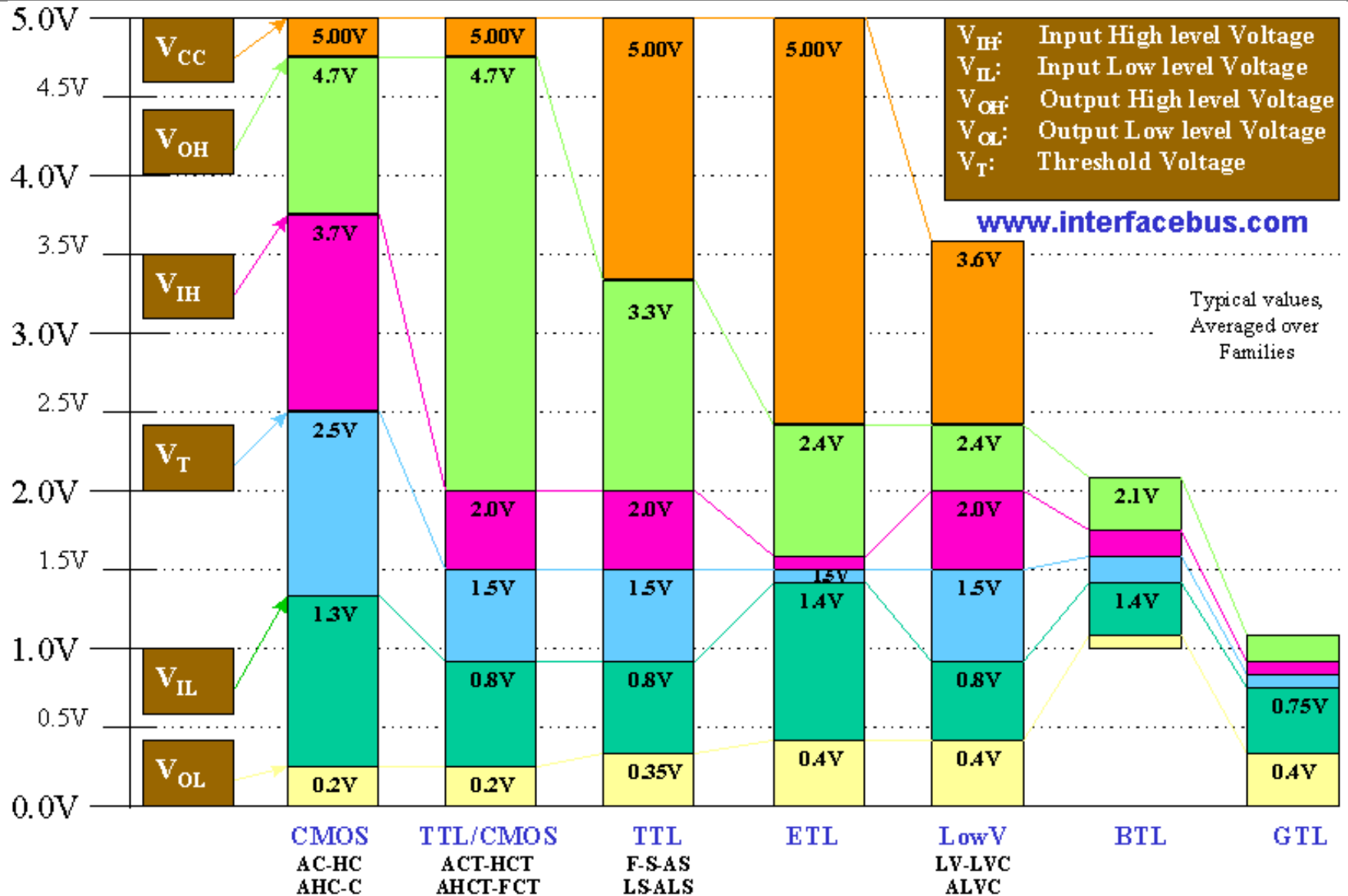
Spannung: TTL 3,3V

TTL 3,3V Out

TTL 3,3V In



Spannung: Familien

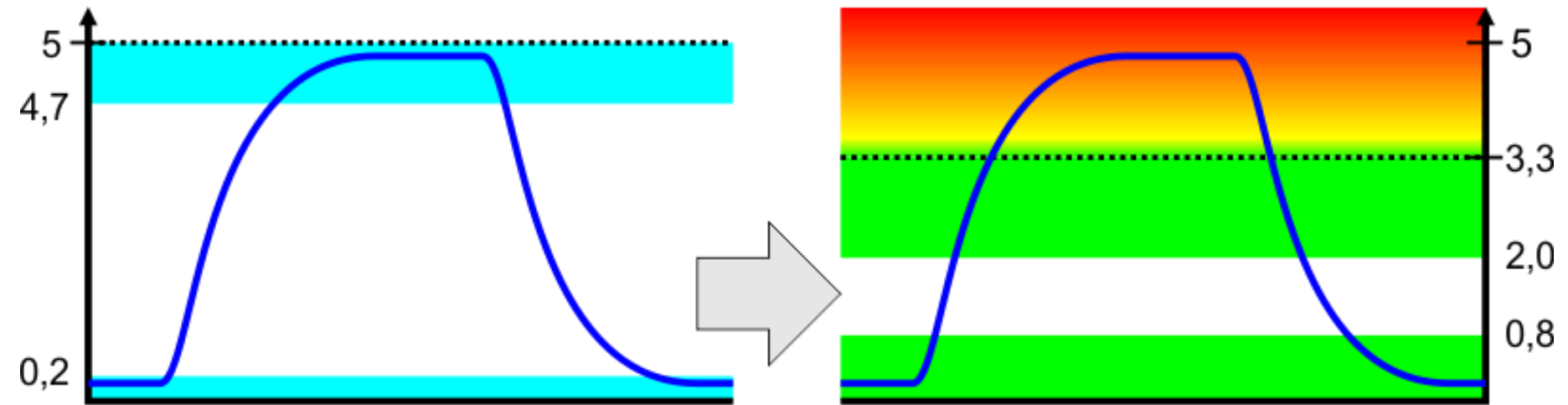


5V \rightarrow 3,3V

Problem: 3,3V-In an 5V-Out

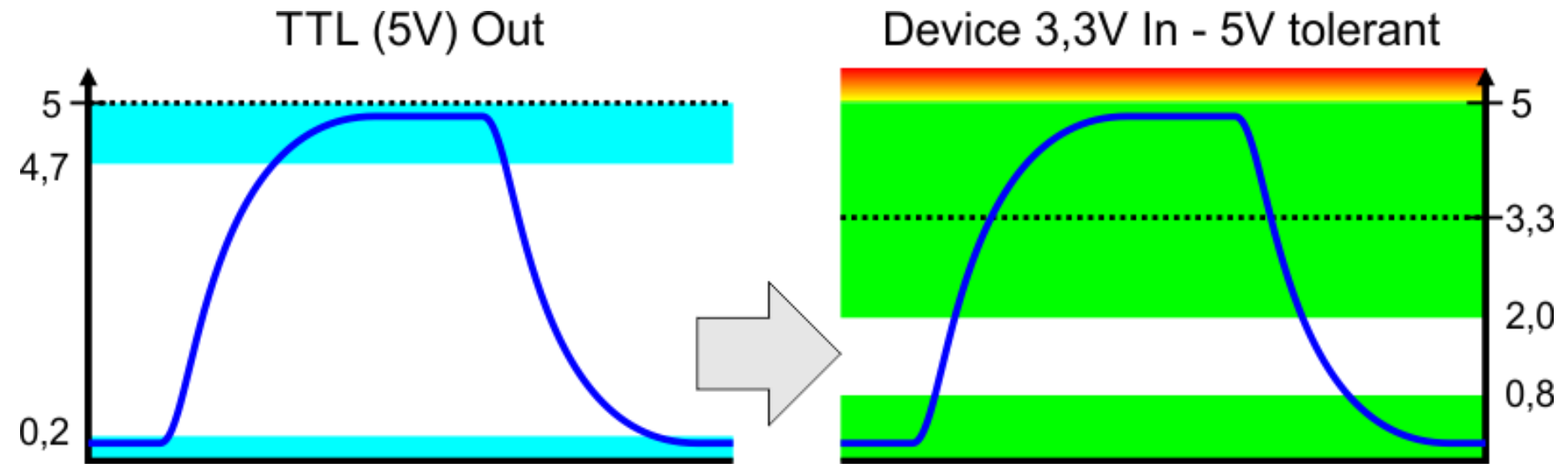
TTL (5V) Out

TTL 3,3V In



5V → 3,3V

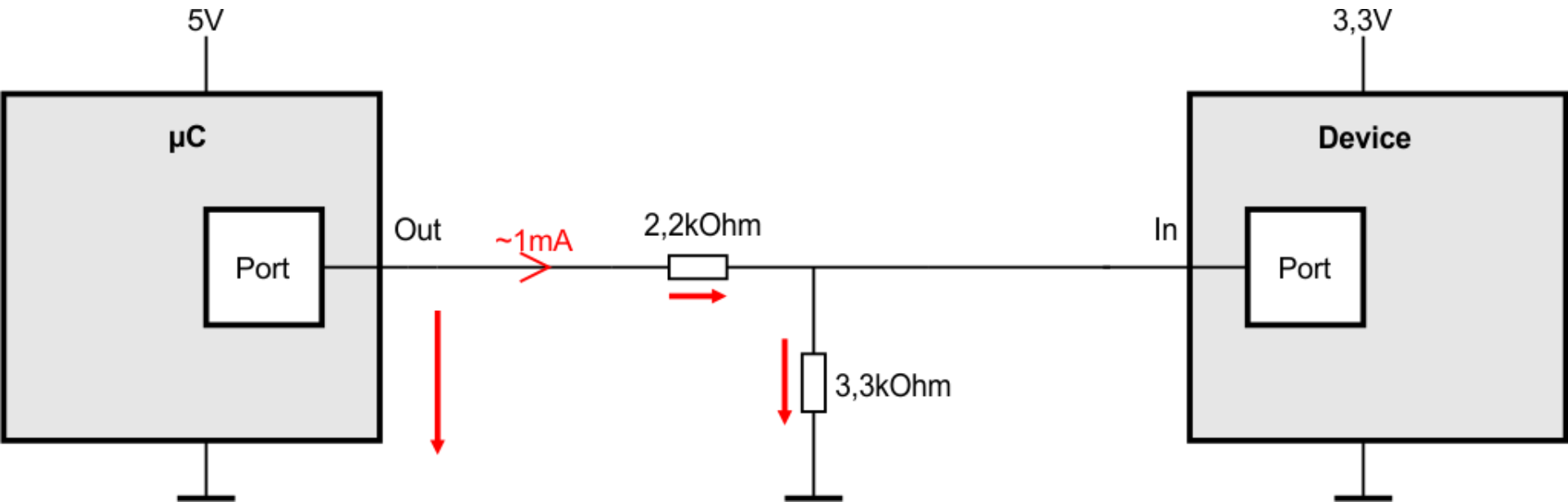
Lösung:



z.B. *STM32* μ C (einige Pins)
NXP Arm μ C

5V \rightarrow 3,3V

Lösung:



Wichtig bei Raspberry Pi!!!

3,3V → 5V

Problem: NeoPixel an 3,3V- μ C



WS2812B

Intelligent control LED
integrated light source

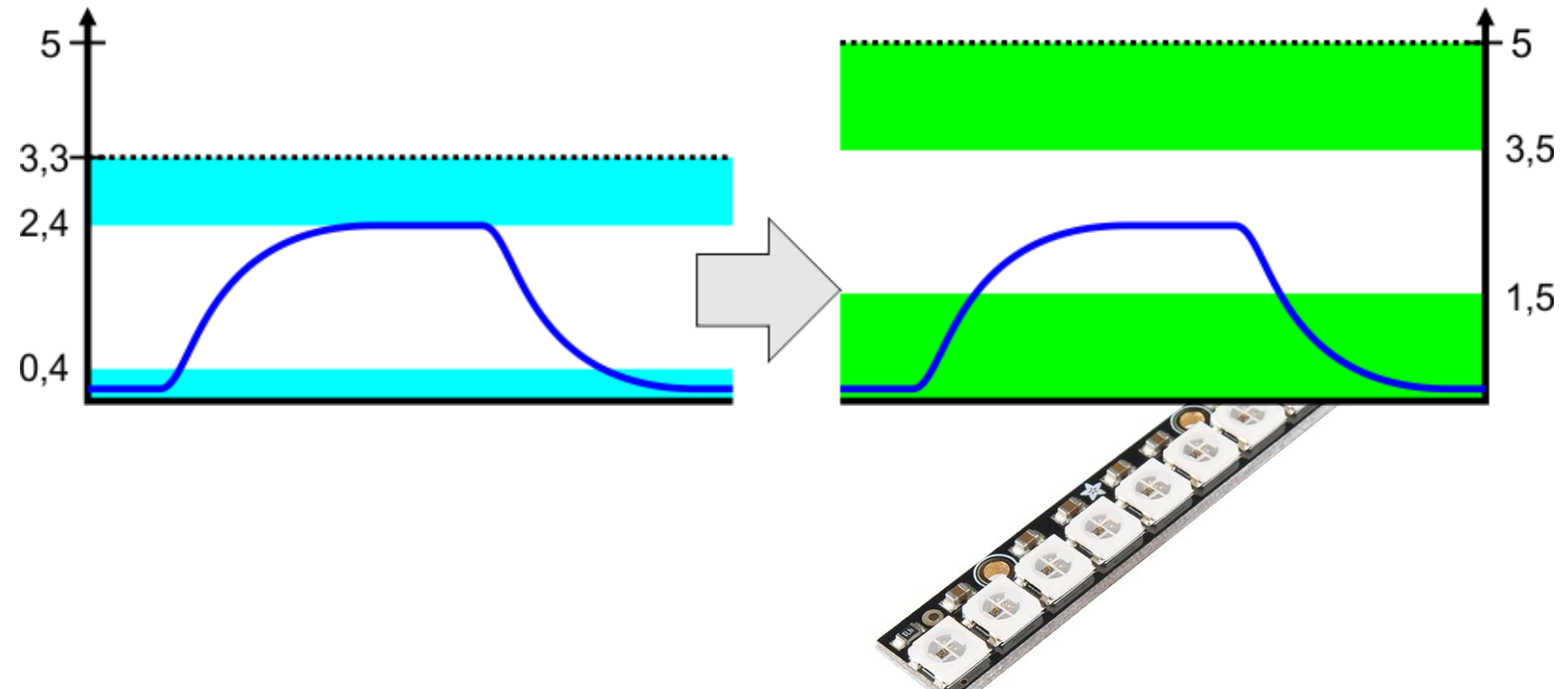
Parameter	Symbol	conditions	Min	Tpy	Max	Unit
Input current	I_I	$V_I = V_{DD}/V_{SS}$	—	—	± 1	μ A
Input voltage level	V_{IH}	D_{IN}, SET	$0.7V_{DD}$	—	—	V
	V_{IL}	D_{IN}, SET	—	—	$0.3 V_{DD}$	V
Hysteresis voltage	V_H	D_{IN}, SET	—	0.35	—	V

3,3V → 5V

Problem: NeoPixel an 3,3V- μ C

TTL 3,3V Out

Neopixel / WS2812

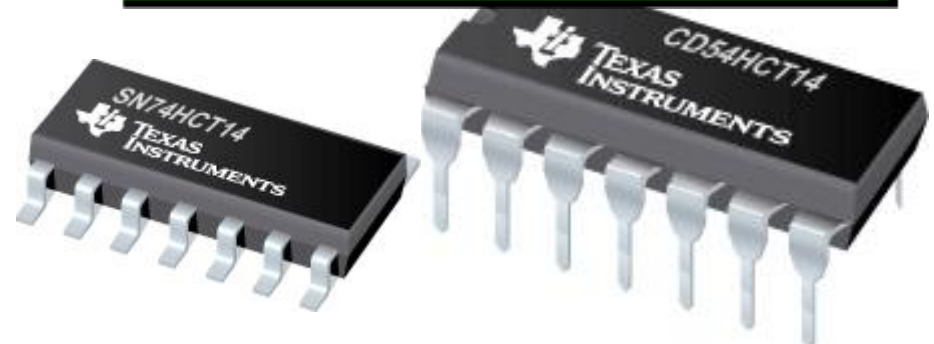
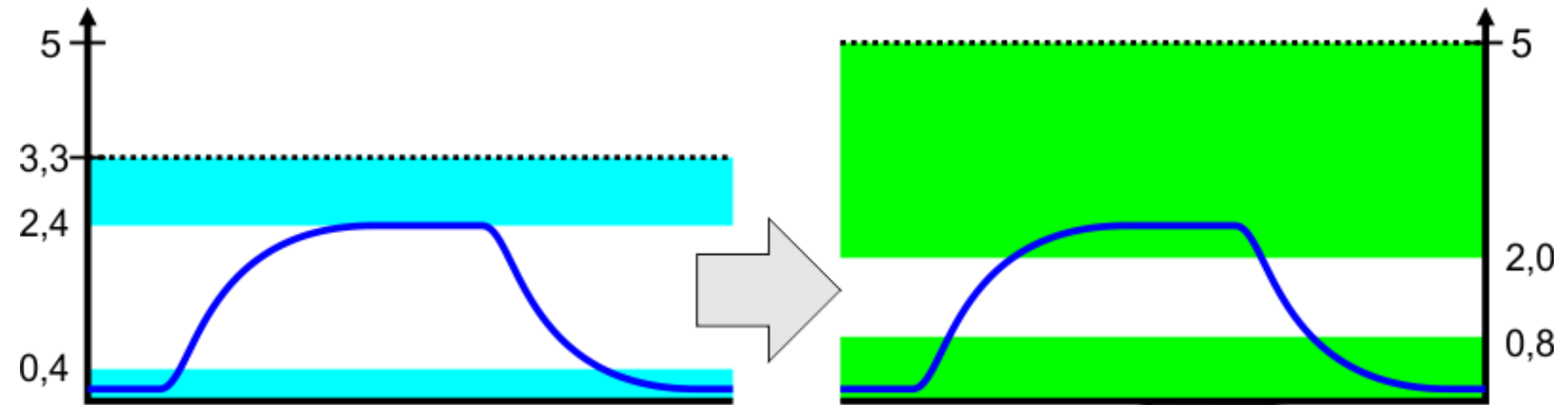


3,3V → 5V

Lösung:

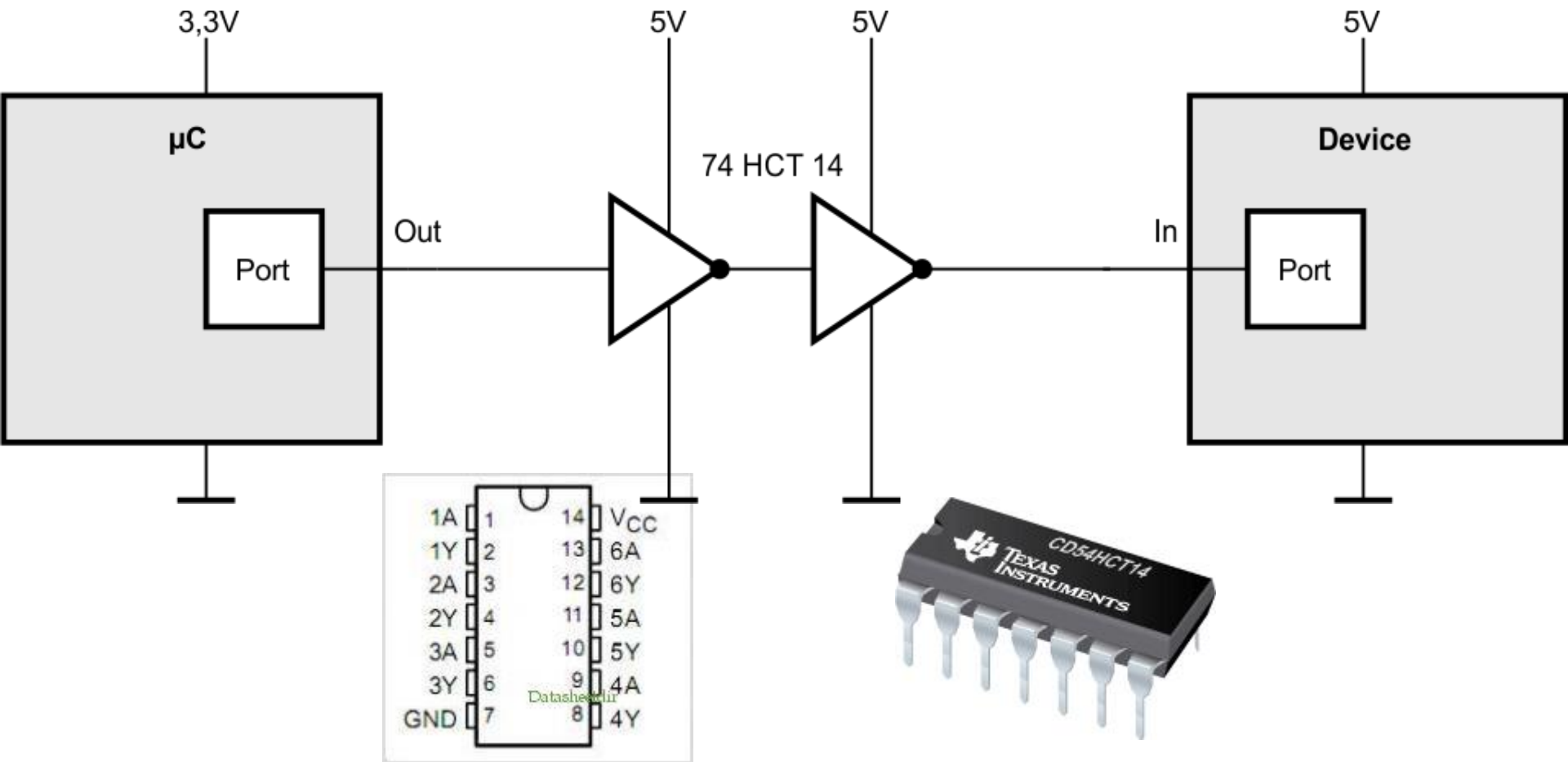
TTL 3,3V Out

74 HCT xxx



3,3V → 5V

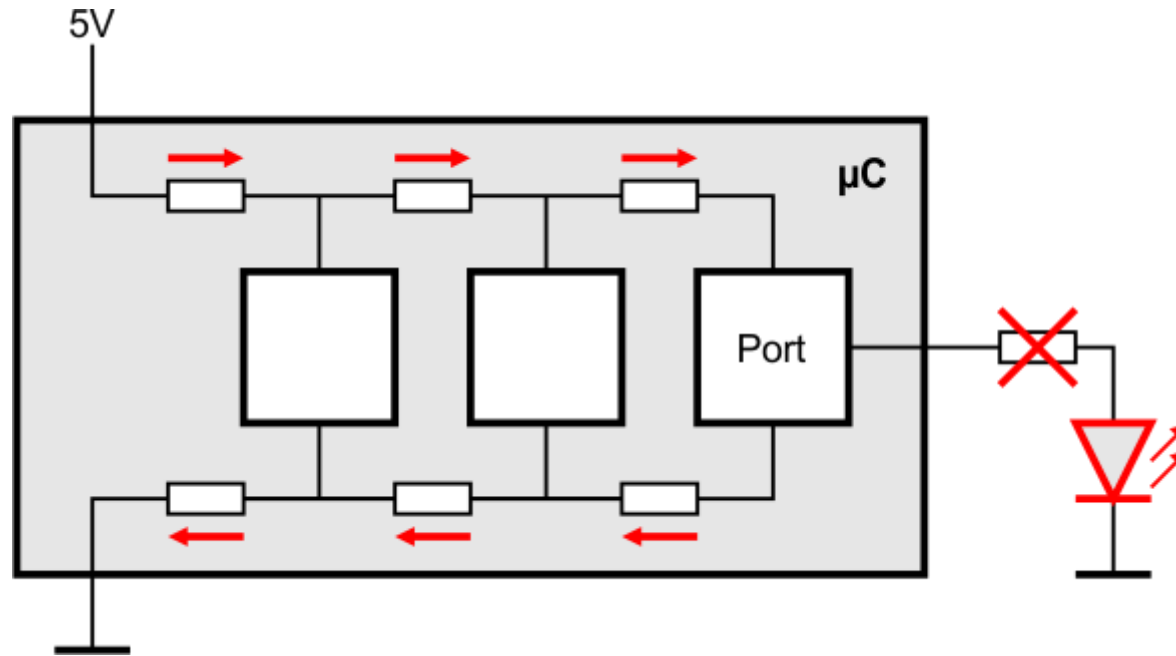
Lösung:



Strom

Strom

Problem: zu hoher Strom am Out



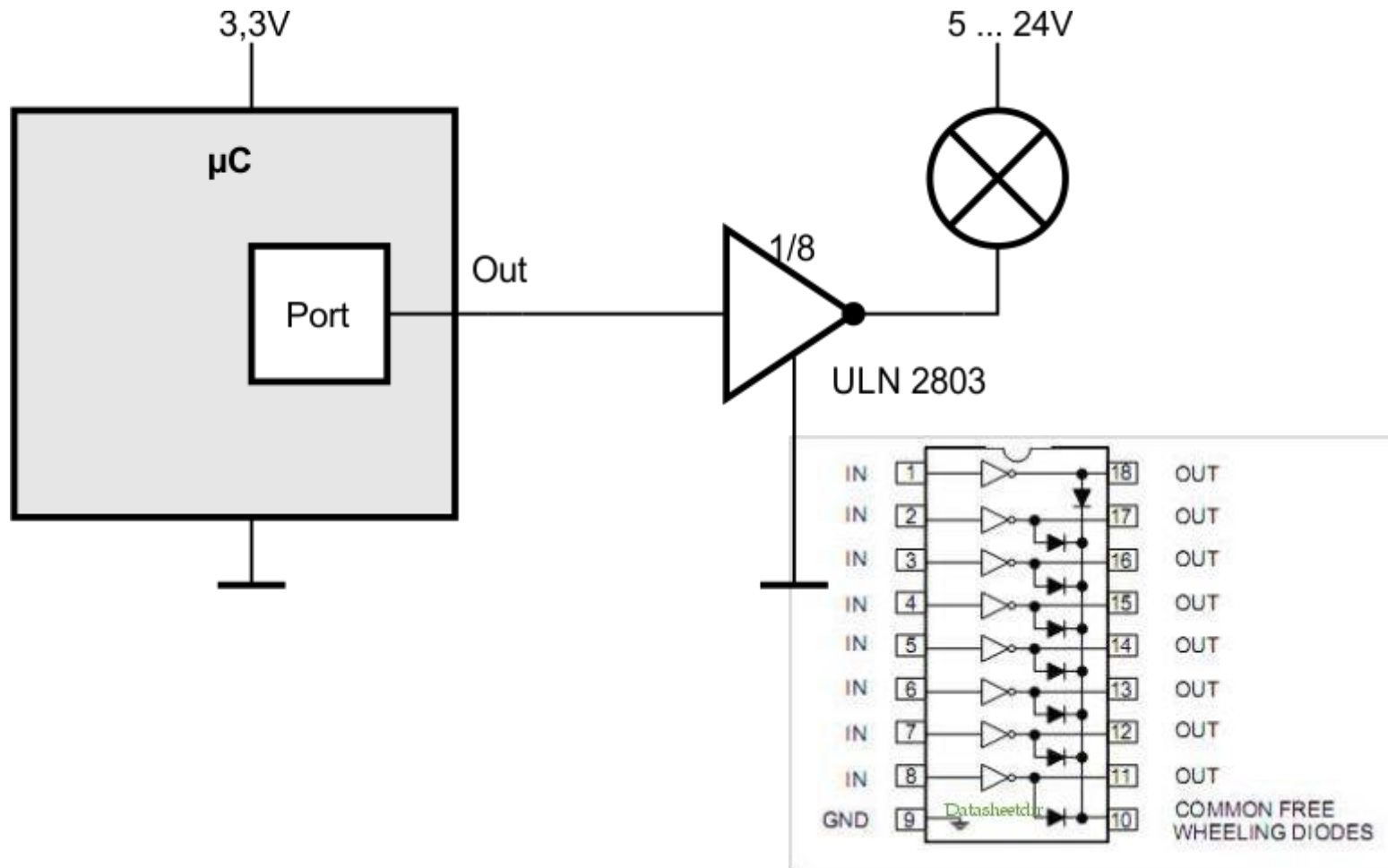
Strom

Max. Strom am Port:

Microcontroller	Strom je Port [mA]	Strom Summe [mA]
Raspberry Pi	2...16	50
ESP 8266	12	192
STM32 (CortexM3)	25	120
Arduino (AVR)	40	200

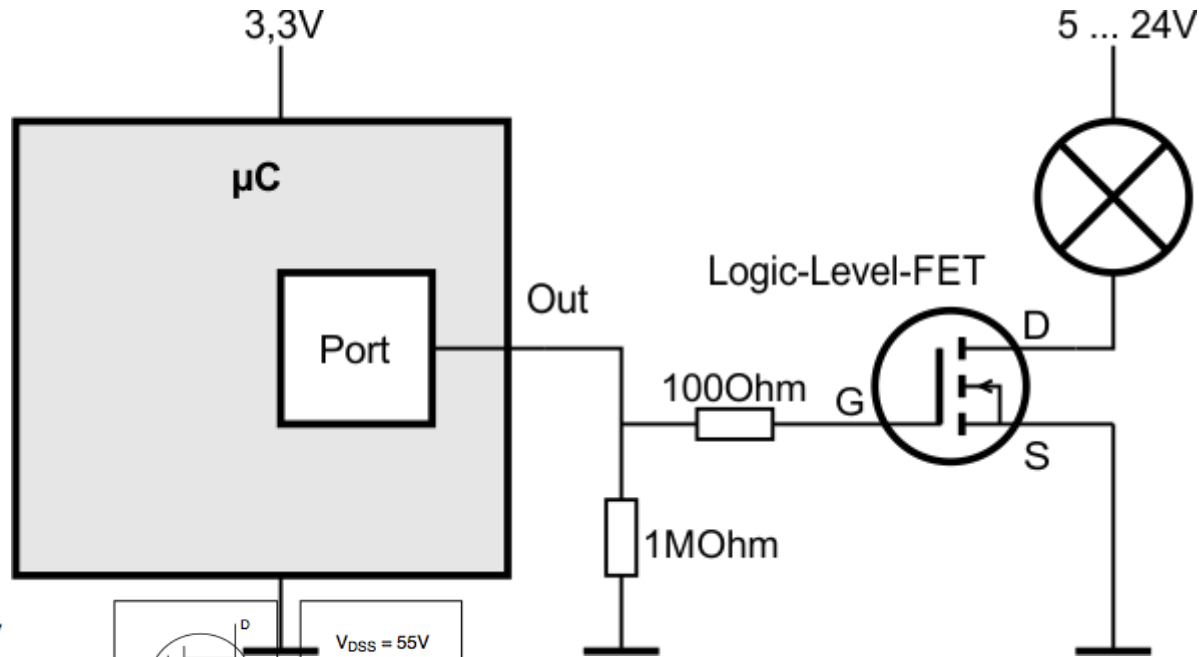
Strom

Lösung:



Strom

Lösung:

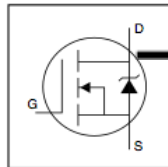


- Logic-Level Gate Drive
- Advanced Process Technology
- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching
- Fully Avalanche Rated

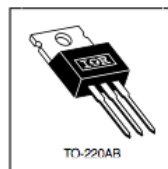
Description

Fifth Generation HEXFETs from International Rectifier utilize advanced processing techniques to achieve the lowest possible on-resistance per silicon area. This benefit, combined with the fast switching speed and ruggedized device design that HEXFET Power MOSFETs are well known for, provides the designer with an extremely efficient device for use in a wide variety of applications.

The TO-220 package is universally preferred for all commercial-industrial applications at power dissipation levels to approximately 50 watts. The low thermal resistance and low package cost of the TO-220 contribute to its wide acceptance throughout the industry.

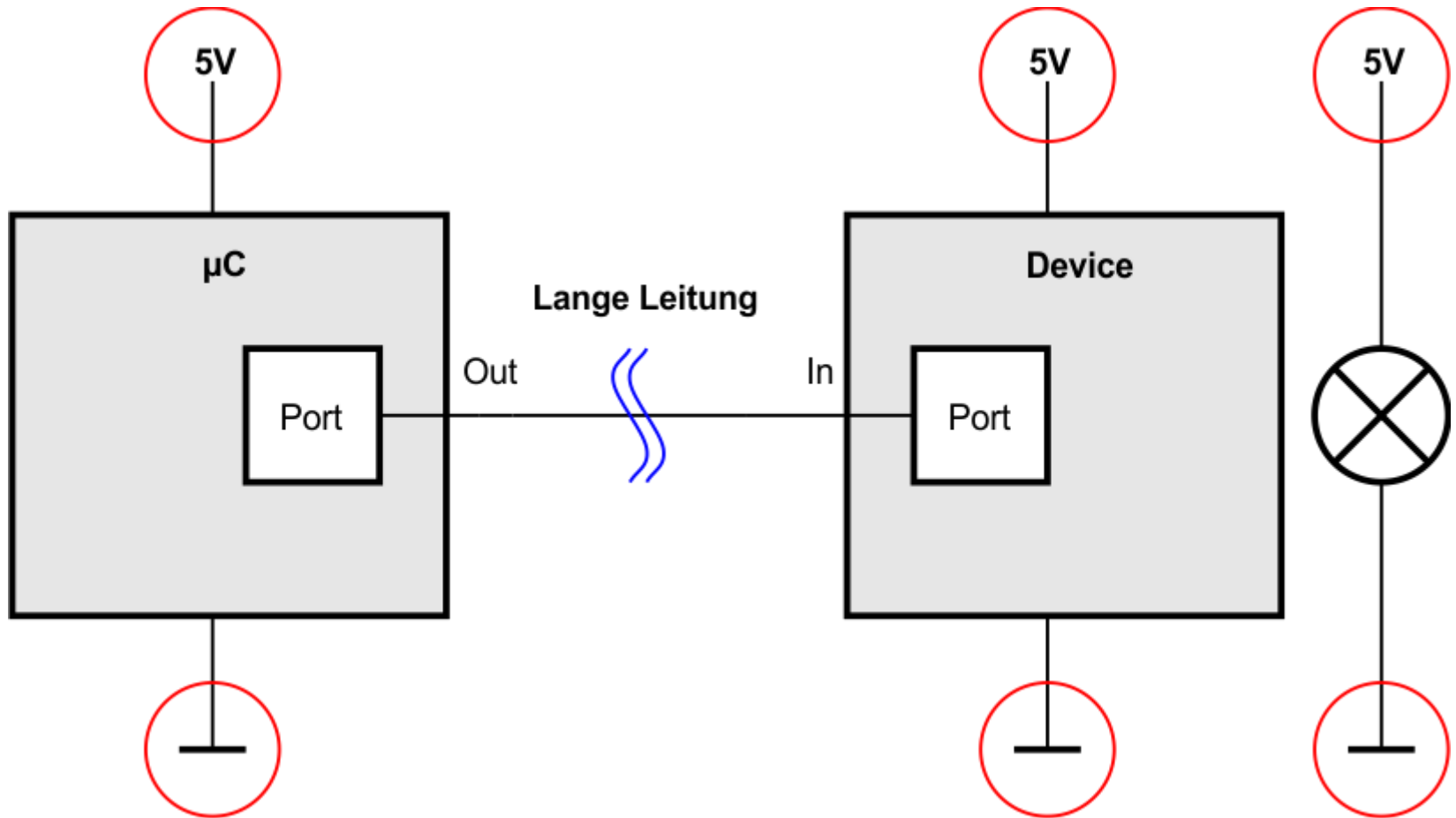


$V_{DSS} = 55V$
 $R_{DS(on)} = 0.035\Omega$
 $I_D = 30A$



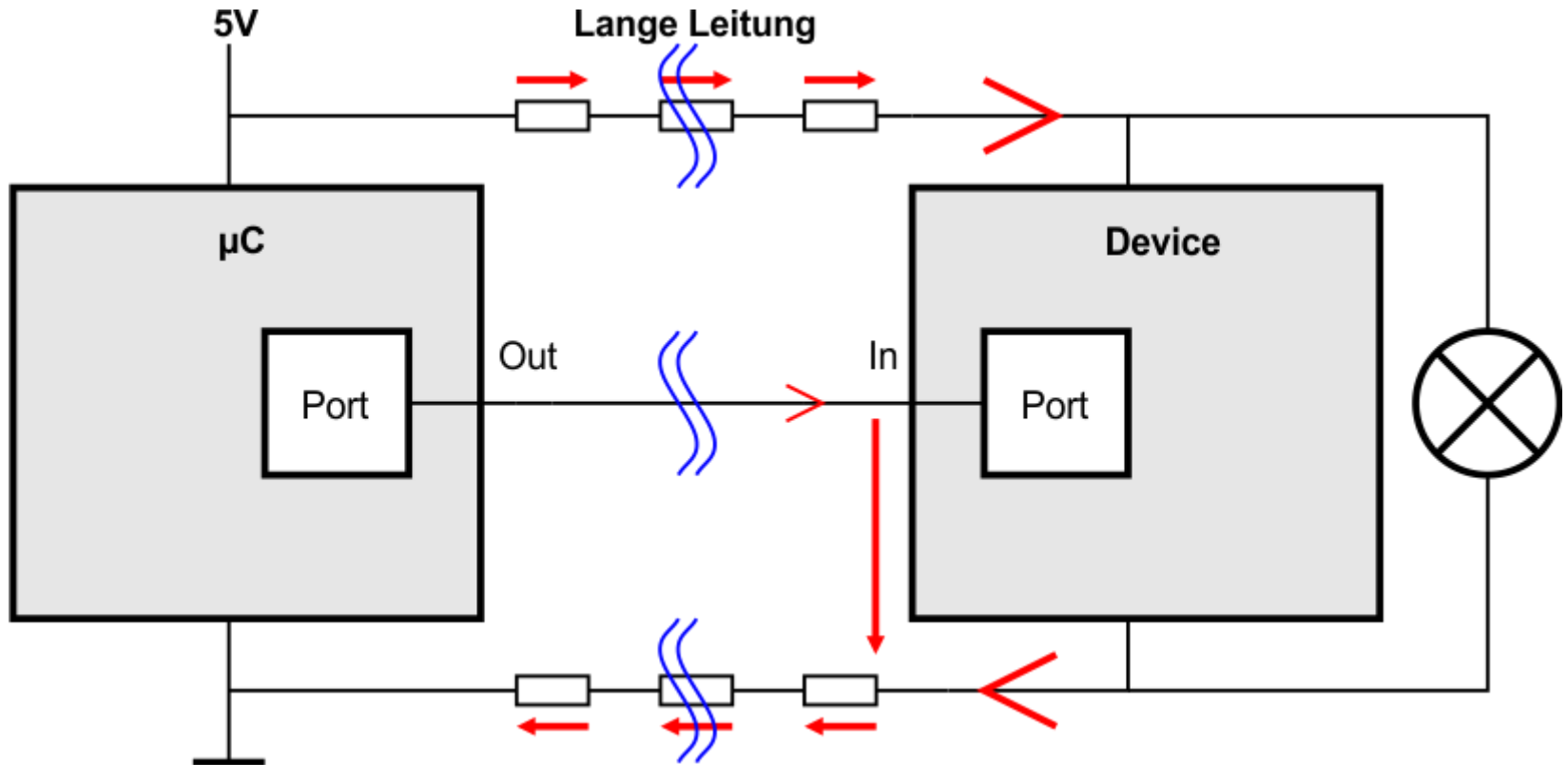
Ground (GND) Masse

GND



GND

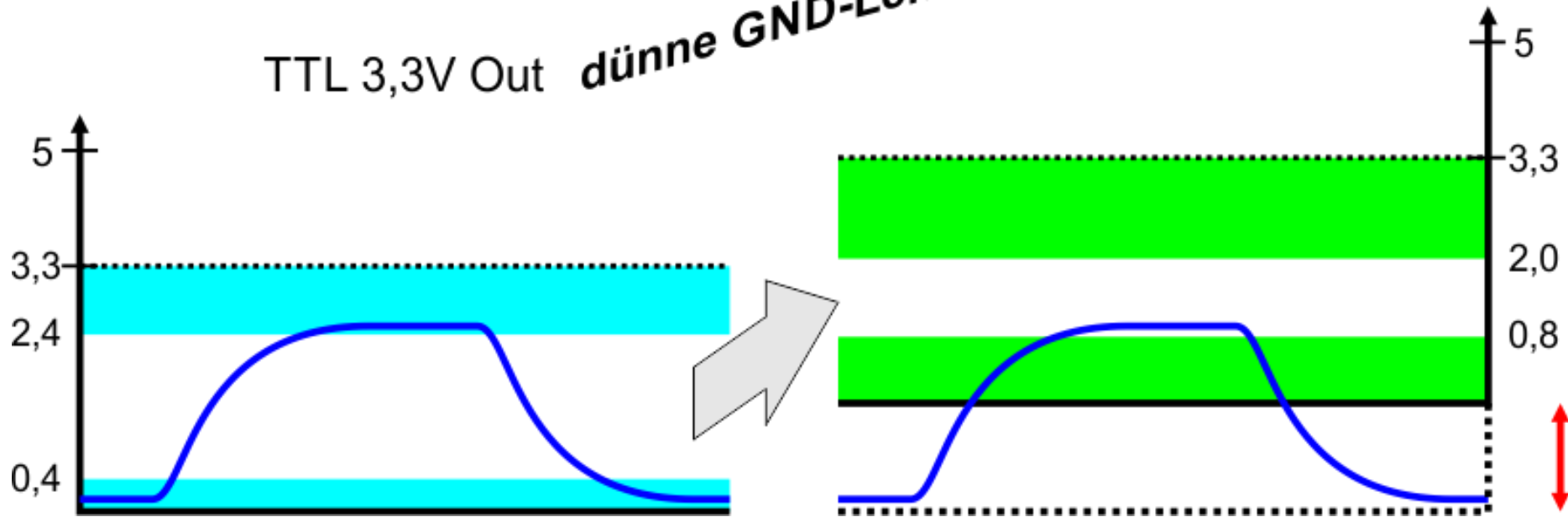
Problem:



GND

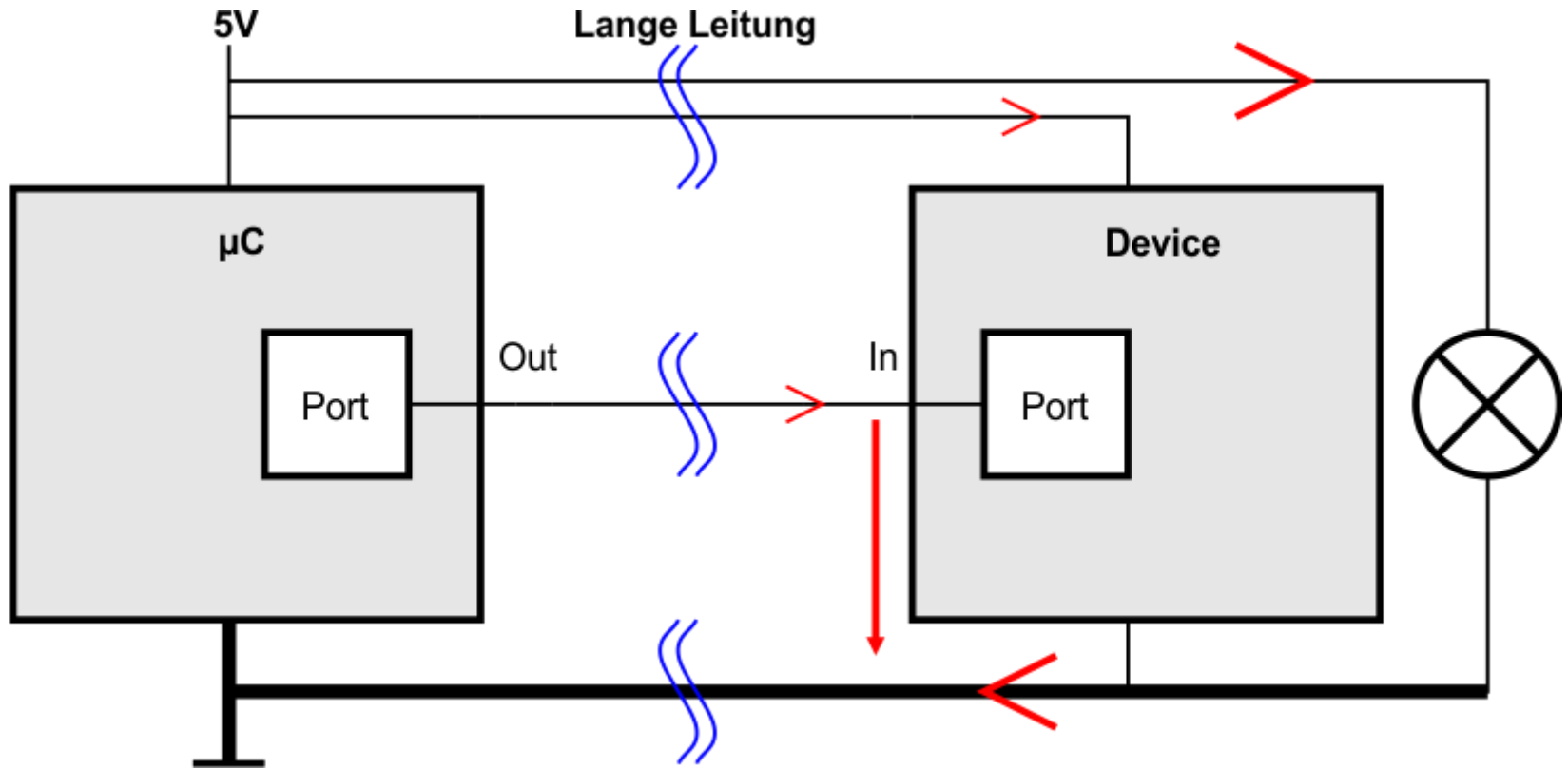
Problem:

TTL 3,3V Out dünne GND-Leitung TTL 3,3V In



GND

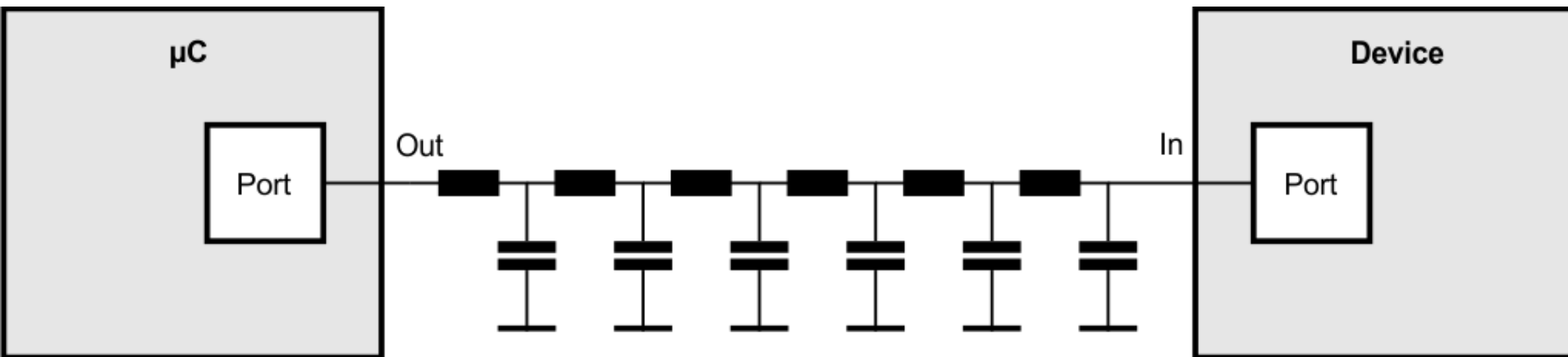
Lösung:



Lange Leitung

Lange Leitung

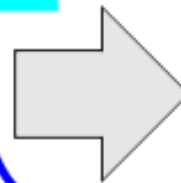
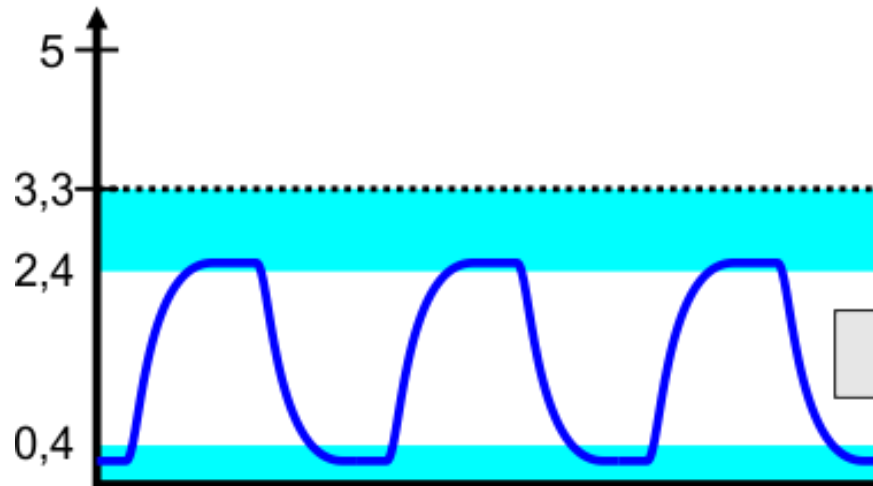
**Problem: schnelle Signale
über lange Leitung**



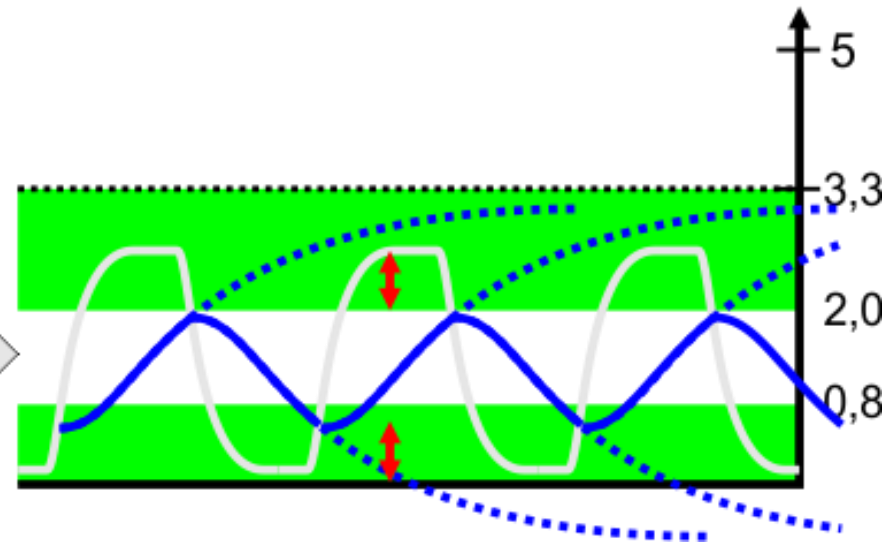
Lange Leitung

Problem:

TTL 3,3V Out



TTL 3,3V In



Lange Leitung

Lösung:

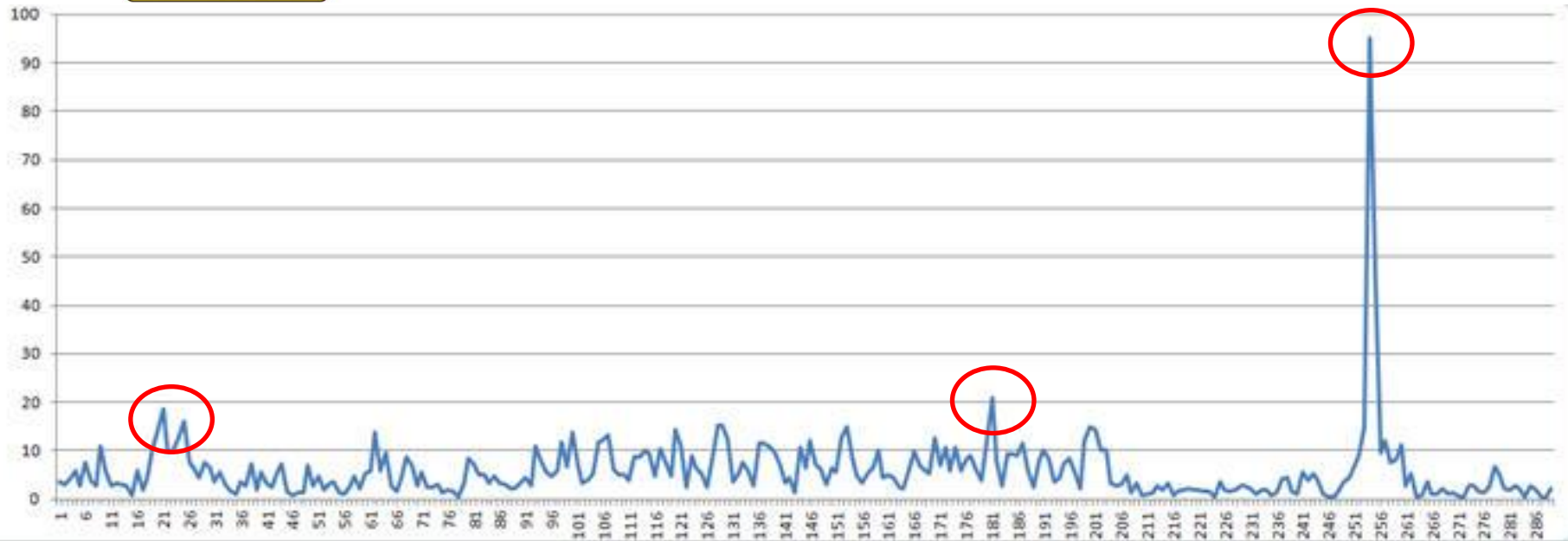
- **Kürzere Leitung**
- **Niedrigere Datenrate (Frequenz)**
- **Geeignetes Bussystem (! I²C, SPI)**
- **Geeignete Leitungstreiber**
 - **RS232 (10m)**
 - **RS422 / RS485 (1km)**
 - **CAN**

A large, stylized yellow lightning bolt with a red outline is positioned diagonally across the center of the slide. The text is overlaid on this graphic.

EMV

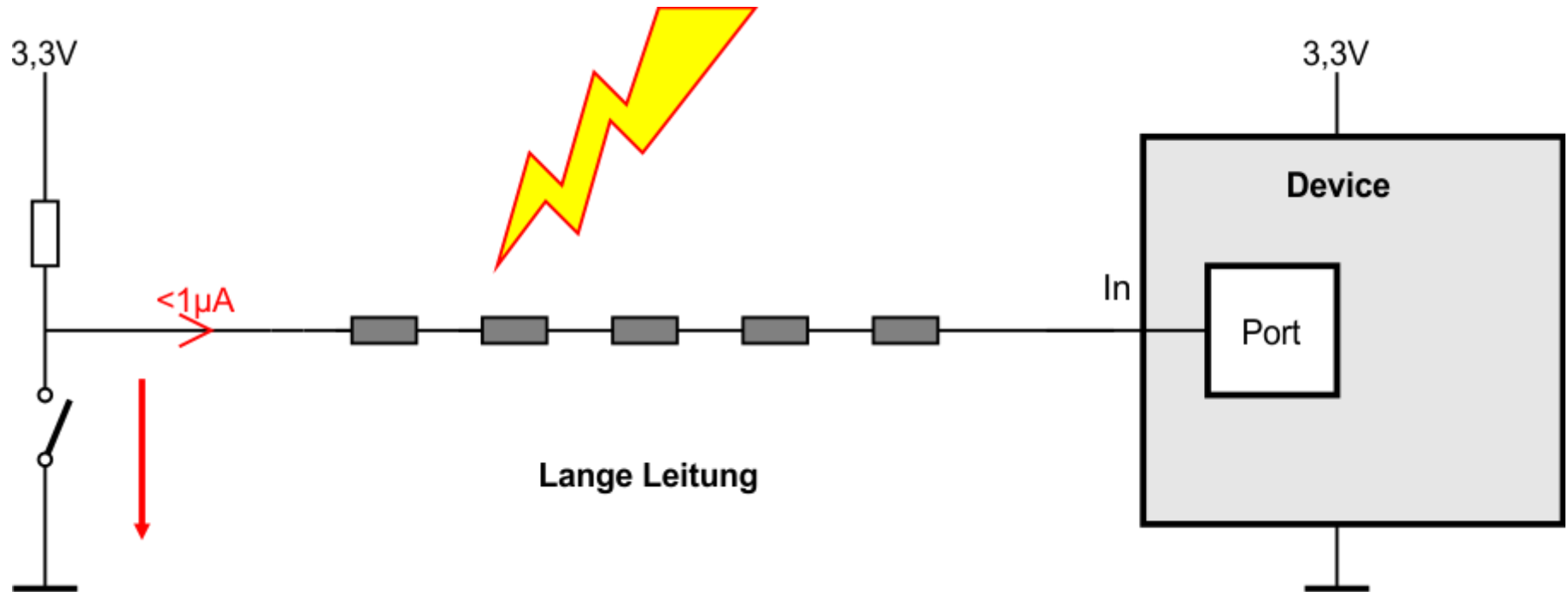
Elektromagnetische Verträglichkeit

EMV

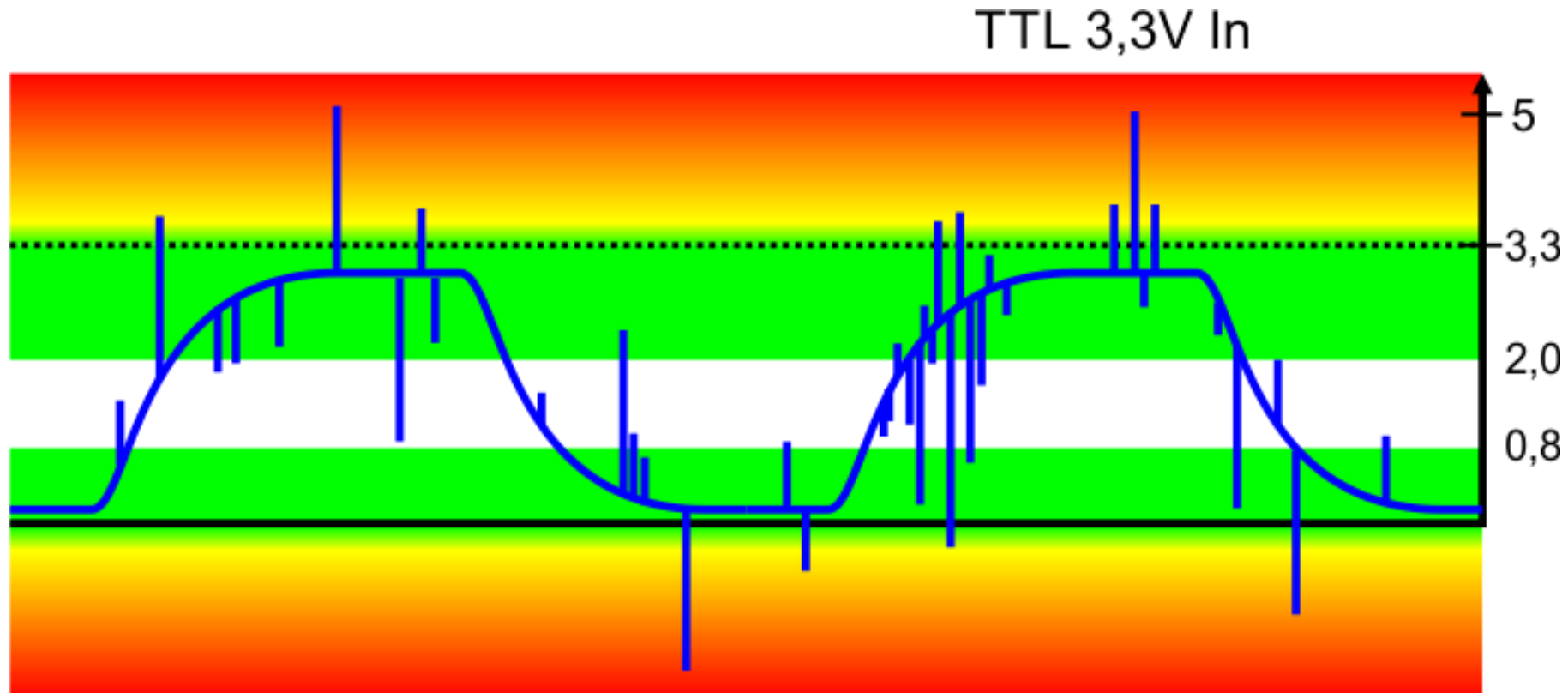


Eine Frage der Wahrscheinlichkeit

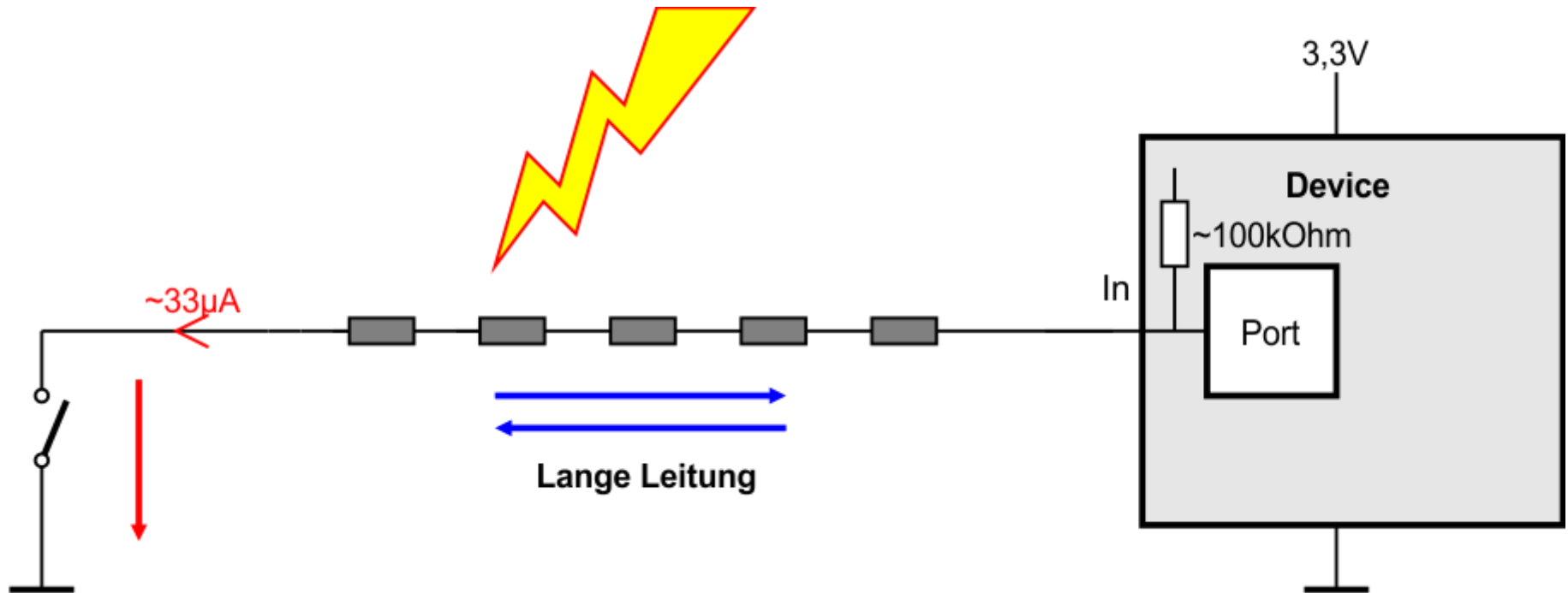
Problem:



Problem:

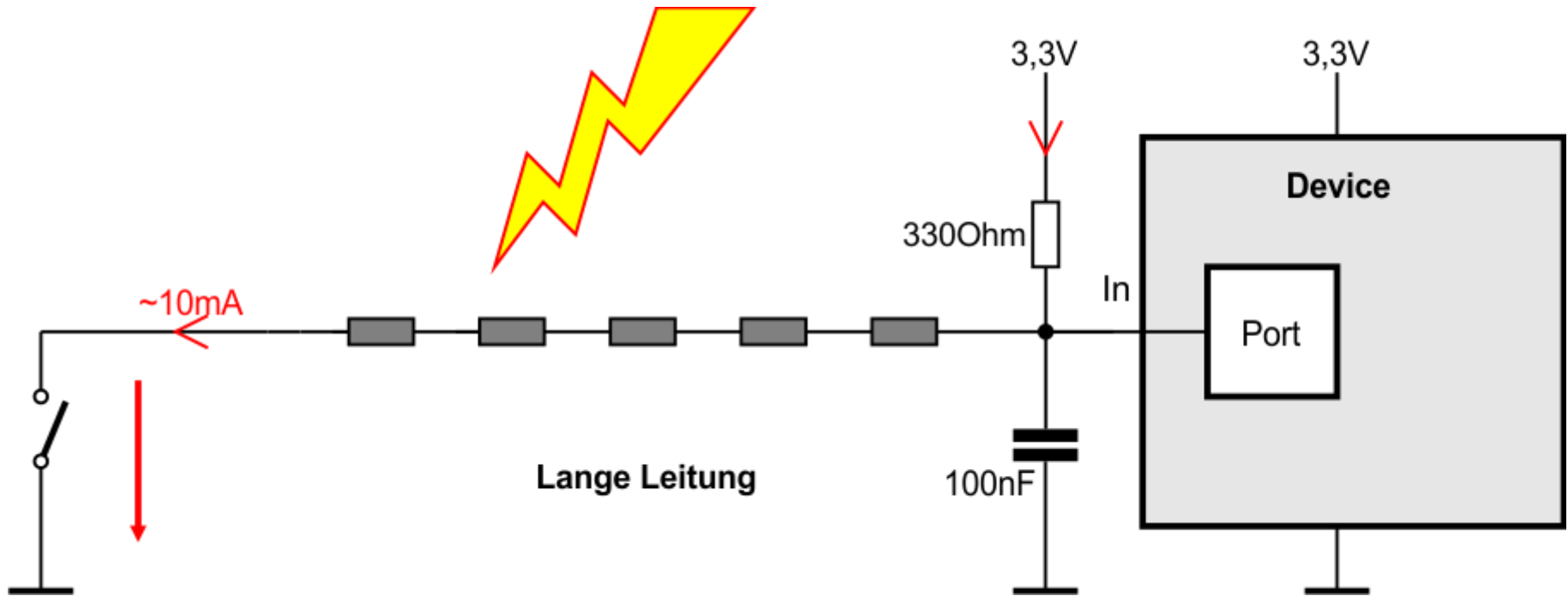


Lösung:



Interner PullUp-Widerstand

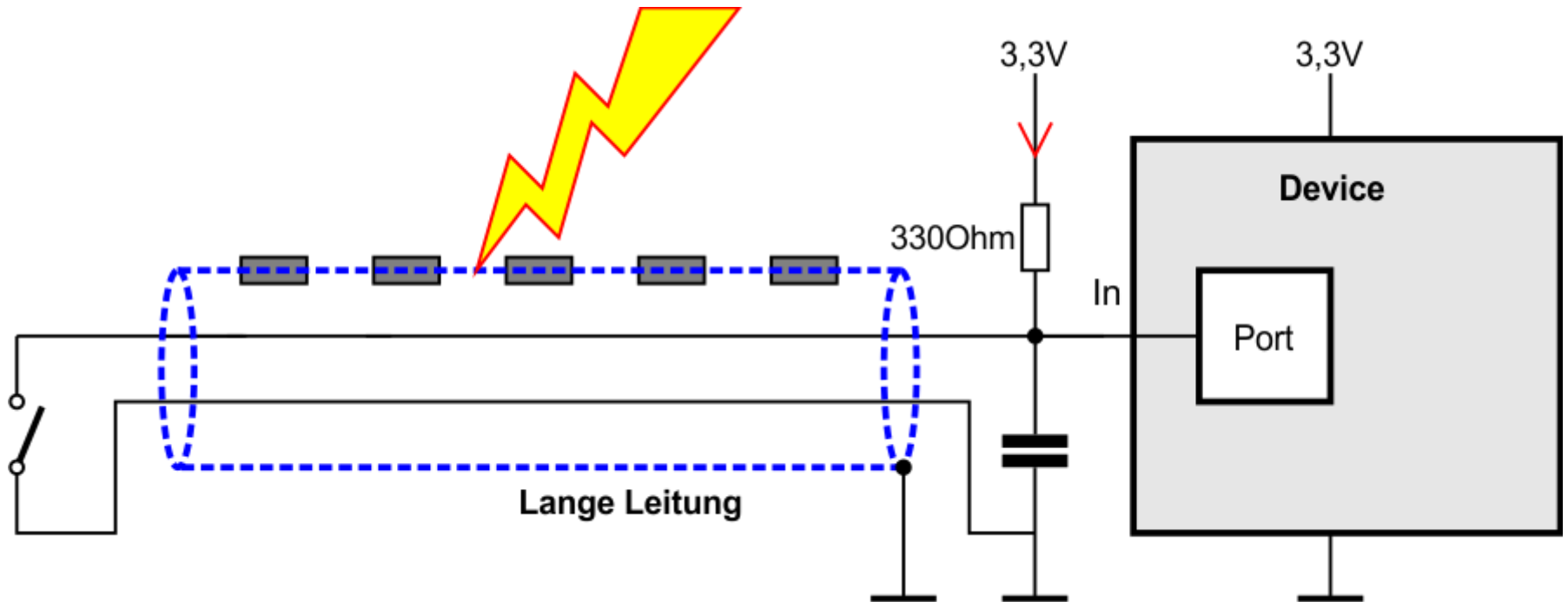
Lösung:



Strom-Schleife + Entstör-Kondensator

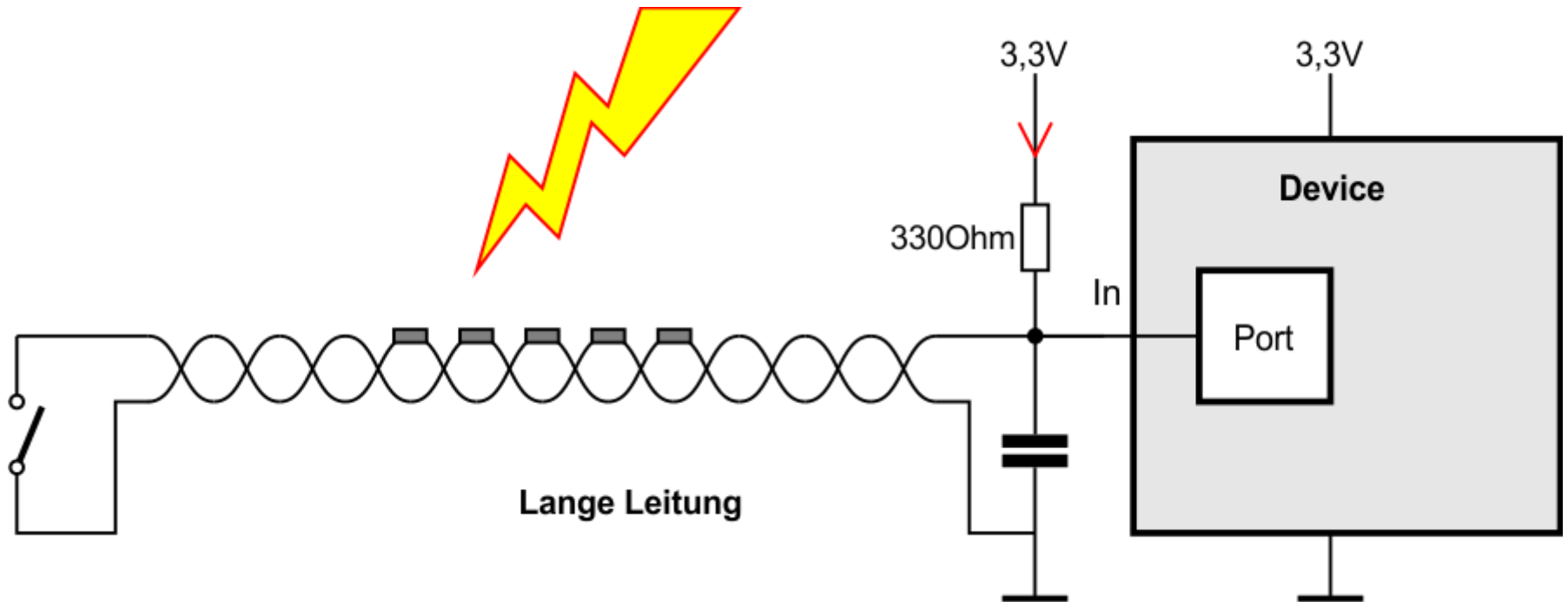
EMV

Lösung:



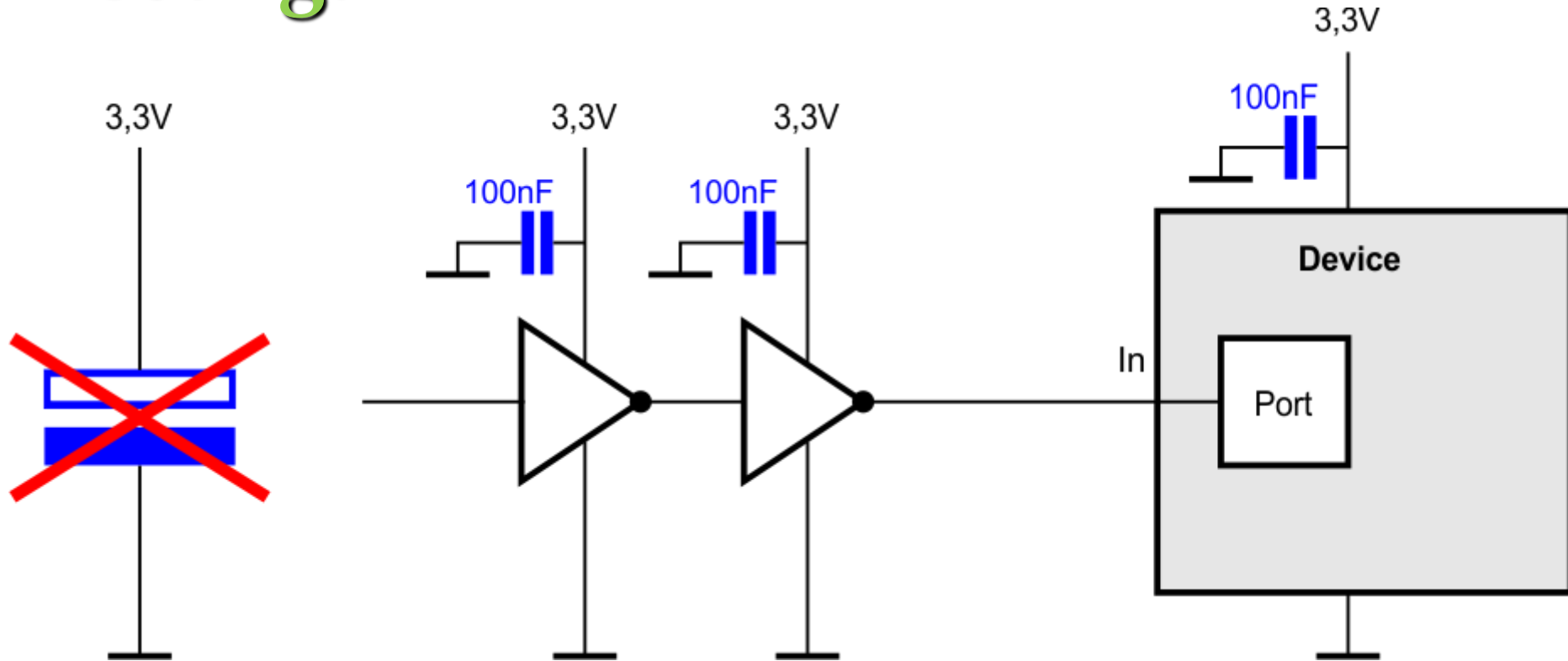
Geschirmte Leitung

Lösung:



Verdrillte Leitung

Lösung:



Keramische Block-Kondensatoren

Lösung: Software

```
/* returns change in encoder state (-1,0,1)*/  
int8_t read_encoder()  
{  
    static uint8_t old_AB = 0;  
    int8_t enc_states[] =  
        {0,-1,1,0,1,0,0,-1,-1,0,0,1,0,1,-1,0};  
  
    old_AB <<= 2;    //remember previous state  
    old_AB |= ( ENC_PORT & 0x03 ); //add state  
    return ( enc_states[ ( old_AB & 0x0f ) ] );  
}
```

Fragen?

Experten → FabLabs



<http://www.fablab-nuernberg.de/>

<https://fablab.fau.de/> (Erlangen)

<https://fablab-wuerzburg.de/>

<http://www.fablab-regensburg.de/>



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