THE SYMPHONY OF OSCILLATORS: HARMONIZING SIGNALS FOR SUCCESS

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AGENDA

- Introduction
- Types of Noises
  - Oscillator
  - Power Line
  - Output Line
- PCB Layout Recommendations

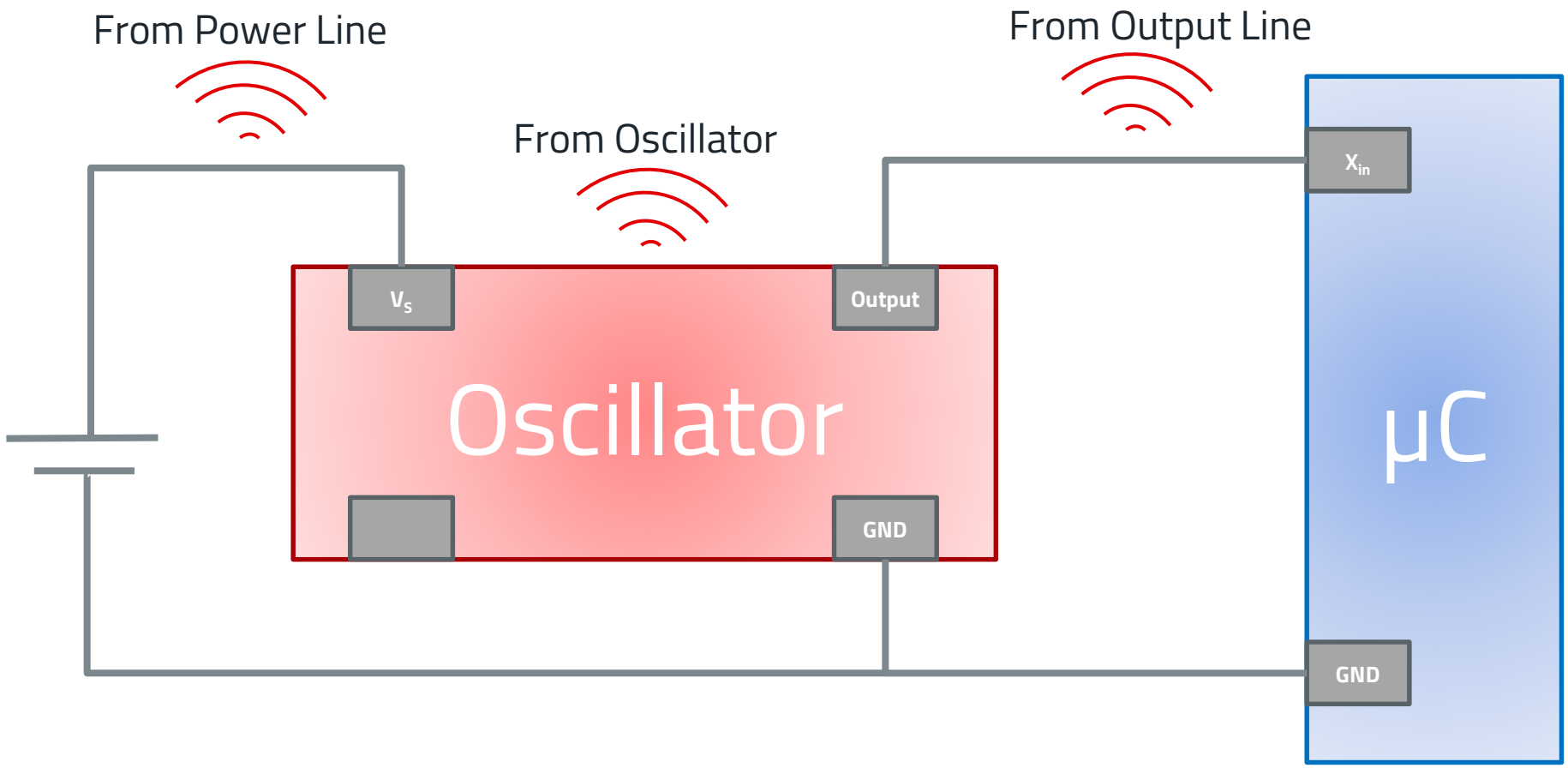
EMC & EMI

Introduction

- What is EMI and EMC?
  - Electromagnetic interference and electromagnetic compatibility
- In respect of oscillators?
  - Oscillators can both be effected by EMI but also generate EMI
- In general
  - Appropriate measures must be taken

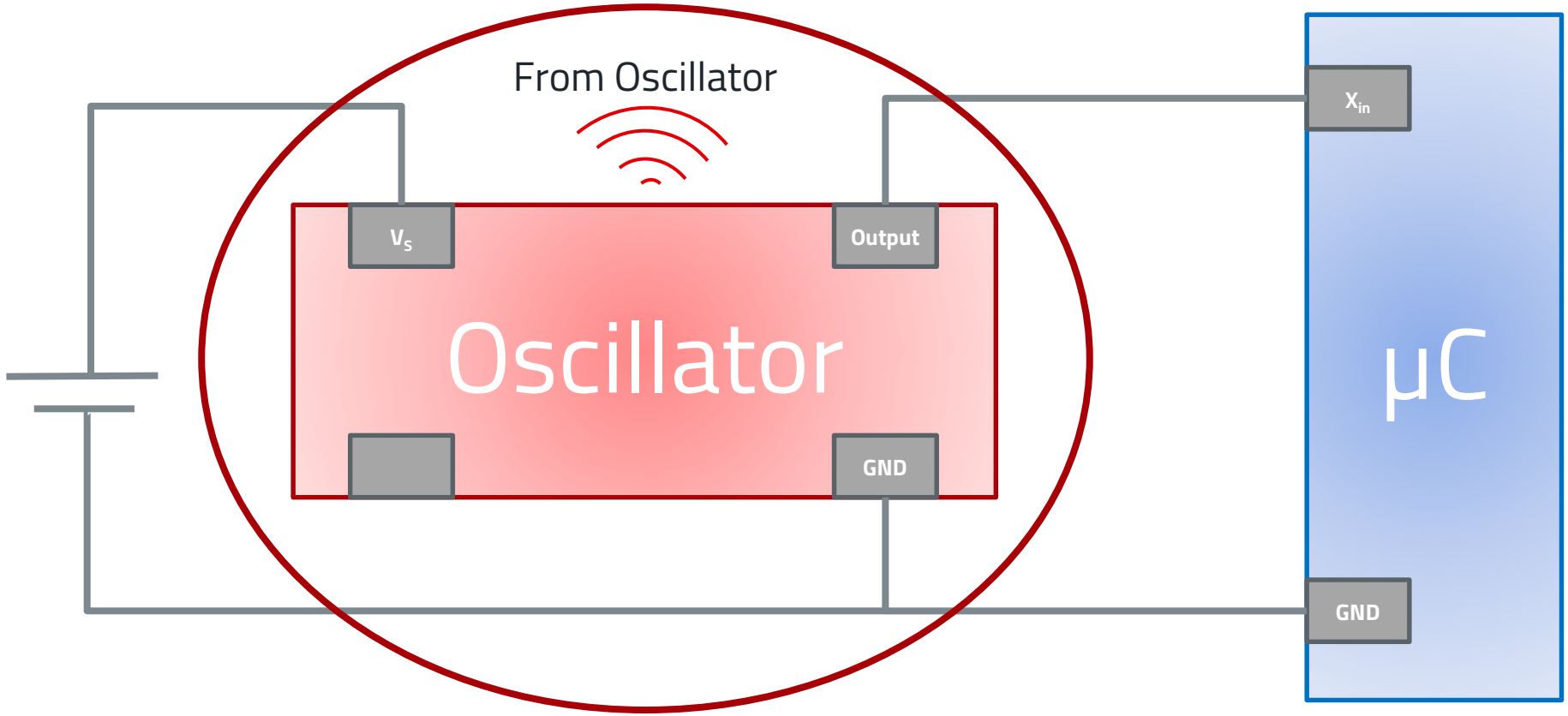
EMC & EMI

Type of Noises



EMC & EMI

Noise From Oscillator



NOISE FROM OSCILLATOR

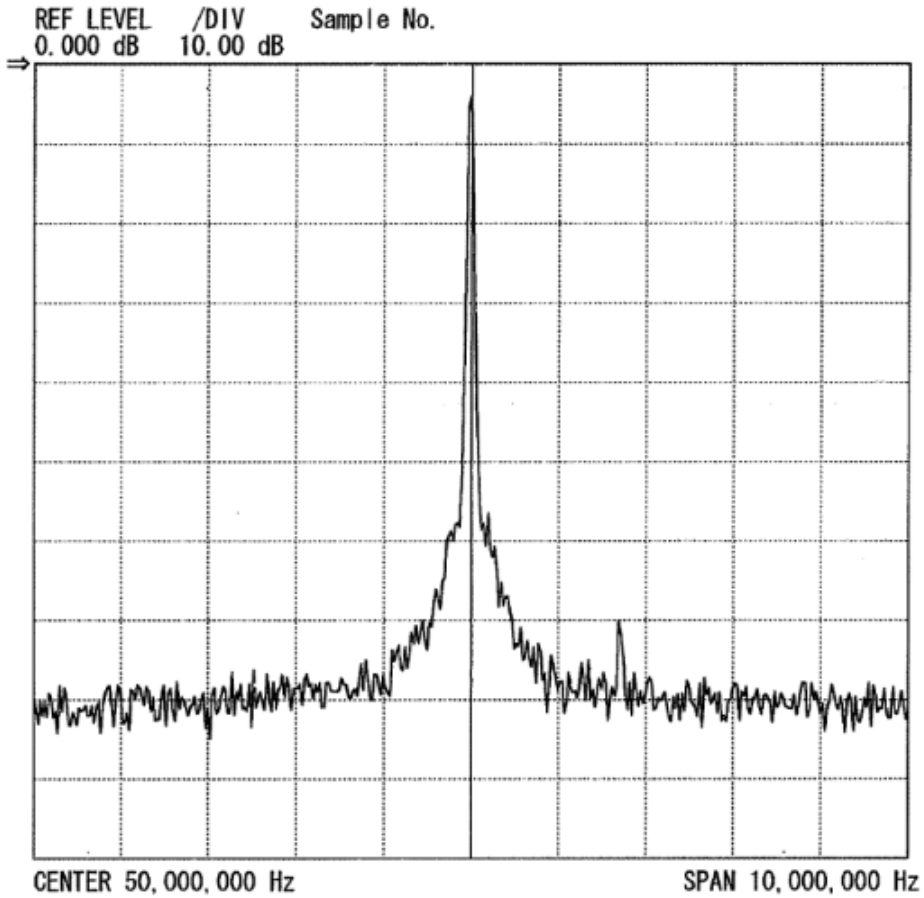
Choice of Specification Parameters

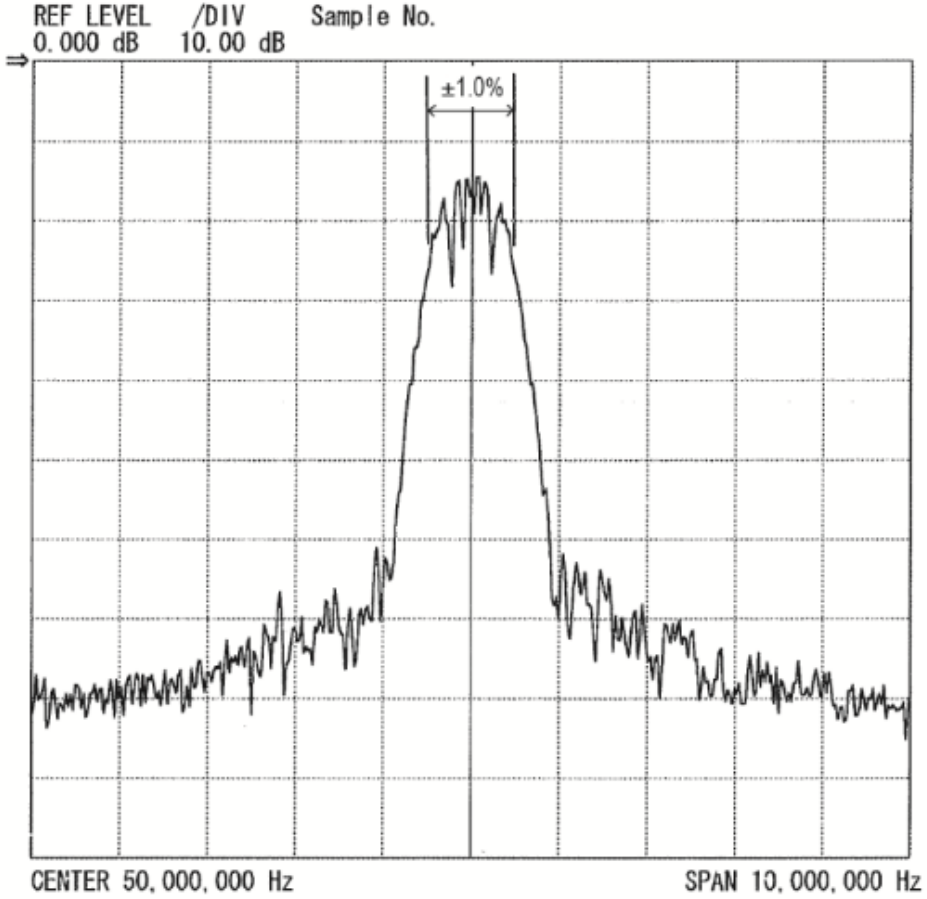
▪ Type of Oscillator	▪ OCXO: good; VCXO & TCXO: not so good; XO: good compromise
▪ Size	→ smaller is better
▪ Output Signal	▪ CMOS: worse; Sinewave: good but sensitive; Differential: good if designed properly
▪ Rise & Fall Time	→ take it slow
▪ Frequency	→ lower is better
▪ Supply Voltage	→ smaller is better

NOISE FROM OSCILLATOR

Spread Spectrum Oscillators

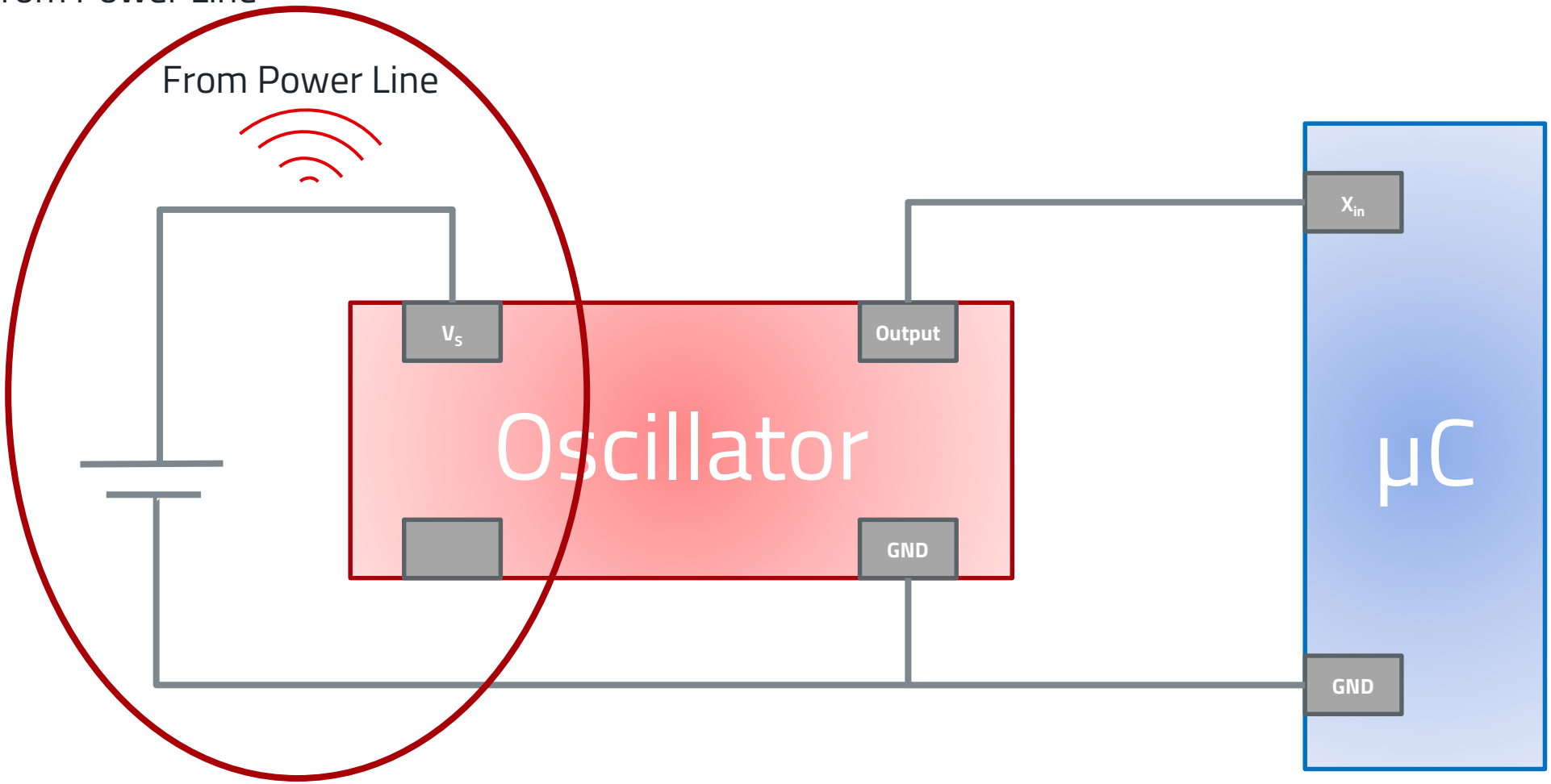
- Spectrum measurement of an CFSS-2 @ 50 MHz





EMC & EMI

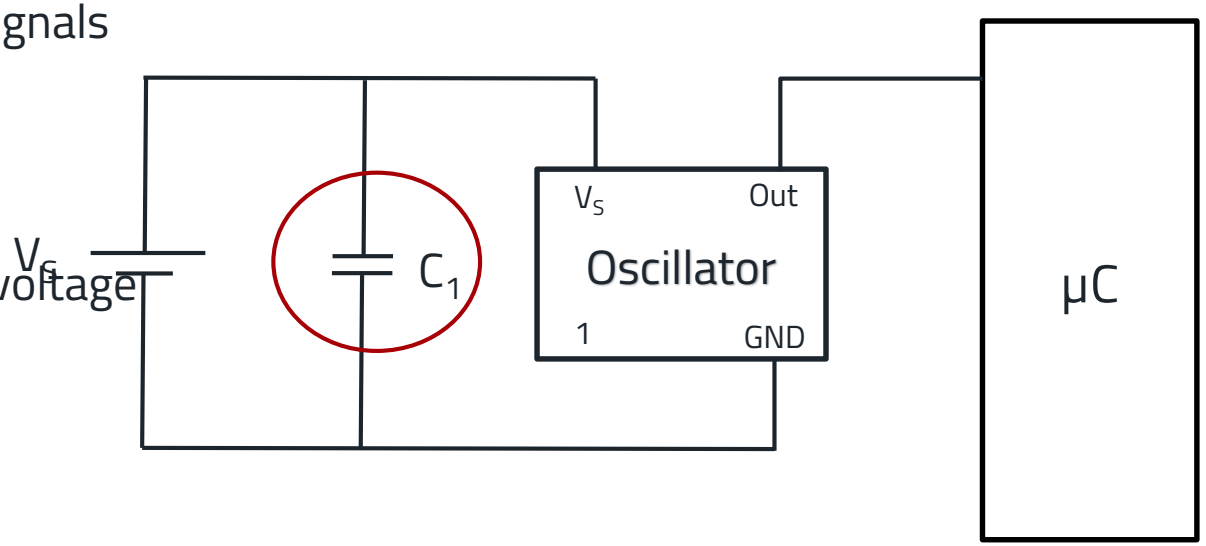
Noise From Power Line



NOISE FROM POWER LINE

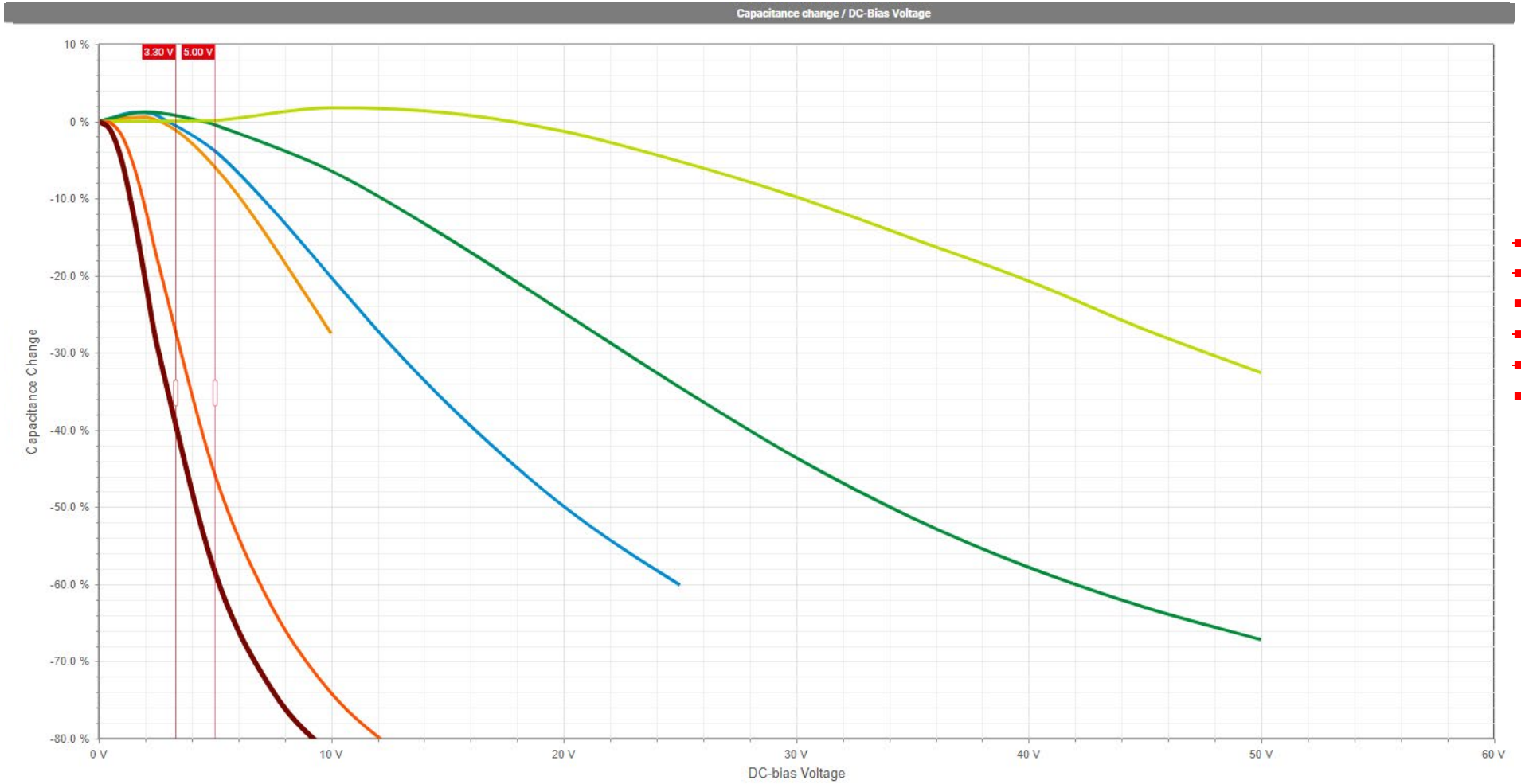
Decoupling Capacitor

- Minimum recommendation
- Isolates AC from DC signals
- Energy storage
- Ensure stable supply voltage
- Filter



NOISE FROM POWER LINE

Decoupling Capacitor



- ~~X7R // 0201 // 10 nF // 10.0 V~~
- ~~X7R // 0201 // 10 nF // 25.0 V~~
- X7R // 0603 // 10 nF // 50.0 V
- ~~X5R // 0201 // 100 nF // 10.0 V~~
- ~~X5R // 0201 // 100 nF // 25.0 V~~
- X7R // 0603 // 100 nF // 50.0 V

NOISE FROM POWER LINE

Decoupling Capacitor

- X7R // 0201 // 10 nF // 10.0 V
- X7R // 0201 // 10 nF // 25.0 V
- X7R // 0603 // 10 nF // 50.0 V
- ~~X5R // 0201 // 100 nF // 10.0 V~~
- ~~X5R // 0201 // 100 nF // 25.0 V~~
- ~~X7R // 0603 // 100 nF // 50.0 V~~

NOISE FROM POWER LINE

Filtering

- Low pass filter
- Theoretically 20 dB/decade attenuation per filter component
- Ideally filter up to ~10^{th} harmonic
- Various filter topologies
  - CL - Filter
  - Π - Filter

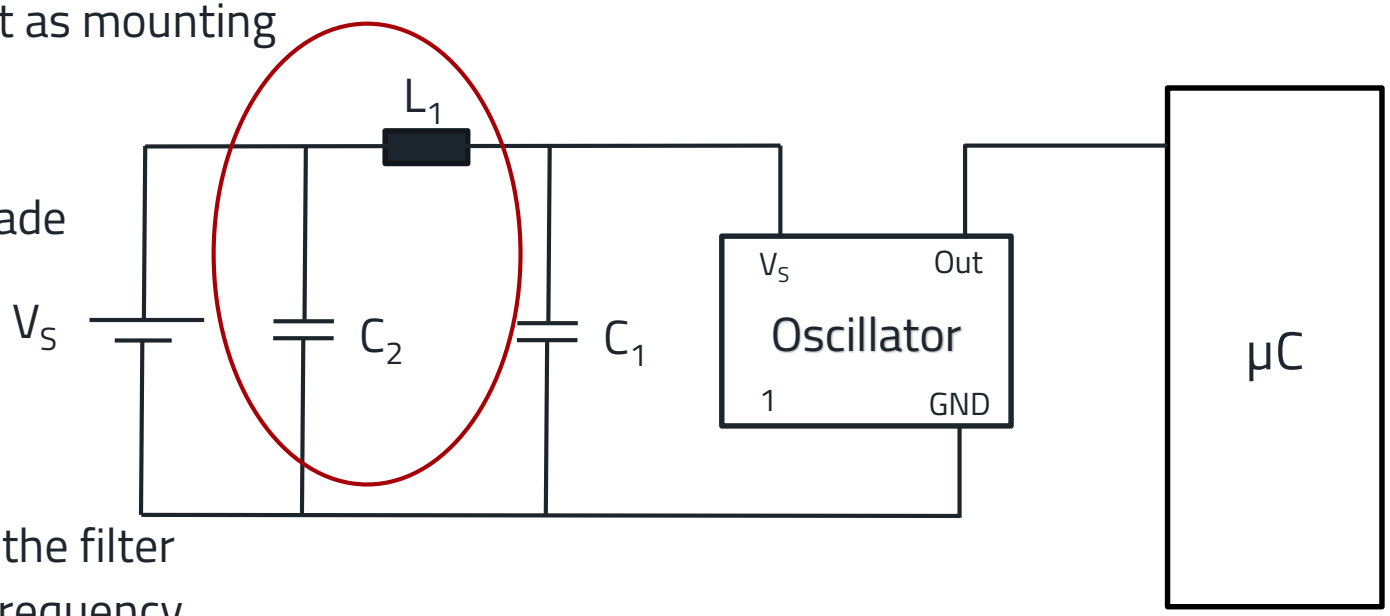
NOISE FROM POWER LINE

CL - Filter

- Recommended to add at least as mounting option
- Adds theoretically 40 dB/decade

$$f_r = \frac{1}{2\pi\sqrt{L*C}}$$

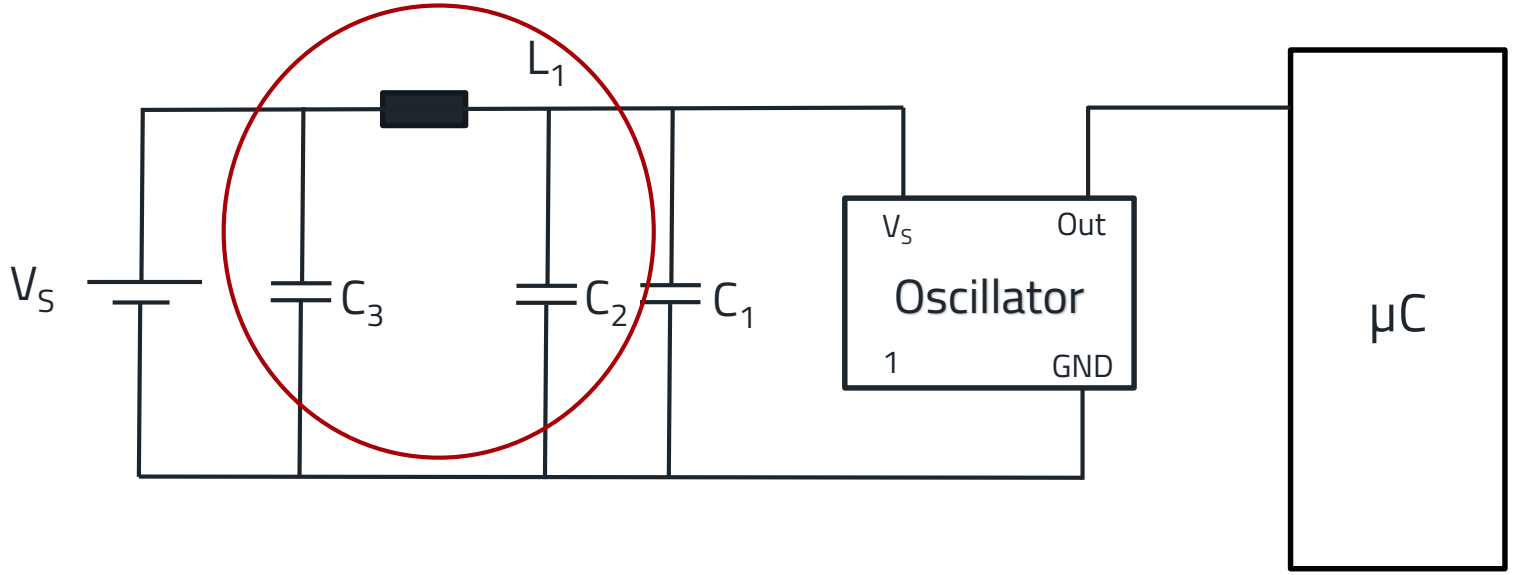
- f_r = resonance frequency of the filter should be 1/10 of oscillator frequency



NOISE FROM POWER LINE

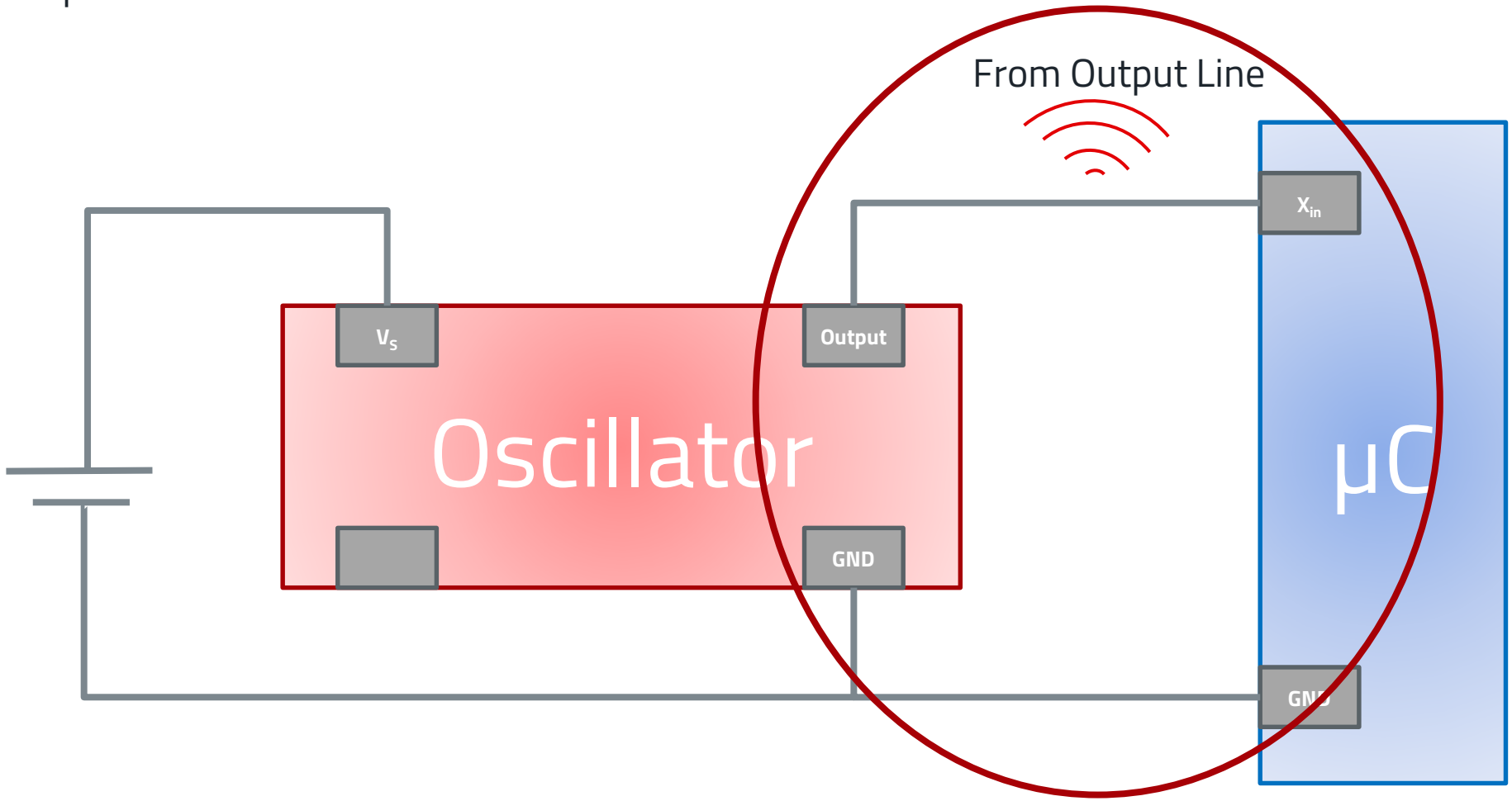
Π - Filter

- Theoretically adds 60 dB/decade



EMC & EMI

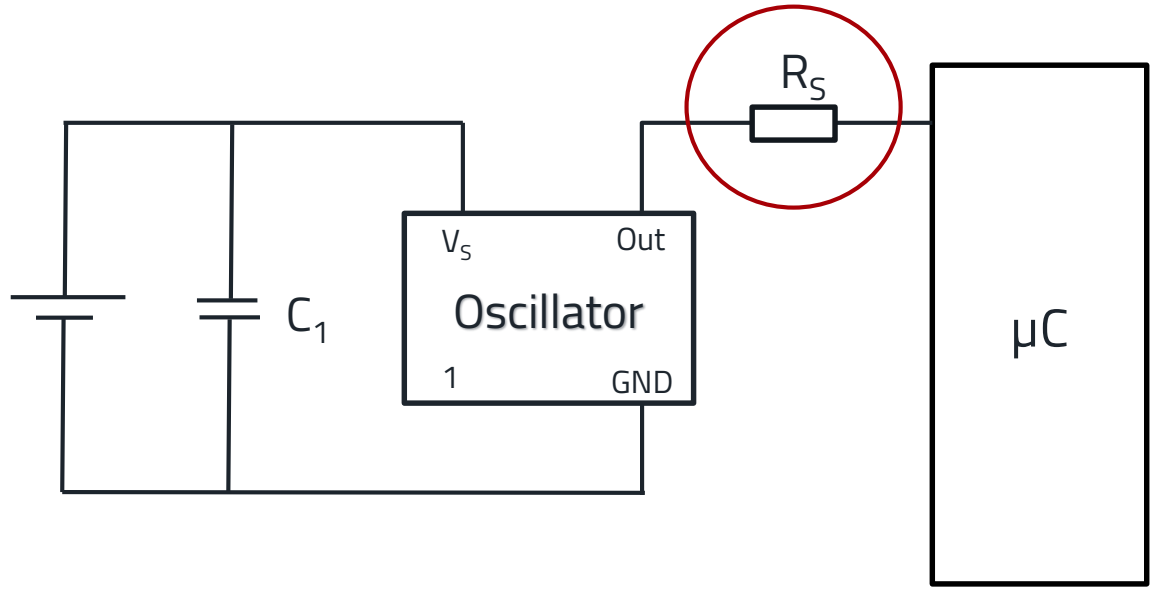
Noise From Output Line



NOISE FROM OUTPUT LINE

Serial Resistance

- In line between oscillator & µC
- Recommended to be added as mounting option / equipped with 0 Ω
- Eliminate undesired waveform distortions
- Test for ideal value



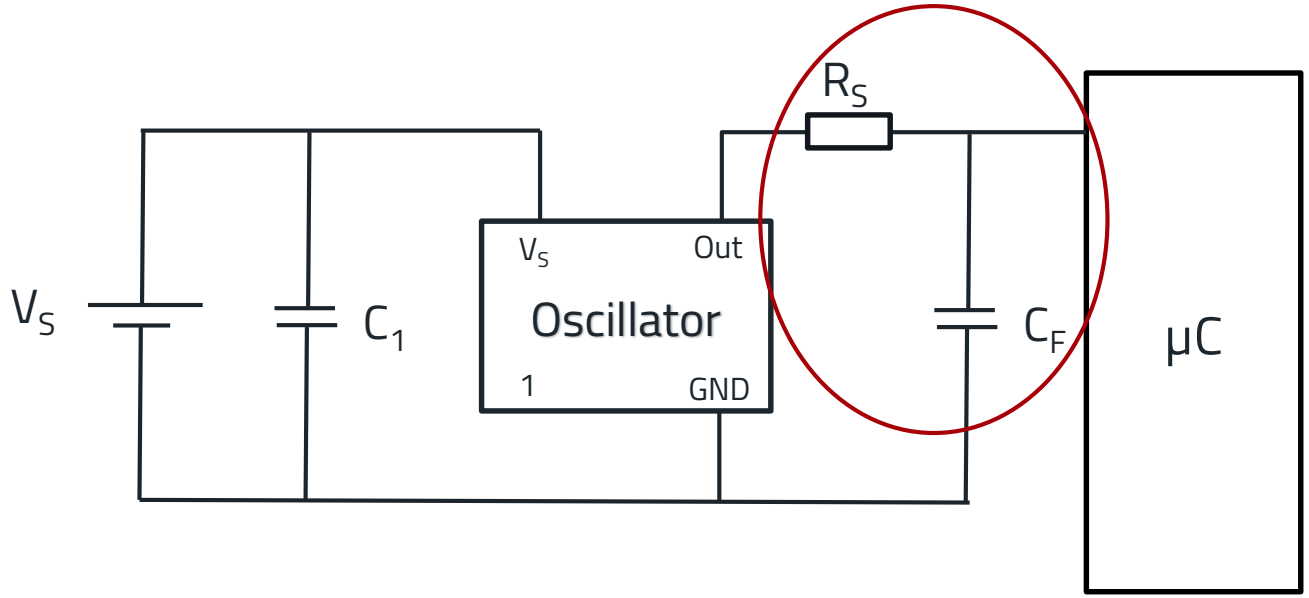
NOISE FROM OUTPUT LINE

RC - Filter

- Recommended to be added as mounting option
- ~20 dB attenuation
- Cutoff frequency higher than oscillator frequency

$$f_C = \frac{1}{(2\pi R_S C_F)}$$

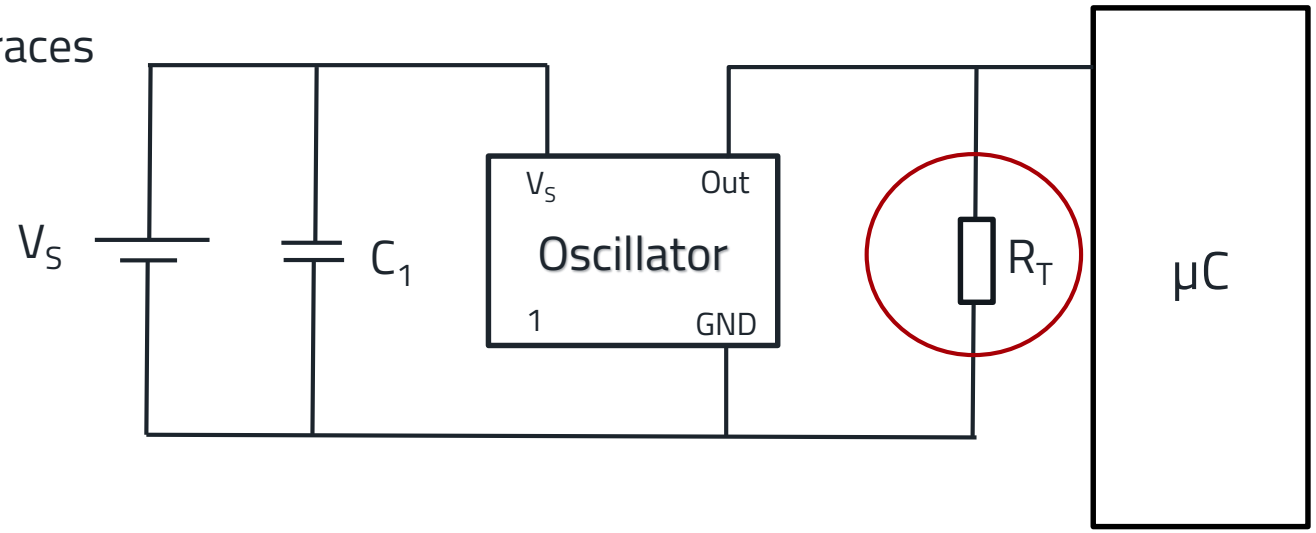
- Optional: Use LC Filter



NOISE FROM OUTPUT LINE

Termination / Impedance Matching

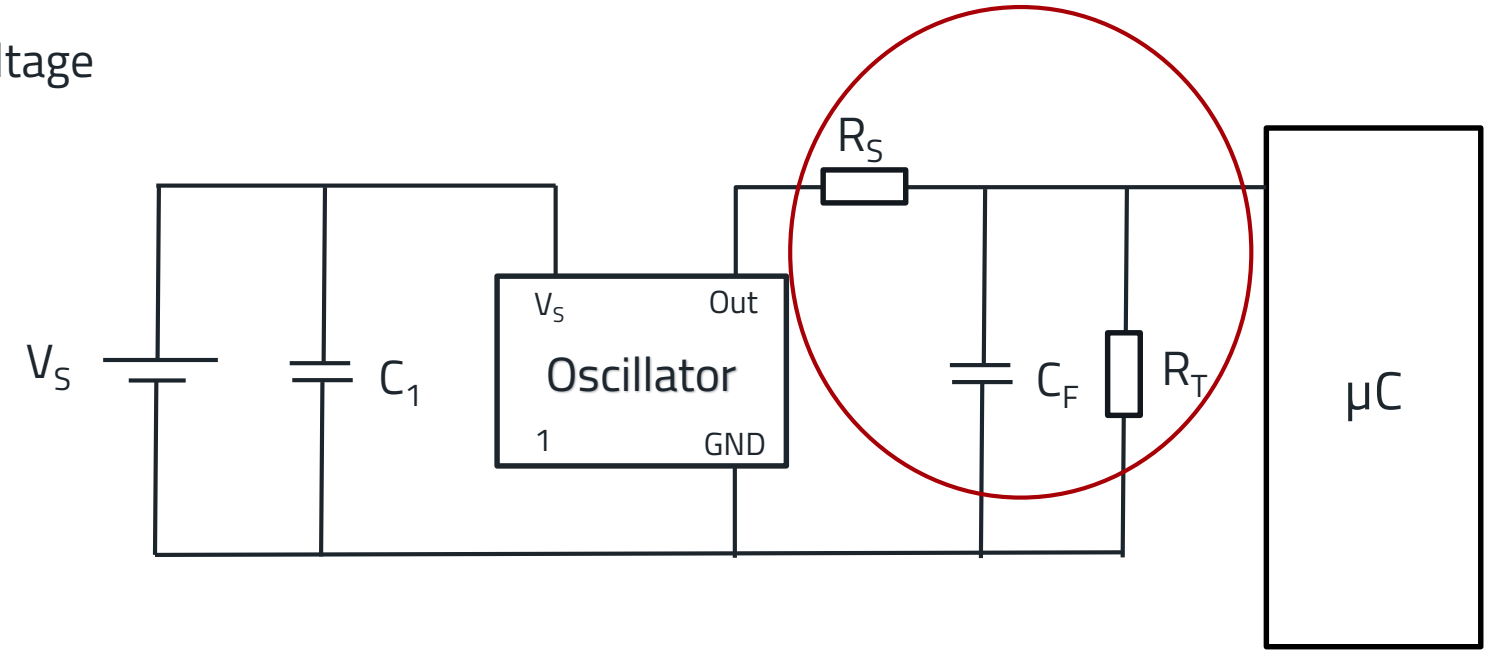
- Between oscillator & GND
- Mainly important when having long traces
- May add as a mounting option



NOISE FROM OUTPUT LINE

Termination + RC - Filter

- Attention: R_S & R_T build a voltage divider → R_S <<R_T !!



EMC & EMI

Shielding

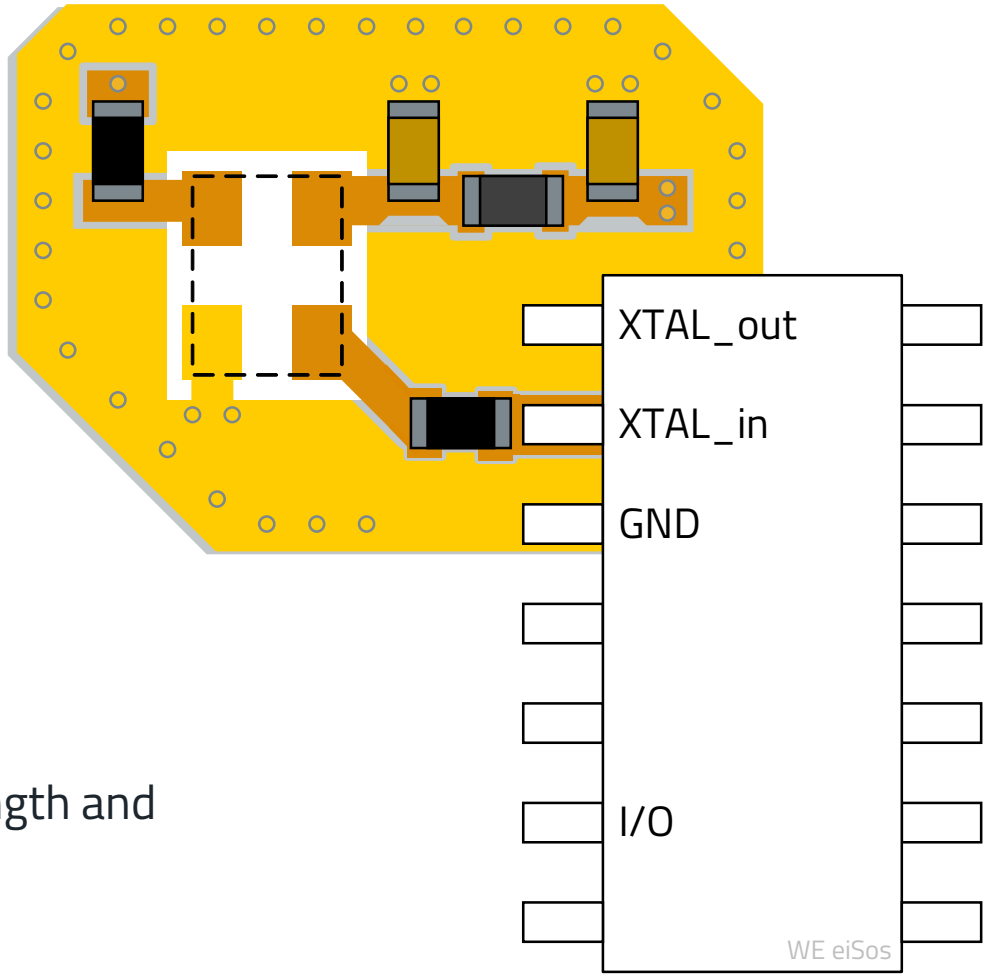
- Effect of oscillator housing
  - Plastic enclosures do not have any effect on shielding
  - Metal lids without connection to ground will only have a minor effect
  - Metal lids with connection to ground still only have a small effect

- May enclose the oscillator circuit (+µC) in
  - Metallic enclosures
  - Shielding cans

PCB LAYOUT

General Notes

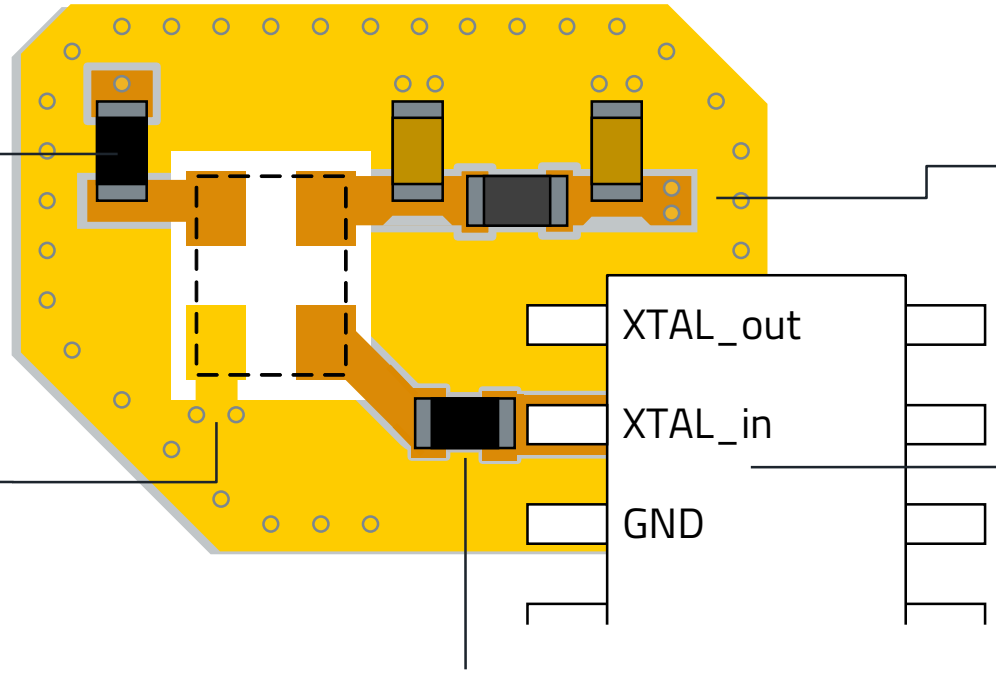
- **Keep the traces as short as possible!**
- Avoid 90° bends – round right angles!
- Do not cross any other signal lines!
- Do not run any signals and lines under oscillator or close by!
- No loops!
- Keep differential output traces the same or close to the same length and close to each other!



PCB LAYOUT

Oscillator Specific Notes

Add a **Pull-up resistor**
Never leave pin open!



Decoupling Capacitor / Filter:
as close to oscillator as possible – ideally have an option for decoupling / π - Filter

Apply best **grounding** practices, e.g. via fence, cut out GND plane under oscillator

Connect oscillator as **close** to **$XTAL_{in}$** as possible, leave $XTAL_{out}$ open

Have at least mounting option for a **serial resistor**, ideally for **RC - Filter**
With long traces a **termination resistor** may be required