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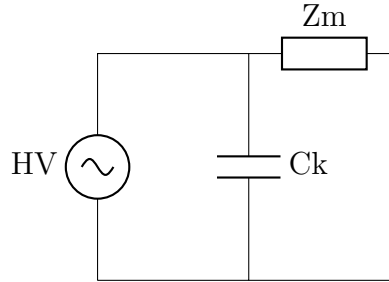
1 Introduction

Partial discharge (PD) measurements are sensitive to circuit conditions and impedance placements. This lecture covers different impedance measurement setups, sensor types, frequency response considerations, and best practices to minimize noise and maximize signal clarity.

2 Measurement Setup Options

We consider three options for measuring impedance placement in a high-voltage (HV) test circuit:

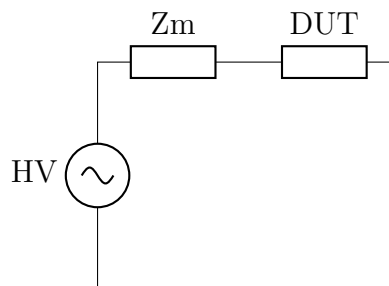
2.1 Z_m in Branch (Parallel Configuration)



Pros: No risk to Z_m during DUT breakdown.

Cons: Lower sensitivity compared to in-series configuration.

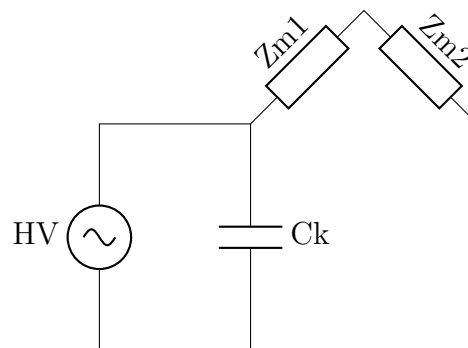
2.2 Z_m In-Series with DUT



Pros: Higher sensitivity.

Cons: Z_m at risk during breakdown.

2.3 Bridge Configuration



Pros: Enhanced sensitivity due to differential mode rejection.

Cons: Requires balanced impedance paths.

3 Measuring Impedance (Z_m)

The purpose of Z_m is to convert high-frequency current pulses into measurable voltage signals.

Why Voltage Instead of Current?

- Current is difficult to measure (low magnitude: pA to nA).
- Voltage can be amplified easily.
- Integration and DSP easier in voltage domain.
- Most equipment measures voltage.

4 High-Frequency Current Transformers (HFCT)

HFCT: Measures PD currents inductively using Faraday's law.

Issues:

- Additional integration steps introduce phase errors.
- Saturation from low-frequency (50/60 Hz) currents.

5 Analog and Digital Signal Processing

- RC integrators used after HFCT.
- High-speed digitization followed by DSP.

6 Summary Table: Zm vs HFCT

Aspect	Zm	HFCT
Signal Type	Voltage ($V = IZ$)	Vout
Contact	In-series (grounded)	Non-invasive
Frequency Range	30 kHz – 1 MHz	100 kHz – 100 MHz
Noise Immunity	Good (shielded)	Excellent (isolated)

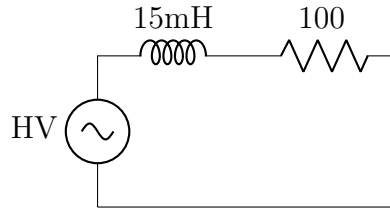
7 Designing Zm

$Z_m = R + j\omega L$; *typically a high-pass filter.*

High vs Low Zm

- **High Zm:** Better sensitivity, risk of saturation.
- **Low Zm:** Lower sensitivity, better for high current.

Example Filter:



8 Coupling Capacitor (Ck)

Ck allows high-frequency PD currents to bypass DUT.

Selection:

- Higher Ck $\Rightarrow$ better SNR.
- But increases required power supply current.
- Impacts pulse width: $\tau = RC$.

9 Frequency Band Selection

Noise Types:

- **White Noise:** Flat FFT.
- **Switching Noise:** Sharp peaks.
- **Sinusoidal:** Narrowband peaks (e.g., AM/FM).

Step: Always evaluate FFT noise floor before PD test.

10 Conclusion

Effective PD measurement depends on a carefully selected impedance, proper placement, and noise rejection strategies. The choice between Zm and HFCT depends on application-specific constraints and sensitivity requirements.