



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

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Simplified and Low-Cost Characterization of Medium- Voltage Low-Power Voltage Transformers in the Power Quality Frequency Range

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Introduction

C2.b Task 2.2: Guidance for industrial calibration setups and performance of ITs

The aim of this task is to study and implement architecture for simplified calibration setups and methods to be used for the characterisation of ITs in industrial premises. The realised simplified measurement systems will be compared with the reference systems according to Task 2.1. The results of this Task will be used for the setup of a good practice guide.

- ✓ Too many ITs to test
- ✓ Simplify existing procedures
- ✓ Add new procedures
- ✓ Etc



LPVT

Introduction

[1] Crotti,G.; Gallo, D.; Giordano, D.; Landi, C.; Luiso, M.; Cherbaucich, C.; Mazza, P. Low cost measurement equipment for the accurate calibration of voltage and current transducers. In Proceedings of the 2014 IEEE International Instrumentation and Measurement Technology Conference (I2MTC) Proceedings, Montevideo, Uruguay, 12–15 May 2014.

[2] Letizia, P.S.; Crotti, G.; Giordano, D.; Delle Femine, A.; Gallo, D.; Landi, C.; Luiso, M. Low Cost Procedure for Frequency Characterization of Voltage Instrument Transformers. In Proceedings of the 2019 IEEE International Instrumentation and Measurement Technology Conference (I2MTC), Auckland, New Zealand, 20–23 May 2019.

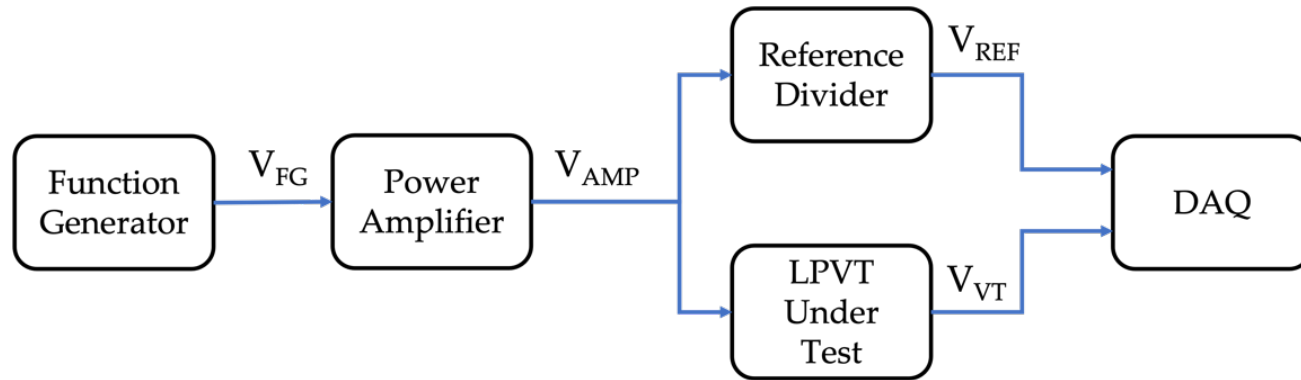


Introduction

The Idea

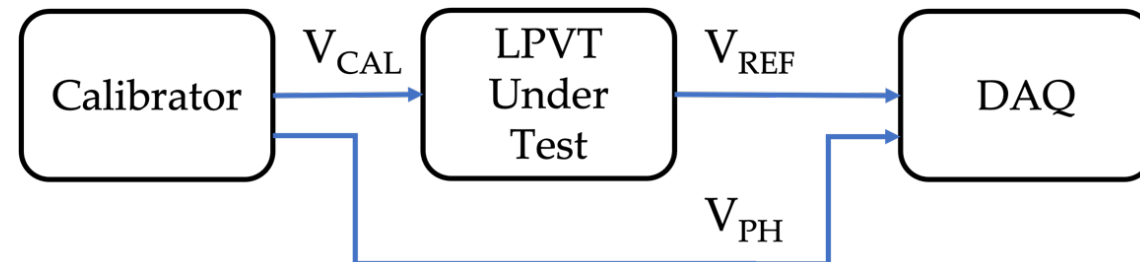
- Harmonic characterization
- Low Voltage
- No 50 Hz component
- Low cost equipment

Measurement Setup



MAIN

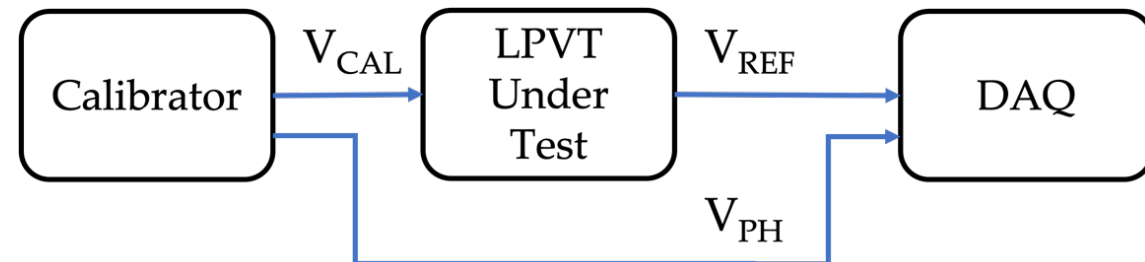
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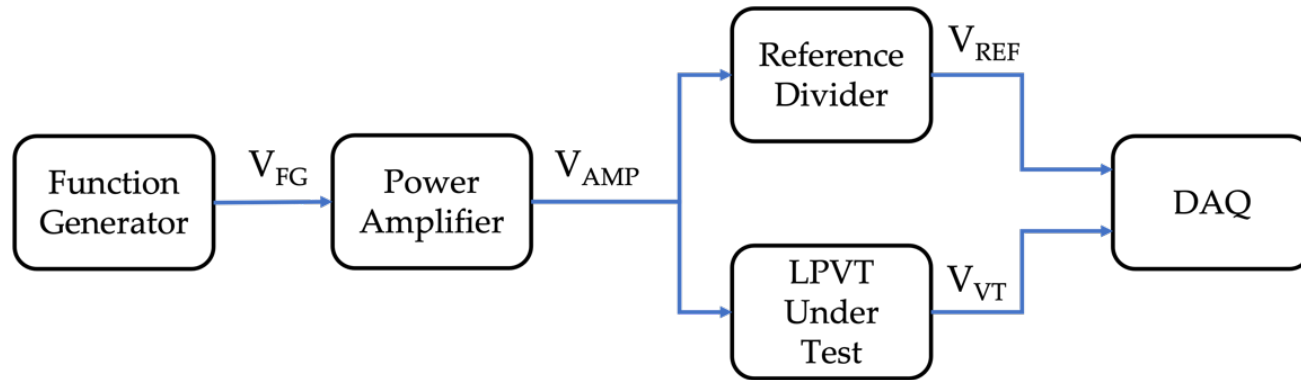
Measurement Setup

- NI 9239 DAQ
- FLUKE 6105A

REFERENCE



Measurement Setup



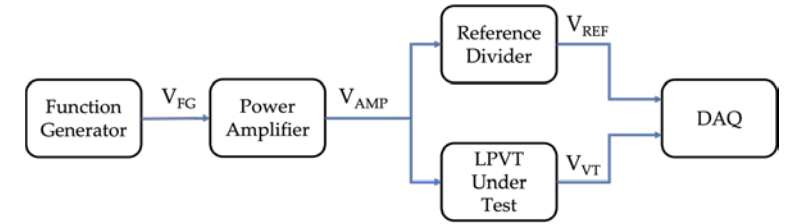
MAIN

- NI 9239 DAQ
- FG RIGOL DG1022
- Reference Resistive Divider
- Analog Device ADHV4702-1 Op. Amp.

Dual supply	$\pm 12\text{ V to } \pm 110\text{ V}$	CMRR	160 dB
Slew rate	74 V/ μs	Input bias current	Max 2 pA
Input noise	8 nV/ $\sqrt{\text{Hz}}$	Bandwidth	10 MHz

Experimental Tests

- Sinusoidal waveforms (150 Hz to 2000 Hz)
- Amplification
- Data collection
- Error computation



$$\varepsilon = \frac{K_r U_S - U_P}{U_P} \times 100$$

$$\Delta\varphi = \varphi_S - \varphi_P$$

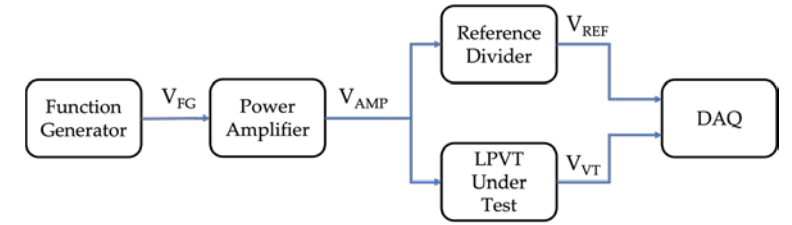
Experimental Tests



Passive

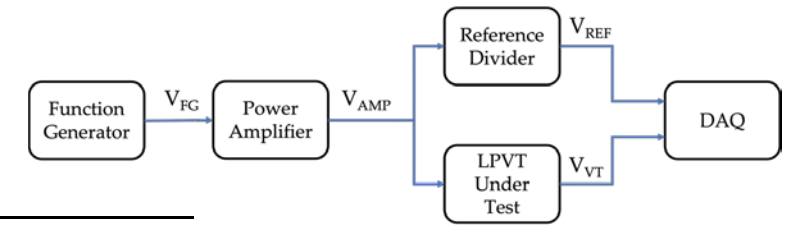


Active



EN 50160

Experimental Results

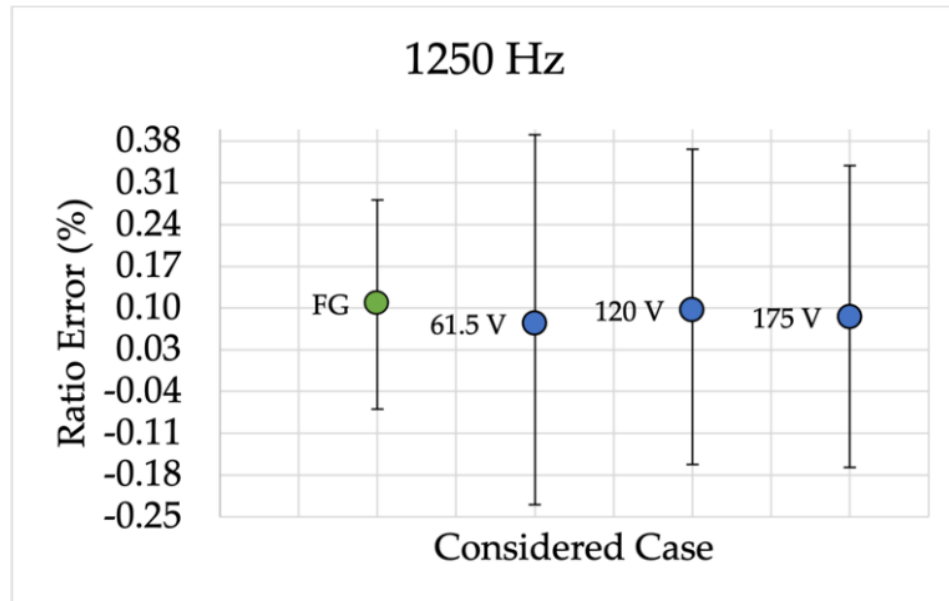


Frequency (Hz)	Applied Voltage		A		P	
	%	(V)	$\Delta\Phi$ (rad)	$\Delta\varepsilon$ (%)	$\Delta\Phi$ (rad)	$\Delta\varepsilon$ (%)
150	~0.5	61.5	$3.7 \cdot 10^{-4}$	-0.16	$4.0 \cdot 10^{-4}$	$-6.8 \cdot 10^{-3}$
	5.0	580	$4.2 \cdot 10^{-4}$	$-8.0 \cdot 10^{-2}$	$4.0 \cdot 10^{-4}$	$-6.4 \cdot 10^{-4}$
250	~0.5	61.5	$7.6 \cdot 10^{-4}$	-0.17	$7.4 \cdot 10^{-4}$	$-2.9 \cdot 10^{-2}$
	6.0	695	$8.3 \cdot 10^{-4}$	$-8.1 \cdot 10^{-2}$	$8.0 \cdot 10^{-4}$	$-2.2 \cdot 10^{-2}$
350	~0.5	61.5	$1.1 \cdot 10^{-3}$	-0.17	$9.9 \cdot 10^{-4}$	$-7.0 \cdot 10^{-3}$
	5.0	580	$1.2 \cdot 10^{-3}$	$-8.3 \cdot 10^{-2}$	$1.0 \cdot 10^{-3}$	$-3.1 \cdot 10^{-3}$
450	~0.5	61.5	$1.5 \cdot 10^{-3}$	-0.17	$1.3 \cdot 10^{-3}$	$-1.1 \cdot 10^{-2}$
	1.5	175	$1.5 \cdot 10^{-3}$	-0.11	$1.3 \cdot 10^{-3}$	$-1.3 \cdot 10^{-2}$
750	~0.5	61.5	$2.7 \cdot 10^{-3}$	-0.17	$2.5 \cdot 10^{-3}$	$-1.8 \cdot 10^{-3}$
1000	~0.5	61.5	$3.7 \cdot 10^{-3}$	-0.11	$3.0 \cdot 10^{-3}$	$3.5 \cdot 10^{-2}$
1250	~0.5	61.5	$4.6 \cdot 10^{-3}$	-0.10	$4.2 \cdot 10^{-3}$	$3.4 \cdot 10^{-2}$
	1.5	175	$4.7 \cdot 10^{-3}$	$-7.8 \cdot 10^{-2}$	$4.4 \cdot 10^{-3}$	$2.4 \cdot 10^{-2}$
1600	~0.5	61.5	$5.7 \cdot 10^{-3}$	-0.11	$5.1 \cdot 10^{-3}$	$2.9 \cdot 10^{-2}$
2000	~0.5	61.5	$7.3 \cdot 10^{-3}$	-0.11	$6.1 \cdot 10^{-3}$	$3.3 \cdot 10^{-2}$

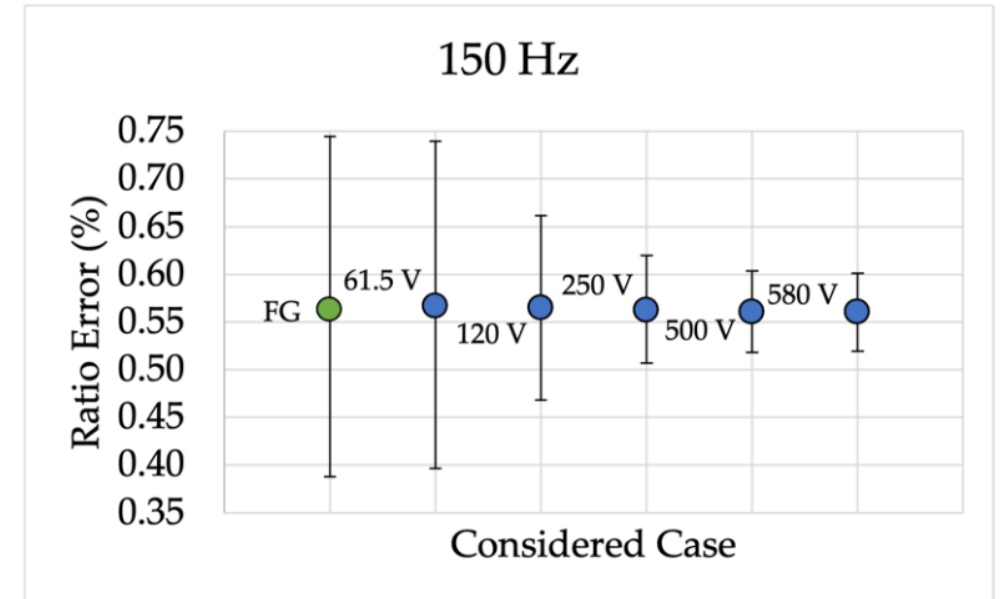
Experimental Results

Uncertainty Evaluation

- Find the uncertainty sources
- Implement MonteCarlo
- Compare with reference method



Active

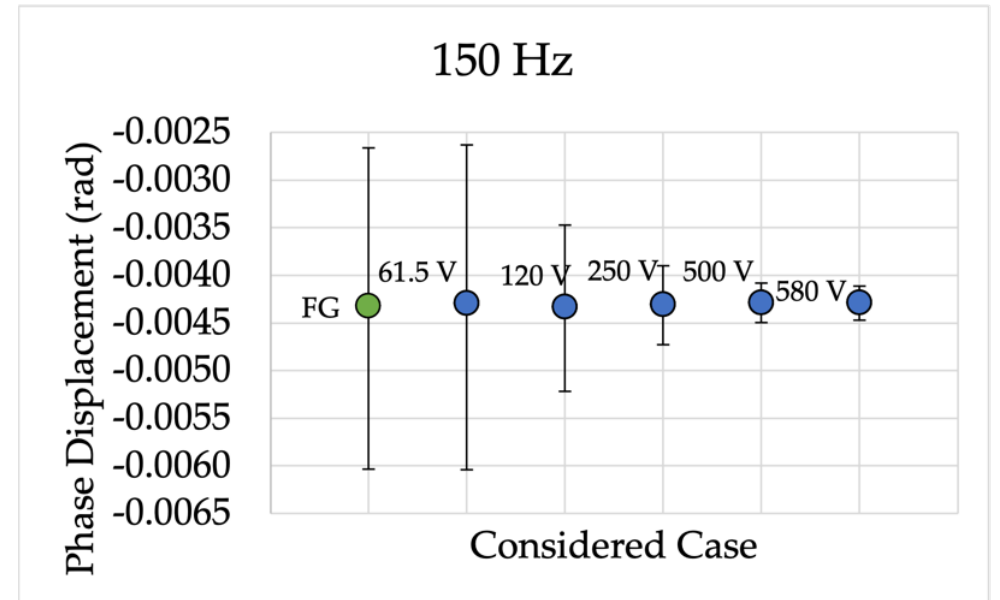
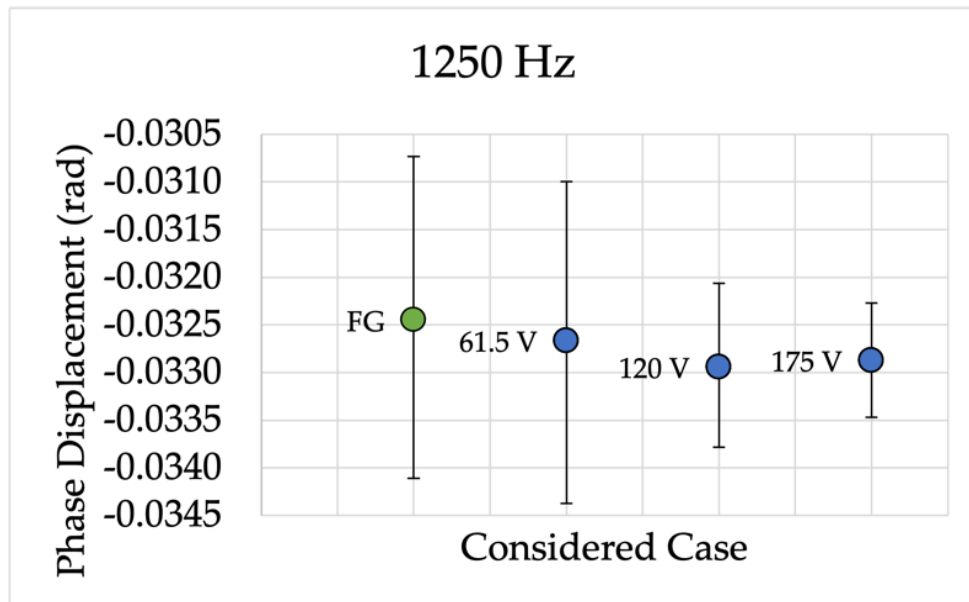


Passive



Experimental Results

Uncertainty Evaluation



Passive

Conclusion

- Cheap equipment
- Simplified LV procedure
- Uncertainty is not affected
- 50 Hz testing needed anyway



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