RECHERCHE

MESURE
MÉTROLOGIE

ESSAIS

CERTIFICATION

EXPERTISE
ET INNOVATION

FORMATION

ADMIT
AC & DC
High
Frequency
Instrument
Transformers

CRÉER
LA
CONFIANCE

CHARACTERIZATION OF AC AND DC MV INSTRUMENT TRANSFORMERS IN EXTENDED FREQUENCY RANGE UP TO 150 KHz (ADMIT) JUIN 2023- MAI 2026

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20/06/2023

Kick off meeting

"The project 22NRM06 ADMIT has received funding from the European Partnership on Metrology, co-financed by the European Union's Horizon Europe Research and Innovation Programme and from by the Participating States."

OVERVIEW OF THE WP2

ADMIT
AC & DC High Frequency Instrument Transformers

INRIM	Istituto Nazionale di Ricerca Metrologica	Italy
FFII	Fundación para el Fomento de la Innovación Industrial	Spain
LNE	Laboratoire national de métrologie et d'essais	France
RISE	RISE Research Institutes of Sweden AB	Sweden
VSL	VSL B.V.	Netherlands
VTT	Teknologian tutkimuskeskus VTT Oy	Finland
RSE	Ricerca sul Sistema Energetico – RSE S.p.A.	Italy
SUN	Università degli studi della Campania Luigi Vanvitelli	Italy
UNIBO	Alma mater studiorum Università di Bologna	Italy
UNIGE	Università degli Studi di Genova	Italy
ARTECHE	Electrotécnica Arteche Hermanos, Sociedad Limitada	Spain
UNARETI	Unareti SpA	Italy
METAS	Eidgenössisches Institut für Metrologie METAS	Switzerland

35.7 Months

OVERVIEW OF THE WP2

Infrastructure for voltage generation and traceable measurement chain

Task 1

Development of Generations systems

50 kV DC, 35 kV AC
+
500 V (9 kHz to 150 kHz)

Task 2

Development of reference measuring systems

Frequency	U (ratio Voltage)	U (phase)
DC and 50 Hz	0.01 %	0.01 crad
9 kHz to 150 kHz	0.2 % to 1 %	0.2 crad to 1 crad

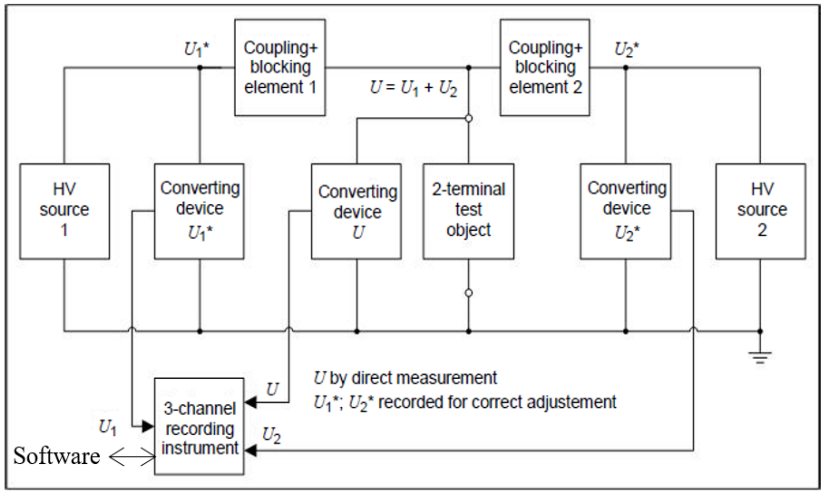
Task 3

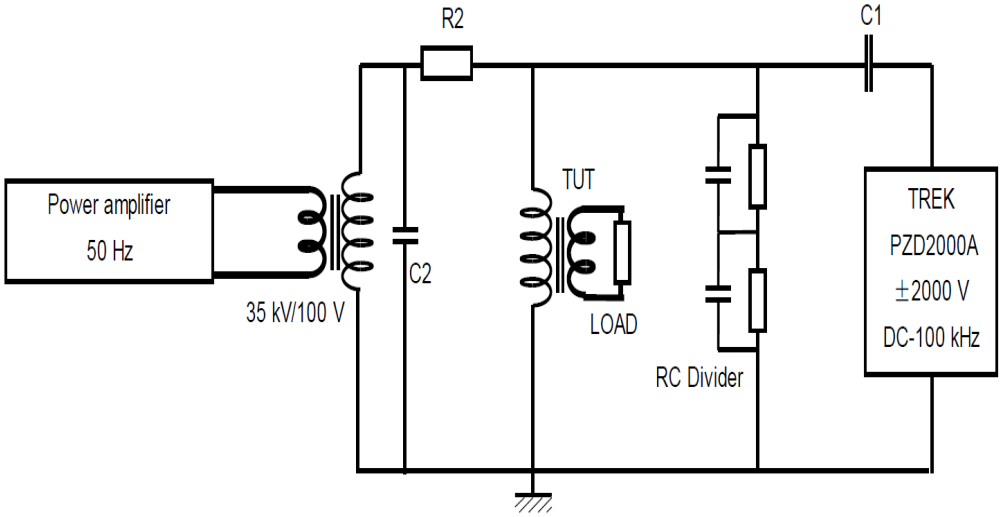
Industry-oriented VT test procedures

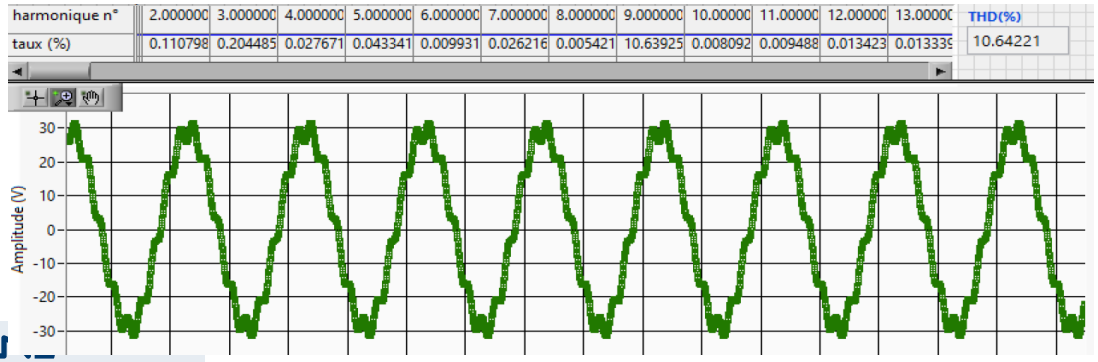
Development of Industrial test procedure
500 V (9 kHz to 150 kHz)

TASK 1 : GENERATORS

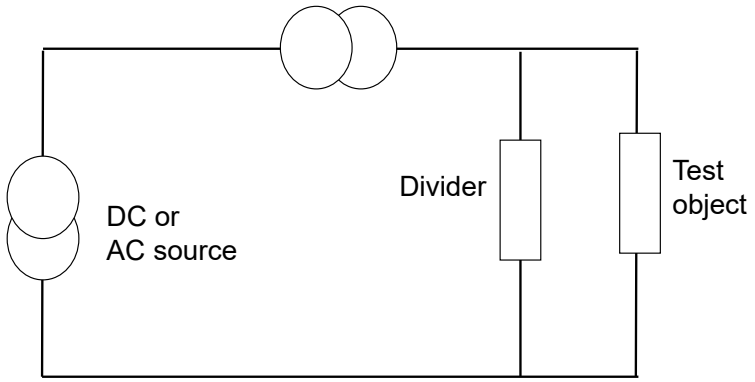
IEC 60060-1 (tested up to 10 kHz)







Isolated 150 kHz source



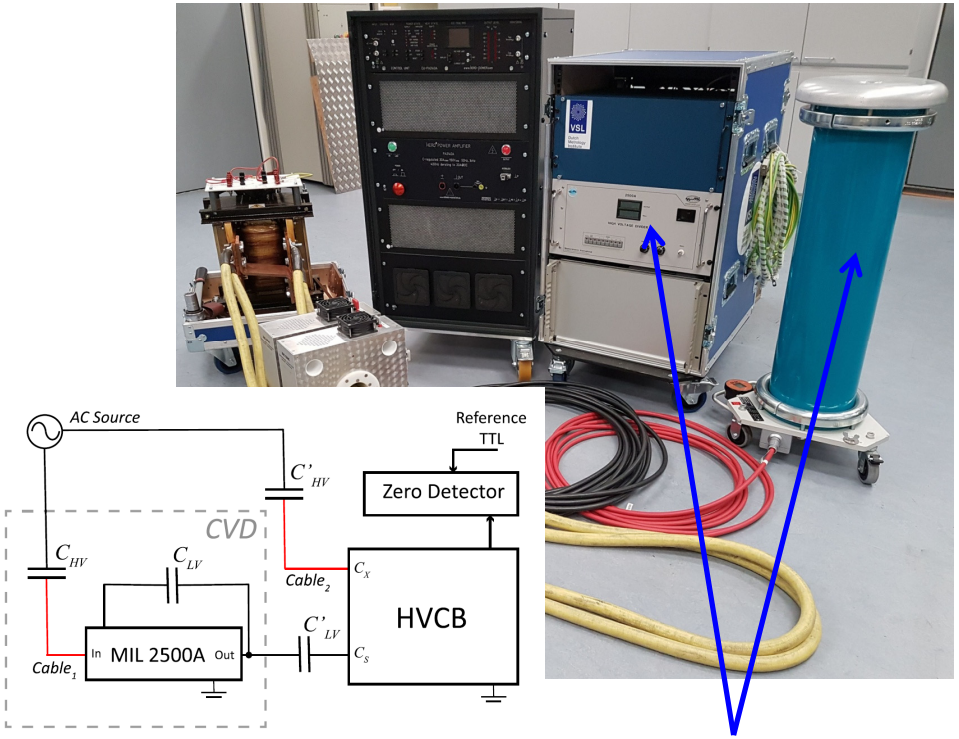
TASK 2 : MEASURING SYSTEMS

			Wideband dividers															
#	Lab	Identification	Make	Model	Type	Max. DC voltage	Max. Peak AC voltage	Low -3 dB	High -3dB	Rin	Cin	Internal damping	External damping	Nom. SF	Height	Weight	Floor area	HV electrode
0	VTT MIKES	RCR200LI	VTT	RCR200	Universal	200 kV	200 kV	DC	10 MHz	1.25 GΩ	425 pF	240 Ω	250 Ω	2000	1.3 m		ø 0.8 m	ø 0.8 m
1	VTT MIKES	ZES20	ZES ZIMMER	HST12-3	Resistive	20 kV	20 kV	DC	300 kHz	40 MΩ	20 pF	-	-	4000	0.11 m	7.2 kg	0.25 m x 0.6 m	-
2	FFII		ROSS		Resistive	200 kV	200 kV	DC	10 MHz		10 pF							
3	FFII		TETTEX		Capacitive	200 kV	200 kV	50 Hz (?)	60 Hz (?)									
4	FFII		LCOE		Parallel	40 kV	25 kV	100 Hz	5 kHz	50 MΩ	400 pF							
5	VSL		HVDC		Shielded parallel	200 kV	200 kV	DC	300 kHz	1 GΩ	2 nF							
6	RISE		RISE		Universal	125 kV	100 kV	DC	5 MHz	2.5 GΩ	600 pF							
7	RISE		RISE		Universal	500 kV	320 kV	DC	5 MHz	2 GΩ	250 pF							
8	LNE	VD75	ROSS		Resistive	75 kV	150 kV	DC	10 MHz	300 MΩ	10 pF				30 cm	1 kg	1 m	10 cm
9																		
10																		
11																		

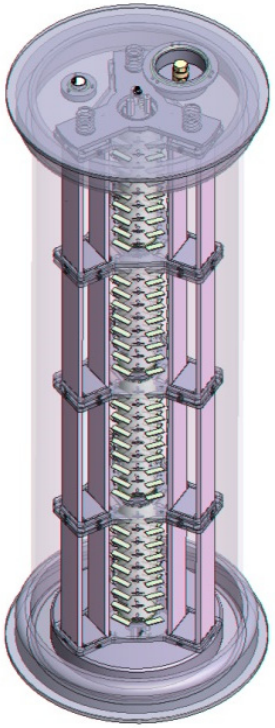
		Digitizer									
#	Lab	Make	Model	Channels	Input R	Input C	Resolution	Sampling rate, max.	Max. BW	Lowest range, fsd	Highest range, fsd
0	VTT MIKES	NI	PXIe-5164	2	1 MΩ	2.5 pF	14 bits	1 GS/s	300 MHz	0.25 V	100 V
1	VTT MIKES	Applicos	WFD20	2	100 MΩ	?	20 bits	2 MS/s	> 800 kHz	0.554 V	8.16 V
2	RISE	NI	PXI-5922	2 (?)			16 bits		1 MHz		
3	LNE	Keysight	3458A	1	10 GΩ	270 pF	16 bits	100 MS/S subsampling	10 MHz	0.1 V	10 V
4											
5											
6											
7											
8											

TASK 2 : MEASURING SYSTEMS

VSL WIDEBAND VOLTAGE DIVIDERS

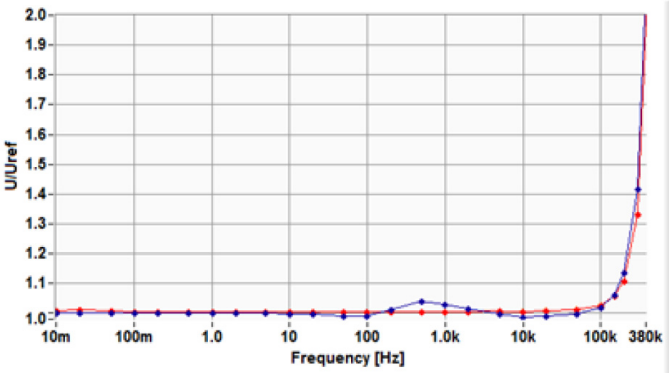


Current comparator-based capacitive voltage divider
(17 ppm error at 5 kHz)



Built in the HVDC project

- TC: within ± 2 ppm/C
- VC: -10 ppm/kV up to 200 kV
- BW: > 100 kHz



TASK 2 : MEASURING SYSTEMS

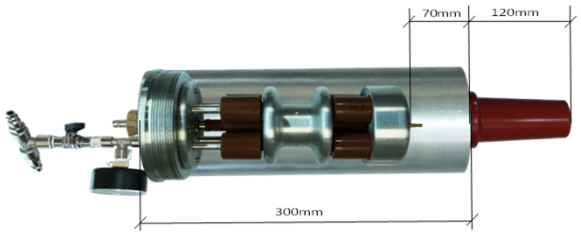
LCOE-FFII WIDEBAND VOLTAGE DIVIDERS

LCOE's experiences about RC HV Dividers up to Medium Voltage with bandwidth in the frequency range from DC up to 150 kHz

Previous participation in EMRP / EMPIR projects: ENG61 FutureGrid I, 16ENG04 MyRailS and 19NRM07 HV-com².

"The Design and Characterization of a Prototype Wideband Voltage Sensor Based on a Resistive Divider". F. Garnacho, A. Khamlichi, J. Rovira. Sensors Journal, 2017.

DC Resistive Divider	ROSS	1 - 200 kV	0.01%
AC 50/60 Hz Capacitive Divider	Tettex	1 - 200 kV	0.05%
AC 100 Hz - 5 kHz RC Divider	LCOE	1 - 25 kV	0.5%



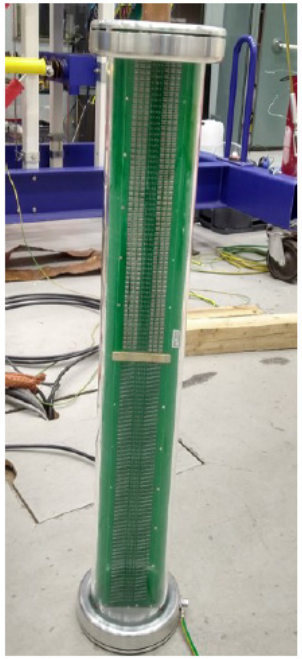
25 kV AC, 40 kV DC, SF6

FutureGrid divider 25 KV

Accuracy class: 0.2 for a frequency range from 20 Hz to 5 kHz and 0.5 for 1 Hz up to 20 Hz.
HV arm: R = 2x25 MΩ; C = 800pF/2 = 400pF
LV arm: R = 50 kΩ
Nominal Ratio = 1000

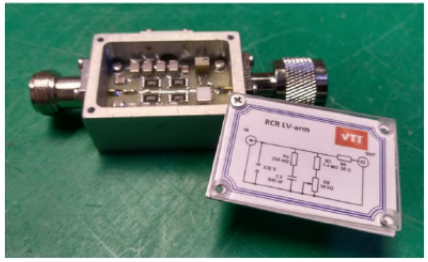
TASK 2 : MEASURING SYSTEMS

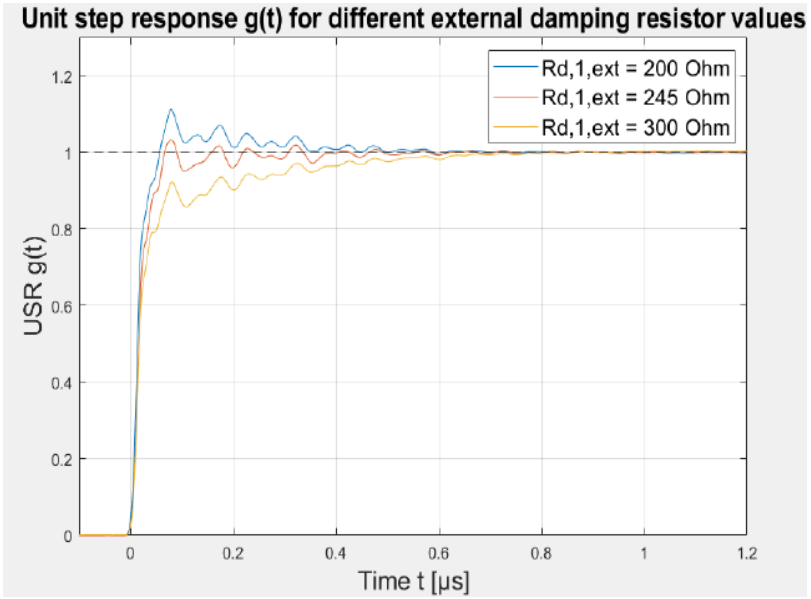
VTT WIDEBAND VOLTAGE DIVIDERS



a)

b)

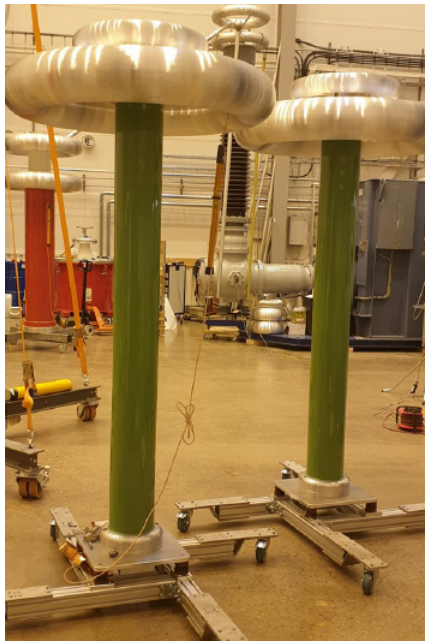


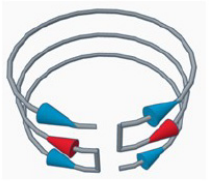


- 10 MHz
- 200 kV
- 400 pF//1.25 GΩ

TASK 2 : MEASURING SYSTEMS

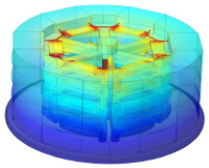
RISE WIDEBAND VOLTAGE DIVIDERS





Current flow in the HV stack

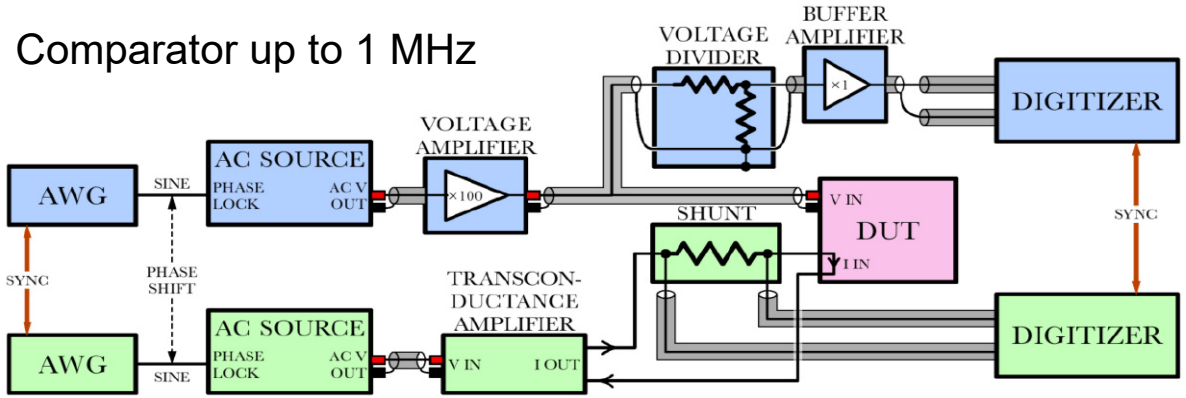
Divider HV construction

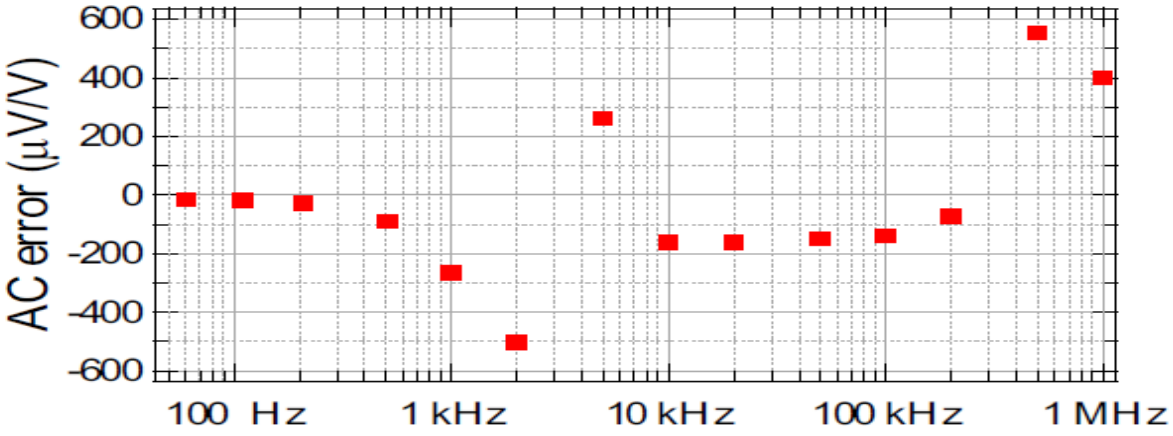


HV Components and properties

- Total capacitance - 250 pF, 600 pc - WIMA FKP1
- Total damping R 1200 kΩ, 300 pc - Ohmite OX + OY
- Total Bleeder R – 2 GΩ, 600 pc - Caddock TF050R 3.33 MΩ
- The current flow, component mounting and field strengths is shown in the figures on the left side

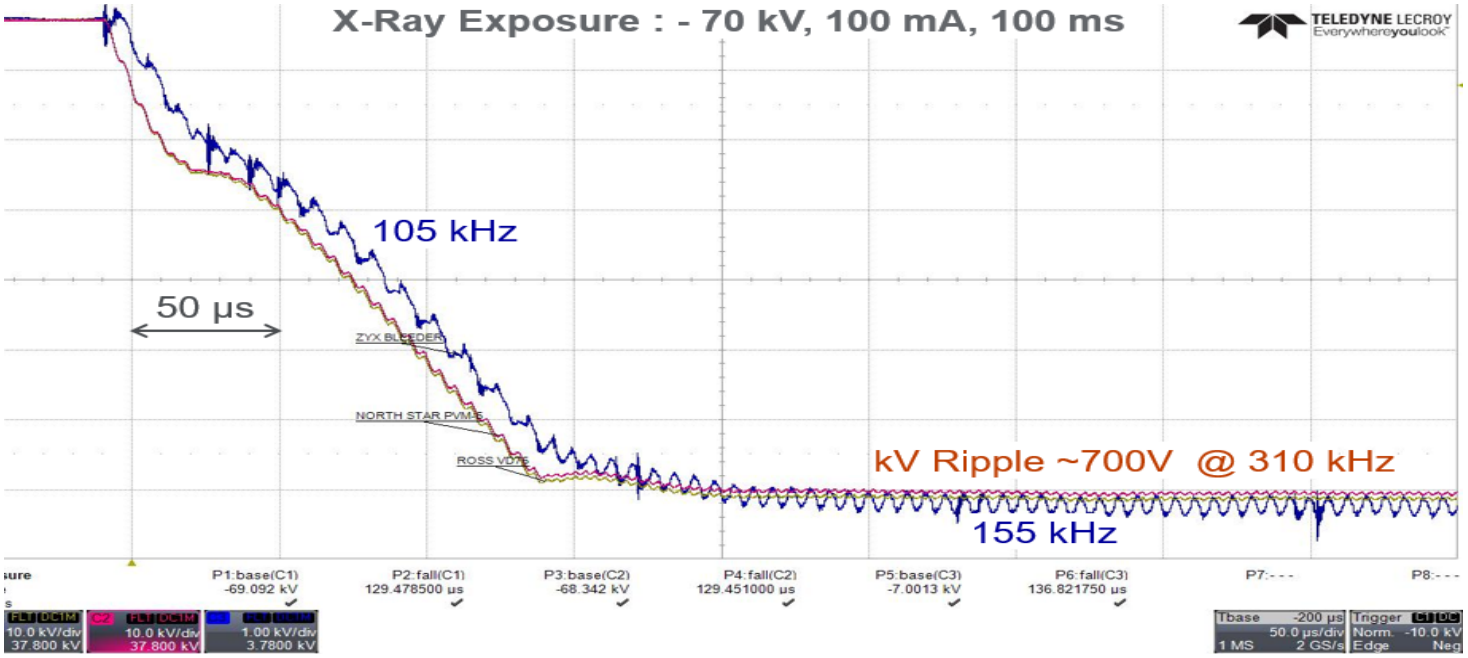
Comparator up to 1 MHz





TASK 2 : MEASURING SYSTEMS

LNE DIVIDERS FOR DC



Advantage:

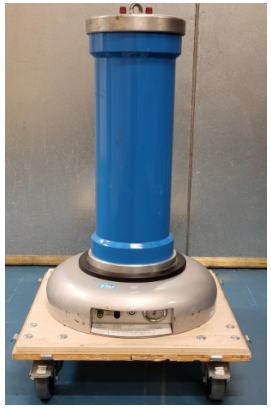
- 10 pF input impedance
- Uncertainty of 0.5 % up to 150 kHz
- Accuracy at DC <0.01 %
- Bandwidth of 10 MHz

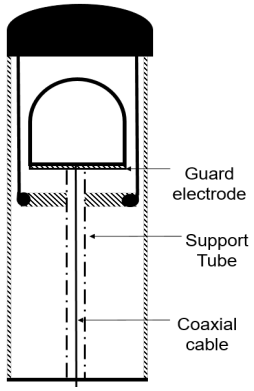
Disadvantages:

- Measurement of ratio error and phase is difficult with 0.01 %
- Frequency response not linear (1 % from Dc to 150 kHz)
- Large proximity effect (free area of 1 meter)

TASK 2 : MEASURING SYSTEMS

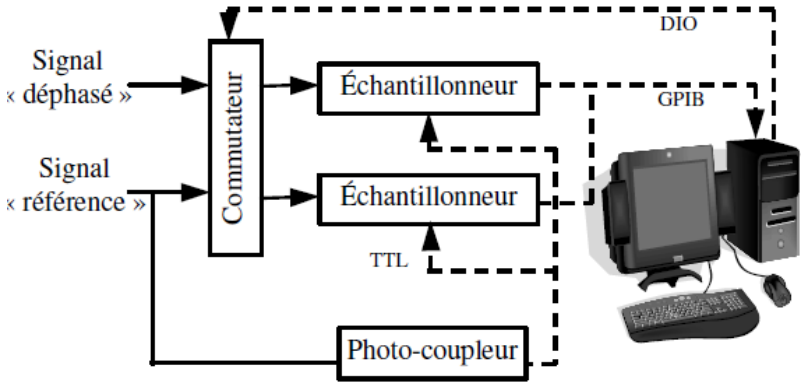
LNE DIVIDERS FOR AC

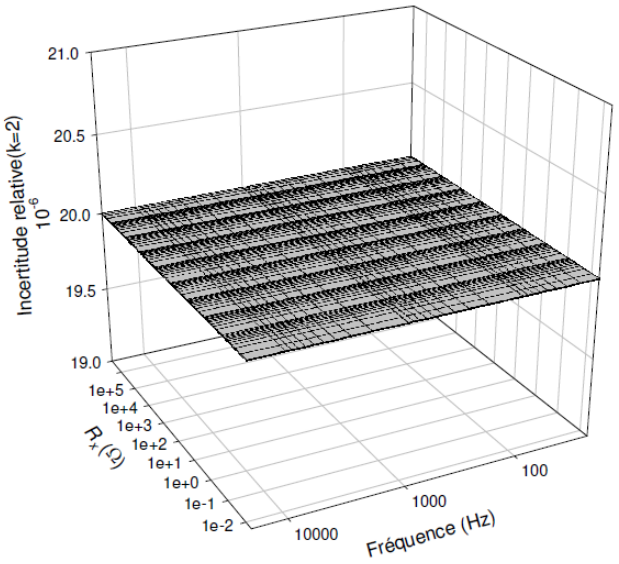


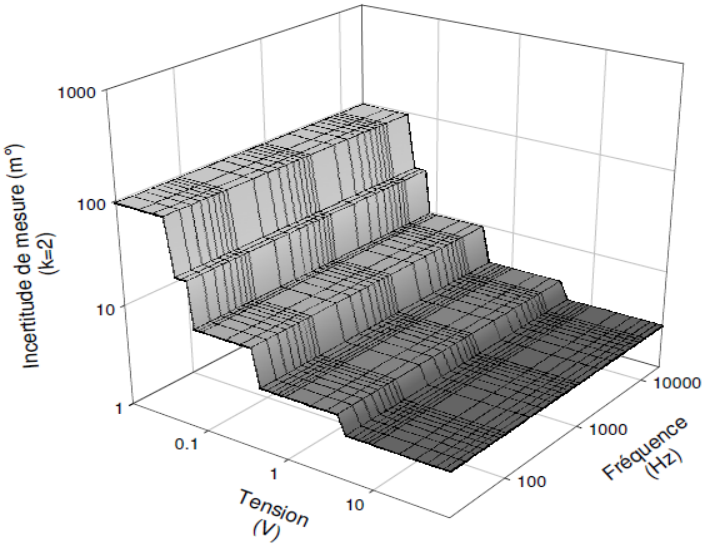


$$C = \frac{2\pi\varepsilon l}{ln\frac{r1}{r2}}$$

- 10 MHz
- 100 kV
- 100 pF
- VC les than 10 µV/V at 50 Hz
- Phase < 10 µrad up to 10 kHz
- Frequency dependance les than 5 µV/V up to 10 kHz
- TC of 30 µV/(V.°K)







TASK 3 : INDUSTRIAL TEST PROCEDURES

- Test procedures will be developed (easy to implement at industries)
- A lot of samples will be tested (LPIT, inductive, resistive, capacitive, …etc)
- Stakeholders, partners or industries are invited to send their samples

Application		MV Electrical Distribution		
Type		NEXANS	G&W electrica CVS-24-O	Zelisko SMVS-K1112
Model				
Voltage	Waveform	Sinusoidal	Sinusoidal	Sinusoidal
	Rated value (kV)	20 kV/racine(3)	20 kV/racine(3)	30 kV/racine(3)
	Range of temperature	-5 °C to +40 °C	-5 °C to +40 °C	-5 °C to +40 °C
	Humidity range	N.C	N.C	N.C
	Frequency range	50/60 Hz	30 Hz to 20 kHz	50/60 Hz
	Nature	Capacitif	Capacitif	Capacitif
	Impedance Burden	MΩ	MΩ	MΩ
	Scale factor	10000	10000	10000
	Accuracy S.F	0.01%	0.50%	0.50%
	Accuracy phase	0.01 crad	0.5crad	0.5crad

WP2 : DELIVERABLES

Relevant objective	Deliverable number	Deliverable description	Deliverable type	Partners (Lead in bold)	Delivery date
3 (A2.1.8)	D3	Good practice guide for voltage generation of power frequency quantity, up to 36 kV for AC and 50 kV for DC, with superimposed frequency components up to 150 kHz	Good practice guide	**INRIM**, LNE, FFII, RISE	Aug 25 (M27)
4 (A2.2.11)	D5	Validation report on the traceability of voltage reference measuring systems, up to 36 kV for AC and 50 kV for DC, with superimposed frequency components up to 150 kHz including a) description of the chosen/developed voltage divider, b) the upgrade of the comparators, c) the characterisation and the traceability of the whole reference voltage measurement system, d) the uncertainty evaluation	Validation report	**VTT**, FFII, INRIM, LNE, RISE, VSL	May 26 (M36)

THANK YOU

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