The Usage of High Voltage Amplifiers to Set up Reference Calibrators for Combined and Composite Voltages up to 1 kV

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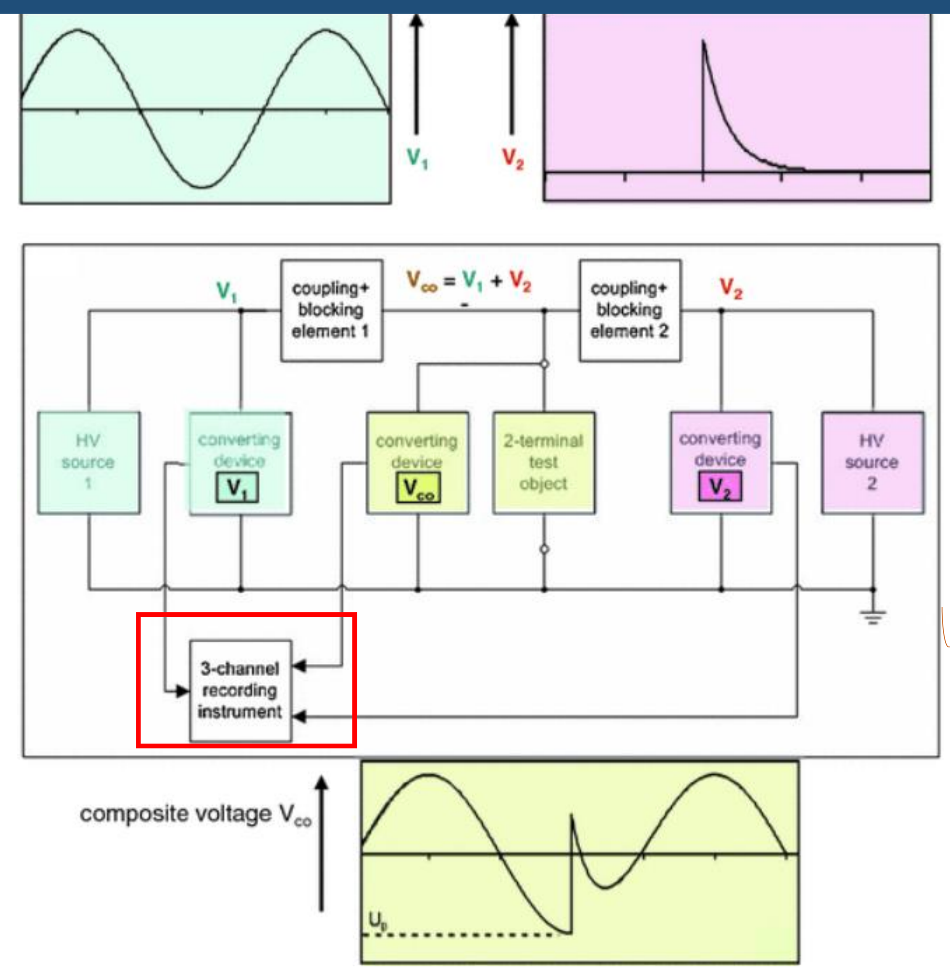
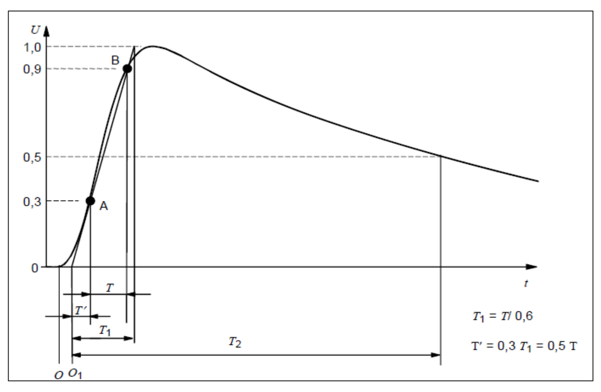
Introduction

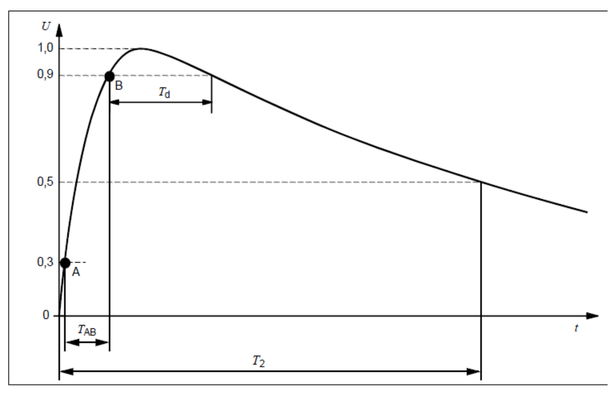
An approach to set up reference calibrators to generate combined voltages, using voltage amplifiers, has been demonstrated. Four high voltage amplifiers were tested and studied. Measurements and experiments have shown that this approach could be used to set up calibrators for combined voltages, at least up to 1 kV. The advantage is the flexibility to generate separate or combined wave shapes (combination of AC, DC, distorted shapes, double exponential impulses such as lightening and switching impulses). This method could be beneficial to the fields where impulses, combined or not with DC or AC voltages, need a reference calibrator to calibrate digitizers. This method, relatively cheaper and simple to develop, reaches high metrological performance. For example, for lightning impulses up to 900 V, the uncertainties are lower than 0.2 % for the peak voltage, 1 % for the front time and 0.5 % for the time to half value . The traceability to the international system of units can be ensured by characterizing the gain using a step response, followed by the convolution technique.

Needs : Calibration of digitizers for High voltage impulses and superimposed impulses

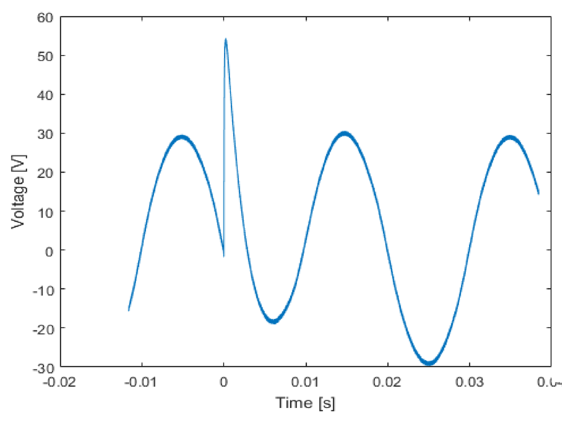




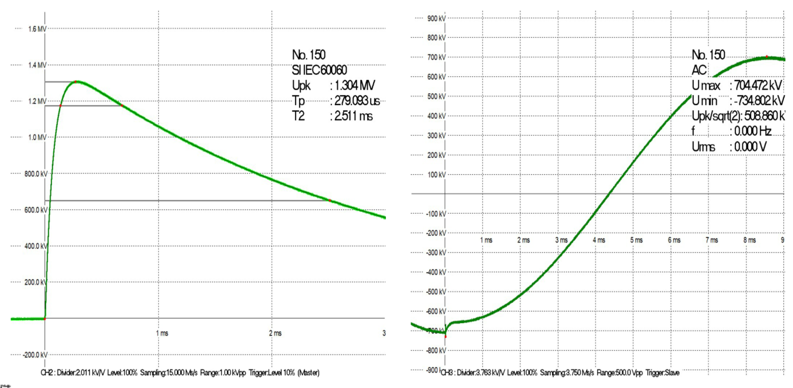
Lightening Impulses (LI)
0.84 µs<T1< Few µs
40 µs<T2< 60 µs
According to IEC60060-1&2



Switching Impulses (SI)
10 µs<TAB< 300 µs
1000 µs<T2< 4000 µs
According to IEC60060-1&2



Impulse superimposed to AC
According to IEC60060-1&2



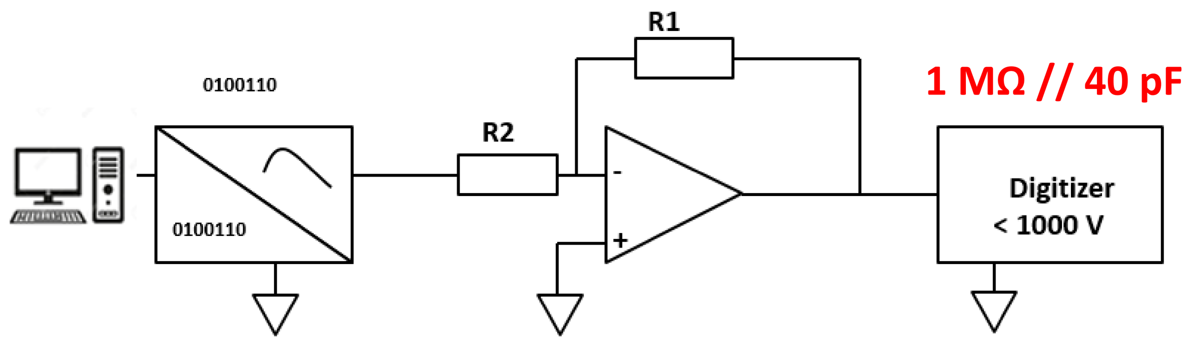
Impulse superimposed to DC
According to IEC60060-1&2

Calibrators exist for LI and SI but need one electrical block for each impulse type.

No calibrators for superimposed wave shape do not exist yet on the market

One electrical block to cover all the impulse types and all the superimposed wave shapes : High voltage amplifier

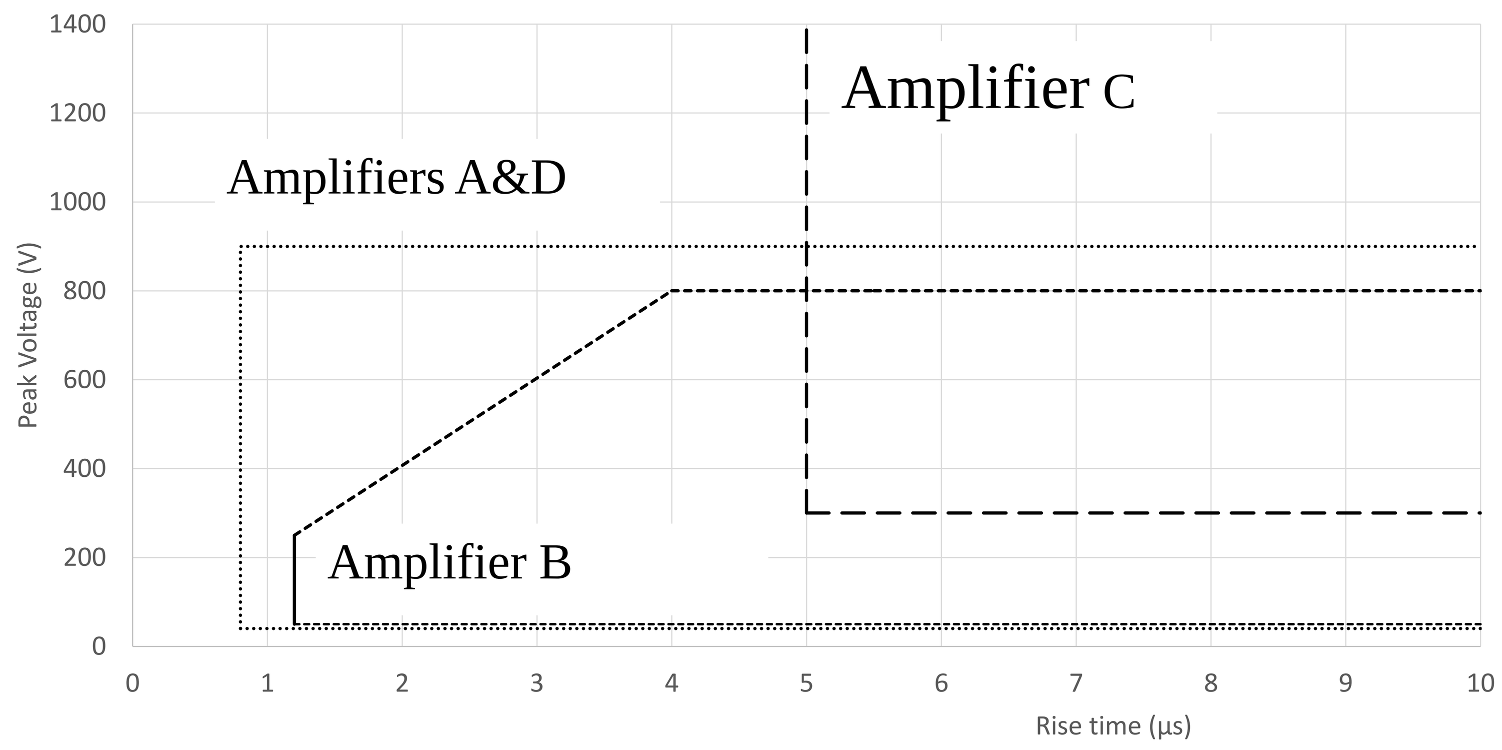
Solution and results



1 MΩ // 40 pF

4 amplifiers were studied

Reference calibrator principle

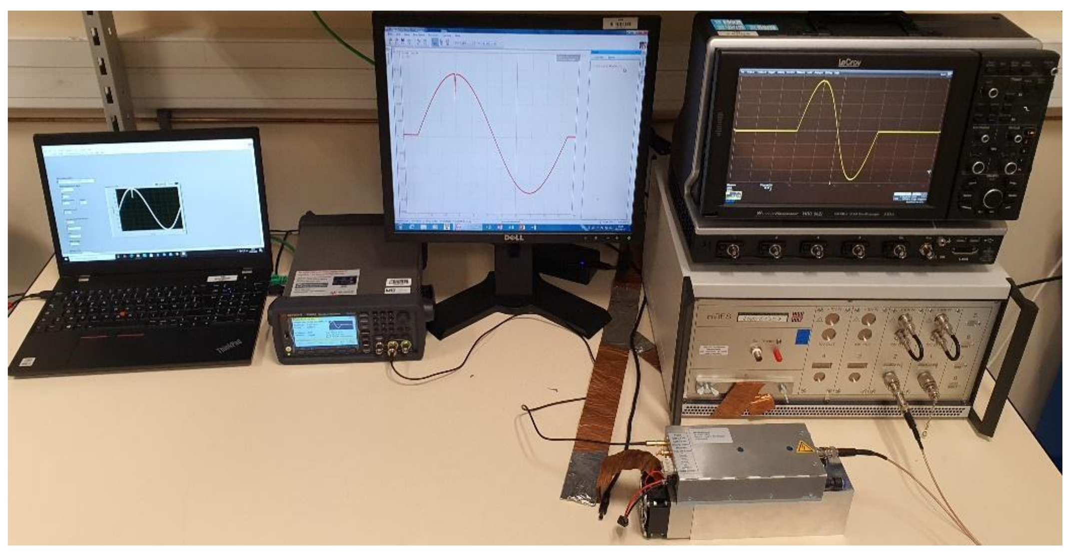


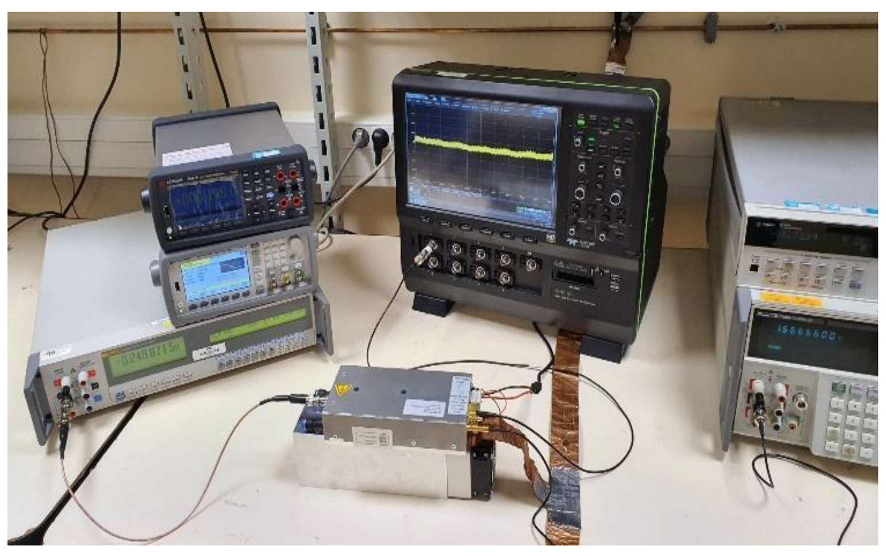
Amplifier :	A	B	C	D
Model	APEX	Newton	Trek	Adamietz
Type	LPA194	LPA400	PZD2000	HVAB-0.9-0.2A
Voltage Peak (Vpp)	900	800	4000	900
Slew rate (V/µs)	2000	350	750	2000
Peak current (mA)	200	50	400	100
Gain	-100	100	200	150
Bandwidth (kHz)	1400	100	60	500
DC offset (mV)	300	150	800	250
Operating temperature (°C)	0-85	0-40	0-40	20-30
Open Loop Gain (dB)	100	100	100	100
Input impedance (kΩ)	0.05	10	25	0.05

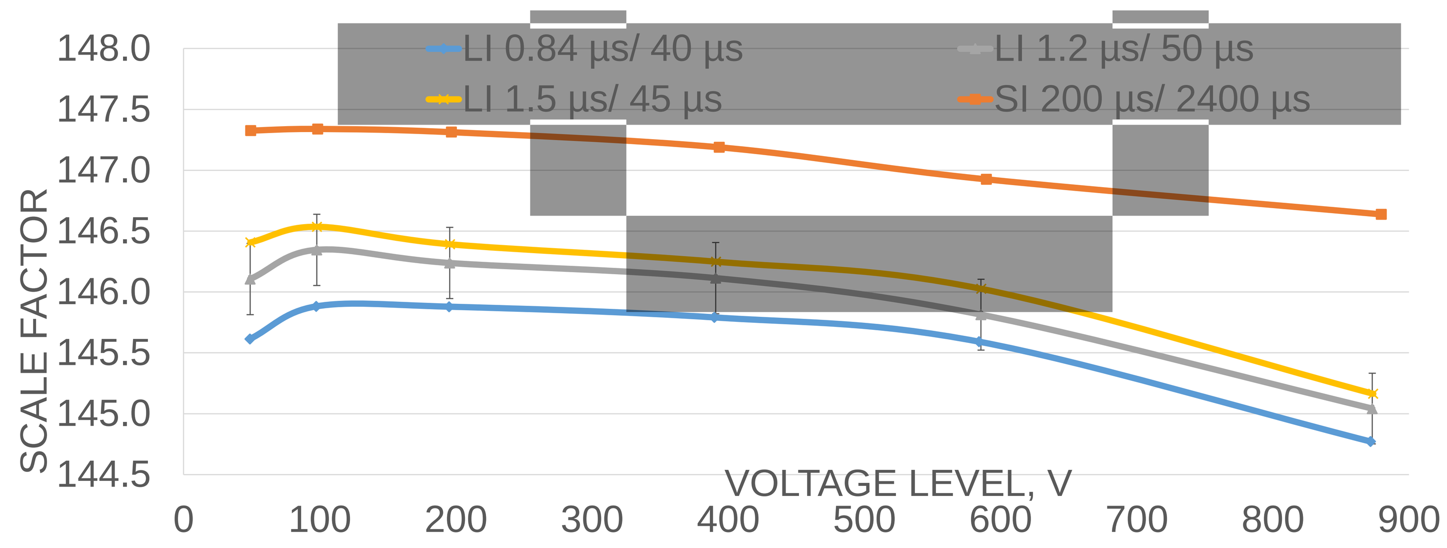
Shapes	Amplifier B	Amplifier C	Amplifier A & D
DC and AC	800 Vpp	3700 Vpp	900 Vpp
Short LI (0.84 µs)	50 V - 250 V	NO	50 V- 900 V
Long LI (1.56 µs)	50 V- 250 V	NO	50 V - 900 V
SI	50 V - 800 V	300 V- 3700 V	50 V - 900 V
Superimposed	Yes	Only for SI	yes
Lowest rise time	1,2 µs	5,5 µs	0,8 µs
Accuracy of voltage	0,2 %	0,2 % V	0,2 %
Time accuracy	<1 %	<1 % V	<1 %

Compensation of load impedance is needed for such amplifiers because the output impedance is not 50 Ω

Characterization of amplifier D

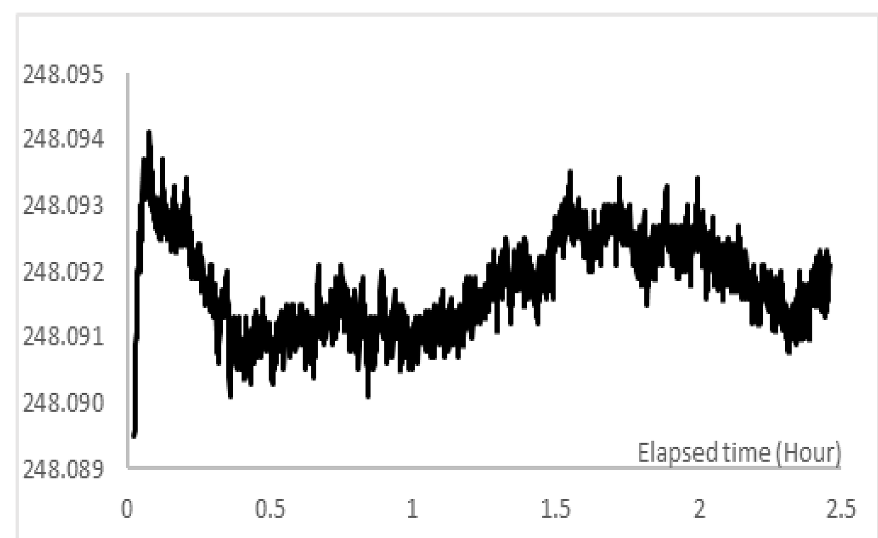




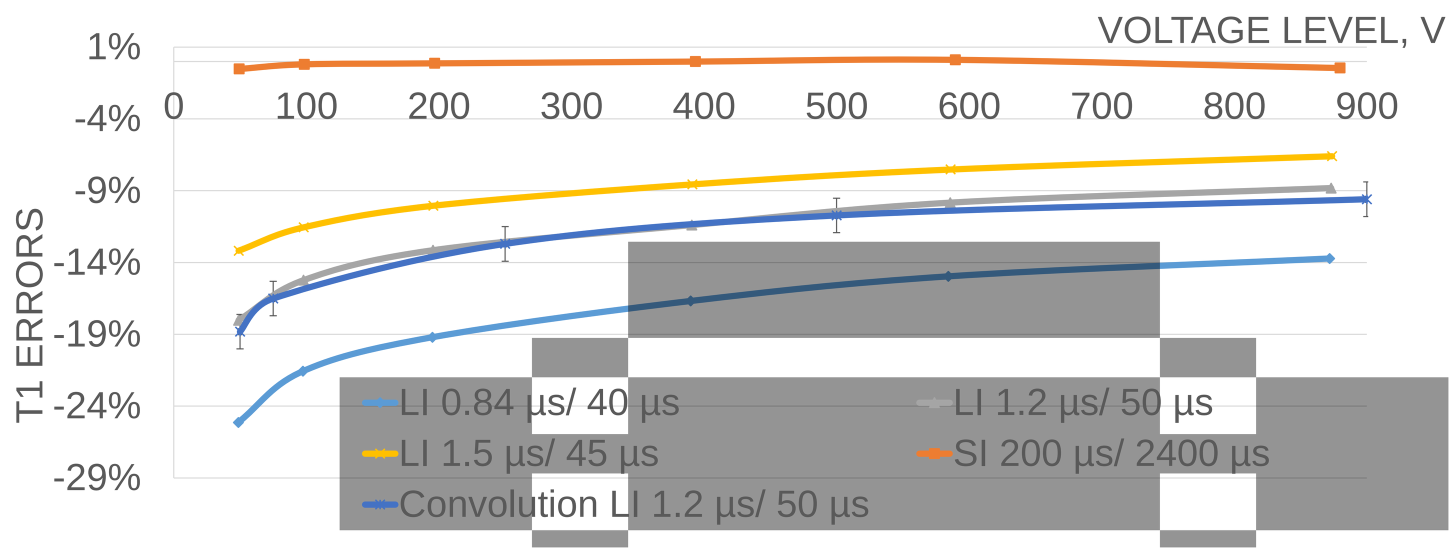


Voltage Peak	LI			SI		
	Vc	T1	T2	Vc	Tp	T2
50 V	0.12%	1.10%	0.26%	0.03%	0.23%	0.09%
100 V	0.05%	0.18%	0.12%	0.01%	0.16%	0.07%
200 V	0.03%	0.09%	0.05%	0.01%	0.08%	0.03%
400 V	0.03%	0.13%	0.05%	0.01%	0.08%	0.02%
600 V	0.04%	0.12%	0.04%	0.02%	0.09%	0.02%
900 V	0.02%	0.13%	0.04%	0.07%	0.11%	0.03%
KAL1000 600 V	0.02%	0.02%	0.02%	0.01%	0.04%	0.02%
RIC22 600 V	0.04%	0.2 %	0.05%	0.02%	0.10%	0.03%

Testing repeatability of amplifier D for LI/SI with comparison to KAL1000 and RIC22



Testing amplifier D at DC/AC voltages: stability over 2.5 hours at 250 V



T1, T2 and Tp errors of the amplifier D (LOAD = 1 MΩ // 40 pF)

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