

Impulse-Calibration-System KAL 1000

Calibration-Software TRAS-KAL

according to IEC 61083-1, IEEE 1122 and IEC 60060-2, IEEE 4

DR. STRAUSS

Impulse Measurement
Calibration - Diagnosis
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Application

For the calibration and for performance tests and checks according to IEC 1083-1 und IEC-60-2 several calibration generators with high accuracy are required which are optimally adapted to the digital impulse voltage measuring system to be tested.

For this purpose a new family of precise calibration generators became developed including the necessary software to perform the required calibrations and tests in the high-voltage test-field in accordance with IEC 61083-1 and IEC 60060-2 in an easy manner and in short time to save costs.

The impulse calibration system KAL 1000 is a modular system to perform tests on complete impulse voltage measuring systems and on digital recorders for the measurement of high impulse voltages and impulse currents. Its modular design allows an optimal KAL configuration depending on the actual application.

Additional, this modularity allows to upgrade or modify an existing KAL 1000 system in case of changing or additional requirements.

The technical design of the impulse calibration system KAL 1000 was done considering the international standards IEC 61083-1, Digital recorders for measurements in high-voltage impulse tests and the revision of IEC 60060-2, at this time under consideration, the requirements for calibration generators in IEC61083-1, Table 3 are fulfilled.

Calibration of Digital-Recorders according to IEC 61083-1

the calibration, performance check or performance test of the measuring ranges of the digital impulse voltage measuring systems TR-AS® according to IEC 61083-1 may be performed either by the method pulse calibration or alternatively by a separate calibration of voltage and time with a step voltage calibration and a time calibration.



Pulse Calibration

The pulse calibration is performed with help of the impulse calibration generators KAL-LI 0.84/60 (optional KAL-LI 1.56/60) for full and chopped lightning impulse voltage or with help of the impulse calibration generator KAL-SI 20/4000 for full or chopped switching impulse voltage.

The time-to-chopping can be set to any value from 0.1 μ s to 10 000 μ s including the standard chopping time of 0.5 μ s.

Step Voltage Calibration

The step voltage calibration is performed with help of the impulse calibration generator KAL-STEP.

Time Calibration

The time calibration is performed with help of the time mark generator KAL-TIME.

Calibration-Software TRAS-KAL

The impulse calibration system KAL 1000 is controlled automatically by the digital impulse voltage measuring system TR-AS® with help of an built-in or complementary relay.

The channels under calibration were connected separate or parallel to the respective output of the calibrator. After setting the d.c. charging voltage the calibration is done simultaneously on all channels for the selected measuring

range.

With help of the control relay in the measuring system automatically the selected number of e.g. 20 measurements are performed and evaluated according to IEC 61083-1.

The mean value of the selected number of records and the largest deviation detected is stored into a protocol file for generation of the calibration certificate subsequently.

The basic system includes the electronically controlled d.c. voltage source with a precise tunable output voltage, available on a coaxial output and additional two measuring taps for control measuring with an calibrated external d.c. voltmeter.

In this way the calibration may be referenced to a National Standard, e.g. to an approved DKD-testlab or the PTB.

At the start of the automatic calibration procedur the value of this d.c. charge voltage must be input to the measuring system as reference level for the calculations.

Calibration Record

The calibration results of a KAL 1000 impulse calibrator with shapes STEP, ZEIT, LI, LIC und SI performed with an high-resolution digital impulse voltage measuring system TR-AS® 200-12 is documented in parts in the following calibration record:

Impulse-Calibration-System RIG 1000

Calibration-Software TRAS-TEIL

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Calibration STEP											
Ch	Uo	Un	Usm	Fi	δm	StA	Max	MaxU	tmin	tmax	
	V	V	V	Un/Usm	%	%	%	%	µs	µs	
1	16	-15.89	-15.86	1.002	-0.16	0.06	0.62	0.10	0.25	1	
1	50	-49.65	-49.48	1.003	-0.34	0.02	0.55	0.05	0.25	1	
1	100	-99.3	-99.04	1.003	-0.26	0.02	0.60	0.03	0.25	1	
1	500	-496.5	-495.5	1.002	-0.20	0.01	0.55	0.02	0.25	1	
1	1000	-993	-986.9	1.006	-0.61	0.07	0.55	0.11	0.25	1	
1	16	-16	-15.96	1.002	-0.22	0.07	0.23	0.13	0.42	8000	
1	50	-50	-49.87	1.003	-0.27	0.02	0.24	0.04	0.42	8000	
1	100	-100	-99.74	1.003	-0.26	0.02	0.24	0.03	0.42	8000	
1	500	-500	-499.2	1.002	-0.17	0.01	0.24	0.02	0.42	8000	
1	1000	-1000	-995.5	1.004	-0.45	0.02	0.29	0.05	0.42	8000	

Calibration LI 0.84/60													
Ch	Uo	Un	Usm	δm	StA	T1n	T1	δm	StA	T2n	T2	δm	StA
	V	V	V	%	%	µs	µs	%	%	µs	µs	%	%
1	50	48.84	48.6	-0.48	0.02	0.839	0.832	-0.88	0.11	60.2	60.4	0.32	0.04
1	55	53.71	53.43	-0.52	0.04	0.836	0.829	-0.88	0.10	60.0	60.3	0.56	0.04
1	75	73.36	73	-0.49	0.02	0.834	0.824	-1.20	0.10	60.1	60.3	0.29	0.05
1	110	107.3	107.1	-0.22	0.02	0.835	0.828	-0.82	0.10	60.0	60.3	0.55	0.02
1	150	146.4	145.9	-0.33	0.02	0.836	0.828	-0.95	0.09	60.2	60.3	0.20	0.05
1	220	214.9	214.1	-0.35	0.03	0.839	0.830	-1.11	0.09	60.0	60.3	0.54	0.04
1	300	292.8	292.1	-0.24	0.01	0.841	0.831	-1.20	0.07	60.2	60.4	0.38	0.06
1	440	429.2	428.7	-0.11	0.03	0.840	0.832	-0.90	0.12	60.1	60.4	0.44	0.03
1	600	585.5	584.6	-0.15	0.02	0.841	0.834	-0.85	0.09	60.3	60.4	0.14	0.05
1	750	731.8	730.1	-0.24	0.02	0.843	0.836	-0.81	0.10	60.4	60.5	0.17	0.06
1	900	877.9	875.4	-0.29	0.03	0.843	0.836	-0.78	0.13	60.5	60.6	0.09	0.05
1	1000	976	972.7	-0.33	0.02	0.846	0.838	-0.95	0.07	60.1	60.6	0.88	0.03
1	50	-48.78	-48.58	-0.41	0.03	0.835	0.830	-0.64	0.10	60.0	60.1	0.19	0.02
1	55	-53.66	-53.43	-0.44	0.02	0.833	0.825	-0.94	0.07	59.9	60.2	0.44	0.03
1	75	-73.25	-72.98	-0.36	0.02	0.828	0.819	-1.07	0.09	59.9	60.1	0.27	0.04
1	110	-107.2	-106.9	-0.24	0.03	0.827	0.821	-0.71	0.13	59.9	60.1	0.34	0.05
1	150	-146.3	-145.8	-0.32	0.02	0.831	0.824	-0.81	0.11	60.0	60.2	0.36	0.05
1	220	-214.6	-214.1	-0.22	0.03	0.834	0.828	-0.75	0.11	59.9	60.1	0.41	0.04
1	300	-292.4	-292.1	-0.10	0.03	0.835	0.829	-0.72	0.12	60.1	60.2	0.22	0.04
1	440	-428.8	-428.7	-0.02	0.01	0.837	0.829	-0.96	0.08	60.0	60.2	0.41	0.04
1	600	-584.9	-584.3	-0.10	0.02	0.838	0.830	-0.98	0.07	60.2	60.2	0.07	0.03
1	750	-730.8	-729.7	-0.16	0.04	0.839	0.832	-0.85	0.15	60.2	60.4	0.33	0.06
1	900	-876.8	-875	-0.21	0.02	0.840	0.834	-0.71	0.08	60.2	60.4	0.28	0.04
1	1000	-973.9	-971.7	-0.23	0.02	0.841	0.834	-0.79	0.13	60.0	60.5	0.91	0.10

Calibration LIC													
Ch	Uo	Un	Usm	δm	StA	T1n	T1	δm	StA	TCn	TC	δm	StA
	V	V	V	%	%	µs	µs	%	%	µs	µs	%	%
1	100	76.4	76.68	0.36	0.06					0.502	0.506	0.84	0.06
1	200	150.5	150.9	0.28	0.08					0.498	0.501	0.52	0.05
1	300	225.3	226.1	0.35	0.08					0.500	0.501	0.36	0.04
1	400	300.2	301.4	0.40	0.06					0.501	0.503	0.41	0.03
1	600	450.7	453.5	0.61	0.07					0.503	0.505	0.45	0.05
1	800	600.8	603.8	0.50	0.05					0.503	0.506	0.51	0.02
1	1000	750.6	751.9	0.17	0.05					0.503	0.504	0.28	0.03
1	100	-76.48	-76.88	0.53	0.10					0.501	0.505	0.82	0.06
1	200	-150.7	-151.2	0.36	0.07					0.495	0.498	0.69	0.13
1	300	-225.8	-226.9	0.49	0.05					0.498	0.501	0.67	0.04
1	400	-300.8	-302.5	0.58	0.06					0.501	0.503	0.47	0.03
1	600	-451.7	-454.8	0.69	0.06					0.502	0.505	0.57	0.03
1	800	-600.3	-605	0.78	0.08					0.500	0.503	0.65	0.05
1	1000	-747.6	-750	0.32	0.06					0.497	0.498	0.20	0.04

Calibration SI 250/2500													
Ch	Uo	Un	Usm	δm	StA	T1p	T1p	δm	StA	T2n	T2	δm	StA
	V	V	V	%	%	µs	µs	%	%	µs	µs	%	%
1	50	42.33	42.56	0.54	0.03	247.60	249.000.58	0.16	2524.0	2530.0	0.24	0.09	
1	100	84.71	85.11	0.47	0.02	247.40	248.800.55	0.10	2526.0	2532.0	0.22	0.03	
1	500	422.9	426	0.74	0.04	247.70	248.400.28	0.11	2529.0	2532.0	0.13	0.06	
1	1000	845.6	851.3	0.67	0.03	246.90	248.700.75	0.09	2537.0	2532.0	-0.19	0.09	
1	50	-42.28	-42.42	0.38	0.04	247.20	248.400.47	0.07	2504.0	2502.0	-0.09	0.05	
1	100	-84.46	-84.85	0.47	0.02	247.00	248.000.39	0.11	2499.0	2504.0	0.18	0.06	
1	500	-421.6	-425	0.80	0.02	247.00	248.100.43	0.06	2503.0	2505.0	0.10	0.06	
1	1000	-843.8	-848.6	0.57	0.02	246.90	248.000.44	0.13	2512.0	2508.0	-0.16	0.05	

Calibration TIME					
Ch	Range	Time interval	δm	StA	Max
	V	µs	%	%	%
1	25	20000	0.0008	0.0001	0.0001

Ch	Range	Time interval	δm	StA	Max
	V	µs	%	%	%
1	10	20000	0.0138	0.0001	0.0001

Calibration of Impulse-Measuring-Systems according to IEC 60060-2

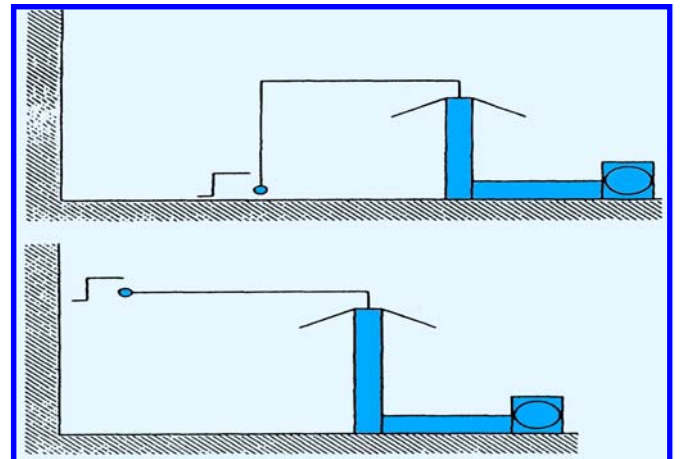
The automatic controlled calibration of complete measuring systems comprising an impulse voltage divider, necessary leads / measuring cable and the digital impulse voltage measuring system TR-AS®, follows by parameter method with help of the unit-step-voltage-generator RIG 1000 and the calibration software TRAS-TEIL.



Unit-Step-Voltage-Generator RIG 1000

At the parameter method, applicable for performance check or test, the impulse scale factor and the time parameters of the measuring system are determined by measuring and evaluating the step response of the measuring system. The result can be compared with the manufacturers specification or with performance tests or checks performed in the past.

For automatically calibration and generation of an calibration report the powerful software TRAS-TEIL with menu-oriented operations is available.



Test setup according to IEC 60060-2

Impulse-Calibration-System RIG 1000

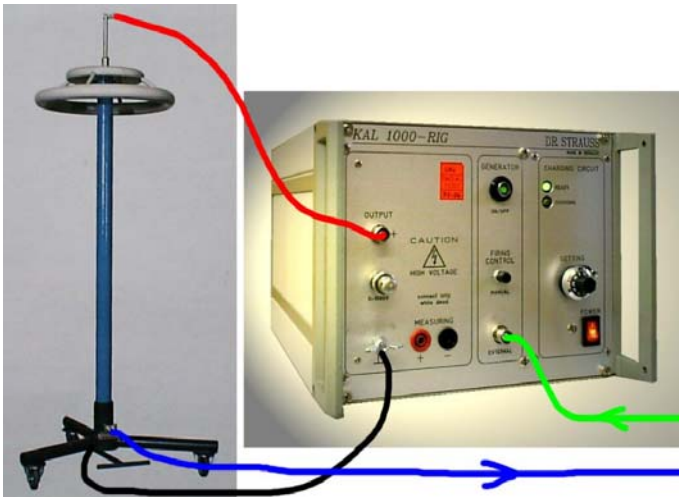
Calibration-Software TRAS-TEIL

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The determination of the impulse scale factor and the response parameters of the complete measuring system according to IEC 60060-2 is done with the unit step voltage generator RIG 1000 using a repetitive sampling method included in the software TRAS-TEIL, which allows sampling rates of 1 to 5 GHz corresponding to sampling intervals of 1 ns down to 200 ps with our digital recorders TR-AS®.

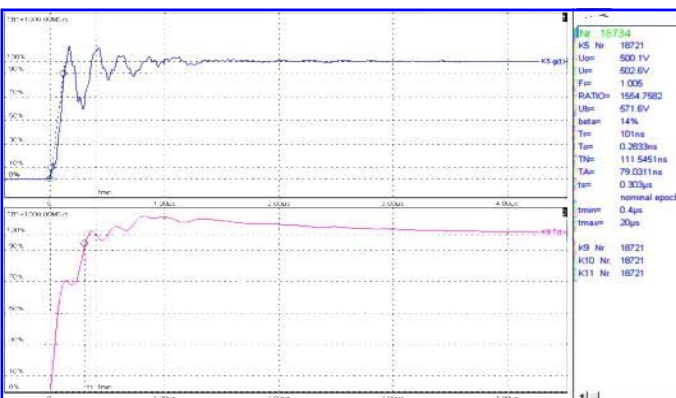


The unit step voltage generator RIG 1000 is controlled automatically by the digital impulse voltage measuring system TR-AS® with help of an inbuilt or completable relays.

For example, the performance check of an 3 MV impulse voltage divider in the h.v. testfield of an big transformer manufacturer was performed, the test results are shown in the following.

First of all the step response $g(t)$ is measured, whereby a sampling rate of 1 GHz corresponding to 1 ns time resolution yields a satisfying accuracy within a short testing time.

The response parameter of the measured step response $g(t)$ and the time behavior of the response time $T(t)$ by integration of the function $1-g(t)$ automatically is calculated by control computer of the TR-AS® measuring system.



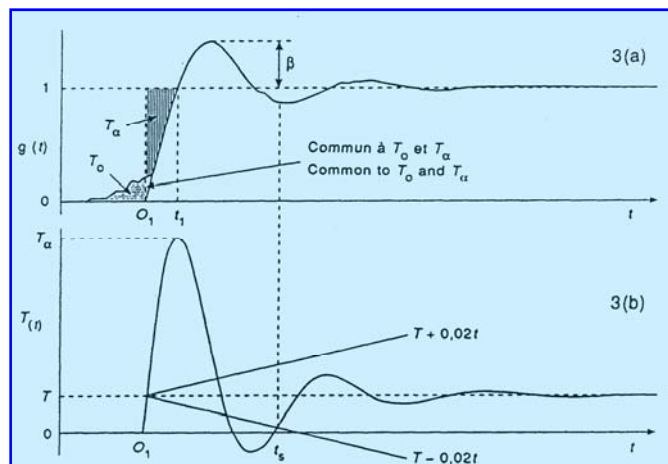
Calibration of a 3 MV impulse voltage divider in a big transformer testfield

The evaluation of the response time $T(t)$ follows inside of an selectable time intervall t_{min} to t_{max}

PARAMETER	ref. val.	dim	act. val.	dim	difference [%]	tolerance [%]	accepted
F	1.00		1.00		-0.01	± 1.00	YES
beta	14.00	%	14.00	%	0.00	± 30.00	YES
ts	0.30	µs	0.30	µs	0.00	± 20.00	YES
Tα	79.03	ns	78.16	ns	-1.10	± 20.00	YES
tr	101.00	ns	100.00	ns	-0.99	± 20.00	YES
T0	0.28	ns	0.30	ns	4.20	± 20.00	YES
TN	111.55	ns	110.63	ns	-0.82	± 20.00	YES

The calibration report includes the test results of the reference measurement REF in the past as also the actual test results of the AMS (approved measuring system). For each individual parameter the actual difference AMS/REF-1 is calculated and then compared with an earlier specified accepted differenc. The test result "accepted" or "not accepted" automatically is written to the rightmost column.

E.g., the determination of the impulse scale factor shows in the selected time interval 0.4 - 20.0 µs negligible deviations from the specified value of the manufacturer. The scale



Definition of response parameters and settling time

The calculated results of the measurement are:

- β overshoot
- F actual impulse scale factor
- O1 virtual origin, set to $t=0$
- Tα partial response time
- TN experimental response time at $t=t_{max}$
- ts settling time
- tmin begin of evaluation
- tmax end of evaluation

For automatically determination of the settling time the limiting functions $T \pm 0.02t$ are calculated and displayed together with the response time $T(t)$. The latest point of intersection of $T(t)$ with the limiting functions is the wanted settling time according to IEC 60060-2.

