Study Committee D1

Materials and Emerging Test Techniques

Paper D1-PS1-11116

Impact of Different Blocking Elements on the DC-Impulse Composite Waveform

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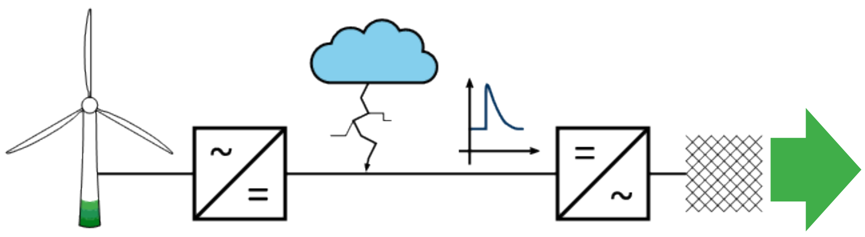
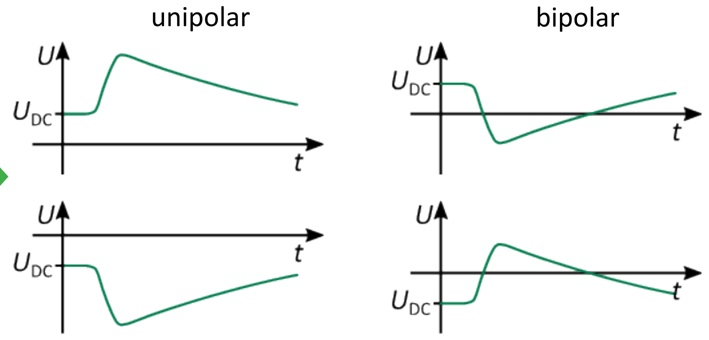
Motivation

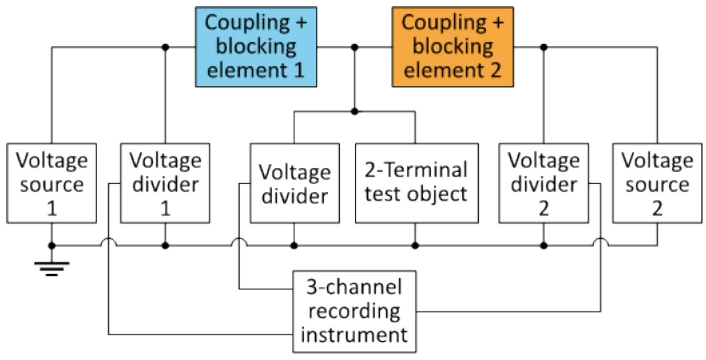


Dielectric tests with composite voltages necessary



State of the Art

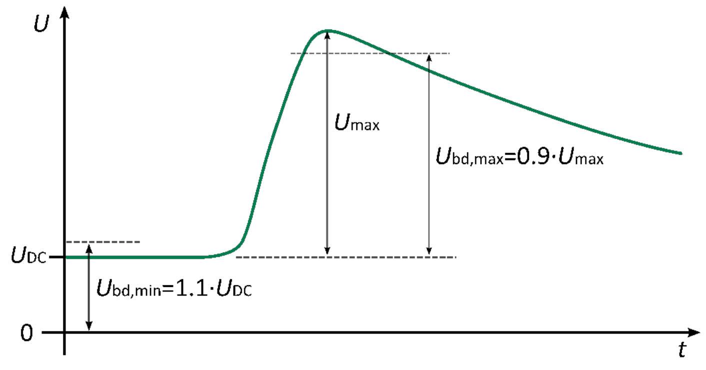
- IEC 60060-1 defines a general test circuit to superimpose two voltages to one test object (DUT)
- Coupling and blocking elements
  - protect the respective voltage source against the voltage of the other voltage source
  - must couple both voltages to the DUT and should not influence the composite voltage



- Possible coupling and blocking elements to superimpose DC and impulse voltages:

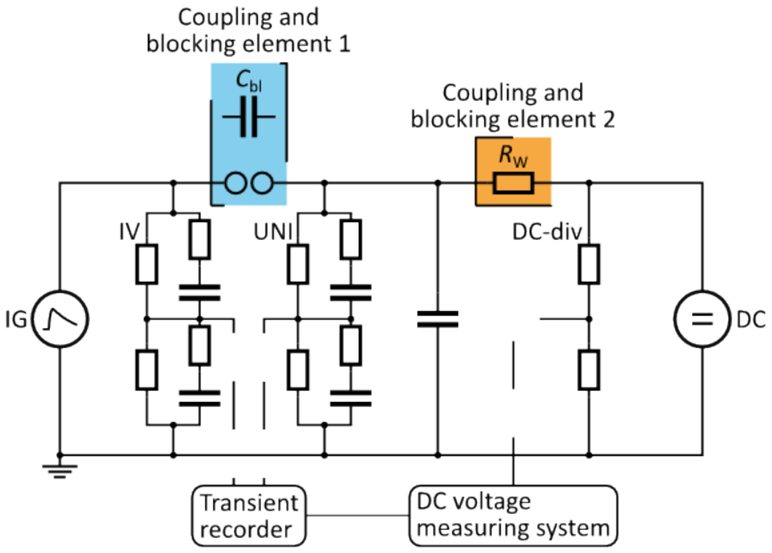
Voltage	Coupling and Blocking Elements
DC	…
Impulse	…

- Adjustment of the spherical spark gap ignition voltage U_{bd} according to IEC 60052



Experimental Techniques

- Implementation of the test circuit according to IEC 60060-1:



C_{bl}	Blocking capacitor	IG	Impulse voltage generator
C_{DUT}	Device under test	UNI	Universal voltage divider
DC	DC voltage source	R_W	Protection resistor
DC-div	DC voltage divider	SG	Spherical spark gap
IV	Impulse voltage divider		

- Combinations of the coupling and blocking elements investigated:

	Coupling and blocking element 2	
Coupling and blocking element 1	$R_{W1} = 6\ M\Omega$	$R_{W1} = 1\ M\Omega$
$C_{bl1} = 17.5$ nF	X	X
$C_{bl2} = 11.6$ nF	X	
SG: $d_1 = 25$ cm	X	X
SG: $d_2 = 10$ cm	X	

- Tests with and without short-circuited coupling and blocking element and with and without DC voltage
- Evaluation of the parameters according to IEC 60060-1 from 10 test executions :
  Test voltage U_p, peak time T_1 and time to half-value T_2

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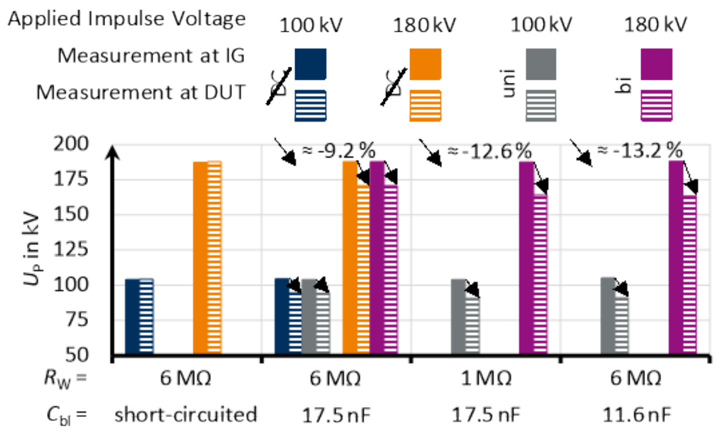
Experimental Results

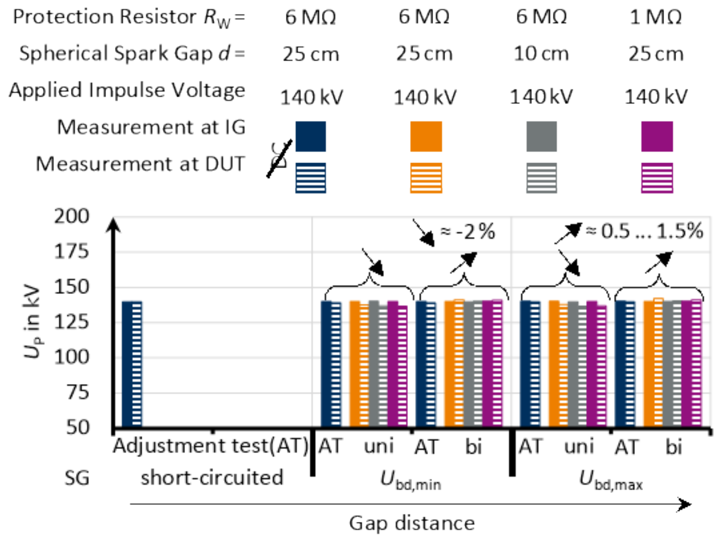
Blocking Capacitor

Spherical Spark Gap

Peak Voltage U_P



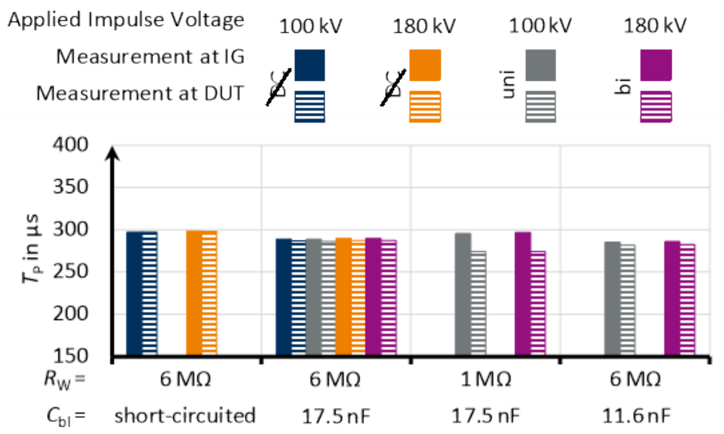
- Utilisation of a blocking capacitor leads to a reduction of the peak value U_P at the DUT
- Applied DC voltage has no influence on the peak value
- Small blocking resistor R_W does not fulfil its decoupling task ⇨ further reduction of the peak value U_P at the DUT



- Deviations of U_P between IG and DUT are significantly smaller when using a SG instead of a blocking capacitor

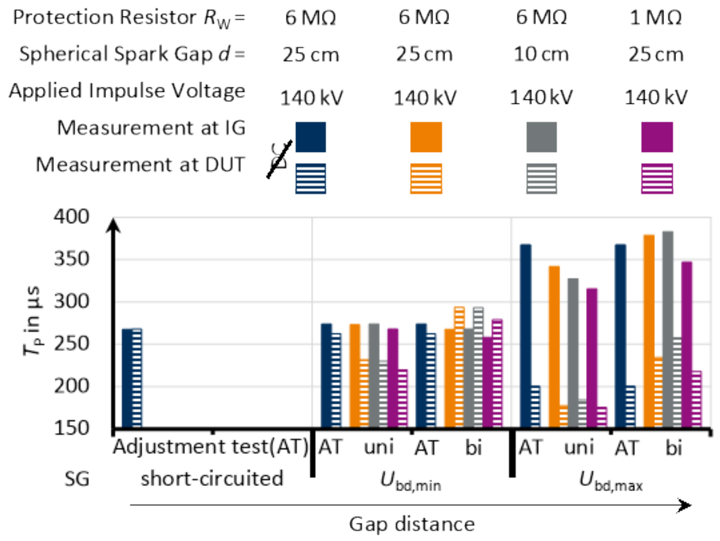
Peak Time T_P

- Shorter peak Times T_P can be measured at the IG and DUT, when a blocking capacitor is utilized (not short-circuited) ⇨ Smaller load capacitance because of the series connection of the blocking and DUT capacitance



- A smaller capacitance of the blocking capacitor leads to shorter peak times
- Applied DC voltage has no influence
- The small blocking resistor R_W does not fulfil its decoupling task ⇨ further reduction of the peak time T_P at the DUT

- Without applied DC voltage: Shorter peak times at the IG and larger at the DUT with increasing ignition voltage of the spherical spark gap



- Unipolar applied DC voltage: Further reduction of the peak times at the DUT
- Bipolar applied DC voltage: Increase of the peak time at the DUT

⇨ Reason is the different voltage behaviour at the DUT for bipolar and unipolar superposition

- ⇨ Unipolar: After ignition of the SG large steep voltage rise at the DUT
- ⇨ Bipolar: Discharge from DC-voltage

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Experimental Results (continued)

Blocking Capacitor

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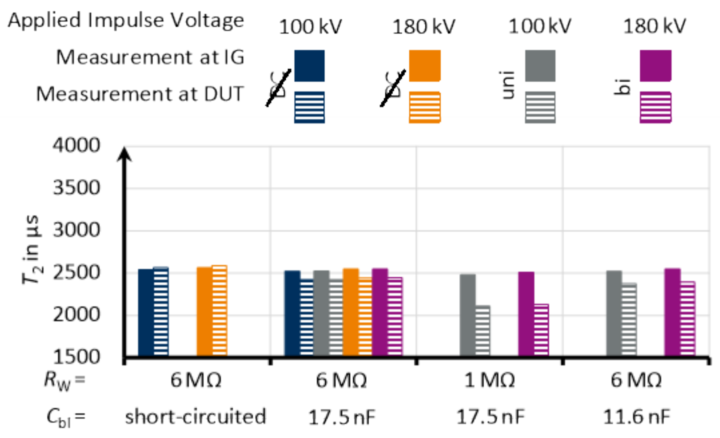
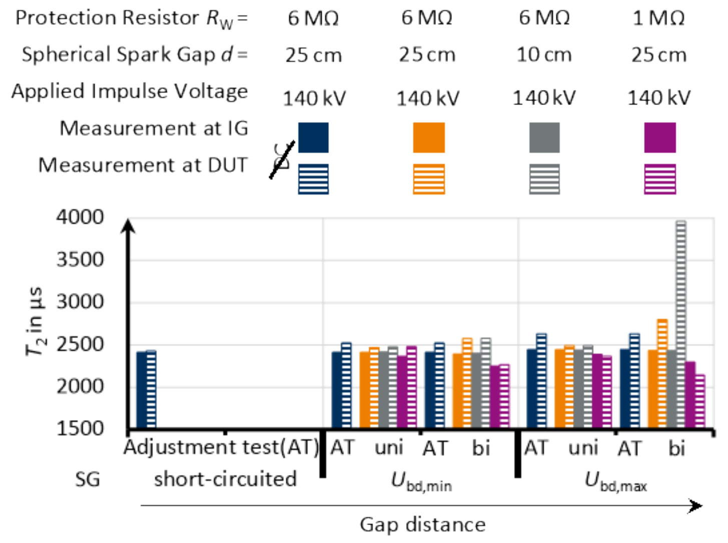
Time to Half-value T_2



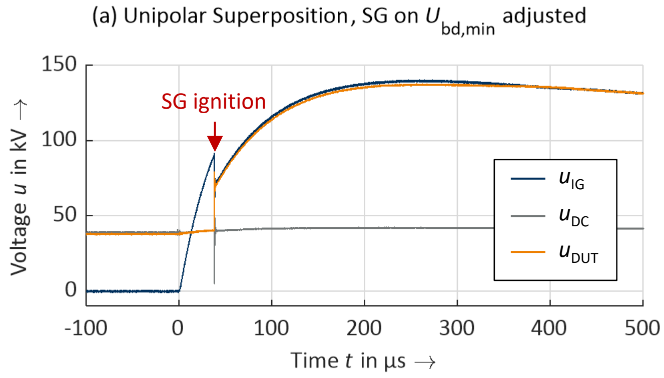
- The smaller the capacitance of the blocking capacitor, the shorter the time to half-value T_2 at the impulse voltage generator and the DUT
- With connected blocking capacitor the time to half-value T_2 at the DUT is shorter than at the IG
- Applied DC voltage has no influence
- Small blocking resistor R_W does not fulfil its decoupling task ⇨ further reduction of the time to half-value T_2 at the DUT

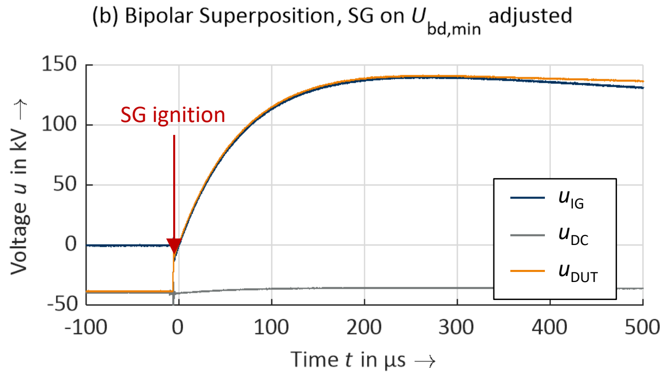


- Time-to-half-value T2 remains almost constant at the IG for all investigated sphere diameters, gap distances and protection resistors (T_2 = 2424 ± 33µs)
- Compared to the adjustment tests the time-to-half-value increases for unipolar and decreases for bipolar superposition of DC and impulse voltage
- Sphere diameter has no influence on the time to half-value T_2 (outlier for bipolar superposition because of extinguishing of the SG)

Selected composite voltage waveforms

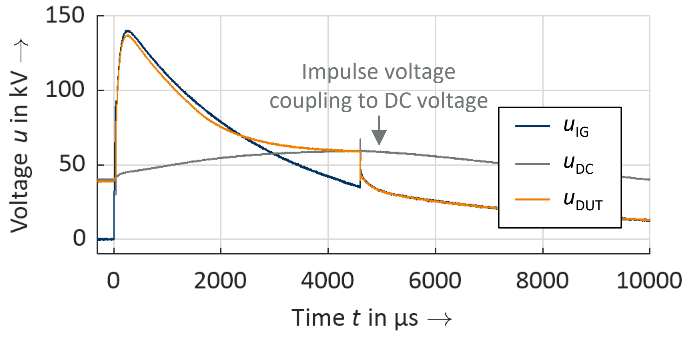
Uni- and bipolar superposition with spherical spark gap





- Differences in the time parameters between uni- and bipolar superposition because of the different ignition behaviour of the spherical spark gap

Small blocking resistor R_W = 1 MΩ and spherical spark gap



- Coupling of the impulse voltage to the DC voltage due to too low blocking resistance

Conclusion

- IEC60060-1 time parameter adjustment should be carried out with utilized coupling and blocking element
- Blocking resistor has to be chosen large enough to not couple the impulse voltage to the DC voltage
- Steep rise of voltage is not covered by the evaluation process of the time parameters according to the standard IEC 60060-1