Measuring Lightning Currents on Wind Turbines

J. Birkl, *DEHN+SOEHNE GmbH + Co. KG., Neumarkt, Germany*
E. Shulzhenko, *Group for Lightning and Overvoltage Protection, Germany*
F. Heidler, *University of the Federal Armed Forces Munich, Germany*
G. Diendorfer, *OVE Service GmbH/Dept. ALDIS Vienna, Austria.*

Abstract: This paper is dedicated to the question of measuring lightning current events on tall objects such as wind turbines. Because of their height, location at the open or uplands area, the probability of lightning strike increases significantly. Modern wind power plants with total height up to 200 m are able to trigger upward or ground-to-cloud flashes, especially during winter season, which are different from downward flashes. In general, upward lightning is critical for the air-termination system of wind turbine with regard to transferred charge, which can easily exceed the value of 300 As specified for lightning protection level I (LPL I) in the international standard IEC 62305 [1]. For proper operation and efficient maintenance regimes measurement of the lightning events on wind turbines is needed. The measuring principle, based on Rogowski coil sensors is presented in this paper. The data obtained from the measuring system allow to evaluate the effects of lightning strikes on wind turbines. Some specifics during the measuring of lightning events on tall objects are discussed as well. In particular, the peak value of lightning impulse currents, to be able to be measured, should be greater than 200 kA specified again for LPL I. Also upward lightning may have only a long duration initial continuing current (ICC-only), which is difficult to be detected by LLS and to be measured. Both of these lightning parameters have different effects on components of wind turbines, which are discussed in detail in the paper.

Keywords: Wind turbine, Upward lightning, Lightning current measurement

1. INTRODUCTION

The lightning current is the primary source for all thermal and mechanical damages caused by lightning. Besides that, the rate-of-rise of the lightning currents may induce overvoltages in electric and electronic systems or devices. The responsible IEC technical committee TC 81 “Lightning protection” defined maximum values of lightning current parameters as the common basic criteria for any lightning protection measures [1], [2]. In order to evaluate the effects of lightning strikes on structures, such as wind turbines (WT), it is necessary to measure the lightning currents flowing through the WT during a lightning flash.

IEC 61400-24 [3] briefly summarizes why it is advisable to equip WTs with lightning current measurement or detection systems. Such equipment provides:

- information to the operator on the level of lightning strikes that have affected the WT and to give input to operation and maintenance regimes,
- valuable data on lightning strikes to wind turbines and to assess the lightning magnitude / characteristics, contributing to risk assessment processes.

In order to use such lightning current measurement system for the definition of maintenance levels, it is necessary that the system gives information about the lightning current waveform or provides the relevant lightning current parameters. The peak current I_p, the transferred charge Q, the specific energy W/R, the duration T and the current steepness di/dt are the relevant lightning current parameters which need to be considered both for the design and the testing of lightning protection systems (LPS) and their components. In order to ensure that the lightning protection components provide their safety function throughout the complete lifetime, regular inspections and/or maintenance is a fundamental condition. For comparing the actual stress of LPS components with their expected service lifetimes, it is necessary to assess the real lightning current stress of the individual turbine.

Possible maintenance levels could be defined according IEC 61400-24 for example as follows:

1) Level 1 – non-critical condition i.e. no or minor damage or no immediate repair required
2) Level 2 – moderate condition which requires maintenance or repair as soon as possible
3) Level 3 – serious condition which requires immediate repair
4) Level 4 – severe / catastrophic damage

For a reliable maintenance regime based on the assessment of the real lightning current stress, the lightning current measurement systems should be designed to measure as much and as accurate as possible all lightning currents (discussed in clause 2).

A WT consists of numerous components, but the rotor blades are the most critical components with regard to lightning damage. The blades are reaching the highest point of the turbine and are most frequently hit by lightning [4]. Therefore, in this paper the lightning current effects on blades are the main focus. It should be mentioned that lightning currents affect all components of a WT, which are in the direct path of the lightning current: electrical and electronic systems and installations caused by a Lightning ElectroMagnetic impulse (LEMP) originated from the lightning

Contact Address:
Josef Birkl
DEHN Test Centre
DEHN+SOEHNE GmbH + Co. KG., Hans-Dehn-Str.1,
92318 Neumarkt, Germany
E-mail: josef.birkl@technik.dehn.de

current impulse. However, a complete description of all these phenomena is outside the scope of this paper.

2. LIGHTNING CURRENTS ON TALL OBJECTS

This paper is specially dedicated to the question of measuring lightning current events on tall objects such as WT. Because of their height and location, the probability of lightning strike increases significantly.

2.1 DOWNWARD LIGHTNING FLASHES

In general, it is assumed that downward flashes (downward cloud-to-ground flashes CG) place a greater stress on the object hit by lightning. Low buildings and constructions up to about 100 m are exclusively struck by downward lightning. The peak values are typically in the range of several 10 kA. Especially positive first strokes may exhibit high peak currents, exceeding the value of 100 kA. The recorded values of lightning peak current produced by a single lightning stroke are in the range of 2 kA to 300 kA. The maximum recorded values of transferred charge and specific energy are some hundreds of Coulombs (C) and, on very rare occasions, up to 20 MJ/Ohm [13], respectively. Fig. 1 shows examples of positive and negative downward lightning currents, adopted from Berger's measurements [5]. It can clearly be shown that due to the longer duration the positive return stroke transfers more charge to ground compared to the negative first return stroke.

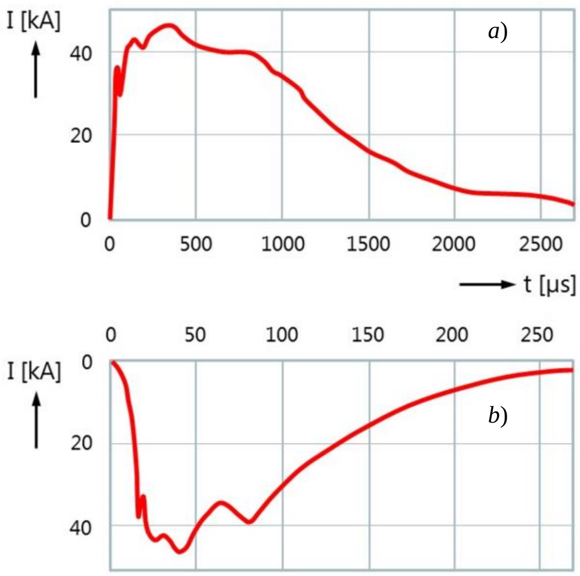

Fig. 1. Currents of *a*) first positive return stroke and *b*) first negative return stroke according to Berger (adopted from [2])

The lightning current parameters of downward positive return strokes are usually used for the design and testing of LPS and components of normal structures. The peak current I_p, the transferred charge Q, the specific energy W/R, the duration T and the current steepness di/dt are the relevant lightning current parameters to be considered. It was the intention of IEC TC 81 to cover the stress of about 99 % of all lightning events for lightning protection level (LPL) I. This resulted in the maximum values of lightning current parameters summarized in Table 1. The values are used for the design and testing of LPS components.

TABLE 1. LIGHTNING CURRENT PARAMETERS OF THE FIRST (SHORT) RETURN STROKE

Test parameter	Unit	LPL I
Peak current I_p	kA	200
Charge Q_{short}	C	100
Specific energy, W/R	MJ/Ω	10

The general requirement according to IEC 61400-24 is that the lightning protection of all subcomponents of WT shall be protected according to LPL I. Thus, a lightning current measurement system, installed in a WT needs to register the first stroke current of positive and negative downward lightning with peak values up to at least 200 kA.

In addition, the first (short) stroke in a downward CG flash may be followed by a continuing current (CC) and this current component also needs to be recorded by the measurement system. The presence of CC in positive flashes is very common [6]. The duration of CC in positive downward CG flashes is much longer than in negative downward CG flashes. In Fig. 2 the cumulative probability distributions of CC durations (greater than or equal to 3 ms) in negative and positive strokes is shown.

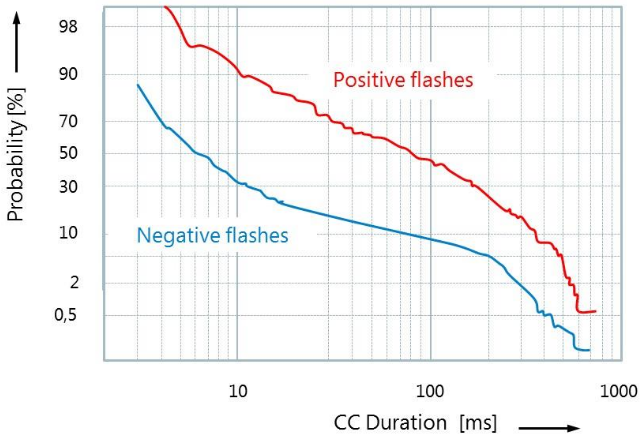

Fig. 2. Distribution of continuing current duration of downward lightning adopted from [6]

This means, to cover both, steep first stroke currents as well as continuing current, the measurement system should operate over a wide range of frequency, ideally from DC up to the MHz-range. It means also that the recording time of the measurement system shall be at least 1 second.

2.2 UPWARD LIGHTNING FLASHES

In case of upward flashes, it is very important that the long duration current, or also classified as Initial-Continuous-Currents (ICC), is considered. Long duration currents might include superimposed impulse currents, also classified ICC pulses and might be followed by subsequent impulse currents, also classified as return strokes (RS) – see Fig. 3.

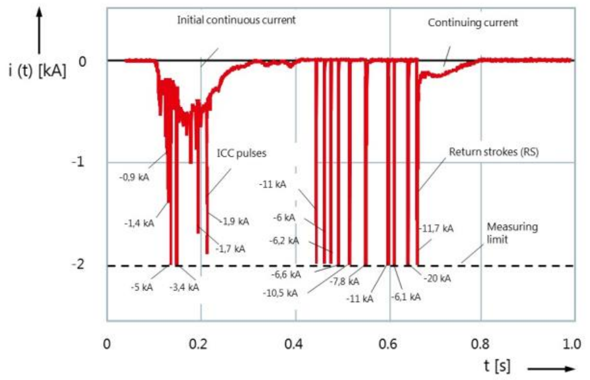

Fig. 3. Current of a negative upward lightning measured at the Peissenberg tower, Germany [7]

The process of upward lightning flashes for conventional tall buildings such as telecommunication towers is well understood and described in the literature [e.g. 7]. The electric field at the top of a structure increases with the object height. At a tall building the electric field may be enhanced to such an extent that an upward leader starts from the top of it. To exceed the critical electric field strength, the object must have a height of about 100 m at minimum. The upward propagating leader is associated with an ICC flowing through the object [7].

Examinations on WT have shown that upward lightning activity might be influenced by other parameters, such as winter lightning activity as well as by local topographic conditions where the wind farm is erected, e.g. terrain complexity and height above sea level [8], [9]. The results of this research has been taken into account during preparing the latest committee draft of IEC 61400-24 Edition 2 [10].

The committee draft proposes a methodology to determine average annual flash rate to turbines of a wind farm by increasing the location factor to consider upward lightning from WT. IEC 61400-24 Edition 2 proposes a methodology to estimate the average annual flashes or strokes to WT and upward lightning activity in WT. Experience has shown that even WT located in flat terrain without winter lightning activity can be affected by significant percentages of upward lightning activity. Upward lightning activity according to the mechanisms described in the draft standard may be influenced by winter lightning activity as well as by local topographic conditions where the wind farm is erected. Based on this hypothesis the percentage of upward lightning under winter lightning conditions for typical WT heights in flat terrain, is summarized in Table 2.

TABLE 2. RANGE OF UPWARD LIGHTNING ACTIVITY AS A FUNCTION OF WINTER LIGHTNING ACTIVITY FOR WIND FARM LOCATED IN FLAT TERRAIN

Winter lightning activity level	Percentage of upward lightning
High activity	80 – 99 %
Medium activity	40 – 90 %
Low activity	20 – 50 %
No activity	10 – 40 %

It can be concluded that for most locations more than 50 % of all lightning flashes on tall buildings are upward lightning. This estimation is supported by numerous scientific measurements. In [7] it is reported that only 1 out of 117 recorded flashes at the Peissenberg Tower in Germany did not start with an initial continuing current.

Similar results are reported from the Gaisberg Tower in Austria. Almost 100 % of the flashes are tower initiated upward lightning flashes starting with an ICC [11], [12].

Most of these scientific measurements are performed on very exposed sites. For WT more realistic values could be found in the NEDO-report [13]. In this report, all lightning incidents on 23 WT with installed measuring equipment are considered. The main results of the NEDO-report are briefly recapitulated. The lightning observations involve the period from 2008 to 2013. In total about 832 lightning events were registered, 687 events from them with available / detected lightning current data (I_p, Q, W/R). 513 (75 %) out of the 687 events could be clearly identified as upward lightning due to the presence of the ICC-currents.
Table 3 gives an overview of the total transferred charges of the 513 ICC. Roughly 1 % of the recorded charges exceeded 600 Coulombs.

TABLE 3. CHARGE TRANSFER OF THE EXAMINED ICC IN THE NEDO-PROJECT

Charge Q, As	Number	Percentage from total events
$Q < 100$	304	59.2
$100 \leq Q < 200$	162	31.6
$200 \leq Q < 600$	43	8.4
$Q \geq 600$	4	0.8

It has to be noticed, that the system used for the NEDO-campaign recorded only for 0,5 seconds with a pre-trigger time of about 100 ms. Therefore, the transferred charge is even higher for those ICC which lasted longer than the recording time of measuring system. For the cited Peissenberg- measurements, two flashes out of 117 recorded events exceed the total recording time of 1 second [7].

It can be concluded, that a recording time of ≥ 1 second seems to be necessary for lightning current measurement system in order to cover the complete time of current flow.

2.3 ICC-ONLY DISCHARGES

In [14] it is reported that a significant fraction of upward lightning, different from natural of downward lightning, consists of an upward propagating leader (ICC) only and is not followed by any return strokes. This type of lightning current of ground-to-cloud flash, initiated from tall objects, is classified as Initial Continuous Current Only, ICC-only. The currents of the upward lightning are free from any superimposed impulse current or subsequent impulse current. According to [14], around 47 % of all recorded discharges at the Gaisberg Tower are „ICC-only type discharges.

A similar number has been reported from measurements at the Peissenberg Tower. Around 75 % of the negative flashes had no subsequent impulse current and around 66 % of these flashes could be classified as ICC-only-discharges [6].

In order to evaluate if the high percentages of ICC-only type discharges, given above, are related to the very exposed sites of Gaisberg and Peissenberg, the NEDO report has been analyzed to estimate the percentages of ICC-only type discharges during the measurements in Japan. As the original data were not available, the percentage of discharges with a peak value below 5 kA has been used for this categorization. The results are given in Table 4 for both polarities of lightning current.

TABLE 4. PEAK CURRENT DISTRIBUTION OF LIGHTNING CURRENTS IN NEDO-REPORT

Smaller than, kA	Percentage from total events
< 5	53
< 3	32
< 2	16

It has to be noticed that some of the ICC-only type discharges, recorded for example at the Gaisberg Tower, showed a total transferred charge exceeding 300 As. In case of WT those flashes could have certainly a severe impact on blades and could cause potential blade damage. Therefore, it is mandatory that lightning current measurement systems installed at WTs are able to collect also ICC-only type discharges of low amplitude (several tens of amperes) and especially its total charge content. This also means, that the actual trigger level of the measurement system needs to be low enough to detect as much as possible of ICC-only type flashes.

Another aspect of such ICC-only type of flashes, which has to be taken into account, is that such lightning events are not detected by lightning location system (LLS) [14]. LLS are typically detecting radiated fields from return strokes and therefore the performance in detecting upward lightning is very much different compared to downward lightning. In [14] overall detection efficiency of 43 % has been reported for the Gaisberg Tower measured lightning events. 338 out of 715 tower recorded flashes were classified as of ICC-only type discharges and none of them has been detected with LLS. This is important to consider when the data from LLSs are used to investigate lightning events as the cause of damage on WT (e.g. damage to rotor blades).

2.4 ACCUMULATED CHARGE

Considering the surface erosion of air-termination systems due to the transferred charge, the damage is cumulative – see clause 4. The accumulated charge is defined as the totally transferred charge of several flashes to the WT during a single thunderstorm or/and as the total charge resulting from flashes during a defined period. An extreme example is described in [15]: 20 flashes to the Gaisberg Tower during one night in February, 2005 (winter season) were reported. The 20 flashes to the tower within 5 hours period transferred a total charge of more than 1.800 coulomb to ground – see Table 5. In this particular case the maximum charge transferred to ground by an individual flash was 385 C, which – according to IEC 62305-1 – exceeds the charge of the long duration current of LPL I almost by the factor 2.

TABLE 5. FLASHES RECORDED AT GAISBERG TOWER DURING A SINGLE STORM IN 2005 [15]

№	Date	Time (UTC)	Total flash charge, C	Flash duration, ms
1	12.02.2005	22:36:25.7177557	385	720
2	12.02.2005	22:37:35.2847776	41*	800*
3	12.02.2005	22:42:16.3270326	305*	800*
4	12.02.2005	22:44:39.1948516	192	545
5	12.02.2005	22:45:13.0403521	44	180
6	12.02.2005	22:45:51.9393443	63	760
7	12.02.2005	22:47:02.7003477	87	425
8	12.02.2005	22:49:07.0143733	116	670
9	12.02.2005	22:50:05.2234882	12	120
10	12.02.2005	22:51:01.4220826	60	530
11	12.02.2005	22:53:37.7474034	51	665
12	12.02.2005	22:58:31.1188651	109*	800*
13	12.02.2005	23:03:00.3350503	21	470
14	12.02.2005	23:17:26.3692610	34	590
15	12.02.2005	23:42:56.3492248	64	550
16	12.02.2005	23:53:10.5239686	69	420
17	12.02.2005	23:56:03.6235213	40	310
18	13.02.2005	00:00:26.8253293	60	580
19	13.02.2005	03:20:11.7672662	46	440
20	13.02.2005	03:21:50.9704771	14	300
Total charge			**1.813**	

* – Flash current lasted > 800 ms which is the maximum recording time

The accumulated charge for each of the observed WTs in Japan, including all lightning events, has been also derived from the already cited NEDO-report – see Table 6. The results are considered in the latest draft of IEC 61400-24 Edition 2. In the testing section of this draft various test levels for the maximum accumulated charge are described. Higher test levels are proposed for locations with expected winter lightning exposure. It is necessary to compare the accumulated charge measured at a specific WT during a certain period with the tested charge level of this turbine. Therefore, it is mandatory, that the lightning current measurement system provides data about the accumulated charge. Based on this information, the maintenance of the turbine can be adjusted properly, as it is described above in clause 1.

TABLE 6. ACCUMULATED CHARGE FOR EACH OBSERVED WT DERIVED FROM NEDO-REPORT [13]

WT	Observation from 12.2008 to 02.2013, C	Average in one year, C
Iwata	8.10	1.91
Muroran	62.20	14.64
Setana	303.60	71.44
Suttsu	332.10	78.14
Shibata	428.80	100.89
Sakata	631.70	148.64
Fukui	1031.30	242.66
Shiga	1321.10	310.85
Masuda	1373.60	323.20
Suzu	1402.00	329.88
Mitane	1572.80	370.07
Joetsu Unit 1	1873.40	440.80
Uchinada	1903.30	447.84
Hokuei	2132.10	501.67
Shonai	2655.60	624.85
Awara	2998.90	705.62
Yurihonjo	3100.70	729.58
Joetsu Unit 3	3108.40	731.39
Tottori	3998.90	940.92
Nyuzen	6708.90	1578.56
Oyabe	6834.50	1608.12
Oga	8738.50	2056.12

It has to be noted that the very high accumulated charge, reported in Tables 5 and 6 applies especially for areas with winter lightning. The cold season promotes the multiple inception of upward lightning from tall structures. This is highly relevant for WT.

In conclusion, a lightning current measurement system for WT must be able to record several flashes and process the corresponding data during a single thunderstorm. It is also required that a measurement system provides information about the accumulated charge totally transferred to ground during a specified period.

3. EFFECTS OF LIGHTNING CURRENTS – LIGHTNING DAMAGE

In this clause, we summarize the different effects of the various lightning current components on LPS. Due to these very different effects, it can be concluded that it is necessary to measure all of the various lightning current parameters described in clause 2.

Annex D of IEC 62305-1 describes the main effects of lightning currents [1], [2]. For the LPS of WT, mainly two lightning current components are considered [3]:

- Impulse current of the first positive stroke
- Long duration current of the upward flash

3.1 FIRST POSITIVE RETURN STROKE CURRENT

The currents of first positive return strokes of downward flashes are the main problem regarding ohmic heating and mechanical effects of the air-termination and down-conductor system. In general, the first positive impulses are the most severe stress on connection components due to combined stress related to thermal, mechanical and arcing effects.

Due to the fact that these various effects are determined by the current peak I_p and the specific energy W/R, it is mandatory that the measurement systems record these parameters.

In WT all components in the current path(s) between the air termination system and the WT's earthing system need to withstand the effects of first positive return stroke current. This includes the down-conductor and its connections in the rotor blade and bearings including possible sliding contacts, brushes and also surge protection devices (SPDs). All these components shall be designed and selected in proper way to conduct the share(s) of lightning current.

Thus it would be advantageous, if a measurement system provides not only information about the total lightning current which flows due to a direct strike to the WT, but gives also additional information about the lightning current distribution, the point of strike, etc. This information would be helpful to determine the actual path for the lightning current from the point of strike to ground.

3.2 LONG DURATION CURRENT

Material melting and erosion at the attachment point of air-termination systems is the main effect of long duration currents.

For WT, placed in certain geographical areas where they are exposed to high numbers of upward lightning particularly during winter, it may be relevant to increase the required durability of air termination systems (e.g. receptors) with regard to flash charge to more than the requirements of LPL I (Q_{flash} = 300 C). The charge is responsible for the wear (melting) of materials and therefore influences the need for maintenance of air termination systems. In WT, this melting effect is especially important for the lifetime of the receptors integrated in the rotor blades. Fig. 4 gives an example of such melting effects due to direct lightning flashes to such a blade receptor.

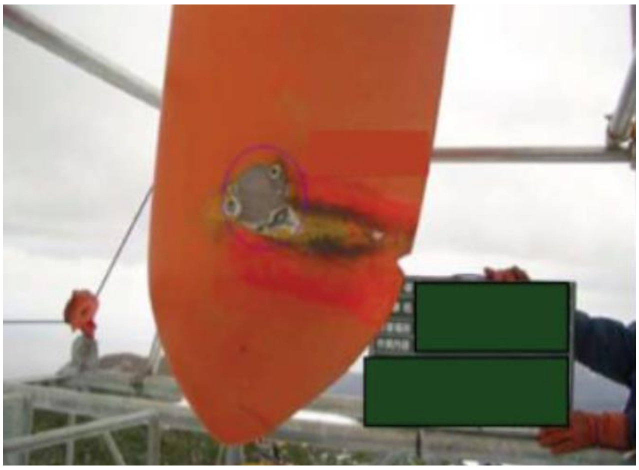

Fig. 4. Melting effects on blade receptor [16]

As pointed out in IEC 62305 for air termination systems, the erosion attachment point is a relevant failure mechanism which needs to be considered by simulating the effects of lightning on LPS components. Therefore, IEC 61400-24 describes an arc entry lightning current test to determine the direct (physical damage) effects that may result at the locations of possible lightning channel attachment to a blade.

Previous laboratory experiments based on this standardized test arrangement showed that the melting effects of impulse currents representing lightning currents of positive or negative downward return strokes, show a different appearance compared to long duration currents reprensenting upward flashes. Meltings of metal sheets caused by impulse currents show a large melted area. The melted material is spread over a large area with diameters of several cm up to 10 cm. In contrast meltings of metal sheets caused by long duration currents show a smaller, but deeply melted area. [17].

These general findings could be confirmed by repeating these investigations on samples representing blade receptors.

A preliminary test with an single impulse current with 200 kA of peak current and the waveform 10/350 µs resulted in melting effects as shown in Fig. 5. The melted areas are surrounded by a zone of splashed material -see the large circle in Fig. 5. However, the erosion caused by impulse current occurs only at one single attachment point – see the small circle in Fig. 5.

Fig. 5. Melting effect of an 200 kA 10/350 µs impulse current test

In comparision, Fig. 6 shows the melting effects of a receptor sample tested - once with a long-duration current of 300 Colombs for 0.5 seconds. Due to the longer time of current flow compared to the impulse current, the erosion caused by long current occured at several attachment points – small circles.

Further and more detailed analysis and testing seems to be necessary. However, it can be concluded, that the melting effects of impulse currents and long duration currents are different. A measurement system which allows to distinguish between those two different lightning current components would be helpful for further field analysis of real world lightning incidents.

Fig. 6. Melting effect of long duration current with the charge of 300 As and the duration of t=0,5 s

4. LIGHTNING CURRENT MEASUREMENT SYSTEM WITH ROGOWSKI COILS

The various lightning current components described in this clause have been recorded with a measurement system using Rogowski coil sensors. Lightning current measurements by specially designed Rogowski coils is a well-known and approved method [18]. Because of the proper chosen frequency range for Rogowski coil suitable for ICC, the system on the basis of Rogowski coil can depict the ICC shape very accurately by ignoring the lightning strokes during time integration, which could cause a significant failure [19].

In order to verify the accuracy of measurement system, a comparative measuring with ALDIS/Austria lightning research group on a communication tower on Gaisberg has been carried out. This showed a sufficient accuracy of the measuring unit based on Rogowski coils. The range of lightning detection of the measuring unit is enlarged due to the usage of two Rogowski coils per one location: one for effective measurement of impulse currents and another one for continuous currents [20].

4.1 MEASUREMENT OF DOWNWARD LIGHTNING

Fig. 7 shows the recorded impulse current of a negativ downward lightning to the Gaisberg tower measured by both systems, the scientific measurement system of ALDIS and the mobile lightning current measuring system of DEHNusing Rogowski coils. The visual comparison shows a good agreement of the current waveforms. The recorded negative downward flash has a maximum current of about 29 kA and a charge of about 4.4 As. A second slowly rising negative lightning current of about 5 kA is superimposed over the decreasing impulse current. In lightning research this characteristic lightning current component is also referred to as M-component. Both systems recorded this subsequent current. impulse.

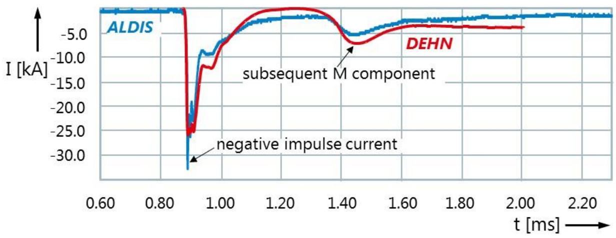

Fig. 7. Measurement of the current of a negative downward first return stroke including M-component

4.2 MEASUREMENT OF UPWARD LIGHTNING

As the current oscillograms given in Fig. 8 show, the measurement system can also be used for the recording of long duration currents. Because of the proper chosen frequency range for Rogowski coil suitable for ICC, the system using a Rogowski coil can depict the ICC shape very accurate by ignoring the lightning strokes during time integration, which could cause a significant failure.

The lightning current characteristic shows a typical negative upward flash by an initial continuing current of negative polarity. The initial continuing current with an amplitude of some 100 A rises relatively slowly at the beginning and flows for a relatively long period of some 100 ms. This is a typical characteristic of negative upward flashes. Five impulse currents (ICC pulses) of negative polarity are superimposed over the continuing current. The ICC is followed by six return strokes (RS). One of the return strokes could be referred as a M component. A total discharge of about 50 As was determined

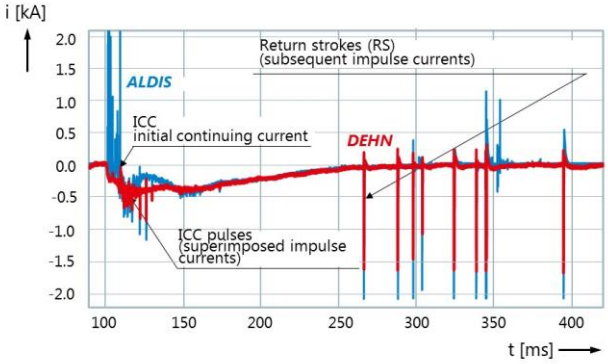

Fig. 8. Measurement of a negative upward stroke including superimposed ICC pulses and subsequent return strokes (RS)

4.3 CASE STUDY ICC-only

In January 2017, the measurement system on the basis of Rogowski coils, which has been installed on the Gaisberg Tower, recorded the long duration current shown in Fig. 9. This lightning current can be classified as a typical ICC-only event as this lightning current does not include any superimposed ICC pulses and shows also no subsequent return stroke current. The peak value of the lightning current analyzed for this case study was around 550 Ampere. The total time of current flow did result in a charge transfer of around 70 Coulombs. In case of WT rotor blades such a lightning current usually may not result in any severe blade damage. However, such an incident adds a signification input to the accumulated charge.

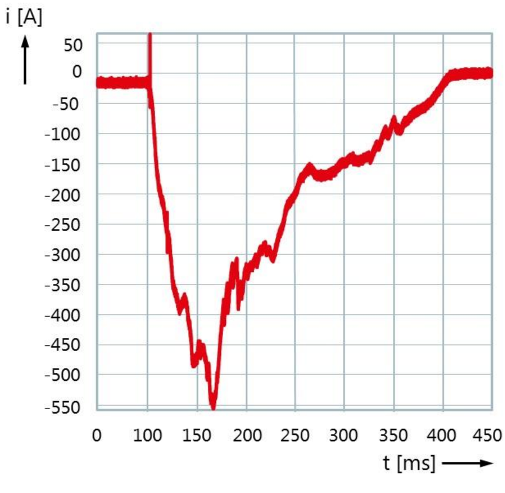

Fig. 9. Case study: ICC-only measured at Gaisberg Tower on January 5th, 2017

As Fig. 10 shows, this lightning flash on January 5th, 2017 was not detected by the lightning location system (LLS).

Fig. 10. Case study: No lightning activity detected by LLS at Gaisberg Tower on January 5th, 2017

In order to verify, that the recorded current is no misclassification, the E-field record from a field mill close to the Gaisberg Tower (170 m) has been analyzed. Fig. 11 shows the recorded E-field during the lightning strike. The sharp change of the E-Field is significant and can be considered as the typical change of the E-field during a direct strike to the tower.

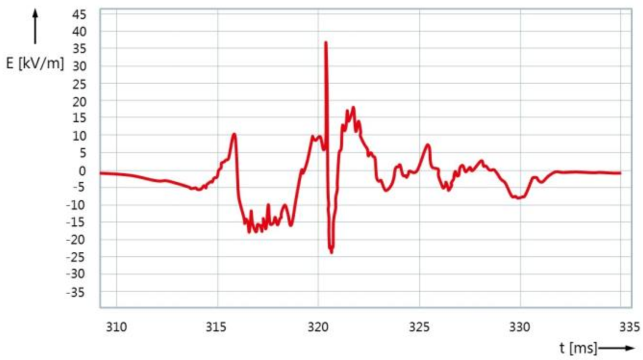

Fig. 11. Case study: recorded E-field by a field mill at Gaisberg Tower on January 5th, 2017

This case study shows exemplary the occurrence of ICC-only type discharges of upward lightning which are typically not detected by LLS but might have the potential for severe blade damage. Therefore, a lightning current measurement system for WT should be able to detect also ICC-only type lightning.

5. CONCLUSIONS

The main purpose of this paper is to provide the essential information for designing of lightning current measurement system for wind turbines, which is capable to measure all lightning events. Thus, it was important to review and summarize important parameters of all possible lightning events which can trigger a modern wind turbine. Particularly, the tall buildings and constructions are able to trigger so-called upward going flashes, which are different from the performance of the detection and measurement of downward flashes. Therewith, the article answers following basic questions:

Why is it advisable to install lightning current measurement systems in wind turbines?

- It can be expected that wind turbines experience in many locations a high number of direct lightning flashes due to the exposed location and the increasing height of wind turbines;
- Lightning current measurements can provide valuable input to operation and maintenance regimes;
- Data of lighting current measurements systems allow the evaluation of the effects of lightning strikes on wind turbine.

Why is it necessary to measure lightning currents ≥ 200kA peak?

- LPS of wind turbines are usually designed for at least lightning protection LPL I, considering first positive strokes. These currents are the most severe stress due to thermal and mechanical effects.

Why is it necessary to measure long duration current and especially ICC-only type discharges of upward lightning?

- It is expected that a very high percentage (50 … 90 %) of direct flashes to wind turbines are upward lightning;
- Long duration current can cause possible damage to blades due to erosion effects;
- The detection efficiency of lightning location systems of ICC-only type discharges is very low.

Why is it necessary to provide information about accumulated effects?

- Wind turbines might experience several direct flashes during a single thunderstorm;
- Lightning damage, especially surface erosion is cumulative.

The measuring principle, based on Rogowski-coil sensors presented in this paper allows to measure the lightning current with sufficient accuracy in comparison with the scientific lightning measurement system. This applies to the time characteristic of the lightning currents, the number and magnitude of the impulse currents and the charge of the lightning flash.

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