UNIVERSITI PUTRA MALAYSIA

DISTRIBUTION OF TRANSIENT OVERVOLTAGE IN WIND TURBINE SYSTEMS UNDER DIRECT LIGHTNING STRIKES

REBAZ JAMAL AHMED

FK 2014 11

DISTRIBUTION OF TRANSIENT OVERVOLTAGE IN WIND TURBINE SYSTEMS UNDER DIRECT LIGHTNING STRIKES

By

REBAZ JAMAL AHMED

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

July 2014

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DEDICATION

To the bright memory of **Bakhtiyar J. Thenon**

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DISTRIBUTION OF TRANSIENT OVERVOLTAGE IN WIND TURBINE SYSTEMS UNDER DIRECT LIGHTNING STRIKES

By

REBAZ JAMAL AHMED

June 2014

Chairman: Chandima Gomes, PhD

Faculty: Engineering

Wind turbines are tall structures, and the reflections of a direct lightning at various interfaces have a significant effect on the voltage distribution; hence they should be taken into account in the computation models. Thus, this thesis contains a brief introduction to lightning, lightning discharge process and the consequences of a direct lightning strike to an elevated structure (such as a wind turbine), an analysis on the effects of overvoltage produced by electromagnetic environment, and the effects of the reflections.

All parts related to the power generation in a wind turbine, including step up transformers are modeled by lumped parameters using the Matlab/Simulink software. The transient response is obtained by applying the lightning impulse current to the equivalent circuit under several values of the grounding resistance (i.e. 1 ohm, 10 ohm and 20 ohm) and several cable sheath grounding methods with different lightning strike waveforms.

For the channel base lightning representation, many current functions were considered in the past. Some of these functions were found to have problems related to their discontinuities or the discontinuities of their derivatives at the onset. Such problems appear in the double exponential function and its modifications. However, these problems have been solved in Heidler functions, where they are used and modeled for the purpose of this study.

The main contribution of the thesis is that; real lightning current source parameters have been used for the lightning current source which in the other studies only standard parameters is used and they donot resemble the direct lightning current, and this causes underestimation of the results.

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The results show that the location of the cable shield grounding, the lightning current type and the grounding resistance values have significant influence on the produced overvoltage at the input and output of transformer terminals. For instance if the cable shield is grounded from both the top and the bottom ends of the transformer, the lowest overvoltage is obtained on the transformer terminals Also, appropriate surge protection devices are designed to reduce harmful effects due to dangerous overvoltage impulses. And it's shown that with these surge arresters the overvoltage values are lowered to a safe level.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGAGIHAN VOLTAN LAMPAU FANA DALAM SISTEM TURBIN ANGIN SEMASA PANAHAN KILAT LANGSUNG

Oleh

REBAZ JAMAL AHMED

Jun 2014

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Turbin angin adalah struktur tinggi, dan pantulan kilat langsung di pelbagai antara muka mempunyai kesan penting ke atas pengagihan voltan; oleh itu mereka perlu diambil kira dalam model pengiraan. Oleh itu, tesis ini mengandungi pengenalan ringkas kepada kilat, proses pelepasan kilat dan akibat mogok kilat langsung kepada struktur bertingkat (seperti turbin angin), analisis mengenai kesan-kesan voltan yang dihasilkan oleh persekitaran elektromagnet, dan kesan-kesan pantulan.

Semua bahagian yang berkaitan dengan penjanaan kuasa di turbin angin, termasuk langkah sehingga pengubah dimodelkan oleh parameter tergumpal menggunakan perisian Matlab / Simulink. Sambutan fana diperolehi dengan mengenakan semasa kilat gerak hati ke litar setara di bawah beberapa nilai-nilai rintangan pembumian (iaitu 1 ohm, 10 ohm dan 20 ohm) dan beberapa kaedah kabel sarung asas dengan bentuk gelombang yang berbeza kilat.

Bagi perwakilan saluran asas kilat, banyak fungsi semasa dianggap pada masa lalu. Antara fungsi-fungsi ini didapati mempunyai masalah yang berkaitan dengan tidak berterusan mereka atau tidak berterusan derivatif mereka di permulaan. Masalah seperti muncul dalam fungsi eksponen berganda dan pengubahsuaian itu. Walau bagaimanapun, masalah ini telah diselesaikan dalam fungsi Heidler, di mana ia digunakan dan model untuk tujuan kajian ini.

Sumbangan utama tesis ialah; kilat parameter sumber semasa sebenar telah digunakan untuk sumber semasa kilat yang pada kajian-kajian lain hanya parameter standard digunakan dan mereka donot menyerupai semasa kilat langsung, dan ini menyebabkan memandang rendah keputusan.

Keputusan menunjukkan bahawa lokasi asas perisai kabel, kilat Jenis semasa dan nilai rintangan pembumian mempunyai hubungan yang signifikan voltan yang dihasilkan di input dan output terminal pengubah. Sebagai contoh jika perisai kabel adalah berasaskan dari kedua-dua bahagian atas dan hujung bawah pengubah, voltan yang paling rendah diperolehi pada terminal pengubah Juga, peranti perlindungan lonjakan yang sesuai direka untuk mengurangkan kesan negatif kerana impuls voltan berbahaya. Dan ia menunjukkan bahawa dengan arresters lonjakan nilai voltan diturunkan ke tahap yang selamat.

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ACKNOWLEDGEMENTS

The deepest gratitude is to ALLAH (Subhanahuwata'ala) who guided and aided me to make this work possible and to his mercy that enabled me to conduct my studies with patience.

I feel deeply indebted to my supervisor, Prof. Dr. Chandima Gomes, for his patience, guidance, constant supervision, creative advising and personal involvement throughout the progression of this work. He has been, for me, not only a source of inspiration and encouragement but also a model of ideal academic relations. Much of what I have learned during the progress of this thesis I owe, in fact, to Prof. Gomes. Working under the supervision of a very great investigator of the highest academic and human caliber like Prof. Gomes has formed me and will continue to be an unforgettable and a unique experience of my life.

I would like to express my great appreciation and gratitude to my first co-supervisor Prof. Ir. Dr. Mohd Zainal Abidin Ab Kadir for his guidance, advice and moral support and my second co-supervisor Dr. Mohd. AmranMohd.Radzi for his encouragements while I was behind the schedule to finish my study. And thanks for Dr. Mehdi Izadi for his support.

I am grateful as well to my parents Jamal Ahmed Abdullah and Shireen Ahmed Mohammed for encouraging me and supporting me in every possible way to continue my studies. I am really thankful to god for having such great parents. And my gratitude also goes to my sisters Kanyaw, Kanar and Renaz and my brother Rawa for all their understanding and patience throughout the period of study.

I am extremely grateful as well to Dr. Dhiadeen Mohammed Salih and Dr. MahirFaikIsmaile for their help with the modeling part and their constant guidance, suggestion and valuable input to this work. In addition to that their existence with me whenever I needed them 24/7 for the overall period of my studies and being there at my hardest times when my best friend and brother passed away is highly appreciated. A part from all what I mentioned about them, the lessons that they taught me for life and sharing their great experience's with me are that enabled me to be totally a new person and become who I am today. I am really more than proud of having them as my best friends and brothers for the rest of my life.

A special thanks goes to my best friends Mustafa Mohammed Mustafa, GeylanSadreddin Said and Saman Ismail Hassanfor being there, supporting and encouraging me throughout the period of study.

I would like to acknowledge the other people who have helped and encouraged me. I want to thank Kanan Abdullah, HerishSalih, Bwar Kamal, Tale Saidi, SerdashtSerdar, Irene Wong, HawkarAbdulkhaliq, Jwan Al-Doski, Dr. Rahel Khalid,

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Dr. Moayad Sahib, Dilan Ahmed, SaniBuba, Yunusa Ali, Suleiman Moosa, Mohammed Mirza, NargesFalah, Mina Baoj, Amin Saberian, PeyamFarzan, Nurahmed Omar and all those whom have ever supported me or helped me throughout my studies.

Last but not least, I am deeply indebted, My thanks go to all my Professors at Universiti Putra Malaysia who taught me during my graduate study at the University. I am thankful to the Department of Electrical and Electronic Engineering, Univsersiti Putra Malaysia for offering all facilities and the academic environments that made this work possible.

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I certify that a Thesis Examination Committee has met on 15August 2014 to conduct the final examination of Rebaz Jamal Ahmed on his thesis entitled "DISTRIBUTION OF TRANSIENT OVERVOLTAGE IN WIND TURBINE SYSTEMS UNDER DIRECT LIGHTNING STRIKES" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Uneversiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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