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Transient behaviour modelling of underground high voltage cable systems

Muhamad Zalani Daud
University of Wollongong

Transient Behaviour Modelling of Underground High Voltage Cable Systems

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by

Muhamad Zalani Daud, BEng

School of Electrical, Computer and Telecommunications Engineering

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To my wife, my son and my late mum

Abstract

The behaviour of voltage and current transients when a high voltage (HV) cable is first energised is a problem of practical significance to utilities. Modelling of this behaviour on a suitable simulation platform is an attractive approach, in many cases, provided that the results closely match real-world behaviour. This thesis presents modelling and analysis of transients resulting from energisation of an unloaded cable using PSCAD®/EMTDC™ simulation software. An assessment of the applicability of existing frequency-dependent (FD) cable models is given. The impact of transients on a simulated cable system is also presented and discussed.

In cable system modelling, system components must be accurately modelled, primarily the underground cable. Two common frequency-dependent cable models are based on the travelling wave method, namely the FD-Mode and FD-Phase models. These models are investigated by comparing their ability to predict energisation current transients resulting from the switching of an unloaded 132 kV underground cable. The simulated results are validated by comparison with the measurement data. It was found that, the FD-Phase model provides more accurate results compared to the FD-Mode model. This model is widely applicable and suitable for use in modelling a wide range of frequencies.

The FD-Phase model was used in this study to analyse the distribution of overvoltages at sending and receiving ends of the cable system. Specifically, statistical analysis has been carried out correlating the overvoltage magnitudes induced and the closing behaviour of the circuit breaker (CB). Two statistical switching techniques have been applied, namely the deterministic and probabilistic approaches. Based on the approaches studied, results from probabilistic techniques are recommended owing to the fact that it is closer to reality.

Certification

I, Muhamad Zalani Daud, declare that this thesis, submitted in partial fulfilment of the requirements for the award of Master of Engineering - Research, in the School of Electrical, Computer and Telecommunications Engineering at the University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualification at any other academic institution.

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Muhamad Zalani Daud

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Publications arising from this Thesis

1. M. Z. Daud, P. Ciufo, S. Perera, *Investigation on the suitability of* PSCAD®/EMTDC™ *models to study energisation transients of 132 kV underground cable*, Proc. Australasian Universities Power Engineering Conference (AUPEC 2008), Paper ID: 037, December 2008, Sydney, Australia.

2. M. Z. Daud, P. Ciufo, S. Perera, *Statistical analysis of overvoltages due to the energisation of a 132 kV underground cable*, Proc. Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology Conference (ECTI-CON 2009), Paper ID: 1325, May 2009, Bangkok, Thailand.

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List of Abbreviations

HV	high voltage
EHV	extra high voltage
UHV	ultra high voltage
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
EMTP	electromagnetic transients program
DC	direct current
FD	frequency-dependent
CB	circuit breaker
ULM	universal line model
CC	cable constant
CF	curve fitting
BHTS	Baulkham Hills transmission substation
BVZS	Bella Vista zone substation
BTTS	Blacktown transmission substation
SWTS	Sydney West transmission substation
CFTS	Carlingford transmission substation
XLPE	cross-linked polyethylene
PVC	polyvinyl chloride
HDPE	high-density polyethylene
SVL	sheath voltage limiter
RMS	root mean square
FFT	fast Fourier transform
VT	voltage transformer
TV	tertiary voltage
PDF	probability density function
CDF	cumulative density function
SE	sending end
RE	receiving end

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