Improving High Voltage Power System Performance

Using Arc Suppression Coils

by

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ABSTRACT

Arc suppression coils provide a low cost method of increasing both the reliability and safety of high voltage transmission and distribution systems. Although the concept is not new, the advent of modern control equipment allows fresh opportunities for them to be used to save lives and to decrease the cost and inconvenience to industry and the community in general that is caused by electricity supply interruptions without incurring large expenditure. Earth fault currents are reduced to almost zero, thus eliminating many short time power supply interruptions and preventing damage to the electricity supply system at the time of the initial fault. Because of the reduction in damage at the time of the fault, many longer duration interruptions are avoided. It is common for live high voltage conductors to be close to the ground and for the fault not to be detected by conventional power system protection equipment. Arc suppression coil systems can detect high impedance earth faults and broken conductors which cannot be detected by conventional protection systems.

There are many system abnormalities which can cause neutral voltages in arc suppression coil systems. The appropriate action to be taken by the protection system depends on the type of system abnormality. The causes of neutral voltages in arc suppression coil systems are analysed and criteria are developed to differentiate between them based on the phase angle and magnitude of the neutral voltage. Fully computerised power system protection systems are now being implemented. These modern protection systems will be able to utilise the criteria developed in this research to take immediate appropriate action based on the neutral voltage caused by the system abnormality.

In existing distribution systems there is a widespread use of two single phase pole mounted auto-transformers connected in open-delta configuration to provide economic in-line three phase voltage regulation. An original method of representing open delta regulators in symmetrical component analyses is developed. It is shown that when open-delta regulators are used in a power system equipped with an arc suppression coil very high voltages can occur. A solution is proposed whereby three single phase pole mounted auto-transformers connected in a closed-delta arrangement are used.

One of the potential problems with these systems is cross country faults caused by the neutral voltage displacement combined with the transient voltages at the time of the initial earth fault. These transient over-voltages are analysed in detail and a method of testing the capability of existing system components to withstand the over-voltages is developed. Simple methods to estimate the transient voltages on overhead power systems are derived. A new method of minimising the transient over-voltages is proposed.

CERTIFICATION OF DISSERTATION

I certify that the ideas, experimental work, results, analyses, software and conclusions reported in this dissertation are entirely my own effort except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award except where otherwise acknowledged.

Signature of Candidate | Date

ENDORSEMENT

Signatures of Supervisors | Date

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My wife, Margaret, endured my seemingly endless time engrossed in the work. She supported and encouraged me. She helped with the proof reading of this dissertation.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

PUBLICATIONS

The following papers are direct outcomes of this research project.

Published

[1] R. Burgess and A. Ahfock, "The use of arc-suppression coils in power systems with open-delta regulators," in *Universities Power Engineering Conference (AUPEC), 2010 20th Australasian*, pp. 1-6.

[2] R. Burgess and A. Ahfock, "Minimising the risk of cross-country faults in systems using arc suppression coils," *Generation, Transmission & Distribution, IET,* vol. 5, pp. 703-711.

[3] R. Burgess and A. Ahfock, "The use of voltage regulators in power systems with arc-suppression coils," in *Universities Power Engineering Conference (AUPEC), 2011 21st Australasian*

Under consideration for publication

[4] R. Burgess and A. Ahfock, "Evaluation of neutral voltages in arc suppression coil systems".