A PROPOSED BUSBAR PROTECTION SCHEME IMMUNE TO THE IMPACT OF OUTFLOW CURRENT DURING INTERNAL FAULTS

By

Ibrahim Mahmoud Ibrahim Mohamed

A thesis submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

In

Electrical Power and Machines Engineering

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Under supervision of

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2017

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Title of Thesis: A Proposed Busbar Protection Scheme Immune to the Impact of Outflow Current during Internal Faults

Key Words: Busbar Protection; Mimic Filter; One and a Half Breaker Busbar; Outflow Current; Phaselet

Summary:

This thesis describes a proposed busbar protection scheme immune to the impact of the outflow current during internal faults based on the combination of magnitude and phase angle comparisons into a single characteristic with setting adjustment according to the requirements of the busbar protection. The effective relay performance is achieved by implementing the phaselet approach and the adaptive digital mimic filter to facility estimating the current phasor rapidly that causes the proposed relay to operate faster.

The performance of the proposed scheme is extensively analyzed for different fault conditions on a breaker and a half bus substation to ensure its proper response during internal, external and evolving faults. Tests are carried out to investigate the impact of the circulating current, CT saturation, fault inception angle, fault type, fault location and high fault resistance. ATP simulations ensure that the proposed scheme can fulfill all busbar protection requirements within quarter cycle operation time and is not affected by the outflow current during internal faults.

ACKNOWLEDGMENTS

First of all, many thanks to Allah who helped and guided me in preparing this thesis.

I wish to express my deep gratitude to my supervisors; Prof. Dr. Essam El Din Abo El Zahab and Associate Prof. Dr. Doaa Khalil Ibrahim, Electrical Power and Machines Department, Faculty of Engineering, Cairo University for their endless support, insightful comments and excellent suggestions.

Also, I would like to thank my colleagues and managers for their support and advice.

Finally, I can never thank my family enough for their consistent sacrifice, great support and continuous encouragement during my study.

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• Symbols

a	:	The real part of the vector current ratio.
A_o	:	The amplitude of the dc component of the fault current.
A_h	:	The amplitude of the h^{th} harmonic component
b	:	The imaginary part of the vector current ratio
c	:	The percentage of outflow current caused by circulating path
$del1(k)$	:	The first difference current
$del2(k)$	:	The second difference current
$del3(k)$	:	The third difference current
f	:	The percentage of outflow load current caused by high resistance bus fault
h	:	The harmonic index
I_{base}	:	The base current in A
I_{C1}, I_{C2}	:	The circulating path feeder currents
I_{CS}	:	The compensated secondary current of CT
I_{DIF}	:	The differential current
I_E	:	The excitation current of CT
I_F	:	The fault current
$I_{F\,max}$	:	The r.m.s value of the largest fault current
I_i	:	The current passed through the incoming feeder with index i
I_{imag}	:	The imaginary part of the current phasor
I_L	:	CT load current
I_{load}	:	The load current

Im_i_p	:	The imaginary part of the pth phaselet for current signal
I_{mag}	:	The amplitude of the current phasor
I_P	:	The primary current of CT
I_{Pkp}	:	The pickup threshold current
$I_{p\,rating}$	:	The primary current rating
I_r	:	The vector current ratio
I_{real}	:	The real part of the current phasor
I_{Ref}	:	The reference feeder current
I_{RES}	:	The restraining current
I_S	:	The secondary current of CT
I_{SC}	:	The stray capacitance current
I_{SR}	:	The summation of the feeder currents except the reference one
k	:	Sample index
K	:	The gain factor of the digital mimic filter
k_f	:	The most recent sample after fault occurrence
n	:	The number of feeders connected to the protected bus
N	:	Total number of samples per power frequency cycle
ni	:	The total number of the incoming feeders
N_T	:	Number of turns of the CT secondary winding
p	:	The phaselet index
q	:	The number of samples per phaselet
r	:	The amplitude of the vector current ratio
R_1	:	The radius of the small arc in the current ratio plane
R_2	:	The radius of the large arc in the current ratio plane