The Effect of Distributed Generation on Power System Protection

by

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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Abstract

Interconnecting a distributed generation (DG) to an existing distribution system provides various benefits to several entities such as the DG owner, utility and end users. DG provides an improved power quality, higher reliability of the distribution system and covering of peak shaves. Penetration of a DG into an existing distribution system has so many impacts on the system, despite the benefits a DG will provide; it has a negative impact on one of the most important aspects of the system which is the power system protection, and it is a main factor affecting both reliability and stability of the system. DG causes the system to lose its radial power flow, besides the increased fault level of the system caused by the DG. In this thesis, the effect of DG penetration on the short circuit level of the network is investigated through simulating the IEEE 13 bus test feeder using **ETAP.** The simulation is repeated for nine different cases at which the location of one large DG is changed in six of the cases to study the effect of the distance on the fault level, while the rest of the cases are performed using small decentralised DGs. The result of those three cases at which the DG is decentralised are used to investigate the effect of the generating capacity of the generation unit on the distribution network parameters and on the currents flowing through the laterals of the distribution network. Results are compared to that of the normal case to investigate the impact of the DG on the short circuit currents flowing through different branches of the network to deduce the effect on protective devices.

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List of Symbols and Abbreviations

DG: Distributed Generation

PV: Photovoltaic

LTC: Load Tap changer

IGBT: insulated gate bipolar transistor

PCC: point of common coupling

ACSR : Aluminium Conductor Steel Reinforced

XFM-1 : Distribution Transformer number 1 in the IEEE test feeder

AA : Aluminium Conductor

Cu : Copper conductor

NDZ: non detective zone

I_p: Pickup Current

V_{rms}: Root Mean Square of the voltage

TDS: Time Dial Setting

T: Operating Time

T_{ijk}: operation time of relay i of branch j for fault k.

T_{nmk}: operation time of the first backup of R_{ij} for a given fault in protection zone k.

I_{ijk}: the current passing through the relay R_{ij}.

T_{CBB}: time of operation of circuit breaker B

T_{CBK}: time of operation of circuit breaker K

TDSA: time dial setting of relay A

TDSB : time dial setting of relay B

TDSC: time dial setting of relay C

TDSD: time dial setting of relay D

TDSE: time dial setting of relay E

TDSF: time dial setting of relay F

TDSG: time dial setting of relay G

TDSH: time dial setting of relay H

TDSI: time dial setting of relay I

TDSJ: time dial setting of relay J

TDSK: time dial setting of relay K

TDSL: time dial setting of relay L

TBA1: time of operation of relay A for a fault in zone 1 at its close end

TBB1: time of operation of relay B for a fault in zone 1 at its close end

TBC2: time of operation of relay C for a fault in zone 2 at its close end

TBE3: time of operation of relay E for a fault in zone 3 at its close end

TBD2: time of operation of relay D for a fault in zone 2 at its close end

TBK1: time of operation of relay K for a fault in zone 1 at its close end

TBF3: time of operation of relay F for a fault in zone 3 at its close end

TBG4: time of operation of relay G for a fault in zone 4 at its close end

TBH4: time of operation of relay H for a fault in zone 4 at its close end

TBI5: time of operation of relay I for a fault in zone 5 at its close end

TBJ5: time of operation of relay J for a fault in zone 5 at its close end

IpA: the pickup setting of relay A

IpB: the pickup setting of relay B

IpC: the pickup setting of relay C

IpE: the pickup setting of relay E

IpF: the pickup setting of relay F

IpG: the pickup setting of relay G

IpH: the pickup setting of relay H

IpI: the pickup setting of relay I

IpK: the pickup setting of relay K