Load Flow Analysis of Radial Distribution Network with Renewable Energy Application

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Abstract- The short circuit analysis secures the electrical power systems protection scheme. Thus, in turn ensures the power system reliability, safe mode of operation, and uninterruptable power supply. The impact of distributed generation on the power systems stability, power quality, and short circuit level is still unclear and uncertain. The different characteristics of each distributed generation type, such as synchronous generators, induction generators, power electronics inverters make it more complicated to assess. Studying the effect of the penetration of distributed generation on fault current level of existing distribution networks is crucial. This paper will examine the impact of implementing distributed generation mix, including wind turbine generators, photovoltaic, and diesel generators on the fault current level of the distributed network under study. The short circuit analysis is carried out on the IEEE 15-bus distribution test system using MATLAB software. The simulation results are presented in a comparison between four cases, comparing the impact of the distributed generation mix on the fault current level at different levels of penetration.

Keywords- Distributed Generation, renewable Energy, Bus System

I. INTRODUCTION

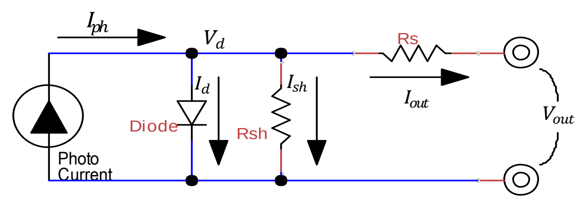
The demand of energy is necessary for the development of the any nation. The scarcity and storage capacity of fossil fuels e. g. coal, gas, oil etc. are limited. In recent years, attraction of human being is increasing towards the power generation based on renewable energy (RE) sources due to various advantageous features such as environmental friendly, small sizes etc. In this context, it is forced to explore more RE sources to meet the demand of power supply [1,2].

PV is increasingly vital RE energy source due to fast development of power generation technology and advantages such as pollution free, low maintenance, no moving parts and grid decentralization. PV cell convert directly sunlight into electricity when semiconductor is illuminated by a photon, and the performance is measured in terms of its efficiency when converting sunlight into electricity [2].

Electrical power systems have three major consequential pillars generation, transmission, and distribution. This paper is specifically concerned with the electrical distribution networks, and the impact of distributed generation (DG) on the fault current level.

The presence of DG alters the conventional theory of the flow of power in one-direction. Some existing networks are not designed to accommodate more DG [3]. The connection of DG to the distribution networks remains a constraint in the power distribution planning. The DG capacity limits; total DG capacity penetration level; DG capacity reserve; and short circuit current limit are considered from the major factors affecting the power distribution planning, when it comes to DG integration [4]. Moreover, there are technical aspects inhibiting the implementation of DG on a large scale; Voltage control, fault level, grid protection, power quality, and power losses [5], [6]. The increasing exploitation of DG units has a significant impact on the short circuit currents and the fault level of the distributed network. Therefore, the introduction of DG will to lead to a change in the fault current. Consequently, this will affect the existing over current protection scheme, which in return may have a significant influence on the power system reliability.

DEVELOP THE MATH PV MODEL:



Solar Cell Equivalent Circuit

The model developed here is based upon this circuit.The *Schockley diode equation*, modified to include the number of cells in the PV array, *n*, is used to define the diode current.

Schockley diode equation

$$I_d = I_{rsat}\left(e^{\frac{qV_d}{nmkT}} - 1\right) \quad (1)$$

The diode voltage is:

$$V_d = V_{out} - I_{out}R_s$$ (2)

The current in the shunt resistor is:

$$I_{s\square} = \frac{V_{out}-I_{out}R_s}{R_{s\square}}$$ (3)

The output current is:

$$I_{out} = I_{p\square} - I_d - I_{s\square}$$ (4)

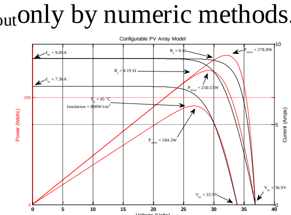
Substitution yields:

$$I_{out} = I_{p\square} - I_{rsat}\left(e^{\frac{q(V_{out}-I_{out}R_s)}{nmkT}} - 1\right) - \frac{V_{out}-I_{out}R_s}{R_{s\square}}$$ (5)

Where:

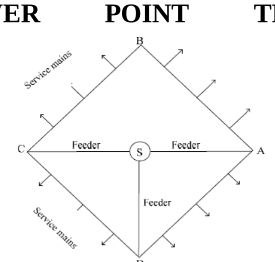
$I_d = Diode\ Current$ (Amperes)
$I_{rsat} = Diode\ Reverse\ Saturation\ Current$ (Amperes)
$V_d = Diode\ Voltage$ (Volts)
$q = electron\ elementary\ c\square arge$
$\cong 1.60218 \times 10^{-19}$(Coulombs)
$k = Boltzmann's\ Constant$
$\cong 1.38065 \times 10^{-23}$(Joules/°Kelvin)
$T = ambient\ temperature$ (°Kelvin)
$m = diode\ ideality\ factor$
$n = \#\ of\ cells$
$I_{p\square} = P\square oto - Generated\ Current$(Amperes)
$I_{out} = Output\ Current$(Amperes)
$R_s = Series\ Resistance(O\square ms)$
$R_{s\square} = S\square unt\ Resistance\ (O\square ms)$

Note that (5), sometimes called the *characteristic equation of a solar cell*, is animplicit equation containing I_{out}on both sides. This equation has no explicit solution and is solvable for I_{out} and V_{out}only by numeric methods.



Effects of parameter

MAXIMUM POWER POINT TRACKING ALGORITHMS



As was previously explained, MPPT algorithms are necessary in PV applications because the MPP of a solar panel varies with the irradiation and temperature, so the use of MPPT algorithms is required in order to obtain the maximum power from a solar array. Over the past decades many methods to find the MPP have been developed and published. These techniques differ in many aspects such as required sensors, complexity, cost, range of effectiveness, convergence speed, correct tracking when irradiation and/or temperature change, hardware needed for the implementation or popularity, among others. A complete review of 19 different MPPT algorithms can be found.

Among these techniques, the P&O and the InCond algorithms are the most common. These techniques have the advantage of an easy implementation but they also have drawbacks, as will be shown later. Other techniques based on different principles are fuzzy logic control, neural network, fractional open circuit voltage or short circuit current, current sweep, etc. Most of these methods yield a local maximum and some, like the fractional open circuit voltage or short circuit current, give an approximated MPP, not the exact one. In normal conditions the V-P curve has only one maximum, so it is not a problem. However, if the PV array is partially shaded, there are multiple maxima in these curves. In order to relieve this problem, some algorithms have been implemented.

II. ELECTRICITY DISTRIBUTION

Electrical Distribution is the final stage in the delivery of electricity to end users. A distribution system's network carries electricity from the transmission system and delivers it to consumers. Typically, the network would include medium-voltage (less than 50 kV) power lines, electrical substations and pole-mounted transformers, lower-voltage (less than 1000 V) distribution wiring and sometimes electricity meters. So that the part of power system used for distribution of electric power for local use is known as a distribution system. In general, the distribution system is the electrical system between the substation fed by the transmission system and the consumer‟s meters.

GLOBAL DESIGN OF ADISTRIBUTION NETWORKS

The electric utility system is usually divided into three subsystems which are generation, transmission, and distribution. A fourth division, which sometimes is made, is sub transmission. However, the latter can really be considered as a subset of transmission since the voltage levels and protection practices are quite similar. The distribution system is commonly broken

(i) Feeders: A feeder is a conductor, which connects the sub-station (or localized generating station) to the area where power is to be distributed. Generally, no tappings are taken from the feeder so that the current in it remains the same throughout. The main consideration in the design of a feeder is the current carrying capacity.

(ii) Distributor*:* A distributor is a conductor from which tapping is taken to supply to the consumers. In Fig. 1.2 AB, BC, CD, and DA are the distributors. The current through a distributor is not constant because tapping is taken at various places along its length. While designing a distributor, voltage drop along its length is the main consideration since the statutory limit of voltage variations is ±10% of rated value of the consumer‟s terminals.

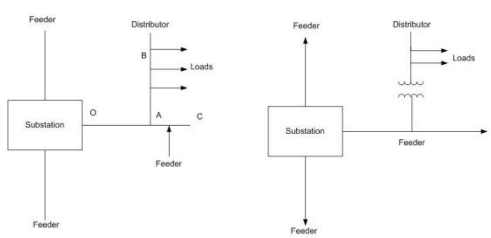
(iii) Service mains: A service main are generally a small cable which connects the distributor to the consumer‟s terminals

III. RADIAL SYSTEM

In this system, separate feeders radiate from a single sub-station and feed the distributors at one end only. Figure 1.5 (a) shows a single line diagram of a radial system for DC Distribution where a feeder OC supplies a distributor AB at point A. Obviously, the distributors are fed at one point only i.e. point A in this case. Figure 1.5 (b) shows a single line diagram of the radial system for AC distribution. The radial system is employed only when power is generated at low voltage and the sub-station is located at the centre of load. This is the simplest distribution circuit and has the lowest initial cost. However, it suffers from the following drawbacks:

(a) The end of the distributor nearest to the feeding point will be heavily loaded.

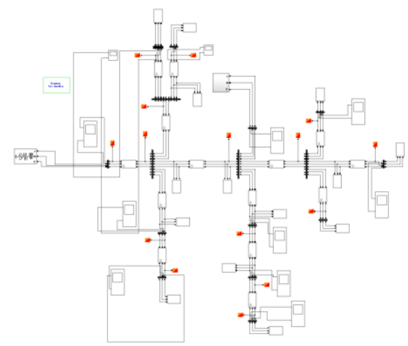
(b) The consumers are dependent on a single feeder and single distributor. Therefore, any fault on the feeder or distributor cuts off the supply to the consumers who are on the side of the fault away from the sub-station.



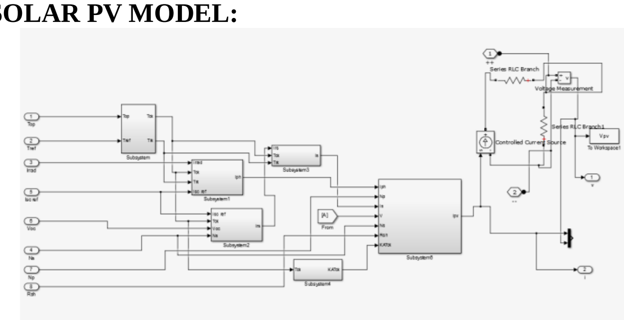
(c) The consumers at the distant end of the distributor would be subjected to serious voltage fluctuations when the load on the distributor changes. Due to these limitations, this system is used for short distances only.

IV. SIMULATION RESULT

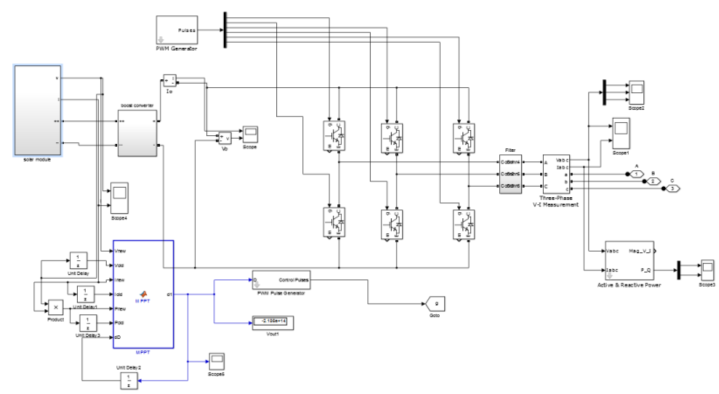
SIMULATION CIRCUIT DIAGRAM:



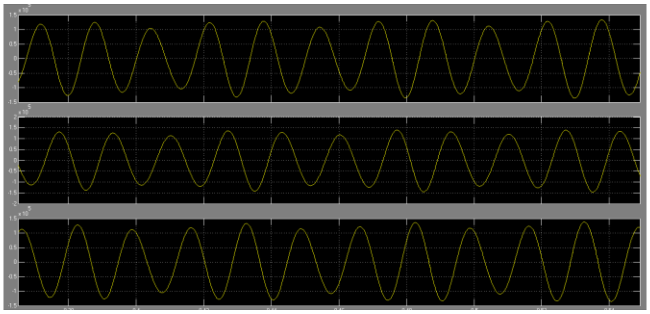
SOLAR PV MODEL:

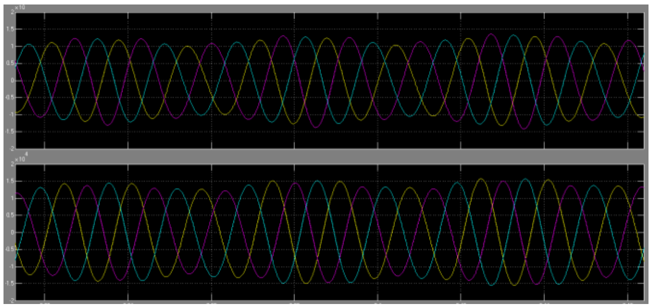


SOLAR MPPT WITH INVERTER:

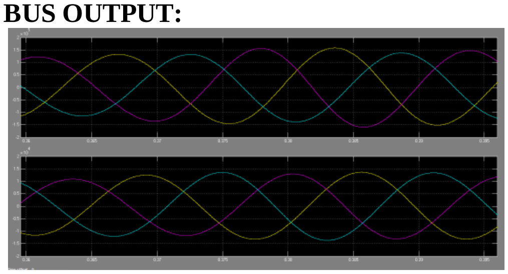


INPUT SOLAR VOLTAGE:





LOAD BUS OUTPUT:



V. CONCLUSIONS AND FUTURE SCOPE OF WORK

CONCLUSIONS:

A novel approach for load flow analysis of a radial distribution network, which is simple to implement and efficient in computation has been proposed and described in detail in this paper. The computational efficiency and speed of the proposed method has been tested and modified IEEE 15-node radial distribution networks. The comparison between the proposed and existing method ensures the speed and accuracy of the proposed approach in terms of CPU time both for varying load conditions and systems of different sizes and configurations

FUTURE SCOPE OF WORK:

After carrying thesis work in the load-flow analysis of distribution systems, the following guidelines seem to be worth pursuing this area:

(i) Load-flow analysis for unbalanced network.

(ii) Fuzzy load-flow analysis.

(iii) Uncertainty in branch impedance.

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