PROTECTION COORDINATION ISSUES DISTRIBUTED GENERATION SYSTEMS

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SUMMARY

With this distributed generation (DG) in distribution systems, its function generally tends to be changed. These effects leads to effects on distribution systems protection. One way to reduce the effects of distributed generation protection system of distribution systems is re-coordination of protective devices. To prevent the high cost, system configuration should be modified to reduce the DG the occurrence of a fault. The problems of DG sources on distribution systems protection generally are: wrong triggering of the generation units (DG), feeders incorrect trip, incorrect trip of generation units, increasing or decreasing of short circuit area, unwanted islanding, prevention of automatic reclosing and unsynchronized reclosing.

Key words: Distributed generation (DG), Coordonation, relay settings, Overcurrent relays, Time Setting Multipliers (TMS), Plug Setting (PS), Pick up (PU).

INTRODUCTION

Words, ,,distributed", ,,dispersed", ,,decentralized or centralized production", DG, EG are key words for a change of paradigm in electricity. There is no single international definition for these terms. In Ackermann [1] is defined as DG, the production of electricity from several W to 50 MW ", according to Electric Power Research Institute. In accordance with the Gas Research Institute, distributed generation is ,,typical between 25 and 50 MW". In Andrew [2], Tarek [3], DG is defined as,, small-scale production", according to required local consumption. Distributed generation (DG) involves a large number of last-generation technologies: small steam turbines, with a cycle organic Rankine cycle (ORC), gas turbines, micro turbines, diesel engines, Stirling engines, fuel cells (high and low temperature), photovoltaic systems, wind turbines and small hydro turbines. There are also different ways to characterize distributed generation. Depending on context, can be fired based on renewable resources (fuel and non-fuel) or non-renewable, controllable or uncontrollable (output variable), depending on the connection and network size (isolated low voltage , medium voltage, high voltage). All matters listed are important in evaluating the use of distributed generation in distributed power systems. Other important factors relate to investment and operational costs, the reliability, service life, the development of technology.

GENERAL LAYOUTS

Currently, the DGs are used for small, located near the consumer or to local generation - on-site "or in emergency situations, ensuring economical operation of power distribution network. Connecting distributed generation to the electricity distribution network requires a network operating principles to be changed from passive to active. If passive network connecting DG is based on planning, which assumes network capacity in all cases of loading and production. Active network management tools is planning the electricity distribution system, automation, communications and control systems. Current research is directed towards two methods of management: active distribution network and virtual power plants (VPP). Active distribution network management will be applied to protect the distribution network, to control voltage affected by DG. Impact protection can be demonstrated with PSCAD simulations, RTD / DSpace, EDSA. With the advent of DG units in the network, it requires a new strategy in terms of protections allocated. Problems include aspects of voltage, frequency, traditional protections, operational aspects and minimize costs to adapt existing network of new energy sources Zoka [4]. It is important to analyze simulation restore power commands phase of circuit breakers, earth fault and compensate the defect phase earth fault, the coordination of protection and distributed generation units. There are several issues to consider when requesting connection to the distribution of DG, such as: a) Studies on the transitional regime; b) Analysis of voltage dips; c) Power quality; d) System configuration and the transformer connection type; e) Capacity switching equipment to interrupt fault currents.

TECHNICAL CONCERN

Which is the influence distributed generation on distribution network, the analysis and planning functions? Which protections are coordination problems when connecting DGs to the distribution? Connection standards are met? Which are power quality problems? A large number of DG could lead to stability problems and system frequency. If until now the problems have been relevant in the transport system, it has become important for distribution, is necessary for the operation and management technologies. Traditional protection schemes used so far should be reviewed and interconnection protections depends on many factors, such as power generator, grid connection point (distribution and transport), type generator. Modern systems using power electronic converters require special consideration for protection of DG, through detailed simulations. Implementation of renewable energy is actually distributed generation introduction of hybrid systems consisting of various generators connected to a micro (MicroGrid)

ASPECTS OF PROTECTION UNITS DG INTERCONNECTION

The new standards are designed to achieve more detailed requirements for integrating DG in the distribution system. Because the voltage level from the point of interconnection is necessary to use an intermediary transformer. Protection is determined by the point of common coupling (PCC) and interconnection transformer, can be mounted either on the primary circuit interconnection, as presented in Figure 1 or the secondary side as presented in Figure 2. To achieve protection schemes can be used in system solutions for high voltage, but problems appear in the low voltage network, which is used fuses. Network operating in low voltage transformer that powers the network and also with DG unit is possible that a failure occurs at a distance of DG and because relatively high impedance of the system unit to supply the defect, even if transformer protection would function. Protection generator is installed to limit the PCC and protect the DG from internal defects or abnormal operating conditions. Each generator has its own protection, situated as in Figure 3. Choosing interconnection transformer has an important role in connecting DG to the network, presented in Figure 4.

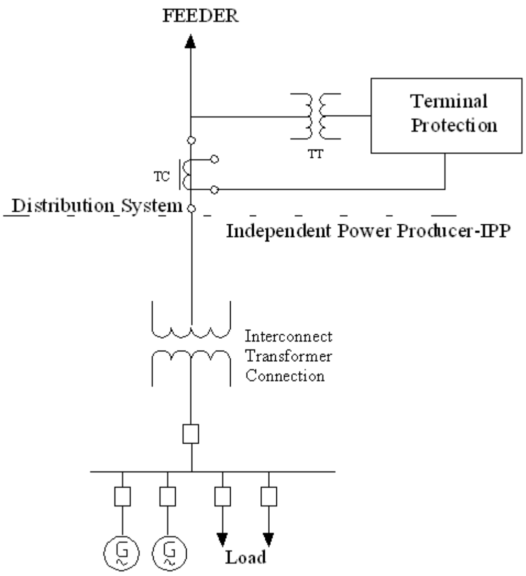

Fig. 1 (source[2])

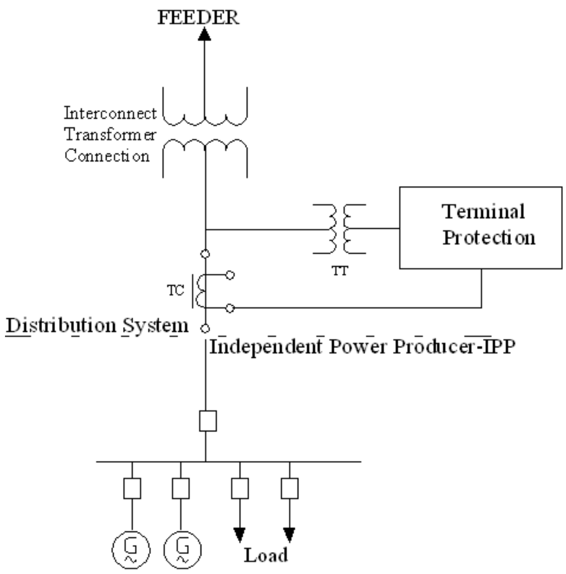

Fig. 2 (source[2])

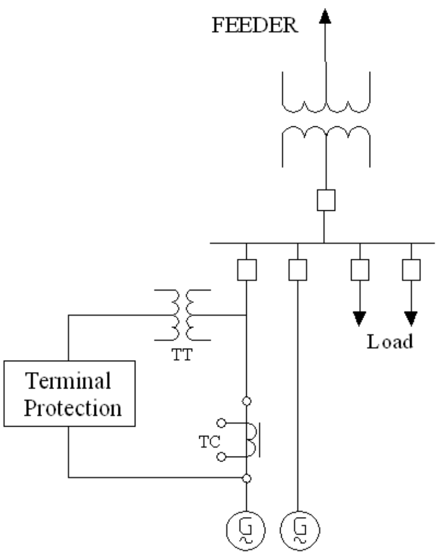

Fig. 3 (source[2])

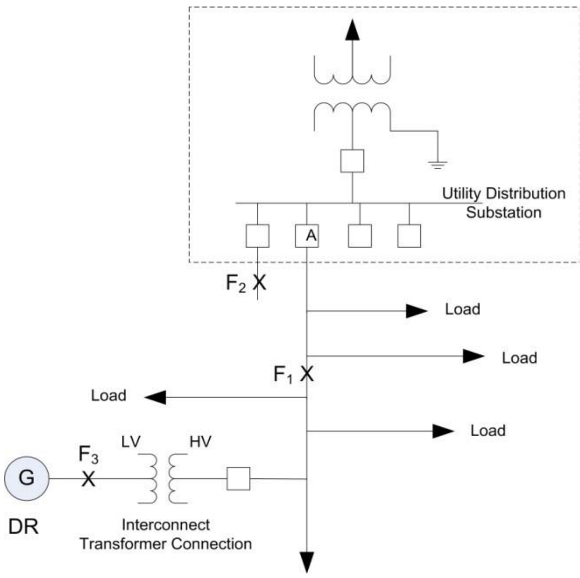

Fig. 4 (source[2])

All connections shown in the literature have advantages and disadvantages, which must be taken into account and producer of electricity. Five types of transformer connections are used extensively for interconnection of DG to the utility system, presented in Andrew [2]. Connections will affect the choice of overvoltage fault and phase fault current value having the source, distribution system. Protection is one of the most important issues affected by the interconnection of distributed generation, as presented in Charles [5]. Units of distribution system protection (reclosers, fuses, overload relays) are designed taking into account short-circuit current.

PROTECTION REQUIREMENTS

When connecting the generator to the distribution equipment is necessary to interface the system to have adequate protection, both for manual and automatic coupling. Distributed generation protection and control equipment must include, in part or completely, the following: protection of minimum and maximum voltage; protection of minimum and maximum frequency; directional overcurrent protection; earth fault protection; supply protection in d.c. relay; protection of the trigger circuit interruption;

protection from loss of power. Adjustment calculation is based on the maximum possible, the minimum and maximum fault current and / or feeder's impedance protected. How to show protection system to connect the DG. An example is presented at the end of the document (Figure 5). In the analyzes carried shows that change with the introduction of the DG fault current value and current phasor phase angle, depending on the fault. Fault current magnitude and direction are parameters which vary with power injection of DG and its position Carpinelli [6]. An important impact of DG on distribution system is the system of protection made in the classic case of nondirectional current relays, reclosers, load dividers, fuses and breakers, system to be reviewed, adjusted and coordinated with the existing and in the modern, with directional feature for detecting faults in the system correctly. Significant attention must be given to the protection of interconnection, except the failure detection of overcurrent relay. The main function of these interconnection protection is the detection of islanding situations and disconnect immediately of the generating equipment. Typical minimum protective functions of the interconnection protection system are over-/underfrequency and over-/under-voltage. In Papathanassiou [7] are presented indicative settings for the interconnection protection relays. to achieve sensitive islanding detection. An overcurrent relay normally has a current setting multiplier referred to as Plug Setting (PS) in Razavi [8]. However, the variables of interest in the optimal coordination problem are the Time Setting Multipliers (TSMs). Researchers have described various optimization methods to find the directional overcurrent relay settings in Kazemi [9], Razavi [8]. The results of the coordination methods may be different. The best coordination method should isolate the fault as soon as possible, especially in the sensitive lines. The delays in the operating time of the relays increase the probability of undesired trip of the backup relays or the relays of other points in the network.

CONSTRAINTS ON PROTECTION SETTING

The minimum short circuit current must be used to verify proper functioning of the digital relay. To do this, check that the ratio of the fault current (I in amperes secondary), and the PU set (I_S) is greater than 1.5 (Figure 6).

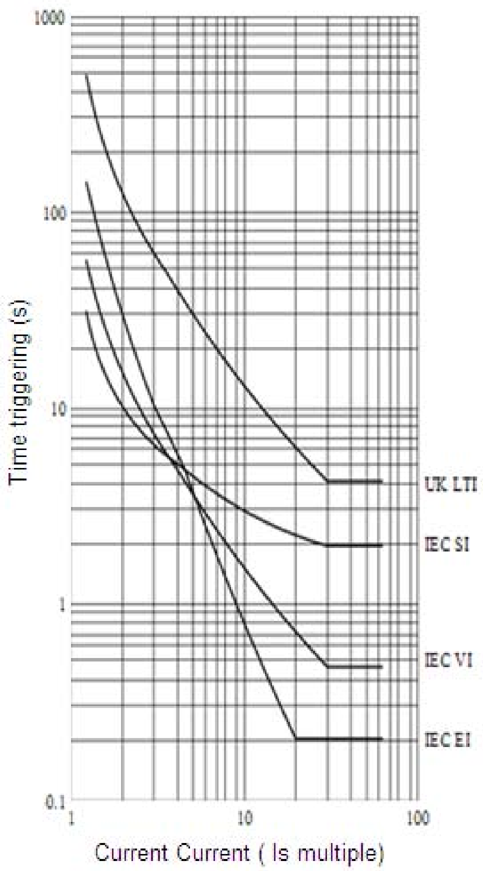

Fig. 6 IEC type curves

Thermal limits of the elements protected (motors, cable) must be checked if they are met, once established as a maximum protection for curves of current. Starting value, PU must be chosen to take into account the transitional regime happens when resupply consumers (motors, transformers, etc.). The connection transformer units, will take into account the magnetizing current, $I_{Inrush} = k*I_{nom}$, where k is constant equal to 8 for S = (500-2500)kVA and 10 for S over. 2500 kVA I nom - rated current of current transformer. The magnetizing current may have a duration of 0.1 s.
Using inverse sequence characteristics. Polyphase fault detection can be improved by using the characteristic negative sequence relays (50/51Q), whereas no negative sequence component (I2), a balanced load. Also, phase-earth faults and not exist zero-sequence component (I0), the balanced loads.PU to determine the amount of negative sequence element is necessary to take into account that the current amplitude for phase-phase fault is 87% of the three phase at the same point of failure. Elsewhere, phase-phase fault current amplitude of negative sequence components are obtained from the relationship:

$$I_{a2} = \frac{1}{3} \cdot (I_a + a^2 \cdot I_b + a \cdot I_c)$$

For example, phase-phase fault we have Ia = 0, and Ib =-Ic. Therefore, the amplitude of negative sequence components is 58% (1/1, 73) the amplitude of fault current. For example, if we have two digital relays PU whose values are 75 and 100 A, then in order to achieve their selectivity (selectivity between them), must be for defects phase-phase the relay with 100A PU must be amplified by 1,73 or. In other words PU value is 1.73 * 100 A = 173 A. A calculation example to achieve the selectivity protections of digital relays installed in a distribution network is presented in the paper Balan [10].

CONCLUSION

Using digital relays and proper use of IEC type characteristics can reduce the time to eliminate defects, reducing the dynamic and thermal stresses of the electrical equipment. This unit of DG in the electricity lead to changes in active and reactive power flow, short circuit modification and equivalent impedance network scheme. These issues can affect the correct operation of system protection relay. Sensitivity and selectivity can be modified protections. This DG units should not lead to unexpected disconnections, to connections in inadequate conditions and do not affect protective functions of the system.
Connect DG units to require a detailed study on possible operating regimes and modification of protective relay in accordance with the functions required in the new network configuration. Consideration should be given to correlate the internal protection unit of DG with the grid protection system. Also, linking to parts of the neutral scheme DG unit must be made consistent with the neutral treatment of the network to which it connects.

Example: How to show protection system connecting DG?: Let these elements of network:

- $Z_{source} + Z_{line\ A+B} = 6.501+j14.01\ \Omega$
- Impedance generator : $Z_{gen}=1.611+j37.306\ \Omega$
- $Z_{line\ B+C}=4.37+j4.46\ \Omega$

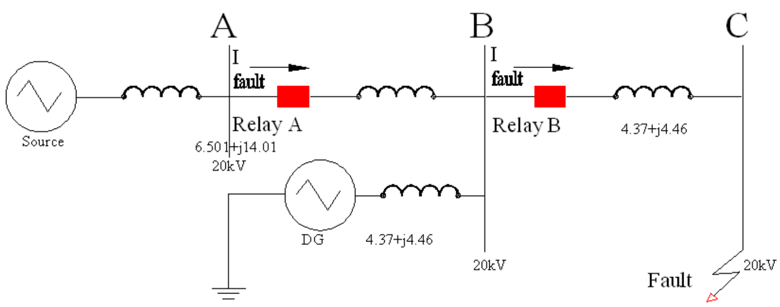

Fig. 5 Model 20 kV distribution network with DG

Before connecting to the bar B DG 20 kV for a fault on the bar C, the fault current at the rate of 1.07 pu predefect voltage will have value.

$$I_{fault} = \frac{Voltage\_Bar \cdot 1.07}{\sqrt{3} \cdot (Z_{sursă} + Z_{BC})} \approx 577A/phase\angle 59,55^0$$

Adding a source distributed on the bar B, the total fault current for a fault bar C will be:

$$I_{fault} = \frac{Voltage\_Bar\, 1.07}{\sqrt{3} \cdot (Z_{paralel} + Z_{BC})} \approx 734A/phase\angle 77,67^0$$

Total fault current contribution is composed of source and generator:I_{source} ≈ 570 A / phase, 58^o and $I_{generator}$ ≈ 162 A / phase, 74^o. Value of fault current by introducing DG, increases from 577A to the 734A, and if the B relay is one of overload, overcurrent or the impedance start, may determine his action.

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