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Effect of Dispersed Generation On Distribution System Security – An Overview

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ABSTRACT

Due to the increasing demand of energy consumption along with the need for renewable energy sources, distributed generation (DG) has come into picture in recent days. Power system protection is one the foremost concern which arises due to the incorporation of a DG into an existing distribution system. The interference of this DG could affect power quality issues, deprivation in system dependability, decrease in the efficiency, over voltages and safety issues. This paper discusses the different definitions projected in the literature. Further the DG system to become a major contributor in the current power expansion it needs to be connected with the prevailing grid system. This incorporation will cause some technical, functional and economic impacts on distribution systems. A summary of the operating concerns that must to be tackledin context with the distribution protection with DGs areconversed. This article also recapitulates these unusualconsequencesof DG on the power system.

Keywords: Distribution System,issues, impact, islanding, coordination, Protection schemes.

I. INTRODUCTION

Electrical energygenerated and dispersed to consumerssets up one of the biggest consumer markets in the world.

As a nation we have turned out to be so reliant that most of the day-to-daytasks would be deferred if there were any disruption in electric energy production, transmission and dissemination [3]. Traditionally there has been anexcessive deal of effort put into modeling and improving the reliability of the generation and transmission systems. Yet, when equated to the generation and transmission systems, substantial less resources has been placed on the facts of making the distribution system more dependable[1]. Bulk of all disruptions experienced by the consumer in a given year are owed by the distribution system.

Incorporation of DG creates a lot of issues in the power system due to the fact that the power system would not have been designed or planned keeping DG in the thought. The procurement of DGmay perhaps influence power quality hitches, deprivation in system reliability, drop in the efficiency, over voltages and safety disputes [7]. On the converse the power system dispersal are finelyplanned which might take care the adding of DG if there is appropriateEarthing, transformers and protection is delivered.

But there are limits to the addition of distributed generations if it goes beyond its limit then it is important to modify and change the already designed distributed system equipment and protection, which could in a result facilitate theincorporation of new compeers [6].

On the other hand, interconnected DG could worsen the performance of the power system leading to negative upkeep benefits. The assimilation of DGmay possiblyconsequence the power

quality owing to deprived voltage regulation, voltage flickers and harmonics. These circumstances can have a thoughtfulimpression on the functioning and robustness of the electricalpower system and also cause destructiveconditions to equipment [12].

This paper aims to broadly review all protection practices which have been endorsed for distribution networks. It is expected that the work presented will be advantageous for research scholars in DG protection in finding appropriate references and applying suitable protection schemes. Subsequently, application of the correct protection scheme will enhance the dependability and fidelity of active distribution networks.

II. INCORPORATION OF DG

Dispersion of DG in Distribution networks has an impact on various fields. These impacts could be positive ornegative and are considered as the benefits and drawbacks of the distributed generation.
The DG protection is recognized from the Point of ConjointConnection (PCC) and the interconnection transformer. [2]
The objective of the interconnection protection is to safeguard the grid from the DG unit on the grid-side throughout the paralleloperations of the DG and the grid. The protection can be positioned either on the primary side of the interconnectiontransformer or on the secondary.Even though DG is a reasonableoption to bump into the power demand of the market, there are multiplicities of practical,functional, commercial, and supervisorydisputes that have tobe measuredafore the DG plants are intersected withthe centralgridiron. The interconnection issues have enough prospective toavoid distributed generation schemes from being developed.[5]

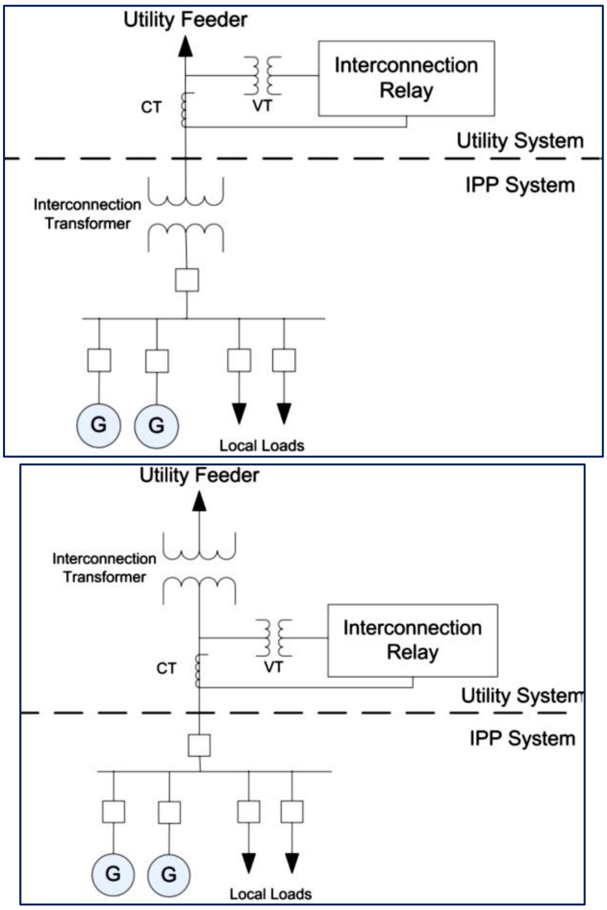

Figure 1. Interconnection Protection at the Secondary

III. TECHNICAL ISSUES

The key technical issues for DG connection connect to power quality, protection, islanding and stability of the system.

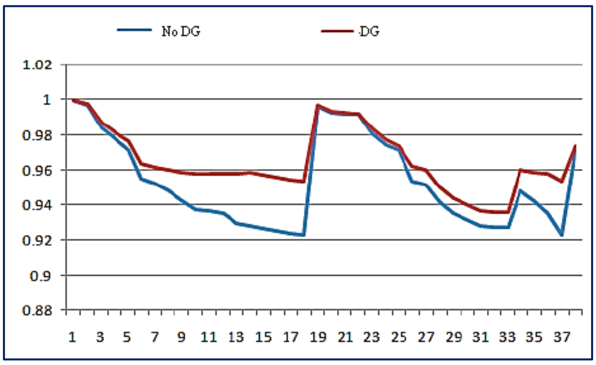

Figure 2. Interconnection Protection at the Primary

The integration of DG couldupshot in disparities in voltage profile alongside a feeder by altering the track and scale of active and reactive power flows.DG consequence on voltage regulation can be optimistic or pessimisticliable on distribution system and distributed generator topographies as well as DGlocality [3].

The connection of DG entities alongside the power distribution feeders may expedite to overvoltage owed to superfluous of active and reactive power. For example, a minor DG system partaking a conjoint distribution transformer with numerous loads possibly willshoot the voltage on the ancillary side, which is adequate to root high voltage at these consumers [5].

ForinconsequentialDG unit(less than 10MW) the influence on the primary is trivial. On the other hand, if the collective competencyfeeder upsurges in anticipation ofperilous thresholds, then voltage regulation analysis is compulsory to surefire that the feeder voltage will be secure surrounded by appropriate boundaries [3].

- **Voltage Glitches:**

A Voltage glitch is initiated by variation of dynamism which upshots due to spasmodic production from wind turbine generators and photovoltaic grounds, or association and suspension of induction generators from the distribution network.

Most of the DG mechanism are competent to delivergrid lock generation during the instance of interludes or cessation of the central system. DG centered on an induction generator, or with an incorrigible inverter, or lacking proper storage might be unqualified to function in off gridgenre. [6]

- **Harmonics**

A few types of DG, i.e., photovoltaic (PV) and fuel cells, are linked to the dispersalnetwork through power electronic converters. The contemporaryconverters use pulse width modulation (PWM) practice and as a result yieldsmaller amount Variable frequency components than the conventional compeers of thyristor based line commutated inverters.

DG centered on induction and synchronous generators tune the reaction of the scheme to the other Variable frequency componentbases by fluctuatingvocal impedance of the grid. In addition, one of the roots for resonance are the condensers used for excitation of induction generators

Table 1. Variable Frequency Components (Harmonics) current instillationnecessitiesas per IEEE 519-1992.

Order	Permissible limit
Less than 11^{th} order	4.00%
11^{th} to 17^{th} order	2.00%
17^{th} to 23^{rd} order	1.5%
23^{rd} to 35^{th} order	0.5996%
35^{th} or superior orders	0.298%
Overall Harmonic Variation	5.00%

- **Voltage Unbalance**

Voltage unbalance can arise due to incorporation of a solitarystage DG, i.e., DG grounded on PV units, in DisseminationSystem. This destabilizationturns out to beobvious as graduallysolitary stage DG entities are acquainted withDissemination System. [6]

3.2 Protection Issues

The existence of DG may perhapssource a numerouscomplicationscorrelated to inappropriate action of coordinationsecurities. The clangs amongst

DG and safety schemes are:

(*i*) Deficiency of dexterity in the defense system;
(*ii*)Unpredicted rise in smallpathundercurrents (SCC);
(*iii*)Undesired islanding and ill-timed stumbling of generators boundary securities.

Customarydispersalschemes were not planned to devourdynamicpower engenderingcomponents in them. Power is deliveredby the transmission scheme and power drift is primarilyunidirectional. With the incorporation DG in the structure, power flow can be bi-directional [5]

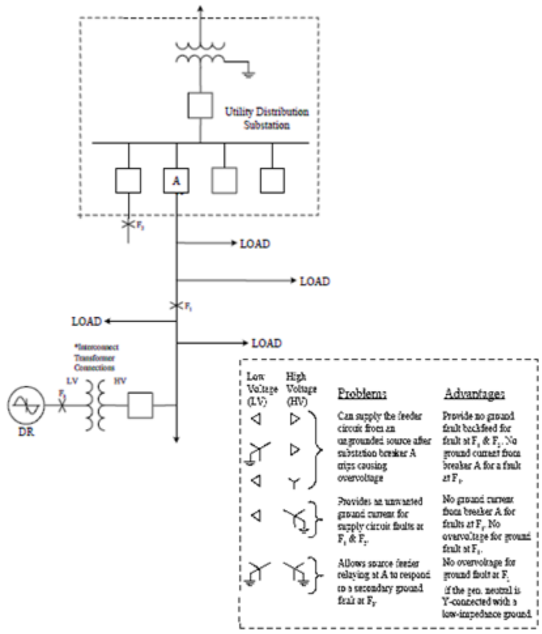

Figure 3. Interconnection Transformer Connections

a).Influence of co-ordination on Protection Scheme: Coordination can be apprehended by the subsequentinstance.

The current I_{UC}deprived of the DG is not equivalent to the currentI_{UC}using the DG as understood from the figure. Through the DG interrelated, the fault current perceivedby the recloser (I_{RE}) would be greater than shorn of the DG associated. This would commonly not source a problem usingthe recloser size as long as the new superiorI_{RE}does not overdo the recloser extremeinterjectinggrade.

Nevertheless, it is to be expected that harmonizationamongst the recloser and a few fuses will be mislaid. For the reason thattogether the recloser and fuses functionmore rapidly at greater error currents, the essentialboundariesconcerning there closer curvature and the fuse least possible melting curvaturemay perhaps be condensed to dropsynchronization [6].

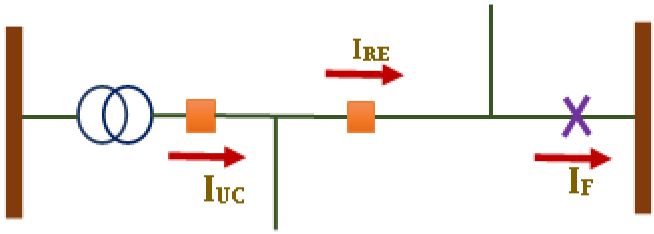

Figure 4. Classic feeder by means ofinclusion of DG up track recloser.

I_{UC} - Current from the Utility Center
I_{RE} - Fault current perceived by the recloser.
I_F - Fault Current
Deprived of DG : $I_{UC}= I_{RE}= I_F$
Using the DG pooled : $I_F= I_{UC}+ I_{DG}$
$I_{RE}= I_F$
However, $I_{RE}\neq I_{UC}$

Liable on features of the grid and DG, numerousaddedsafetycomplications can arise. They are:

1. Feeders may experience False Tripping which is also called as sympathetic tripping)
2. Variation in fuse coordination with fast tripping of recloser due to DG action
3. Generating units may undergo nuisance tripping
4. Protection unsighting
5. Amplified or diminished fault intensities
6. Unsolicited islanding
7. Proscription of spontaneous reclosing
8. Unsynchronization in the reclosing action

b) Consequenceon Short Circuit Levels of the Network due to DG

The short circuit levels of the grid might get upset due to manifestation of DG. An escalation is created in the fault currents whileequated to usual situations where DG is not incorporated to the grid [3].

Adiscrete DG may not have a great fault impact, nonethelessthere will be anupsurge in the fault current. In the occasion of large number of minorentities, or limited large entities, the short circuits levels can be reformed adequate to be a motivation for miss coordination between defensive elements such as fuses or relays. The reliability and safety of the distribution system may be disturbed due to this.

Figure 6displays a usual fuse adjacent on a feeder where fuse optimization is engaged and DGs are implanted in the scheme. In this circumstance if the fault current is sufficiently huge, the fuse might not match up with the feeder circuit breaker in the course of a fault.

This may lead to superfluous fuse functioning and declineddependability on the adjacent [3].

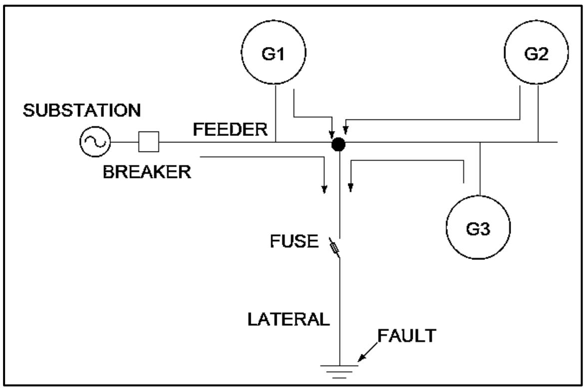

Figure 5. Fault influences due to DGs injected to the system. Fuse-breaker super visionmight not be accomplished.

In case the DR is positioned intermediate of the fault and the utility center, a reduction in fault current from the utility center may be witnessed. Conversely, if the DRs arerobustwhen related to the servicecenter, it may have a momentousimpression on the fault current upcoming from the service center. This might be the root cause to trip, serial tripping, or synchronization problems [14].

The characteristics of the DG also influences the short circuit intensities. The synchronous generator is the uppermostcontributing DG to faults. In the course of the first few sequences its involvement is one and the same as of the induction generator and self-excited synchronous generator, whereas after a first few phases the synchronous generator is the extreme fault current causal DG type. The inverter interfaced DG typedonates the minimum fault current. In a few inverter categories the fault contribution persists for less than one succession. [11].

c). Instantaneous Reclosing.

Figure 7 shows theprinciple of fault currents and the recloseintermission between "shots". [5] It displays first TwoShots of a Usual Distribution System ReclosingArrangement in the course of a Short Circuit. Many utilities practice "instantaneous" reclose for power quality persistence and obfuscate the concern. The recloseinterval is technically 0.5s but can be as small as 0.2s.

However, this upturns the option that the DG may notdetach in time. The encounter between necessity of a DG anduse of instantaneous reclose will become significant withcumulative penetration of DGs. Henceforth it is suggestedin contradiction ofconsuming instantaneous reclose on feeder sections thatcontain DG. A reclose interval of 1.0s or more would bedesirable. This will radicallycondense the probabilities thatthe DG will be unsuccessful to detach in time, but will also causereduced power quality to a certain section of customs.

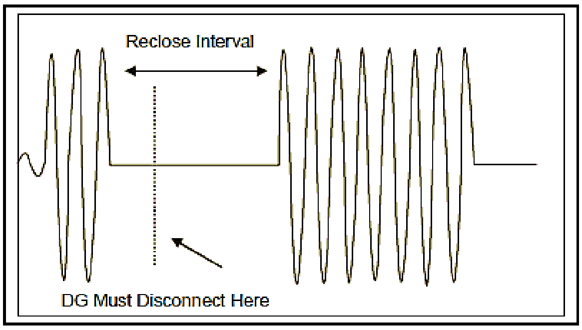

Figure 6. Fault current and Reclose interval

3.3 Coordination in the protection system. Universally,fortification of power systems is pitched in such a way thatonly the faulted part of the system is quarantined when a faultoccurs. This amendment is called protection coordination, whichcan be undesirably affected by the existence of DG [13].Undesired islanding and ill-timed tripping for faultson diverse feeders. This concern is very imperative anddiscussed unconventionally in the next section.

a) Islanding

An island is “That fragment of a power system comprising of one or more power sources and load that is, for a certain periodof time, disconnected from the rest of the system.”

Islanding is the circumstance when the DG is no longer functioning in analogous with the utility and may occur as aconsequence of the following situations:

- A fault that is sensed by the utility, and which upshots in opening a disconnect device but which is notsensed by the DG protection devices
- Unintentional opening of the usual utility supply be equipment failure
- Utility switching of the distribution system and loads
- Deliberatedetach for servicing either at a point on the utility or at the service entrance
- Human error
- Act of nature [16]

In the Figure 8, a substation is shown which steps downtransmission voltage into distribution voltage. One of the feedersis shown in detail. There are many consumer joiningpoints in the feeder. Large DGs are normallyattached to the primary feeders (DG1 and DG2).Small DGs such as inverter based PVsystems are linked to the low voltage secondary feeders (DG3). Islanded procedure can be Intentional Islanding orUnintentional islanding**.** In intentional islanding, the islandinghas been scheduled prior and the system has been intended to handlethe situation. The DG at that time is well suitable to regulate voltage and frequency in theislanded grid. [14, 15] Unintentional islanding takes place if the switching devicebetween the DG and the rest of the utility grid is openedand the DGcarries on to feed the distribution grid.

The DG equipment may not at all be appropriate to control voltageand frequency. The voltage and frequency caneven get so out of range that connectedconvention equipment isruined. [7]

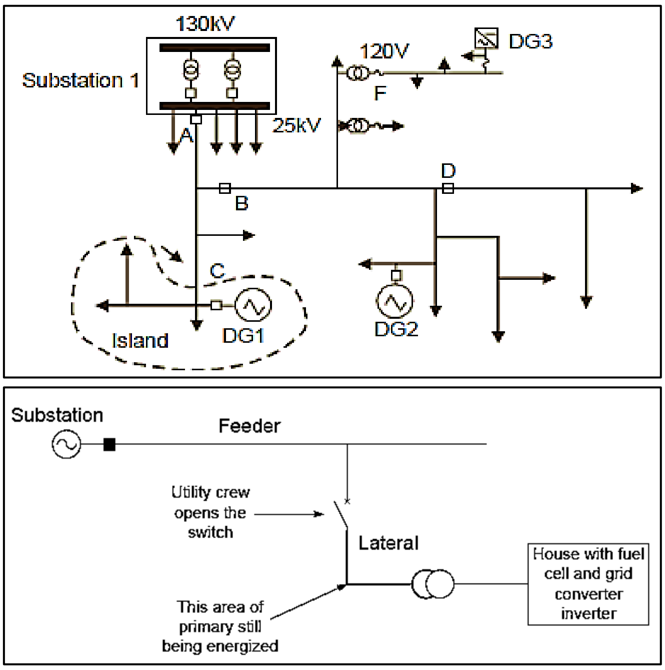

Figure 7: Islanding of a DG system

b) Temporary faults

In radial schemes, fault clearance necessitates the opening ofonly one device since there is only one sourcecontributing current to the fault. On the contrary, meshedsystems call for breakers at both ends of afaulted line to open. Apparently, when DG is existing, there are several power sources and opening only theutility breaker does not assure that the fault will clearrapidly. [5][6]

As a result, DG will be mandatory to detach fromthe system when a fault is suspicious, before the fastreclosing time has lapsed, so that the system regresses toa true radial system and the normal fault clearing processmay proceed.

In fact, there is the opportunity that DG will get detached either too rapidly or too slowly with adamaging influence on the distribution system. Thiscreates several potential operating clashes withrespect to overcurrent protection and voltage restrictions.

In this outlook DG appears to be rather discordantspecifically with fast reclosing during temporary faults.This procedure may not allow the DG units to haveenough time to be cut off from the grid. In thiscase DG units may tolerate the voltage and fault arc,avoiding effective reclosing in the instance of temporaryfaults. [11]

c) Sympathetic tripping

Sympathetic tripping arises when a protective devicefunctions unreasonably for faults in other protection zones.This can happen with distributed generation due tounpredicted fault contributions from the DG.

An exampleof how sympathetic tripping may perhaps arise is shown in Figure 9.
The relays at breaker “A” and there closer are not directional.

Therefore, adequate fault current undeniably from the distributed generation would source any of these devices to function in “sympathy (understanding)” with “B” which essentially perceives thefault.[7][4]

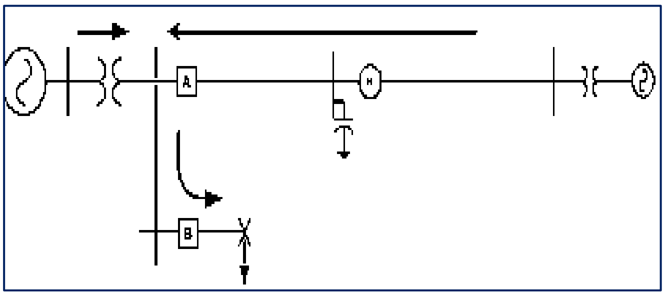

Figure 9: Illustration of Sympathetic tripping

IV. CONCLUSION

DG has much potential to upsurge the systemperformance. Nevertheless,distribution system schemes and functional practices aretypically based on radial power flows and this produces an unusual challenge to the incorporation of distributedgeneration. Diverse concerns related to power quality when DR is integratedwith the existing power system has been conversed in the paper.
DGs are a feasible substitute for emerging countries where grid supply has dependability below appropriate levels.

The association of DGs todistribution grids significantly influences the grids performance.
This paper has defined a few of the concerns thatneed be deliberated to assure that DG will not worsen the system’s power quality, safety or reliability.

Penetration of DG can be magnificently in corporated with the power system on condition that the interconnection strategiesbump into the in tricatenecessities that contemplate not only power quality but also system efficiency, power reliability and safety.

This paper also emphases on the DG’s influence on the gridsmechanism and protection patterns. A number of protection problems are recognized to study the requirements for protection in the existence of DGs.

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