International Journal of Engineering & Technology, 7 (2.21) (2018) 237-241

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Improvement of power quality of power system using contingency analysis

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Abstract

Contingency analysis is a widely known feature in present day Energy Management System (EMS).The purpose of this strength gadget evaluation feature is to offer the operator records approximately the static security. Contingency analysis of electricity gadget is a major pastime in power device planning and operation. In fashionable an outage of any person of transmission line or transformer might also result in over hundreds in other branches and/or unexpected machine voltage upward push or drop. Contingency evaluation is used to calculate violation. This paper shows the instance on IEEE-14 bus system which offers statistics of violation & remedial action to do away with violations. Exact studies had been completed to work out the contingency plans.

Keywords: *Distributed Generation, Transmission Line, Energy Management System (EMS), Voltage Magnitude, Losses, Generating Limits*.

1. Introduction

Contingency analysis is one of the primary component in contemporary current electricity control systems. For the reason of rapid estimating system balance proper after outage, the examine of contingency evaluation includes performing green calculations of machine performance from a set of simplified machine conditions.
Contingency evaluation is one of the most vital project encountered via the making plans and operation engineers of bulk electricity system.
The Line Outage Distribution Factor (LODF) is one of the crucial linear sensitivity factor which play a key function in locating the effect of the essential contingency and for this reason suggesting possible preventive and correction moves to resolve the violation inside the machine.

- LODF's are used to approximate the change in the glide on one line because of the outage of a 2nd line.
- Commonly they're best used to determine the exchange inside the mw waft as compared to the pre-contingency float.
- LODF's are approximately impartial of flows however do rely on the assumed community topology.
- Show the linear zed effect of a transfer of energy.

The growing load demand in power systems without accompanying investments in generating and transmission has affected the analysis of balance phenomena, requiring more dependable and faster device.

2. Problem identification

In IEEE-14 bus system in regular running conditions all bus voltage in strong kingdom which means voltage importance limits are in range among a 0.9 p.u < v<1.1 p.u .If any outage occurring any transmission line outages will failure it output turn out to be zero. Closing mills are overloaded generator limits among gi_min < gi < gi_max. If exceeding gi_max restrict generator gets heated and transmission losses also will increase to triumph over this hassle additionally dg's has furnished in proposed system.

Contingency Analysis

Contingency analysis is one of the security analysis application in a power utility control centre that differentiates an energy management system from a less complex SCADA system.It's purpose is to analyse the power system in order to identify the overloads problems that can occur due to a contingency.
Contingency evaluation is strange circumstance in electric community. It placed complete machine or part of the system below strain. It happens due to unexpected commencing of a transmission line. Generator tripping. Surprising trade in generating. Surprising exchange in load values. Contingency evaluation presents device for coping with, growing, reading and reporting listing of contingencies and associated violations.
CA is used as a observe device for the off-line analysis of contingency events, and as an online device to show operator what would be the results of future outages.

- Safety is determine with the aid of the potential of the device to withstand gadget failure.
- Susceptible element are people who gift overloads inside the contingency situation (congestion).

- Widespread approach is to carry out a unmarried (n-1) contingency evaluation simulation.
- A ranking method can be verified to prioritized transmission making plans.
- CA is therefore a number one tool used for education of the once a year preservation plan and the corresponding outage schedule for the strength gadget.

Types of violations in transmission line

Line contingency and generator contingency are commonly maximum common kind of contingencies. Those contingencies especially reason two varieties of violations.

Voltage magnitude violation

This kind of violation occur at the buses. This shows that the voltage on the bus is much less than the desired cost. The operating range of voltage at any bus is generally 0.9 p.u < v < 1.1 p.u. Hence if the voltage falls underneath 0.93 p.u then the bus is said to have low voltage. If the voltage rises above the 1.1 p.u then the bus stated to have excessive voltage hassle. It's far regarded that in the energy system community usually reactive electricity is the motive for the voltage issues. Therefore inside the case of low voltage problems reactive electricity is furnished to the bus to boom the voltage profile at the bus. Within the case of excessive voltage reactive electricity is absorbed at the buses to maintain the system normal voltage.

Line MVA limit violation

This type of contingency arise inside the device while the MVA rating of the road exceeds given score. That is in particular because of the increase within the amplitude of the present day flowing in that line. The lines are designed in this type of way that they should be capable of face up to 130% in their MVA restrict. Primarily based on utility practices,if the modern-day crosses the 70-80% of the restrict it's far declared as an alarm state of affairs. Distinct kinds of remedial movements to clear up this hassle are explained later on this paper.

3. Modelling of load

The alternatives regarding gadget reinforcements and machine performance is inside the foremost primarily based on the consequences of strength flow and balance simulation research. For acting analysis of strength device, models must be integrated to include all relevant system additives, collectively with generating stations, sub stations, transmission and distribution peripherals and cargo devices. Heaps hobby has been given to modeling of technology and transmission or distribution gadgets. but the modelings of loads have acquired loads a great deal less interest and stays to be an unexplored frontier and consists of plenty scope for future improvement. Latest research have determined out that illustration and modeling of load should have a awesome effect on evaluation effects. Efforts within the instructions of improving load-fashions were given excessive importance. Benefits of load modeling in energy glide studies

- The version of power name for with voltage permits better manage capacity.
- Actual calculation of lively and reactive strength call for at respective buses.
- Manipulate of over and below voltage at load buses.
- Minimization of losses.
- Improvement in voltage profile.
- Discount of incremental fuel value.

Power system analysis using eurostag simulation

All through this paper, the software EUROSTAG developed via RTE (previously EDF) and tractable engineering has been used to run every simulation. It's miles one of the software analyzing temporary stability in electric energy gadget. EUROSTAG can be used to observe a huge range of electric phenomena from short-circuits (numerous tenths of milliseconds) to voltage collapses (numerous tenths of mins). The entire community is represented through a differential algebraic device, which can be pretty huge: the modeled network can collect several thousand nodes. The key characteristic of EUROSTAG is to use a variable time step – from 1 millisecond to60 seconds - relying on the dynamic behavior of the system. for that reason whatever the nature of the perturbation (gradual or rapid), the period of the vital observation (as much as numerous hours) or the scale of the machine, EUROSTAG permits viewing the behaviour of the strength machine till it retrieves its equilibrium nation. To run a simulation in EUROSTAG, 3 steps are vital:

1. Getting ready information and modeling: EUROSTAG has every electric powered models to symbolize each elements of the community: turbines, vehicles, transformers, masses models, safety relay, and so forth, and additionally a extensive library of additives accumulating general fashions of regulators (voltage or generator speed) and different gadget (steam turbine, facts, hvdc…). The consumer thanks to a picture interface can of direction put in force every non-present model. The diagram of the studied community is then constructed way to a community editor.
2. Simulations: The calculation of the preliminary state of the power machine is administered with the aid of a load float module which takes as enter the records file: nodes' voltage, present day and electricity through branches, sources and prices, operating factor of machines. the software program allows contemplating numerous forms of occasions occurring in the community such as coupling production devices, opening/final of breakers, manipulate of faucet changers transformers, masses dropping, set-points' adjustments. Every event may be scheduled or be the result of an automaton motion (safety relays or tap changers). EUROSTAG also has a module to calculate routinely critical clearing time. To try this, the fault as well as the clearing actions have to be unique and then the software calculates mechanically the essential clearing time.
3. Post processing: The consequences of simulations are time-plots including turbines data (speed, electric powered and mechanical torque, voltage excitation), voltages at certain buses, contemporary or electricity going via branches, etc. all of those results allow studying the behavior of the electric electricity gadget at some point of precise occasions to study:
    - Device balance
    - Comfort moves capability
    - Protection plans
    - Regulators' tuning.

System formation

Load float analysis is the backbone of the power device research and design, and via it the voltage value and segment attitude at every bus and the complicated strength flowing in every transmission line can be received. We are use the weight-go with the flow to perform a sensitivity evaluation of the IEEE-14 bus System.IEEE-14 Bus records proven in table 3.1. We discover the maximum complicated strength flowing in every transmission line in case of no fault and in case of any person technology outages or fault within the constant country condition. The end result of this analysis facilitates identify the most minimizing total losses.

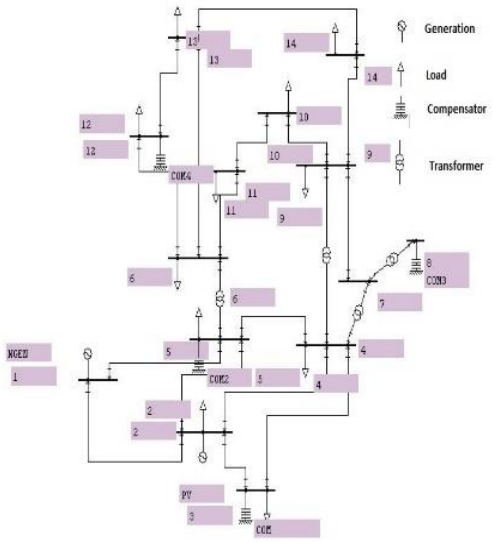

Figure 3.1: IEEE-14 bus system

Table 3.1: Load Data for IEEE 14 Bus System

Bus No	P load [p.u]	Q load [p.u]
Bus1	0.0	0.0
Bus2	2.17	0.87
Bus3	9.42	1.90
Bus4	4.78	0.39
Bus5	0.76	0.16
Bus6	1.12	0.75
Bus7	0.0	0.0
Bus8	0.0	0.0
Bus9	2.95	1.66
Bus10	0.90	0.58
Bus11	0.35	0.18
Bus12	0.61	0.16
Bus13	1.35	0.58
Bus14	1.49	0.5

Evaluation of IEEE-14 bus System generation equals to load and losses in system earlier than outages voltage limits aren't exceeding among limits. In each bus actual and reactive load given in p.u representation in desk 3.1.
Total power generation, load and losses are given in table 3.2.

Table 3.2: Total Generation, Load and Losses Data for IEEE 14 Bus System

Total Generation (p.u)	33.71
Total load (p.u)	33.63
Total losses (p.u)	0.08

Above analysis of total generation, load and losses are will be balancing equal if mismatch losses and generation losses are high in the system.

4. Analysis of after transmission line outages

In system having 20 transmission strains if outage occurs on each line and to be evaluation of each bus voltage magnitude, go with the flow restrict of other transmission traces and remaining mills are overloaded voltage significance tiers decreased below 0.93 p.u, q_limit additionally exceeding its limits. If transmission traces are overloaded that mean MVA restriction will not exceeding it's gets heated and energy dissipated in from of warmth.

Table 4.1: Voltage Magnitude and Phase Angle Data for 1 – 5 Line Outage

Bus	Voltage magnitude [p.u]	phase [Deg]
Bus6	0.90	-15.20
Bus10	0.92	-16.35
Bus11	0.91	-15.97
Bus12	0.93	-16.08
Bus13	0.91	-17.65
Bus14	0.91	-18.18

In the analysis of 1-5 line outages other line gets overloaded voltage magnitude reduced below 0.93 p.u it's lower voltage and above 1.05 p.u it's over voltage in table 4.1 Buses all get under voltage.

Table 4.2: Power Flow Data for 1 – 5 Line Outage

From Bus	To Bus	Power Flow [MVA]
Bus1	Bus2	166.5

Table 4.3: Total Generation, Load and Losses Data for 1 – 5 line outage

Total Generation (p.u)	37.94
Total load (p.u)	33.63
Total losses (p.u)	4.311

In above analysis table 4.3after outage total generation is 37.94 MW comparing to before outage generation 4.2 MW increasing losses of system also get increasing.

Table 4.4: Voltage Magnitude and Phase Angle Data for 2 – 3 Line Outage

Bus	Voltage magnitude [p.u]	phase [Deg]
Bus3	0.78	-28.39
Bus4	0.87	-14.78
Bus5	0.91	-11.71
Bus6	0.86	-11.99
Bus10	0.86	-14.88
Bus11	0.86	-13.76
Bus12	0.89	-15.67
Bus9	0.88	-15.00
Bus13	0.85	-15.12
Bus14	0.84	-16.70
Bus7	0.87	-14.80
Bus8	0.88	-14.81

In the analysis of 2-3 line outages other line gets overloaded voltage magnitude reduced below 0.93 p.u it's lower voltage and above 1.05 p.u it's over voltage in table 4.4 Buses all get under voltage.

Table 4.5: Power flow Data for 2 – 3 Line Outage

From Bus	To Bus	Power Flow [MVA]
Bus2	Bus4	100.1
Bus4	Bus3	105.6
Bus4	Bus5	105.0

Table 4.6: Total Generation, Load and Losses Data for 2 – 3 Line Outage

Total Generation (p.u)	42.26
Total load (p.u)	33.63
Total losses (p.u)	8.632

In above analysis table 4.6 after outage total generation is 42.26 MW comparing to before outage generation 8.63 MW increasing losses of system also get increasing.
Above analysis tables power not balancing this line outages we reducing losses and reliability of system needed to overcome this problem additionally static synchronous compensator and DFIG (Distributed generation).

5. Analysis of after integrating DG and compensator

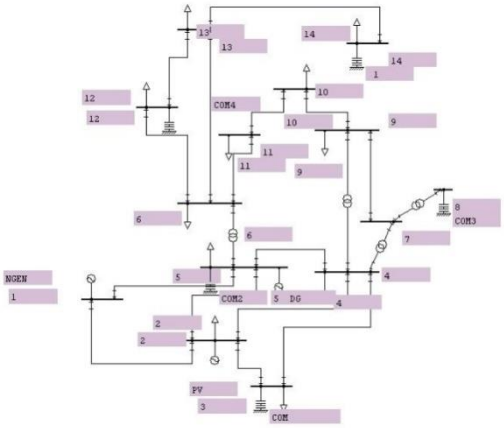

Figure 5.1: Modified IEEE 14 bus system

In the Modified IEEE-14 Bus system to improve voltage stability and reduction of losses to be minimized arranging of wind generation and compensator as shown in figure 5.1. In the Bus 5 and Bus 14 voltage magnitude is lower compared to other Buses the Static Synchronous Compensator is fixed.

STATCOM

The Static Synchronous Compensator (STATCOM) is a parallel connecting device of the flexible ac transmission systems (facts) family the usage of energy electronics to govern power go with the waft and enhance brief stability on energy grids. The STATCOM regulates voltage at its terminal with the useful resource of controlling the quantity of reactive power injected into or absorbed from the power machine. While machine voltage is low, the STATCOM generates reactive electricity (STATCOM capacitive). at the same time as gadget voltage is high, it absorbs reactive power (STATCOM inductive).the static synchronous compensator (STATCOM) is a parallel connecting tool of the bendy ac transmission structures (records) own family the usage of power electronics to govern power go along with the waft and decorate quick balance on energy grids. The STATCOM regulates voltage at its terminal with the useful resource of controlling the quantity of reactive energy injected into or absorbed from the energy system. While device voltage is low, the STATCOM generates reactive strength (STATCOM capacitive). At the same time as machine voltage is high, it absorbs reactive electricity (STATCOM inductive).

Table 5.1: STATCOM Data

Rating name	Unit	Value
Power and Voltage	[MVA KV]	[100 146]
Voltage magnitude	[p.u]	[1.00]
Qmax and Qmin	[p.up.u]	[0.7 -0.3]

Bus 5threal and reactive power drift higher than other buses Static Synchronous Compensator gently real power compensating but now not enough to compensating the whole technology in fifth bus. to supply the energy distribution technology will be constant which means on this proposed gadget renewable power source act as distribution generation use this renewable strength supply the voltage value of all buses will be stabilizing the wind generation is renewable electricity source on this proposed gadget. Doubly fed induction era is used in this device. Due to more benefit using this gadget of different wind generations.

DFIG

Doubly fed electrical generators are like AC electrical turbines, however have extra skills which allow them to run at speeds slightly above or underneath their natural synchronous pace. That is useful for massive variable pace wind generators, because of the fact wind speed can alternate suddenly. Even as a gust of wind hits a wind turbine, the blades try to boost up, but a synchronous generator is locked to the velocity of the electricity grid and can't accelerate. So big forces are developed within the hub, gearbox, and generator because the strength grid pushes lower back. This causes put on and damage to the mechanism. If the turbine is authorized to hurry up proper now while hit via a wind gust, the stresses are lower and the energy from the wind gust is converted to beneficial electricity.

One technique to allowing wind turbine velocity to vary is to truely accept something frequency the generator produces, convert it to dc, and then convert it to AC on the preferred output frequency the usage of an inverter. Ahis is commonplace for small residence and farm wind turbines. But the inverters required for megawatt-scale wind turbines are large and expensive.

Table 5.2: DFIG data

Rating name	Unit	Value
Power, Voltage and frequency	[MVA KV HZ]	[40 146 60]
Inertia constants	[KWs/KVA]	[5]
Pitch control gain and time constant Kp, Tp	[p.u. s]	[10 3]
Voltage control gain	Kv [p.u.]	[10]

Totally 20 wind generations are connected in compose block.

Power flow results

Table 5.3: Analysis for 1-5 Line Outage after DG and Compensator Integrating

Bus	Voltage magnitude [p.u]	phase [Deg]
Bus6	0.98	-11.72
Bus10	1.00	-12.36
Bus11	0.99	-12.18
Bus12	1.01	-14.65
Bus13	0.98	-13.73
Bus14	0.99	-13.96

In above analysis table 5.3 after integrating DG and compensator during 1-5 line outage the all Bus voltage magnitude will be stabilizing between 1.05 p.u and 0.95 p.u. And DG supplies 40MVA power to system. It leads to reduce the MVA flow rate on the transmission line. That analysis below table 5.4.

Table 5.4: Power flow Data for 1 – 5 Line Outage after Integrating DG and Compensator

From Bus	To Bus	Power Flow [MVA]
Bus1	Bus2	130

In during line outage line 1-2 MVA limit exceeds to above 160MVA level that line would capable of 140MVA but extra amount of power flowing that leads to power dissipation.

Table 5.5: Total Generation, Load and Losses Data for 1 – 5 Line Outage after Integrating DG and Compensator

Total Generation (p.u)	35.02
Total load (p.u)	33.63
Total losses (p.u)	1.403

Above analysis to integrating DG and Compensator Total generation reduce to 35.0MW and losses reduce to 1.403 MW.

Table 5.6: Analysis for 2-3 Line Outage after DG and Compensator Integrating

Bus	Voltage magnitude [Kv]	phase [Deg]
Bus3	0.96	-21.67
Bus4	1.00	-11.26
Bus5	1.02	-9.46
Bus6	0.96	-9.72
Bus10	0.98	-11.34
Bus11	0.97	-10.74
Bus12	1.01	-13.75
Bus9	1.00	-11.24
Bus13	0.98	-14.07
Bus14	1.02	-19.00
Bus7	1.00	-11.26
Bus8	1.00	-11.29

In above analysis table 5.6 after integrating DG and compensator during 2-3 line outage the all Bus voltage magnitude will be stabilizing between 1.05 p.u and 0.95 p.u. And DG supplies 40MVA power to system. It leads to reduce the MVA flow rate on the transmission line. That analysis below table 5.7.

Table 5.7: Power flow Data for 2 – 3 Line Outage after Integrating DG and Compensator

From Bus	To Bus	Power Flow [MVA]
Bus2	Bus4	82.8
Bus4	Bus3	95.8
Bus4	Bus5	69.5

In during line outage line 2-5 MVA limit exceeds to above 100MVA level that line would capable of 100MVA but extra amount of power flowing that leads to power dissipation.

Table 5.8: Total Generation, Load and Losses Data for 2 – 3 Line Outage After Integrating DG and Compensator

Total Generation (p.u)	37.68
Total load (p.u)	33.63
Total losses (p.u)	4.05

Above analysis to integrating DG and Compensator Total generation reduce to 37.6MW and losses reduce to 4.05 MW.
To adding compensator and distributed generation after analysis of system all bus voltage magnitude are within limits shown above tables.
To integrating of DFIG and Static compensator at Bus 5and Bus 14 all bus voltage stabilizing, Reducing losses from 8.609(MW) to 4.083(MW) at bus 14 and system total losses reducing upto 20% of total generation. The DFIG providing 4.0 (MW) power of total energy it will compensating of generation outage and Static Synchronous Compensator to compensating of required amount of reactive power.
In above analysis of tables losses are reduced to minimum level and total losses are reduced minimum level.
In previous existing systems total system losses are reduced to 20% to 23% and in proposed system total system losses of total generation reduced to 17% to 20%.

6. Conclusion

The remedial activities viably expelled the breaking point infringement inside the framework. The consequences received through the proposed calculation are found to be very unique and therefore, this paintings offers new equipment to creating healing manage sports for better request possibilities. Possibility investigation examine fortifies the underlying important arrangement. It's far moreover beneficial to create framework administrators to beautify their capacity to decide difficulty. This device facilitates specially the bustling pressure framework administrators.

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