

Protection and Automation B5

Addressing Protection related challenges in network with low inertia and low fault current PS1

10471_2022

Renewable energy protection challenges & overview of pre-synchronization study for renewable energy generation in Southern regional grid in India

Muthu Kumar T*, Pradeep reddy M, Abhishek R.S, Kumar S.P, Suresh V

Power System Operation Corporation Limited, India

Motivation

- Section I : Bring out the various protection challenges observed with Renewable Energy (Wind & Solar) stations.
- Section II : Overview of pre-synchronization study being done for Renewable Energy (Wind & Solar) Generation : LVRT, HVRT, Voltage control, Harmonics & DC current injection

Method/Approach

- Section I : Event analysis carried out with the help of DR, EL, SCADA, Synchrophasor data and feedback from utilities.
- Section II : Pre-synchronization study done with Power system computed aided design (PSCAD).

Objects of investigation

- Section I : Protection of RE & its associated system.
- Section II : Simulation studies are conducted to ensure that renewable energy sources comply with the various Indian grid code and regulatory obligations.
- Results of the simulations are investigated by system operator and any non-compliance of the regulations is taken up with RE developer.

Experimental setup & test results

- Section I : Case studies - Mis-operation of anti-islanding relays; presence of high zero sequence current at Photo Voltaic (PV) inverter stations, high grid voltages; Improper Protection co-ordination.



- Section II : Aggregated model of a typical solar farm connected to grid through DC-AC Inverter, Inverter Duty Transformer, transmission line, and power transformer.

Discussion

- Section I: Anti-islanding relay maloperation was resolved by modifying the relay sensing logic.
- Presence of zero sequence voltage during solar generation period may affect protection using zero sequence as sensing threshold.
- Improper protection co-ordination of line DEF with PV inverter feeder was corrected.
- Night mode operation of PV inverters explored to contain the over voltage conditions in grid.
- Weak infeed protection enabled where remote end (Inverter end) not able to feed fault current.
- Section II : RE plant response to different type of scenarios such as L-G, L-L, 3-ph, successive faults, high voltage at Point of interconnection are verified.
- Results show that RE are able to comply with LVRT, HVRT, Voltage control, reactive power and Harmonics as specified in regulations.

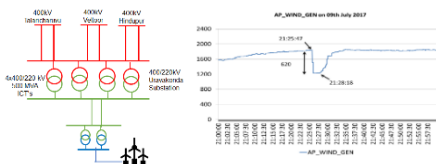
Protection and Automation B5

Addressing protection related challenges in network with low inertia and low fault current PS 1

10471_2022

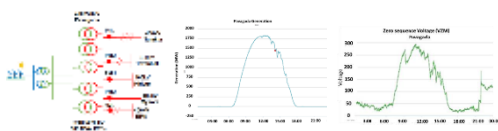
Renewable energy protection challenges & overview of pre-synchronization study for renewable energy generation in Southern regional grid in India

Mis-operation of Anti-islanding relay



- Mis-operation of Vector surge relay in Wind farm leading to wind generation interruption.
- Remedial action : Ride through time delay of 200ms. If condition for anti-islanding is persisting for 200ms then relay shall actuate to trip.

Presence of high zero sequence voltage



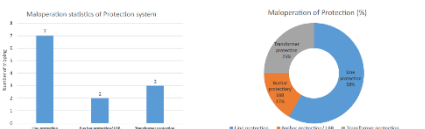
- Increase in Zero sequence voltage with solar generation.
- Injection of a zero-sequence component into CHB converter output voltages for managing Inter-phase power imbalance.
- Can impact the protection relays which use zero sequence voltages as a sensing threshold.

Protection Co-ordination



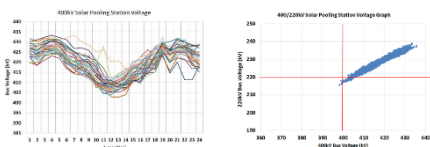
- Undesired tripping due to improper co-ordination of directional earth fault relay of 220kV line.
- Remedial action : protection co-ordination was set right.

Maloperation of protection relays



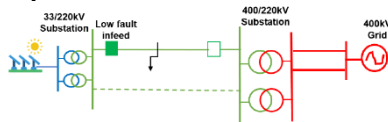
- Transmission line protection : Improper distance relay configuration; Improper DEF co-ordination.
- Transformer protection : Mis-operation of Buchholz relay; Mal-operation of overflux relay; mal-operation due to enabling of undesired protection such as overvoltage for transformer.

Over voltage in 220kV Grid



- High grid voltages during Non solar hours and during lean wind generation period.
- Remedial action : Enabling of over-voltage protection in 220kV lines, Night mode operation of PV Inverters.

Improper/ Non-operation of distance relays



- Distance relays not operating at times due to the less fault infeed from the PV inverters.
- Remedial action : Enabling of weak infeed protection.

Conclusion

- Proper coordination of protection system to avoid any unwanted tripping.
- Leverage on new technologies and use adaptive protection.
- Develop a uniform protection philosophy/ guideline for RE sources and carry out regular protection audits.

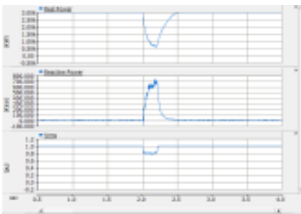
Protection and Automation B5

Addressing protection related challenges in network with low inertia and low fault current PS 1

10471_2022

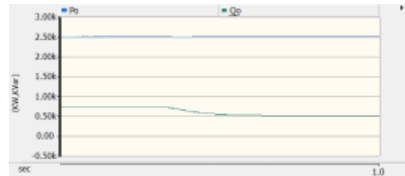
Renewable energy protection challenges & overview of pre-synchronization study for renewable energy generation in Southern regional grid in India

RE response during L-L fault



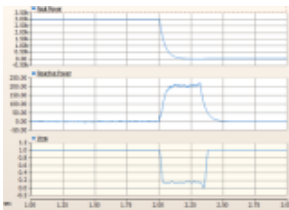
- Simulations are carried out to check the capability of the inverter to ride through the fault and inject reactive power during fault.
- LVRT performance and ability to restore power within one second after the fault is checked.

Voltage control



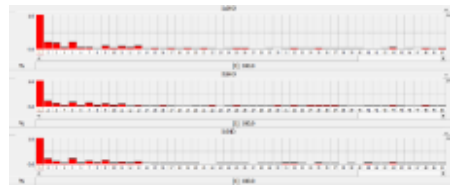
- Capability of RE to operate in voltage control, constant reactive power control or constant power factor control mode are verified.

RE response to long duration faults



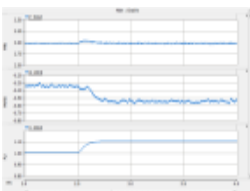
- RE plant response to a fault outside the trip zone of the LVRT curve is tested to check the compliance.

Harmonic current Injection & DC injection



- Harmonics injected by the RE plant during steady-state and fault condition is analyzed by carrying out a FFT analysis.
- Results are compared with the harmonic limits specified in IEEE-519 standard for compliance.

RE HVRT characteristics



- The response of the RE farm for high voltages at interconnection point is studied and their compliance to grid code is verified.

Conclusion

- Pre synchronization simulation studies provide first hand information of RE compliance with grid code.
- Any unintended results are taken up with the RE developer to comply.