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Low-Voltage Ride-Through Operation of Grid Interfaced Solar PV System with Harmonic Compensation Capability

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ABSTRACT

- This work deals with low-voltage ride-through operation of solar photovoltaic (PV) array along with power quality (PQ) improvement features in the distribution grid such as grid currents balancing, improve solar power penetration into the distributed network, power factor correction features.
- Under balanced/unbalanced grid voltage faults, the proposed strategy controls DC-DC converter in such a way that voltage source converter (VSC) currents are achieved within its permissible limits along with improving stability of the grid. (it is mandatory to follows since 2014 as per IEEE-1547-2014 and E.ON standards)
- The effectiveness of the GI algorithm is illustrated with frequency domain analysis and Lissajous plot to extract fundamental load component (FLC).
- Test results show satisfactory performance for a proposed system under steady state and dynamic conditions such as load currents unbalancing, variable solar insolation, distribution static compensator mode and line to ground fault.

FUNCTIONALITIES OF THE CONTROL STRATEGY

- Ride-through operation under symmetrical and unsymmetrical faults in the grid.
- Inverter is protected by accommodating its rating into control strategy.
- Balanced grid currents are achieved even under imbalanced load currents.
- Improve dynamics of the grid currents by including solar PV feed-forward term.
- Reduce losses in VSC: Adaptive DC link approach is adopted for reference DC link voltages.
- System performance is not affected even under presence of DC offset (for continuous/short time) in the load current.
- Capable to operate even under distorted grid voltages.
- Grid currents are balanced even under balanced and unbalanced faults and its total harmonics distortions are maintained according to IEEE-519 standard.

PRESENTED TOPOLGY AND CONTROL STRATEGY

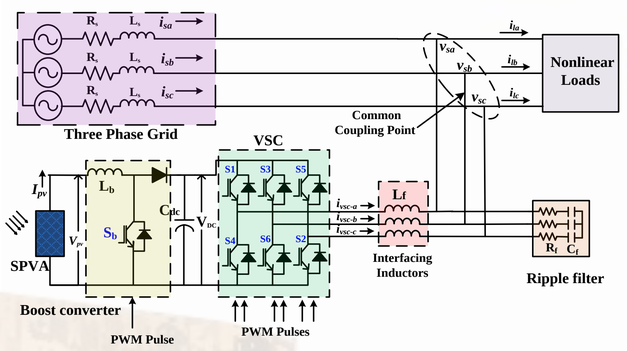


Fig. Double stage grid interfaced SECS

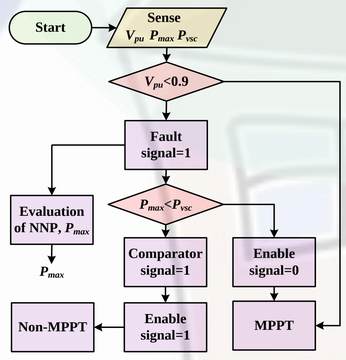


Fig. Operating point of SECS

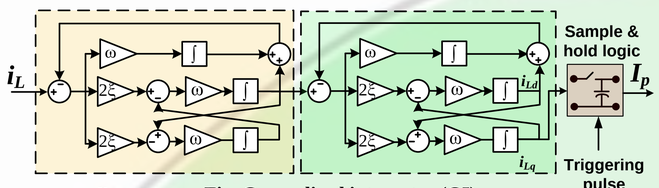


Fig. Generalized integrator (GI)

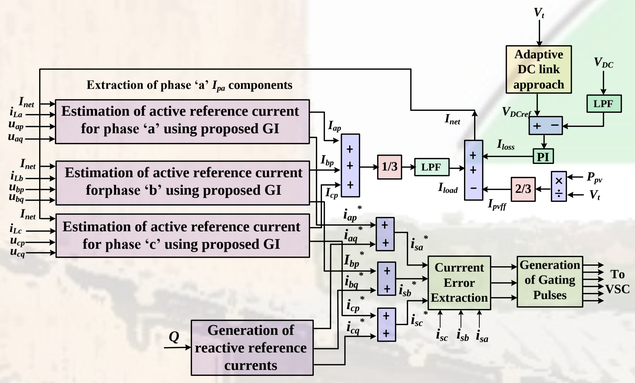


Fig. Switching strategy of VSC

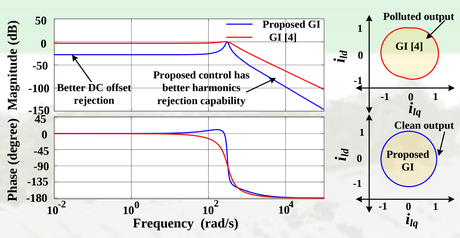


Fig. Effectiveness of generalized integrator

INDUSTRIAL SIGNIFICANCE

- The proposed control strategy provides better system performance under weak grid scenario, which is major issues in under-developed and developing countries.
- It follows IEEE-1547.4 standard and grid code of country (as per designed in control structure).
- The feed forward term provides better dynamic response under variation of solar insolation and voltages at point of common coupling.
- The stability of distribution grid is improved as reactive power is supplied to the distribution grid based on revised grid code.
- It is able to suffice various functionalities, 1) Reactive power control, 2) Frequency control through active power control, 3) Dynamic grid support capability.

CONCLUSIONS

- The performance and behaviour of the system are found robust and reliable using generalised integrator based adaptive control strategy under dynamic and steady-state conditions.
- The proposed control effectively provides reactive power control, frequency regulation, and dynamic grid support.
- The performance of the control strategy is found satisfactory, which is validated through simulations results and through a developed setup in the laboratory for different operating conditions.
- The proposed GI based algorithm is effectively extracted the fundamental component of load current under any operating scenarios.
- The total harmonic distortions (THDs) of grid currents are found within limits of IEEE-1547.4. and IEEE-519 standards.

SIMULATION RESULTS

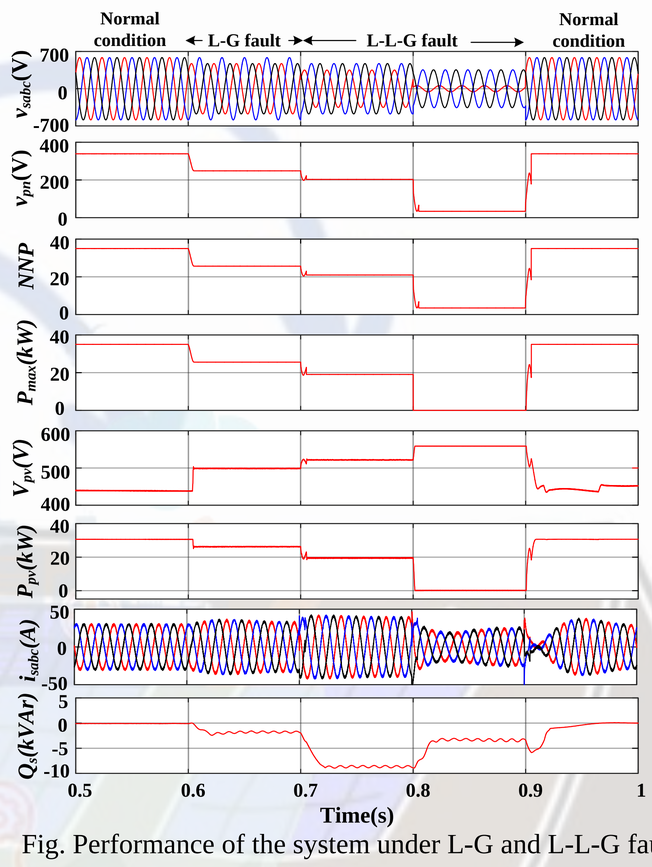


Fig. Performance of the system under L-G and L-L-G fault

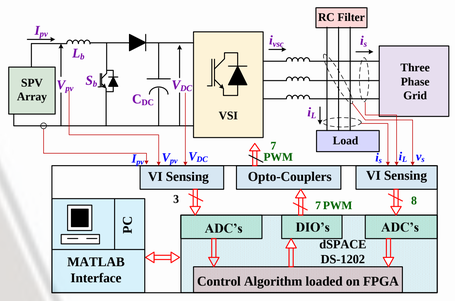
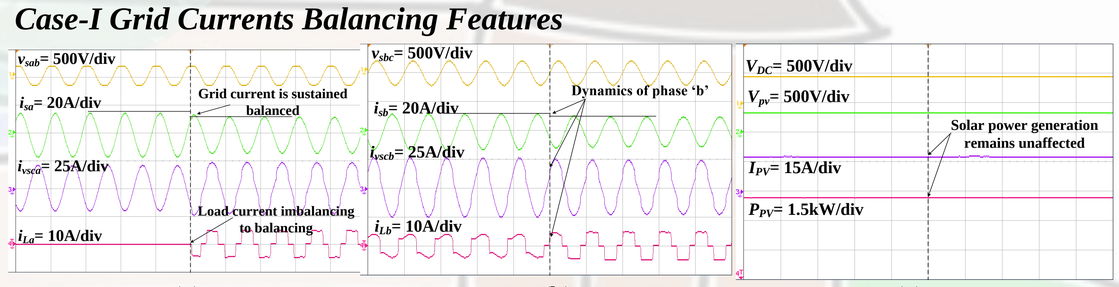


Fig. Equivalent circuit of experimental prototype

EXPERIMENTAL RESULTS

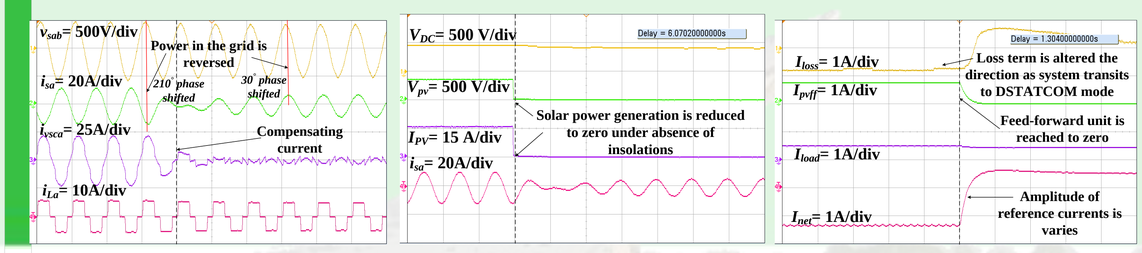
Case-I Grid Currents Balancing Features



(a) (b) (c)

Fig. (a) grid voltage, grid current, VSC current, load current for phase 'a' (b) grid voltage, grid current, VSC current and load current for phase 'b' (c) DC link voltage, PV array voltage-current-power

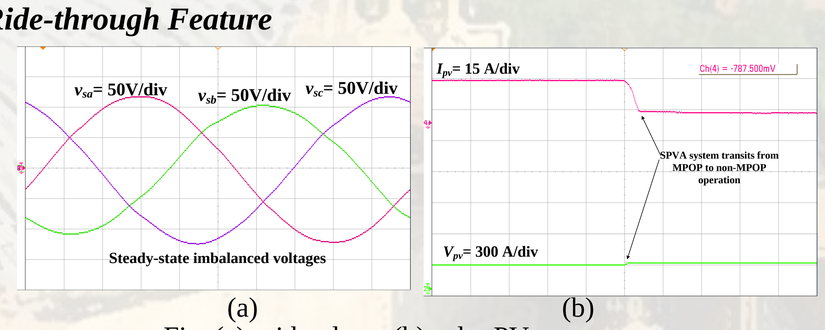
Case-II DSTATCOM Feature



(a) (b) (c)

Fig. (a) grid voltage, grid current, VSC current, load current for phase 'a' (b) DC link voltage, PV array voltage-current-power (c) intermediate control signals

Case-III Ride-through Feature



(a) (b)

Fig. (a) grid voltage (b) solar PV array current

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