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Power Quality Improvement of Grid with Adaptive DC Link Approach Enabling Unified Power Quality Conditioner Feature

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ABSTRACT

- This work deals with power quality improvement of the distribution grid using unified power quality conditioner for grid interfaced double stage solar energy conversion system.
- The presented control provides multifunctional functionalities such as grid currents balancing, improve solar power penetration into the distributed network, power factor correction and voltage regulation of common coupling point.
- The generalized integrator based algorithm is presented to estimate the weight of the fundamental load component without prior knowledge of the load current.
- Simulation results shows the satisfactory response of the control strategy at event of voltage sag and voltage swell. The maximum power point of the solar PV array is maintained even under voltage sag and voltage swell phenomenon.
- Test results are carried out to validate the performance of the system under steady state and various dynamic conditions such as voltage sag and voltage swell.

FUNCTIONALITIES OF THE CONTROL STRATEGY

- The common coupling voltage are effectively regulated in case of voltage sag and voltage swell phenomenon.
- The total harmonic distortion of the grid voltages are achieved within IEEE-519-2014 standard.
- The positive and negative sequence powers are not injected even under load unbalancing or voltage unbalancing scenarios.
- 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.
- Capable to operate even under distorted grid voltages.
- Grid currents are balanced even under unbalanced and unbalanced load currents and its total harmonics distortions are maintained according to IEEE-519-2014 standard.

PRESENTED TOPOLGY AND CONTROL STRATEGY

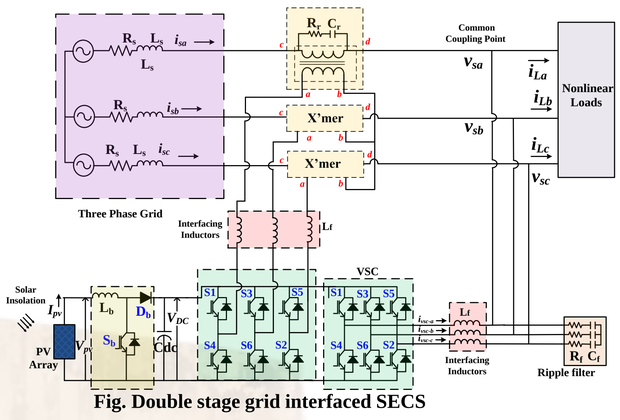

Fig. Double stage grid interfaced SECS

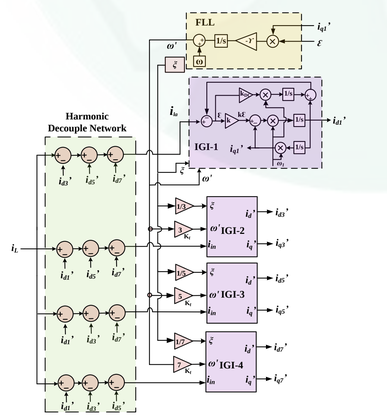

Fig. Generalized Integrator

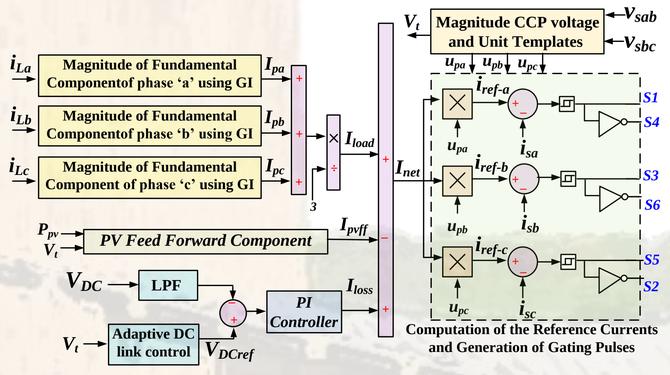

Fig. Switching strategy of shunt VSC

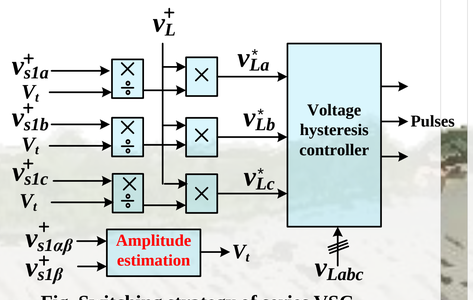

Fig. Switching strategy of series VSC

INDUSTRIAL SIGNIFICANCE

- The presented work provides better voltage regulation than conventional three phase grid interfaced SECS under weak grid voltages.
- It follows IEEE-519-2014 and IEEE-1519 standards.
- The series and shunt converters provide better voltage regulation and harmonic compensation to improve the power quality of the grid even under presence of nonlinear loads.
- The performance of the connected critical loads are not affected, which is mandatory in hospital, industry (as torque is directly proportional to square of voltage)
- It is able to suffice various functionalities, 1) harmonic control, 2) maximum power point tracking operation, 3) voltage regulation.

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 various functionalities, 1) harmonic control, 2) maximum power point tracking operation, 3) voltage regulation.
- The generalized integrator based algorithm is effectively estimated the magnitude of the fundamental load component.
- Simulation and experimental results show satisfactory response under case of the voltage sag and voltage swell phenomenon.
- The total harmonic distortions (THDs) of grid currents and voltages are found within limits of IEC-61727 and IEEE-519 standards.

SIMULATION RESULTS

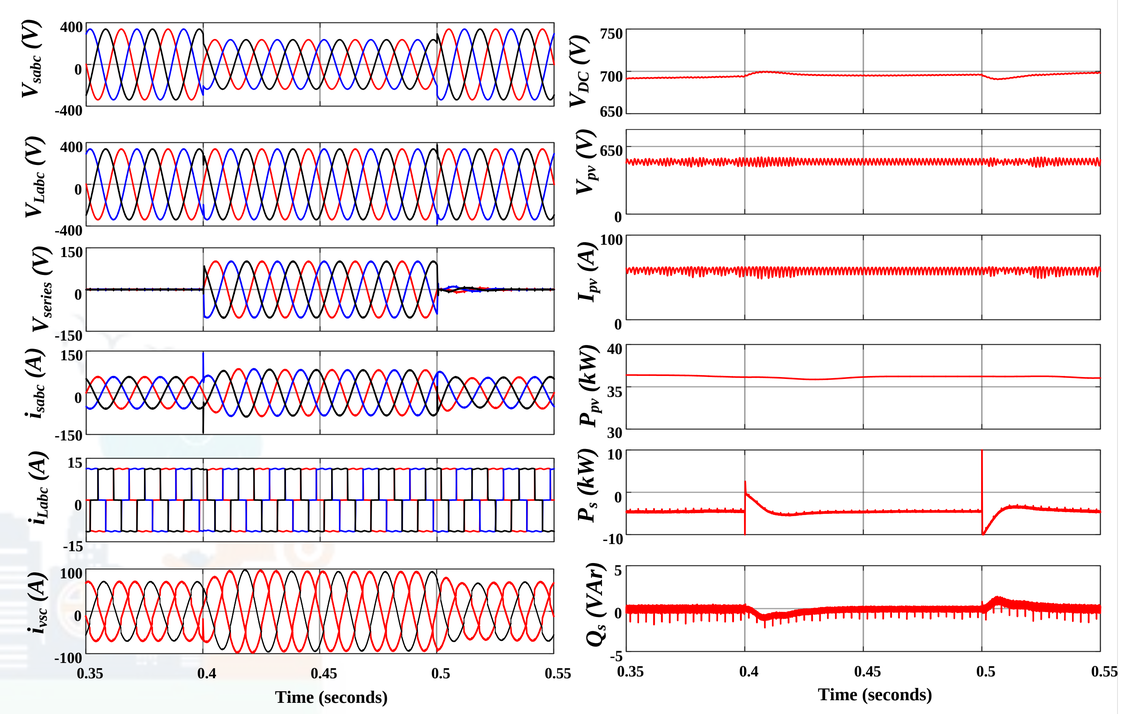

Fig. Performance of the system under voltage sag phenomena

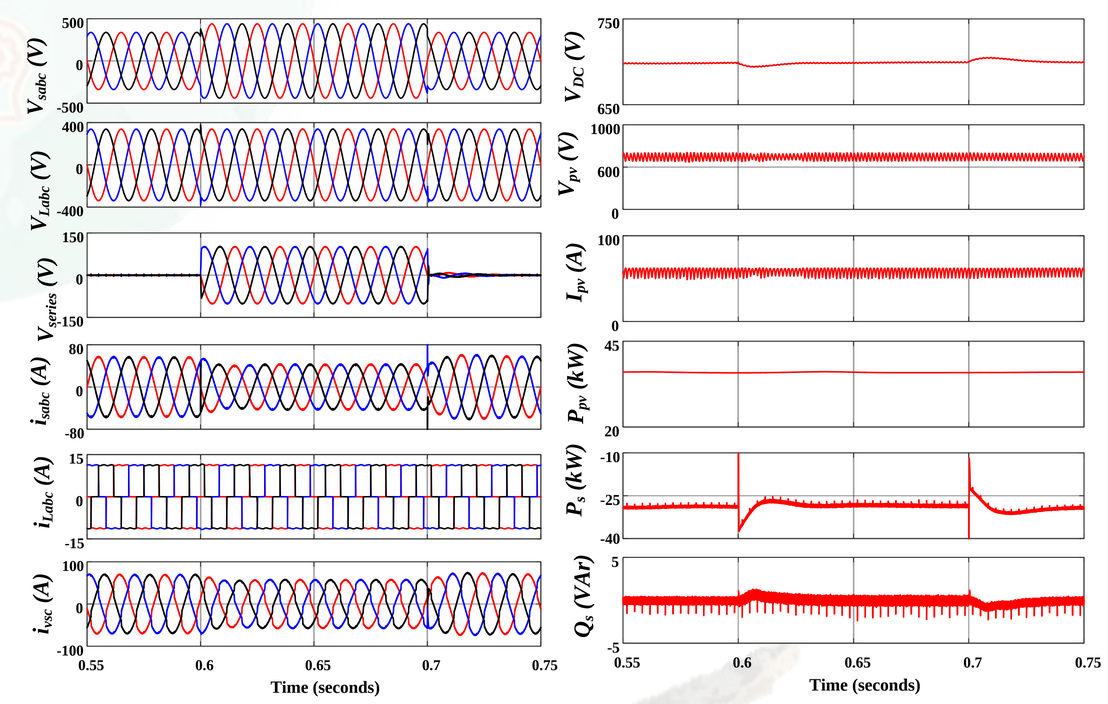

Fig. Performance of the system under voltage swell phenomena

EXPERIMENTAL RESULTS

Case-I Variation under Solar Irradiations

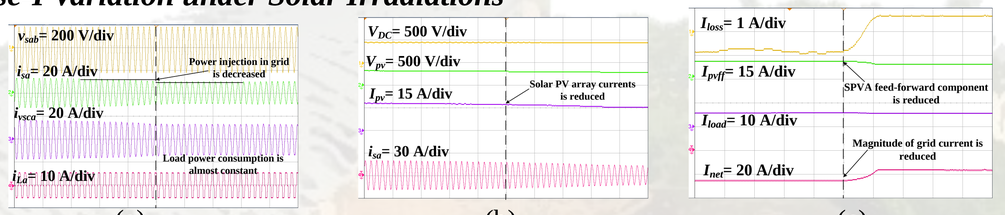

Fig. (a) grid voltage, grid current, VSC current, load current for phase 'a' (b) grid voltage, grid current, VSC current and load current for phase 'b' (c) intermediate control signals

Case-II Voltage Sag Event

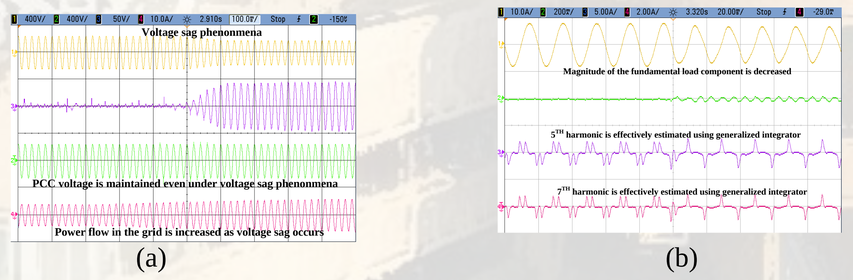

Fig. (a) grid voltage, series compensated voltage, common coupling voltage, grid current (b) fundamental load component, 3rd harmonic, 5th harmonic, 7th harmonic load components

REFERENCE

- Y. M. Qasim and V. Khadkikar, "ADALINE based control strategy for threephase three-wire UPQC system," in Proc. 16th Int. Conf. Harmon. Qual. Power, May 2014, pp. 586–590.
- A. B. Shitole et al., "Grid interfaced distributed generation system with modified current control loop using adaptive synchronization technique," IEEE Trans. Ind. Electron., vol. 13, no. 5, pp. 2634–2644, Oct. 2017.