ZSI for PV systems with LVRT capability

ABSTRACT:
This study proposes a power electronics interface (PEI) for photovoltaic (PV) applications with a wide range of ancillary services. As the penetration of distributed generation systems is booming, the PEI for renewable energy sources should be capable of providing ancillary services such as reactive power compensation and low-voltage ride through (LVRT). This study proposes a robust model predictive-based control strategy for grid-tied Z-source inverters (ZSIs) for PV applications with LVRT capability. The proposed system has two operation modes: normal grid condition and grid fault condition modes. In normal grid condition mode, the maximum available power from the PV panels is injected into the grid. In this mode, the system can provide reactive power compensation as a power conditioning unit for ancillary services from DG systems to main ac grid. In case of grid faults, the proposed system changes the behavior of reactive power injection into the grid for LVRT operation according to the grid requirements. Thus, the proposed controller for ZSI is taking into account both the power quality issues and reactive power injection under abnormal grid conditions. The proposed system operation is verified experimentally, the results demonstrate fast dynamic response, small tracking error in steady-state, and simple control scheme.

SOFTWARE: MATLAB/SIMULINK
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EXPECTED SIMULATION RESULTS

Fig. 2 System performance evaluation in steady-state MPPT mode and transition between LVRT and MPPT modes
(a) Grid voltage ($v_g$), grid current ($i_g$), inductor L1 current ($I_{L1}$), and pulsating dc-link voltage ($V_{dc}$) when the system is operating in MPPT mode and unit power factor in normal grid condition, (b) Grid voltage ($v_g$), grid current ($i_g$), inductor L1 current ($I_{L1}$), and pulsating dc-link voltage ($V_{dc}$) when the system is operating in MPPT mode and unit power factor in normal grid condition with distorted grid voltage, (c) Grid voltage ($v_g$), grid current ($i_g$), inductor L1 current ($I_{L1}$), and pulsating dc-link voltage ($V_{dc}$) when the 25% grid voltage sag occurs at $t_1$ and the system changes its mode of operation from MPPT to LVRT with reactive current injection, (d) Grid voltage ($v_g$), grid current ($i_g$), inductor L1 current ($I_{L1}$), and pulsating dc-link voltage ($V_{dc}$) when the grid goes back to normal condition at $t_2$ and the system changes its mode from LVRT to MPPT with unity power factor.
Fig. 3 System performance evaluation to changes in solar irradiance in MPPT and LVRT modes
(a) Grid voltage \(v_g\), grid current \(i_g\), inductor \(L_1\) current \(i_{L1}\), and pulsating dc-link voltage \(V_{dc}\) with a step change in solar irradiance level from 1000 to 700 W/m² at time \(t_3\) when the system is operating in MPPT mode under normal grid condition. 
(b) Grid voltage \(v_g\), grid current \(i_g\), inductor \(L_1\) current \(i_{L1}\), and pulsating dc-link voltage \(V_{dc}\) with step change in solar irradiance level from 700 to 1000 W/m² at time \(t_4\) when the system is operating in LVRT mode and 25% grid voltage sag.

Fig. 4 Active and reactive powers when the grid voltage sag of 25% occurs for time intervals \(t_1- t_2\). The system is operating in normal grid condition before \(t_1\) and after \(t_2\).

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CONCLUSION:

This paper proposes a single-stage PEI based on impedance-source inverter for PV applications with LVRT capability during the grid voltage sag according to grid standards. By using the MPC framework, a simple control strategy is proposed with an adaptive cost function to seamlessly operate under normal and faulty grid conditions. The proposed system eliminates the requirements of multi–nested-loop of classical controller. Owing to the predictive nature of the controller, the proposed system has fast dynamic response to change in solar irradiance or grid reactive power requirement according to LVRT operation. The system is switching between LVRT and MPPT modes of operations seamlessly. The proposed system can be extended for overnight operation of PV sources in DGs with reactive power compensation capability as ancillary service from DG to main grid. Several experiments have been conducted to verify the performance of the proposed system. The results demonstrate robust operation, MPP operation during the healthy grid condition, high-power quality injection during steady-state condition, negligible overshoot/undershoot in grid current injection due to change in solar irradiance or reactive power reference, no observation of inrush current during dynamic change in MPC cost function references for LVRT operation, and maintaining constant peak grid current during the LVRT mode.

REFERENCES:


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