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Novel Control Algorithm for control of qZSI as Front – End Converter during nonsunlight hours

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Degrading effect of energy generation from fossil fuel are extensively discussed and debated leading to paradigm shift to renewable energy generation. Energy generation from PV panels is the best alternative for state of Qatar which gets abundant sunlight throughout the year. Development of energy generation from PV panels helps in achieving the notion of "Energy Security". Energy security refers to availability of reliable, cheap and quality power for consumption from customer point of view. Development in power electronics helps in achieving this idea by developing and operating converters circuits with good efficiency, efficacy, reliable, robust and free from maintenance. Encouraging the nurture and development of local energy suppliers will help in minimizing the cost of installation and maintenance. Including these economic constraints in the design of converters has become a crucial factor in developing industry oriented products through academic research. Suitability of several power converters for synchronizing the power generated from PV panels to utility grid. Recently developed Impedance source based converters are highly suitable for synchronizing the power generated from renewable energy to the utility grid. They eliminate the need for extra dc-dc converter by boosting the input voltage supplied from PV panels. Impedance source based converters are categorized as: Z Source Inverter and quasi Z Source Inverter (qZSI). qZSI is preferred due to its higher performance and continuous input current. Several methods are discussed in the literature to achieve boosting of input voltage. Inverter control requires modification in conventional Sine-Triangle compared based PWM. Operation of qZSI at different MPPT algorithms is also discussed. Cascaded qZSI operation to achieve higher power rating are also discussed. Implementation of

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advanced control techniques such as Model predictive control is also presented. Energy efficient qZSI achieved through different methods are also discussed. This paper presents novel control algorithm for control of qZSI as Front-End Converter (FEC) during non-sunshine hours. During sunshine hours, qZSI is controlled to inject active and reactive power into the grid. In absence of sunlight, qZSI can be operated as FEC to control reactive power management with the utility grid. To validate the proposed control algorithm, simulation results are presented for grid-connected qZSI powered from solar panel as shown in Fig. 1. Simulation results are formulated into following three sections: (a) Control of qZSI for active and reactive power management, (b) Transient response for qZSI to FEC transition and (c) Control of FEC for reactive power management.Control Algorithm: Control algorithm must satisfy the following requirements: a) When controlled as qZSI, i) Boosting of input voltage must be controlled to achieve the desired output rms voltage ii) Current injected into the grid can be at any power factor – unity, lagging or leading. b) Smooth transition from qZSI to FEC. c) When operated as FEC, i) DC Bus Voltage must be maintained constant and ii) Controlled reactive power management must be achieved.   Proposed control algorithm is as shown in Fig. 2. It consists of two types of control blocks. Control blocks which are specific to a type of control algorithm and other which are common for both. Converter reference voltage generation and conventional Sine – Triangle comparison is common to control algorithms of both the inverters. For control of the inverter as qZSI, condition of Vin>Vth must be satisfied which means voltage generated from PV panels is sufficient for grid synchronization. During this mode, S1 and S3 are closed and S2 is opened. qZSI control consists of grid current control and dc bus voltage (Vdc) control. Active and reactive power demand is converted to current proportional and passed through PI controller to generate the converter voltage reference. DC Bus voltage controller gives the shoot-through duty cycle (D). Based on the value of D, shoot-through pulses are ORed with conventional pulses generated by sine-triangle comparison.   When Vin>Vth is not satisfied, then the position of relays is changed. S1 and S3 are opened and S2 is closed. Due to this, the solar panel is disconnected from the inverter. The dc bus formed due to series connection of C1 and C2 must be controlled from the grid voltage. The dedicated control block shown in Fig. 2 for FEC generates the active current reference and add it up with required reactive current reference to give the grid current reference. This is passed through PI Controller to give the converter voltage reference. Conventional Sine-triangle comparison is performed to generate switching pulses.SIMULATION RESULTS To verify the control algorithm, the simulation results are shown in Fig. 3. Up to t = 2 sec, the inverter is operated as qZSI injecting controlled active power into the grid. At t = 2 sec, the relays are operated disconnecting the solar panel at the input and now inverter is controlled as FEC. Due to this, the dc bus voltage shoots up which is controlled with the control algorithm. To maintain the dc bus voltage, active current is drawn from the grid. Active current drawn is negligible compared to reactive power managed with the utility grid. Fig. 3(a) shows the response of dc bus tracking during the operation. In qZSI mode, active power injection is controlled as shown in Fig. 3(b) and Fig. 3(c). When the inverter is controlled as FEC, reactive power absorbed and supplied are shown in Fig. 3(d) and Fig. 3(e) respectively.