Synchronous DC Link Voltage Control System Lowers the Cost of Solar Microinverters While Improving Reliability and Power Density

New microinverter controller quickly and accurately prevents voltage ripple and harmonic distortion in solar energy conversion without needing high value film or electrolytic capacitors.

UCF researchers have invented a robust DC link voltage control system that improves the performance, reliability and power density of two-stage microinverters used in solar photovoltaic (PV) energy conversion. The new, low-cost Phased-Locked-Loop (PLL)-Synchronized DC Link Voltage Control System enables microinverters to operate more efficiently by mitigating the effects of large voltage ripple and corresponding increases in total harmonic distortion (THD). Voltage ripple and THD in the output current of a microinverter may adversely affect an inverter’s performance, such as its efficiency in transferring power from a solar cell and the ability to provide quality electrical power into the grid.

To smooth voltage ripple, typical DC link voltage controllers use high value film capacitors (which are expensive) or unreliable electrolytic capacitors. They may also use digital or analog filters; however, such components provide inferior performance and only increase circuit complexity and cost. The UCF invention offers a better, cost-efficient solution by using existing controller functional blocks and a simple, accurate synchronous sampling method. The invention also facilitates the use of less expensive low value film capacitors (≤30 μF) for the DC link capacitor and eliminates the need for analog and digital filters. Thus, the new controller reduces design costs and improves microinverter reliability and power density by avoiding the adverse impacts of high DC link peak-to-peak voltage ripple.

Technical Details

The unique PLL-Synchronized DC Link Voltage Controller regulates a two-stage microinverter in which the input couples a DC/DC converter to a PV panel and the output couples a DC/AC inverter to a power grid, as shown in Figure 1. The invention supports single-phase half-bridge, single-phase full-bridge, or three-phase half-bridge configurations. An example embodiment comprises an analog-to-digital converter (A/D), a loop compensator, and a PLL synchronized to the grid voltage.

Key to the invention is a synchronous control method that measures and tightly regulates the DC link average voltage. The method involves sampling the DC link voltage at specific, predetermined points, so that the controller can measure the DC link average voltage level at which little or no harmonic distortion occurs. Since the harmonics in the DC link voltage are phase-locked to the grid voltage, the controller uses the relationship to accurately predict when the AC component of the ripple voltage intersects the DC link average voltage value (with little or no harmonic distortions). The PLL then instructs the A/D to sample the DC link voltage only during the times when the DC current reaches the DC link average voltage value. By sampling the voltage only at those specific times, the controller prevents distortions in the inverter output.
current waveform. Thus, the error signal input to the loop compensator is a DC value that produces a peak current reference free of unwanted harmonics. Consequently, the peak current reference multiplied by the PLL generates a pure sine wave input to the pulse-width modulation block.

Benefits

- Reduces cost and circuit complexity
- Increases reliability
- Removes high voltage ripples from DC link capacitor
- Does not require any modification, compared with similar state-of-the-art methods

Applications

- Inverters
- Motor controllers
- Power electronic circuits that contain a DC link capacitor for energy storage

Related Technologies

33928

Technology #33719

- Provisional Patent Application Filed

Inventors

Seyed Milad Tayebi • Issa Batarseh, Ph.D.