Modulation Technique for Single-Phase Transformer less Photovoltaic Inverters with Reactive Power Capability

Introduction:

Photovoltaic (PV) energy has remarkable growth in recent decades owing to the renewable energy policy, feed-in-tariff and the cost-reduction of the PV installations. According to IEA-PVPS annual report, the cumulative capacity of installed PV reaches 230 GW by 2015, out of which the majority (~90%) is grid-connected system.

The increase in the demand of the PV installation, especially grid-connected PV system, indicates that there is a need for in-depth research and development. In grid-connected PV systems, an inverter is used to convert the direct current (dc) from the PV array into alternating current (ac) to supply the electricity to the utility grid. Generally, there are two types of grid-connected PV inverters, that is, with and without a 50/60Hz transformer. Since a transformer is bulky, expensive and has low efficiency, transformerless inverters have become a solution for high-performance application

Existing system:

H5 and HERIC are two mainstream transformerless PV inverters due to the simple structure and high efficiency. The leakage current has been successfully reduced to adhere to standard
requirement. Even though transformerless inverters in literature are capable of suppressing the leakage current, most of which are designed for unity power factor operation only. Conventional bipolar modulation is reported as a potential candidate for next-generation PV inverter. Besides leakage current elimination, bipolar modulation technique is able to provide reactive power support. However, reactive power capability comes at a cost of high switching loss due to two-level modulation. In every switching transition, the voltage changes across the inductor by twice of input voltage.

As a result, several transformers less PV inverter topologies with reactive power capability have been proposed via three-level modulation (unipolar modulation). In order to provide reactive power control in conventional H5 topology, combined unipolar and bipolar pulse width modulation (PWM) was proposed. The PWM is switched from unipolar to bipolar during the negative power region. Although reactive power control is attained, the implementation is complicated.

**Dis-advantages:**

- The current ripple and switching loss are high due to the adoption of bipolar PWM.
- Thus, efficiency is low for bipolar modulation.

**Proposed system:**

In order to generate reactive power, a new current path is required in order to achieve zero-voltage state during negative power region. Based on the analysis, modulation techniques are proposed which provides bidirectional current path during freewheeling period. As a result, reactive power control is realized in H5 and HERIC inverters, without any modification on the converter structures. Furthermore, the common-mode behavior of which is not
compromised. The CMV is maintained at constant which helps to suppress the leakage current.

With proposed modulation technique, reactive power control is achieved in H5 and HERIC inverters, without any modification on the converter structure. Furthermore, the common-mode behavior is not compromised. Leakage current is suppressed within the permissible level. Only additional duty cycle generators are required for each switch. The sinusoidal voltage reference ($V_{ref}$) is injected to the corresponding duty cycle generators to generate the desired voltage reference for each switch.

**Advantages:**
- Provides bidirectional current path during freewheeling period.
- The CMV is maintained at constant which helps to suppress the leakage current.

**Applications:**
- Inverters applications
Block Diagram:

PV INPUT → H5 INVERTER WITH REACTIVE POWER CAPABILITY → LOAD

12VDC → Gate driver circuit

5VDC → Buffer circuit

Microcontroller circuit