Converter Design for Electrolytic capacitor-less Two Stage PV System

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Existing Grid-Tied PV Systems

The conventional photovoltaic system has a simple control structure with independent control scheme - easy to design for small PV grid-tied systems.

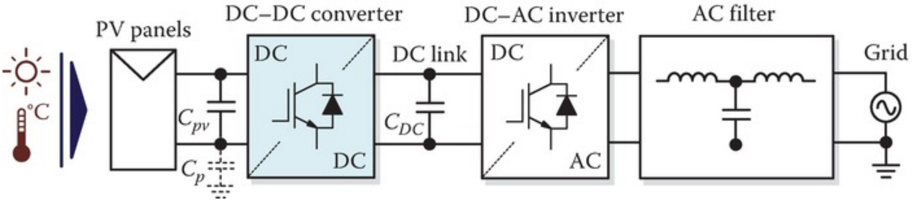

Figure 1: Two-Stage Grid Tied PV System Architecture

The Challenge of Electrolytic Capacitors

The intermediate dc-link electrolytic capacitor has reliability issues and is one prominent cause of inverter failure and limited life.

1. Usage of a heavy electrolytic capacitor over a comparatively smaller system.
2. Low lifespan (2.5 years) as compared to PV array (25 years).
3. Requires continuous monitoring to check for ageing and dry-out.

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Transition to Electrolytic Capacitor-less Topology

- Using dual-active bridge converter with high-frequency transformer-
  - Electrolytic Capacitor can be replaced with thin-film capacitor
  - Film capacitor is reliable with upto 15 years lifespan.
  - The introduction of DBC with film capacitor and SPM leads to overall lower maintanence cost, including protection because of HF isolated transformer .

Theory of Operation

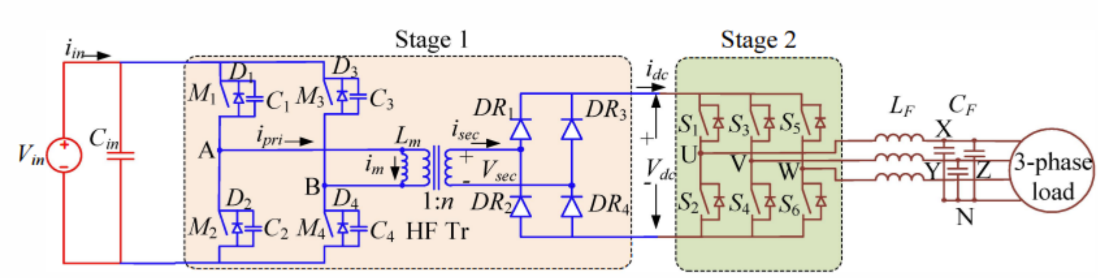

Figure 2: Schematic of the capacitor-less three phase inverter

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DC to Pulsating DC Stage

Stage One

In this power conversion stage-

1. Dual bridge converter (DBC) connected with output three phase inverter
2. H-bridge inverter, high frequency transformer and diode rectifier
3. Film capacitor between DBC and three-phase inverter.
4. Simple control architecture - Closed loop DBC Control.

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Design of Converter: Open-Loop

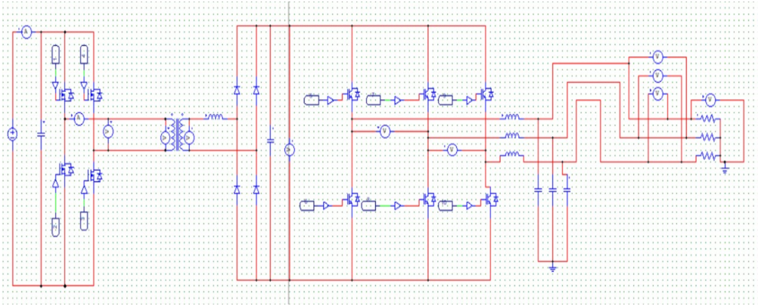

Figure 3: Schematic of the electrolytic capacitor-less three phase inverter-openloop

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Design of Converter: Six Pulse Modulation

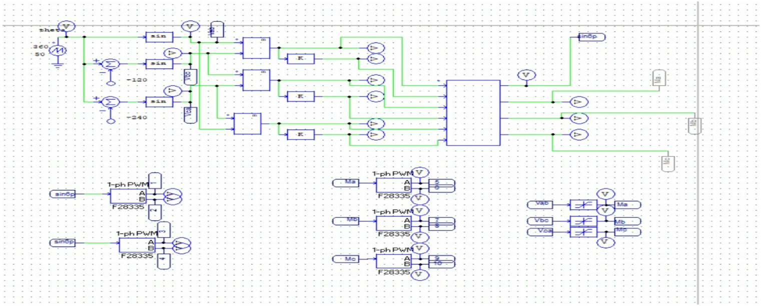

Figure 4: Open-loop control logic (SPM and SOLM)

Design of Converter: Closed-Loop

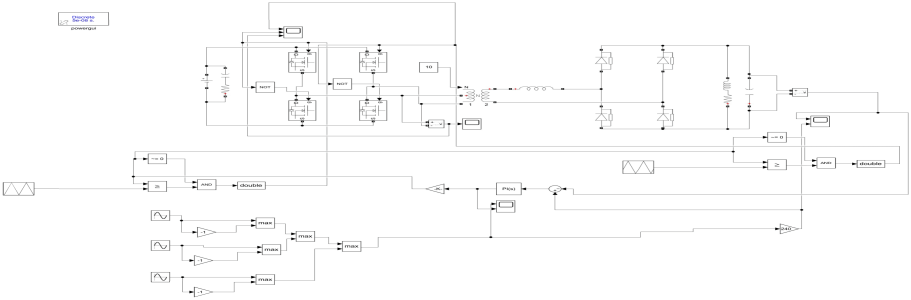

Figure 5: Schematic of the electrolytic capacitor-less closed loop three phase inverter

Conclusion

PSIM and MATLAB is used for design and simulation of the system

1. Design and implementation of a simple open-loop and closed loop control for the dc bus electrolytic capacitorless system to obtain three-phase balanced sinusoidal voltage at the output.
2. Understanding the operation of the H-bridge inverter BCM cases.
3. Achieving a 3.4kW power rating and a THD of 3.11% for a dc to three-phase ac converter

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Gating signal generation by six-pulse modulation reference for H-bridge

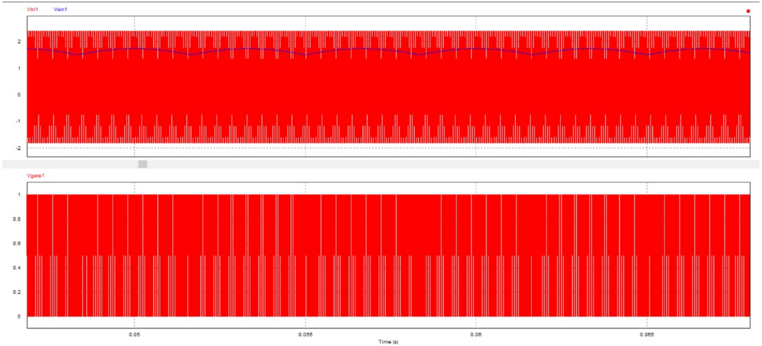

Figure 6: Modulating signal (Vsin1), Carrier signal (Vtri1), Gating Signal (Vgate)

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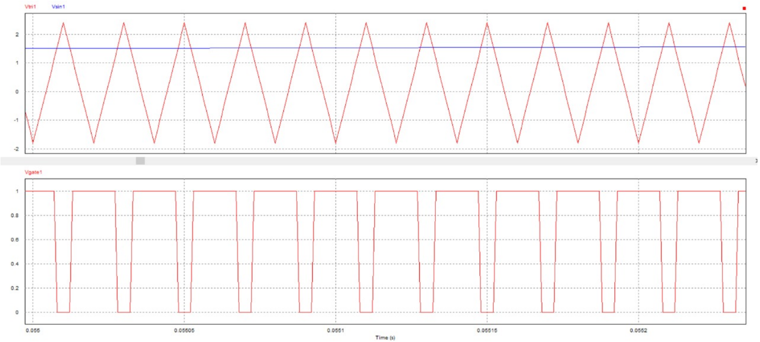

Figure 7: Zoomed version of Fig. 2

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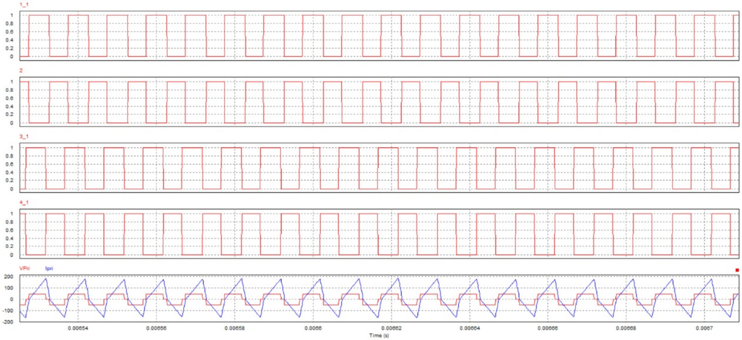

Figure 8: H-bridge Gating Diagram, Primary Voltage, Primary Current in BCM

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Figure - Stage Outputs

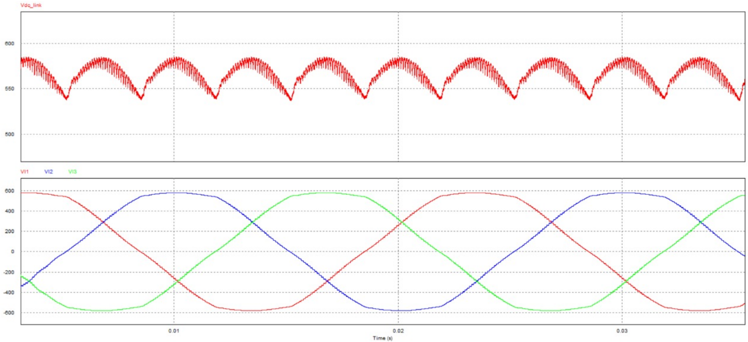

Figure 9: Pulsating DC and Inverter Output Waveforms in Open-Loop Mode

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Figure - Stage Outputs

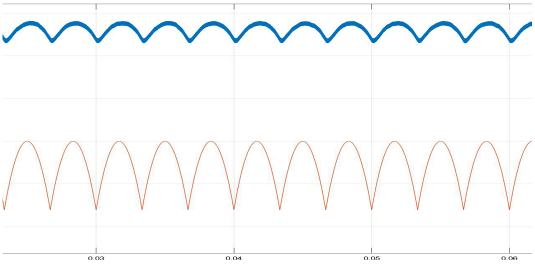

Figure 10: Pulsating DC Stage Voltage Waveform (Blue) in Closed-loop control