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On Determining the Control Techniques Embedded in a Commercial Single-Phase Grid-Tied PV Inverter

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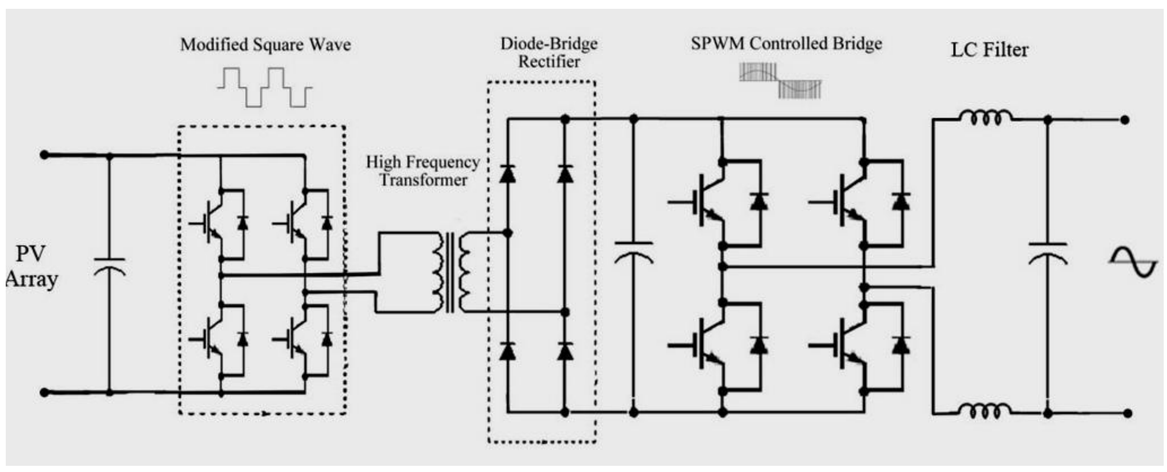
Content: In this paper, a reverse engineering attempt is made to determine the techniques implemented in a commercial 2.5 kW grid-tied inverter to track maximum power, control of power injected into the grid, and anti-islanding protection.

Methodology: Measure the voltage and current waveforms under normal operation and during utility outages, analyze such waveforms, and replicate these with simulations of common control methods using PSCAD software.

Type of Inverter Studied: Two-stage topology – Fig. 1 – verified by tracing inverter circuitry.



Measured and Simulated Waveforms: (under normal operation).

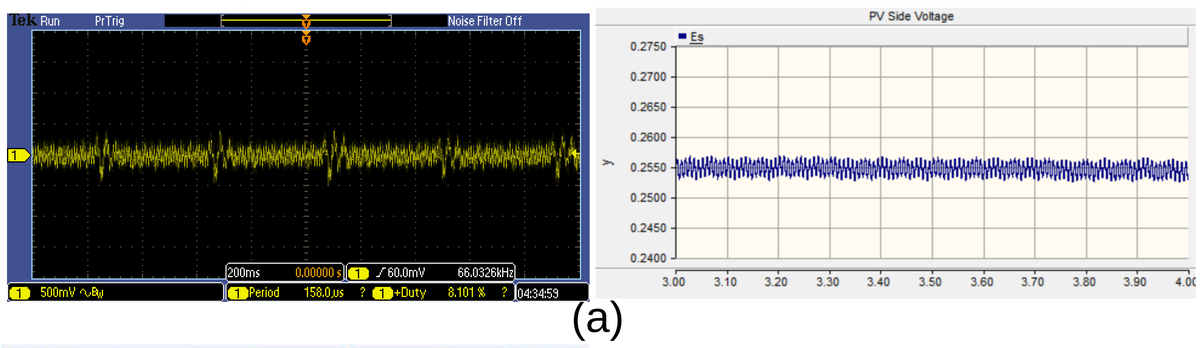


Fig. 2: Measured and Simulated Waveforms: (a) DC-Side Voltage, (b) AC-Side Voltage and Current before Filtering, and (c) AC-Side Voltage and Current after Filtering.

Inverter Response to Power Outage:

Case	P_{PV} (W)	P_{Load} (W)	$\sqrt{(P_{PV}/P_{Load})}$
A	1,710	2,570	0.82
B	1,680	1,685	1
C	1,700	1,060	1.27

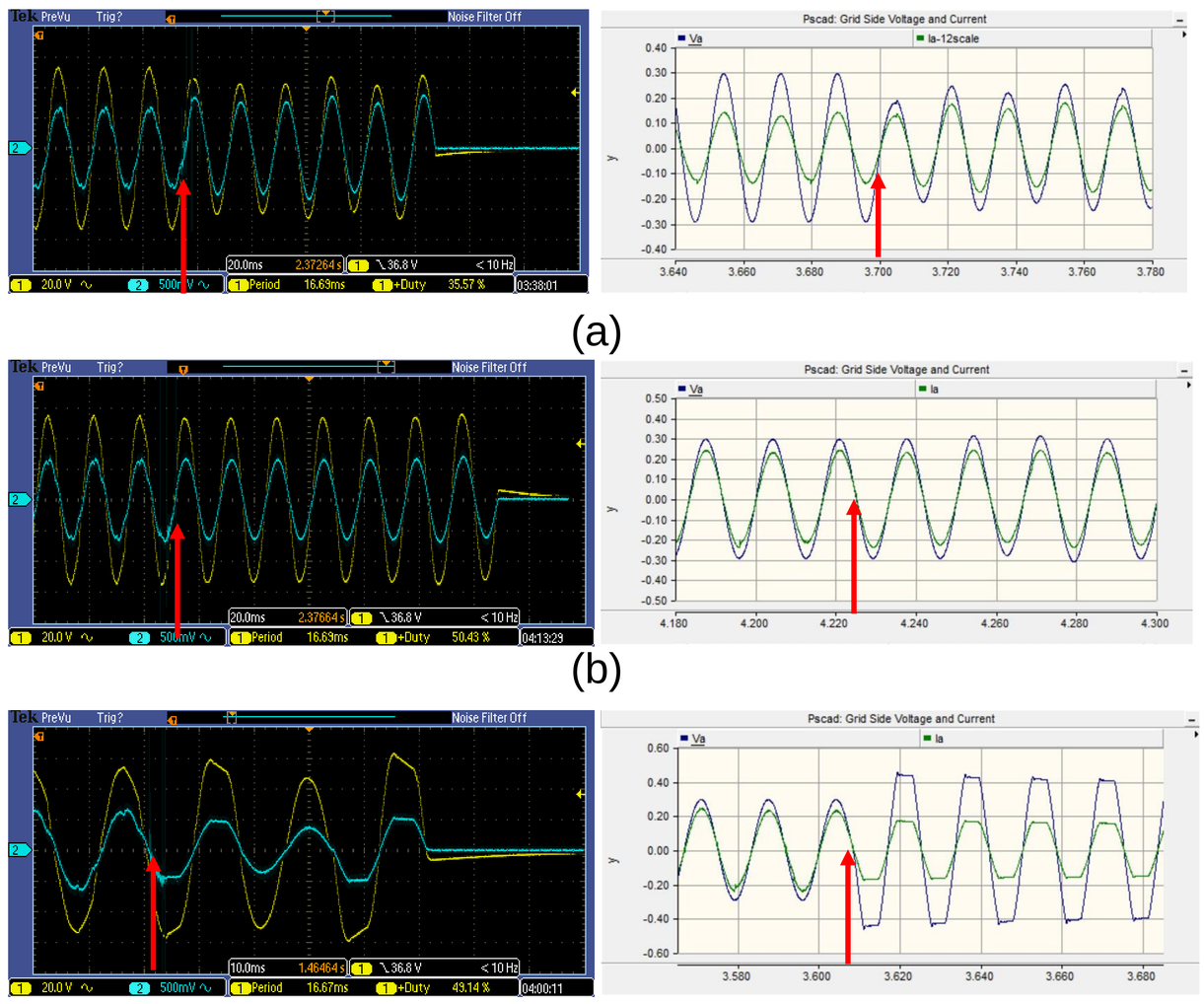


Fig. 3: Inverter Output Voltage and Current - (a) Case A, (b) Case B, (c) Case C.

Remarks and Conclusions: From recorded and simulated voltage and current waveforms during normal operation and grid outage, the authors could not point with certainty to particular MPPT and anti-islanding methods used in the inverter, due to their large variety. However, signatures on some waveforms suggest some likely known techniques.

- DC voltage jumps of nearly ± 2.5% occur every 25 cycles – this is most probably due to MPPT tracking.
- AC current hold at zero crossing for nearly 0.25 msec (or 5.5^{o}) may be done intentionally for the purpose of anti-islanding.

The experience gained from this academic exercise is found to be very valuable to students.