Increasing Lifetime of Residential Photovoltaic Inverters Through Dynamic Hardware Allocation (DHA)

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Background and motivation:
- Power electronic converters have become one of the most fragile parts in the entire photovoltaic (PV) system [1]
- High failure rate of PV inverters contributes to a high lifetime maintenance and energy cost
- Proposed dynamic hardware allocation (DHA) will enhance reliability and extend PV inverter lifetime from 10 to 20 years

Technical approach:
- DHA uses a plurality of n identical modules that shift operation between active power filtering (APF) and line frequency inverter operation
- System uses a dual-current programmed mode (DCPM) control to achieve zero voltage switching

Conclusion:
- Full bridge operation with DCPM control network
- Module level implementation of DHA
- DHA would increase PV inverter lifetime to 20 years

Dynamic Hardware Allocation (DHA) Concept

- DHA inverter topology consists of n phases/modules
- Each module shifts operation between active power filtering (APF) and line frequency inverter operation (INV)
- High frequency operation (up to 1MHz)
  - High power density
  - Gallium Nitride (GaN) power devices
- Boundary current mode (BCM) modulation
  - Zero voltage switching
  - Minimal converter losses at high frequency
  - Dual current programmed mode (DCPM) controller regulates peak and valley current in each period

Fig. 4. Proposed DHA inverter topology
Fig. 5. BCM inductor current waveform
Fig. 6. DHA module level schematic
Experimental Results

- Full bridge inverter operation at 500W
- Successful implementation of DCPM control loop network
- Switching frequency varies from 120kHz to 750kHz
- Uses XILINX Spartan 6 FPGA for digital logic and control
- Future work will include full implementation and operation of DHA at 2kW
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