

## Firmware-based 3.3kW Bridgeless Totem-pole PFC Reference Design

### Overview

New technologies and high-performance DSPs offer new alternatives to silicon for developing sophisticated power solutions for high-efficiency topologies such as GaN-based bridgeless totem-pole PFCs.

The TDTP3300-RD 3.3kW totem-pole PFC reference design provides an excellent platform for evaluating the use of Transphorm GaN FETs as well as a great starting point for designing a PFC product. The DSP firmware-based totem-pole PFC gives designers a turnkey design solution with no code expertise required, simplifying design and accelerating time to market.

### Specifications

- 3.3kW CCM bridgeless totem-pole PFC with TP65H050WS 650V 50mΩ GaN FET
- Universal input range: 85V<sub>AC</sub>~265V<sub>AC</sub>, 15Arms (3.3kW max)
- Switching frequency: 45kHz~150kHz
- Firmware-programmable V<sub>OUT</sub>: 373V<sub>DC</sub>~393V<sub>DC</sub>

### Applications

- Automotive on-board chargers (OBCs) (AEC-Q101 qualified GaN)
- Industrial power supplies
  - 80 PLUS Titanium telecom, data center, server
  - High-end PC front-end PFCs (AC-DC)

### Key features

- Gen-III GaN FET technology
  - High gate robustness: V<sub>GSS</sub> = ±20V
  - High noise immunity: V<sub>GS(th)</sub> = 4.0V
  - Optimized device performance (C<sub>oss</sub> matching)
- DSP firmware-based state-machine for fully-functional PFC converter
- Operational state-machine states
  - Power up → DSP initialize → Initialize variables and constants → Monitor AC line → Soft start → Main operational state → Soft/hard shutdown → Process fault → Restart/latch-off
- Facilitates DSP-based design without code expertise
- User defined operational parameters, e.g., V<sub>OUT</sub>, switching frequency, soft-start, fault limits, etc.
- Fault processing, e.g., V<sub>IN</sub>/V<sub>OUT</sub> overvoltage, OCP, OTP, latch-off or programmable restart timers, etc.
- Integrated auxiliary power supply eliminates external supply and provides second-stage power
- TMS320F28335 DSP circuitry integrated onto motherboard for layout optimization
- Incorporates IEC/ANSI/UL regulatory/safety circuits

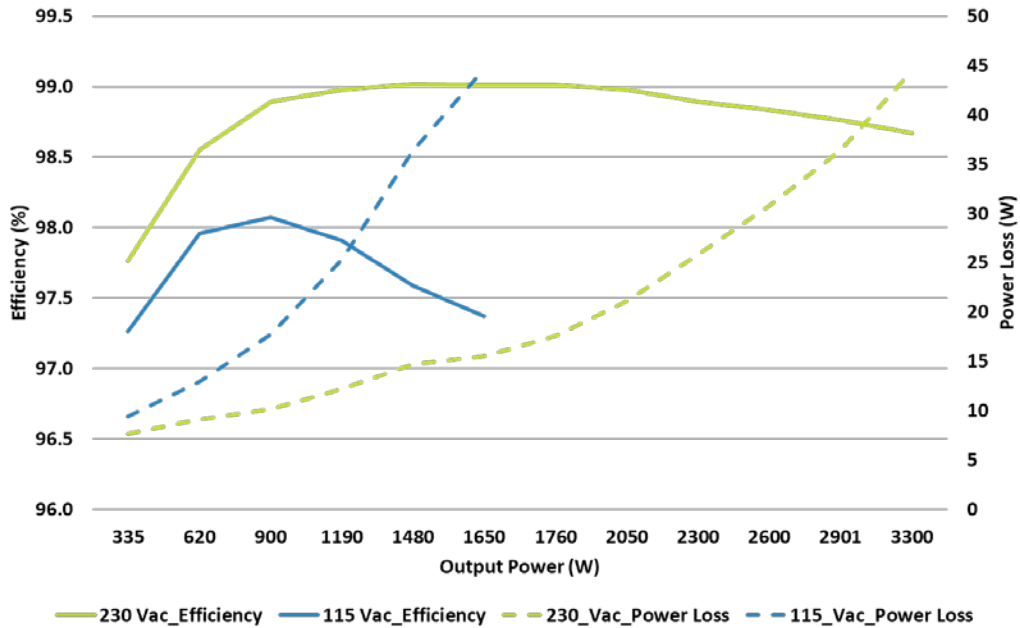
### EMI considerations

With EMI qualification being defined by both the standard being achieved and the circuit board layout, we took the approach of using a standard EMI input filter design employing two common mode chokes, one differential inductor, three X-caps, and four Y-caps. Ultimately, it is the responsibility of the engineer doing the final design to make sure the design passes the required EMI specifications.

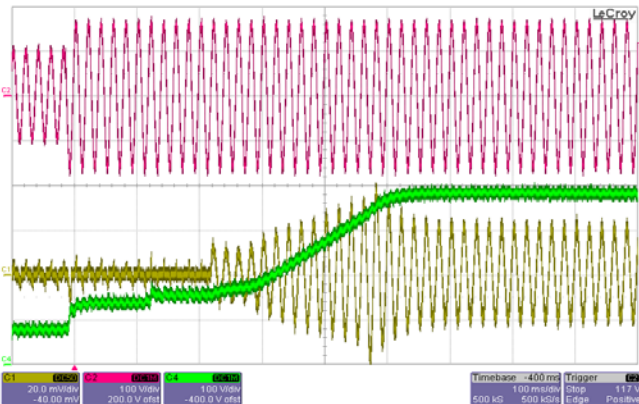


**Firmware-based 3.3kW bridgeless totem-pole PFC reference design demo board**

# TDTTP3300-RD: 3.3kW Bridgeless Totem-pole PFC

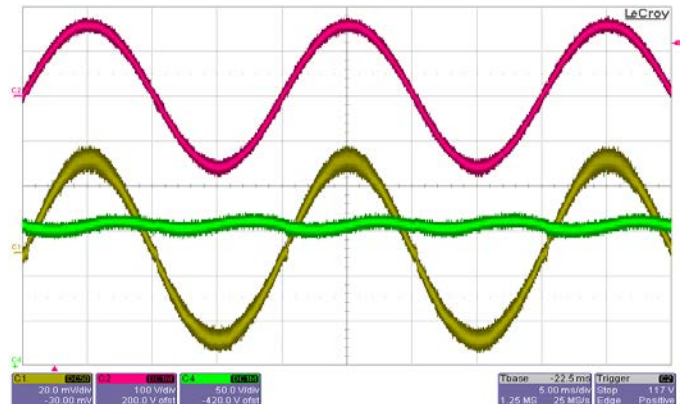


3.3kW bridgeless totem-pole PFC efficiency at 50kHz with on-board auxiliary power supply



DSP-controlled brown-in, in-rush, soft-start

Gold=inductor current: 10A/div  
 Green=output voltage: 100V/div  
 Red=line input voltage (65Vrms~115Vrms):  
 100V/div, 10mSec/div



Full load steady-state operation

Gold=inductor current: 10A/div  
 Green=output voltage: 50V/div  
 Red=line input voltage: 100V/div, 5mSec/div