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Totem-Pole PFC Controller Provides High Performance, Cost Effective Design

ON Semiconductor's NCP1680 is described as the industry's first dedicated critical conduction mode (CrM) totem-pole PFC controller. The NCP1680 can accommodate any switch type whether it is superjunction silicon MOSFET or wide-bandgap switches such as SiC or GaN devices. This device enables power supply designs for telecom 5G, industrial and high-performance computing, that operate with universal mains (90 to 265 Vac) at power levels up to 350 W. Above this power level, continuous conduction mode (CCM) is generally used.

According to Ali Husain, senior manager for Strategy and Corporate Marketing at ON Semiconductor, the significance of having a totem-pole PFC controller that offers CrM operation is that it extends use of the totem-pole PFC architecture to lower power levels. As Husain observes, "I don't think there's anyone pushing totem pole into this range of sub 100 W to 350 W." He adds that the controller also provides a light-load DCM capability.

According to ON, existing solutions on the market for this lower power range, generally rely on more-complex, microcontroller-based solutions, which require designers to write software code and incur additional costs through their requirements for current sensing.

According to the vendor, the NCP1680 CrM totem-pole PFC controller employs novel current limit architecture and line phase detection while incorporating proven control algorithms to deliver a cost-effective totem-pole PFC solution without compromising on performance. Near unity power factor is maintained across the load range (Fig. 1).

At the heart of this IC is an internally compensated digital loop control. The device employs a constant on-time CrM architecture with valley switching. Modern efficiency standards, including those that require high efficiency at light load, can also be met, says the vendor, due to discontinuous conduction mode (DCM) operation with valley synchronized turn-on during frequency-foldback operation. A skip mode is also provided for operation under very light loads. With 230-Vac mains input, PFC circuits based on the NCP1680 are capable of achieving close to 99% efficiency at 300 W (Fig. 2).

Just a few simple components are required externally to realize a full-featured totem-pole PFC, thereby saving space and component cost. Further reducing component count, the cycle-by-cycle current limit is realized without the need for a Hall Effect sensor (Fig. 3).

In conventional PFC circuits, the rectifier bridge diodes account for around 4 W of losses in a 240-W power supply, representing around 20% of total losses. In contrast, PFC stages are typically 97% efficient and the LLC circuit achieves similar performance. However, replacing the lossy diodes with switches in a totem-pole configuration and pulling in the boost PFC function can cut down the bridge losses and significantly improve overall efficiency.

Adoption of the totem-pole architecture has been largely driven by adoption of SiC and GaN devices because of their advantages (mainly low reverse-recovery charge) when used in the fast leg of the totem pole. However, the requirement for wideband switches has mainly been driven by their use in CCM operation. With CrM operation, superjunction MOSFETs with low Q_{RR} are also a viable option (Fig. 4).

Depending on the switch technology selected for the fast leg of the totem pole, the NCP1680 can be used with either the NCP51820 half-bridge GaN HEMT gate driver or the NCP51561 isolated SiC MOSFET gate driver. The NCP51561 is an isolated dual-channel gate driver with 4.5-A source and 9-A sink peak current capability. The NCP1680 is suitable for fast switching of silicon power MOSFETs and SiC-based MOSFET devices, offering short and matched propagation delays.

Two independent, 5-kVrms (UL1577 rated) galvanically isolated gate driver channels can be used as two low-side, two high-side switches or a half-bridge driver with programmable dead time. An enable pin will shut down both outputs simultaneously and the NCP51561 offers other protection functions such as independent undervoltage lockout (UVLO) for both gate drivers and the enable function.

Housed in a tiny SOIC-16 package, the NCP1680 is also available as part of an evaluation platform that allows rapid development and debugging of advanced totem-pole PFC designs. A CCM-mode version of this controller, the NCP1681, is also in the works, and the company plans to introduce it in Q3.

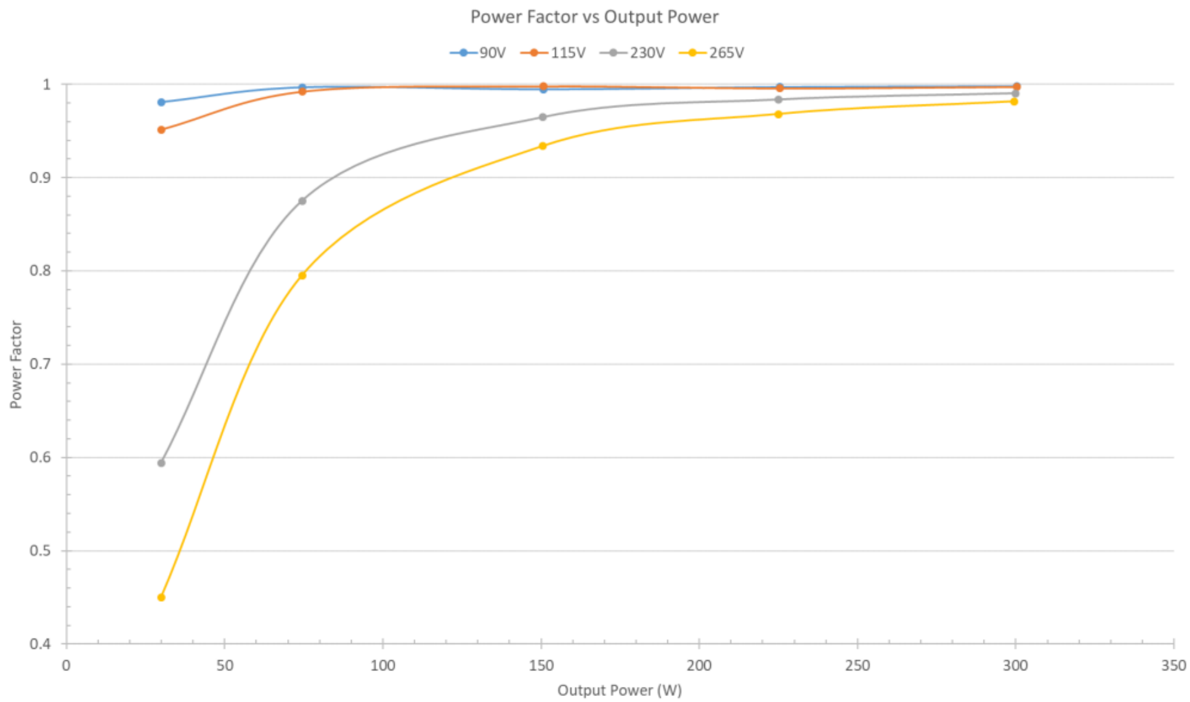

Fig. 1. The controller achieves near unity power factor in all operating modes.

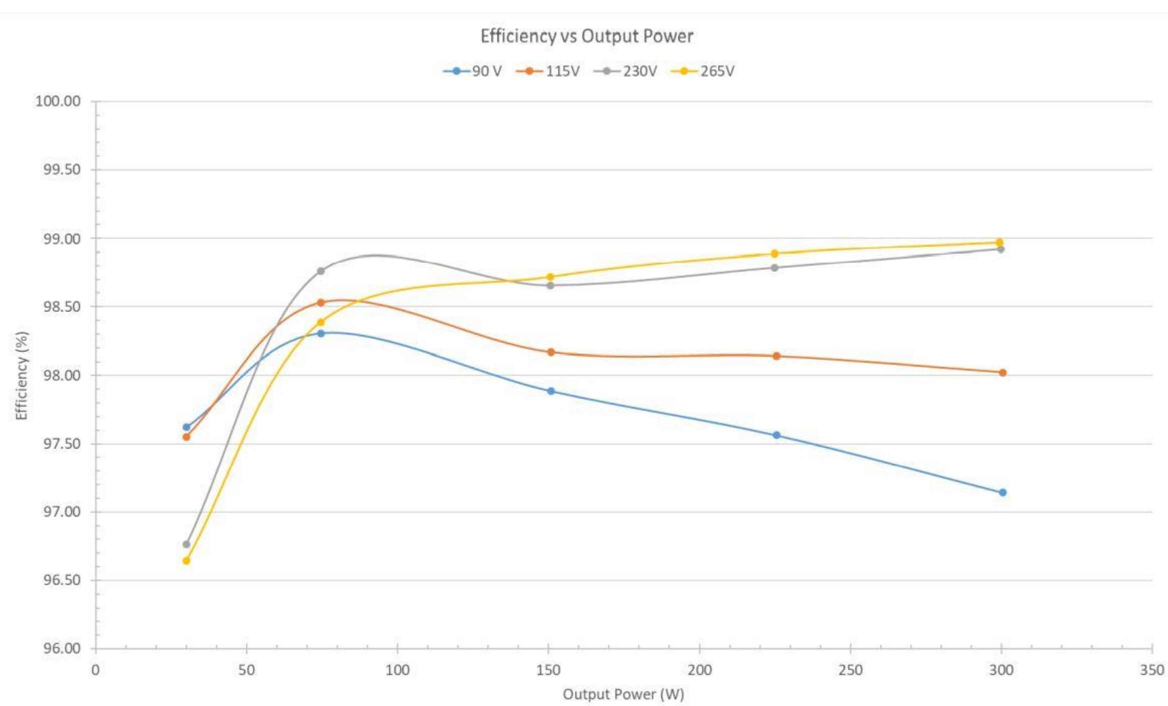

Fig. 2. The NCP1680 is a CrM totem-pole PFC controller capable of constant on-time CrM and valley synchronized frequency foldback for optimized efficiency across the entire load range. Totem-pole PFC circuits based on this controller can achieve almost 99% efficiency at 300 W and maintain over 98% efficiency at power levels down to about 50 W, when operating with a 230-Vac input.

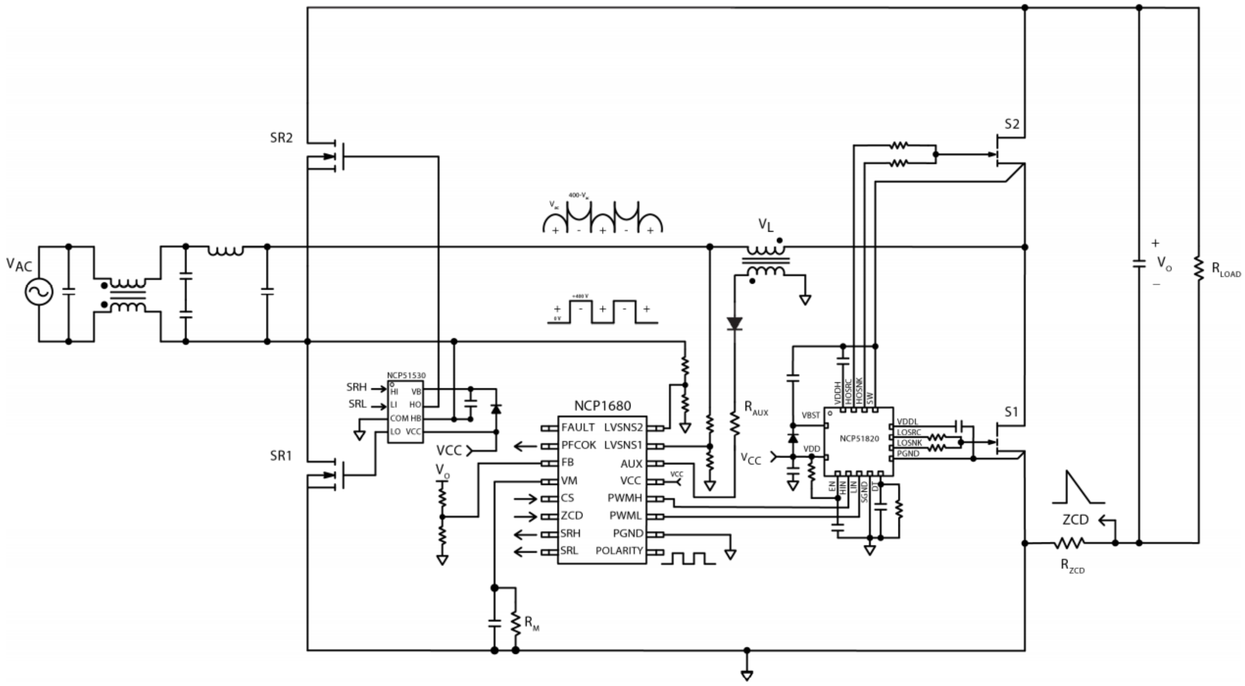

Fig. 3. Typical application schematic for the NCP1680, which offers a highly integrated solution for a CrM totem-pole PFC. Its proprietary current-sensing architectures eliminate the need for a Hall effect sensor, helping to reduce component count and BOM cost.

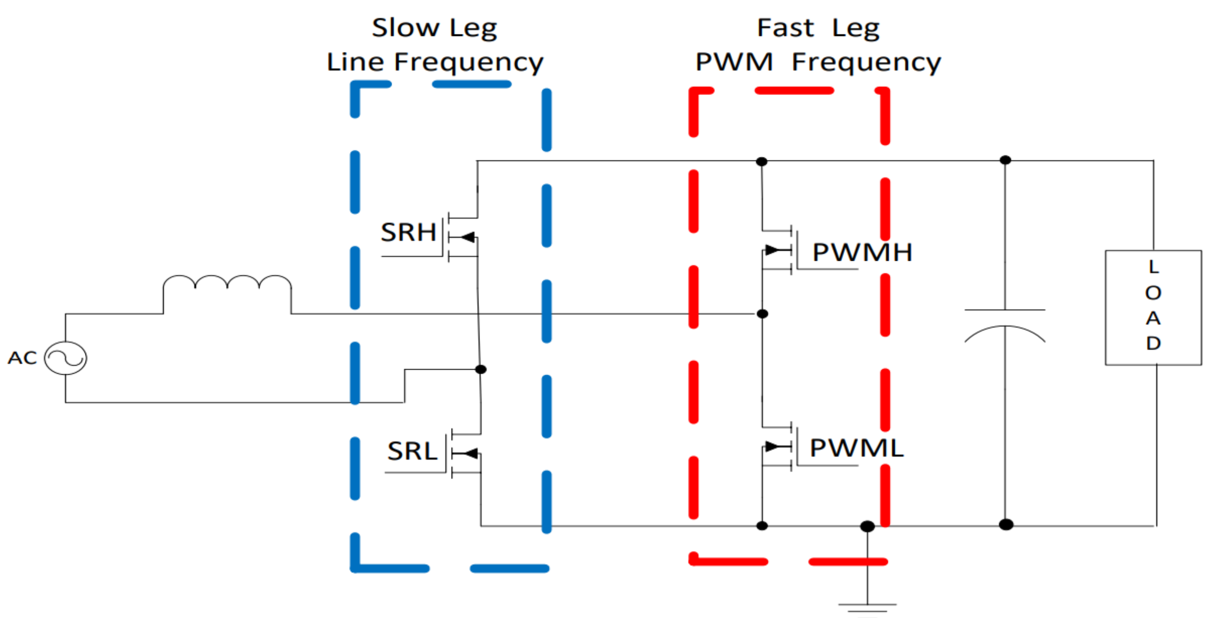

Fig. 4. The bridgeless totem-pole PFC is a power factor correction architecture that consists of a fast switching leg driven at the PWM switching frequency and a second leg that operates at the ac line frequency. This topology eliminates the diode bridge present at the input of a conventional PFC circuit, allowing significant improvement in the power stage efficiency.