

# Next-generation Ceiling and Exhaust Fans Leverage BLDC Drive Technology for Increased Efficiency and High Power Factor

---



Krishna Dora



Key requirements for next-generation [ceiling fans](#) include high efficiency, high power factor (PF) and low-input-current total harmonic distortion (THD). Hence, there is a drive toward brushless DC (BLDC)-based ceiling fans in conjunction with a power factor control (PFC)-based input power stage.

BLDC drives have traditionally used discrete circuitry, including a high-end microcontroller, gate drivers, discrete MOSFETs, an auxiliary power supply, and sensing & protection circuitry. TI's DRV10983 is a highly integrated and protected single-chip sensorless sinusoidal BLDC motor controller that can replace all of the circuitry of a BLDC drive. This makes a DRV10983-based BLDC drive solution cost-effective and easy to manufacture.

The [TIs Mains Operated 24V, 30W BLDC Motor Drive with Highly Efficient, High Power Factor Power Supply reference design](#) uses this single-chip solution to realize a complete, ready-to-adapt BLDC drive for less than 30 W ceiling fan applications. The input power stage offers a peak efficiency of 91.5% and a power factor greater than 0.95 across a large range of input voltages. The power supply is based on a single-stage buck PFC topology, which not only helps meet the required specifications but optimizes system cost.

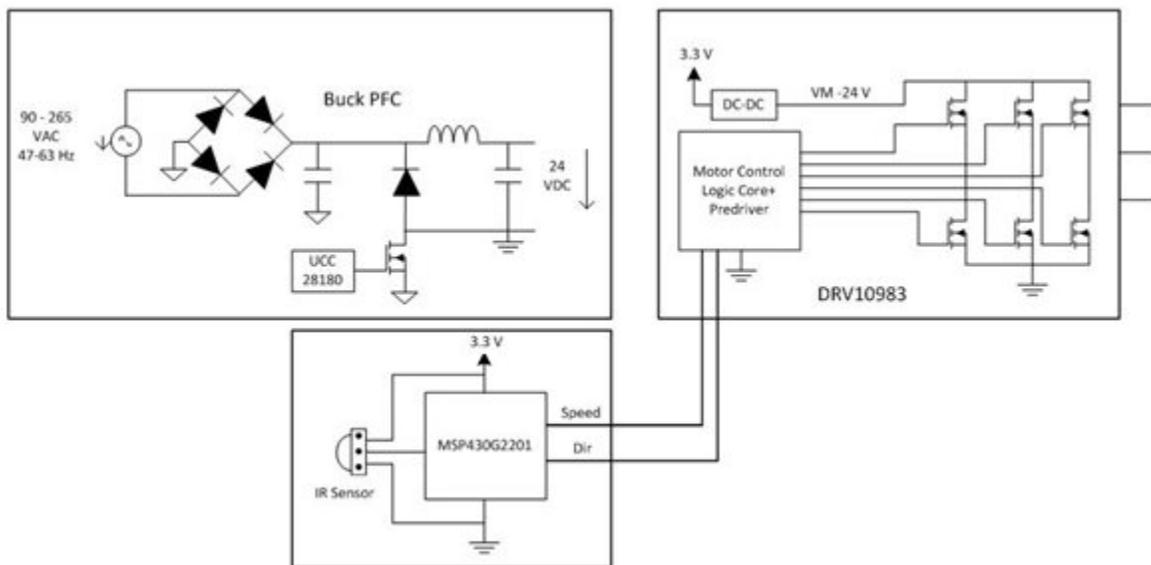


**Figure 1. Board Image of TI Design: Mains-operated, 24V, 30W BLDC Motor Drive W/highly Efficient, High Power Factor Power Supply (TIDA-00652)**

### Circuit description

As shown in [Figure 2](#), the board consists of a buck PFC power stage that converts the 85-230V 50/60Hz input to a 24V<sub>DC</sub> output. The UCC28180 pulse-width modulation (PWM) integrated circuit (IC) controls the power stage. The 24V<sub>DC</sub> generated by the power stage powers the DRV10983, which in turn drives an external BLDC motor to control its speed.

The DRV10983 also generates a 3.3V supply to power the ultra-low-power [MSP430™ microcontroller](#) (MCU). The MSP430 MCU transmits the speed reference to the DRV10983 in the form of a 1.5 kHz PWM signal (producing a duty cycle proportional to the desired speed) based on the signal received from the infrared (IR) sensor, which in turn is activated by a general-purpose IR remote control. The MSP430 firmware is easily adaptable to any remote-control button.



**Figure 2. TIDA-00652 Circuit Description**

## Why 24V<sub>DC</sub> And Not 400V<sub>DC</sub>?

A commercial ceiling fan's BLDC drive can have a DC voltage anywhere between 5V and 400V. But given the required power rating of 30W and the availability of a fully integrated drive solution, it is beneficial in terms of cost and complexity to opt for a 24V<sub>DC</sub> solution.

## Topology Selection

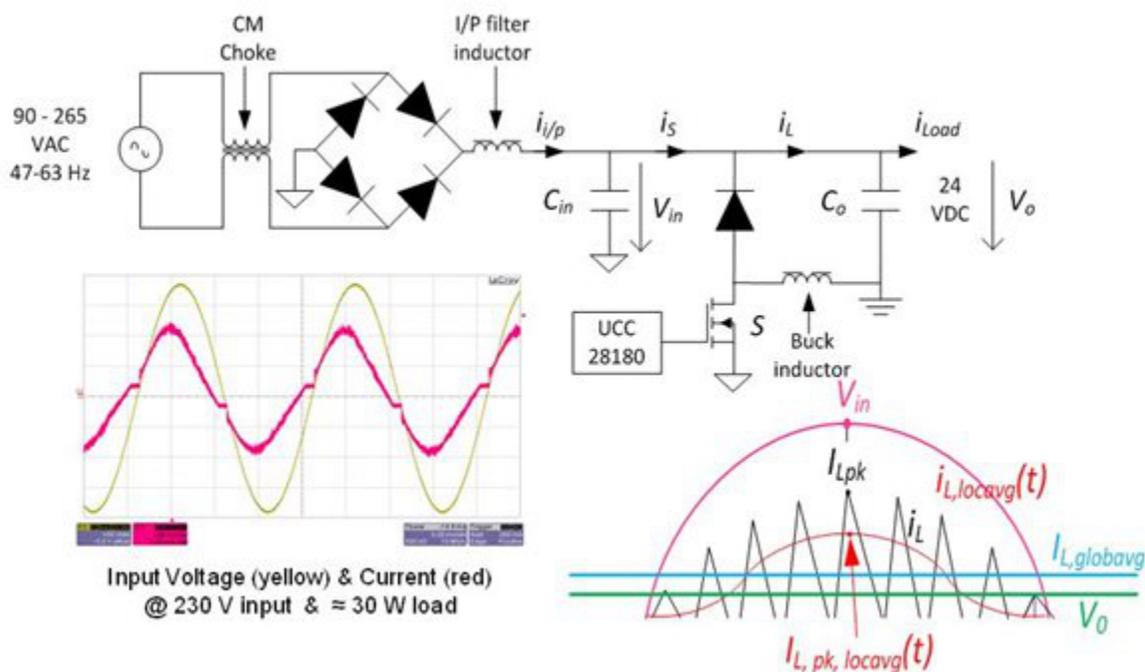
A 24V<sub>DC</sub>-based system is the obvious choice for the application. But you'll need to think about what type of power-supply topology can generate this 24V<sub>DC</sub> supply from a universal-input AC voltage (85-265V<sub>AC</sub>).

Two main driving factors for topology selection are cost and performance. A two-stage topology comprising a boost PFC circuit that converts the universal input voltage to 400V<sub>DC</sub>, followed by a DC/DC supply that converts that 400V<sub>DC</sub> to 24V<sub>DC</sub>, will give the best PF and THD performance. The cost of such a power supply will be higher and the efficiency will be lower, however. Thus, the idea to reduce cost by going for a single-chip drive solution will be negated by a two-stage solution.

Another option that comes up is the flyback PFC topology. Although this is a better option for the application compared to a two-stage solution, it also suffers from lower efficiency and higher cost.

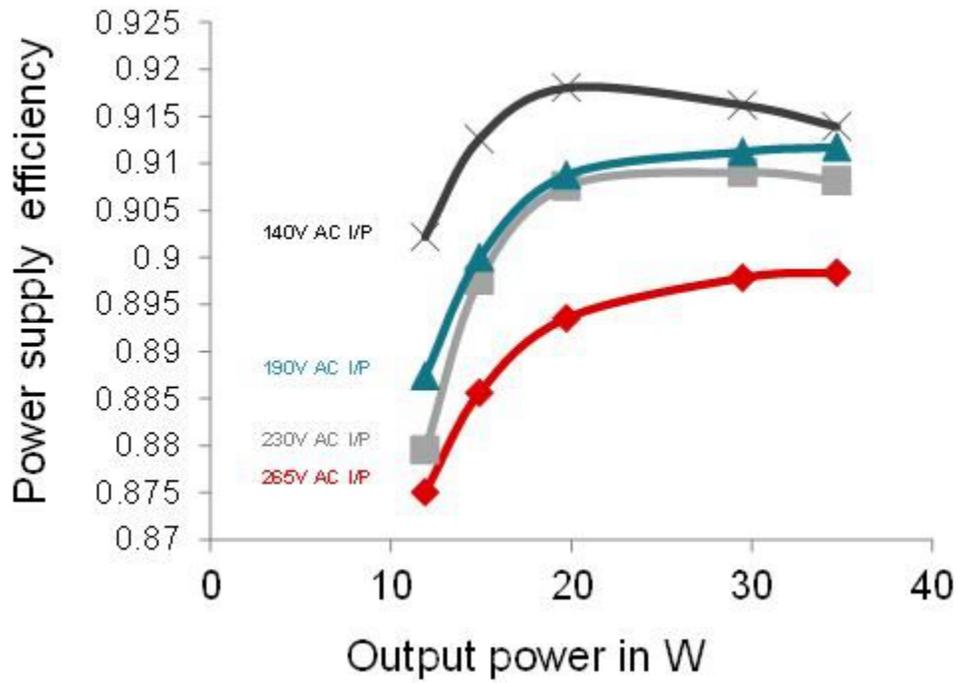
A buck PFC circuit seems to be the ideal choice in terms of PFC, THD performance and cost. Being a single-stage topology, it also offers better efficiency.

Figure 3 shows the circuit diagram of a buck PFC circuit, along with some important waveforms that explain the circuit operation. Interestingly, this design uses a continuous-conduction-mode boost PFC integrated circuit (UCC28180) to realize a discontinuous-conduction-mode buck PFC topology. This is possible mainly due to the flexibility offered by the UCC28180. Selecting such a widely used IC also provides a cost-optimized solution.



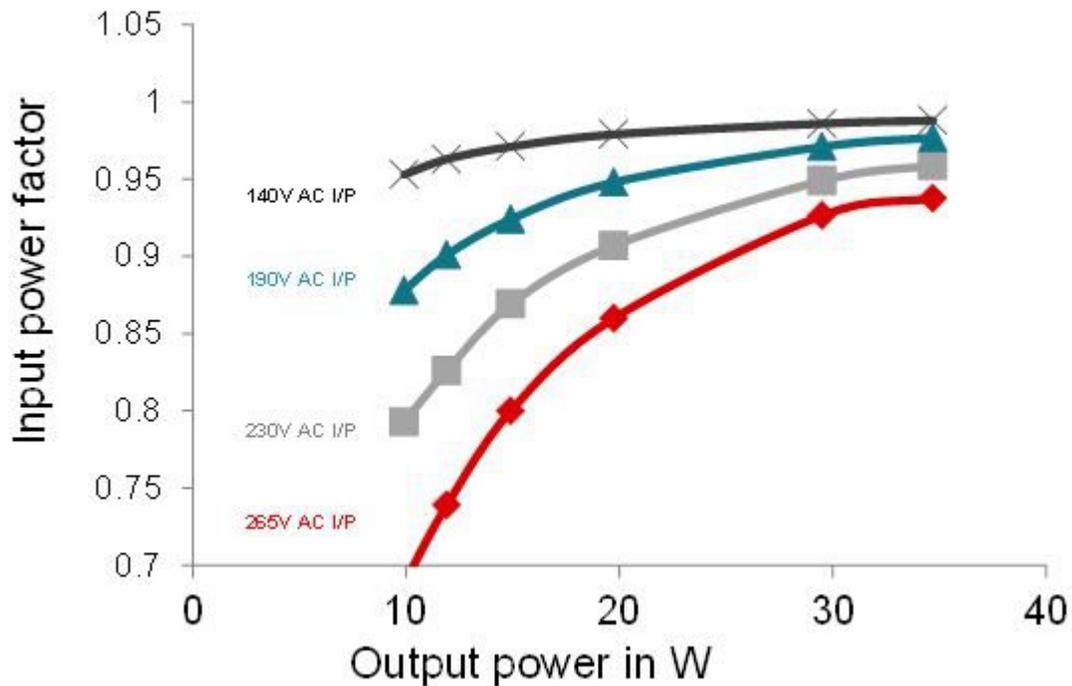
**Figure 3. Circuit Diagram of the Buck PFC Topology**

Figure 4 shows the efficiency performance curves of the 30W buck PFC power supply. The efficiency at 230V<sub>AC</sub> nominal operation is 91.5%, which is good for the power levels (<30W) under consideration.

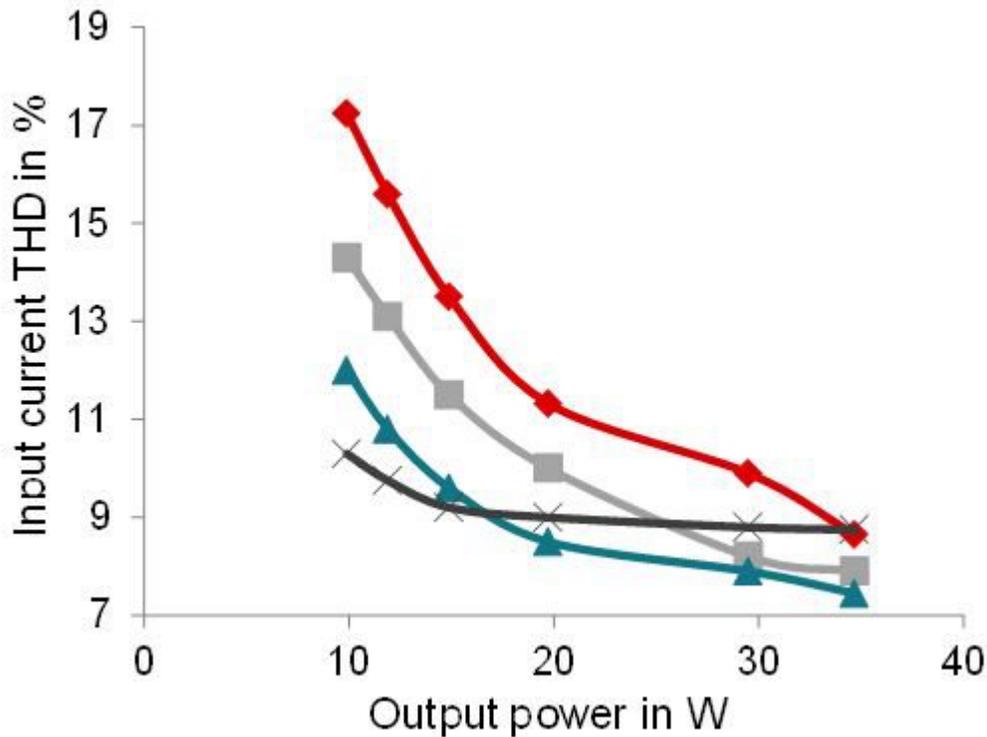


**Figure 4. Efficiency Performance Curves**

Figure 5 and Figure 6 show the input PF and THD performance of the converter, respectively.



**Figure 5. Input PF Performance Curves**



**Figure 6. Input Current THD Performance Curves**

In summary, a buck PFC solution gives the optimal performance metrics and is the right choice for front-end power supply in applications involving low-power BLDC drives like the modern next generation ceiling and exhaust fans.

**Additional Resources:**

- [Ceiling fans and other fan solutions from TI](#)
- Check out another post on ceiling fan design:
  - [Designing and energy-efficient BLDC ceiling fan solution](#) by Milan Rajne
- [Overview of TI Motor Drive & Control solutions](#)

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2023, Texas Instruments Incorporated