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# Design Considerations for Magnetics in High-Power GaN-Based Three-Phase Flying Capacitor Inverters

## APPLICATION NOTE

Texas Instrument's TIDA-010957 Platform Features Bourns® MAG-3002584 Inductor and MAG-3002585 4-Phase Line Choke

## Introduction

Increasing demand for energy storage solutions, particularly batteries, are well-supported by hybrid and battery-based inverters. These technologies enable efficient energy management and grid stabilization, addressing the growing need for reliable renewable energy solutions. The market for solar power inverters is expected to grow between 2024 and 2033 with a CAGR of 7.8 % to achieve a market value of $14 billion USD.

The TIDA-010957 platform is a complete system design released by Texas Instruments offering a bidirectional 15 kW converter that supports from 900 V (battery or PV) to 400 VAC and vice versa. This GaN-based multilevel three-phase-plus-neutral flying capacitor power stage delivers an outstanding 98.5 % peak efficiency.

Some inverter designers may be concerned by the increased level of complexity involved in a multilevel design compared to traditional topologies. Their concerns are due to the higher number of switches and isolated gate drivers needed. However, above a certain power level (usually in the greater-than 3 kW range), there are several benefits in taking a multilevel approach. Advantages that justify the additional complexity include that ability to reduce size and weight combined with meeting higher efficiency and power density requirements.

The multilevel flying capacitor topology also enables meaningful reductions in inductor size and cost, as detailed in the design analysis on the folllowing page.

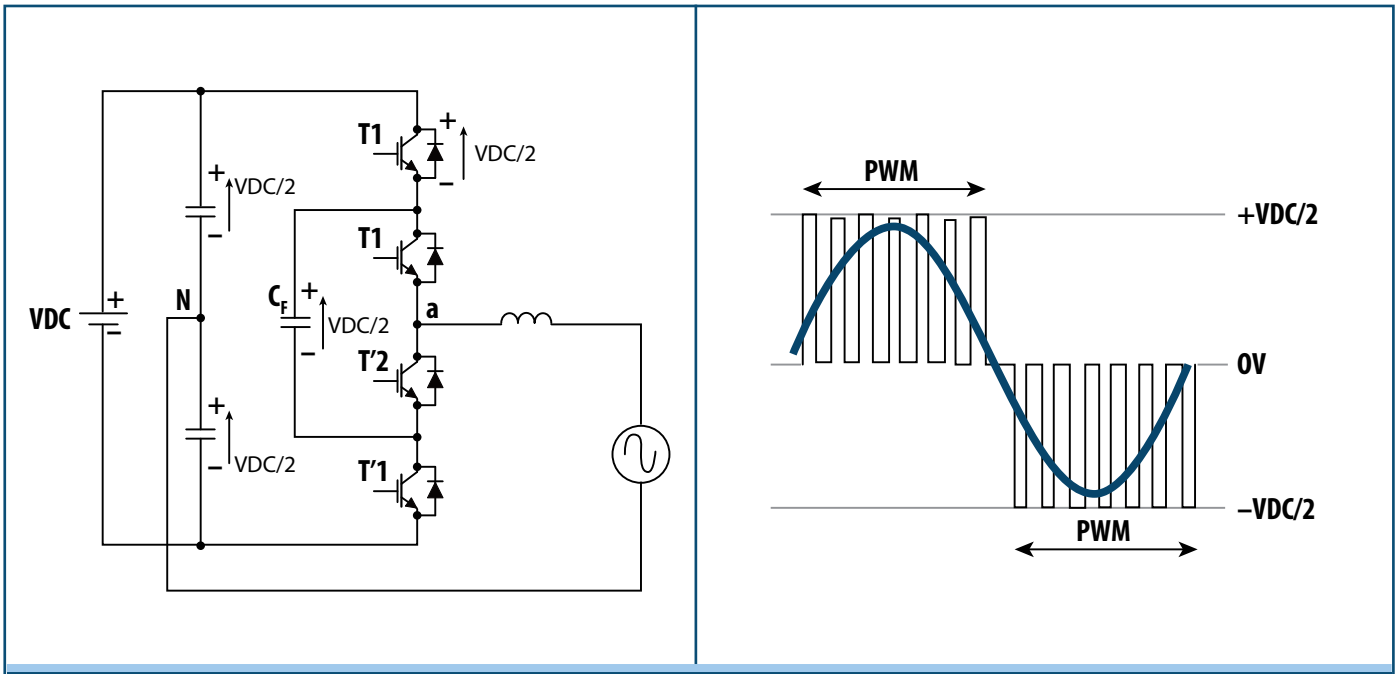


*Figure 1.* | *A block diagram of a single phase in a three-phase flying capacitor inverter model*

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## Inductor Design Flying Capacitor Inverter Advantages

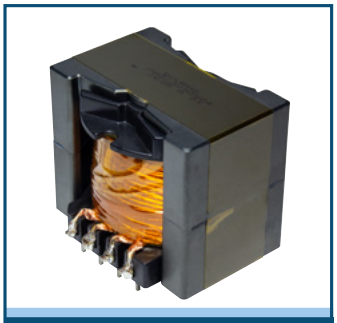
Referencing the block diagram, designers will see that the voltage across the Bourns® Model MAG-3002584 inductor connected at the switch node is effectively halved by this configuration. The effective switching frequency has also doubled thanks to this configuration due to the switches being controlled 180 degrees out of phase. Both of these elements can help reduce the size of the inductor as well. The inductor value can be calculated from the following formula:

$$\Delta I_{boost} = \frac{V_{DC} \times (D_{eff}(1 - D_{eff}))}{4 \times L_{SW} \times f_{SW}}$$

By increasing the switching frequency ($f_{SW}$) and setting the duty cycle to 50 %, the inductance value can be reduced by a factor of four assuming the ripple current is kept constant. This design has an effective switching frequency of 125 kHz.

This design has an effective switching frequency of 125 kHz. The design also keeps the ripple current to within 20 % of the main current, and provides the ability to control AC conduction, core losses as well as EMI. In addition, lowering the inductance value allows for a smaller inductor core to be used and, hence, aids in reducing size and cost.

## Bourns® Magnetic Solutions for Texas Instrument's TIDA-010957 Platform



*Bourns® Model MAG-3002584 Inductor*


*Bourns® Model MAG-3002585 4-Phase Line Choke*

The Bourns Model MAG-3002584 inductors on the TIDA-010957 platform board each feature an inductance of 87µH and a peak current of 42 A. The Model MAG-3002585 line choke is a 4-phase line choke designed to provide effective differential-mode noise suppression for this application. It is constructed with three windings for each phase and one for the neutral point, and features a common mode inductance of 3 mH at 10 kHz. Both devices are connected in the EMI filter on the grid side of the board. Both Bourns Magnetic components are available now.

For additional product information, please see:
https://bourns.com/resources/reference-design