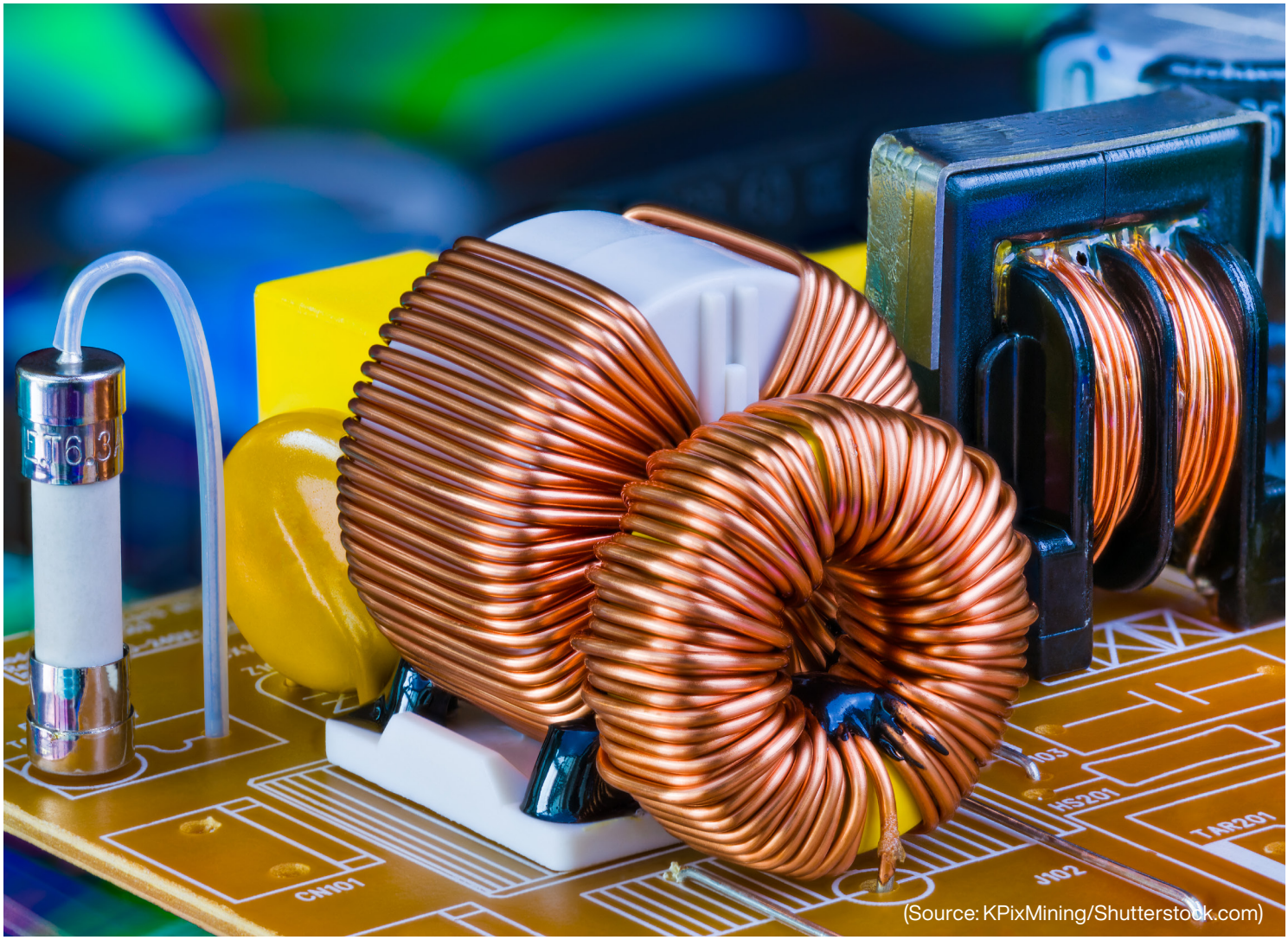
Innovative Transformer Solution Addresses Traditional Challenges

By Adam Kimmel for Mouser Electronics



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Introduction

An electronic device that changes direct current (DC) from one voltage to another is a DC-DC converter. Typical uses range from low-voltage cell phone and laptop batteries to high-voltage circuits and power metering. As voltage increases, though, maintaining electrical isolation becomes more challenging in DC-DC converters.

Isolation

DC-DC converters employ isolation to ensure safety for operators. This approach reduces the risk of electric shock, avoids ground loops due to different potential levels, and prevents voltage transients from input to output through galvanic isolation. Engineers can achieve isolation through isolation transformers, which contain high-resistance insulation between the primary and secondary circuits to withstand the voltage between the windings. There are varying degrees of isolation, selected based on the severity of the application:

- **Functional**–isolated output, but no protection from electric shock
- **Basic**–contains a physical barrier, offering shock protection if the barrier is intact
- **Supplementary**–adds a redundant barrier to basic isolation for added safety
- **Reinforced**-highest-safety choice; input and output windings are separated by a large distance or two physical barriers (like supplementary)

Push-Pull

Push-pull is a type of DC converter topology that uses a multiple winding transformer coupled with two transistors to convert DC voltage. Voltage is applied to the primary transformer circuit as the well timed transistors are alternated between on and off states. This design draws current during both halves of the switching cycle, smoothing the input current supply. As a result, push-pull converters provide a steadier input current, create less noise on the input line, and enjoy higher efficiencies in higher-power applications than alternative styles.

Market Data

Isolated DC-DC converters are used in high-voltage circuits, power metering, healthcare technology, battery management systems, onboard charging, and CAN receivers. With such a wide span of applications, market researchers expect the isolated DC-DC converter market to reach $2.7 billion (USD) by 2024.

Given the importance of physical barriers for isolated DC-DC converters, achieving high-isolation performance in a low-profile, compact design offers design engineers an opportunity to develop an innovative solution. This paper provides an overview of the Bourns® HCT Series AEC-Q200 Compliant Power Transformer, a high-clearance and creepage isolation power transformer that incorporates the latest safety features for DC-DC conversion.

Product Solutions

The HCT series (**Figure 1**) offers features well-suited for isolated DC-DC conversion applications such as automotive, industrial, communications, and consumer. They have a 6.5mm profile with more than 8mm clearance and creepage, along with

Electrical Specifications @ 25°C

Bourns Part Number	Primary Inductance @ 100 kHz	Leakage Inductance @ 100 kHz / 0.1 V (All Sec. Pins Shorted)	Turns Ratio P(1-3) : S(6-4)	Pri. (1-3) DCR (Ω) Max.	Sec. (6-4) DCR (Ω) Max.
	L 1-3 (µH) Min.	Lk 1-3 (µH) Max.			
HCTSM80101AAL	250	0.8	1:1	0.30	0.20
HCTSM80102AAL	250	0.6	1:2	0.30	0.35
HCTSM80201AAL	250	1.2	2:1	0.30	0.15
HCTSM80304BAL	300	0.6	3:4	0.30	0.30
HCTSM80305BAL	300	0.6	3:5	0.30	0.30
HCTSM80308BAL	300	0.7	3:8	0.50	0.85
HCTSM80403AAL	250	0.8	4:3	0.30	0.20
HCTSM80803AAL	250	1.8	8:3	0.30	0.15
HCTSM80809AAL	250	0.6	8:9	0.30	0.25
HCTSM80910BAL	300	0.9	9:10	0.30	0.25
HCTSM81017CAL	350	0.9	10:17	0.42	0.48

Figure 1: *HCT series part numbers qualified to work with Texas Instrument's chipset. (Source: Bourns Inc.)*

reinforced insulation for working voltages up to 800VAC. The transformers are compliant with AEC-Q200, RoHS, and three IEC standards (described in detail on previous page).

This transformer solution for isolated DC-DC conversion comes in a fully AEC-Q200 compliant part, manufactured in an IATF 16949-certified factory. It offers multiple turn ratios (1:1 to 1:2.7), and design engineers can customize the high-voltage isolation performance to specific application requirements, along with additional customization options. HCT transformers are also fully validated and approved by Texas Instruments.

The HCT series components (**Figure 2**) run at between -40°C and +125°C operating temperatures, and they provide up to 350mA output. The transformers also accept 3.3V-3.5V inputs and provide 3.3V-15V outputs.

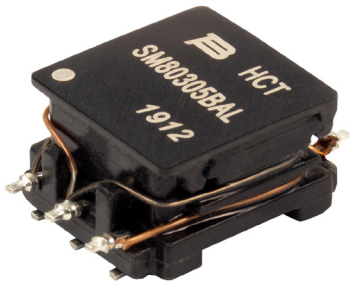

Figure 2: *HCT transformer Series (Source: Mouser Electronics)*

Engineers designed the HCT series transformers specifically for Texas Instruments transformer driver chipsets. Below is a summary of TI SN6501 and SN6505, two chipsets that work well with the HCT components.

SN6501

The SN6501 transformer driver (**Figure 3**) is designed for economical, compact,

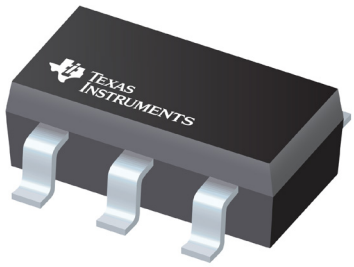

Figure 3: *SN6501 transformer driver from Texas Instruments. (Source: Texas Instruments)*

isolated DC-DC converters that use push-pull topology. The driver is used in applications such as CAN, process control, industrial automation, and low- to medium-risk medical equipment. Used for input and output voltages ranging from 3-5.5V, design engineers recommend implementing a low dropout regulator (LDO) to stabilize the current supply without dependence on load. Including an LDO maximizes efficiency while providing a stable power supply.

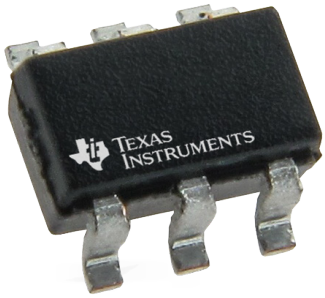

Figure 4: *SN6505 transformer driver from Texas Instruments (Source: Mouser Electronics)*

SN6505

Like the SN6501, the SN6505 transformer driver (**Figure 4**) is a push-pull transformer driver, designed for compact, isolated power supplies. Applications of this driver include process control, radio supplies, medical and precision instruments, low-noise filament supplies, and low-noise isolated USB supplies. The SN6505 is low-noise and low-electromagnetic interference (EMI) in addition to push-pull capable and drives low-profile, center-tapped transformer 2.25-5.5V power supplies. Design engineers recommend LDOs with this driver as well, to maximize efficiency while providing stable source current.

In addition to the two chips above Bourns HCT series is qualified for another two automotive grade TI chipsets: SN6505B-Q1 and SN6505D-Q1.

Standards Compliance

As safety is the primary function of an isolation transformer, quality engineers highly value compliance with industry standards. Bourns® HCT series transformers meet the UL/IEC 62368-1 Hazard-Based Safety Standard. The intent of the standard, which takes effect in December 2020, is to provide design engineers added flexibility to incorporate new technology into their product designs.

Complying to UL is a critical gate that establishes credibility with the customer base. UL is often used as the Gold Standard for electronic device compliance and covers a broad scope of highly technical industries, such as computing and networking, consumer electronics, telecommunications, monitors and televisions, and office supplies.

Competitive Benchmark

While being measured against an industry standard, the HCT series outperforms two anonymous competitive benchmark components in several categories:

- **High Potential Capability (tested):** HCT series transformers withstood up to 7.5kV, while the competitors rated at parity and 6kV
- **DC Resistance (DCR):** advantage over both competitors, providing a higher degree of isolation to enable increased safety

- **Thermal Derating:** advantage over both competitors, dissipating more power (without enduring damage) at a given case temperature
- **Working Voltage for Reinforced Isolation:** the HCT transformers operate at 800VAC, while the competitive products operated between 250-400VAC
- **Available Turn Ratios:** more than either competitor (11 for HCT, 7 and 9 respectively for competitive parts)
- **Creepage Distance:** a critical metric for an isolation transformer, the HCT component contains greater than 8mm creepage distance, while the competitive transformers were at parity or 7mm

Innovative Creepage Path Design

The HCT series contains an innovative body design that enables a high minimum creepage path between the terminal and the electronics. The lid contains protrusions that extend into the body, providing an elongated, tortuous path for the current to travel. This design increases creepage while maintaining a compact package footprint by adding internal surface area that increases the distance of the current flow path as shown above (**Figure 5**).

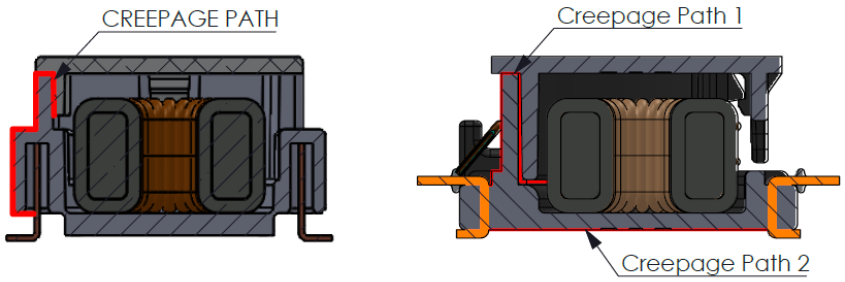

Figure 5: *Creepage Path (Source: Bourns Inc.)*

Conclusion

The Bourns® HCT series transformers were designed with reinforced isolation, increasing creepage distance. This series can be used with several of Texas Instruments automotive application chipsets. An innovative body design contains integrated routing paths for the current, creating a compact package that maximizes creepage and overall isolation performance for safe DC-DC conversion. The components have a low-profile form factor, making them ideal for UL/IEC 62368-1 compliance.

For push-pull DC-DC converters with reinforced isolation, the Bourns HCT series offers the best-in-class solution for technical performance while maintaining a small packaging size.