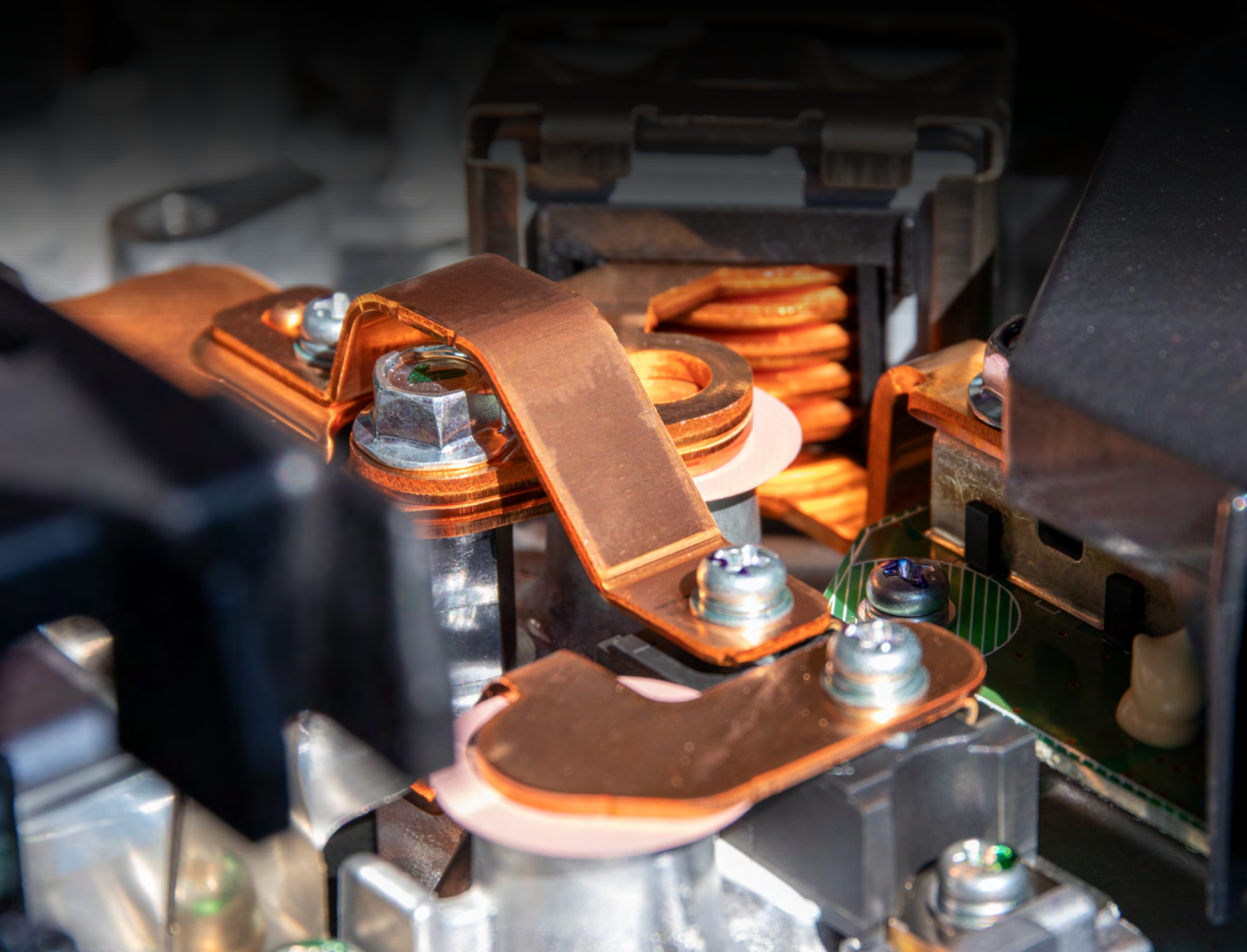
TRIAD

MAGNETICS

Power Components in the EV Industry



POWER COMPONENTS IN THE EV INDUSTRY

Over the past decade, electric vehicles (EVs) have increased in popularity, changing the landscape of the transportation industry. While most traditional passenger vehicles require a combustion engine, EVs rely on a rechargeable battery pack and electric motor. The use of magnetics also plays a vital role in the proper functioning and operability of EVs.

This eBook will discuss the various transformers and inductors necessary to meet the needs of a broad range of EV applications, selection considerations when choosing EV components, safety regulations to keep in mind when designing, and custom magnetics product options from Triad Magnetics to support the growing EV market.

Developing EV Infrastructure

By 2027, the electric vehicle market is predicted to reach a compound annual growth rate of 21.7%, with an estimated 233.9 million units expected on the roadways. However, the rapid expansion of the EV market has presented several challenges to the automotive and transportation industries.

One of the major hurdles associated with the rapid rollout of EVs and renewable energy is how the existing grid infrastructure throughout the country will hold up to the increased electrical consumption. This concern has led to demands for upgrading and modernizing grids to meet the additional capacity.

EV charging infrastructure must quickly evolve to keep up with the anticipated exponential growth of EVs over the next few years. Developing innovative, advanced transformer technology is essential to supporting sustainable EV infrastructure.

Transformers and Inductors in the EV Industry

The demand for inductors and transformers has significantly increased in the EV industry as more and more vehicles become equipped with enhanced smart technology for improved efficiency. Transformers play a crucial role, helping to operate everything from safety features to passenger comfort to power train functions.

Here are some of the key EV applications that require custom transformers and inductors.

Powering Electric Vehicle Charging Stations

Transformers can be designed to accommodate different levels of EV charging:

- **Level 1:** This low-voltage transformer, as low as 2kVA, can provide two to five mph of charging for an EV, with a 120V onboard car charger.
- **Level 2:** This low-voltage transformer is typically 30A but can go up to 80A and charges an EV with a 240V or 280V onboard car charger. It provides 10 to 11 mph of charging.
- **Level 3:** Creating DC power from a single- or three-phase source of 240V or 480V, this fast-charging transformer can provide 50 to 100 mph of charging.
- **Level 4:** These transformers can produce DC power from a 240V to 800V single or three-phase source to provide 170+ mph of charging. Fast-charging 350kW units can charge an EV for 200 miles in 15 minutes.

Lighting and Vision Systems

Vision systems in vehicles include sensors and light detection and ranging (LIDAR) technology that tracks the car's position on the street. Automakers such as Tesla and Rivian use various transformers to operate their autopilot and vision systems. Tesla's Sentry Mode and Rivian's Gear Guard also require transformers to allow the technology to record data when the driver is away from the vehicle. In a vehicle's lighting system, inductors can be used in the power supply circuit to smooth the flow of current to the lights, helping to improve the brightness and stability of the lights.

Electronic Control Units

Electronic control units (ECUs) are advanced systems that control the motors, brakes, engines, and sensors of an EV. The most recent EV models require more ECUs, often over 100 interconnected units per vehicle, to manage increasingly sophisticated functionalities and features.

ECUs have DC-DC converters that maintain the ideal voltage level of the battery while distributing power to different EV components. These converters contain power inductors that allow DC power to pass while resisting AC power. The integrated circuits (ICs) combined with these inductors perform high-speed switching, allowing DC-DC converters to adjust voltages to the appropriate levels.

As EVs become equipped with more ECUs, there is a rapidly growing demand for electronic components such as inductors, capacitors, and other electromagnetic compatibility (EMC) products to help these systems operate effectively.

Transformer Selection Considerations for EV Components

To specify the right transformer for an EV application, consider the following factors.

Harmonics

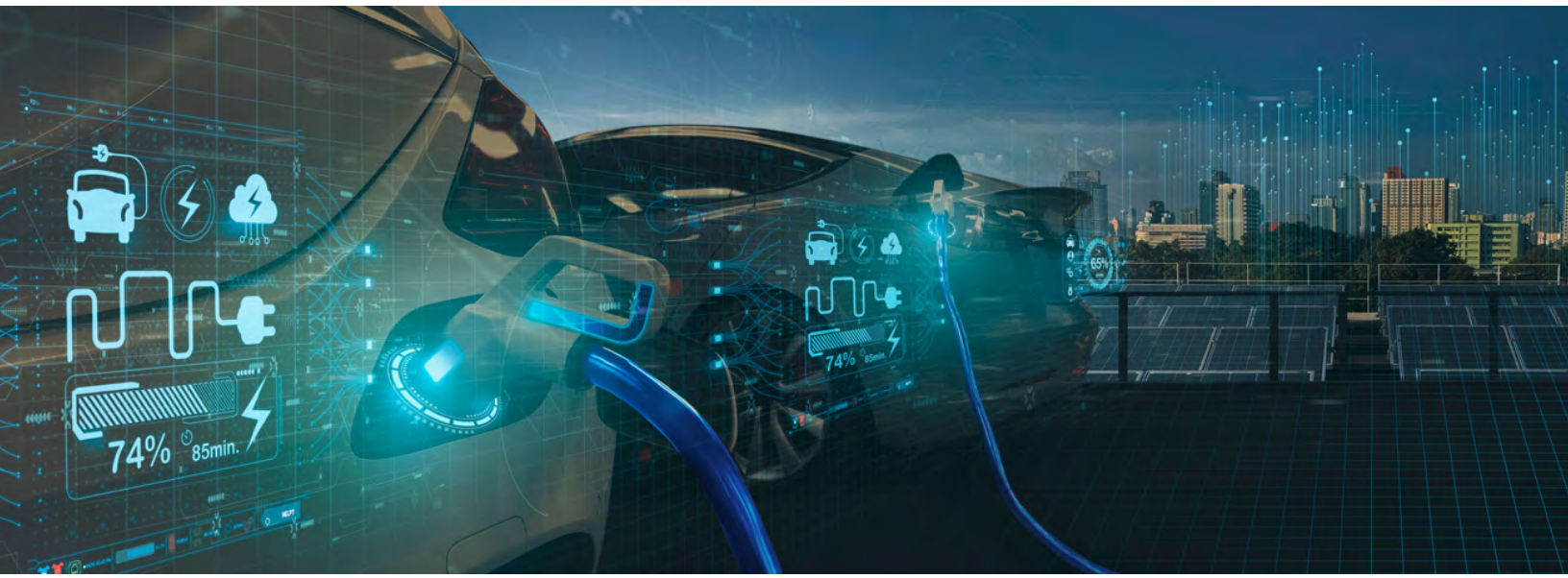
EV chargers act as non-linear loads to the electrical grid, causing voltage and current harmonics and distortion. Due to these harmonics, selecting the right transformer is vital to the proper function of the transformer and the system as a whole. Consider the levels of EV charging:

- Level 1 and Level 2 EV chargers are lower-capacity, single-phase loads most commonly found in parking lots, residential areas, and commercial fleets, with loads of 2-4 kVA. Multiple-unit installations of these chargers can create harmonic voltage and current distortion issues.
- Level 3 and Level 4 chargers, commonly higher than 200kVA, can quickly charge an EV in 10-20 minutes. These high-power draws often require large 600V class transformers for proper operation.

Power Quality

National standards restrict the amount of charger harmonics allowed to be transmitted to the power line via the transformer. The harmonic transmission can be effectively reduced by transformers with the following features:

- Multiple phase shifted, secondary windings
- Electrostatic shields
- Harmonic mitigating, zig-zag windings



Local Environmental Conditions

Environmental conditions can influence mounting choices and whether the transformer will require an enclosure. In a non-temperature controlled area, an 80 °C or 115 °C temperature rise transformer unit can handle high ambient temperatures. Enhanced NEMA 3R enclosures can be used in settings with heavy or horizontally blowing snow and rain.

Low Site Voltage

Buck-boost transformers or integral taps can adjust the voltage input transferring to the transformer.

Other Considerations

In addition to the above considerations, the following are other factors that may affect transformer selection:

- Primary and secondary voltages
- Winding connection
- Winding conductor material types
- Power factor
- Cooling methods
- Mounting arrangement
- Frequency of operation
- Efficiency

Safety Considerations for EV Components

Safety is paramount in the automotive and transportation industries. Here are the central safety considerations for EV power components.

Design Configuration and Installation

Charging units should be installed in areas inaccessible to the general public. If that is not possible, the following options are available:

- Tamper-resistant hardware
- Lockable, hinged enclosures
- Non-ventilated enclosures

Local electrical codes often require bollards or other forms of protection to prevent impact and damage from vehicles. Transformers should also never get installed near water drains or lines, which could direct water into an enclosure if it is broken.

Thermal Management

Due to an EV's high-temperature and high-voltage nature, the designs for inductors and other electronic components must consider heat management issues to guarantee safe operation. At the same time, cooling systems must be small enough to fit into certain areas of the vehicle.

Common issues associated with thermal management systems include the limited cooling effectiveness of controllers, capacitors, and gate drives. To address these problem areas, EV manufacturers should utilize electrically isolated and highly conductive thermal materials that are cost-effective and do not compromise vehicle efficiency.

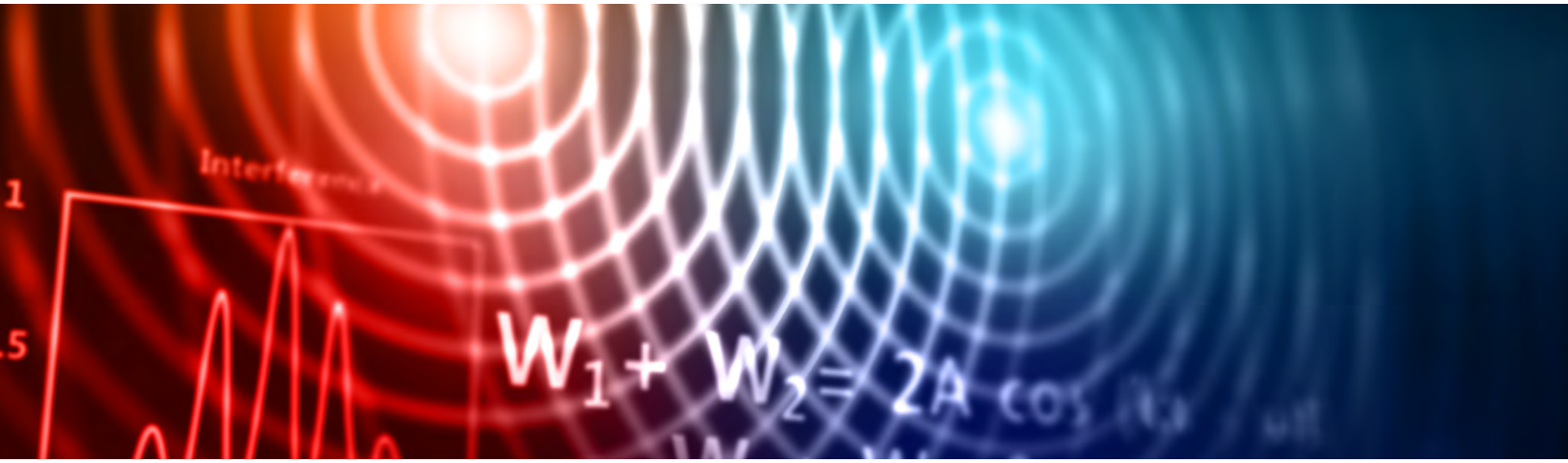
At EV charging stations, the rapid charging rates can result in significant voltage harmonics and losses, which could overload the transformer during peak demand. In addition to overheating the capacitor and transformer, these issues cause degraded power quality. Chargers located in areas without climate control must have transformers with low temperature rise specifications to protect the charger from extreme low and high ambient temperatures.

Electrical Radiation Standards

Electromagnetic interference (EMI) is a potential issue for all electronic components, especially those in EVs. Automakers must ensure the electromagnetic compatibility (EMC) of EV powertrain components, which can malfunction if not protected from EMI.

The largest sources of EMI in charging stations are AC-DC and DC-DC converters. To charge the EV with the appropriate amount of power, signals and circuits must be protected from disruption due to EMI. EMC-compliant chargers protect devices from external EMI as well as prevent EMI emissions. Regulations for EMC-compliant charging stations can vary, but several of the common standards include the following:

- FCC Part 15 Part B - Class A / Class B
- IEC 61851-21-2
- IEC 61851-23



IATF Standards

The International Automotive Task Force (IATF) sets standards for the manufacture of automotive products around the world, and IATF 16949:2016 is the specific standard for the quality management system of automotive manufacturers. It is based on ISO 9001:2015 and applies to all organizations producing parts and assemblies for automotive applications.

EV developers should work with suppliers that are IATF 16949:2016 certified, ensuring that all products and processes are optimized to:

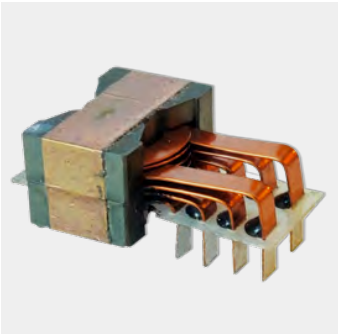
- Comply with all applicable regulatory and legal requirements
- Enhance customer satisfaction and safety
- Minimize defects and errors, which would otherwise lead to recalls

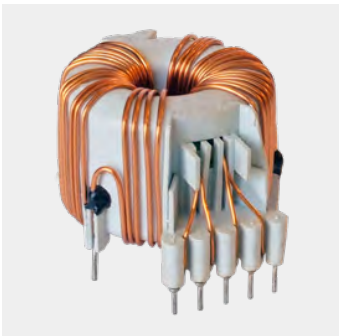
Triad Magnetics is IATF 16949:2016 certified to supply safe, reliable, and high-quality magnetics products to our customers.

Custom Transformers for EV Applications from Triad Magnetics

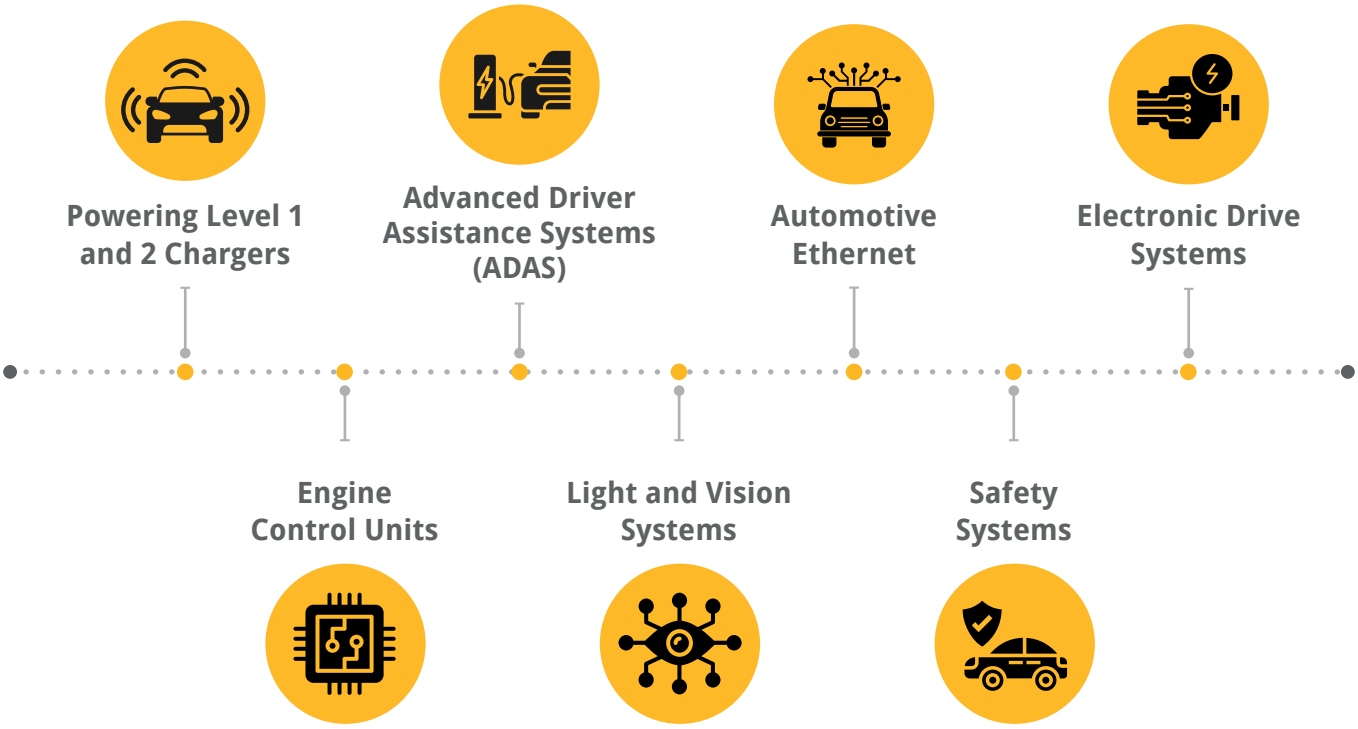
With inductors and transformers playing an increasingly important role in the EV marketplace, many applications in this industry will need custom solutions. The engineering team at Triad Magnetics has the engineering design expertise, prototyping capabilities, and product development skills to deliver custom solutions to meet the ever-evolving demands of the transportation and automotive industries.

For a recent customer, our engineering team developed a custom LLC transformer that operates in the circuit, allowing for a generous margin. Our team created the unit with leakage inductance and specific inductance in the same package and then designed an external resonant inductor for the specific inductance.





Custom transformers are used in the following EV applications:



Partner with Triad Magnetics

For over 80 years, Triad Magnetics has met the dynamic needs of various growing industries with reliable, high-quality products and services. From our Perris, CA, facility, we are fully certified to develop and test EV components for optimal performance, and our manufacturing teams adhere to a highly evolved system of critical self-inspection to ensure our automotive magnetics meet the highest standards for our valued customers. Let our years of industry experience help you navigate the growing EV demand for new magnetics products.

Contact us to learn more about Triad Magnetics, or **request a quote** for information related to your specific magnetics application.

ABOUT TRIAD MAGNETICS

EXPERIENCE

Triad Magnetics is a global leader in the design and manufacture of transformers, power supplies and inductors for a wide range of applications, including switchmode/high frequency, wall plug-in, power transformers, inductors and audio transformers. Having served the needs of our industry for more than 80 years, we believe our experience makes the difference. We try to understand the true objectives of every customer, creating partnerships that strive to exceed those objectives.

STANDARD OR CUSTOM

Over 1,000 standard part numbers mean you will probably find the component you need in our standard product line. If not, the creative thinkers of Triad Magnetics can offer powerful custom solutions. Every product is backed by Triad's pioneering design process that promotes innovation. Each engineer has direct ownership and takes pride in managing projects from initial concept through production. There are thousands of Triad Magnetics designs providing application solutions in industries throughout the world, from audio to medical, power conversion to telecommunications, commercial equipment to renewable energy.

FOCUS ON QUALITY

Triad is dedicated to producing products for long-run reliability, providing extensive resources and support to ensure the ongoing excellence of our products. The Triad Magnetics system of in-process inspection, pre-ship audits, and failure analysis has allowed many of our customers to eliminate their own incoming inspection process. Our continuous improvement protocol provides the highest levels of product quality and reliability, which leads to greater long-term value.

WORLD-CLASS MANUFACTURING

Our production techniques provide the flexibility of both high and low volume production, capable of handling one piece to 10 million pieces, making us the perfect supplier for customers who have a "high mix" of product requirements. Triad operates manufacturing facilities in the United States and the Philippines. Our Perris, CA, headquarters is home to our engineering design and production teams along with our shipping and warehouse center that can provide just-in-time delivery of all of your component needs.

Contact Us Today

View Our Product Demonstrations

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