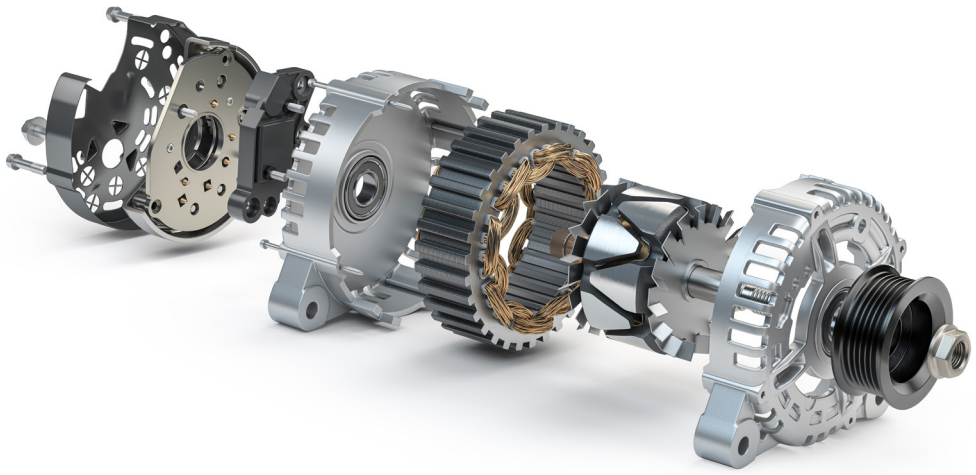
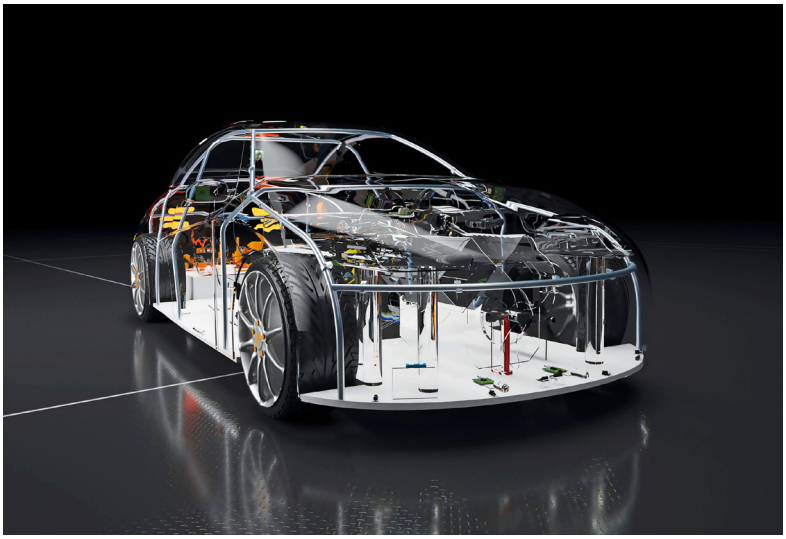
WHITE PAPER

# DRIVING EV EFFICIENCY

Introducing AMPLIVAR splice for flat magnet wire terminations

**CONNECTED LIVING SOLUTIONS**





# THE FUTURE IS NOW IN ELECTRIC VEHICLES (EVS)

Around the world, a new level of demand for EVs has emerged to meet cleaner energy and sustainability objectives.

Through regulatory requirements, financial incentives, and consumer preferences, EV production and adoption continue to increase, as the shift to EVs remains a pivotal strategy in reducing transport-related greenhouse gas emissions by 90% by 2050.

## The result is that EV growth is expanding globally across categories.

According to the latest Global EV Outlook 2025[1], more than 25% or approximately 20 million new car sales are expected to be EVs. This global growth, however, is not limited to cars. In heavy-duty EVs, the electric bus market is forecasted to reach $41 billion in 2025, while the smaller electric truck market is expected to reach nearly $6 billion, reflecting a compound annual growth rate (CAGR) of 48%.[2]

E-bikes and other personal electric transport represent another category of explosive EV growth. Growing in popularity in both urban and remote rural areas, the E-bike market is expected to reach $51 billion in 2025.[3]

**Global EV Adoption and Growth**
According to a 2024 forecast from Gartner Inc., an estimated 85 million electric vehicles (EVs), including cars, buses, vans, and heavy trucks, are expected to be on the road by the end of 2025.[4]

- China is the dominant EV market; sales reached 11 million units and accounted for 50% of all car sales in 2024[5]; the market is projected to grow at a Compound Annual Growth Rate (CAGR) of 17.15% between 2025 and 2030[6]
- Europe is the second-largest EV market and is thriving, marking a 25% increase in sales in early 2025[7], with Italy, Spain, and Germany reporting growth rates exceeding 40%[8]
- Japan experienced a slowdown in EV sales in 2024[9]; however, the market is expected to realize a CAGR of 32.9% between 2025 and 2030[10]
- U.S. EV sales accounted for 8.1% of new car sales in 2024[11]; first quarter sales increased 11% year-over-year (YoY)[12], with overall sales projected to realize a CAGR of 32% from 2025 to 2030[13]
- Latin America has experienced slow regional growth; however, Mexico realized a 70.2% EV sales increase in 2024[14], and in Brazil, EV sales soared 90% in 2024[15] and increased by nearly 40% in 1Q 2025 YOY[16]
- India experienced record EV sales in 2024, surpassing two million units[17]; in 2025, electric two-wheelers are leading the charge[18] while production of EV passenger vehicles is expected to soar by 140.2% YOY[19]

## Meeting Demand, Delivering Advantages

The growing demand for EVs underscores the need for more efficient, cost-effective, and sustainable production strategies. As a result, EV makers are now relying on advanced magnet wire technology to improve the performance of compact coil systems.

This explains the transition from circular to flat magnet wire termination, a solution that optimizes the filling factor of the stator cavity. In motor development, this is critical for enhancing overall efficiency, improving winding processes, increasing power exchange capabilities, and offering better heat dissipation.

**It is also the impetus for introducing AMPLIVAR splice, TE Connectivity (TE)'s next-generation flat magnet wire terminals.**

As EV makers look to ensure high-performing sustainable practices across motor development, traditional termination methods are becoming obsolete. The use of brazing, soldering, and welding not only results in higher costs but also in longer production cycles. These methods also use chemical processes to pre-strip the flat magnet wires.

TE's advanced methodologies effectively address these concerns. Our technology applies a solderless process that is virtually free of chemicals and fumes, while also eliminating the risk of thermal damages typically associated with traditional approaches. This consumes less energy, eliminates manual labor costs, and helps to ensure clean and greener working environments. In addition, the reduced scrap ratio contributes to more overall cost savings.

**OUR AMPLIVAR SPLICE FLAT MAGNET WIRE TERMINAL(S) PRODUCTS ACHIEVE GREATER EFFICIENCY, ENVIRONMENTAL CLEANLINESS, AND COST SAVINGS**

No wire pre-stripping processes

No manual/labor costs

No high-temperature processes

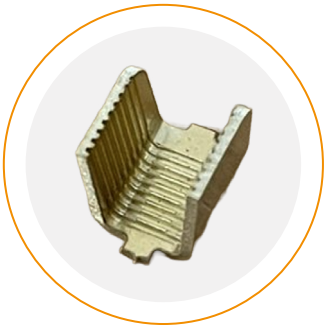
Low applied costs ($$$)

No chemical compounds needed

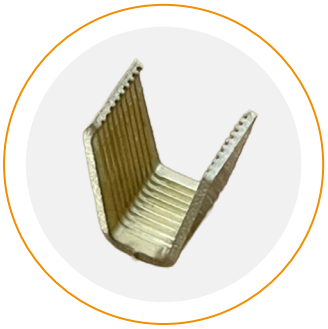
Reduced scrape ratio (currently ~1.4% with welding process)

More importantly, our advanced, solderless methodologies can now facilitate flat magnet wire termination, providing EV makers a more efficient alternative.

Using our proprietary AMPLIVAR splice technology, two advanced flat magnet wire terminal products are now being offered. Suitable for copper and aluminum wires, these products can also be customized to meet customer needs and specifications:



**AMPLIVAR splice – Single Flat Magnet Wire Termination**



**AMPLIVAR splice – Double Flat Magnet Wire Termination**

Our rigorous R&D included extensive testing to validate these terminals by checking electrical, mechanical, and environmental performance. A strong adhesion of the wire and terminal bonding at an atomic level has delivered optimal results.

> Our AMPLIVAR splice terminal products are the first to offer a solderless solution for flat magnet wire. This innovation can increase efficiency while using a more sustainable process in motor development – the very essence of what EVs are all about.
>
> **Fabio De Pasquale**
> TE Research & Development
> Product Development Engineer

# PRODUCT DEVELOPMENT OVERVIEW – OUR ENGINEERING SCIENCE

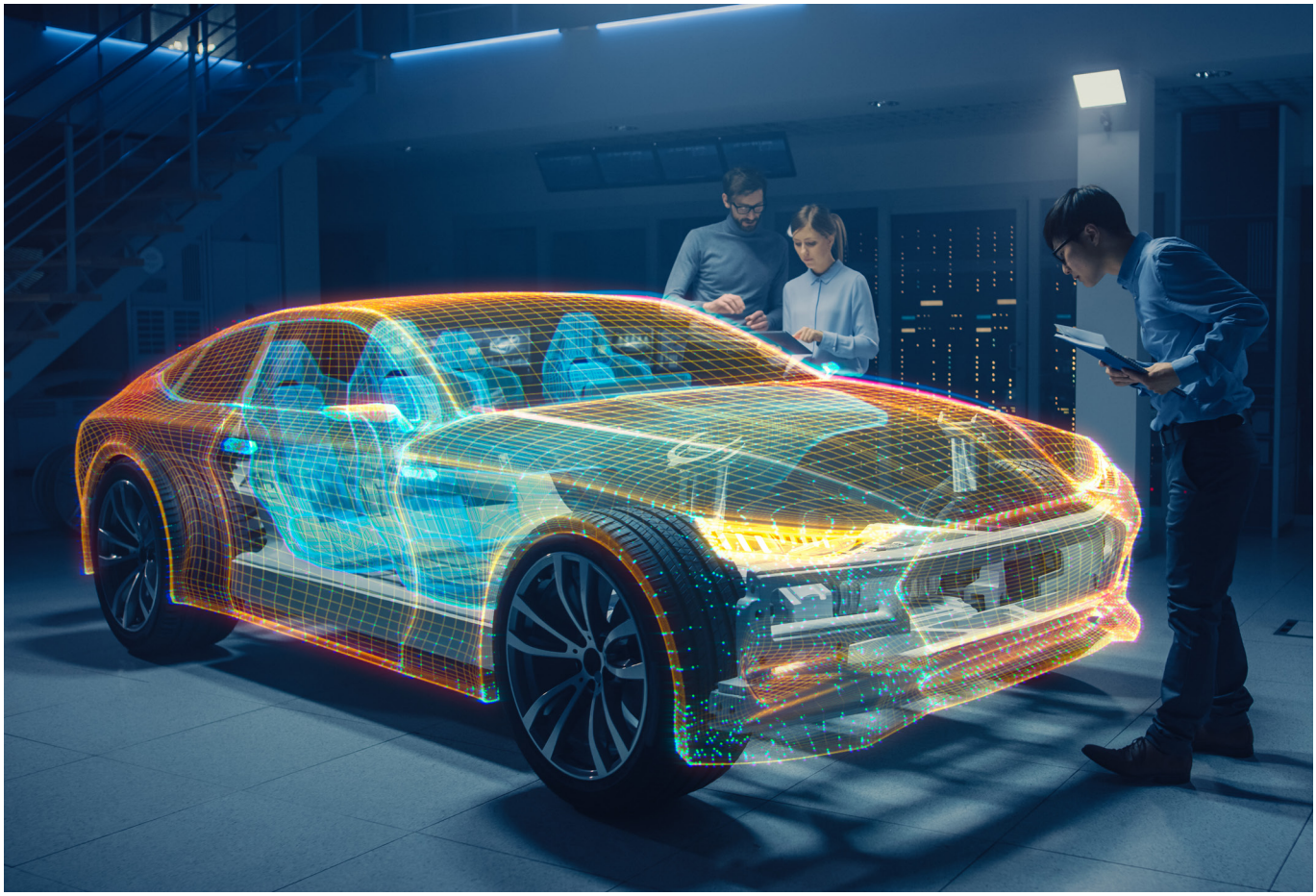
AMPLIVAR terminals and splices utilize a proprietary splice technology developed by TE Connectivity and they are crimp terminals specially designed to terminate copper and aluminum magnet wires. They have machined, sharp-edged serrations inside their crimp barrels with burrs at each edge to cut through the wire-coating barrier and penetrate the wire.

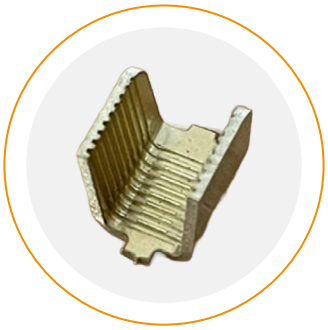
The AMPLIVAR splices are folded applying the traditional F-Crimp or the overlapping crimp method. This results in a solderless, airtight, solid electro-mechanical connection where the wire is extruded into the serrations and the oxides are removed. AMPLIVAR splices can be implemented in semi- and fully automatic machines with programmable sequencing for different crimp-height settings and Crimp Quality Monitoring (CQM), to help ensure ongoing performance.

## Why the flat magnet wire?

- Optimizes filling factor in the winding/coil process
- Provides more electrical power than the standard round wire
- Offers superior heat dissipation to round wire, given the nominal temperature differential between the internal and external parts of the coil
- Improves the design of the coil to achieve better frequency characteristics

**Development of the single flat magnet wire termination informed the development of the double flat magnet wire termination.**



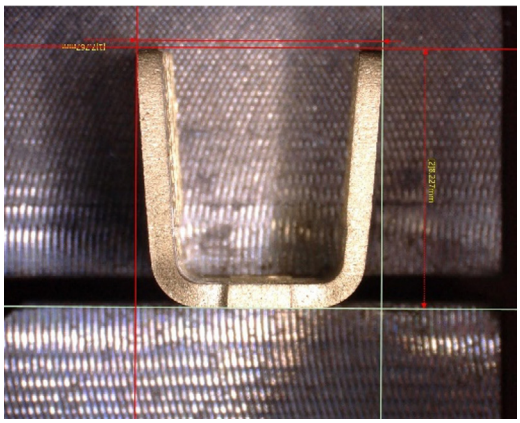


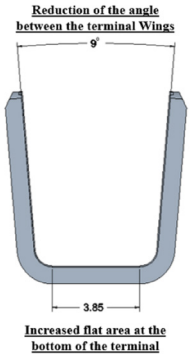
## Single Flat Magnet Wire Termination

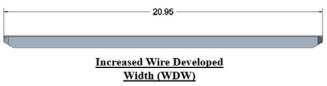
**Advanced Design:** The shape and geometry were tailored to fine-tune the termination of the considered flat magnet wires, including an improved splice design for single/F-Crimp flat wire termination.

**Main parameters:**

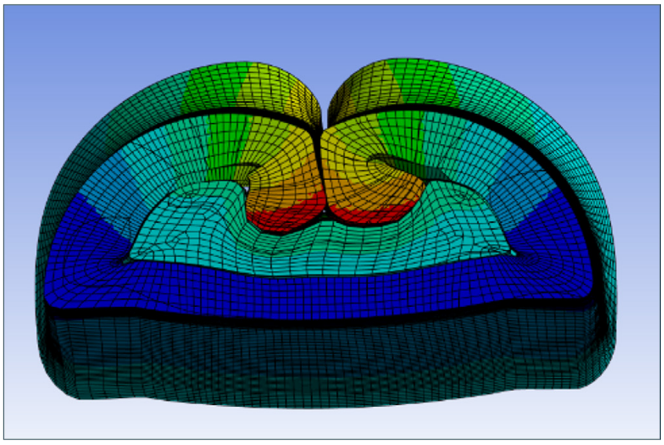
- Wings angle to help ensure proper terminal crimping
- Bottom flat area of the terminal provides stability and alignment
- Wire Developed Width (WDW) is a value pivotal to accommodating the flat wire





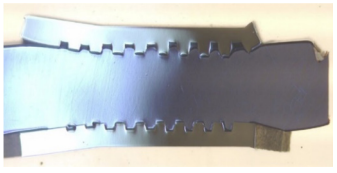




**Simulation:** The simulation reviewed the crimping process with the improved concept design and calculated design parameters. Different wire dimensions and crimping parameters were considered to determine the final and correct solution.

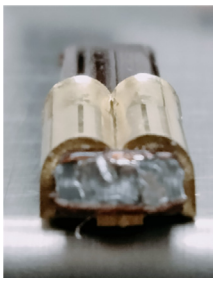


Crimping simulation

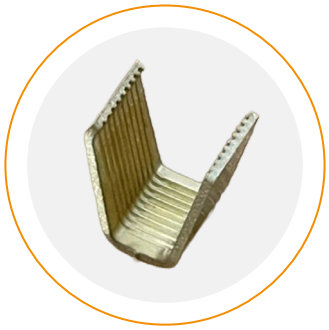
**Sections' Analysis:** To evaluate the good crimping of a splice, the sections were made along the longitudinal and cross directions of the terminal. Good penetration of the burrs inside the wire and a good compression occurred. There were no voids, and the coating was well removed.



Longitudinal section, Al wire



Cross-section, Aluminum wire

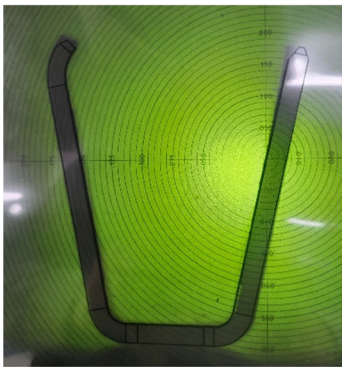


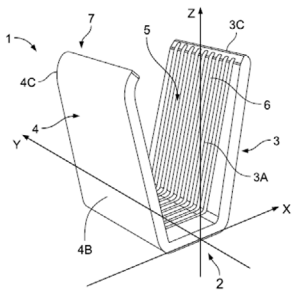
## Double Flat Magnet Wire Termination

**Advanced Design:** Based on the single wire design prototype, a better splice for double flat magnet wire termination was developed with various design improvements.

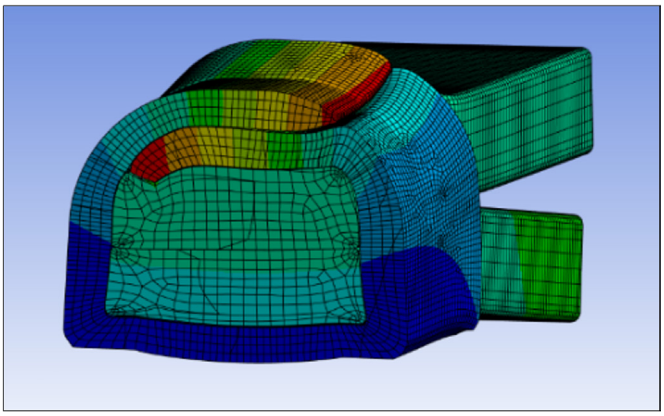
**Main parameters:**

- Tall tines overlap to eliminate the center seam opening of the traditional “F” shape
- One tine straight, the other tine with an internal chamfer, to facilitate bypassing along the top of the crimper
- Increased wrap for variations in cross-sectional area per square millimeter (CMA) for versatility and adaptability to different wire size requirements
- Tool crimper changed to provide for correct closure of the terminal
- “U” shape of the crimper is appropriately sized based on the dimensions of the terminal



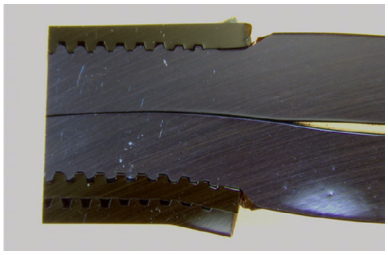



**Simulation:** The simulation provided information on the crimping height, the compression of the wire, the correct functionality of the crimper for the overlapping process, and the sealing resistance of the splice.

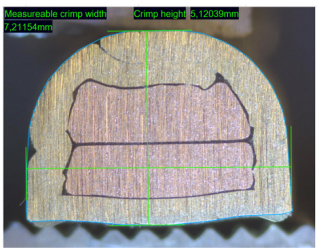


Overlap crimping simulation

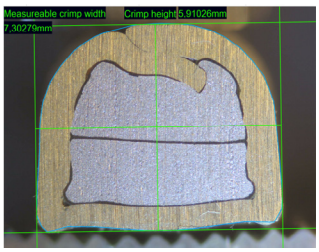
**Sections’ Analysis:** Cross-sections showed a good penetration of the burrs inside the wire and a good compression. There were no voids, and the coating was well removed. The two tines overlapped with a good holding resistance.



Longitudinal section, Aluminum wire




Cross section,
Double Copper wire




Cross section,
Double Aluminum wire

## Testing/Results

Utilizing EIA-364 – the standard for minimum test sequence and test procedures on electrical connectors – the two splice terminals were tested for electrical, mechanical, and environmental performance. This included Low Level Contact Resistance (LLCR), thermal shock, tensile strength, vibration tests, and temperature rise vs current.

LLCR was performed before and after each of the mentioned tests, and low and stable resistance variation values were consistently observed on all the tested samples. These results highlighted the robustness and the reliability of the connection system.

> After testing and validation, our flat magnet wire terminal products are proving to deliver the mechanical and electrical performance EV motors require.
>
> **Clinton Pereira**
> TE Supervisor
> R&D/Product

## Sources

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## About TE Connectivity

TE Connectivity plc (NYSE: TEL) is a global industrial technology leader creating a safer, sustainable, productive, and connected future. Our broad range of connectivity and sensor solutions enable the distribution of power, signal and data to advance next-generation transportation, energy networks, automated factories, data centers, medical technology and more. With more than 85,000 employees, including 9,000 engineers, working alongside customers in approximately 130 countries, TE ensures that EVERY CONNECTION COUNTS. Learn more at www.te.com and on LinkedIn, Facebook, WeChat and Instagram.

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