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Revolutionizing Data Connectivity System with Copper-Clad Aluminum and Lay Length Optimization

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Extended Abstract

As part of the eco-system development and to support the automotive business Growth, this innovation was driven by two major objectives Low cost and keeping the same performance.

Our crucial focus was on bringing solutions that offers competitive advantage, together with being the most cost attractive to automotive customers, improvement and optimization of the data connectivity cables are outlined within this resolution.

Coaxial cables are around 40% from the cable assembly cost, and the copper content itself is 60% from the cost of the cable, and this material particularly is not stable on the market as it's a part of the London Metal Exchange (LME).

We have identified two innovation ideas:

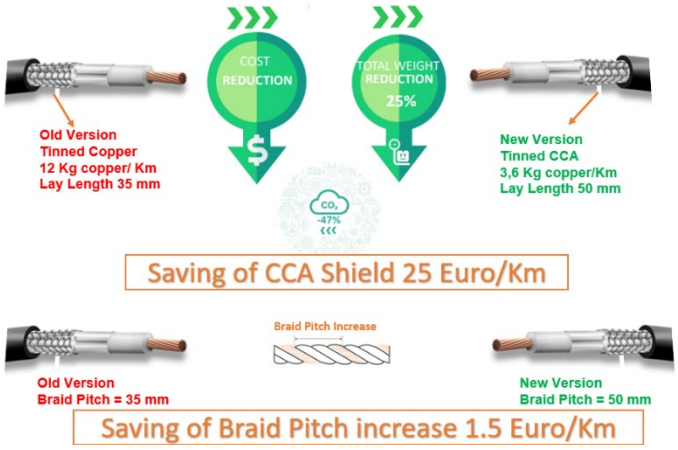

Figure 1 – Innovative coaxial cable Overview.

Primary the Copper cladded Aluminum (CCA) material to replace the pure copper on the braid shields, moving from 12 Kg/Km to 3,6 Kg/Km generating a saving of 25 Euro/Km.
Besides this important saving amount, it's eco-friendly product with a weight reduction from the standard version of 25%, on top of that it's -47% (KgCO2eq/Km) on CO2 emission.
Moreover, the CCA material can be used in all data cables to maximize the data platform efficiency, our next target will be the multigigabit differential cables.

Secondly, while we were working on the original equipment manufacturer (OEM) specification analysis, we have identified that there is no specific Lay Length/ angle for the Braid pitch, as the only requirement for the
shield is to be on minimum coverage of 90%.

Consequently, we introduced the increase of the braid pitch from 35mm to 50 mm with a saving of 1,5 Euro/Km.

The combination of both ideas and based on our coaxial platform will increase Operating Income (OI) of each automotive cable assembly manufacturer of 2,5 points.

I. PROBLEM STATEMENT

In today's highly competitive automotive industry, manufacturing plants are constantly challenged to deliver high-quality products while maintaining cost efficiency. This chapter delves into the specific challenges faced by automotive plants in producing data cables a critical component in modern vehicles. These cables are essential for the efficient operation of various electronic systems, from infotainment to advanced driver-assistance systems (ADAS). The dual mandate of

maintaining competitiveness and ensuring superior quality is particularly pronounced in this niche but vital segment of automotive manufacturing.

Apart from the cable performance, our major objective is the introduction of this new innovative cable in automotive plant current full automated lines without any additional Capex, therefore manufacturing trials have been accomplished and followed by the mechanical and Radio Frequency (RF) tests to comply the requirements.

The automotive industry is characterized by rapid technological advancements, stringent regulatory requirements, and fluctuating market demands. Manufacturers must navigate these complexities while controlling costs and optimizing production processes. The competitive landscape is further intensified by the global nature of the market, where plants must compete not only with local but also international players.

II. Methods And Results

To align with market dynamics and establish ourselves as a leading cable assembly manufacturer, we have collaborated with a cable maker to propose an innovative and efficient solution for our customers. We are introducing a new material, "copper-clad aluminum" (CCA), for the braids of coaxial cables. Given that RTK031 is the preferred cable for data and infotainment applications, we have selected this type for our initial introduction and validation with vehicle manufacturers.

1. Concept & Simulation:

We began by conducting simulations based on the selected characteristics of the copper-clad aluminum (CCA) material when used in combination with SMB connectors. The initial results from these simulations appeared very promising, indicating the potential for high performance in practical applications. Encouraged by these results, we promptly initiated a comprehensive validation process for the raw cable. This validation focused primarily on two critical parameters: characteristic impedance and transfer impedance.

The characteristic impedance is crucial for ensuring signal integrity and minimizing reflections, which is vital for data and infotainment applications. By validating this parameter, we aim to ensure that the cable will perform reliably in high-frequency environments typical of modern vehicles.

Transfer impedance, on the other hand, is a key measure of the shielding effectiveness of the cable. High transfer impedance can lead to greater susceptibility to electromagnetic interference (EMI), which can degrade signal quality. Therefore, validating and optimizing the transfer impedance is essential to guarantee that the cable can provide robust performance even in the electromagnetically noisy environment of a vehicle.

Through rigorous testing and validation of these parameters including aging tests according to USCAR17 & 49 together with LV214 as we are targeting European and US customers, to deliver a high-quality, reliable product that meets the stringent demands of our customers in the automotive industry.

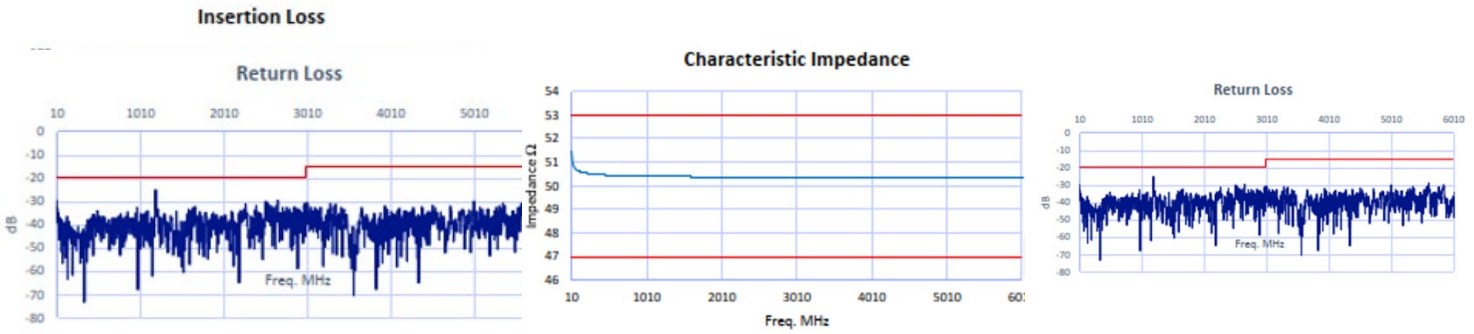

Figure 2 : Raw Cable signal integrity propreties

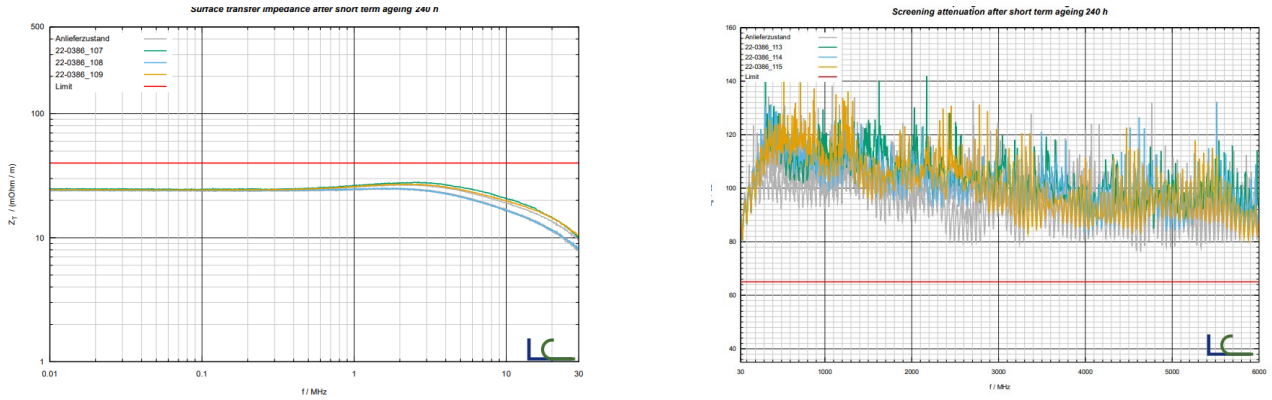

Figure 2: Raw cable EMC propreties

2. Experiment and Tests performances:

For specific configurations such as Miniaturized Automotive Coaxial Connector System, we carried out a Design of Experiment (DOE) to define the optimized process parameters, with maintaining the RF performance mainly the insertion Loss and gated return loss together with impedance monitoring along with the mechanical properties, as the first test and simulations that we have conducted using the same Crimp heights for inner ferule and center contact were out of the limits as described in the below figure:

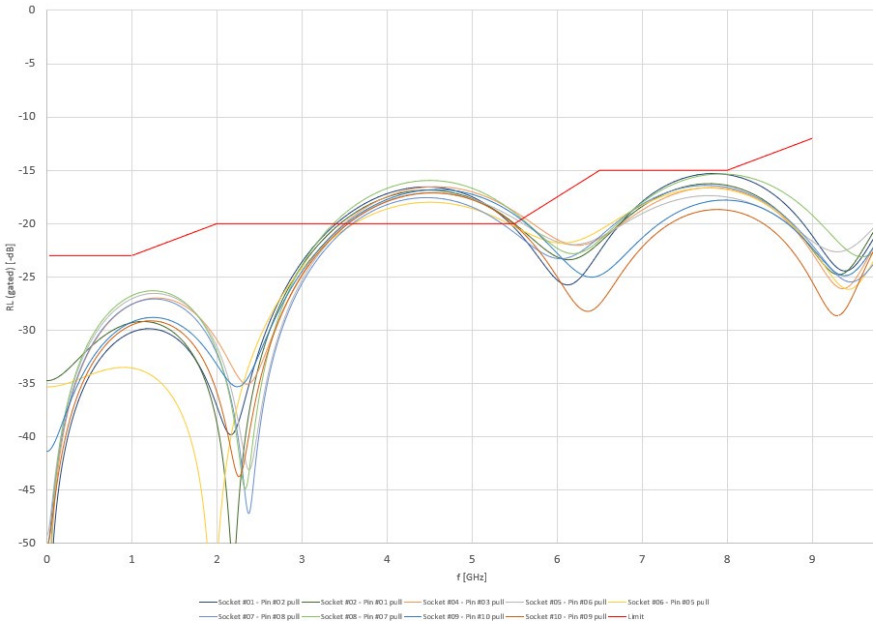

Figure 3 : Return loss of data miniaturized system.

Based on the findings, we have conducted simulations with various crimp heights using the clamp method, as illustrated in the figure below. These simulations were aimed at defining the precise process parameters necessary for all manufacturing steps. This comprehensive analysis includes determining the optimal cable stripping dimensions. The goal is to ensure consistency, quality, and efficiency across the entire production process.

By adjusting and refining these parameters, we aim to achieve optimal crimp quality, secure electrical connections, and overall product reliability. The detailed process parameters will guide the manufacturing team in implementing the best practices for cable preparation, including precise stripping lengths and crimping techniques, thus ensuring that each component meets the desired specifications and performance standards.

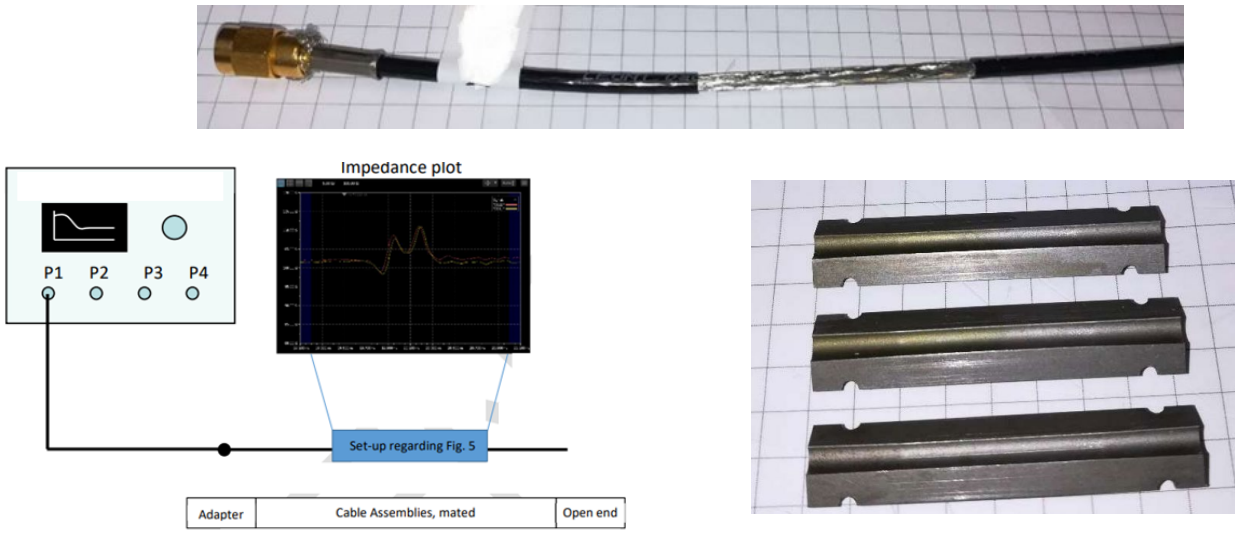

Figure 4 : Schematic Test Setup for Measurement of Parameter Cable Impedance

for good measure we have conducted complex successful aging tests mainly Current heating, derating / Thermal time constant/ Thermal Shock / Humidity heat, cyclic to boost our confidence level about this innovative cable in front of OEMs and finally we managed to have a global a complete test report according to the automotive international standards with very optimized high frequency performances. (see below figure)

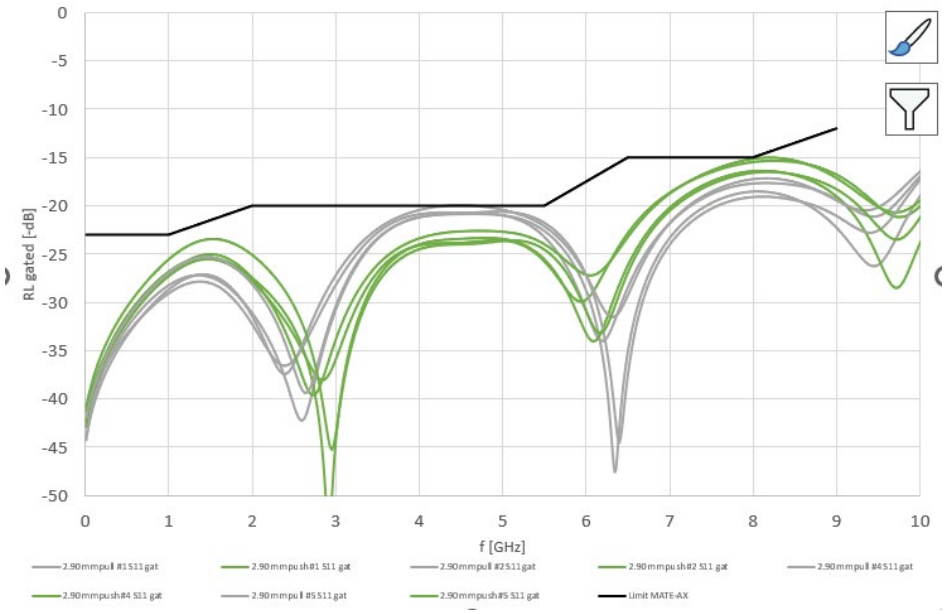

Figure 5 : Gated Return Loss after Aging

III. Discussion And Key Points

The implementation agreement is currently under development with leading strategic car manufacturers in the market. This collaborative effort aims to establish a robust framework that will facilitate seamless integration and cooperation among all involved parties. The agreement outlines key terms and conditions, including timelines, responsibilities, and performance metrics, to ensure that all objectives are met efficiently and effectively.

The extensive validation process we have undertaken has proven to be robust and comprehensive, ensuring that we are well-prepared to proceed with the implementation on a dedicated validation car line. This implementation will require only minimal customization of the validation report limits specific to each Original Equipment Manufacturer (OEM) we are targeting. Such customization is straightforward and ensures that the validation data meets the precise standards and requirements of each OEM, thereby facilitating smoother integration and acceptance.

One of the significant advantages of this approach is the considerable cost savings it offers. As previously mentioned, we anticipate a cost reduction of 26 euros per kilometer, which is a substantial financial benefit. These savings are achieved through the efficient and targeted validation process, which reduces unnecessary expenditure and optimizes resource utilization.

Additionally, our product stands out as a sustainable solution in the automotive market. The reduced weight of our product directly contributes to lower CO2 emissions, aligning with global efforts to mitigate environmental impact and comply with increasingly stringent emission regulations. Moreover, the lighter weight of our product also translates to reduced transportation costs. Since transportation costs are closely linked to the weight of the goods being shipped, the lighter product will lower overall shipping expenses, adding another layer of cost efficiency to the supply chain.

IV. Conclusion:

We have conducted comprehensive benchmarking of our innovative data cable against similar products in other regions, specifically within the automotive business unit. This benchmarking ensures the accuracy and relevance of our evaluation, addressing the main aspects that need to be assessed. Furthermore, this new Copper Clad Aluminum (CCA) cable is applicable across all cable assembly manufacturing sites for various business units in different regions. Its implementation will significantly enhance efficiency, productivity, and competitiveness, thereby supporting growth and enabling us to win more business.

Moreover, our solution is in sync with the broader automotive vision, as it has a direct positive impact on sustainability. By reducing the weight of our products, we not only contribute to lower CO2 emissions but also achieve cost savings in transportation, aligning with industry goals for environmental responsibility and economic efficiency. This comprehensive approach ensures that our product is well-positioned to meet current and future demands in the automotive market while promoting sustainable practices.