

Technical Issues of 100Mbit/s Ethernet Transmission based on Standard Automotive Wiring Components

Reinhard Felgenhauer and Michael Rucks
Delphi Automotive

ABSTRACT

The presentation describes a technical solution for 100 Mbit/s Ethernet Data transmission cabling. This solution considers the specific requirements of automotive wiring harness and manufacturing. It bases on standard automotive connectors and headers.

Currently the development of automotive electronic architecture considers central ECU or data backbone structure for the upcoming EE architecture (e. g. single ECU for network; SEN). For these structures solid and cost effective data backbone solutions are essential.

Ethernet, a wide distributed and well-known bus system for office and industry data distribution provide a wide range of software tools and many physical layer solutions. Several cabling systems are available. Based on this we propose a solution for automotive application.

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INTRODUCTION

Several car manufacturers are planning to use data backbone architectures. All these solutions provide a high speed data backbone for the upcoming data distribution requirements. Ethernet is a candidate to enter automotive technology. The reasons from data transmission software position are obvious. Automotive industry is on its way to autonomous driving and the demand of data transmission is rising continuously. Automotive industry expects to reduce hard and software development cost due to the synergy with office, industrial and avionic Ethernet applications. This close relationship with other Ethernet installations, promise cost reduction and additional safety aspects for automotive use.

Scalability, a feature of Ethernet, is an additional aspect for future data transmissions and an essential reason for this technology.

100 Mbit/s is the current standard for data transmission. A bitrate of 1Gbit/s is scheduled as a future extension step.

PHYSICAL LAYER FOR ETHERNET IN AUTOMOBILE

The challenge is, to provide a physical layer (cable, connector, inline), which fulfill the technical requirements for such a transmission media combined by low cost and technical robustness.

The manufacturing of such devices should be possible in the current chain of automobile wiring harness production.

Special cable and connector with dedicated termination processes will increase the cost of the transmission media.

This investigation fulfills the technical requirements and base on standard automotive terminals and automotive connectors to achieve cost reduction.

An electronic company provides a transmission system chip set for unshielded twisted pair (UTP) cables as transmission media. This chipset is designed for a symmetric twisted pair.

The technical requirements for twisted pairs are unusual for automotive wiring harness suppliers. Due to this, the single wire of the harness becomes an electronic device with new and specific features.

The high speed data stream has to be transmitted with low losses; low reflections and without electromagnetic interference with other electronic devices inside and outside the automobile. The electromagnetic interferences are reduced by a symmetric cable and connector design. Shielding and transmission requirements will be achieved by a dedicated termination process.

DATA TRANSMISSION

The electronic transmission is calculated by the data transmission theory. (Fourier transformation) This mathematical theory based on the transfer calculation from time functions into functions in the frequency area. For each electrical signal, a transformed function in the frequency area can be calculated.

The transfer-function of the transmission system is specified in frequency parameters. Based on this an output signal is calculated.

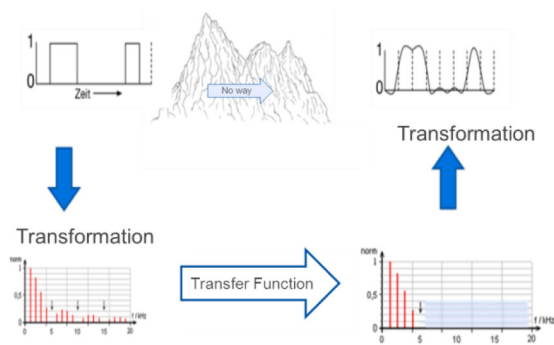


Figure 1. path of mathematical calculation

After this, the function is recalculated into the time function. (see: Figure.1)

This is the basics of the data transmission calculation. Several parameters in this frequency parameter area are defined to verify the technical features of data transmission channel. (see: Figure.2)

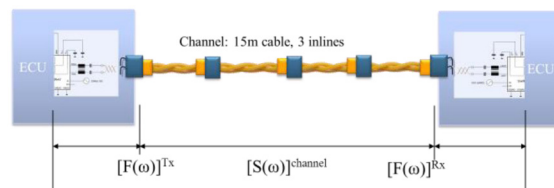


Figure 2. Electrical Transmission System

Due to this, the focus of interest changes from time range to frequency range.

The transfer functions and other transmission parameters of the data channel in frequency area are in focus of investigation. Data channel is a synonym for all the passive devices of the data transmission link.

A suitable way to describe the behavior of the channel in frequency range is using S-Parameters.

S-PARAMETERS

The relevant S-Parameters for transmission behavior are: S_{21} is the insertion loss (IL) and S_{11} the return loss (RL) or reflection.

The insertion loss describes the attenuation of a signal in respect to the frequency level.

The return loss indicates the reflection of a signal in the transmission channel in respect to their frequency.

A specific feature of this kind of twisted pair transmission technique is the conversion mode.

The differential signal on the twisted wires is transferred into a common signal on both wires by asymmetry mechanical and electrical properties. This effect is tested by the S-Parameters "Transverse Conversation Loss" (TCL) and "Equal Level Transverse Conversation Mode" (ELTCTL)

DATA CABLE TRANSMISSION REQUIREMENTS

We considered coated and uncoated twisted pair cable with $2 \times 0.35 \text{ mm}^2$ (AWG 22) with an impedance of $(100 \pm 5) \Omega$.

Coated cables have better impedance stability than uncoated designs.

PVC cables have high attenuation and a worst temperature stability of the data transmission parameters. The reason is the bipolar characteristics of the insulation material PVC.

The well-known PVC isolation material is not suitable for data cable, because PVC has a significant change at its relative permittivity (ϵ_r) in the automotive temperature range of $-40 \dots +105^\circ\text{C}$.

(Change from 2 ... 6).

PVC cables do not meet the impedance requirement of $(100 \pm 5) \Omega$ in the specified temperature range.

PP or similar materials are appropriate for isolation materials.