Preface

In the last five decades, landline network communication has mainly been considered for application in telecom areas. The most well-known use is for high-speed, middle, and long distance systems as well as MAN and LAN networking; any last-mile application, including in-house communication to a single users’ desk, needs to be connected to the rest of the world. Finally, mobile communication, in particular cell phones, more recently smart phones, tablets, tablet PCs, laptops, PCs, etc. have been developed to replace cable-based phone calls, emails and internet communication.

In the last ten years, communication in transportation systems has been more and more in demand – for communication within a vehicle, from one vehicle to another and to land-line networks, too. Development started in high-end cars with application in the infotainment area and has already reached airplanes and vessels where sensor-relevant needs were also addressed. These techniques began with low data rates. Car communication technologies for the coming decade will also include high bit-rate systems up to the region of Gbit/s.

In this book, the contributors present state-of-the-art and next-decade technologies for optical data buses in automotive applications. There are electrical, optical, and microwave solutions to meet the target. Media Oriented System Transport (MOST) an optical data-bus technology is nowadays used in cars. MOST150 is the current standard with a bit rate of 150 Mbit/s, and it is an adequate solution for optical multimedia data transmission in automobiles. MOST 150 operates with LEDs, a Polymer Optical Fibre (POF) and silicon photodiodes. However, to enable the next step towards autonomous driving, new bus systems with higher data rates will be required.

New generation aircraft covered by carbon fibre instead of conventional metal fuselages present additional challenges. In such cases, optical data transmission based on new laser types, VCSELs and Polymer Clad Silica (PCS) fibres, enables EMC compatibility and paves the way for the future.

Furthermore, in the last five years, we have learned a lot about the needs of companies producing state-of-the-art systems. Companies use practical systems in order to compete in the market of such products. They want a complete solution for their needs, and they do not care if fibre optics was part of the solution or not. Consequently, nowadays, other physical techniques have to be developed: Wireless applications open up a new field of data transmission. High-speed wireless LED transmission offers short-range data transmission without EMI/EMC problems. Visible light communication (VLC) using high power LEDs is an interesting technique. The first aim using these light sources is to light a room. However, at the same time, they can be modulated and transmit a data signal. Higher bandwidths compared to non-optical wireless applications will offer high-speed up and downloads not only in transportation systems but also in offices, labs, and private homes. Finally, non-optical techniques should be mentioned. WLAN and even radar systems can be used in automotive applications, for example, to guarantee greater safety in limited visibility situations like heavy rain, fog or snow. Moreover, combinations of optical and microwave solutions like radio over fibre (RoF) have to be considered as well.
Also non-electromagnetic microwave physical layers, like ultrasonic techniques, must be considered, as they are necessary to give the driver information about physical objects in close proximity to a car. This application is extremely useful in assisting manual parking or even automated parking as well as in dangerous situations, for example, when moving slowly through a crowded pedestrian area.

Automotive manufacturers are also interested in ready-to-integrate system solutions which offer many options, enabling a cost-effective mass production set-up adapted to the particular application. The complete product chain will be available: hard-ware components, low and high-level communication protocols implemented in soft-ware and/or hard-ware, conformance tests, measurements tools, simulations models, application development tools and, last but not least, standard soft-ware modules for ECUs. Their hardware and software interfaces will be flexible and defined clearly. Perfect compatibility is not usually required; the focus is on straight-forward portability approaches. Hardware flexibility in particular enables the finding of cost-effective solutions. However, system designers are challenged in supporting a proper development procedure; plug-and-play approaches are usually not available.

Chapter 1 mainly introduces lecture notes to give an overview of Optical Data Buses for Automotive Applications. The most important devices for fiber-optic transmission systems are presented, and their properties discussed. These systems can operate as transmission links with bit rates up to 40 Gbit/s. But communication systems are also used for recent application areas in the MBit/s region, e.g. in aviation, automobile and maritime industry. Therefore - besides pure glass fibers - polymer optical fibers (POF) and polymer-cladded silica (PCS) fibers have to be taken into account. Moreover, even different physical layers like optical wireless and visible light communication can be a solution solution as well as non-optical techniques or microwaves in Radio over Fiber (RoF) systems - even ultrasonic techniques (non-microwaves) are necessary to give the driver information about bodies surrounding the car at small distances.

In Chapter 2, the authors divide communication networks generally into four different classes: Ring (one directional or bidirectional), Star (active or passive), Tree and Bus (passive). These classes of communication networks are also used in transportation systems. The main properties of these networks are overviewed. Then the most important automotive networks are discussed: LIN, CAN, MOST, Ethernet, and Flexray, and their implementations in cars. For the MOST and Ethernet networks, different physical layer implementations are possible. The different factors determining the choice of a network are discussed.

Chapter 3 gives an overview of different cables used in automotive communication systems: Electrical cable types and optical cable types, unshielded Twisted Pairs (UTP), Coax cable and 1 mm PMMA POF. Graded Optic Fibers (GOF) and multimode PCS are in discussion. Moreover, electrical connectors used in LIN and CAN networks and the optical connectors standardized by MOST are overviewed. Furthermore, different fiber optic transceivers used for MOST, MOST25, and MOST150 transceivers are discussed.

The idea of Chapter 4 is to give a complete overview of a matrix approach to describe light propagation in strongly multimode fibers such as 1-mm diameter plastic optical fibers. These large core fibers accept such a huge number of travelling modes that they can be viewed as a continuum. Thus, light propagation can be described as a power flow by a differential equation that can be more easily solved using matrices. The key of this method is the propagation matrix that is calculated from the diffusion and attenuation function characteristics for a given fiber type. One of the most critical parameters when designing a network is its bandwidth and how it decreases when increasing the link length.

Chapter 5 presents modern vehicles being no longer imaginable without using technologies to broadcast local available data. The speed information for example is used by many well-known functions: anti blocking system, radio, dash board, cruise control, electronic stability program, etc. Usually these
data are distributed among vehicle’s electronic control units by various serial bus systems. The succeeding sections introduce the automotive communication system named FlexRay™. The development of FlexRay™ had been initialized by the requirements expected for drive-by-wire systems. The content is focused on its electrical physical layer. Comparisons to the state of the art system CAN are used to support the comprehensibility.

In Chapter 6 automotive bus systems like e.g. LIN, CAN, and FlexRay™ distribute their serial data streams among communication nodes. These nodes are interconnected by passive nets. Depending on the type of application some of these nets may consist of up to one hundred meter different bus cables arranged in various topologies. Common known transmission line theory focused of the physical effects being relevant for automotive serial bus communication in the time domain is discussed.

Chapter 7 reviews network topologies and technologies in automotive- and similar applications, and describe how optical wireless can be a viable technology to include. This is because today’s vehicle consists of numerous interacting circuits, sensors, and many other electrical components. Thus communication is necessary amongst this circuits and functions of a vehicle. If all of electrical devices, sensors, switches, and motors in vehicles are gathered together, using current techniques, then the resulting amount of cabling and networks is considerable. Thus, optical networking provides a more effective method for complex in-vehicle communications.

In Chapter 8, the authors discuss resilient optical transport networks as backbone for future Internet protocol (IP) networks with enhanced quality of service (QoS). They avoid loss of data and revenue and provide acceptable service in the presence of failures and attacks. Moreover, this chapter presents the principles of designing survivable Dense-Wavelength-Division-Multiplexing (DWDM) optical transport networks including failure scenarios, survivability hierarchy, routing and wavelength assignment (RWA), demand matrix models, and implementation approaches.

In Chapter 9, the authors present an overview of Radio over Fiber (RoF) access networks for transportation with special attention on the figures of merit and the basic enabling technologies for downlink/uplink transmission. They review the up-conversion techniques to millimeter waves, followed by use of Base Station configurations. Finally, the authors apply these concepts to the development of a network proposal for in-vehicle wireless application.

The idea of Chapter 10 is to report on Vehicular Ad-Hoc Networks (VANETs). These networks are electrical wireless networks which are primarily meant to enforce vehicular safety. The incumbent international VANET solution is based on an adaptation of WLAN to the 5.9 GHz band and to the vehicular environment: it is universally known as IEEE 802.11p – a decentralized solution that is able to work in the absence of an infrastructure.

In Chapter 11, authors discuss that communication in transportation systems not only involves the communication inside a vehicle, train or airplane but it also includes the transfer of data to and from the transportation system or between devices belonging to that system. Fundamentals of mobile communication networks are described as well as possible future candidate networks. Moreover, also hybrid networks are discussed. The devices may use the best suited network for a given situation but also change to another network while continuing the on-going connection or data transfer. Here the design of the handover or relocation plays a critical role as well as localization. Possible system layouts and handover implementations are given.

Chapter 12 deals with vehicular networks as hybrid networks, which consist of a cooperation of different radio access networks. Seamless communication in vehicular networks relies on proper network planning and thorough dimensioning of network protocols. In transportation networks the location of the
mobile devices and their pattern of movement are very important. Therefore, different mobility models suited to vehicles in transportation networks are introduced. As an example a hybrid handover protocol is given in detail. It provides low handover latency with additional mutual authentication to allow the transfer from one radio access network to another while maintaining the network’s built-in security standard.

One of the main parameters for providing traffic safety of vehicles is the knowledge of their speed. In Chapter 13, the authors present results of a microwave radiometric correlation sensor for speed measurements of land vehicles. The nature and statistical characteristics of radio thermal radiation of a terrestrial surface and objects are considered. Concerning the influence of parameters of the antenna system and the linear path of the receiver on parameters of the signal formed at the output of the correlator, a statistical analysis of the radiometric system of correlation type is carried out. An optimization of antenna system and radiometric receiver parameters for various types of objects observed on a terrestrial surface has been performed, too.

The idea of Chapter 14 is to give an overview of ultrasound technology to transmit data at short ranges. The advances that have made this a useful technology include the ability to utilize a sufficiently wide bandwidth, and the availability of instrumentation that can send and receive ultrasonic signals in air. Various aspects such as attenuation, spatial characteristics, and the most suitable forms of modulation are discussed. Moreover, it is demonstrated that ultrasonic systems are a practical possibility for in-room communications.

Chapter 15 deals with driver assistance systems. They increase safety and comfort by supporting the driver in critical or stressful traffic situations. A great variety of surround sensors with different fields of view include radar, ultrasonic, laser, and vision systems. These sensors are based on different technologies and measurement principles. Hence, such sensors are used in various configurations to explore the surroundings ahead, sideways, and behind a vehicle. In addition, vehicle dynamics information from speed, steering angle, yaw rate, and acceleration sensors is available. The driver can be informed or warned in critical situations. Some driver assistance systems perform driving tasks like following, lane changing, or parking already autonomously. The art of designing valuable driver assistance systems includes many factors and aspects and is still an engineering challenge in automotive research.

This collection provides a wide-ranging overview of many extraordinary issues in communication systems for automotive application. The idea of this book is to address a broad scope of readers in order to give them an introduction to communication in transportation systems. For this reason, contributors not only present work on state-of-the-art methods, but promising techniques of the future are discussed as well. On the one hand, it is important that the key differences between optical and non-optical systems are appreciated; yet, on the other hand, similarities can be seen, too. Moreover, a combination of these different physical techniques might lead to excellent results which cannot be reached using them separately. Taking all these optical microwave and ultrasonic techniques as well as GPS in common together with a high-speed high-data processing device and software may be the old human dream of autonomous driving could be realized in a not too far future.

For readers not familiar with all these topics, there is coverage of many of the fundamentals, particularly in chapter 1. The book is intended to help undergraduate, graduate, and PhD students with basic knowledge of the subjects studying communication in transportation systems. In addition, R&D engineers in companies should also find this book interesting and useful. This is true for novices as well for experts checking certain facts or dealing with areas of expertise peripheral to their normal work.

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