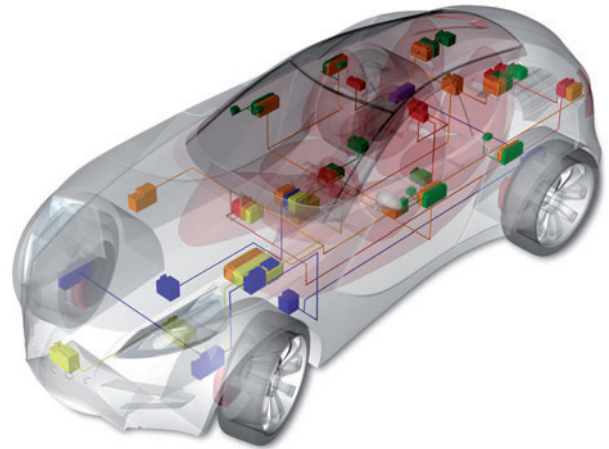


Serial Bus Systems in the Automobile

Part 5:

MOST for transmission of multimedia data

A premium class car is growing to resemble a mobile office. In response to customer demand, increasing numbers of entertainment and information media that are making their way into automobiles. The most significant challenges in this area are, first, to keep wiring expense as low as possible, and second, to fully satisfy the heightened functional requirements of an infotainment system in the car. As a result, the MOST (Media Oriented System Transport) bus system is now used to transmit audio and video signals in approx. 50 model series.



Electronics is responsible for a large number of innovative safety and convenience functions in automotive technology. Experts predict that in just a few years electronics will represent a share of up to 30 percent of vehicle value, and the worldwide market for electronics in cars will grow by approx. 6 percent annually to 230 billion euros by the year 2015. The automotive industry is forecast to exhibit rapid growth rates, above all in the infotainment area, given the continually increasing vehicle-kilometers on Germany's roads (according to DIW [1] approx. 700 billion). The average citizen spends about 270 hours in a car annually, whether it is on the way to work, shopping or vacation.

Over the course of time, the car radio was supplemented by the CD and MP3 player. This came to include CD changers and navigation devices, and finally display screens also made their way into cars for replaying DVD and video films. Moreover, hands-free Bluetooth units with integrated microphones and iPod control are gradually turning the cockpit a multimedia center, in which all of the play lists and directories of a digital MP3 player can be displayed and started directly on the in-vehicle display.

The already extensive wiring cost and effort are increasing due to continual growth in networking of continually higher performance infotainment devices of dimensions that can hardly be managed any longer. Fortunately, some automotive OEMs recognized the advantages that bus networking would also offer in this area early on. In the mid-1990s, BMW and Daimler began to develop a uniform communication technology for serial transmission of audio and video signals in the vehicle based on the D2B bus (Digital Data Bus) developed by Matsushita and Philips.

MOST Cooperation

In 1998, BMW, Daimler, Harman/Becker and SMSC (formerly OASIS SiliconSystems) founded the MOST Cooperation [2]. Since that time, MOST has established itself as a de-facto standard for the transmission of multimedia data in the vehicle – the MOST Cooperation is made up of 15 international automotive OEMs and more than 70 device producers. The user organization laid the foundation for success of the technology by defining an extensive specification. Version 2.5 of the MOST specification has been in existence since October 2006. It is organized into the areas of Application, Network and Hardware.

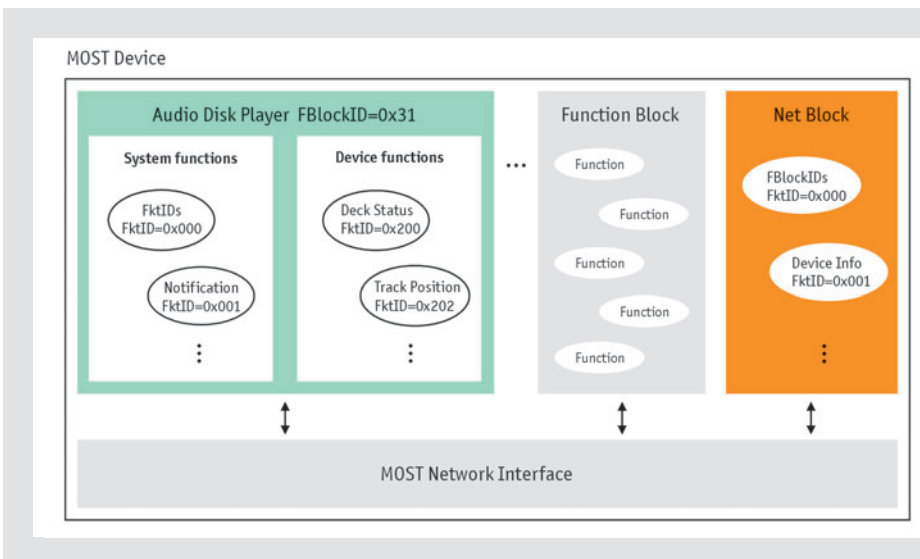


Figure 1: Structure of a MOST device that among other things hosts the "Audio Disk Player" functional block. For system management, the Net Block is mandatory for each MOST device, and system functions are mandatory for each function block.

The “Application” area describes a logical device model based primarily on object-oriented methods, with the purpose of transparent modeling and control of distributed infotainment systems. Furthermore, it defines a hierarchical communication model as well as services for managing an infotainment system. The “Network section” describes the MOST Network Interface Controller and its services, network management, and handling of data transport in a MOST system. The “Hardware section” deals with aspects of the hardware structure of a MOST device.

Functional modeling

A MOST device is subdivided into a functional level and a network level (MOST Network Interface). On the functional level, infotainment functionalities are embodied in so-called function blocks. Each function block, e.g. the Audio Disk Player, provides the MOST network with a dedicated set of functions, e.g. “Track position”, that can be accessed by operation types such as “Set” for setting a track or “SetGet” for setting and reading a track (Figure 1).

Functional addresses (FBlockID, FktID) are assigned to both the function blocks and to the functions provided by a function block. They can be taken from the so-called “Function Catalog”, as can the identifiers of the operation types. For example, the “Audio Disk Player” FBlock has FBlockID=0x31 and the “Track Position” function has FktID=0x202.

The separation of function and network and functional modeling make it possible to implement a functional communication model that is fully independent of physical components (MOST devices). Therefore, it does not matter which of the MOST devices is used to contain a specific function.

Hierarchical communication model

MOST systems are patterned on a three-stage hierarchical control philosophy based on the “Master-Slave principle” (Figure 2). Placed at the uppermost hierarchical level is the HMI (Human Machine Interface), an exposed controller that provides the user with overall functionality. On the middle hierarchical level are the usual controllers. They cover part of the system functionality, and they share their partial system knowledge with the HMI as the “System Master”.

The lowermost hierarchical level is made up of the system slaves, whose functions are used by one or more controllers. They are not equipped with any system knowledge, and this substantially enhances their flexibility with regard to configuration. It is easy to add system slaves or remove them from a MOST system. MOST

commands are used for control communication. Their core components are the FBlockID, FktID, Operation Type and up to 65535 useful bytes.

System management

The Application section defines higher-level function blocks and functions for system management. System functions include the “FktIDs” function (FktID=0x000) that is used to query the functions supported by a function block, for example. The “Notification” system function (FktID=0x001), on the other hand, enables creation of the “notification matrix” for a function block. Emerging from the “notification matrix” is information on which MOST device should be notified if a certain property of a function block has changed. This mechanism prevents an unnecessary increase in bus load in the MOST system.

To query its function blocks and addresses, each MOST device has the “Net Block” (system) function block with FBlockID=0x01. The function blocks can learn about the function blocks implemented on a MOST device using the FBlockIDs function (FktID=0x000). The FktIDs 0x002, 0x003 and 0x004 are used to find the physical address, logical address and group address of a MOST device.

The Network Master plays an important role in the management of a MOST system. It is responsible for the system start and management of the “Central Registry”. This registry contains the logical addresses of the MOST devices implemented in a MOST system and the addresses of function blocks contained in the MOST devices.

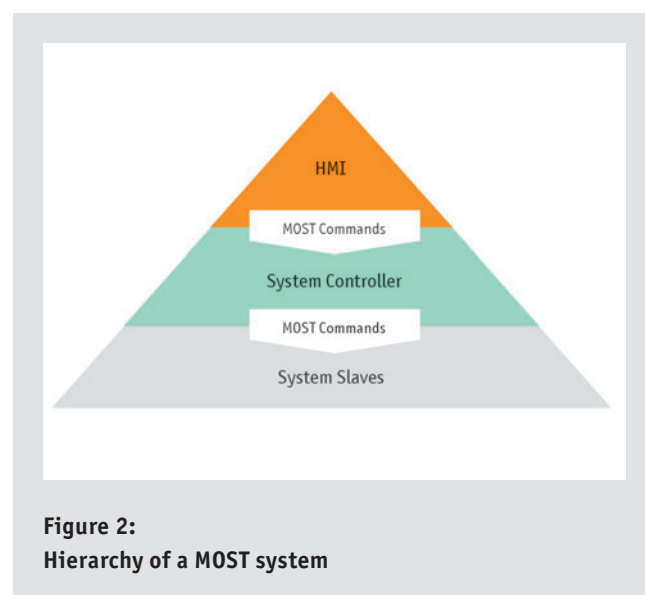


Figure 2:
Hierarchy of a MOST system

MOST Network Interface

The MOST Network Interface (Figure 3) ensures that the function blocks housed on the various MOST devices are capable of real communication with one another. The MOST System Services (Low Level System and MOST Network Services) provide the communication functionalities needed to transport all multimedia relevant data (time-continuous bit streams, packet data and control data). Low Level System Services (Layer 2 services) are implemented in hardware (Network Interface Controller – NIC) and are placed over the Physical Layer.

MOST Network Services, which encompass the Transport Layer in the form of Basic Layer System Services and higher management in the form of an application socket, are housed on an external Host Controller (EHC) and control the NIC. It must be ensured that the EHC can serve the time-critical parts of the Network Interface. Over time, with the progressive development of MOST technology from MOST 25 to MOST 50 and MOST 150, this architecture has now encountered its limits.

In new developments, INIC (Intelligent Network Interface Controller) replaces NIC. While INIC assumes control of execution of time-critical portions of the network driver of the EHC, just a relatively small part of the network driver still runs on the EHC, which essentially represents a socket for the application. The INIC architecture thereby relieves the load of the EHC. For control, the INIC provides the EHC or MOST API (MOST Network Services) with a functional interface, the so-called INIC-API. The functions of the INIC are encapsulated in a function block (FBlock INIC).

MOST Networking

MOST technology enables transmission of continuous bit streams (bit streaming) without buffering or unnecessary overhead. This involves having a specially designated MOST device (Timing Master) feed the MOST frame (Figure 4) at a fixed frequency (44.1 KHz or 48 KHz) into the transmission medium, which is typically optical.

In a MOST25 system, the MOST frame provides 60 streaming channels at 8 bits (or 15 quadlets of 4 bytes each) for transmission of continuous bit streams (source data area). The bandwidth of a streaming channel yields either 352.8 KBit/s (44.1 KHz) or 384 KBit/s (48 KHz).

Since the MOST devices are physically interconnected into a ring, each MOST frame must pass through every MOST device at the frequency prescribed by the Timing Master. As soon as the relevant

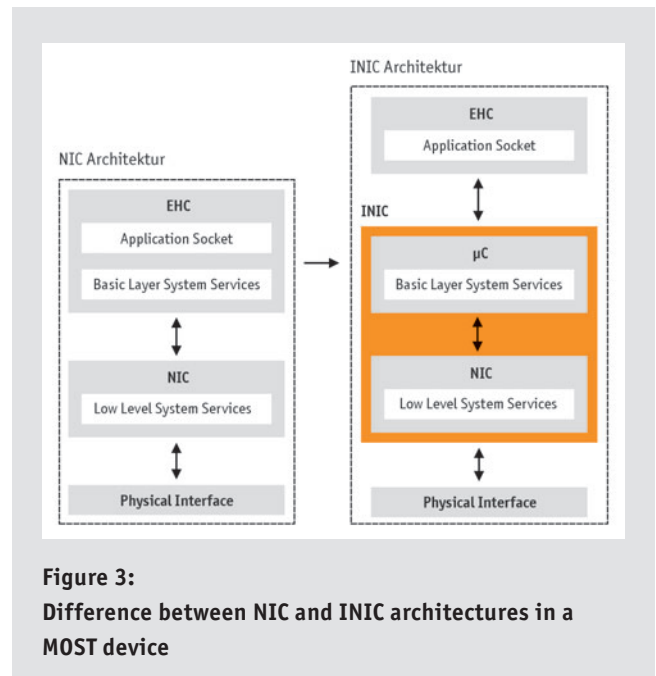


Figure 3:
Difference between NIC and INIC architectures in a MOST device

communication partners (data source and sink) have connected to the same streaming channel, bit streaming begins (Figure 5).

Connection or disconnection is usually made by a query by the function block “Connection Master – CM” (FblockID=0x03). For this purpose, the CM provides the two functions “BuildSyncConnection” and “RemoveSyncConnection”.

In the framework of building a connection, the CM requests that the relevant data source, e.g. the TV tuner, have the suitable number of streaming channels allocated by the Timing Master. That is because the Timing Master is responsible for management of the “channel resource allocation table”. The CM passes the addresses of the allocated streaming channels to the data sink, e.g. to the display, so that it can connect to the streaming channels. Finally, the CM updates the “sync connection table”, which it uses to manage all synchronous connections. Disconnection is performed according to the same scheme.

To enable transmission of data packets, the user has the option of reducing the number of streaming channels by up to 24 (six quadlets) using the “Boundary Descriptor”. All those streaming channels that are not reserved for bit streaming, are combined to form the packet channel. While a maximum transmission rate of up to 12.7 MBit/s is possible at a frequency of 44.1 KHz, a maximum rate

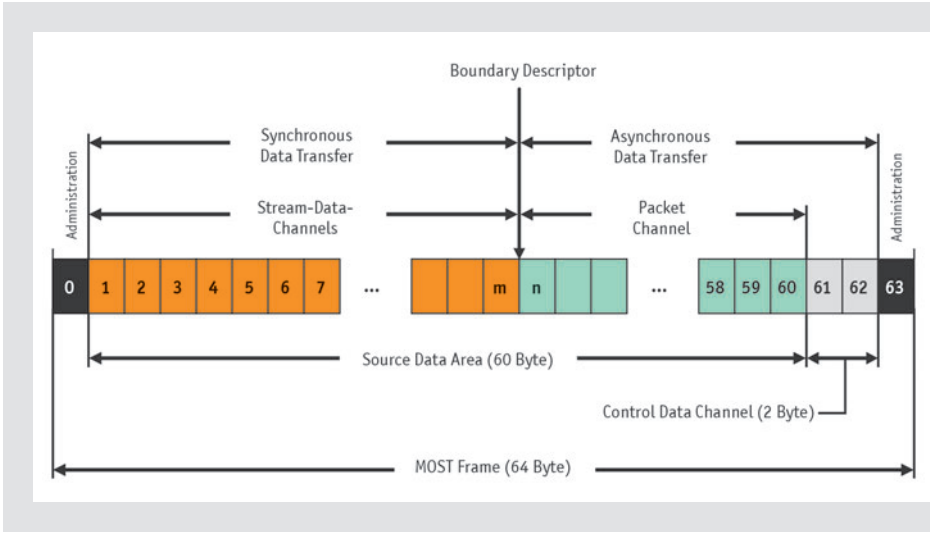


Figure 4: Layout of the MOST frame: Sent in administrative byte 0 are synchronization information and the boundary descriptor, and in administrative byte 63 the status bits and a parity bit for protection of the MOST frame.

of up to 13.8 MBit/s is attained at 48 KHz. The boundary descriptor is managed by the Network Master function block (FBlockID=0x02). It can be set via the "Boundary" function (FktId=0xA03).

A Layer 2 protocol is used to transmit data packets. The frame comprises the arbitration field, source and target address, data length code, data field (either 48 or 1014 byte) and data protection. A token circulating in the ring regulates bus access. The MOST device that takes the token from the ring may access the packet channel.

Finally, the MOST system must transmit the MOST commands needed for management and control. Control messages (Figure 6) are used here, which are transmitted on the control channel (2 bytes). Therefore, 16 MOST frames (MOST block) are required to transmit a control message. The bandwidth at 44.1 KHz is 705.6 KBit/s, and at 48 KHz it is 768 KBit/s. Transmission of control messages is also based on a Layer 2 protocol. Bus access is implemented by the CSMA method (Carrier Sense Multiple Access).

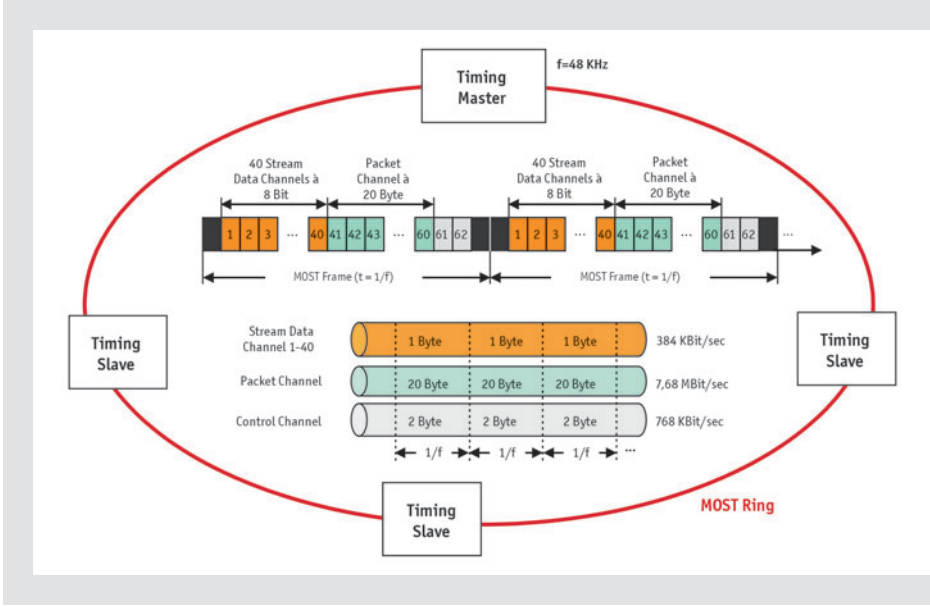


Figure 5: Principle of bit streaming: The Timing Master transmits MOST frames at a frequency of 48 KHz. 40 streaming channels (10 quadlets) are available for allocation, each operating at 384 KBit/s (boundary descriptor = 0xA). The packet channel (20 bytes) provides a bandwidth of 7.68 MBit/s for the transmission of data packets.

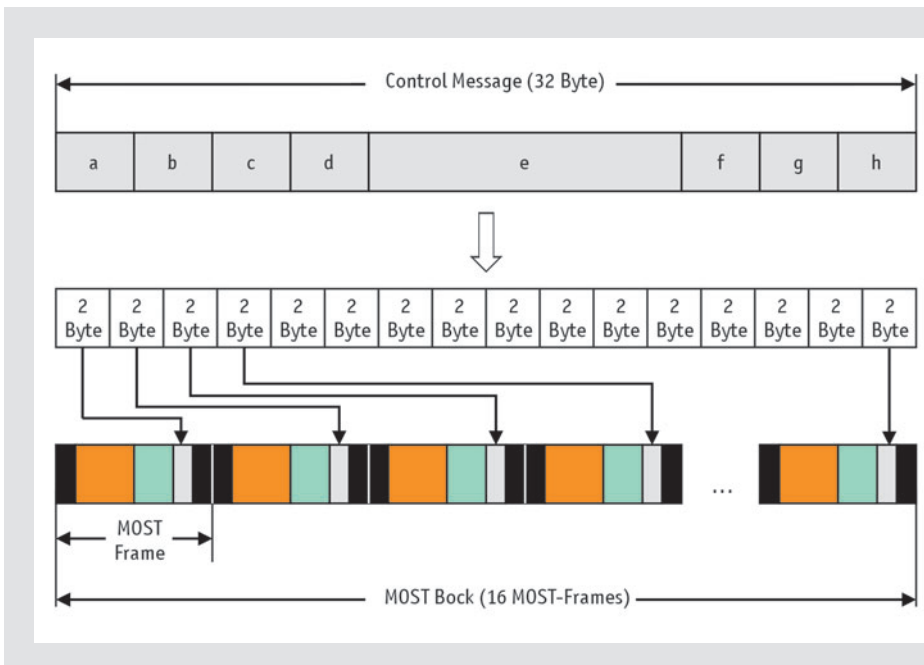


Figure 6: Control message. A MOST block is required to transmit a control message. The control message is composed of: arbitration (a), target address (b), source address (c), message type (d), data field (e), data protection (f), acknowledgment (g), and reservation (h).

Physical Layer

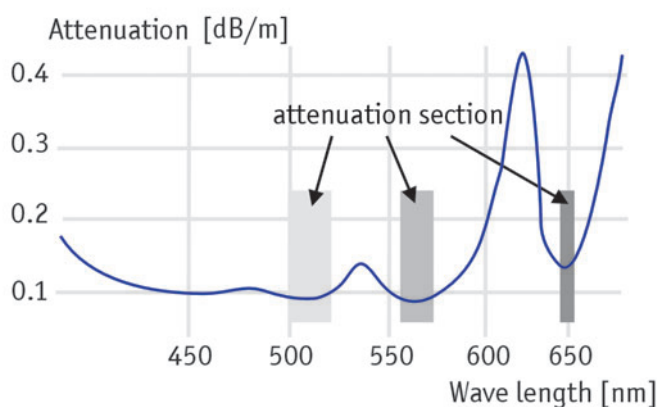
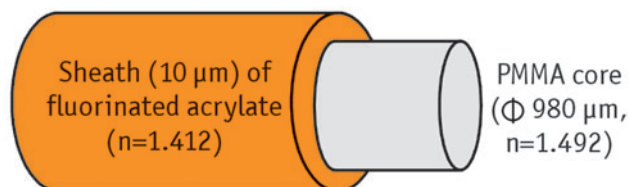
Today, optical conductors of polymer fibers (POF – polymer optical fiber) are the state-of-the-art technology for transmitting audio and video signals in the MOST system (Figure 7). Overall, the technical properties of polymer fibers are far superior to those of electrical transmission media. Especially noteworthy are its excellent electromagnetic immunity and relatively high signal transmission rate of up to 500 MBit/s. Furthermore, the combination of POF, a red light-emitting diode as the light source (wavelength 650 nm) and a silicon PIN photodiode as the receiver represents a very economical and comparatively simple and manageable form of optical signal transmission.

MOST 150, which follows MOST 50, is a MOST system that is current ready to start. It is based on this sender and receiver technology and offers the user a transmission rate of 150 MBit/s. It can therefore handle the relatively short paths in the car of up to 20 meters can without any problems.

Development, testing and analysis of MOST systems

Vector Informatik GmbH has been an associate member of the MOST Cooperation since 1999. Besides its extensive activities in the area of serial bus systems such as CAN, FlexRay and LIN, the Stuttgart-based networking specialist has been supporting the development and analysis of infotainment solutions in the automobile since the year 2000. It offers a comprehensive product lineup of analysis, development and test tools for applications such as high-end audio systems, multimedia streaming, telephone and navigation. Hardware interfaces for bus access, a multibus data logger as well as training courses and engineering and development services round out its offering [3]. The Vector Academy [4] supplies the necessary basic knowledge related to ECU communication in the automobile in the framework of seminars on CAN, LIN, FlexRay and MOST.

Background knowledge on signal transmission in a MOST system via POF



When a light beam passes from one transparent medium to another, it is refracted. The greater the angle of incidence, the greater the refraction. The medium in which the light beam forms a smaller angle with the primary axis is the optically denser medium. In the

transition from the optically denser to the optically less dense medium, the beam is refracted away from the primary axis. The angle of refraction α can be calculated if the so-called indices of refraction n of the two media are known (Snellius Law). If the light beam exceeds an incidence angle α_0 in the transition from the optically denser medium to the optically less dense medium, then total reflection occurs.

This property makes it possible to transport light in an optical conductor. In the MOST system, polymer fibers are usually implemented for optical signal transmission, where a core of PMMA (polymethylmethacrylate) is encased in a thin sheath of fluorinated acrylate. PMMA has a larger refractive index than the fluorinated polymer. If the angle of the incident light beam is greater than the limit angle, then the light is conducted in the core due to total reflection. The smallest attenuations for transmission of light in a so-called step-index PMMA fiber are obtained at 520 nm (green), 560 nm (yellow) and 650 nm (red). Red LEDs are generally used (attenuation 0.14 dB/m), since they are very inexpensive.

Figure 7:
Background knowledge on optical signal transmission in a MOST system

Literature and links:

- [1] www.diw.de
- [2] www.mostcooperation.com
- [3] www.vector-group.net/most/en
- [4] www.vector-academy.com



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(Graduate engineer; technical teaching certificate); after vocational training as a communication electronics technician, he studied electrical engineering and technical education at the Technical College of Ravensburg/Weingarten and the University of Stuttgart. Since 1999 he has been employed at Vector Informatik where he works as a Senior Trainer.