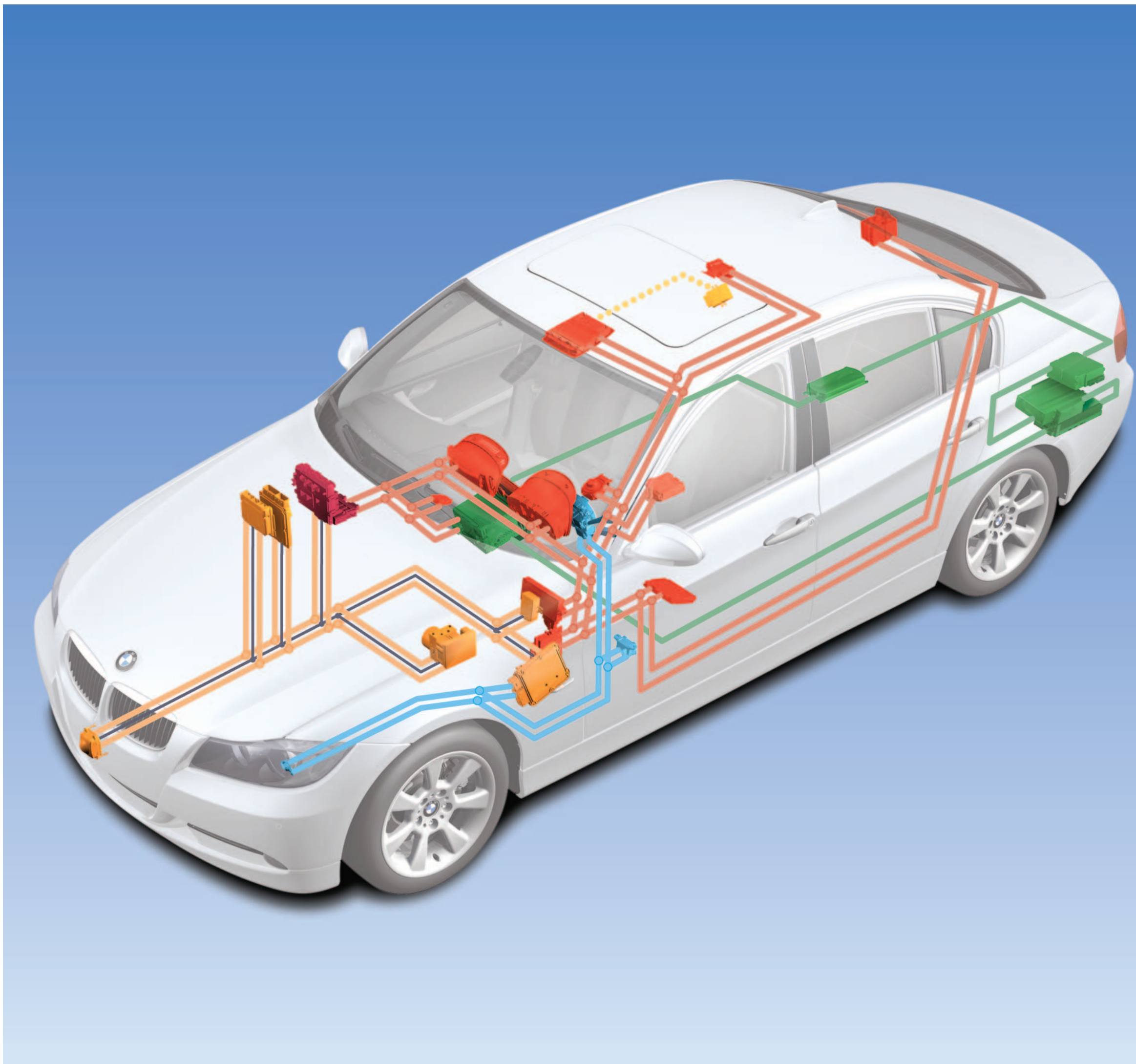
Participant's Manual
Bus systems



BMW Service

Aftersales Training

The information contained in this Participant's Manual is intended solely for the participants of this seminar run by BMW Aftersales Training.

Refer to the latest relevant "BMW Service" information for any changes/supplements to the Technical Data.

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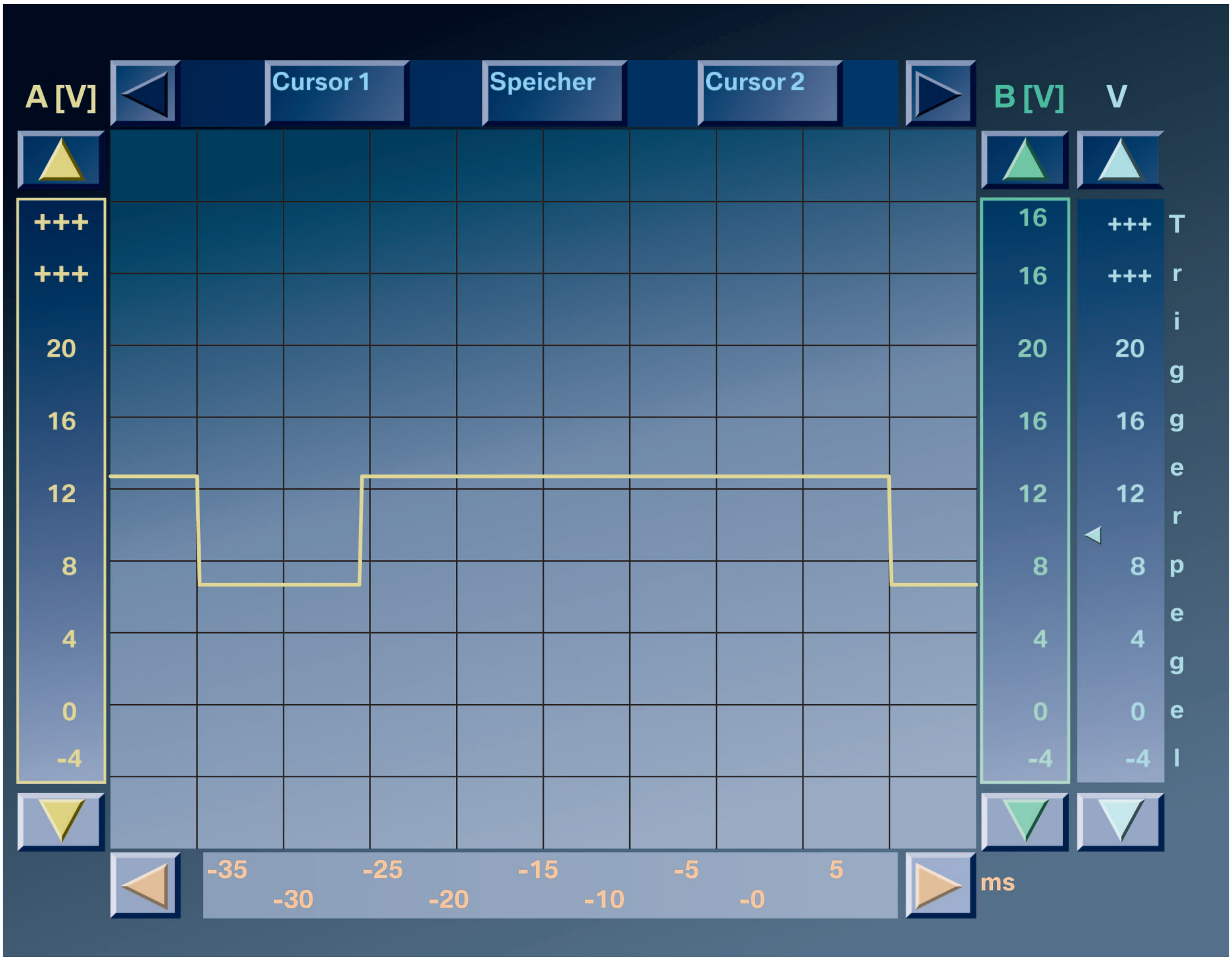
Participant's Manual
Bus systems

Control units can use sensor data for various tasks

Information is transmitted in real time

Efficient diagnosis of the systems network

Light pulses now used to transmit data



Notes on this Participant's Manual

Symbols used

The following symbols are used in this Participant's Manual to facilitate better comprehension and to draw attention to important information.

⚠ contains information for better understanding of the described systems and their functions.

◄ identifies the end of an item of information.

Current content of Participant's Manual

In view of the constant further developments in the design and equipment of BMW vehicles deviations may arise between this Participant's Manual and the vehicles made available as part of the training course.

The background material refers exclusively to left-hand drive vehicles. The controls are in part arranged differently in right-hand drive vehicles than shown on the graphics in the Participant's Manual.

Additional information sources

You will find further information on the individual vehicle topic in the BMW diagnosis and repair systems as well as on the Internet under www.bmw.com.

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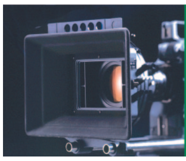

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Objectives
Bus systems

Reference material for practical applications to accompany you throughout the training course

This Participant's Manual provides you with information on the fundamental functions and various options of data transmission by means of bus systems.

This manual outlines the part bus systems play in BMW vehicles and defines the vehicles, in which bus systems are installed.

This manual is designed to provide essential information throughout the training course and complements the seminar material used in the BMW Aftersales Training course.
The SIP Fundamentals of Bus Systems and Power Supply should be worked through as the prerequisite for preparation for the seminar.

Building on the technical training and in connection with the practical exercises as part of the training course, the participant will be able to perform diagnosis work in the area of the bus systems in BMW vehicles.

Please do not forget to work through the Training and Information Program (SIP) on this topic.
Basic knowledge ensures competence in theory and practical applications.

Bus systems and their use

The following table shows the use of the bus systems in the various BMW vehicles.

Model	Term	K-bus	I-bus	M-bus	CAN	K-CAN	K-CAN P+S	PT-CAN	MOST	*byteflight*
E31	1989-1999		X							
E36	1990-2002				X					
E38	1999-2001	X		X	X					
E39	1995-2004	X		X	X					
E46	1997-	X		X	X					
E52	2000-	X		X	X					
E53	1999-	X		X	X					
E60	2003-					X		X	X	X
E61	2004-					X		X	X	X
E63	2003-					X		X	X	X
E64	2004-					X		X	X	X
E65	2001-						X	X	X	X
E66	2001-						X	X	X	X
E67	2002-						X	X	X	X
E83	2003-	X						X		
E85	2002-	X						X		X
E87	2004-	X				X		X	X	

Why bus systems?

Today's vehicles, ranging from the small car through to the luxury class, contain a wide variety of electronic devices and components.

The use of electronics in motor vehicles will also increase substantially in the foreseeable future. Both legislation as well as customers demand this development. Legislation is interested in improving the quality of exhaust emissions and reducing fuel consumption. Customer requirements are focussed on improving driving comfort and safety.

Control units that meet these requirements have long been used. Examples include the control units employed in the area of the digital motor electronics and airbag systems.

The complexity of the realized functions renders data exchange between the control units unavoidable. Conventionally, the data are transmitted via signal lines. However, in view of the increase in complexity of the control unit functions, this type of data exchange can now be realized only with ever growing expenditure.

Originally autonomous processes of individual control units are being coupled to an ever increasing extent via bus systems. This means that the processes are distributed, implemented throughout the vehicle systems network and interact in co-ordinated functions.

The data exchange within the systems network is therefore constantly increasing. This data exchange also enables many new functions, culminating in increased driving safety, higher comfort levels and improved vehicle economy.

These requirements can no longer be realized with the previous vehicle electrical systems and networks.

Limits of previous system networks

The increasing use of electrical and electronic components in motor vehicles is limited by various factors:

- Increasing scope of wiring/cabling
- Higher production costs
- Increased space requirement in the vehicle
- Component configurations that are difficult to manage
- Reduced reliability of overall system

Networks are used in the vehicle electrical system with the aim of minimising these disadvantages.

These networks are referred to as bus systems in the following.

Bus systems enable networking of the individual control units in the vehicle via "serial interfaces". This provides various advantages that facilitate the use of the systems in motor vehicles.

Advantages of bus systems

- Higher reliability of overall system
- Reduced extent of wiring/cabling
- Reduction in the number of individual cables
- Reduced cross sections of wiring harnesses
- Flexible installation of cables
- Multiple use of sensors
- Transmission of complex data possible
- Higher flexibility for system modifications
- Expansion of scope of data possible at any time
- Implementation of new functions for the customer
- Efficient diagnosis
- Lower hardware costs

Overview of bus systems

In principle, a distinction is made between two groups of bus systems:

- Main bus systems
- Sub-bus systems

Main bus systems are responsible for cross-system data exchange.

Sub-bus systems exchange data within the specific system. These systems are used to exchange relatively small quantities of data in specific systems.

Main bus systems

The following busses are used as main bus systems:

Main bus system	Data rate	Bus structure
K-bus*	9.6 kBits/s	Linear - single-wire
D-bus	10.5 - 115 kBits/s	Linear - single-wire
CAN	100 kBits/s	Linear - two-wire
K-CAN	100 kBits/s	Linear - two-wire
F-CAN	100 kBits/s	Linear - two-wire
PT-CAN	500 kBits/s	Linear - two-wire
byteflight	10 MBits/s	Star - fibre optics conductor
MOST	22.5 MBits/s	Ring - fibre optics conductor

* Also known to as I-bus in earlier models

Sub-bus systems

The following busses are used as sub-bus systems:

Sub-bus systems	Data rate	Bus structure
K-bus protocol	9.6 kBits/s	Linear - single-wire
BSD	9.6 kBits/s	Linear - single-wire
DWA bus	9.6 kBits/s	Linear - single-wire
LIN bus	9.6 - 19.2 kBits/s	Linear - single-wire

Gateways

A gateway serves as an interface between several networks. The gateway enables data exchange despite different transmission rates of the individual bus systems.

The following gateways are currently installed in BMW vehicles:

Vehicle	Gateway
E38	Instrument cluster
E46	Instrument cluster
E60/61	SGM
E63/64	SGM
E65/66/67	ZGM or SGM
E83	Instrument cluster
E85	Instrument cluster
E87	Junction box

Number systems

Three important number systems are used in computer technology: the decimal, the binary and the hexadecimal number system.

Roman numerals represent another well-known number system:

I, II, III, IV, V, VI, ..., X, ..., L, ..., C, ..., D, ..., M

Decimal system

The decimal system is the most commonly used Arabic numeral system.

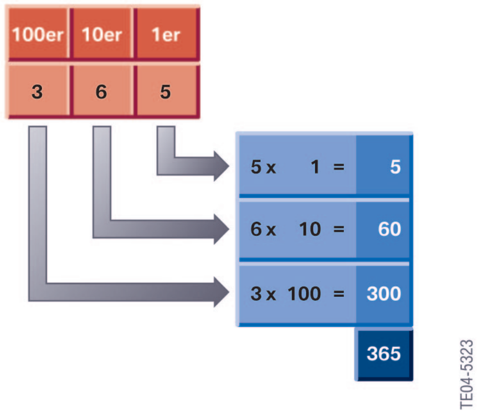
This number system has the base 10, i.e. it has ten different symbols for each individual numerical position.

This results in ten different options of representing a single-digit number: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Consequently, there are 100 options of representing a two-digit number: 10 options for the first position times 10 options for the second position, i.e. $10^2 = 10 \times 10 = 100$ options. The result can be very easily counted (0 to 99).

To represent three-digit numbers there are analogously:

$10^3 = 10 \times 10 \times 10 = 1000$ options



1 - Decimal numbers

This base system therefore involves power of 10. The place value is multiplied by 10 from place to place, from left to right.

Binary system

The binary system is one of the most commonly used number systems in data processing as it recognizes only two states: 0 and 1 or ON or OFF or high voltage or low voltage.

Symbols, images or even sounds consist of a certain series of binary characters such as 10010110. The computer or the control unit can process information with the aid of this binary code.

The hexadecimal system is used as a way of abbreviating binary characters. 8-place binary numbers can be represented by two hexadecimal numbers.

Options in information transmission systems

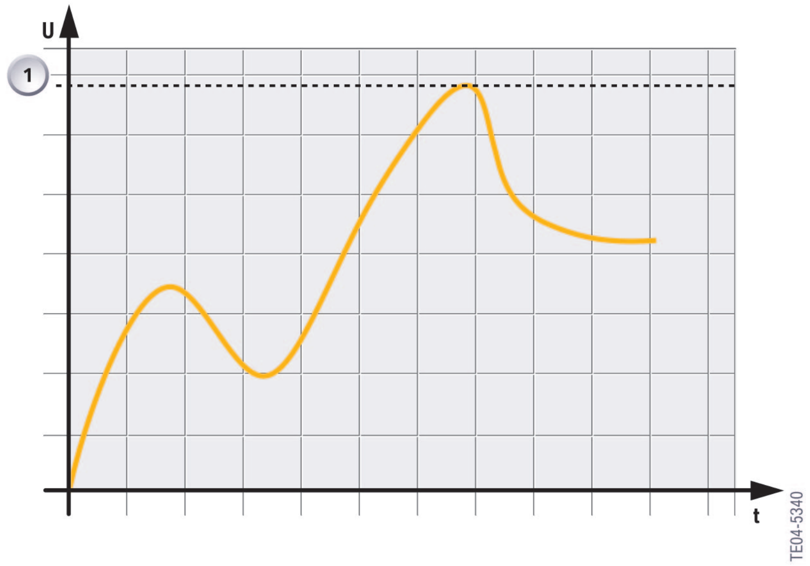
Analogue transmission

The term analogue comes from the Greek (analogos) and means corresponding to, analogous to.

Analogue representation of data (= information) is based on representation by a continuously changing physical variable that is directly proportional to the data.

A characteristic of an analogue signal is that it can assume any value between 0 % and 100 %. The signal is therefore infinitely variable.

Examples: Pointer measuring instruments, mercury thermometer, hands of a watch



2 - Analogue signal

Index	Description
1	Maximum
U	Voltage
t	Time

When listening to music, for example, the ear receives the analogue signals (constantly changing sound waves). This sound is represented in the same way in electrical devices (audio system, radio, telephone etc.) by means of continuously changing voltages.

However, when such an electrical signal is transferred from one device to another, the information arriving at the receiver is no longer exactly the same as what was sent by the transmitter.

This is due to interference factors such as:

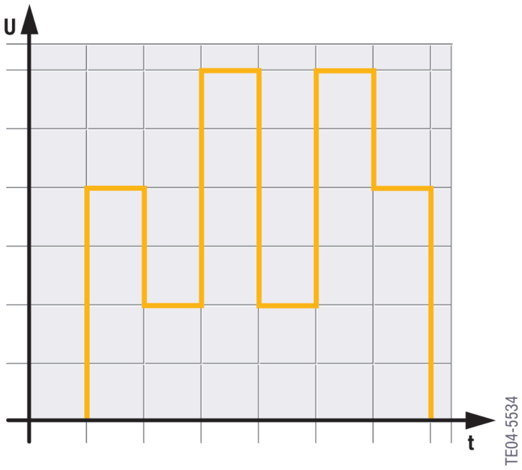
- Cable length
- Line resistance of the cable
- Radio waves
- Mobile radio signals

The analogue transmission of information in vehicle applications is not feasible for safety and reliability reasons. In addition, the changes in voltages would be much too small so that reliable values could not be represented (ABS, airbag, engine management etc.).

Digital transmission

The term digital originates from the Latin world digitus and means finger or toe.

Digital is therefore everything that can be counted on a few fingers or put more accurately everything that can be divided into discrete steps.



3 - Digital signal

Index	Description
U	Voltage
t	Time

Digital representation involves the representation of constantly changing variables in numerical form. Particularly in computers, all data are represented as a sequence of zeros and ones (binary). Digital is therefore the opposite of analogue.

Examples: Digital multimeter, digital clock, CD, DVD

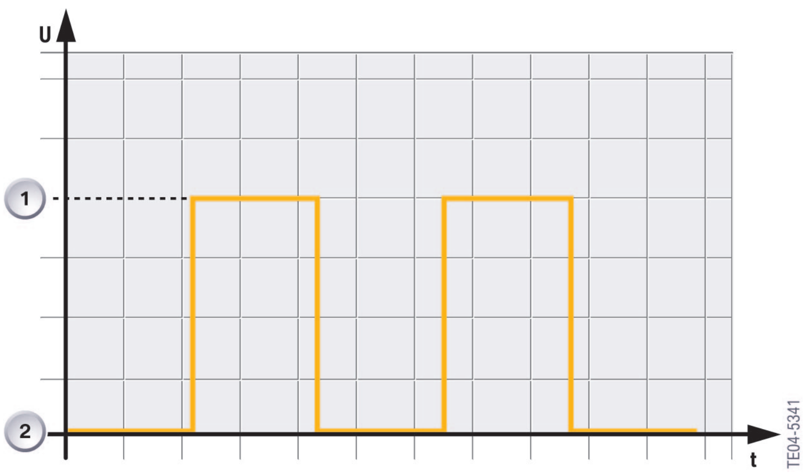
Binary transmission

The word bi comes from the Greek and means two.

A binary signal therefore has only two possible states: 0 and 1 or High and Low.

Examples:

- Lamp lights - lamp does not light
- Relay has dropped out - relay has picked up
- Voltage is applied - voltage is not applied



4 - Binary signal

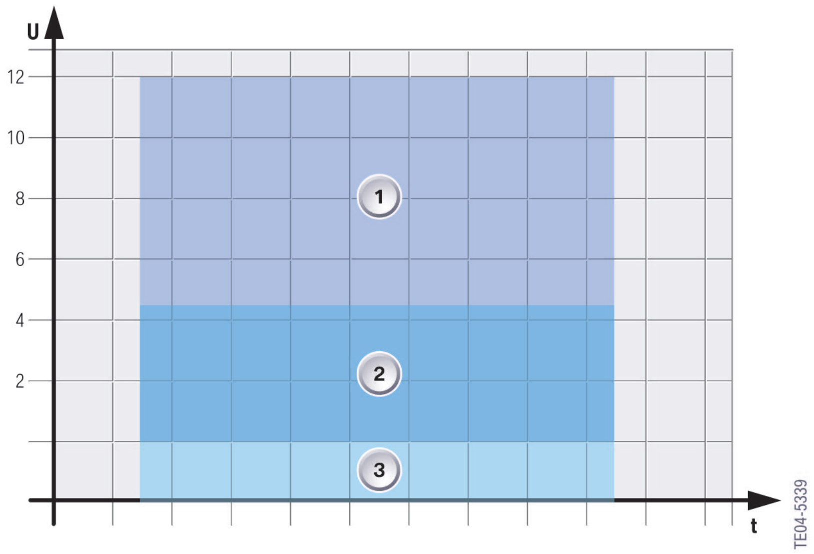
Index	Description	Index	Description
1	High	U	Voltage
2	Low	t	Time

Signal level

In order to be able to clearly distinguish between the two states High and Low in motor vehicle applications, a clearly defined range is assigned to each state:

- The High range is between 6 V and 12 V
- The Low range is between 0 V and 2 V

The range between 2 V and 6 V is the so-called prohibited range that is used for fault detection purposes.



5 - Signal level

Index	Description	Index	Description
1	High range	U	Voltage
2	Prohibited range	t	Time
3	Low range		

Coded representation

A code is a distinct set of rules for depicting a character set in another character set.

An example of a code is the Morse alphabet. Each letter of the alphabet and the numbers are encrypted by signals of different lengths.

In Morse code, the well-known distress signal SOS (save our souls) is:

short short short	long long long	short short short
S	O	S

The code is used to convert information that is represented in encrypted form into another form of representation where the information content is not changed.

Important codes in EDP are ASCII and the hexadecimal code.

For example, a person using a computer presses the D key on the keyboard. The letter is converted (coded) into a binary sequence 0100 0100. This character sequence is then sent in the form of an electrical signal from the keyboard via the cable to the computer. The computer interprets (decodes) this character sequence correctly as the letter D.

The character sequence and its electrical signal are known as coded information.

Bit and Byte

All information in computers is stored as bits (binary digit = smallest information unit). All data (letters, numbers, sounds, images etc.) must therefore be converted into a binary code for processing in the computer.

The most commonly used systems and codes use eight bits for the purpose of representing a character.

Eight bits are combined to form one byte, allowing 256 characters to be coded.

Standard designations for larger units of bytes:

- 1 Kilobyte (KB) = 2^{10} bytes, i.e. 1024 bytes
- 1 Megabyte (MB) = 2^{20} bytes, i.e. 1024 KB (1.048.576 bytes)
- 1 Gigabyte (GB) = 2^{30} bytes, i.e. 1024 MB (1.073.741.824 bytes)

⚠ The conversion does not correspond to exactly the factor 1000 but rather the factor 1024. ◄

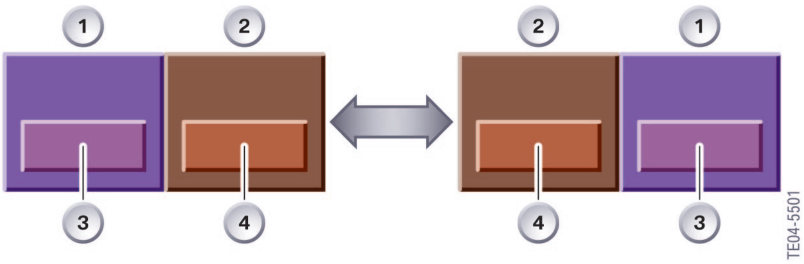
Types of interface connections

Fundamentals

An interface establishes the connection between a computer and its environment (other devices).

The hardware and software employed by all users must be identical to ensure the data are transmitted correctly via an interface.

If these preconditions are not met, a gateway (control unit) will ensure compliance.



6 - Interface

Index	Description	Index	Description
1	Computer	3	Software
2	Interface	4	Hardware

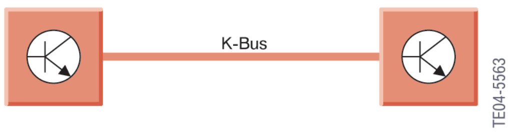
A distinction is made between two types of connection for establishing the connection between devices through interfaces:

- Point-to-point connection
- Multipoint connection

Point-to-point connection

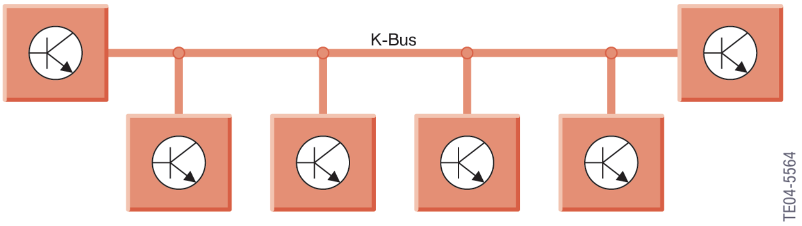
The point-to-point connection is only suitable for connecting two devices on a transmission link.

The following graphic shows an example of a point-to-point connection. The two control units are connected by the K-bus.



7 - Point-to-point connection

Multipoint connection



8 - Multipoint connection

With multipoint connections there can be more than two devices in the same transmission path.

For this purpose, it is necessary to assign distinct numbers (addresses) to the individual devices so that they can be specifically addressed.

The function of controlling the transmission path is normally assigned to one of the devices. This devise is then known as the master control unit. All other devices assume a slave function.

Interface data transmission methods

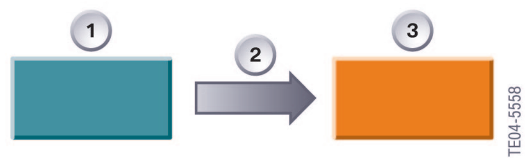
Irrespective of the transmission direction, a distinction is made between three fundamental operating modes for transmitting data via an interface:

- Simplex transmission
- Half-duplex transmission
- Full-duplex transmission

Simplex transmission

Data transmission takes place in only one direction, i.e. unidirectional: The transmitter sends data to the receiver.

Example: PC - printer



9 - Simplex transmission

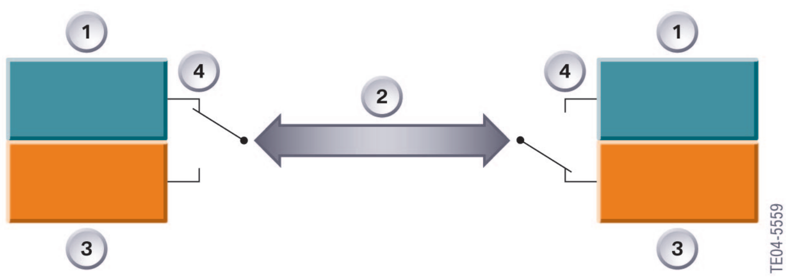
Index	Description
1	Transmitter
2	Data
3	Receiver

Half-duplex transmission

Both devices can exchange data between each other. They can alternately assume the function of a transmitter or receiver. The data, however, cannot be transmitted simultaneously.

Example:

When using walky-talkies or radio telephones, it is possible to speak (send) only when a certain button is pressed. This button must be released to hear (receive) a voice.



10 - Half-duplex transmission

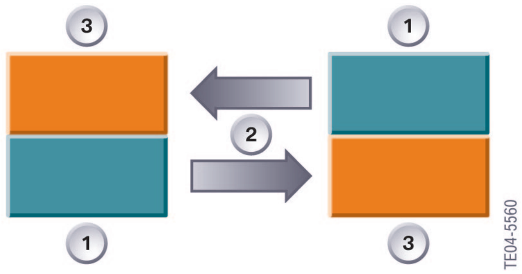
Index	Description	Index	Description
1	Transmitter	3	Receiver
2	Data	4	Switch

Full-duplex transmission

Data exchange can take place simultaneously in both directions, i.e. bi-directional. A separate line (data channel) is provided for each direction.

Example:

It is possible to both send and receive (speak and hear) when using a telephone.



11 - Full-duplex transmission

Index	Description
1	Transmitter
2	Data
3	Receiver

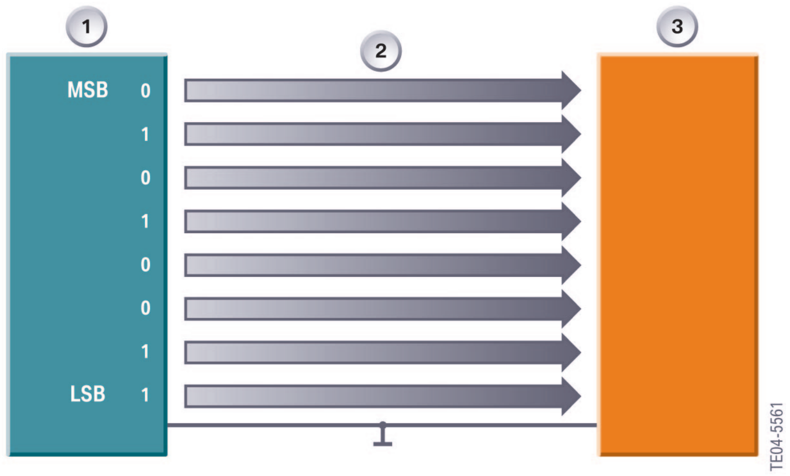
Data formats for data transmission

7-bit codes (ASCII) or 8-bit codes (IBM; extended ASCII code) are used for the purpose of encoding a message. For this reason, the standard unit in data transmission is an 8-bit code = 1 byte.

A distinction is made between parallel and serial transmission formats depending on how the individual bytes of a message are sent by the transmitter to the receiver.

Parallel transmission format

Seven to eight bits are transmitted simultaneously (parallel) from the transmitter to the receiver using parallel data transmission. There must be cable with seven or eight parallel lines (plus ground line) between both devices for the purpose of transmitting data in parallel.



12 - Parallel transmission format

Index	Description	Index	Description
1	Transmitter	MSB	Most significant bit
2	Data	LSB	Least significant bit
3	Receiver		

Parallel data transmission can therefore be characterized as follows:

Bit-parallel and byte-serial

This form of data transmission is always used whenever a high transmission rate is required.

Parallel data transmission is used, however, only for short transmission paths due to demanding requirements in terms of plug connections and cables.

Example:

PC - printer

Serial transmission format

The serial interface mainly serves the purpose of facilitating digital communication between data processing devices.

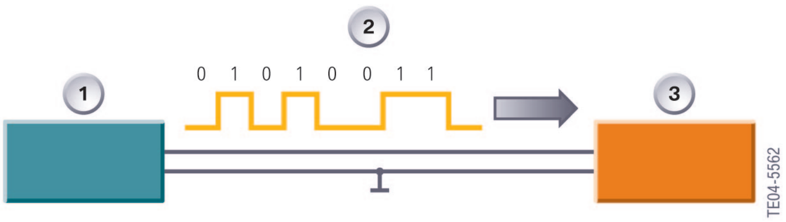
The data to be transmitted are sent in bits one after the other (serial) on a single line.

This method offers the advantage of reducing the scope and costs of the wiring.

The disadvantage of transmitting the bits one after the other is that this method is slower.

While an 8-bit parallel interface can transfer one data byte in one time unit, a serial interface requires at least eight time units for the same byte.

Nevertheless, the greater the distance to be covered, the more attractive the advantages of serial data transmission.



13 - Serial transmission format

Index	Description
1	Transmitter
2	Data
3	Receiver

Serial data transmission can therefore be characterized as follows:

Bit-parallel and byte-serial

Transmission rate and formats of serial interfaces

Serial interfaces are mostly used when one or several of the following conditions apply:

- Large distances to be covered, e.g. between the control units
- Reduction of individual cables
- Demanding requirements regarding interference immunity (shielded cables)
- Small data quantities

The main problem of serial data transmission is the time synchronization of the data flow between the transmitter and receiver.

The transmitter sends, dependent on the clock frequency, each data bit of a defined length. Errors will occur in the transmitted data if the receiver does not evaluate these bits in the same clock cycle.

The transmission speed is known as the baudrate, which indicates how many signal states (symbols) are transmitter per second. A symbol can also transport several bits (parallel) depending on the transmission method. The baudrate is then lower than the bit rate.

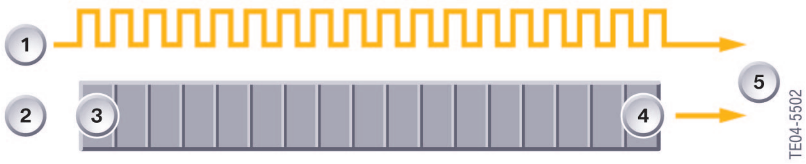
The bit rate is the same as the baudrate only when one bit is transported per symbol (serial).

The time for one bit can be determined by the characteristic value of the baudrate (1 : baudrate).

Synchronous data transmission

One way of keeping the time control synchronous in the transmitter and receiver is to use a common clock generator.

This method is known as the synchronous transmission format. Here, only the clock generator of the transmitter is used. Its clock frequency must be sent via a separate line to the receiver.



14 - Synchronous transmission format

Index	Description	Index	Description
1	Synchronization pulse	4	Start
2	Data	5	Receiver
3	End		

Data are normally sent in blocks in connection with synchronous transmission. The receiver must be synchronized to block transmission for this purpose. To this end, a start symbol is sent at the beginning of the block and an end symbol at the end.

Asynchronous data transmission

The most commonly used type of time control between transmitters and receivers is the asynchronous transmission format.

In asynchronous data transmission there is no common system clock between the transmitter and the receiver. The beginning and end of the data block are identified by start and stop bits.

The transmitter does not send the next data before the receiver confirms receipt of the previous data.

This methods is relatively slow. The data transmission rate also depends on the length of the bus.

In the case of asynchronous data transmission, synchronism between the transmitter and receiver is established and maintained only for the duration of one character/symbol.

This method is known as the start-stop method. Due to the time required for achieving synchronism every time, the bit rate is lower than for synchronous data transmission.

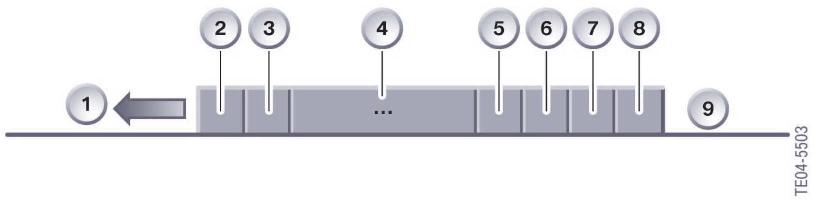
Each character/symbol in asynchronous transmission begins with a start bit. The receiver can synchronize itself to the clock of the transmitter with this start bit. This is followed by five to eight data bits and possibly a check bit (parity bit).

Starting with the least significant bit, the data bits are sent on the line. The most significant bit is transmitted last. This is followed by one or two stop bits. These stop bits serve as the minimum break between the transmission of two characters.

The stop bits provide the receiver with time to prepare itself for the next characters.

This unit consisting of start bit, data and stop bits is also known as the character frame.

The illustration below shows the structure of a character frame for asynchronous data transmission:



15 - Asynchronous data format

Index	Description	Index	Description
1	Receiver	6	Control bits
2	Start bit	7	Stop bit
3	Least significant bit	8	Stop bit
4	5 - 8 bit data	9	Signal: free bus
5	Most significant bit		

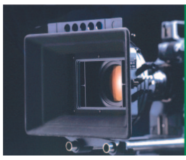
The transmission format must be identical at the transmitter and receiver. This means that the following parameters must be set the same in both devices:

- Baud rate
- Parity check
- Number of data bits
- Number of stop bits

Contents
K-bus / Body bus

System overview 1

E85 Bus Overview 1



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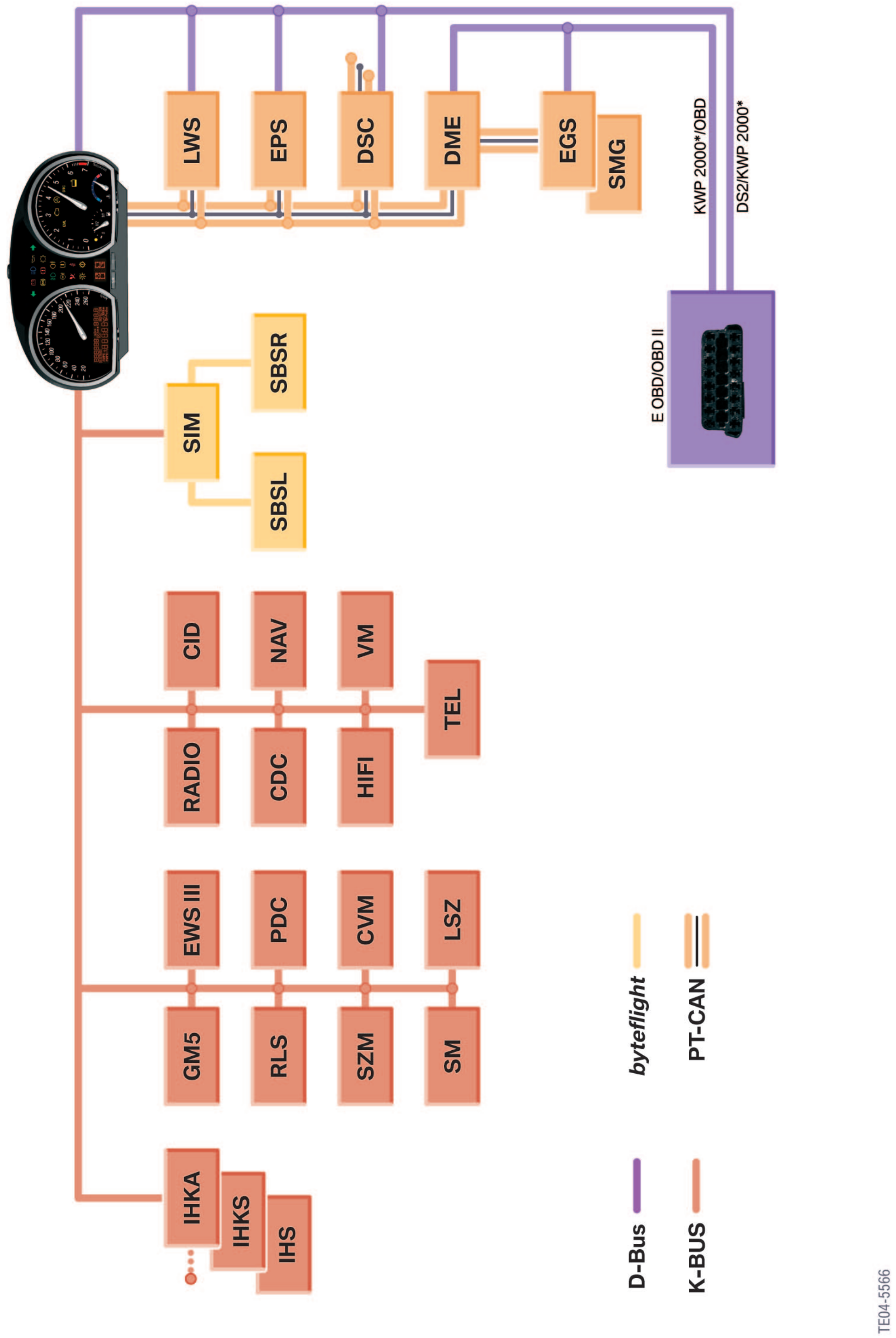
General information 5

Voltage level on the K-bus 6

E85 Bus Overview

The following pages show the system overview of the E85. This graphic illustrates the K-bus with its control units.

The other two illustrated bus systems, i.e. ***byteflight*** and PT-CAN, will be described and explained in separate chapters.



1 - K-bus in the E85

K-bus in the E85:

Index	Description	Index	Description
CDC	CD changer	LSZ	Light switch cluster
CID	Central information display	NAV	Navigation
CVM	Convertible top module	PDC	Park distance control
EWS III	Electronic immobilizer	RADIO	RADIO
GM 5	General module 5	RLS	Rain/lights sensor
HIFI	HiFi	SM	Seat module
IHKA	Automatic climate control	SZM	Centre console switch cluster
IHKS	Integrated heating control	TEL	Telephone
IHS	Integrated heating control	VM	Video module

General information

The K-bus interlinks or networks the components of the general vehicle electrical system, the information and communication systems as well as the safety system.

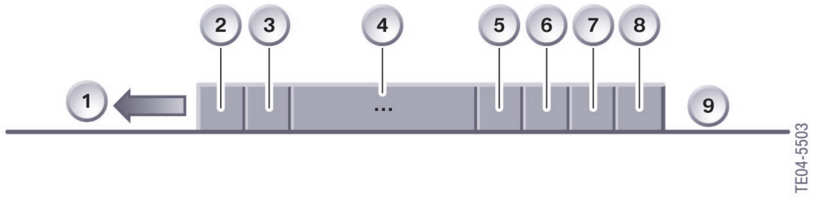
The other control units that feature communication capabilities and exchange data among each other are also connected to the K-bus. The K-bus is a bidirectional one-wire interface.

Data transmission

Since the K-bus has available only one single line yet it transmits data in both directions, data are transmitted in half-duplex mode. Consequently, it is possible to only transmit or receive at any one time.

The data are transmitted asynchronously as the transmitter does not send the system clock. The transmitter and receiver use their own separate clock generators.

Synchronization between the transmitter and receiver is achieved by the start bit in the transmitted string of characters.



1 - Asynchronous data transmission

Index	Description	Index	Description
1	Receiver	6	Control bits
2	Start bit	7	Stop bit
3	Least significant bit	8	Stop bit
4	5 - 8 bit data	9	Signal: free bus
5	Most significant bit		

Initially, a start bit is sent which the receiver uses to synchronize itself to the clock of the transmitter. Depending on the code used, 5 to 8 data bits are then sent followed by a parity bit if applicable.

The block is then concluded with two stop bits. These stop bits serve as the minimum break between the transmission of two characters. They provide the receiver with time to prepare itself for the next characters.

To secure the data transmission, a parity bit can be inserted between the most significant data bit and the stop bit. The parity bit provides a simple check for the transmitted data. The parity is the number of logic 1-levels in a binary data value. If this value contains an even number of 1-bits (0, 2, 4,....) it has even parity. With an odd number (1, 3, 5,....) it has odd parity. The parity check can be agreed between the transmitter and receiver, however, it is not essential.

If the parity is even, for example, the parity bit adds to the number of ones to produce an even number. If a bit already has even parity, the transmitter sets the parity bit to logic "0". If, on the other hand, a bit is odd, the transmitter will set the parity bit to logic "1". Consequently, the total number of ones is even again during transmission.

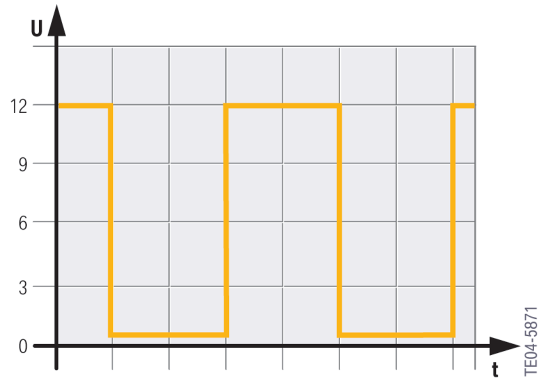
The parity of the received character is evaluated in the receiver. A transmission error is signalled if it does not correspond to the agreement.

Voltage level on the K-bus

The voltage level is between 0 V and 12 V when a message is sent on the K-bus.

The voltage level changing from low to high indicates a logic 1.

The level changing from high to low indicates a logic 0.



2 - Voltage level on the K-bus

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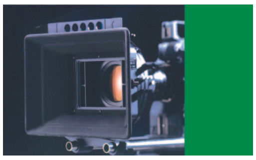

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Introduction
K-CAN

General

K-CAN stands for Karosserie (body) Controller Area Network. CAN was developed by Robert Bosch GmbH as the bus system for motor vehicles.

Thanks to the access protocol and object-oriented addressing, highly efficient, event-controlled systems can be built up very effectively with CAN. Data can be exchanged directly between any number of bus users in the CAN multimaster system.

Use in motor vehicles

The K-CAN (Karosserie (body) Controller Area Network) transmits information in the area of the vehicle body. In the E65/66, the K-CAN is further subdivided in the K-CAN system and the K-CAN periphery.

The K-CAN operates as a twisted two-wire copper line with a transmission rate of 100 kBits/s and replaces the previous K-bus.

A further bus in the CAN family is the F-CAN. F-CAN stands for Fahrwerk (chassis) Controller Area Network. This bus is structured and functions in exactly the same way as the K-CAN. However, the F-CAN is used exclusively for data transmission of the chassis/suspension components such as the dynamic stability control for example.

Advantages

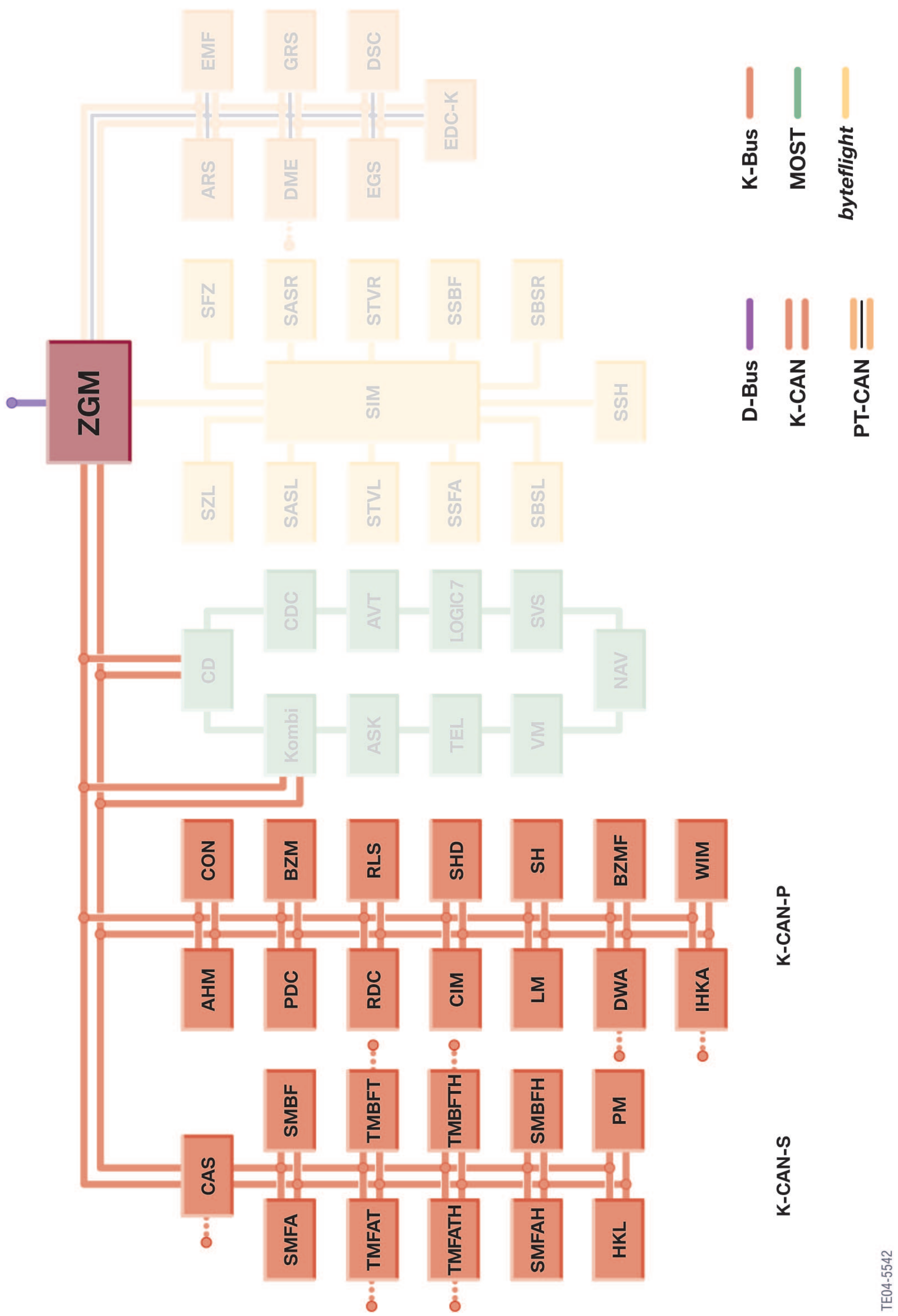
The advantages of the CAN bus are:

- Higher data transmission speed compared to conventional wiring
- Improved electromagnetic compatibility (EMC)
- Improved emergency operation characteristics

K-CAN

The following pages show the K-CAN in the E65. The K-CAN in the E65 is divided into two areas:

- K-CAN SYSTEM
- K-CAN PERIPHERY

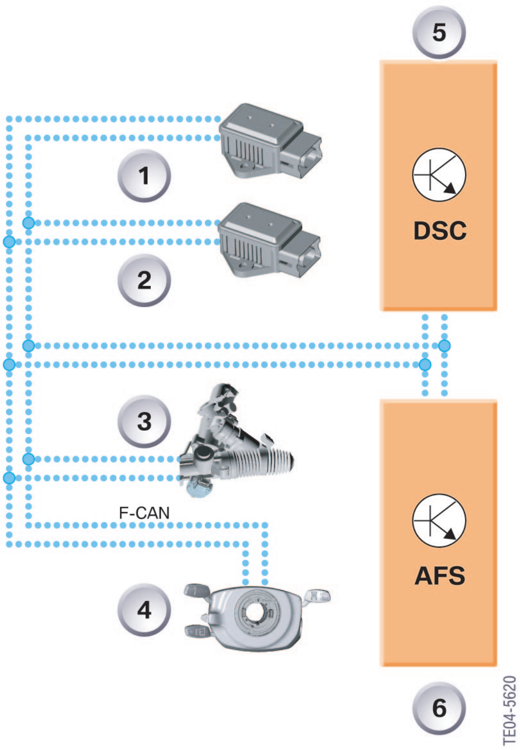


1 - K-CAN system/periphery E65

K-CAN in the E65:

Index	Description	Index	Description
AHM	Trailer module	RLS	Rain/lights sensor
BZM	Centre console switch cluster	SH	Auxiliary heating
BZMF	Centre console switch cluster, rear	SHD	Slide/tilt sunroof
CAS	Car access system	SMBF	Front passenger's seat adjustment module
CIM	Chassis integration module	SMBFH	Rear passenger's side seat adjustment module
CON	Controller	SMFA	Driver's seat adjustment module
DWA	Antitheft alarm system	SMFAH	Rear driver's side seat adjustment module
HKL	Boot lid lift	TMBFT	Front passenger's door module
IHKA	Automatic climate control	TMBFTH	Rear passenger's side door module
LM	Lights module	TMFAT	Driver's door module
PDC	Park distance control	TMFATH	Rear driver's side door module
PM	Power module	WIM	Wiper module
RDC	Tyre pressure control		

F-CAN



2 - F-CAN in the E60

Index	Description
1	DSC sensor 1
2	DSC sensor 2
3	Actuator motor for active steering
4	Steering column switch cluster
5	Dynamic stability control - DSC
6	Active steering - AFS

Fundamentals

The Karosserie (body) Controller Area Network, abbreviated to K-CAN, is used in BMW vehicles for the purpose of networking components of the comfort and vehicle body electronics.

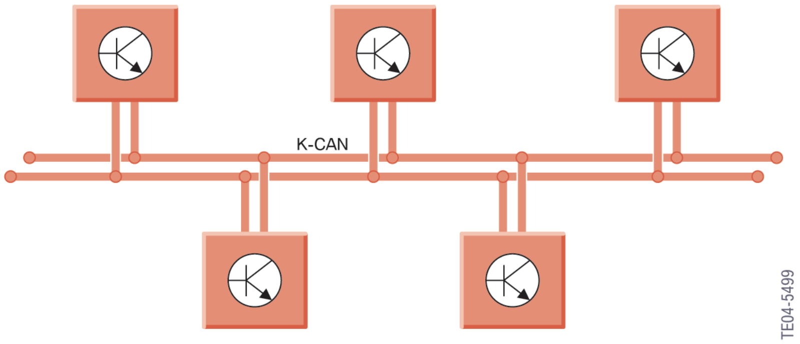
These functions include lamp control, seat adjustment and air conditioning.

The transmission rate is 100 kBits/s.

K-CAN is based on linear topology, i.e. it conforms to a bus structure.

Bus structure

Each terminal unit (node, control unit) in a network with a bus structure is connected with a common line.



1 - Bus structure of a network

The K-CAN is a multimaster bus. Each control unit that is connected to the bus can send messages.

The control units communicate event-controlled. The control unit wishing to send data sends a message when the bus is free. If the bus is not free, the message with the highest priority is sent.

Since there are no receive addresses, each control unit hears every sent message. Consequently, further receiver stations can be easily added to the system during operation. Neither the software nor the hardware needs to be changed.

Two-wire copper lines are currently used for data transmission. However, solutions based on glass fibre or plastic fibre optics conductors are also possible. Fibre optics conductors are sensitive to high temperatures as occur in the engine compartment.

The advantage of using two-wire lines is that it is possible to fall back on a single-wire line in the event of a fault.

Advantages:

- Easy to install
- Easy to expand
- Short lines
- Emergency operation on one line

Disadvantages:

- Network expansion limited
- Intricate access methods

Terminating resistor

From an electrical point of view, a current-carrying conductor always has an ohmic, inductive and capacitive resistance. When transmitting data from point "A" to point "B", the total sum of these resistances has an effect on data transmission. The higher the transmission frequency, the more effective the inductive and capacitive resistance. Ultimately, it is possible that a signal, which is no longer identifiable, is received at the end of the transmission line. For this reason, the line is "adapted" by terminating resistors, ensuring the original signal is retained.

Inductive resistance occurs, for example, as the result of the coil effect in the line. Capacitive resistance occurs, for example, by installing the line parallel to the vehicle body.

The terminating resistors used in a bus system vary.

They generally depend on the following parameters:

- Frequency of data transmission on the bus system
- Inductive or capacitive load on the transmission path
- Cable length for data transmission

The longer the line, the greater the inductive component of the line.

The control units are divided into basic control units and other control units. The resistance value determines this division.

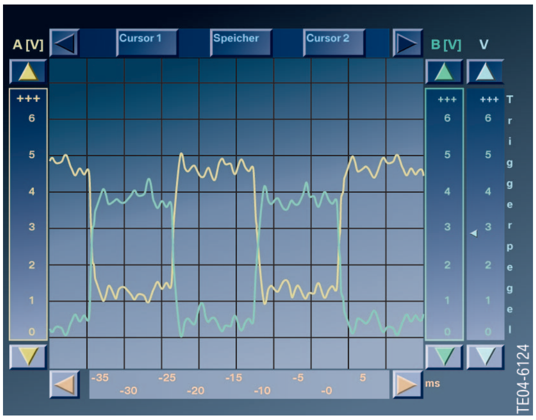
Terminating resistors are used to ensure exact signal progression in the bus systems. These terminating resistors are located in the control units of the bus systems.

Values of the terminating resistors on the K-CAN:

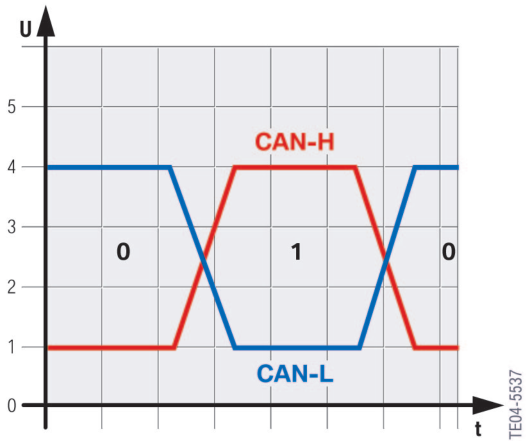
Basic control unit	Other control units
820 Ω	12 000 Ω

Voltage level on K-CAN

A logic 1 is indicated when the signal level of the CAN-High changes from low to high. Logic 0 is indicated when the signal level changes to low again.



2 - Voltage level on the K-CAN (GT-1)



3 - Voltage level on the K-CAN

Index	Description
CAN_H	Signal CAN-High
CAN_L	Signal CAN-Low

The voltage difference between the CAN-H and CAN-L lines is 3 V when a dominant bit is transmitted on the K-CAN.

The voltage on the CAN-H with respect to ground is 4 V.

The voltage on the CAN-L with respect to ground is 1 V.

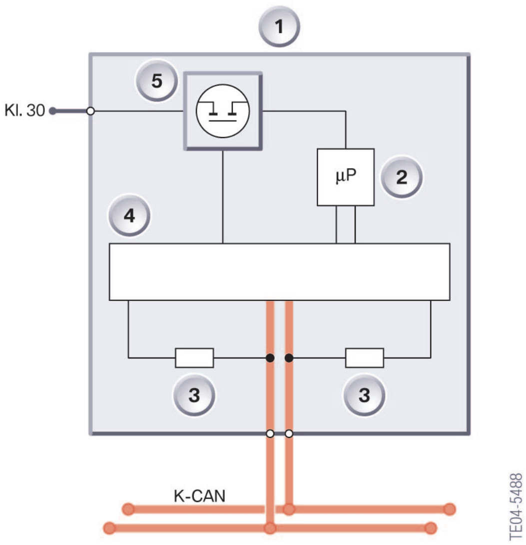
Example:

The voltage level changes due to a defective terminating resistor. This change in voltage affects the CAN system. Communication between the bus users no longer operates correctly.

Wake-up on the K-CAN

The control units in the K-CAN network are woken via the bus. The previous function of terminal 15 as the wake-up line is therefore rendered unnecessary.

The receiver of the CAN routes the wake-up message directly to the output stage of the control unit. The output stage connects terminal 30 and the unit is woken.



4 - Terminating resistor of the K-CAN

Index	Description
1	Control unit
2	Microprocessor
3	Terminating resistor
4	Transmit and receive unit
5	MOS-Fet

Detecting and disabling defective users

The CAN protocol includes a control unit monitoring facility to prevent a defective user disturbing the data traffic on the bus.

On exceeding a defined error rate, a freedom of action of the affected control unit is restricted or the control unit may even be uncoupled from the network.

Emergency operation capabilities

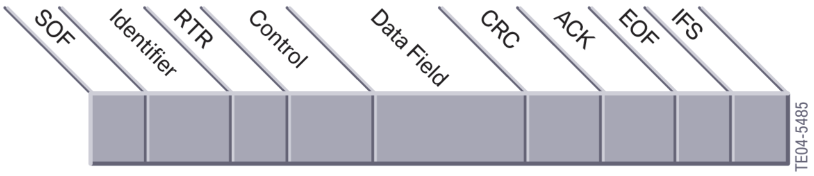
Only the K-CAN features emergency operation capabilities. The K-CAN is operated as a single-wire bus if:

- There is a break in a CAN line (core)
- There is a short to ground on a CAN line (core)
- There is a short to the supply voltage U_{B+} on a CAN line (core)

Data transmission

A message is sent asynchronously, i.e. without synchronization pulses, in a data frame. This data frame contains information such as:

- Starter marker of the data frame
- Identifier - to identify the content of the message and its priority
- Length of data frame
- The actual message with a length of up to 8 bytes
- Mechanisms for error detection
- End marker of the data frame



5 - Message format

Index	Description	Description
SOF	Start of frame	Marks the start of a message format
Identifier	Identifier	Indicates the type of data and its priority
RTR	Remote transmission request	Indicates whether the frame is a data frame or a request frame without data bytes (remote frame)
Control	Monitoring field	Indicates whether a standard or an expanded format is used
Data Field	Data field	Data field with 0 to 8 bytes
CRC	Cyclic redundancy check	Indicates the checksum for detecting bit errors
ACK	Acknowledgement	Correct receipt by the receiver is confirmed in this field
EOF	End of frame	Marks the end of a message format
IFS	Interframe space	Minimum spacing between two messages

A control unit places its message on the bus when it wishes to send data. The control unit is therefore in transmit mode. All other control units are now in receive mode. On receiving the message, they decide based on the identifier whether the message is relevant for them or not. At the end of the message, all control units can again send messages via the bus.

If several control units wish to send simultaneously, the priority of the message determines what control unit can transmit first. This bus access conflict is won by the control unit that has the lowest identifier and therefore the highest priority. This control unit can now send its complete message while the other control units must wait for a free bus.

If a user wishing to send data recognizes that the bus is already occupied, its send request is delayed up to the end of the current transmission.

Message-oriented protocol

The CAN protocol is not based on data exchange involving addressing of the message receiver but rather the data are transmitted by identifying the message with an identifier. This identifier also defines the priority of the sent messages.

All control units check whether the message is relevant based on the identifier of a received message. Messages can therefore be accepted by no, one, many or all bus users.

Bus users can be relieved of the task of accepting messages that are of no interest to them by means of the message filtering options integrated in the control units.

Prioritising of messages

Since the identifier of a message also determines its priority, it is possible to allocate fast data access to messages corresponding to their importance.

Particularly important messages therefore achieve access to the bus with a shorter access time. These shorter access times are dependent on the current bus load. This property ensures particularly important messages have transmission priority also in exceptional situations (e.g. prolonged interference). This function therefore secures system operation also during phases of restricted transmission capacity.

Multimaster capability

Bus access rights are not issued by a higher-ranking control unit (bus master) but rather each bus user has equal rights to start sending its message as soon as the bus becomes free.

If several control units wish to send simultaneously a mechanism is put into place which decides what message can be sent first. The criterion for fast transmission is the message priority. Consequently, each user can communicate directly with every other bus user.

Non-destructive arbitration

Since it is possible to access the bus at any time, it is also possible that several users wish to occupy the bus simultaneously. In other random bus access procedures this would result in the destruction of the sent messages. Resolution of the bus access conflict therefore renders necessary repeated reservation of the bus within the framework of an appropriate resolution strategy.

A procedure is therefore used in the CAN protocol that guarantees that the most important message at the respective point in time is sent. This mechanism is known as non-destructive arbitration.

This procedure compares the identifiers of the messages with each other. The message with the greatest importance (priority) can then be sent first.

This mechanism ensures that no bus capacity is lost while additionally taking into account the priority of the messages.

Error detection and handling

The scope of applications of the CAN protocol in motor vehicles places particularly demanding requirements on the security and reliability of the data transmission. To meet these requirements, the CAN protocol is based on several measures for detecting erroneous messages.

The following mechanisms are used for error detection and handling:

- Bit monitoring
- Monitoring of the telegram format
- Checksum comparison
- Transmitter monitoring
- Monitoring compliance with bit coding rules

Distribution of the K-CAN

In the E65, the functions that were combined in the ZKE (central body electronics) on the E38 are distributed over many individual control units. These control units and new control units are connected to the K-CAN.

The K-CAN SYSTEM and K-CAN PERIPHERY were introduced with the E65.

New control units and functions in the K-CAN include the car access system (CAS), centre console control centre (BZM), rear centre console control centre (BZMF) and the power module (PM).

K-CAN SYSTEM/PERIPHERALS

The number of vehicle components (control units/modules) is divided over two "independent" bus systems. The load on the bus system is relieved by dividing the K-CAN into SYSTEM and PERIPHERY.

As a result, the bus is more readily available also in the event of a crash. Parts could fail due to a short-circuit in the K-CAN in the event of a crash. The K-CAN PERIPHERY extends into such endangered areas. If the K-CAN PERIPHERY should fail, the K-CAN SYSTEM would still be retained.

Advantages of the K-CAN SYSTEM/ PERIPHERY split:

- Expansion of vehicle components per bus is possible at any time
- Lower data load by bus users on the bus system ensured by a second line
- Increased reliability

⚠ The division of the K-CAN into the SYSTEM and PERIPHERY areas can be currently found only on the E65/66. ◄

K-CAN SYSTEM

Components in the K-CAN SYSTEM

The components in the K-CAN SYSTEM are basic control units, other control units and the bus system.

Basic control units:

- Lights switching centre (LSZ)
- Integrated automatic climate control (IHKA)
- Car access system (CAS)
- Central gateway module (ZGM)
- Control display (CD)
- Instrument cluster

Other control units:

- Trailer module (AHM)
- Centre console switch cluster (BZM)
- Centre console switch cluster, rear (BZMF)
- Antitheft alarm system (DWA)
- Chassis integration module (CIM)
- Auxiliary heating (SH)
- Controller (CON)
- Lights module (LM)
- Park distance control (PDC)
- Tyre pressure control (RDC)
- Rain/lights sensor (RLS)
- Wiper module (WM)
- Slide/tilt sunroof (SHD)

K-CAN PERIPHERY

Components in the K-CAN PERIPHERY

The components in the K-CAN PERIPHERY are basic control units, other control units and the bus system.

Basic control units:

- Car access system (CAS)
- Driver's door module (TMFAT)
- Passenger's door module (TMBFT)
- Boot lid lift (HKL)

Other control units:

- Rear passenger's side door module (TMBFTH)
- Rear driver's side door module (TMFATH)
- Rear driver's side seat module (SMFAH)
- Driver's seat module (SMFA)
- Passenger's seat module (SMBF)
- Rear passenger's side seat module (SMBFH)
- Power module (PM)

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Powertrain Controller Area Network

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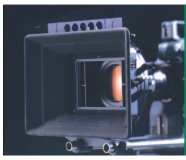

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Introduction
PT-CAN

General

PT-CAN stands for Powertrain Controller Area Network. CAN was developed by Robert Bosch GmbH as the bus system for motor vehicles.

Thanks to the access protocol and object-oriented addressing, highly efficient, event-controlled systems can be built up very effectively with CAN. Data can be exchanged directly between any number of bus users in the CAN multimaster system.

At a transmission rate of 500 kBits/s, the PT-CAN is the fastest CAN bus used in BMW vehicles. This bus connects all control units and modules belonging to the drive train. All bus users are connected in parallel.

The special feature of this CAN bus is that, instead of two lines, it is equipped with three lines.

The third line is used as a wake-up line and has nothing to do with actual operation of the CAN bus.

Use in motor vehicles

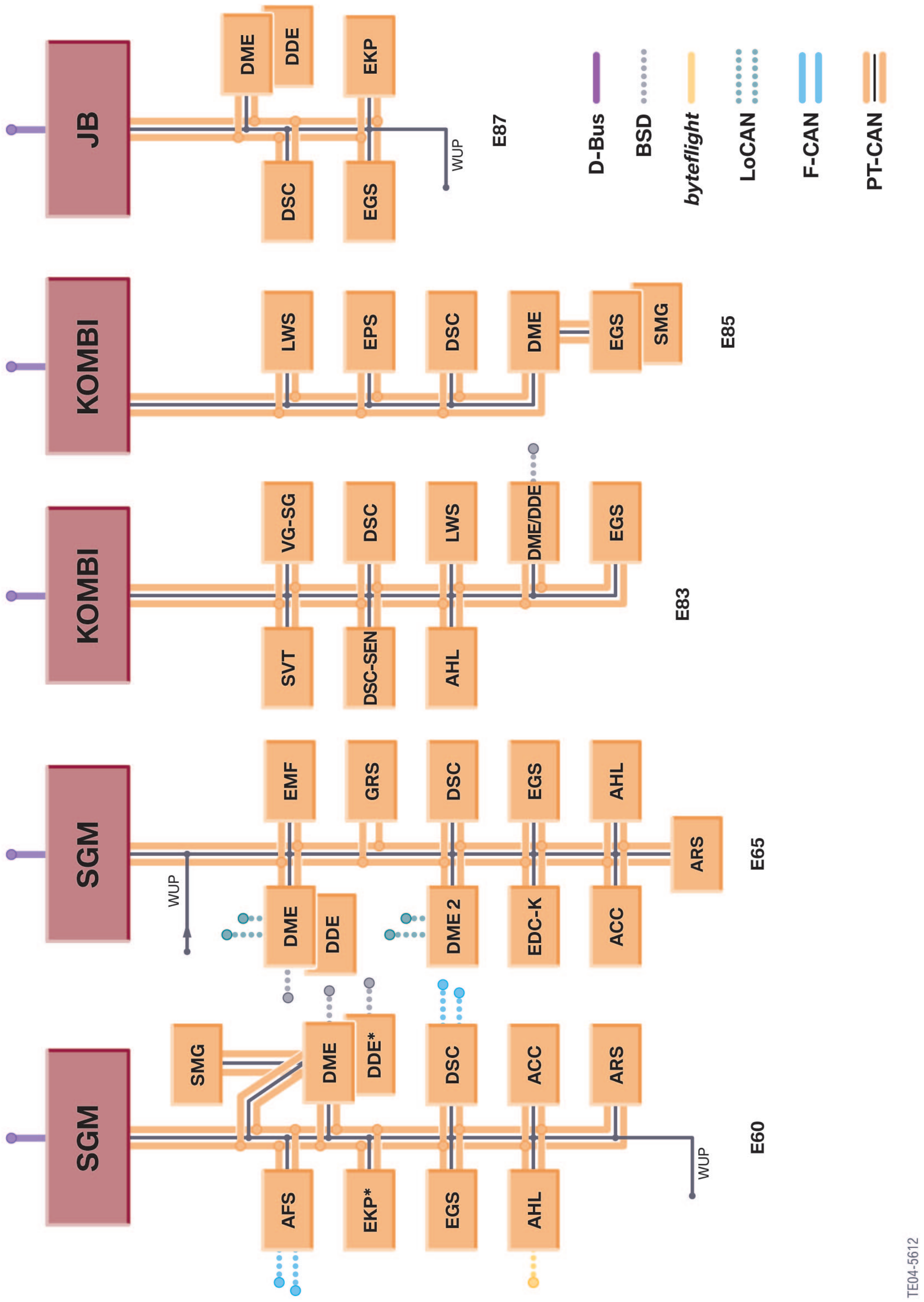
The CAN bus was used for the first time in powertrain management in the E38. The bus system is used for data exchange between the digital motor electronics and adaptive transmission control.

Whereas the PT-CAN is used in the area of the powertrain and chassis.

The CAN bus in the E38, E39 and E46 corresponds to the PT-CAN as from the E65.

PT-CAN

The following pages show an overview of the PT-CAN in various BMW vehicles.



1 - Overview of PT-CAN in various BMW vehicles

PT-CAN in the E60:

Index	Description	Index	Description
ACC	Active cruise control	DSC	Dynamic Stability Control
AFS	Active steering	EGS	Electronic transmission control
AHL	Adaptive cornering light	EKP	Electric fuel pump
ARS	Active anti-roll bar	SGM	Safety and gateway module
DDE	Digital diesel electronics	SMG	Sequential manual gearbox
DME	Digital motor electronics		

PT-CAN in the E65:

Index	Description	Index	Description
ACC	Active cruise control	DSC	Dynamic stability control
AHL	Adaptive cornering light	EDC-K	Electronic damper control, continuous
ARS	Active anti-roll bar	EGS	Electronic transmission control
DDE	Digital diesel electronics	EMF	Electronic parking brake
DME	Digital motor electronics	GRS	Yaw rate sensor
DME2	Digital motor electronics 2	SGM	Safety and gateway module

PT-CAN in the E83:

Index	Description	Index	Description
AHL	Adaptive cornering light	KOMBI	Instrument cluster
DME/DDE	Digital motor electronics/ digital diesel electronics	LWS	Steering angle sensor
DSC	Dynamic stability control	SVT	Servotronic
DSC-SEN	Dynamic stability control sensor	VG-SG	Transfer box control unit
EGS	Electronic transmission control		

PT-CAN in the E85:

Index	Description	Index	Description
DME	Digital motor electronics	KOMBI	Instrument cluster
DSC	Dynamic Stability Control	LWS	Steering angle sensor
EGS	Electronic transmission control	SMG	Sequential manual gearbox
EPS	Electronic power steering		

PT-CAN in the E87:

Index	Description	Index	Description
DDE	Digital diesel electronics	EGS	Electronic transmission control
DME	Digital motor electronics	EKP	Electronic fuel pump
DSC	Dynamic Stability Control	JB	Junction box

Fundamentals

The powertrain controller area network, abbreviated to PT-CAN is used in BMW vehicles to interconnect components of control units belonging to the powertrain, such as the digital motor electronics and dynamic stability control (PT-CAN = 500 kBits/s).

PT-CAN is based on linear topology, i.e. it conforms to a bus structure.

Bus structure

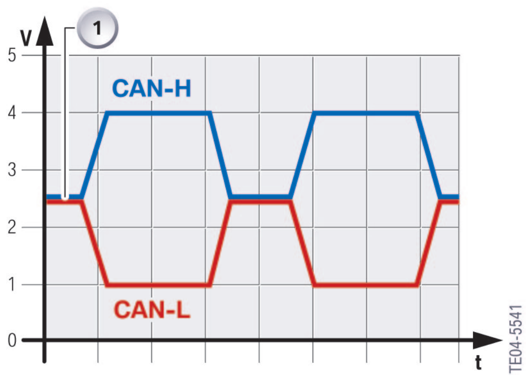
The bus structure of the PT-CAN differs from that of the K-CAN only by the third line.

The third line is used solely as a wake-up line.

Voltage level on PT-CAN

When not active, the bus level, High and Low, is 2.5 V.

When the bus is active, the voltage level of the CAN-Low goes to low (1.0 V). On the other hand, the CAN-High goes to high (4 V), representing logic 1.

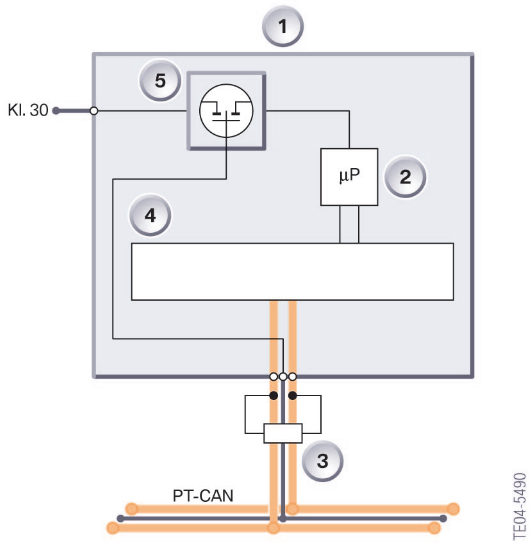


1 - Voltage level on the PT-CAN

Index	Description
1	PT-CAN inactive
CAN_H	Signal CAN-High
CAN_L	Signal CAN-Low
V	Volt (bus level)
t	Time

Terminating resistors of the PT-CAN

Terminating resistors are used to ensure exact signal progression in the bus systems.



2 - Terminating resistor of the PT-CAN

Index	Description
1	Control unit
2	Microprocessor
3	Terminating resistor
4	Transmit and receive unit
5	MOS-Fet

Values of terminating resistors:

	Control unit
Terminating resistor	120 Ω

The terminating resistors on the PT-CAN are installed on the two control units located at the furthest distance. The total resistance resulting from the parallel connection of two 120 Ω resistors is therefore 60 Ω. This resistance can be measured on the bus between the CAN-H and CAN-L lines.

Wake-up line in the PT-CAN network

The wake-up line is a separate line. The wake-up line has nothing to do with actual operation of the PT-CAN.

The function of the wake-up line is to allow control units to assume normal operating mode from sleep mode (power-saving mode).

Data transmission

The data are transmitted in the same way as on the K-CAN.

A messages are sent asynchronously, i.e. without synchronization pulses, in a data frame. This data frame contains information such as:

- Starter marker of the data frame
- Identifier - to identify the content of the message and its priority
- Length of data frame
- The actual message with a length of up to 8 bytes
- Mechanisms for error detection
- End marker of the data frame

The control unit places its message on the bus. All other control units receive the message and decide whether this message is relevant to them.

If several control units wish to send simultaneously, the priority of the message determines what control unit can transmit first.

If a user wishing to send data recognizes that the bus is already occupied, its send request is delayed up to the end of the current transmission.

Error detection and handling

The scope of applications of the CAN protocol in motor vehicles places particularly demanding requirements on the security and reliability of the data transmission. To meet these requirements, the CAN protocol is based on several measures for detecting erroneous messages.

The following mechanisms are used for error detection and handling:

- Bit monitoring
- Monitoring of the telegram format
- Checksum comparison
- Transmitter monitoring
- Monitoring compliance with bit coding rules

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Fibre optics

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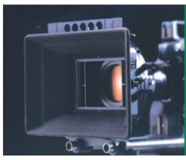

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Why fibre optics?

The volumes of data involved in data, voice or image transmission are ever increasing.

Today, fibre optics technology is already used in telecommunications and industrial systems. This technology is capable of managing these large volumes of data while, at the same time, offering further advantages.

High data rates cause strong electromagnetic radiation on copper lines. This radiation can cause interference in other vehicle functions.

Compared to copper lines, fibre optics conductors require less package space while providing the same available bandwidth or range. In addition, fibre optics conductors have a lower weight compared to copper lines.

Unlike copper lines, on which digital or analogue voltage signals are sent for data transmission purposes, the fibre optics conductors transmit light beams.

The most commonly used fibre optics conductors are:

- Plastic fibre optics conductors
- Glass fibre optics conductors

Plastic fibre optics conductors

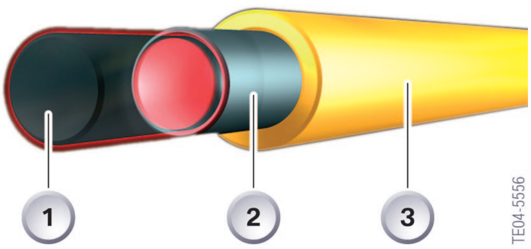
Only plastic fibre optics conductors are used in BMW vehicles.

Plastic fibre optics conductors offer the following advantages compared to glass fibre optics conductors (optical waveguides):

- Large fibre cross section - simplified manufacture
- Relatively insensitive to dust
- Easier handling as plastic, opposed to glass, does not break
- Easier processing - plastic can be cut, ground or melted
- Cost-effective

Structure

A fibre optics conductor is a thin cylindrical fibre made of plastic which is enclosed by a thin sheathing or jacketing. The actual fibre optics conductor is embedded in the sheathing material that serves the purpose of protecting the actual fibres.



1 - Structure of a fibre optics conductor

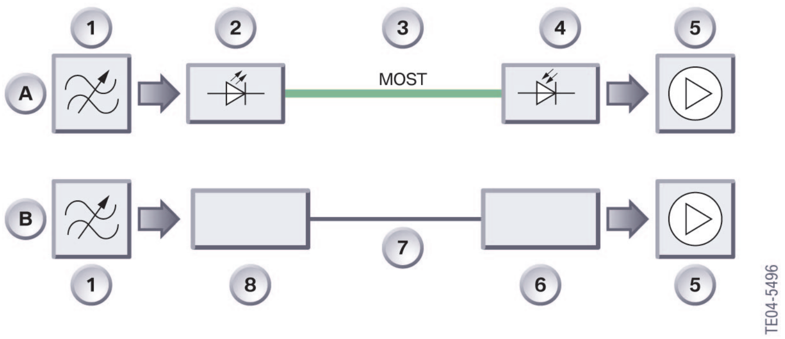
Index	Description
1	Fibre core
2	Sheathing
3	Padding

Principle of optical transmission

In principle, any system that transmits electrical signals with the aid of light beams (luminous radiation) consists of the components shown in the following illustration. The signal controls a light (radiation) source such that the radiation intensity of this source is proportional to the time fluctuations of the signals.

Comparison of an optical message transmission system with a conventional message system

Parallels can be drawn when comparing an optical message system with a modem transmission system (computer - internet):



2 - Comparison of an optical message transmission system with a conventional message system

Index	Description	Index	Description
A	Optical transmission	4	Photodiode (receive diode)
B	Electrical transmission	5	Receiver
1	Source	6	Demodulator (receiver in modem)
2	Light-emitting diode (transmit diode)	7	Cable
3	Fibre optics	8	Modulator (transmitter in modem)

The fibre optics conductor assumes the function of the transmission channel. The fibre optics conductor is particularly insensitive to external electromagnetic influences.

Modem transmission

As part of modem transmission, the modulator, the transmit part of the modem, converts the digital signals into analogue signals. The analogue signals are transmitted via the telephone network to the next computer.

The demodulator, the receive part of the modem, at this computer converts the analogue signals back to digital signals.

Optical transmission

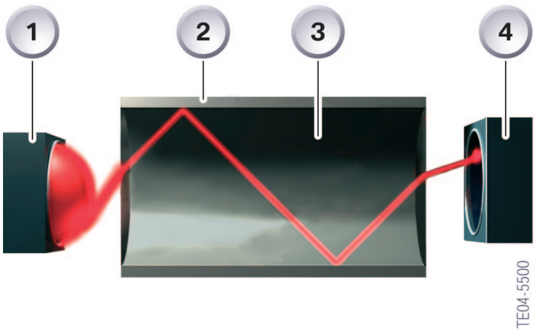
With optical message transmission, on the other hand, the digital signals are converted into optical signals by means of a light emitting diode (LED).

The optical signals are transmitted via fibre optics conductors to the next control unit.

The photodiode at this control unit converts the optical signals back to digital signals.

Principle of light transmission

The electrical signal generated by the control unit is converted into an optical signal in a transmit component and fed (beamed) into the fibre optics conductor. The fibre core serves as the guide for the light waves. The fibre core is sheathed to ensure the emitted light does not escape from the fibre core. The sheathing facilitates reflection of the light and therefore its further passage in the core.



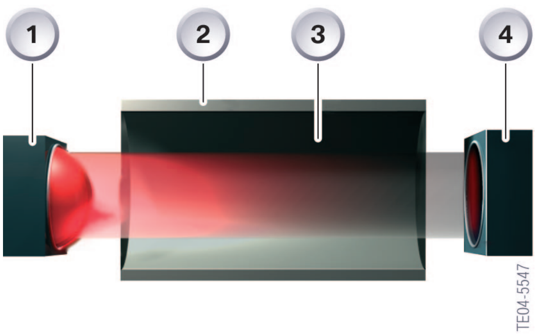
3 - Principle of data transmission with light

Index	Description
1	Transmit diode
2	Sheathing
3	Fibre core
4	Receive diode

The light therefore passes through the fibre optics conductor. The light is then converted back to an electrical signal with the aid of a receiver component.

Light attenuation

The light guided in the fibre looses its intensity over distance. This effect is known as attenuation.



4 - Attenuation of the light within a fibre optics conductor

Index	Description
1	Transmit diode
2	Sheathing
3	Fibre core
4	Receive diode

Application

Two optical bus systems for data transmission have been developed for BMW vehicles: MOST and ***byteflight***.

The light length is 650 nm (red light).

Three different colours are used to differentiate between the fibre optics conductors for the different bus systems:

- Yellow: ***byteflight***
- Green: MOST
- Orange: Service repair line

Handling fibre optics conductors

Particular care and attention is required when working on the vehicle wiring harness. In contrast to copper cables, damage to fibre optics conductors is not immediately apparent in the form of a defect, but rather it becomes noticeable at a later point in time when used by the customer.

A measure for the signal quality is the attenuation. Excessive attenuation can be caused by various factors:

- Bending radius smaller than 5 cm
- Bent/kinked fibre optics conductor
- Crushed or pinched fibre optics conductor
- Padding of fibre optics conductor damaged
- Fibre optics conductor overstretched
- Dirt or grease at the open ends
- Scratches on the open ends
- Fibre optics conductor overheated

Bending radius

The plastic fibre optics conductor must not be bent by a tighter radius than 50 mm. 50 mm corresponds approximately to the diameter of a drinks can. Bending the fibre optics conductor further will impair its operability or even lead to its complete destruction.

Light can emerge through a very tight bend as the light beam can no longer be reflected correctly.

1 - Fibre optics conductor bent

Kinks

On no account must the fibre optics conductors be kinked during installation as this will damage the fibre core and sheathing. This will cause light scatter at the kinked point resulting in transmission losses.

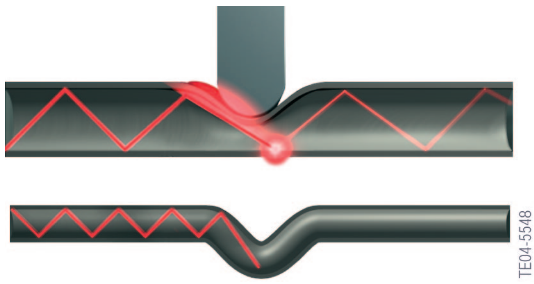
⚠ The fibre optics conductor will be irreparably damaged or destroyed even if kinked only once ◄

2 - Fibre optics conductor kinked

Indentations

Indentations or crushed spots must also be avoided on all accounts as the pressure can permanently deform the light-conducting cross section. The light is then lost during transmission.

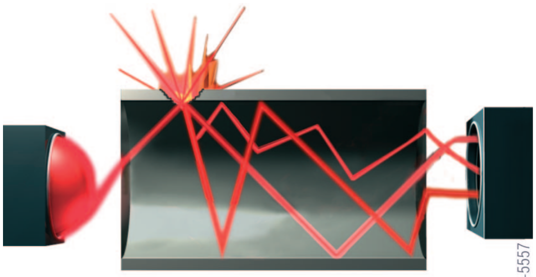
⚠ Overtightened cable ties can also cause such indentations or crushed spots. ◄



3 - Indentation on a fibre optics conductor

Chafing

Unlike on copper lines, chafing of the fibre optics conductor does not lead to short-circuits. Instead, chafing causes light loss or external light intrusion. The system will malfunction or fail completely.



TE04-5557

4 - Chafing on fibre optics conductor

Overstretching

Overstretching will cause the core to stretch, thus reducing the cross section of the fibre core, resulting in a reduced light throughput rate. Overstretching can also cause irreparable damage or destruction of the fibre optics conductor.

TE04-5551

5 - Overstretching of fibre optics conductor

Overheating

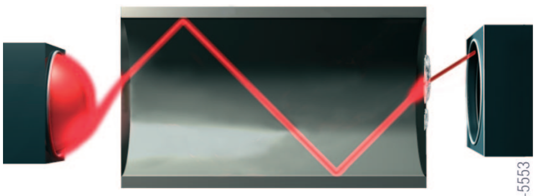
Overheating of the fibre optics conductor is not manifested in an immediate fault but rather leads to a defect at a later point in time.

A temperature of 85 °C, e.g. as achieved when drying paintwork or welding, must not be exceeded.

Soiled or scratched end faces

A further possible source of problems are soiled or scratched end faces. Although the end faces are protected against inadvertent contact, problems may occur if the fibre optics conductor is not handled correctly.

Dirt at the end of the fibre optics conductor prevents the entry and exit of the light beam. The dirt absorbs the light causing high attenuation.



TE04-5553

6 - Soiled end faces of fibre optics conductor

Scratches on the end faces scatter the light beams. Less light arrives at the receiver.

TE04-5554

7 - Scratched end faces of fibre optics conductor

Repair information

⚠ The fibre optics conductors in the MOST system may be repaired only once between two control units. ◄

⚠ The fibre optics conductors in the ***byteflight*** system must not be repaired. ◄

Special crimping pliers are used to fit the sleeves correctly on the fibre optics conductors.

The exact procedure is described in the operating instructions for the crimping pliers.

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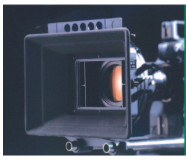

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Introduction
byteflight

Introduction

The ***byteflight*** system was developed by BMW together with Motorola, Elmos and Infineon predominantly for safety-related procedures in motor vehicles. This bus system is mainly used for transmitting particularly time-critical data of the airbag system.

byteflight technology in motor vehicle applications is of particular interest as such applications involve demanding real-time requirements at high data rates. In addition, data transmission must function reliably in a very difficult electromagnetic environment without transmission errors.

Use in motor vehicles

The ***byteflight*** was installed for the first time in the E65/E66/E67 for safety-related components such as the airbag systems. It was subsequently installed in the E85, E60/E61 as well as the E63/E64 vehicles.

The ***byteflight*** system is used in the safety systems ISIS (intelligent safety and information system) and ASE (advanced safety electronics). These safety systems are responsible for control of the airbags, seat belt pretensioners and the disconnection of the safety battery terminal.

E65 and E60 comparison

The SIM and ZGM functions have been combined to form the SGM in the newer models of the E65 as well as in all E60 models.

The door modules in the E60 assume the function of the front door satellites.

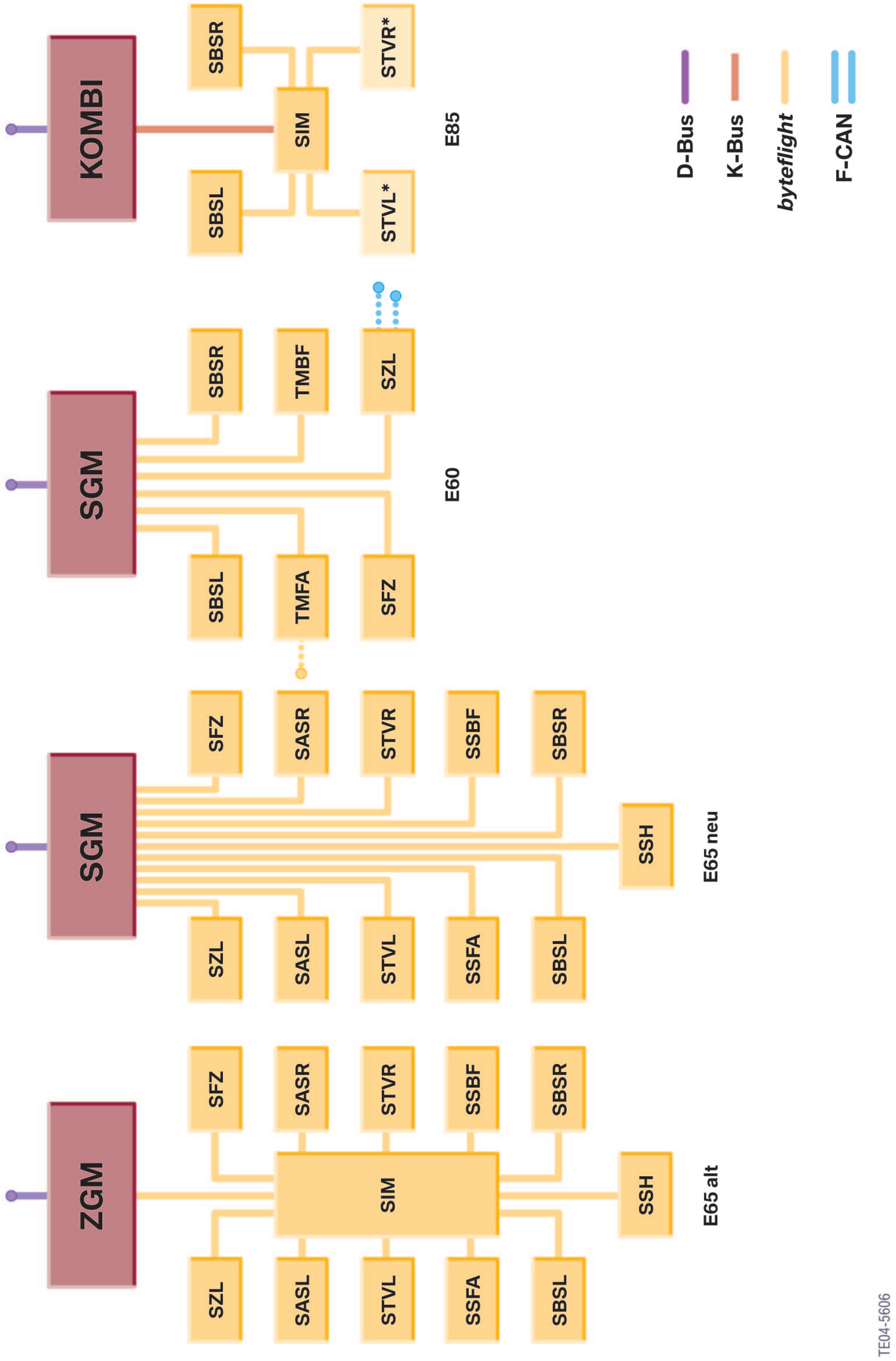
***byteflight* E65 (old)**	***byteflight* E60**
Central gateway module (ZGM)	Safety and gateway module (SGM)
Safety and information module (SIM)	
Steering column switch cluster (SZL)	Steering column switch cluster (SZL)
Vehicle centre satellite (SFZ)	Vehicle centre satellite (SFZ)
A-pillar satellite, left (SASL)	
A-pillar satellite, right (SASR)	
Front left door satellite (STVL)	Driver's door module (TMFA)
Front right door satellite (STVR)	Passenger's door module (TMBF)
B-pillar satellite, left (SBSL)	B-pillar satellite, left (SBSL)
B-pillar satellite, right (SBSR)	B-pillar satellite, right (SBSR)
Driver's seat satellite (SSFA)	
Front passenger's seat satellite (SSBF)	
Rear seat satellite (SSH)	

System overview
byteflight

byteflight

The following pages illustrate the use of the ***byteflight*** system in various BMW vehicles.

In the systems, either the safety and information module or the safety and gateway module serves as the ***byteflight*** master.



1 - Comparison of the ***byteflight*** in various BMW vehicles

E65 (2001-2004):

Index	Description	Index	Description
SASL	A-pillar satellite, left	SSBF	Passenger seat satellite
SASR	A-pillar satellite, right	SSFA	Driver's seat satellite
SBSL	B-pillar satellite, left	STVL	Door satellite, front left
SBSR	B-pillar satellite, right	STVR	Door satellite, front right
SFZ	Vehicle centre satellite	SZL	Steering column switch cluster
SIM	Safety information module	ZGM	Central gateway module
SSH	Rear seat satellite		

E65 (as from 03/2004):

Index	Description	Index	Description
SASL	A-pillar satellite, left	SSH	Rear seat satellite
SASR	A-pillar satellite, right	SSBF	Passenger seat satellite
SBSL	B-pillar satellite, left	SSFA	Driver's seat satellite
SBSR	B-pillar satellite, right	STVL	Door satellite, front left
SFZ	Vehicle centre satellite	STVR	Door satellite, front right
SGM	Safety and gateway module	SZL	Steering column switch cluster

E60:

Index	Description	Index	Description
SBSL	B-pillar satellite, left	SZL	Steering column switch cluster
SBSR	B-pillar satellite, right	TMFA	Driver's door module
SFZ	Vehicle centre satellite	TMBF	Front passenger's door module
SGM	Safety and gateway module		

E85:

Index	Description	Index	Description
Kombi	Instrument cluster	SIM	Safety information module
SBSL	B-pillar satellite, left	STVL	Door satellite, front left
SBSR	B-pillar satellite, right	STVR	Door satellite, front right

Fundamentals

byteflight is used in BMW vehicles for the purpose of networking and interconnecting control units. The control units are used to control the airbag systems, restraint systems and the safety battery terminal.

Plastic fibre optics conductors are used for data transmission. Fibre optics conductors use light pulses for the purpose of transmitting data. For this reason, they are considerably less susceptible in a difficult electromagnetic environment than compared to conventional copper lines.

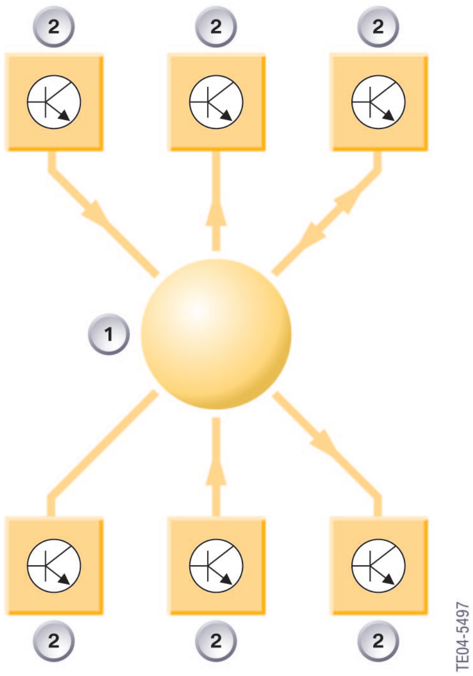
Data are transmitted at a rate of 10 MBits/s. The data transmission rate is therefore more than 20 times higher than on the high-speed bus PT-CAN.

Only one fibre optics conductor is required to interconnect the individual control units. These fibre optics conductors can transmit data in both directions, i.e. they are bidirectional.

The control units communicate time- and event-controlled. Data can be transmitted both synchronously and asynchronously.

Star structure

The ***byteflight*** system is based on a star structure.



1 - Star structure

Index	Description
Master	Higher-ranking control unit
Slave	Lower-ranking control unit
1, 2, 3, 4, 5, n	Users 1, 2, 3, 4, 5, n

The subordinate control units (slaves) in a star structure network are connected by means of a separate line to the higher-ranking control unit (master).

The master receives the data coming from a slave. It immediately distributes the data to all slaves. The slave that is addressed accepts the data.

Since the master recognizes no access control function, but rather serves a pure distribution function, the individual control units must communicate by means of a protocol. This protocol defines what control unit can send when and when not.

Advantages:

- Simple networking
- Simple expansion
- High degree of failure immunity

Disadvantages:

- Intricate and extensive wiring
- Network failure in the event of failure or overload of the master

Due to the star-shaped topology, ***byteflight*** remains operative even in the event of individual control units (slaves) failing.

In each control unit of the ***byteflight*** network, transmit and receive modules convert electrical signals to optical signals.

The safety and information module forms the centre of the star structure. In the newer BMW models, the safety and gateway module assumes the central position.

Data transmission

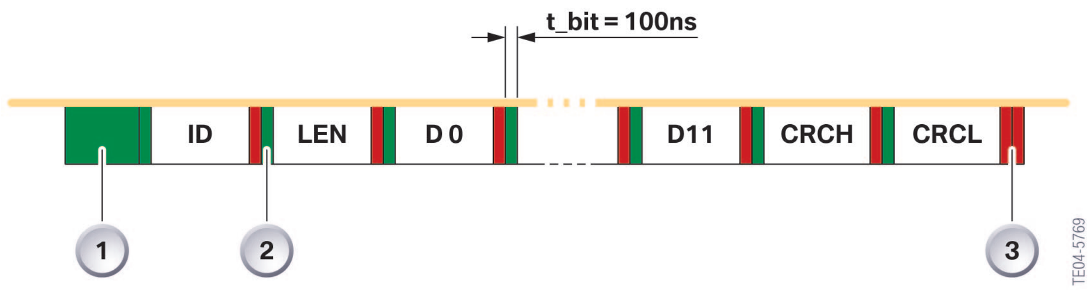
As part of the ***byteflight*** system, there are several sensors installed at strategic points in the vehicle. They are located in the satellites that are connected via the bus system to the SIM or to the SGM.

All sensors are permanently scanned and the data are distributed to all satellites.

Data transmission operates as on the CAN-bus by means of data telegrams which, apart from the number of data bytes, have exactly the same structure. Data with a maximum length of 12 bytes can be transmitted in the ***byteflight*** system.

The data frame contains information such as:

- Starter marker of the data frame
- Identifier
- Length of data frame
- Message with up to 12 bytes
- Mechanisms for error detection
- End marker of the data frame

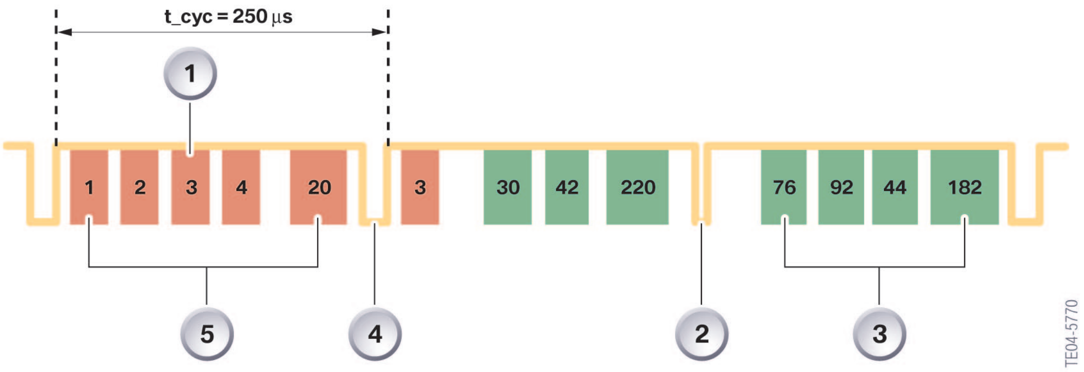


2 - Structure of a data telegram

Index	Description	Description
ID	Identifier	Determines the priority and data content of the telegram
LEN	Length	Contains the number of data bytes (up to 12 bytes)
D 0	Data byte 0	First data byte
D 11	Data byte 11	Maximum last data byte
CRCH	Cyclic redundancy check High	The checksum from ID, LEN and the data with 15 bits is formed
CRCL	Cyclic redundancy check Low	The checksum from ID, LEN and DATA with 15 bits is formed
1	Start sequence	
2	Start bit	
3	Stop bit	

byteflight combines the advantages of synchronous and asynchronous data transmission, thus guaranteeing fast access times for important messages and flexible use of less important messages.

The SIM or SGM sends out a synchronization pulse, to which the remaining control units must comply.



3 - Telegram priorities

Index	Description	Description
1	Identifier	Determines the priority of the telegram
2	Synchronization pulse, alarm	Synchronization pulse in alarm state
3	Low priority message	Telegram with lower priority
4	Synchronization pulse, normal	Synchronization pulse in no-error state
5	High priority message	Telegram with high priority
t_sync	Cycle time	Cycle time of a synchronization pulse

A distinction is made between high and lower priority in the telegrams. The differentiation is defined by the identifier. The permissible range is between 1 and 255 where 1 represents the highest priority.

Messages with high priority are, for example, sensor data.

Messages with lower priority are, for example, status messages and diagnosis.

Satellites

The ISIS has several sensors installed at strategic points in the vehicle. They are located in the satellites that are connected via the ***byteflight*** to the SIM.

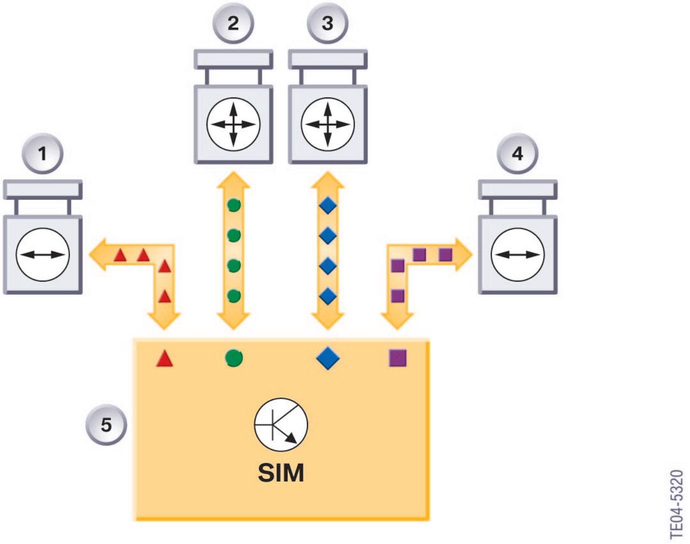
A telegram always begins with the start sequence which is followed by an identifier. This identifier defines the priority of the data telegram.

All sensors are permanently scanned and the data are distributed to all satellites.

Each byte is preceded by a start bit. Each byte is followed by a stop bit. The next byte is a length byte that indicates the number of data bytes.

This is followed by up to a maximum of 12 bytes. Then comes the checksum. A double stop bit marks the end of the telegram.

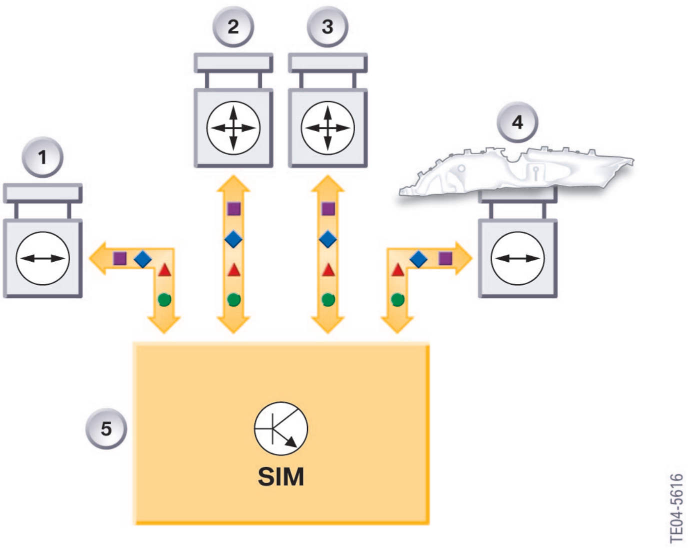
The length of a telegram can vary between 4.6 µs and 16 µs.



4 - Data flow from the sensors to the SIM

Index	Description
1	Satellite with sensors
2	Safety and information module

The illustration shows how all data registered by the sensors are sent via the ***byteflight*** to the SIM.



5 - Data telegrams to the satellites

Index	Description
1	Satellite with sensors
2	Safety and information module
3	Triggered airbag

The illustration shows how all data telegrams supplied by the satellites are forwarded to all satellites.

The respective satellite decides what restraint system is to be triggered.

Bus access procedure

Bus access is controlled by a defined assignment of time intervals. In this control system, only one defined message may be sent within a certain period of time. The message is labelled by its identifier.

Naturally, this procedure requires sufficiently accurate time synchronization of all bus users. The ***byteflight*** system is synchronized by sending a pulse cyclically (repeatedly), i.e. the so-called synchronization pulse. The synchronization pulse is output by the central control unit, the SIM or SGM.

The messages can be sent in the time interval between two synchronization pulses. Very important messages are sent synchronously in each cycle. Less important messages that need to be sent only occasionally are sent asynchronously within the remainder of the time interval.

Transmission example

The control unit A sends the identifier 4 and the control unit B the identifier 1. The time intervals for the identifiers 1 and 4 are as long as required to transmit the messages. The message with the identifier 1 is sent first.

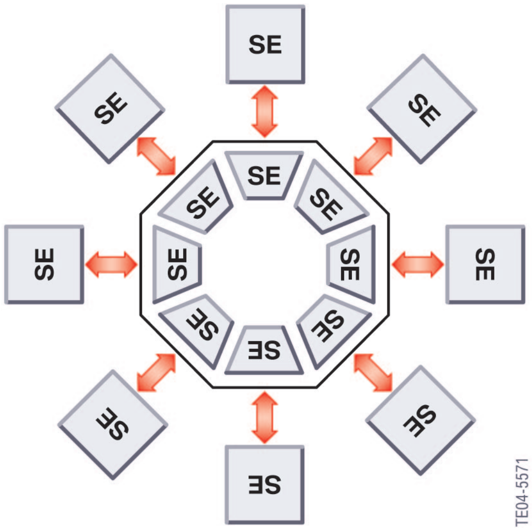
Only when this message has been transmitted completely are the requests received to send the identifiers 2 and 3. Since the time intervals of identifiers 2 and 3 are not defined, they appear as only very short waiting times.

The message with the identifier 4 can now be sent.

Transmit and receive module

The transmit and receive module is capable of converting electrical signals into optical signals and send them via fibre optics conductors. Each satellite has its own electric/optical transmit and receive module (S/E).

The transmit and receive modules are connected via the fibre optics conductor of the ***byteflight*** to the intelligent star coupler in the SIM. There is also a transmit and receive module in the SIM for each satellite.



6 - Star coupler and satellites with transmit and receive module

Index	Description
SE	Transmit and receive module

All information transmitted on the ***byteflight*** is packed in data telegrams that are sent in the form of light pulses. The transmit and receive modules in the SIM receive the light pulses from the connected satellites. The data telegrams are sent to all satellites in the intelligent star coupler. The data exchange is possible in both directions.

The send and receive modules consist of a light emitting diode LED) and a photodiode. They are mounted one above the other based on chip-on-chip technology thus ensuring optimum coupling of both components to the fibre optics conductor.

The transmit and receive module contains the LED for the driver switching circuit. This module also contains the receive amplifier for the purpose of converting the optical signals into digital signals. It also features a monitoring facility for optical transmission quality.

The satellite is shut down if one of the following faults occurs on one of the fibre optics conductors:

- No optical signal received over a defined period of time
- No transmit diode sends a permanent light source
- Attenuation is too high

The loss in lighting intensity (luminosity), comparable with the electrical resistance of a line, is known as attenuation.

The sent lighting intensity (luminosity) is compared with the received intensity. The permissible attenuation is defined in the system.

One of the following faults may be present if the permissible attenuation is exceeded:

- Fibre optics conductor bent or kinked causing increased attenuation
- Pressure load in fibre optics conductor
- Tensile stress in fibre optics conductor (overstretching)
- Break in fibre optics conductor
- Damage to fibre optics conductor

byteflight Master

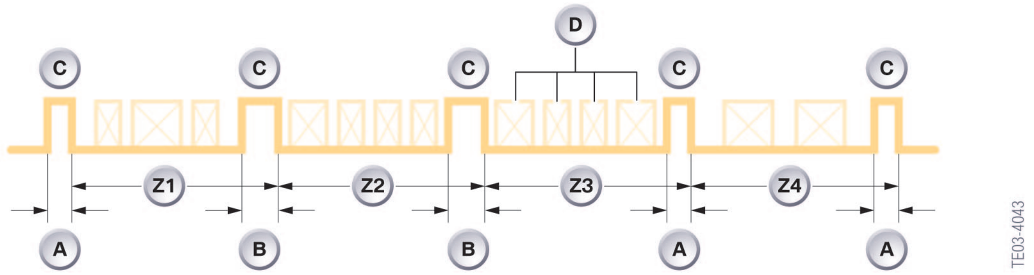
The ***byteflight*** master has two tasks:

- To generate the synchronization pulses (sync pulse)
- To set the satellites in alarm mode

The SIM is configured as the ***byteflight*** master (bus master) in the ISIS. The SGM assumes the ***byteflight*** master function in the ASE. In principle, any satellite can be configured by means of software as the bus master. However, there can only be one bus master in the system. All other users (bus slaves) use the sync pulse for internal synchronization. Each user can send telegrams on the ***byteflight*** between the sync pulses.

Synchronization pulses

The ***byteflight*** bus master in the SIM makes available the synchronization pulses at 250 µs intervals. The alarm mode is transmitted over the width of the sync pulse. The duration of a sync pulse in alarm mode is approx. 2 µs. The sync pulse is normally approx. 3 µs.



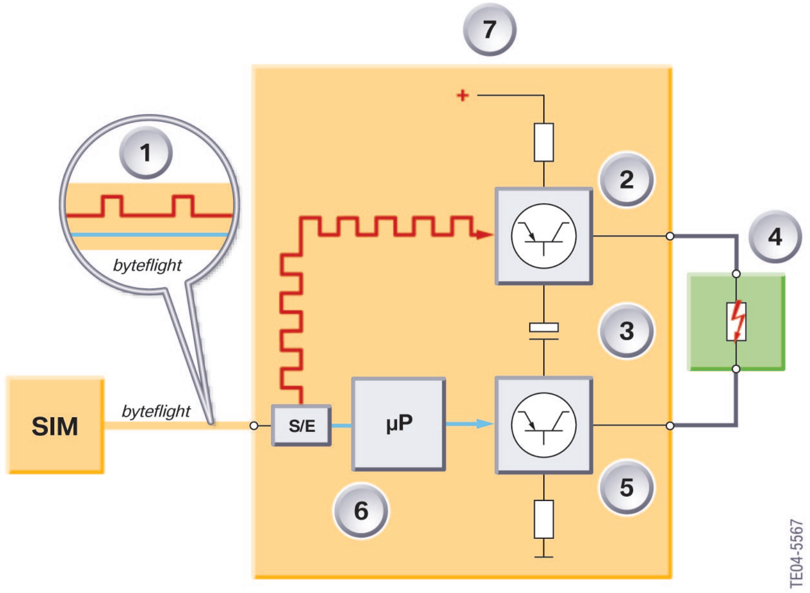
7 - ***byteflight*** cycles

Index	Description	Index	Description
A	Synchronization pulse, alarm	Z1	Cycle 1
B	Synchronization pulse, normal	Z2	Cycle 2
C	Synchronization pulses	Z3	Cycle 3
D	Telegrams	Z4	Cycle 4

Based on the available sensor information, the bus master must decide whether to set the satellites to alarm mode. When the bus master sets alarm mode, all ignition current circuits of the safety system are set to a ready-to-trigger state.

Two separate signals must always be transmitted on the ***byteflight*** in order to trigger an ignition stage. The high-side switch of the ignition current circuit in the satellite is controlled by the alarm mode of the ***byteflight*** system. The low-side switch is controlled by the microprocessor in the satellite. The trigger algorithm determines whether the low-side switch is to be closed by means of the telegrams transmitted with the sensor signals.

Based on the example of an ignition stage, the graphic below shows the signal paths necessary for triggering.



8 - Signal path for triggering an ignition power circuit

Index	Description
1	Alarm mode pulse
2	High-side switch
3	Ignition capacitor
4	Ignition squib
5	Low-side switch
6	Microprocessor
7	Satellite

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Media-oriented system transport

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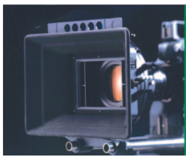

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What is MOST?

MOST is a communications technology for multimedia applications that was specially developed for use in motor vehicles.

MOST stands for Media Oriented System Transport. The MOST bus uses light pulses for transmitting data.

MOST technology satisfies two important requirements:

1. The MOST bus transports control, audio, video and navigation data.
2. The MOST technology makes available a logic frame model for controlling the great variety and complexity of the data.

Advantages of MOST:

- High data transmission rates possible
- Information and entertainment services can run parallel and synchronous without mutually interfering with each other
- Good electromagnetic compatibility

Why is MOST used in BMW vehicles?

Multimedia components such as:

- Telephone
- Radio
- Television
- Navigation system
- CD changer
- Amplifier
- Multi-information display/on-board monitor were installed already in the E38

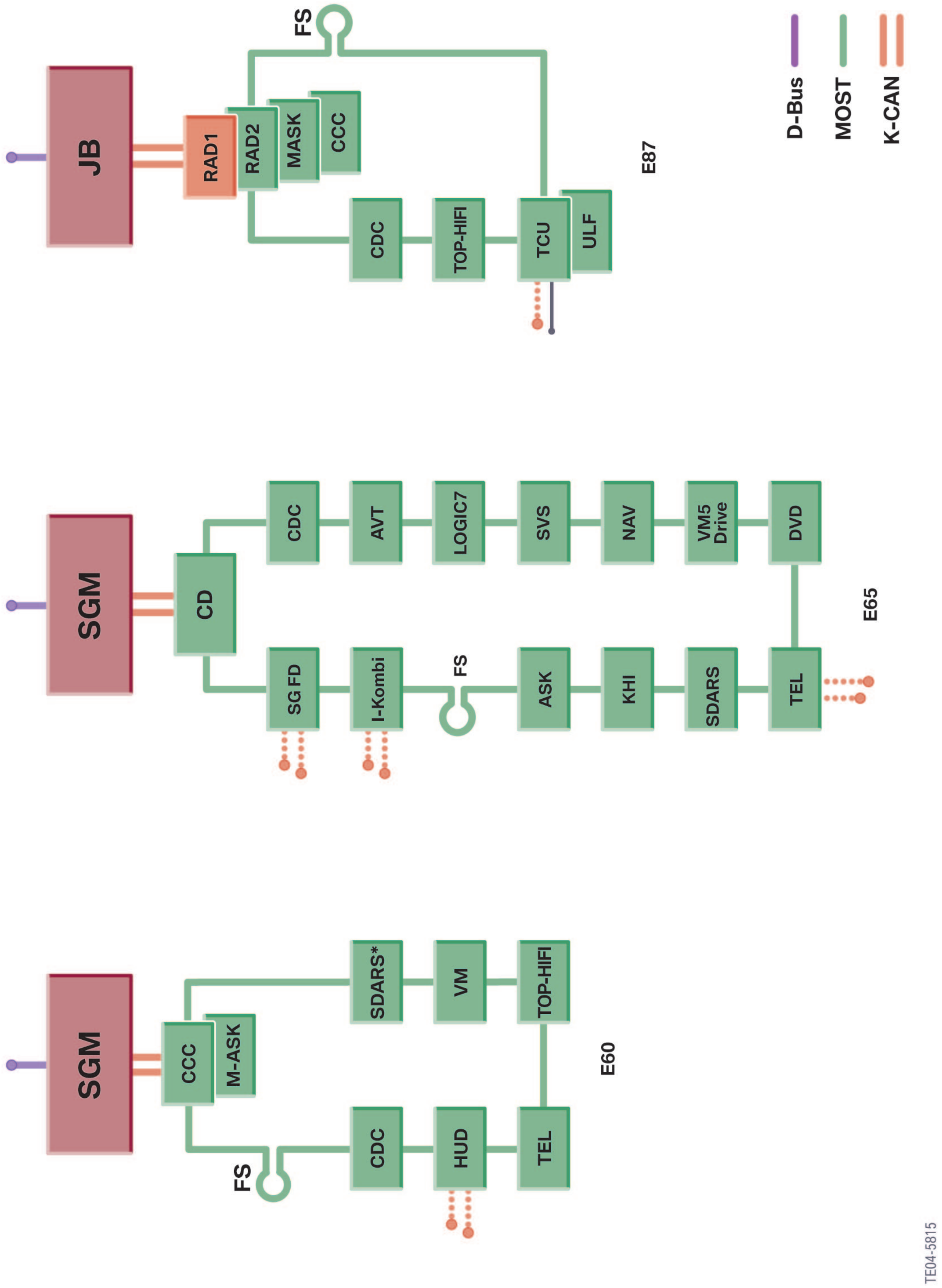
During the course of further development, the number of multimedia components in the vehicle increased along with their enormous expansion in terms of the scope of functions.

The new logic interconnection and networking of the components gives rise to an enormous increase in system complexity.

Since this new dimension of system complexity can no longer be managed with the familiar bus systems, a new bus technology is required: MOST.

MOST

The following pages show an overview of the MOST system in individual BMW vehicles.



1 - MOST overview of various BMW vehicles

MOST in the E60:

Index	Description	Index	Description
CCC	Car communication computer	SGM	Safety and gateway module
CDC	CD changer	TEL	Telephone
HUD	Head-up display	TOP-HIFI	TOP HiFi amplifier
M-ASK	Multi-audio system controller	VM	Video module
SDARS	Satellite digital audio receiver service		

MOST in the E65:

Index	Description	Index	Description
ASK	Audio system controller	NAV	Navigation
AVT	Antenna amplifier/tuner	SDARS	Satellite digital audio receiver service
CD	Control display	SG FD	Control unit for rear display
CDC	CD changer	SGM	Safety and gateway module
DVD	Digital versatile disk	SVS	Voice recognition system
Kombi	Instrument cluster	TEL	Telephone
LOGIC7	Amplifier	VM5Drive	Video module

MOST in the E87:

Index	Description	Index	Description
CCC	Car communication computer	RAD2	Radio 2 (BMW Professional)
CDC	CD changer	TCU	Telematics control unit
JB	Junction box	TOP-HIFI	TOP HiFi amplifier
M-ASK	Multi-audio system controller	ULF	Universal charging and hands-free facility
RAD1	Radio 1 (BMW Audio/ Business CD)		

Fundamentals

The MOST is designed as an optical ring. Various types of data are transmitted (control, audio and graphics data) and data services (SMS, TMC etc.) are made available.

The MOST bus is designed as a ring structure and uses light pulses for transmitting data. Data transmission takes place only in one direction. Fibre optics conductors are used as the data transmission medium.

MOST combines the individual components to form one central unit.

As a result, the components interact to a greater extent. The plug&play principle enables simple system expansion with individual components.

MOST is capable of controlling function that are distributed in the vehicle and to manage them dynamically.

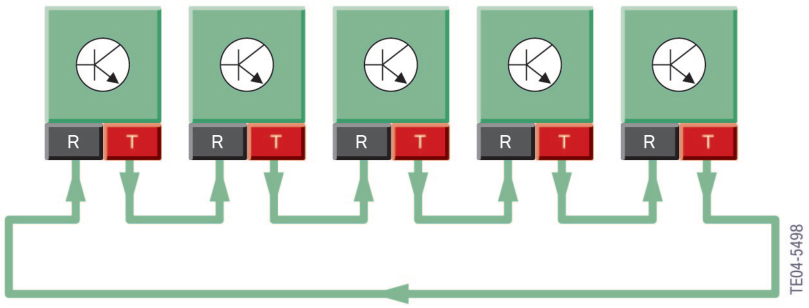
An important feature of a multimedia network is that it not only transports control data and sensor data.

Features

- High data rates: 22.5 MBits/s
- Synchronous/asynchronous data transmission
- MOST assigns the control units nodes in the bus
- Fibre optics conductors as data transmission medium
- Ring structure

The MOST not only represents a network in the conventional sense but it also provides integrated technology for multimedia and network control.

Ring structure



1 - Ring structure of a network

Index	Description	Index	Description
R	Receiver	T	Transmitter

Each terminal device (node, control unit) in a network with a ring structure is connected by means of a cable ring.

A message indicating that transmission is possible circulates on the ring. This message is read and passed on by each node (control unit).

When a node wishes to send data, it changes the ready-to-send message to an "occupied" message. It then adds the address of the receiver, an error handling code and the data.

To ensure the signal strength is retained, the node, through which the data package passes through, generates the data once again (repeater).

The node that is addressed as the receiver copies the data and forwards them in the circuit. If the data reach the transmitter again, it removes the data from the ring and resets the ready-to-transmit message.

Specifically: The physical light direction runs from the master control unit (e.g. multi-audio system controller) to the fibre optics conductor connector and from here to the control units (e.g. CD-changer in the luggage compartment). The light then returns from the last control unit back via the flash connector to the master.

Advantages:

- Distributed control
- Large network expansion

Disadvantages:

- Intricate troubleshooting
- Malfunctions cause network failure
- Intricate and extensive wiring

Data transmission

Each MOST control unit can send data on the MOST bus. Only the master control unit can initiate data exchange between the MOST bus and other bus systems.

In order to meet the various requirements of the different data transmission applications, each MOST message is divided into 3 parts:

- Control data: e.g. light intensity (luminosity) control
- Asynchronous data: e.g. navigation system, vector representation
- Synchronous data: e.g. audio, TV and video signals

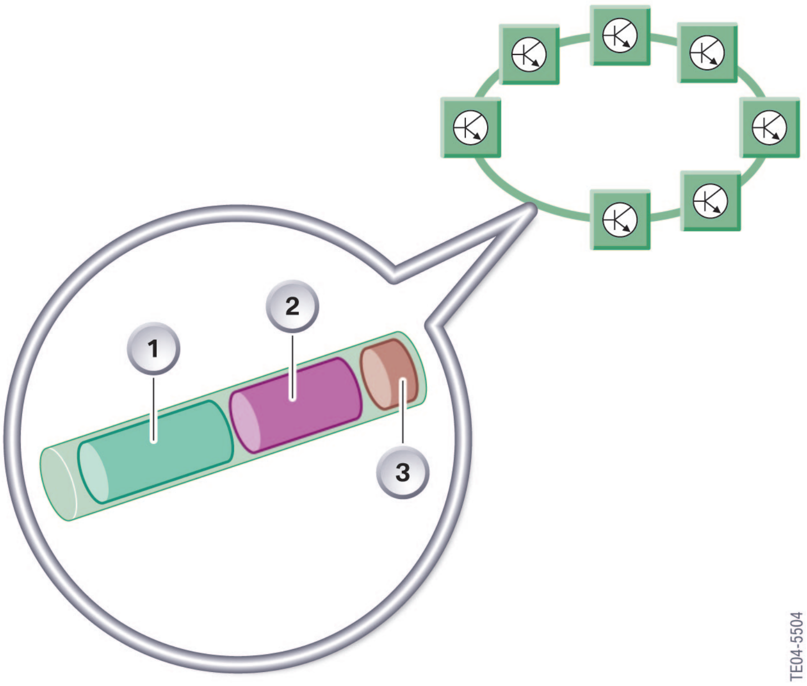
The MOST bus has a ring structure. The various channels (synchronous channel, asynchronous channel and control channel) are transmitted synchronously on a medium. The data are available in the entire ring, i.e. the data are read non-destructively (copied) and can therefore be used by the various components.

The structure of the MOST bus enables easy expansion of the system with further components. The installation location of the components in the ring depends on the specific function. There is no need to operate a reserve for future systems (e.g. double coil speakers).

The receiver and transmitter are connected with each other in the event of a component failing. The ring therefore remains operative. The receiver and transmitter are separated only if one control unit is supplied with power. These two units are completely operative together with the transmit and receive system.

NetService disassembles the data packages in individual parts and reassembles them.

The receiver and transmitter are a BMW development in co-operation with Infineon and Oasis. The information is transmitted by light pulses with a wave length of 650 nm (visible red light). No laser but rather an LED is used to generate the light. The bus can be woken optically, i.e. an additional wake-up line is not required. The power intake in sleep mode is very low.



2 - Data transmission on the MOST-bus

Index	Description	Index	Description
1	Synchronous data	3	Control data
2	Asynchronous data		

Control channel

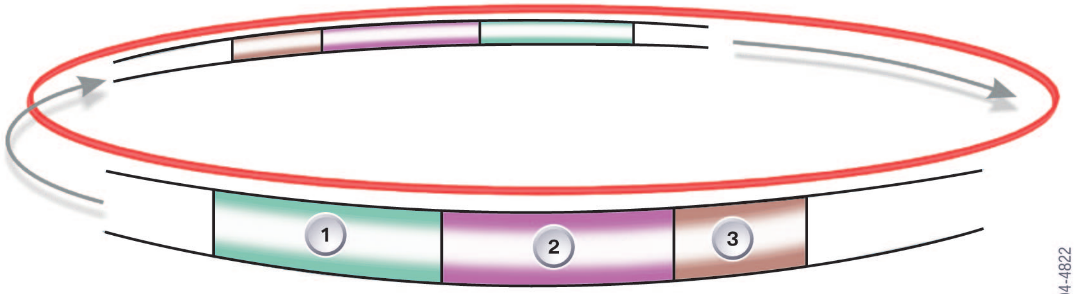
Control signals such as for volume control and diagnosis data are sent via the control channel.

Synchronous channel

The synchronous channel is reserved mainly for sending audio data.

Asynchronous channel

The asynchronous channel transmits graphics data from the navigation system such as for map presentation and direction arrows.



3 - Data flow in MOST system network

Index	Description
1	Synchronous channel
2	Asynchronous channel
3	Control channel

Connection of control units

The connection between the individual control units is provided by a ring bus that transports the data only in one direction.

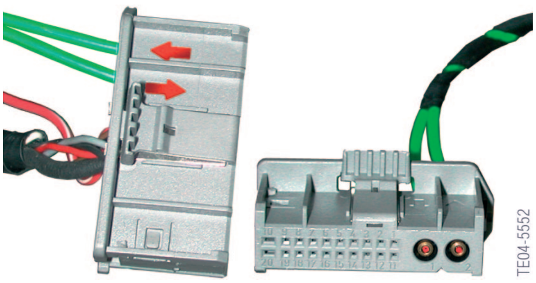
This means that a control unit always has two fibre optics conductors, i.e. one for the transmitter and one for the receiver.

A pure fibre coupling is used in MOST control units. In this way, together with the fibres in the control unit, the transmit and receive diodes can be positioned at any point in the control unit.

As a result, the fibre areas can be set back in the wiring harness connector, thus rendering additional protection for the sensitive end faces unnecessary.

The 2-pole fibre optics conductor module is identical for all types of connector. The parts family and contact parts have been declared as the standard within the MOST co-operation.

Pin 1 is always designated for the incoming fibre optics conductor and pin 2 for the transfer fibre optics conductor.



4 - Connector for fibre optics conductor

Registering the control units in MOST

The control units installed on the MOST bus are stored in a registration file in the master control unit. This information is stored during production and when control units are retrofitted, after programming the control unit.

The control units and their order on the MOST bus are stored in this registration file. The BMW diagnosis system uses the registration file to determine what control units are installed and their sequence on the bus.

When they start up, all control units of the MOST bus send their identifier to the master control unit. In this way, the master control unit detects what control units are connected to the MOST bus. If the logon fails from one or several control units, it is thus possible to locate the fault during diagnosis.

Bandwidths

The bandwidth indicates the capacity of the network, i.e. how many data items can be transmitted simultaneously.

The bandwidth differs considerably in the various applications.

The aim is that in the near future all vehicle occupants will be able to call up different services simultaneously, e.g.

- The driver calls up navigation information
- The front passenger listens to the radio
- A rear passenger listens to a CD
- The other rear passenger watches a DVD

Application	Bandwidth	Data format
AM-FM	1.4 MBits/s	Synchronous
MC	1.4 MBits/s	Synchronous
CD	1.4 MBits/s	Synchronous
MD	1.4 MBits/s	Synchronous
Telephone	1.4 MBits/s	Synchronous
SBS	1.4 MBits/s	Synchronous
Television	1.4 MBits/s	Synchronous
VCD	1.4 MBits/s	Synchronous
DVD	2.8 - 11 MBits/s	Synchronous/asynchronous
Navigation	250 kBits/s	Asynchronous
	1.4 MBits/s	Synchronous
Telematics service	Various	Synchronous

The data transmission rate of 1.4 MBits/s for audio data is derived from a scanning frequency of 44.1 kHz per channel (two channels for stereo) and a resolution of 16 bit.

The bandwidth of the MOST of 22.5 MBits/s is used in time multiplex by synchronous channels, asynchronous channels and control channels. The division in synchronous and asynchronous channels takes place to suit requirements.

Channels for control information have a smaller bandwidth of 700 kBits/s. This corresponds to approximately 2700 telegrams per second. At present there is no device that can accept and process even a third of this number of telegrams per second.

In future, the MOST will be equipped with a data transmission rate of 50-150 MBits/s.

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Sub-bus systems

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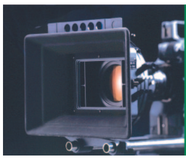
What are sub-busses? 1



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What are sub-busses?

Sub-busses are also used in addition to the bus systems. Sub-bus systems are subordinate serial bus systems.

The most important sub-bus systems are outlined below:

- LIN-bus (Local Interconnect Network Bus)
- BSD (Bit-Serial Data Interface)
- M-bus
- K-bus protocol

Data rates

Sub-bus	Data rate	Bus structure
BSD	9.6 kBits/s	Linear, single-wire
K-bus protocol	9.6 kBits/s	Linear, single-wire
M-bus	9.6 kBits/s	Linear, single-wire
LIN bus	9.6 - 19.2 kBits/s	Linear, single-wire

LIN-bus

The LIN-bus was developed to provide a standard network for the automobile industry.

Standardization saves costs in:

- Development
- Production
- Vehicle servicing

Components

The LIN-bus system comprises the following components:

- Higher-ranking control unit (master)
- Lower-ranking control units (slaves)
- Single-wire line

A bidirectional single-wire bus line serves as the transmission medium for the LIN-bus. The bus protocol is divided strictly hierarchically in master and slaves. A maximum of one master is permitted for a LIN-bus system.

The data transmission rate of the LIN-bus can be up to 19.2 kBits/s.

The following transmission speeds are possible:

- 2.4 kBits/s
- 9.6 kBits/s
- 19.2 kBits/s

Installation location

The LIN-bus is currently installed in the following systems:

- Air conditioning (9.6 kBits/s)
- Between the driver's door module and driver's door switch cluster (19.2 kBits/s)
- Tyre pressure control (9.6 kBits/s)

LIN-bus master

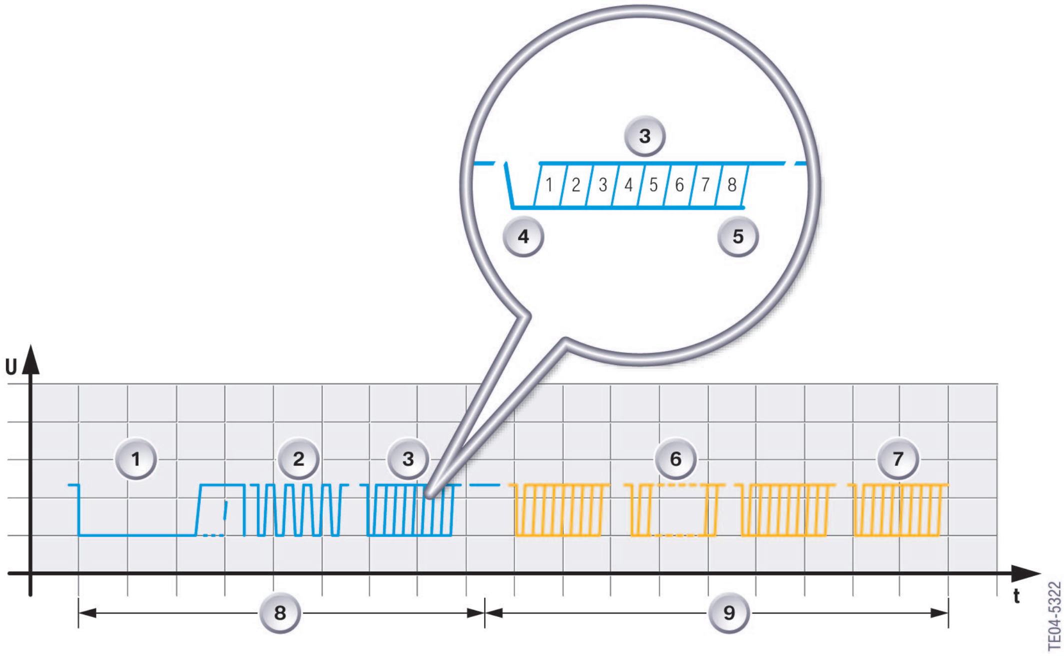
The control panel of the air conditioning system is the LIN-bus master.

The LIN-bus master forwards the requests of the control unit to the slaves (lower-ranking or subordinate control units) in its system.

The LIN-bus master controls and monitors the message traffic on the bus line.

Each message begins with the LIN-bus master sending a message header. This message header consists of a synchronization phase (synchronization pause and synchro byte) followed by the identifier byte.

Data transmission can be 2, 4 or 8 bytes long.



1 - Message structure LIN-bus

Index	Description	Index	Description
1	Synchronization pause	6	Data field
2	Synchronization range	7	Checksum
3	Identifier	8	Message header
4	Start	9	Message body
5	Stop		

The identifier byte contains the following information:

- Address of the slave
- Message length
- Two bits for data safeguarding

The identifier determines whether the master sends data to the slave or whether it expects an answer from the slave. The main body contains the message for the slave. The checksum is located at the end of the message.

The checksum ensures effective data safeguarding during transmission. The checksum is created by the master via the data bytes and is attached at the end of the message.

The current messages are transmitted cyclically by the LIN-bus master.

LIN-bus slave

LIN-bus slaves of the air conditioning system are:

- Actuator motors for the air distribution flaps
- Blower regulator
- Electric auxiliary heater

The LIN-bus slaves wait for commands from the LIN-bus master and communicate with it only on request.

Q LIN-bus slave can send the wake-up sequence of its own accord in order to end sleep mode.

The LIN-bus slaves are installed in the users of the LIN-bus system (e.g. stepper motors for fan flap adjustment).

K-bus protocol and M-bus

K-bus protocol as well as the M-bus are technically of the same design as the K-bus. In contrast to the K-bus, the K-bus protocol does not have diagnosis capabilities.

K-bus protocol

In the same was as the K-bus, the K-bus protocol consists of the following components:

- Transmitter
- Receiver
- Single-wire line

Data transmission is in only one direction, i.e. unidirectional:

The transmission rate is 9.6 kBits/s.

The K-bus protocol is currently used for following systems:

- Multiple restraint system
- Telematics control unit (emergency call)
- Seat occupancy detection
- Electronic outer door handle module
- Driver's door
- Antitheft alarm system

The K-bus protocol connects the electronic outer door handle module of each door and the car access system. Among other things, waking up the entire bus system (e.g. by children playing with the door handle) is prevented via this bus.

The K-bus protocol transfers the signals from the driver's door switch cluster to the door module (e.g. power window, roller sun blind functions).

The antitheft alarm system function is distributed over both control units (antitheft alarm system and emergency current siren). The K-bus protocol facilitates communication between these control units.

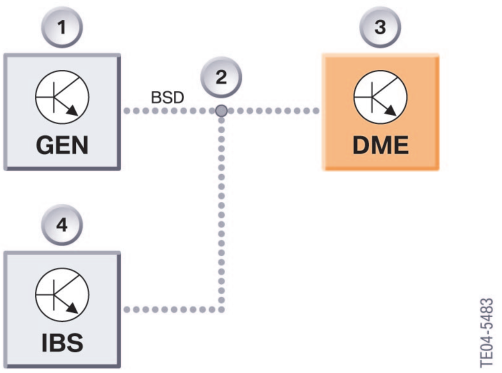
M-bus

Data transmission on the M-bus is unidirectional also at a rate of 9.6 kBits/s.

The M-bus was used for the air conditioning system.

Bit-serial data interface

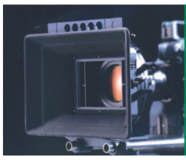
The bit-serial data interface is used to connect the alternator and the intelligent battery sensor to the digital motor electronics.



2 - Overview of bit-serial data interface

Index	Description
1	Alternator
2	Bit-serial data interface
3	Digital motor electronics
4	Intelligent battery sensor

Contents
Gateway



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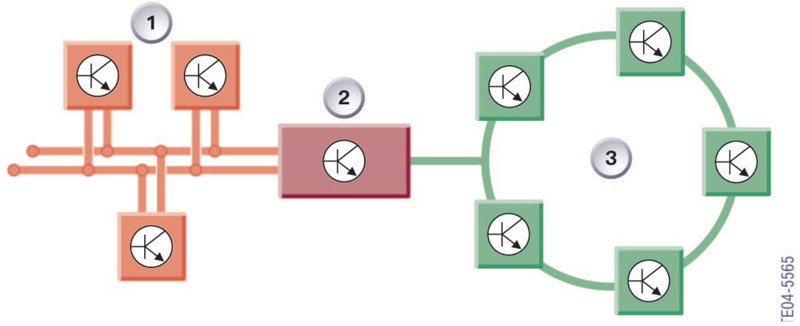
Data exchange

Gateways serve the purpose of coupling different types of bus systems, i.e. gateways connect bus systems with different logic and physical properties.

They therefore ensure data exchange despite the different transmission rates of the individual bus systems.

A gateway performs a dual function:

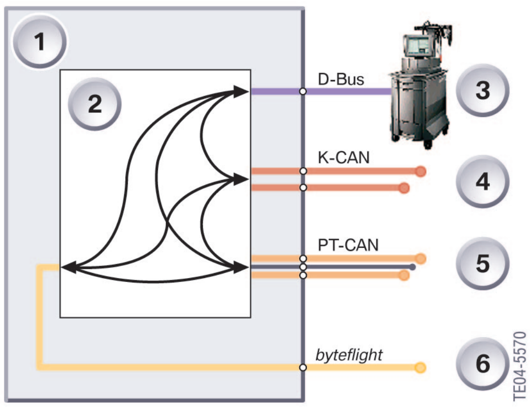
- To collect information from various different networks
- To send information to the correct network



1 - Example of a gateway connection

Index	Description	Index	Description
1	Linear bus system (e.g. K-CAN)	3	Ring-structure bus system (e.g. MOST)
2	Gateway (e.g. M-ASK)		

The data transmitted by the different bus systems reach the gateway. Transmission rates, data volume and priority stages of the individual messages are filtered in the gateway and buffered if necessary.



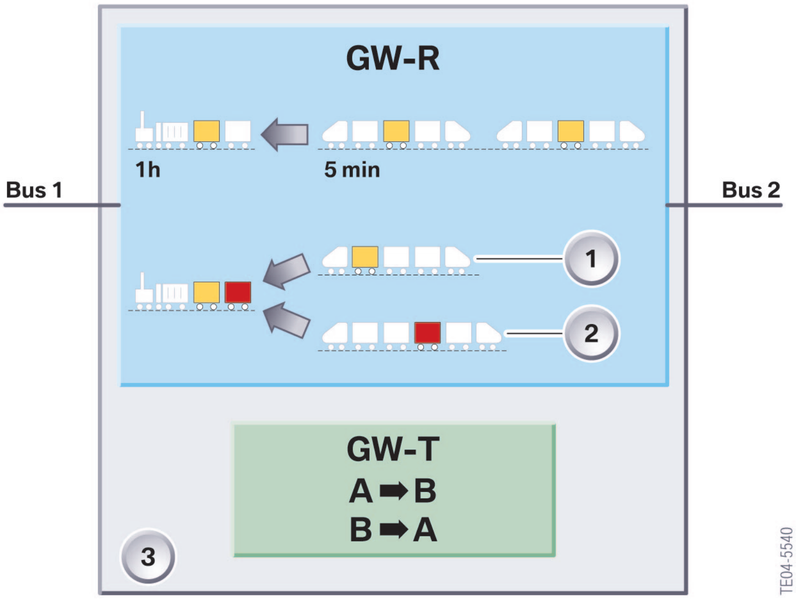
2 - Communication paths in the gateway

Index	Description
1	Gateway
2	Message preparation
3	Diagnosis and information system
4	Body Controller Area Network
5	Power Train Controller Area Network
6	***byteflight***

The gateway converts the messages to suit the respective bus system based on gateway rules and conversion tables.

The respective bus system is now served and the messages reach their target address. If necessary, messages that are not so important remain in the gateway memory. These remaining messages are then sent later.

Gateway rules



3 - Gateway rules based on the example of a train station

Index	Description	Index	Description
GW-R	Gateway rules	Bus 2	Slow bus
GW-T	Gateway table	A -> B	Table example: Message from A to B
1	Train 1 with yellow message	B -> A	Table example: Message from B to A
2	Train 2 with red message	5 min	5-minute intervals
3	Gateway	1 h	1-hour interval
Bus 1	Fast bus		

The express train 1 arrives at the station in 5-minute intervals. This train has a message (yellow) for the train with the steam locomotive. The message is transferred to the first wagon of the train with the steam locomotive.

In the meantime, an express train 2 arrives with a message (red) for the train with the steam locomotive. Since the steam locomotive has not yet departed, the second message is also transferred to the steam locomotive and attached after the first wagon. This procedure is repeated until the train with the steam locomotive leaves the station after one hour.

The messages is parked in the station when the train with the steam locomotive is fully loaded. When available, a new train with a steam locomotive is loaded with these messages.

Gateways

In BMW vehicles, the gateway function is installed in the following control units:

- Central gateway module (ZGM)
- Safety and gateway module (SGM)
- Multi-audio system controller (M-ASK)
- Car access system (CAS)
- Control display (CD)
- Instrument cluster

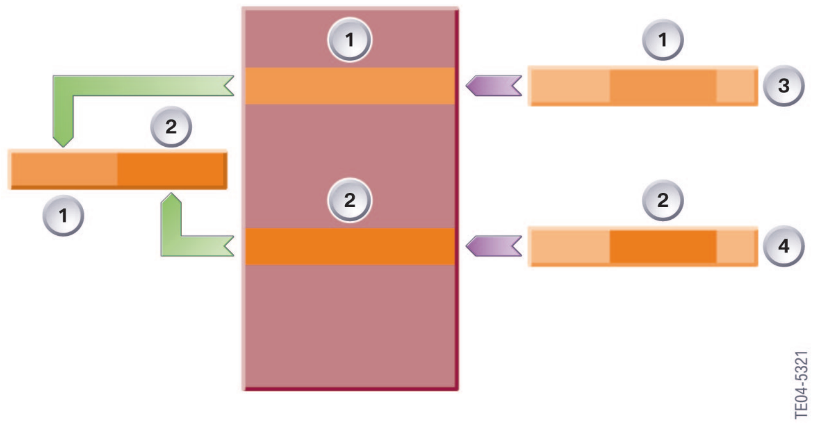
Example - central gateway module

The control units of the dynamic stability control (DSC) and the digital motor electronics (DME) each send a message on the PT-CAN. The messages reach the central gateway module via the PT-CAN.

The messages of the PT-CAN are stored in a gateway buffer. These messages are converted in the gateway based on certain gateway rules and conversion tables for the bus K-CAN system.

Both messages are joined together since the bus K-CAN system is slower than the PT-CAN.

The messages now reach their destinations via the bus K-CAN system.



4 - Transferring messages from DME and DSC to the K-CAN

Index	Description	Index	Description
1	Message from dynamic stability control	3	Signal of dynamic stability control (speed)
2	Message from digital motor electronics	4	Signal of digital motor electronics (engine speed)

Summary
Bus systems

Brief review of all topics

The most important information on the BMW bus systems is summarized in the following.

This list outlines the main topics in concise form, providing a quick check of the main points of this Participant's Manual.

Fundamentals

Bus systems are used in BMW vehicles to interconnect and network the individual control units.

The digital data, bits and bytes are transmitted in serial form over the individual busses.

This data transmission can take place in one direction, alternately in both directions or simultaneously in both directions.

K-Bus

The K-bus is one of the first bus systems to be installed in BMW vehicles.

Using only one single line, the K-bus transmits its data at a speed of 9.6 kBits/s. Data transmission is asynchronous.

K-CAN

The K-CAN is a very efficient event-controlled bus. Its transmission rate is 100 kBits/s in the area of the vehicle body.

By using a twisted two-wire line, the K-CAN features improved electromagnetic compatibility, thus ensuring considerably higher data transmission reliability.

The CAN protocol additionally features various mechanisms for error detection and correction.

PT-CAN

Compared to the K-CAN, at 500 kBits/s the PT-CAN is the faster bus system. For this reason, the PT-CAN is used in the area of the drive train and vehicle chassis.

The PT-CAN additionally features a third line that functions as the wake-up line.

Fibre optics conductor

Fibre optics conductors transport data with the aid of light.

They exhibit very good electromagnetic compatibility. For this reason, fibre optics conductors are particularly suitable for transmitting high data rates.

byteflight

byteflight is a star-structured bus system that transmits data via fibre optics conductors at a rate of 10 MBits/s.

Since the ***byteflight*** combines the advantages of synchronous and asynchronous data transmission, it is used in safety-related areas such as the airbag systems.

MOST

The MOST system has a ring structure and at a data rate of 22.5 MBits/s it is currently the fastest bus used in BMW vehicles.

Thanks to its high data throughput rate, MOST is particularly suitable for data transmission of multimedia components.

It is characterized by its ease of expansion.

Data are transmitted synchronously as well as asynchronously in this bus system.

Sub-bus systems

Sub-bus systems are subordinate bus systems with a data rate of 9.6-19.2 kBits/s.

The sub-bus systems transmit data in linear form on only one line.

The most important sub-busses are:

- LIN bus
- K-bus protocol
- Bit-serial data interface
- M-bus

Gateway

Gateways serve the purpose of coupling different types of bus systems.

For example, gateways enable data transfer from a slow bus system to a faster bus system.

They co-ordinate data traffic similar to a train station.

Abbreviations

ABS	Anti-lock braking system
ACC	Active cruise control
AHL	Adaptive headlight
AM	Amplitude modulation
ARS	Dynamic Drive
ASK	Audio system controller
CAN	Controller area network
CCC	Car communication computer
CD	Compact disc
CDC	CD changer
CID	Central information display
CVM	Convertible soft top module
DDE	Digital diesel electronics
DME	Digital engine electronics
DSC	Dynamic stability control
DVD	Digital versatile disk
EGS	Electronic transmission control unit
EKP	Electric fuel pump
EMF	Electromechanical parking brake
EMV	Electromagnetic compatibility
EPS	Electromechanical power steering
FM	Frequency modulation
HUD	Head-up display
ID	Identification feature
IHKA	Integrated automatic heating/air conditioning
JB	Junction box, junction box control unit
K-Bus	Body bus
K-CAN	Body Controller Area Network
KOMBI	Instrument cluster
LED	Light emitting diode
LSZ	Light switch cluster
LWS	Steering angle sensor
M-ASK	Multi-audio system controller
MD	Mini-disc
NAV	Navigation
PDC	Park Distance Control
PT-CAN	Power Train Controller Area Network
RLS	Rain/driving light sensor
SBSL	B-pillar satellite, left

SBSR	B-pillar satellite, right
SDARS	Satellite digital audio radio service
SFZ	Vehicle centre satellite
SIM	Safety and information module
	Subscriber identification module
SM	Seat module
SMG	Sequential manual transmission
	Sequential M transmission
SMS	Short Message System
SSFA	Driver's seat satellite
STVL	Front left door satellite
STVR	Front right door satellite
SVS	Voice recognition system
SZL	Steering column switch cluster
SZM	Centre console switch centre
TCU	Telematics control unit
TMC	Traffic message channel
ULF	Universal charging/hands-free facility
VM	Video module
ZGM	Central gateway module

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