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F01 Bus Systems

Initial Print Date: 01/09 Revision Date: 11/09

Subject **Page**

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Bus Systems

Model: F01/F02

Production: From Start of Production

OBJECTIVES

After completion of this module you will be able to:

- Understand the changes to the bus systems on the F01/F02
- Understand the expansion of FlexRay
- Understand the use of Ethernet in the F01/F02
- Understand LIN-Bus changes

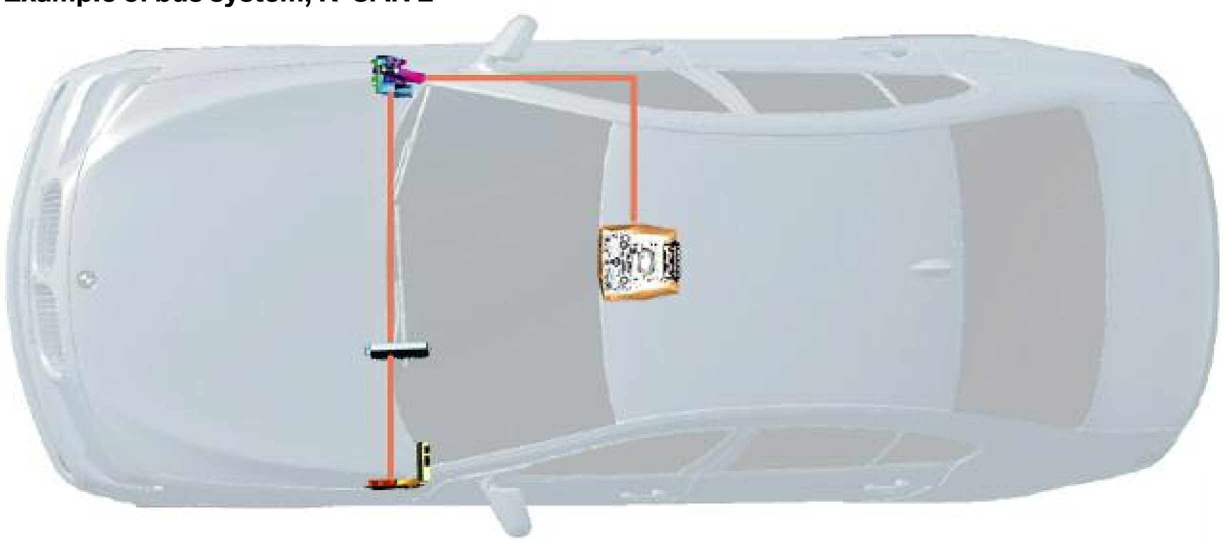
Introduction

Bus Systems F01/F02

In order to integrate the latest electronic features, there have been numerous developments to the bus network as compared to the previous 7-series (E65). Continuing with the philosophy of "distributed functions", there has been more consolidation of various functions. Some bus systems, such as ***byteflight,*** have been eliminated while recent developments such as FlexRay have been expanded. The following innovations have been implemented in the bus systems in the new BMW F01/F02:

- Powertrain CAN PT-CAN has been expanded to include a second PT-CAN 2 bus.
- K-CAN has been expanded to include a second K-CAN 2 bus with 500 kBits/s.
- FlexRay has been expanded and has replaced the F-CAN
- Ethernet has been adopted for faster programming access
- LIN-Bus system with extended functions.

Example of bus system, K-CAN 2

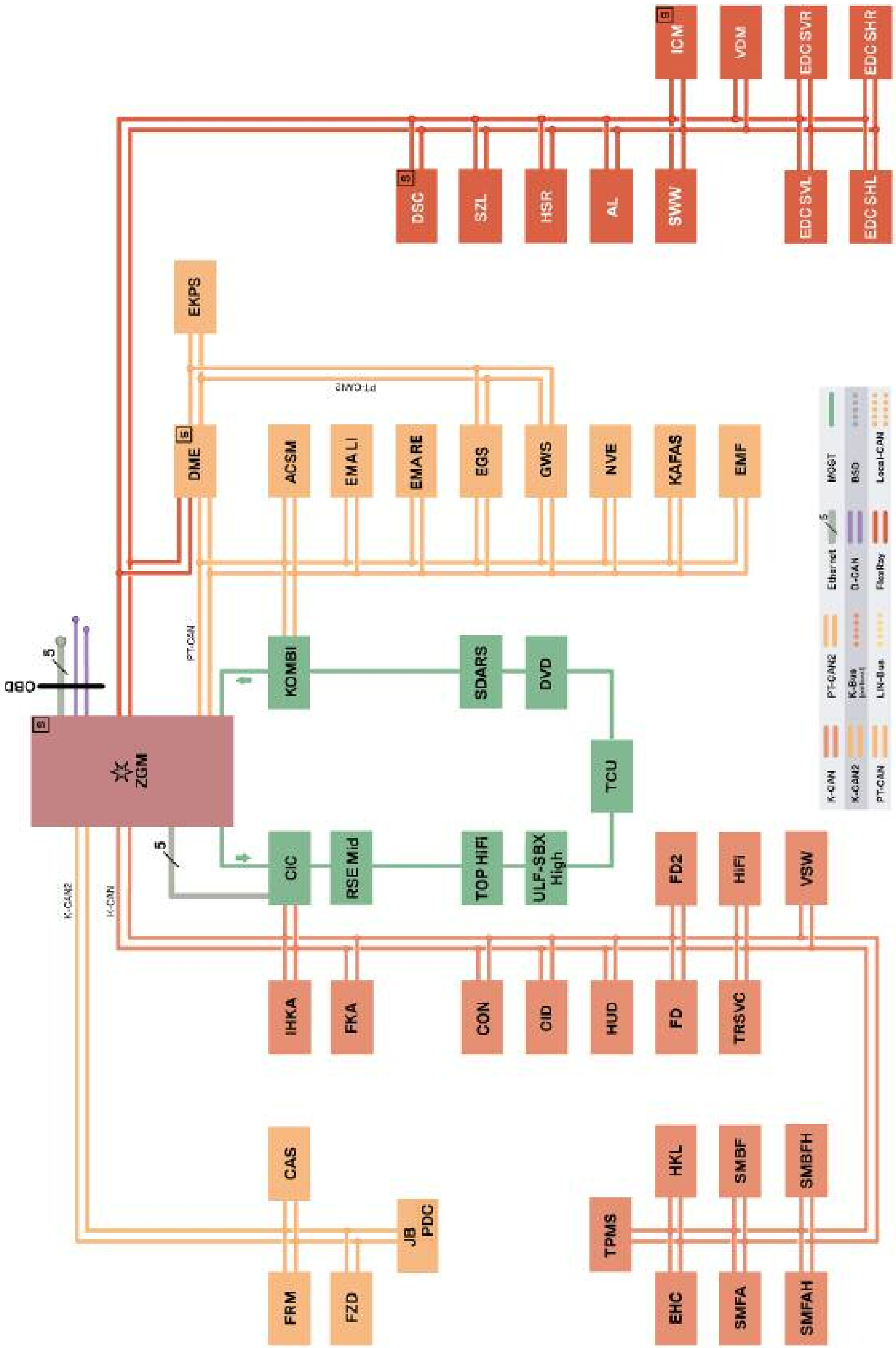


Structure in Vehicle

With deployment of the central gateway module (ZGM), the F01/F02 has a newly linked bus structure. The engine management and chassis control systems are linked across the PT-CAN (or PT-CAN 2) and the FlexRay bus system to the central gateway module (ZGM). The control units of the general vehicle electrics are connected across the K-CAN and K-CAN 2.

The MOST is the information carrier for the majority of control units in the area of information and communication technologies. The vehicle diagnosis communicates across the D-CAN. The vehicle is programmed / encoded via the Ethernet access point. The sub-bus system LIN has other links.

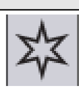
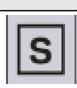
Overall Bus Overview F01/F02



Index	Explanation
ACSM	Advanced Crash Safety Module
AL	Active steering
CAS	Car Access System (CAS 4)
CIC	Car Information Computer
CID	Central information display
CON	Controller
DME	Digital Motor Electronics
DSC	Dynamic Stability Control
DVD	Digital video disc
EDC SHL	Electronic damper control, satellite rear left
EDC SHR	Electronic damper control, satellite rear right
EDC SVL	Electronic damper control, satellite front left
EDC SVR	Electronic damper control, satellite front right
EGS	Electronic transmission control
EHC	Electronic height control
EKPS	Electrical fuel pump
EMA LI	Electrically motorized reel, left, (seat belt)
EMA RE	Electrically motorized reel, right, (seat belt)
EMF	Electromechanical parking brake
FD	Rear display
FD2	Rear display 2
FKA	Rear compartment heating/air conditioning
FLA	High-beam assistant
FRM	Footwell module
FZD	Roof functions center
GWS	Gear selector lever
HiFi	HiFi amplifier
HKL	Trunk lid lift
HSR	Rear-axle drift angle control (Rear steering control module)
HUD	Head-up Display
ICM	Integrated Chassis Management
IHKA	Integrated heating and air conditioning
JB	Junction box electronics
KAFAS	Camera assisted driver assistance systems
KOMBI	Instrument cluster
NVE	Night Vision electronics
PDC	Park Distance Control
OBD	On board diagnostic connector

Index	Explanation
RSE-Mid	Rear seat entertainment (Mid)
SDARS	Satellite radio
SMBF	Seat module, passenger
SMBFH	Seat module, passenger rear
SMFA	Seat module, driver
SMFAH	Seat module, driver side rear
SWW	Lane change warning (Active blind spot detection)
SZL	Steering column switch cluster
TCU	Telematics control unit
TOP-HIFI	Top-HiFi amplifier
TPMS	Tire Pressure Monitoring System
TRSVC	Top Rear Side View Camera Module (for rear/side view camera)
ULF-SBX High	Interface box - high version
VDM	Vertical dynamics management
VSW	Video switch
ZGM	Central gateway module

Key to abbreviations - bus overview

Index	Explanation
BSD	Bit-serial data interface
D-CAN	Diagnosis-on CAN
Ethernet	Fast data protocol
FlexRay	FlexRay bus system
K-CAN	Body CAN
K-CAN 2	Fast body CAN (500 KB)
LIN	Local Interconnect Network
Local CAN	Local CAN bus (in the F01/F02 for environment sensors)
MOST	Media Oriented System Transport
PT-CAN	Powertrain CAN
PT-CAN 2	Powertrain CAN 2
WUP	Wake-up line
	Star coupler - distributor for the FlexRay connections in the central gateway module.
	Startup node -control units responsible for starting up and synchronizing the FlexRay bus system.

Overall Network of the F01/F02

The overall network in the F01/F02 consists of various bus systems that enable communication between the individual control units. In view of the increasing interconnection of the control units, it is possible to use the sensors of one system throughout the network.

The sensors are connected to the control unit that initially requires the information logic-based and virtually in real time. This information, however, can also be made available to other control units.

Using the example of the vertical dynamics management (VDM), initially, the VDM control unit picks up the ride-height levels of the wheels using height-level sensors.

The automatic headlight vertical aim control can also use this information for the purpose of adapting the beam throw of the headlights. The VDM makes available the information via the corresponding bus systems (VDM -FlexRay - ZGM - K-CAN 2 - FRM) to the footwell module.

Apart from the Ethernet, all bus systems in the F01/F02 are already known from other BMW models. This section provides an overview of all bus systems of the F01/F02.

This Product Information contains a detailed description of the Ethernet system, of the FlexRay bus and of the LIN-Bus sub-bus system.

Overview of Bus Systems

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

- Main bus systems such as Ethernet, FlexRay, KCAN, K-CAN 2, MOST, PT-CAN and PTCAN 2
- Sub-bus systems such as BSD, D-CAN, LIN, Local-CAN.

Main-bus systems are responsible for the data exchange between the control modules throughout the vehicle system. This includes system functions such as diagnosis, programming and encoding.

Sub-bus systems exchange data within one function group.

For example, the data of the rain-light-solar condensation sensor are read in by the junction box electronics, processed and forwarded to the wiper module. The connection between the control units of the rain-light-solar-condensation sensor and junction box electronics is a sub-bus and designed as a LIN-Bus.

Main Bus Systems

Main-bus system	Data rate	Bus topology
D-CAN (diagnosis-on CAN)	500 kBit/s	Linear, two-wire
Ethernet	100 MBit/s	Linear
FlexRay	10 Mbits/s	Mixed topology, two-wire (see section dealing with FlexRay)
K-CAN (body CAN)	100 kBit/s	Linear, two-wire, single-wire mode possible for emergency operation
K-CAN 2 (fast body CAN)	500 kBit/s	Linear, two-wire
MOST (Media-Oriented System Transport bus)	22.5 MBit/s	Ring, optical fiber
PT-CAN (chassis CAN)	500 kBit/s	Linear, two-wire
PT-CAN 2 (powertrain CAN)	500 kBit/s	Linear, two-wire

The main bus systems are responsible for cross-system data exchange.

Changes to main bus systems

The most important changes to the changes systems in the F01/F02 are:

- Ethernet -fast vehicle programming access
- Powering up certain bus systems also possible without wake-up line (new now KCAN 2).

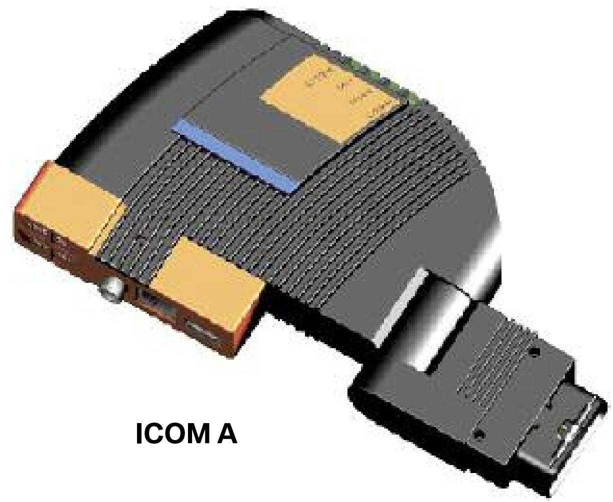
The central gateway module interlinks all the main bus systems.

Diagnosis CAN

After connecting a BMW diagnostic system, the gateway (central gateway module) places the requests of the BMW diagnostic system on the internal buses. The responses undergo the same process in opposite direction.

Only the one new communication protocol will be used for diagnosis. Worldwide, the D-CAN (Diagnostics-on CAN) has replaced the previous diagnostic interface and its protocol which is based on KWP 2000 (Keyword Protocol 2000).

The reason for the changeover was a new legal requirement in the USA requiring that all vehicles be equipped with the D-CAN as from model year 2008. The transitional phase began in September 2006. The E70 was the first vehicle equipped with D-CAN. This modification was then phased in on all new BMW models.



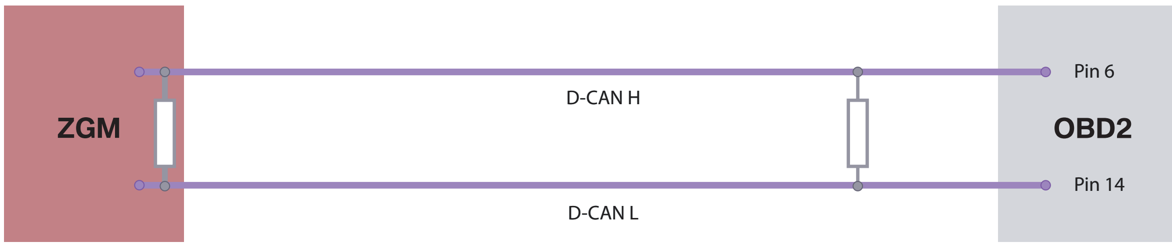
ICOM A

To ensure complete diagnosis for the F01/ F02, an ICOM A is required as diagnosis adapter.

The terminal resistors for the D-CAN are located in the following components:

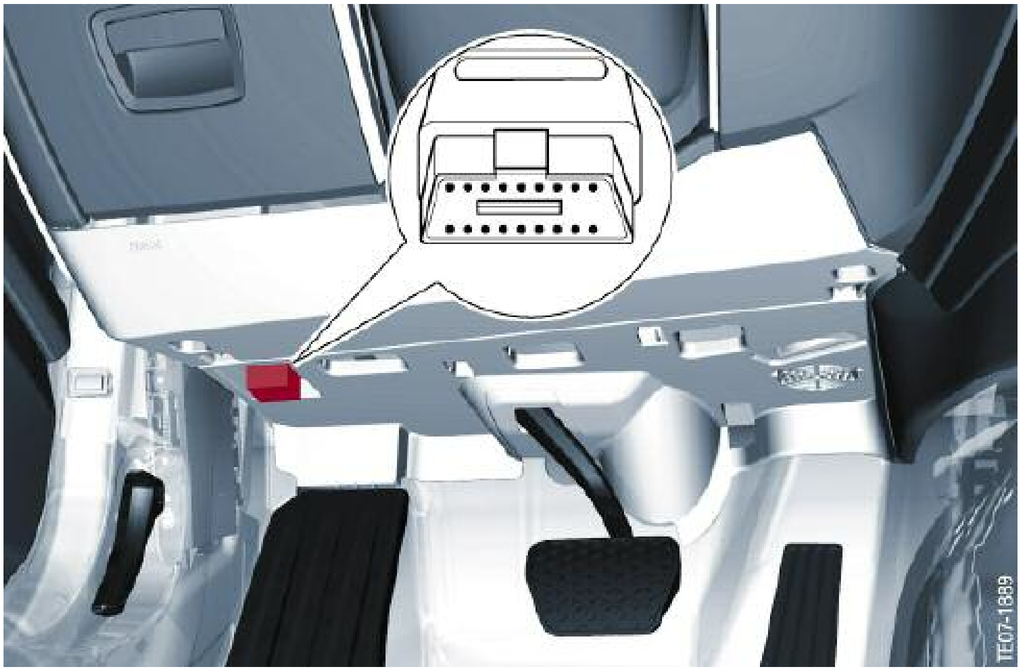
- Central gateway module
- OBD2 connector (on wiring harness side).

Diagnosis access



Location of D-CAN connection

The diagnosis socket is located under the dashboard on the driver's side. The ICOM A is used as the interface to the BMW diagnosis system.



Diagnosis access in vehicle

OBD access in the vehicle will remain unchanged. The pin assignments are as follows:

- 3, 11, 12, 13 = Ethernet connections.
- 16 = Terminal 30
- 5 = Terminal 31
- 14 + 6 = Communication connections
- 8 = activation of Ethernet.

Body CAN
The bus systems used to date are also used in the F01/F02. The K-CAN is responsible for communication of the components with a low data transfer rate. The K-CAN is also connected to the other bus systems via the central gateway module.

The K-CAN is set up as line topology. Some control units in the K-CAN have a LIN-Bus as sub-bus. The K-CAN has a data transfer rate of 100 kBit/s and is designed as a twisted pair of wires. The K-CAN has the possibility to be operated as a single-wire bus in the event of a fault.

The K-CAN control unit is wakened via the bus, without an additional wake-up line.

The following control units are fitted in the KCAN:

- CID Central Information Display
- CON Controller
- EHC, Electronic Height Control
- FD Rear Display
- FD2 Rear Display 2
- FKA, rear heater / air-conditioning system
- HiFi, hi-fi amplifier
- HKL, luggage compartment lid lift
- HUD, Head-Up Display
- IHKA, integrated heater/air conditioning system*
- SMBF passenger seat module*
- SMBFH rear passenger seat module*
- SMFA driver seat module*
- SMBFH rear module on driver' seat side*
- TPMS, Tire Pressure Monitoring System
- TRSVC panoramic camera*
- VSW, video switch
- ZGM, central gateway module.

Body CAN 2

The K-CAN 2 is responsible for communication of the control units with a high data transfer rate. The K-CAN 2 is also connected to the other bus systems via the central gateway module (ZGM). A LIN-Bus as a sub-bus is connected to all control units in the K-CAN 2. The K-CAN 2 can be wakened via any of these sub busses, without an additional (hardwire) wake-up line. This is represented by the "wake authorized" symbol next to all of the control units of K-CAN 2 on the Bus Overview. (See bus chart below).

To provide a rapid start enable, the CAS has an additional redundant bus connection to the DME. On this CAS bus, the data are transferred per K bus protocol.

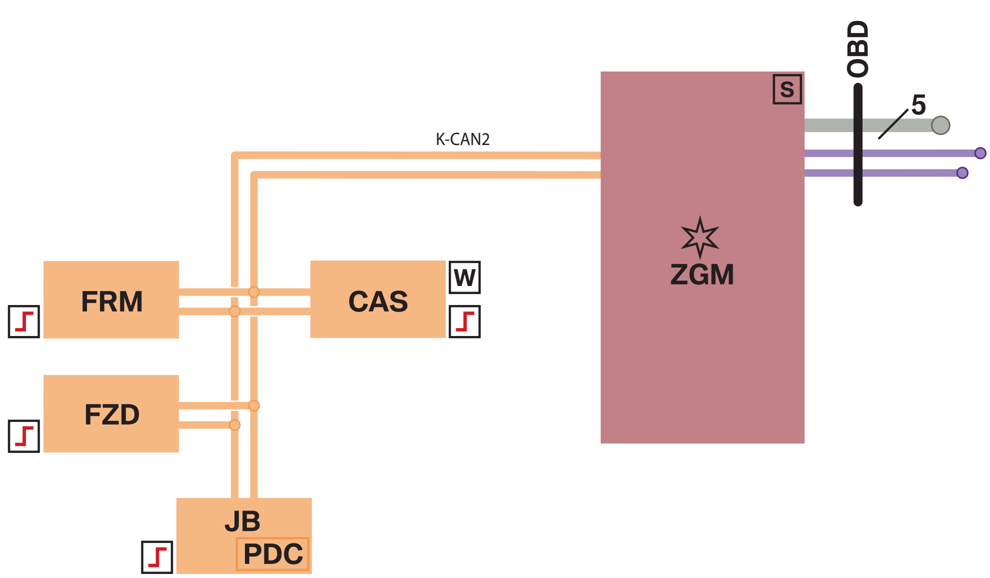
The K-CAN 2 has a data transfer rate of 500 kBit/s and is designed as a twisted pair of wires.

The following control units are fitted in the KCAN 2:

- CAS Car Access System
- FRM, footwell module
- FZD, roof functions center
- JBE, junction box electronics
- PDC, Park Distance Control (integrated in JBE)
- ZGM, central gateway module.

The terminal resistors in the K-CAN 2 are located in the following control units:

- Central gateway module
- Junction box electronics.

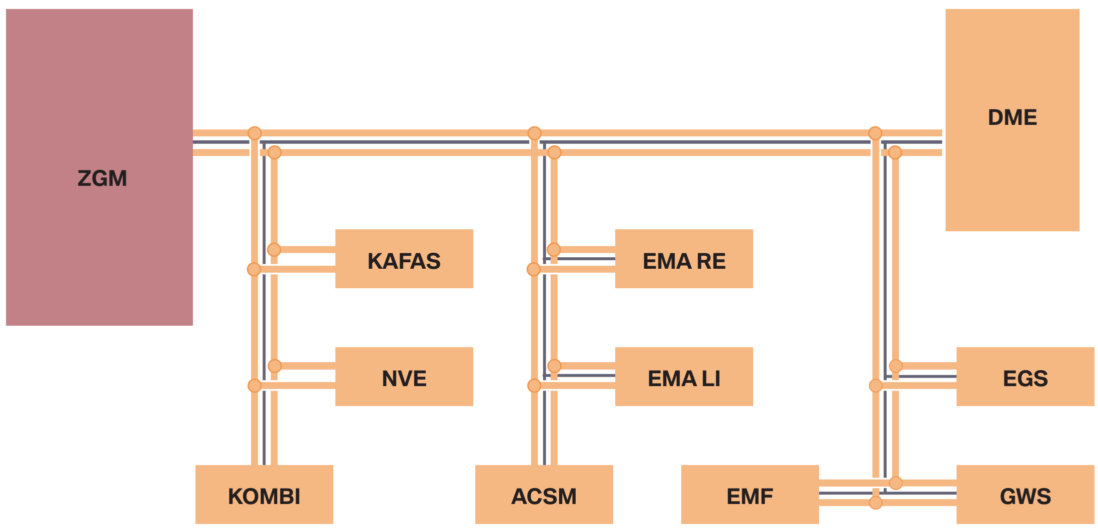


Powertrain-CAN PT-CAN

The PT-CAN connects the engine management system to the gearbox control, but now also interconnects systems in the area of safety and driver assistance systems.

It is line-based with tap lines to the individual systems. The PT-CAN has a data transfer rate of 500 kBit/s and is designed as a twisted pair of wires. Control units with a power supply via terminal 30 have an additional wake-up line (see illustration).

PT-CAN



Index	Explanation	Index	Explanation
ACSM	Crash Safety Module	DME	Digital Motor Electronics
EGS	Electronic transmission control	EMF	Electromechanical parking brake
EMA LI	Electrically motorized reel, left	EMA RE	Electrically motorized reel, right
GWS	Gear selector lever	KAFAS	Camera-based driver assistance systems
KOMBI	Instrument cluster	NVE	Night Vision electronics

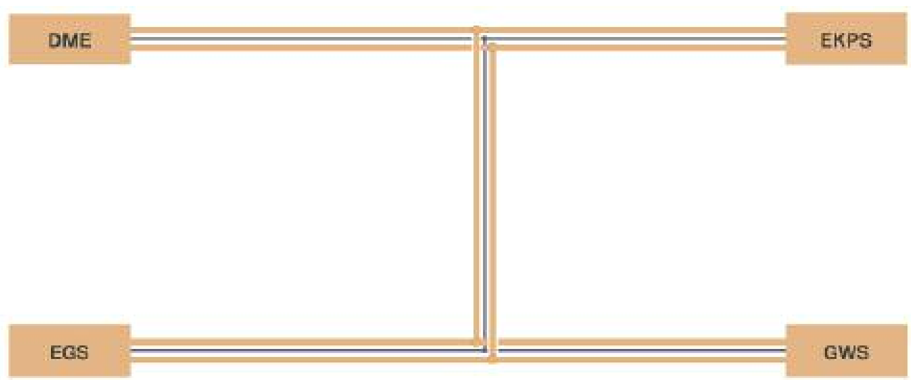
The terminal resistors in the PT-CAN are located in the following control units:

- Instrument cluster
- Electromechanical parking brake.

Powertrain-CAN 2

The PT-CAN 2 forms a redundancy for the PT-CAN in the area of the engine management system and also transfers signals to the fuel pump control. The PT-CAN 2 has a data transfer rate of 500 kBit/s and is designed as a twisted pair of wires with an additional wake-up line.

PT-CAN 2



Index	Explanation	Index	Explanation
DME	Digital Motor Electronics	EGS	Electronic transmission control
EKPS	Electronic fuel pump control	GWS	Gear selector lever

The terminal resistors in the PT-CAN 2 are located in the following control units:

- Digital Motor Electronics
- Control unit for electric fuel pump.

Ethernet - Faster Programming Access

Ethernet in the F01/F02

Ethernet is a manufacturer-neutral, cable-bound network technology. Most computer networks nowadays are based on this data transfer technology.

The so-called Ethernet was developed more than 30 years ago. Since then, the data transfer rates have multiplied. The IEEE 802.3u specification with 100 MBit/s data transfer rate is used in the F01/F02. The IEEE 802.3xx is a standard for cable-bound networks of the Institute of Electrical and Electronic Engineers. This specification is also known as "Fast Ethernet".

The transfer protocols are the protocols TCP/IP (Transmission Control Protocol/ Internet Protocol) and UDP (User Datagram Protocol).

Application in the F01/F02

The Ethernet in the diagnosis socket is only enabled when the BMW programming system (ICOM A) is connected. There is an activation bridge in the programming connector, between pins 8 and 16. This switches the power supply for the Ethernet controller in the central gateway module.

This means that Ethernet access to the central gateway module is disabled while the vehicle is being driven by the customer. The Ethernet connection between the information and communications systems is permanently enabled in the diagnosis socket independently of the activation bridge.

Security

Each participant in an Ethernet has an individually assigned identification number, an MAC address (Media Access Control). This address and the VIN (Vehicle Identification Number) identifies the vehicle to the BMW programming system on connection setup. This prevents changes to the data records and stored values by third parties.

In the same way as in a computer network in the office, each device in a network must receive unique identification. This is why the central gateway module is assigned a so-called IP address by the programming system after connection setup.

The function of an IP address in a network corresponds to that of a telephone number in the telephone network. This IP address is assigned per DHCP (Dynamic Host Configuration Protocol). This is a method of automatic allocation for IP addresses to user devices in a network.

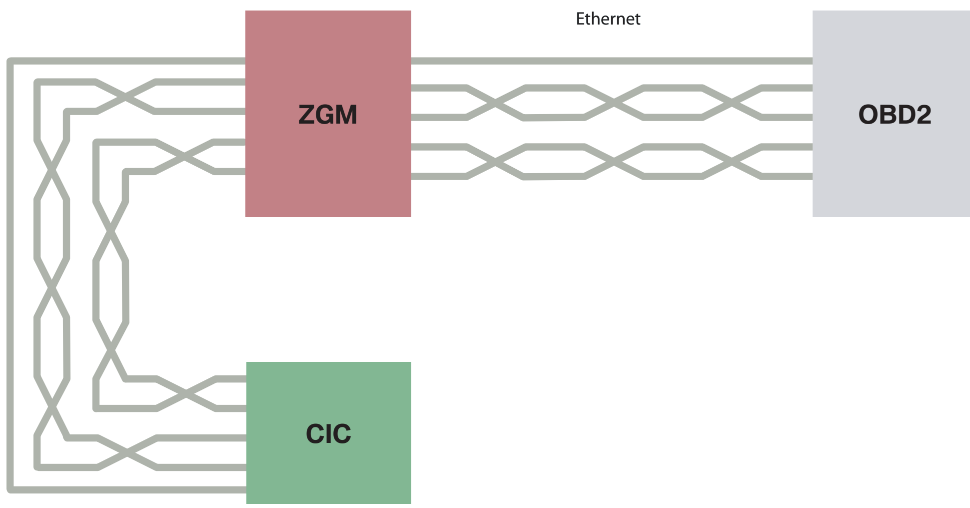
Features of Ethernet

- Very high data rate of 100 MBit/s
- System start time with connection setup and address assignment under three seconds, sleeping under one second
- System access only via BMW programming systems.

Functions of Ethernet

- Faster programming of the vehicle in Service

Ethernet



Index	Explanation	Index	Explanation
ZGM	Central gateway module	OBD2	Diagnosis socket
CIC	Central information computer		

The wiring between the diagnosis socket and ZGM is with two pairs of wires without additional shielding. There is also an activating line that supplies the Ethernet controllers in the control units with voltage.

There is a Cat5 cable between the diagnosis connector and the BMW programming system. These Cat5 cables are network cables with four twisted, unshielded pairs of wires that are approved for signal transfers at up to 100 MHz operating frequency. However, two pairs of wires are sufficient for the transfer capacity required in the F01/F02.

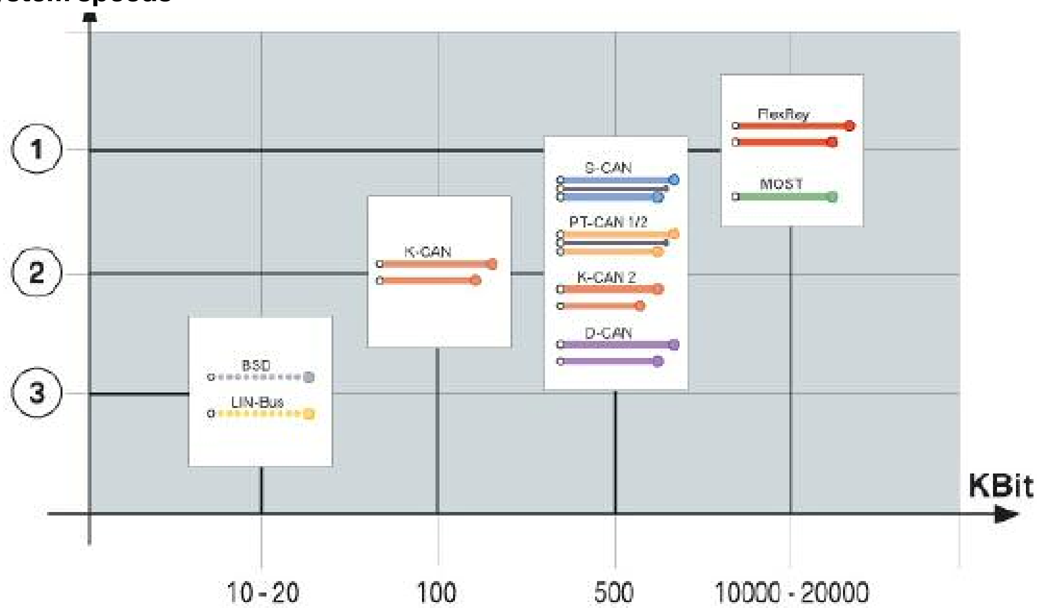
FlexRay

Features of the FlexRay

In future, driving dynamics control systems, driver assistance systems and their innovative interconnection will be ever more important for the differentiation of the BMW marque. Since networking via the CAN bus had already reached its limits, it was necessary to urgently find a suitable alternative for CAN.

In co-operation with Daimler/Chrysler AG and the semiconductor manufacturers Freescale (formerly Motorola) and Philips, BMW AG founded the FlexRay consortium in 1999 for the purpose of developing innovative communication technology.

Bus system speeds



Index	Explanation
1	Real-time capabilities, deterministic (strictly defined) and redundant
2	Conditional real-time capabilities - sufficient for control systems
3	No real-time capabilities

Bosch and General Motors joined the consortium as partners later. Since 2002, the Ford Motor Company, Mazda, Elmos and Siemens VDO have decided to join. In the meantime, almost all significant car makers and suppliers throughout the world have joined the FlexRay consortium.

FlexRay is a new communication system which aims at providing reliable and efficient data transmission with real-time capabilities between the electrical and mechatronic components for the purpose of interconnecting innovative functions in motor vehicles, both today and in the future.

Development of the new FlexRay communication system was prompted by the ever growing technological requirements placed on a communication system for interconnecting control units in motor vehicles and the realization that an open and standardized solution was needed for infrastructure systems. FlexRay provides an efficient protocol for real-time data transmission in distributed systems as used in motor vehicles.

With a maximum data transmission rate of 10 Mbits/s per channel, the FlexRay is distinctly faster than the data buses used to date in the area of the chassis, drive train and suspension of today's motor vehicles. Until now, this data rate could only be achieved with fiber-glass cables.

In addition to the higher bandwidth, FlexRay supports deterministic data transmission and can be configured such that reliable continued operation of remaining communication systems is enabled even in the event of individual components failing.

What are the Advantages of FlexRay?

- High bandwidth (10 Mbits/s compared to 0.5 Mbits/s of the CAN)
- Deterministic (= real-time capabilities) data transmission
- Reliable data communication
- Supports system integration
- Standard in automotive industry

FlexRay - A Standard in the Automotive Industry

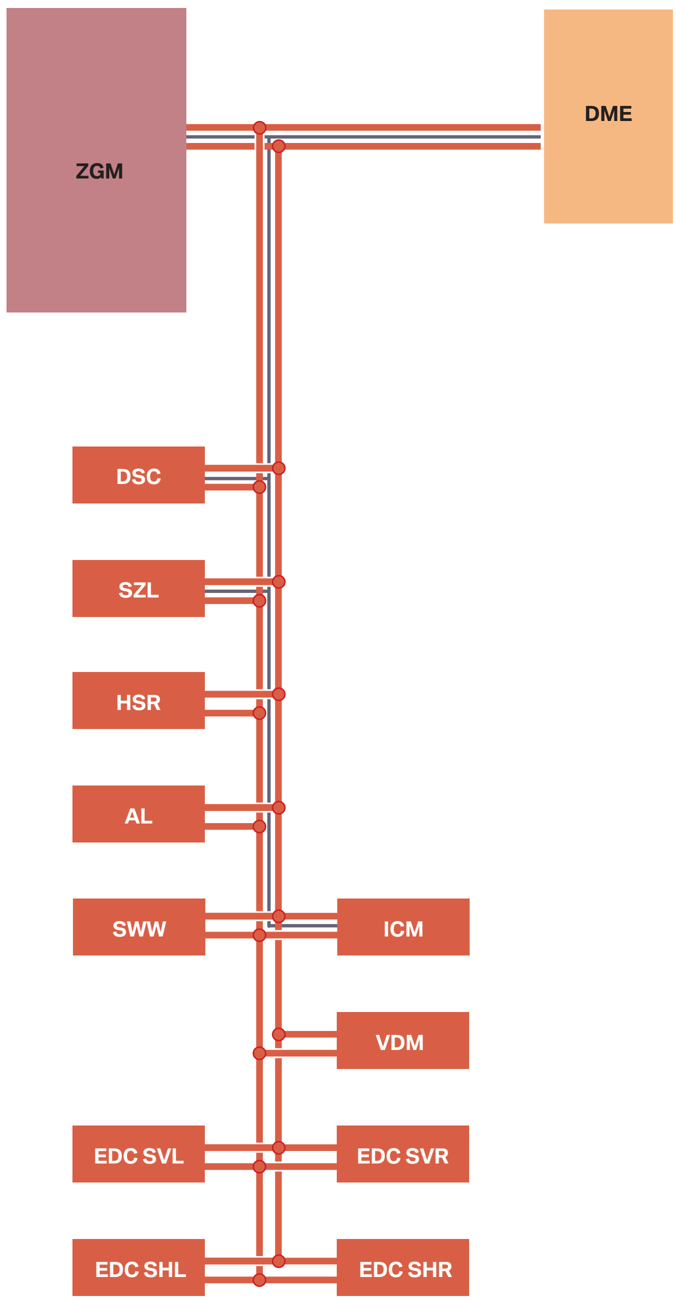
The FlexRay bus system is an industrial standard and is therefore supported and further developed by many manufacturers.

Members of the FlexRay consortium

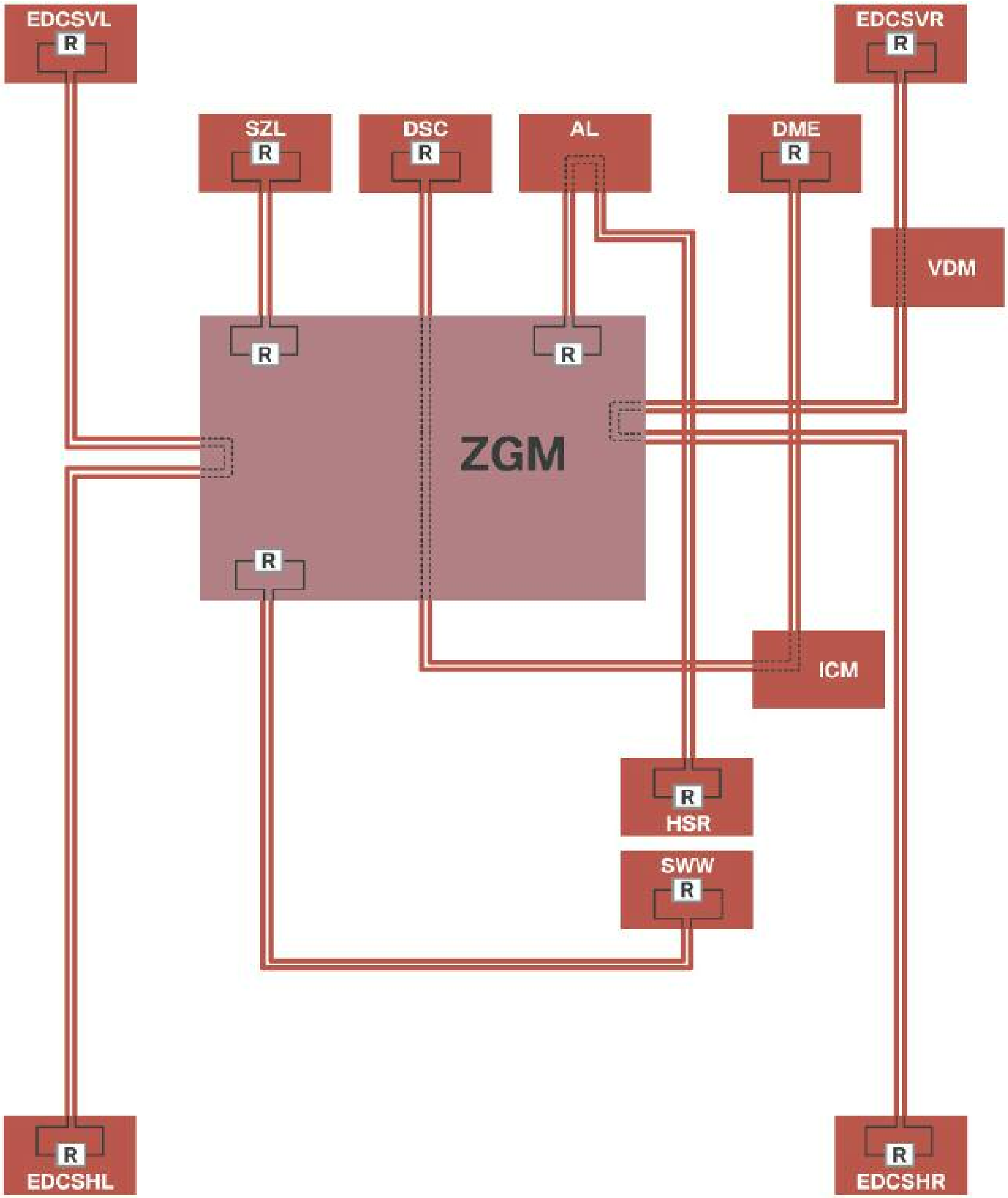
FlexRay - Application in the F01/F02

In the F01/F02, the FlexRay bus system is being used for the first time across systems to network dynamic driving control systems and the engine management system in a series vehicle. The central gateway module sets up the link between the various bus systems and the FlexRay.

FlexRay - simplified view



Physical structure of FlexRay F01/F02 (topology)



Index	Explanation
AL	Active steering system
BD	Bus driver
DM	Digital Motor Electronics
DSC	Dynamic Stability Control
EDCSH	Electronic damper control, rear left satellite
EDCSHR	Electronic damper control, rear right satellite
EDCSVL	Electronic damper control, front left satellite
EDCSVR	Electronic damper control, front right satellite
HSR	Rear-axle drift angle control
ICM	Integrated Chassis Management
SZL	Steering column switch cluster
VDM	Vertical dynamics management
ZGM	Central gateway module

FlexRay Bus Topology on the F01

The FlexRay is shown in a simplified form in the overview of the bus systems. The actual topology is shown in the graphic above.

Depending on the level of equipment of the vehicle, the ZGM contains one or two so-called star couplers, each with four bus drivers. The bus drivers forward the data of the control units via the communication controller to the central gateway module (ZGM). Depending on the type of termination the FlexRay control units have, they are connected to these bus drivers in two different ways.

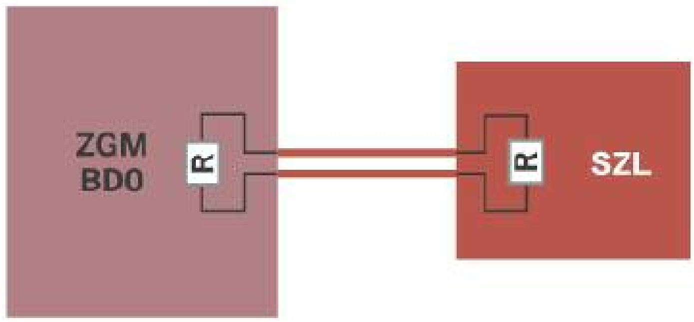
Bus Termination

In the same way as most bus systems, resistors for termination (as bus termination) are also used at both ends of the data lines on the FlexRay to prevent reflections on the lines.

The value of these terminal resistors is determined from the data transfer rate and cable lengths. The terminal resistors are located in the control units.

If only one control unit is connected to a bus driver (e.g. SZL to the bus driver BD0), the connections on the bus driver and on the control unit are fitted with a terminal resistor.

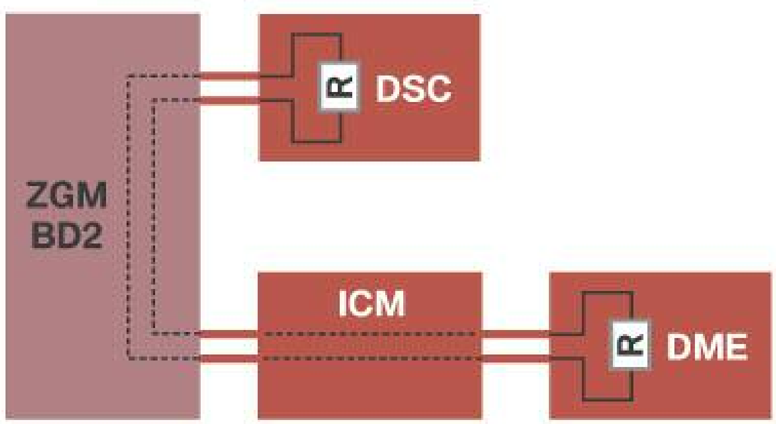
Terminal resistor



This type of connection at the central gateway module is called "end node termination".

If the connection at the control unit is not the physical finish node (e.g. DSC, ICM and DME at the bus driver BD2), it is referred to as a FlexRay transmission and forwarding line. In this case, both components must be terminated at the ends of each bus path with terminal resistors.

Through-looped FlexRay



This connection option exists for the central gateway module and a number of control units. However, the control unit with a transmission and forwarding line has a 'non-end node termination' for data pickup. This type of termination cannot be tested using measurement systems at the control unit connector due to its resistor / capacitor circuit.

To measure the (current-free) FlexRay bus to determine the line or terminating resistance, please be sure to use the vehicle wiring diagram.

Properties of FlexRay

The most important properties of the FlexRay bus system are outlined in the following:

- Bus topology
- Transmission medium - signal properties
- Deterministic data transmission
- Bus signal.

Bus Topology

The FlexRay bus system can be integrated in various topologies and versions in the vehicle. The following topologies can be used:

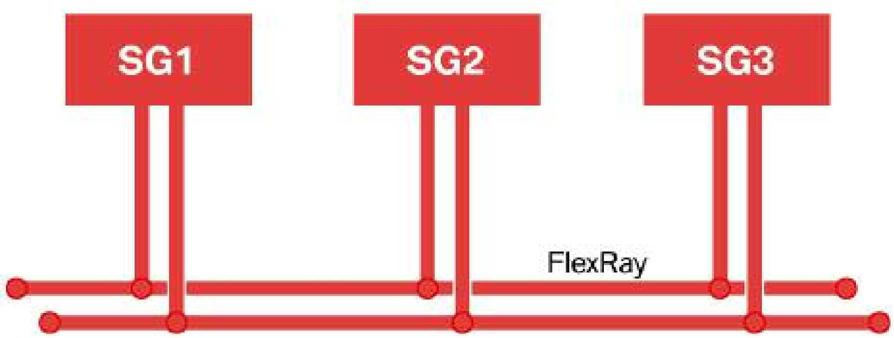
- Line-based bus topology
- Point-to-point bus topology
- Mixed bus topology.

Line-based Bus Topology

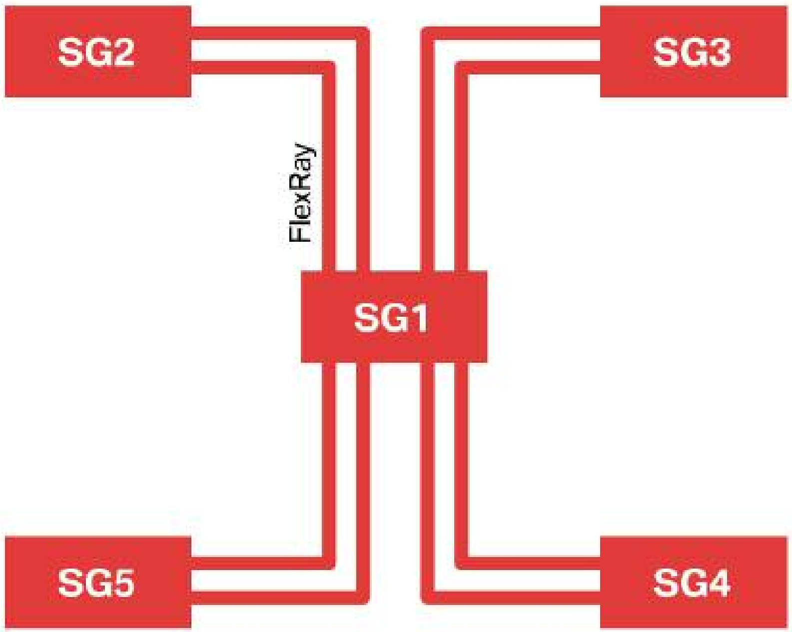
All control units (e.g. SG1 to SG3) in line-based topology are connected by means of a two-wire bus, consisting of two twisted copper cores. This type of connection is also used on the CAN-bus. The same information but with different voltage level is sent on both lines.

The transmitted differential signal is immune to interference. The line-based topology is suitable only for electrical data transmission.

Line-based bus topology



Point-to-point Bus Topology
The satellites (control units SG2 to SG5) in point-to-point bus topology are each connected by a separate line to the central master control unit (SG1). Point-to-point topology is suitable for both electrical as well as optical data transmission.



Mixed Bus Topology

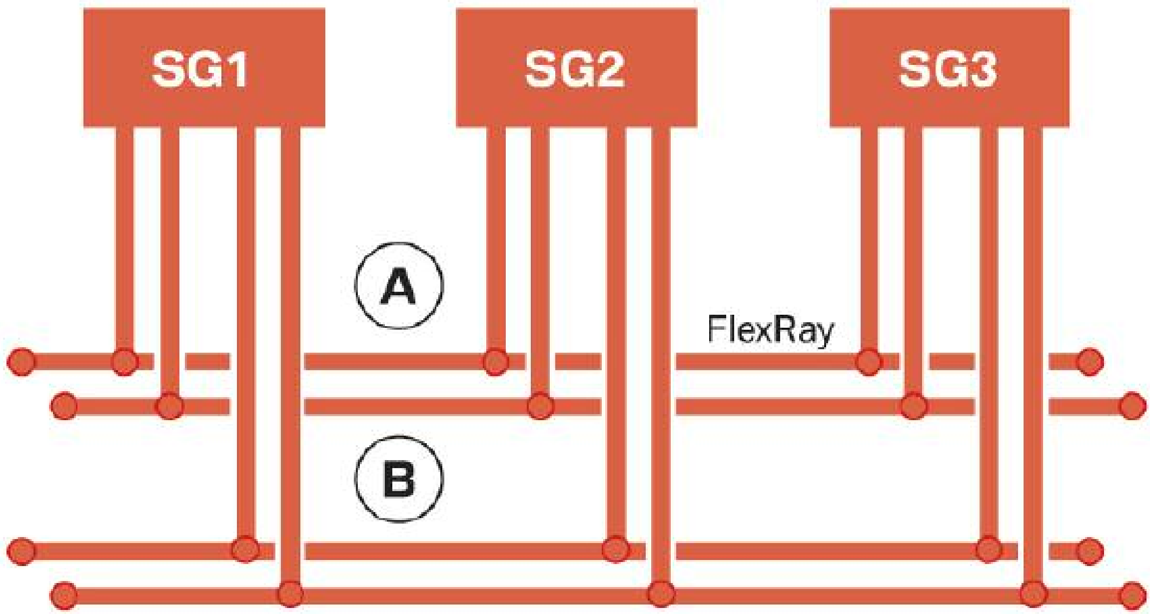
Mixed bus topology caters for the use of different topologies in one bus system.

Parts of the bus system are line-based while other parts are point-to-point.

This bus topology is applied in the F01/F02. The central gateway module (depending on the equipment version) contains one or two active neutral points, each with four bus drivers. This means that up to eight connection options are available.

Redundant Data Transmission

Fault-tolerant systems must ensure continued reliable data transmission even after failure of a bus line. This requirement is realized by way of redundant data transmission on a second data channel.



Index	Explanation
A	Channel 1
B	Channel 2

A bus system with redundant data transmission uses two independent channels. Each channel consists of a two-wire connection. In the event of one channel failing, the information of the defective channel can be transmitted on the intact channel.

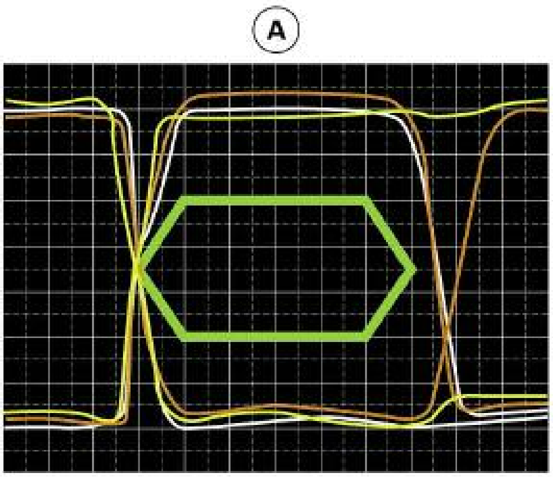
FlexRay enables the use of mixed topologies also in connection with redundant data transmission.

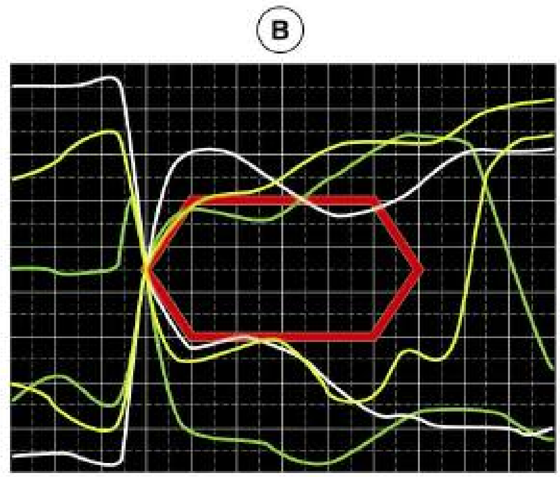
Transmission Medium - Signal Properties

The bus signal of the FlexRay must be within defined limits. A good and bad image of the bus signal is depicted below. The electrical signal must not enter the inner area neither on the time axis nor on the voltage axis. The FlexRay bus system is a bus system with a high data transfer rate and thus with rapid changing of the voltage level.

The voltage level as well as the rise and drop of the voltage (edge steepness) are precisely defined and must be within certain values. There must be no infringements of the marked "fields" (green and red hexagon). Electrical faults resulting from incorrect cable installation, contact resistance etc. can cause data transmission problems.

Good and bad image





Index	Explanation	Index	Explanation
A	Good image	B	Bad image

The images shown above can be depicted only with very fast (laboratory) oscilloscopes. The oscilloscope in the BMW diagnostic system is not suitable for representing such images.

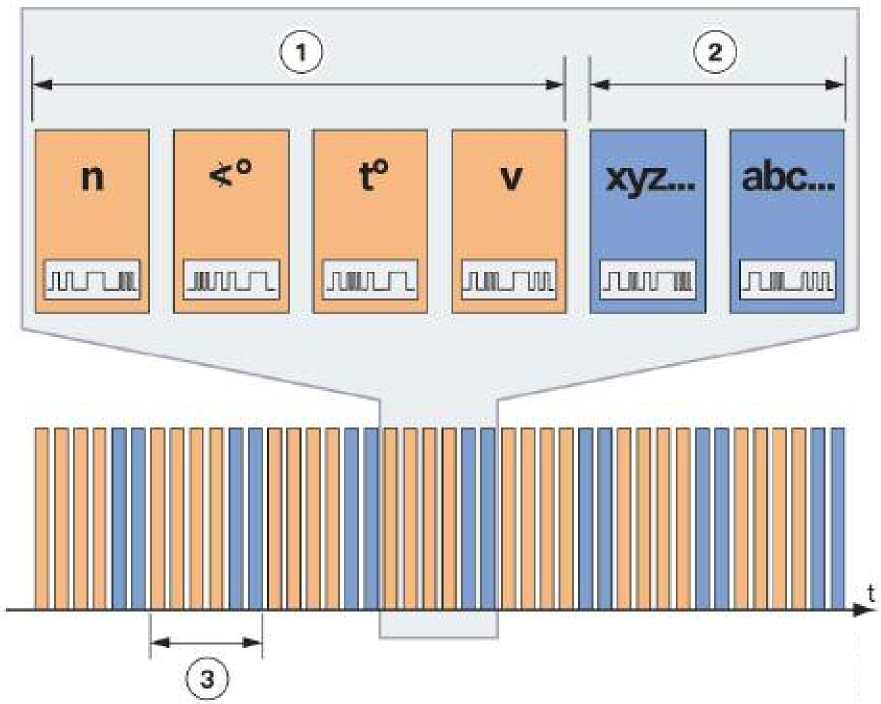
The voltage ranges of the FlexRay bus system are:

- System ON - no bus communication 2.5 V
- High signal - 3.1 V (voltage signal rises by 600 mV)
- Low signal - 1.9 V (voltage signal falls by 600 mV).

The voltage values are measured with respect to ground.

Deterministic Data Transmission
The CAN network is an event-controlled bus system. Data are transmitted when an event occurs. In the event of an accumulation of events, delays may occur before further information can be sent. If an item of information was not sent successfully and free of errors, this information is continually sent until the communication partner confirms its receipt.

If faults occur in the bus system, this event-controlled information can back up causing the bus system to overload, i.e. there is a significant delay in the transmission of individual signals. This would result in poor control characteristics of individual systems.



Index	Explanation
1	Time-controlled part of cyclic data transmission
2	Event-controlled part of cyclic data transmission
3	Cycle [5 ms total cycle length of which 3 ms static (= time-controlled) and 2 ms dynamic (= event-controlled)]
n	Engine speed
<°	Angle
t°	Temperature
v	Road speed
xyz... abc...	Event-controlled information
t	Time

The FlexRay bus system is a time-controlled bus system that additionally provides the option of transmitting sections of the data transmission event-controlled. In the time-controlled part, time slots are assigned to certain items of information. One time slot is a defined period of time that is kept free for a specific item of information (e.g. engine speed).

Consequently, important periodic information is transmitted at a fixed time interval in the FlexRay bus system so that the system cannot be overloaded.

Other less time-critical messages are transmitted in the event-controlled part.

An example of deterministic data transmission is outlined in the following.

Bus Signal
Deterministic data transmission ensures that each message in the time-controlled part is transmitted in real time. Real time means that the transmission takes place within a defined time.

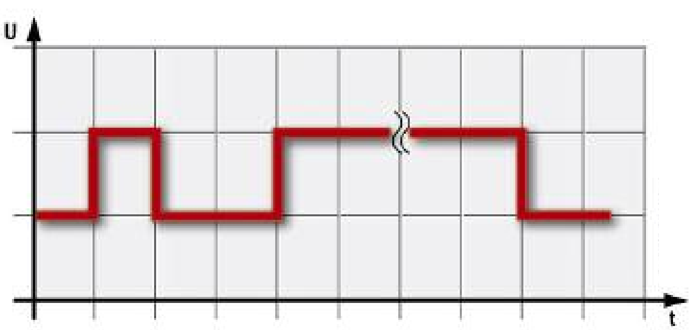
Therefore, important bus messages are not sent too late due to overloading of the bus system. If lost due to a temporary problem in the bus system (e.g. EMC problem) a message cannot be sent again. A current value is sent in the next assigned time slot.

High Bandwidth
The FlexRay bus system provides a maximum data transfer rate of up to 10 MBit/s per channel. This corresponds to 20 times the data transfer rate of the PT-CAN 2 or D-CAN.

Wake-up and Sleep Characteristics
Although the FlexRay control units can be wakened per bus signal, most FlexRay control units are activated across an additional wake-up line by the CAS. The wake-up line has the same function as the previous wake-up line (15WUP) in the PT-CAN. The signal curve corresponds to the signal curve of the PTCAN.

The active steering and the VDM are not wakened via the wake-up cable, rather per bus signal. The four damper satellites are then activated directly by the VDM by switching the power supply.

The "wake-up voltage curve" graphic shows the typical behavior of the voltage curve in response to unlocking and starting the vehicle.



Wake-up signal

Phase 1:

Driver unlocks the vehicle. The CAS control unit activates the wake-up impulse and sends it across the wake-up line to the connected FlexRay control units.

Phase 2:

Car is opened, terminal R is still OFF, the voltage levels in the bus systems drop again.

Phase 3:

Car is started, terminal 15 is ON, the voltages remain at the set levels until terminal 15 is turned off again.

Phase 4:

The complete vehicle network must assume sleep mode at terminal R OFF in order to avoid unnecessary power consumption. Each control unit in the network signs off to ensure that all control units "are sleeping".

An error message is stored if this is not the case. This error message is then evaluated as part of the energy diagnosis procedure.

Synchronization

A common time base is necessary in order to ensure synchronous execution of individual functions in interconnected control units. Time matching must take place via the bus system as all control units operate with their own clock generator.

The control units measure the time of certain synchronization bits, calculate the mean value and adapt their bus clock to this value. The synchronization bits are sent in the static part of the bus message. Synchronization starts in the FlexRay after the system start between two of the control units authorized for wake-up (in the bus overview marked with "S") once the CAS control unit has sent a wake-up impulse.

When this operation is concluded, the remaining control units log on to the FlexRay in succession and calculate their differential values. In addition, there is a calculated correction of the synchronization during operation. This system ensures that even minimal time differences do not cause transmission errors in the long term.

Fault Handling

In the event of faults on the bus lines (e.g. short circuit or short circuit to earth) or on the FlexRay control units themselves, individual control units or entire branches can be excluded from the bus communication. This does not include the branch with the four FlexRay control units authorized for wake-up (ZGM, DME, DSC, ICM). If there is an interruption in the communication between these control units, no engine start is possible.

In addition, a so-called bus watchdog prevents the control units from sending messages are times when they are not authorized to do so. This prevents other messages from being overwritten.

Wiring

The wiring of the FlexRay bus in the F01/F02 is executed as a sheathed, two-wire, twisted cable. The sheathing protects the wires from mechanical damage. Some of the terminal resistors are located in the central gateway module and in the user devices. Since the surge impedance (impedance of high-frequency lines) of the lines depends on external influencing factors, the terminating resistors are precisely matched to the required resistance. The sections of line to the user devices can be checked relatively easily by means of a resistance measuring instrument (ohmmeter, multimeter). The resistance should be measured from the central gateway module. Pin assignment, see 'BMW diagnostic system'.

The terminal resistors in the FlexRay are located in the following control modules:

- Central gateway module (only end node)
- Electronic Damper Control satellites.
- Digital Motor Electronics
- Dynamic Stability Control
- Rear-axle drift angle control
- Steering column switch cluster
- Lane change warning.

Measurements on the FlexRay

For resistance measurement in the FlexRay, be sure to observe the vehicle wiring diagram!

The various termination options mean that misinterpretations of the measurement results can occur.

Measuring the resistance of the FlexRay lines cannot provide a 100% deduction in terms of the system wiring. In the case of damage such as pinching or connector corrosion, the resistance value may be within the tolerance when the system is static.

In dynamic mode, however, electrical influences can cause increased surge resistance, resulting in data transmission problems.

It is possible to repair the FlexRay bus. If damaged, the cables can be connected using conventional cable connectors. Special requirements, however, must be observed when reinstalling the system.

The wiring of the FlexRay system consists of twisted lines. Where possible, this twisting should not be altered during repairs. Repaired areas with stripped insulation must be sealed again with shrink-fit tubing. Moisture can affect the surge resistance and therefore the efficiency of the bus system.

MOST Bus System

Features of the MOST system

MOST is a data bus technology for multimedia applications that was specifically developed for use in motor vehicles.

MOST stands for "Multimedia Oriented System Transport". The MOST bus uses light pulses for the purpose of transmitting data and is based on a ring structure. The data are transmitted only in one direction in the ring.

MOST technology satisfies two important requirements:

1. The MOST bus transports control data as well as audio data, navigation and other services.
2. MOST technology provides a logical model for controlling the data variety and complexity, i.e. the MOST application framework. The MOST application framework organizes functions of the overall system.

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

An important characteristic of a multimedia network is that it not only transports control data and sensor data such as on the CAN bus and LIN-Bus.

In addition, a multimedia network can also transmit digital audio and video signals and transport graphics as well as other data services.

Features

- High data rate 22.5 Mbits/s
- Synchronous/asynchronous data transmission
- MOST assigns nodes in the bus to the control units
- Optical fiber as transmission medium
- Ring structure.

Each MOST control unit can send data on the MOST bus. Only the central gateway module can initiate data exchange between the MOST bus and other bus systems. The Car Information Computer functions as the master control unit; the gateway to the remaining bus system is the central gateway module.

The data are transmitted on various channels on the MOST bus. Corresponding to the application, the data are sent to different time windows within the data flow (channels).

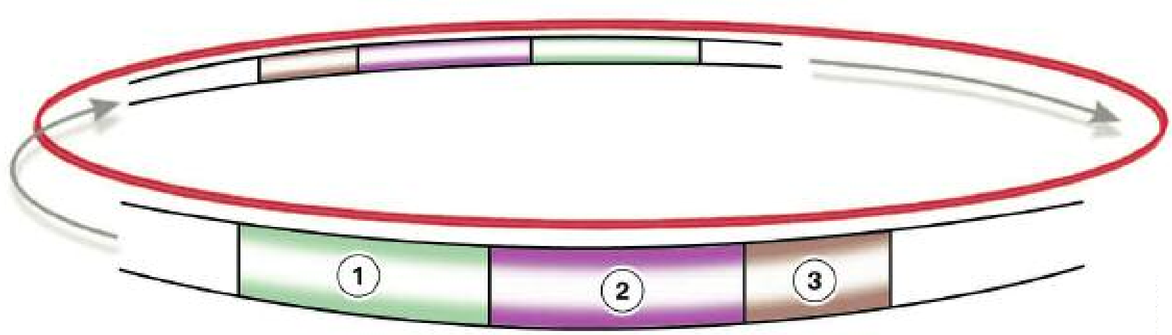
- **Control channel**
Control signals such as volume control for the Top HiFi amplifier and data for diagnosis purposes are sent via the control channel.

- **Synchronous channel**
The synchronous channel is mainly reserved for the purpose of sending audio data.

20 -Data transfer channels

- **Asynchronous channel**
The asynchronous channel transfers image data from the navigation system such as the map view and direction arrows.

The control channel and the asynchronous channel are used for programming the control units on the MOST bus and correspondingly adapt it to the MOST-direct access.



Index	Explanation
1	Synchronous channel
2	Asynchronous channel
3	Control channel

Registration of ECUs in the MOST

Precisely in the same way as on the E6x models, the control units installed on the MOST bus are stored in a registration file in the master control unit. The corresponding data are stored during the production process and, in connection with control unit retrofits, after programming the respective control unit.

The ECUs and their order on the MOST bus are stored in this registration file. With the fiber optic cable connector, it is possible to connect control units in the rear area of the F01/F02 ex factory or after a repair in different order. With the aid of the registration file, the BMW diagnosis system can determine the installed control units and their order.

In addition, this registration file is also stored in the central gateway module so that there is still access to the control unit registration in the event of a fault in the MOST framework. This means that the diagnosis can be used to call up the last functional status from the central gateway module.

Although the master control unit of the MOST, the CIC, is connected to the K-CAN, it does not carry out the function of a gateway control unit. If communication on the MOST is no longer possible, the necessary data can only be read out via the central gateway module.

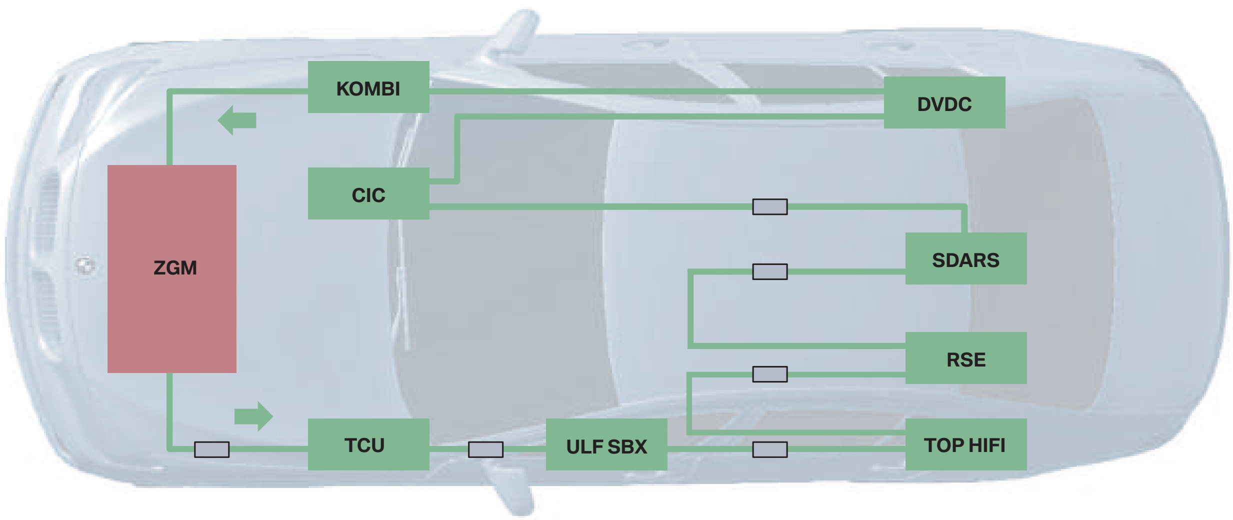
MOST control units and light direction

In the F01/F02, the MOST bus is used for the components in information/communication systems. The Car Information Computer is used as the master control unit. Other bus users may be:

- DVD changer
- Instrument cluster
- Top-HiFi amplifier
- Satellite tuner SDARS (only US version)
- Telephone

The MOST programming access used in models to date is no longer required for the F01/F02. The programming now takes place on these vehicles via the Ethernet access point.

MOST ring in the F01/F02



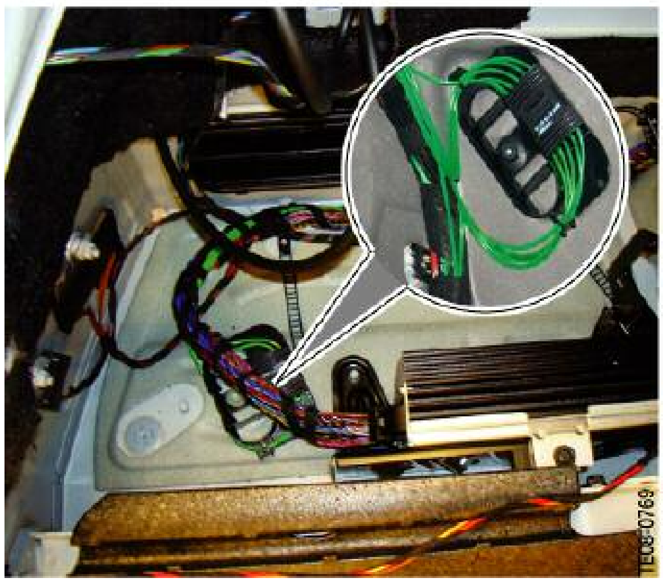
Index	Explanation	Index	Explanation
TOP HIFI	Top-HiFi Amplifier	KOMBI	Instrument Cluster
DVDC	DVD Changer	SDARS	Satellite Tuner
RSE	Rear Seat Entertainment	ULF-SBX	Interface Box
TCU	Telematics Control Unit	ZGM	Central Gateway Module
CIC	Car Information Computer		

■ **Light direction**
Data are always sent in one direction on the MOST bus. Each control unit can send data on the MOST bus.

The physical light direction runs from the master control unit (Car Information Computer) to the DVD changer, to the instrument cluster, to the central gateway module and from there to the fiber optic cable distributor. All the control units fitted in the rear end are connected at the fiber optic cable distributor. From the last control unit, the light returns to the master control unit.

Fiber Optic Connector
The use of the fiber optic connector provides the advantage of being able to easily retrofit control units in the area of the luggage compartment.

Fiber optic cable connector, rear left in the luggage compartment



The fiber optic cable connector is located in the luggage compartment of the F01/F02, to the left behind the side wall trim. The fiber optic cable connector is arranged in the MOST bus system between the front area of the vehicle (head unit, DVD changer) and the rear area of the vehicle (TCU, VM etc.).

One or two fiber optic connectors are installed corresponding to the equipment configuration. One fiber optic connector is responsible for the factory-installed control units. The other fiber optic connector is used for the preparations for options.

The ends of the fiber optic cables, for additional options, are always grouped together on the same row in the fiber optic connector to avoid damage to the ends of the fiber optic cables.

As soon as the retrofit is installed, the fiber optic connectors are reconnected according to instructions and integrated in the MOST bus. Within the framework of programming, the control unit sequence is reloaded into the master control unit.

NOTES
PAGE

Sub-bus Systems

Characteristics of Sub-bus Systems

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

Sub-bus systems	Data rate	Bus topology
BSD (bit-serial data interface)	9.6 kBit/s	Linear, single-wire
LIN (Local Interconnect Network)	9.6 / 19.2 / 20.0 kBit/s	Linear, single-wire
Local CAN	500 kBit/s	Linear, two-wire

BSD

The bit-serial data interface BSD is also used on the F01/F02 (due to lack of available interfaces). It makes the following connections from the engine management to the corresponding subsystems:

- Alternator regulator
- Oil condition sensor

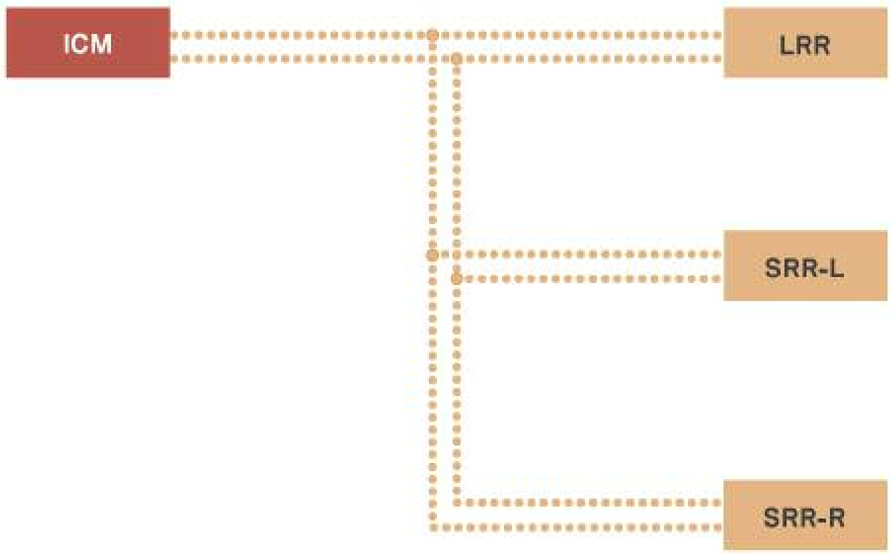
K-Bus Protocol

The term "K-Bus (protocol)" is used for a series of sub-bus systems in the bus overview. These sub-bus systems are used for various purposes. The K-Bus protocol used here is a common component already used in predecessor models. The protocol is used, e.g. on the following systems:

- Connection between ACSM and TCU
- Comfort Access
- CAS bus.
- LIN-Bus

Local CAN

The Local-CAN serves to transfer the high data volumes of the environment sensors to the ICM. (E.g.: short-range sensor to the ICM.) The Local-CAN has a data transfer rate of 500kBits/s and is designed as a twisted pair configuration.



LIN-Bus

The LIN-Bus was used for the first time on the E46 for controlling the outside mirrors. Mainly the versions V2.0 or higher are used in the F01/F02. For the F01/F02, various connections per LIN-Bus are implemented:

- E.g.: Footwell module to driver's door switch cluster
- Connection from footwell module to the outside mirrors
- Connection from roof functions center to rain-light-solar-condensation sensor
- Activation of the 16 IHKA actuator motors per "daisy chain" assignment (series connection of the signal lines).

The Local Interconnect Network was developed as a low-cost communication option for intelligent actuators and sensors in the motor vehicle sector. The LIN is standardized, which is why it is used in development, production and service. The first application of a LIN system in an automobile took place in the year 2001 with version V1.1.

The LIN is a sub-bus configured as a single-wire system. The power supply and signal excursion are at battery voltage level. In all cases, only one master control unit is fitted in a LIN assembly; up to 16 items of equipment (so-called slaves) may be attached to the bus.

There is no prescribed bus topology; only the maximum cable length in a LIN-Bus is limited to 40 meters. In the F01/ F02, the data transfer rate of the LIN ranges from 2.4 to 19.2 kBit/s. Terminal resistors are not required due to the low data transfer rate; these are not fitted in the F01/F02. On the LIN V1.x, all slaves have a fixed identifier and the data protocol only permits periodical messages to be sent.

Synchronization of the LIN takes place at the start of every message sent by the master controller. A so-called "self-synchronization" of the bus takes place without clocking quartz crystal.

The main area of deployment in motor vehicles is mechatronic applications, e.g. mirror adjustment and other actuator motors. One control unit (e.g. junction box electronics) forms the bus master controller; all other connected control units (e.g. wiper module) are the slaves.

In the F01/F02, the following control units still correspond to the V1.x specification:

- Belt hand-over
- Outside mirror
- Blower output stages
- Intelligent Battery Sensor

LIN V2.0 (or V2.1)

LIN components that correspond to the specification of data protocol LIN V2.0 or higher have extended functions.

- The LIN components for V2.x are delivered with a device ID and a base configuration. The final (dynamic) configuration and the allocation of the ID number take place on commissioning by the master control unit. If one of these components is replaced, this operation must be initiated manually by means of the BMW diagnosis system.
- The data protocol has become more variable, permitting, if required, periodic alongside sporadic messages as of specification V2.0. These "sporadic frames" are only sent if the master control unit requires data from the slave control units or outputs data. Without such a request, the time slots in the messages remain empty.
- The master control units can send so-called multiple requests to slave groups. To reduce the bus load, the contacted slaves only respond in the case of changed values (e.g. door contact).

All master control units of the LIN V2.x specification are downwardly compatible to (slave) components of previous specifications. However, all V2.0 slaves also require a V2.x master controller.

A number of the connected components are only diagnosis-capable to a limited degree, for example the rain-light-solar-condensation sensor. In this case, the master control unit serves as the gateway to the remaining bus system. The diagnosis requests from the ZGM or BMW diagnosis system are inserted in the sporadic section of a LIN frame.

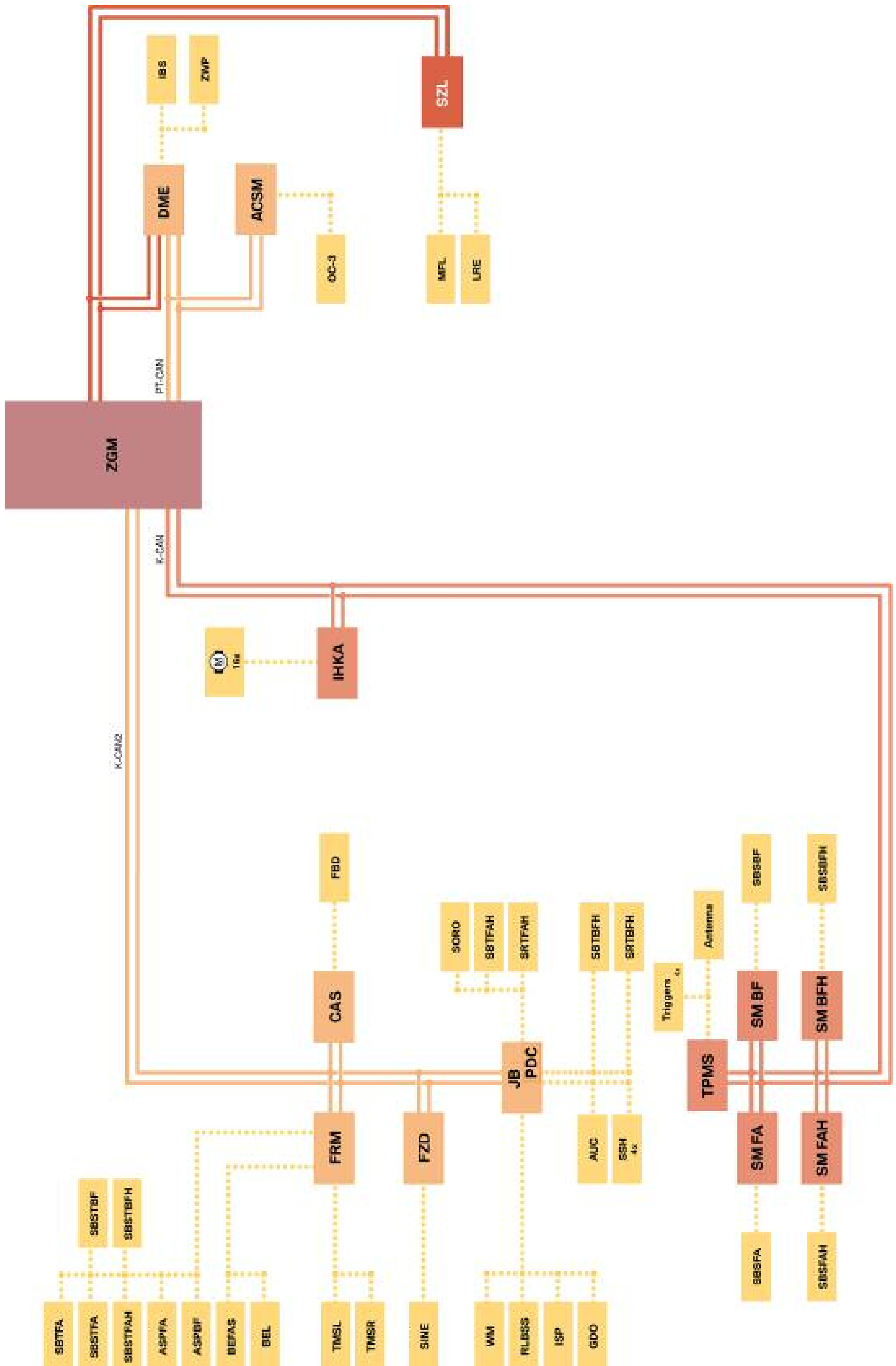
A special feature in the F01/F02 is that the data communication between the Comfort Access and diversity aerial is implemented with 20.0 kBit/s due to the large number of small data packages. The slightly higher transfer rate means that the time slots in the data protocol can be better exploited.

The master control unit sends the "sleep command" to place the LIN in the idle state. The "sleep command" can also be sent with terminal R "On", e.g. for mirror adjustment. The "wake-up command" can also be sent by a slave.

The LIN messages in the data protocol are divided into four sections:

- Synchronization
- Identifier
- Data
- Checksum

LIN-Bus Overview F01/F02



Key for LIN-Bus control units (F01/F02)

Index	Explanation
ACSM	Advanced Crash Safety Module
ASPBF	Outside mirror, passenger
ASPFA	Outside mirror, driver
AUC	Automatic recirculated air control
BEFAS	Driver assistance systems operating unit
BEL	Light operating unit
CAS	Car Access System
DME	Digital Motor Electronics
FBD	Remote Control Services
FRM	Footwell Module
FZD	Roof Functions Center
GDO	Garage door opener
IBS	Intelligent Battery Sensor
IHKA	Integrated Heating and Air Conditioning, automatic
ISP	Interior Mirror
JB	Junction Box Electronics
LRE	Steering Wheel Electronics
MFL	Multi-function Steering Wheel
OC-3	Seat Occupancy Detection, front passenger
PDC	Park Distance Control
RLSBS	Rain-light-solar-condensation sensor
SBSBF	Switch block for seat adjustment, passenger
SBSBFH	Switch block for seat adjustment, passenger's side rear
SBSFA	Switch block for seat adjustment, driver
SBSFAH	Switch block for seat adjustment, driver's side rear
SBSTBF	Switch block for seat memory, passenger
SBSTBFH	Switch block for seat memory, passenger's side rear
SBSTFA	Switch block for seat memory, driver
SBSTFAH	Switch block for seat memory, driver's side rear
SBTBFH	Switch block for windows, passenger's side rear
SBTFA	Switch block for windows, driver
SBTFAH	Switch block for windows, driver's side rear
SINE	Alarm Siren
SMBF	Seat Module, passenger

Key for LIN-Bus control units (F01/F02) cont.

Index	Explanation
SMBFH	Seat Module, passenger's side rear
SMFA	Seat Module, driver
SMFAH	Seat Module, driver's side rear
SORO	Roller sunblind
SRTBFH	Roller sunblind switch, passenger's side rear
SRTFAH	Roller sunblind switch, driver's side rear
SSH	Seat heating switch
SZL	Steering column switch cluster
TMSL	Headlight module, left
TMSR	Headlight module, right
TPMS	Tire Pressure Monitoring System
WM	Wiper Motor/module
ZGM	Central Gateway Module
ZWP	Auxiliary water pump