Introduction

In addition to the familiar CAN bus systems, use has been made for the first time in the Audi A8 ´03 of an optical data bus system.

The name of this data bus system is derived from "Media Oriented Systems Transport (MOST) Cooperation". This is an association formed by various motor vehicle manufacturers, their suppliers and software companies with a view to developing a standard high-speed data transfer system.

MOST®
Media Oriented Systems Transport

The term "Media Oriented Systems Transport" signifies a network featuring media-oriented data transport. This means that, in contrast to the CAN data bus, address-oriented messages are transmitted to a specific receiver.

This technique is used in Audi vehicles for the transfer of infotainment system data.

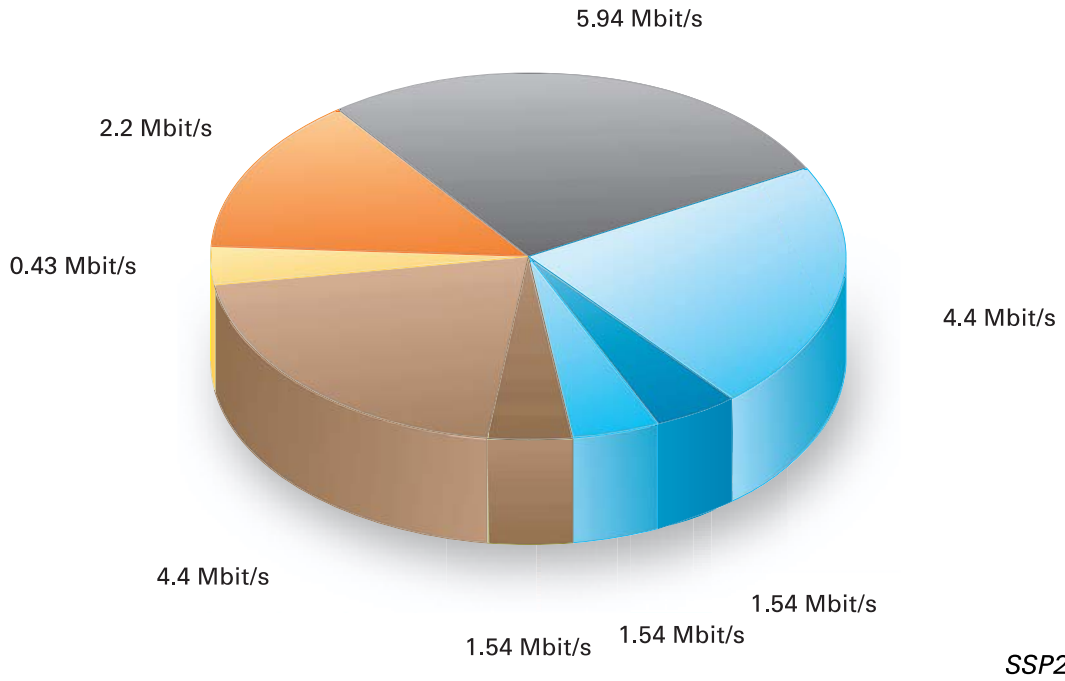
The infotainment system offers a wide range of modern **info**rmation and enter**tainment** media as outlined below.



SSP286_008

MOST bus

Transfer rates of media



SSP286_010

- Navigation
- Telephone (GSM)
- Video (MPEG)
- Video, reduced (MPEG)
- Audio source 1 (stereo) e.g. via rear right headphones
- Audio source 2 (stereo) e.g. via rear left headphones
- Audio source 3 (surround sound) e.g. via digital sound system
- Not used

Optical data transfer is an appropriate means of implementing a complex infotainment system as the CAN data bus systems used to date cannot transmit data quickly enough and thus not in the volume required.

The video and audio applications result in transfer rates of many Mbit/s.

A transfer rate of roughly 6 Mbit/s is required just to transmit a digital TV signal with stereo sound.

The MOST bus permits transfer rates of 21.2 Mbit/s.

In the past such information (e.g. video and audio) could only be transmitted in the form of an analog signal, increasing the scope of harness wiring required.

CAN bus systems have a maximum data transfer rate of 1 Mbit/s. Consequently, it was only possible to use CAN bus systems to transmit the control signals.



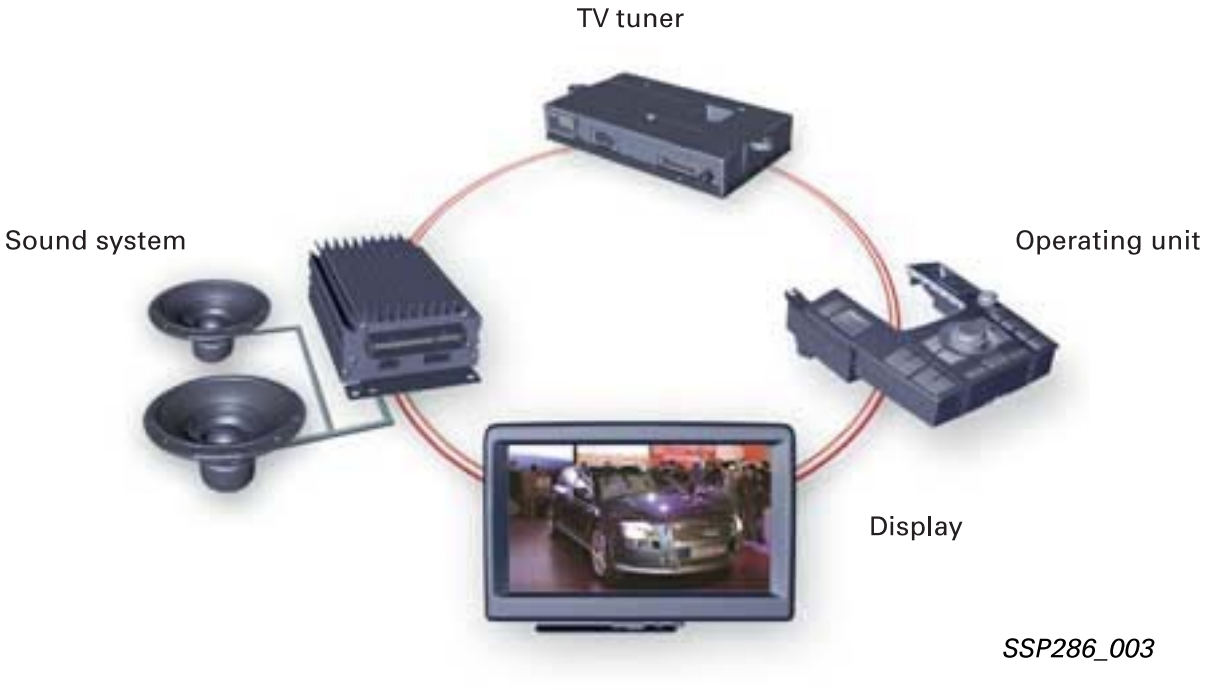
SSP286_002

The optical MOST bus enables data to be exchanged between the components concerned in digital form.

In addition to fewer wires and less weight, light wave transmission provides a far higher data transfer rate.

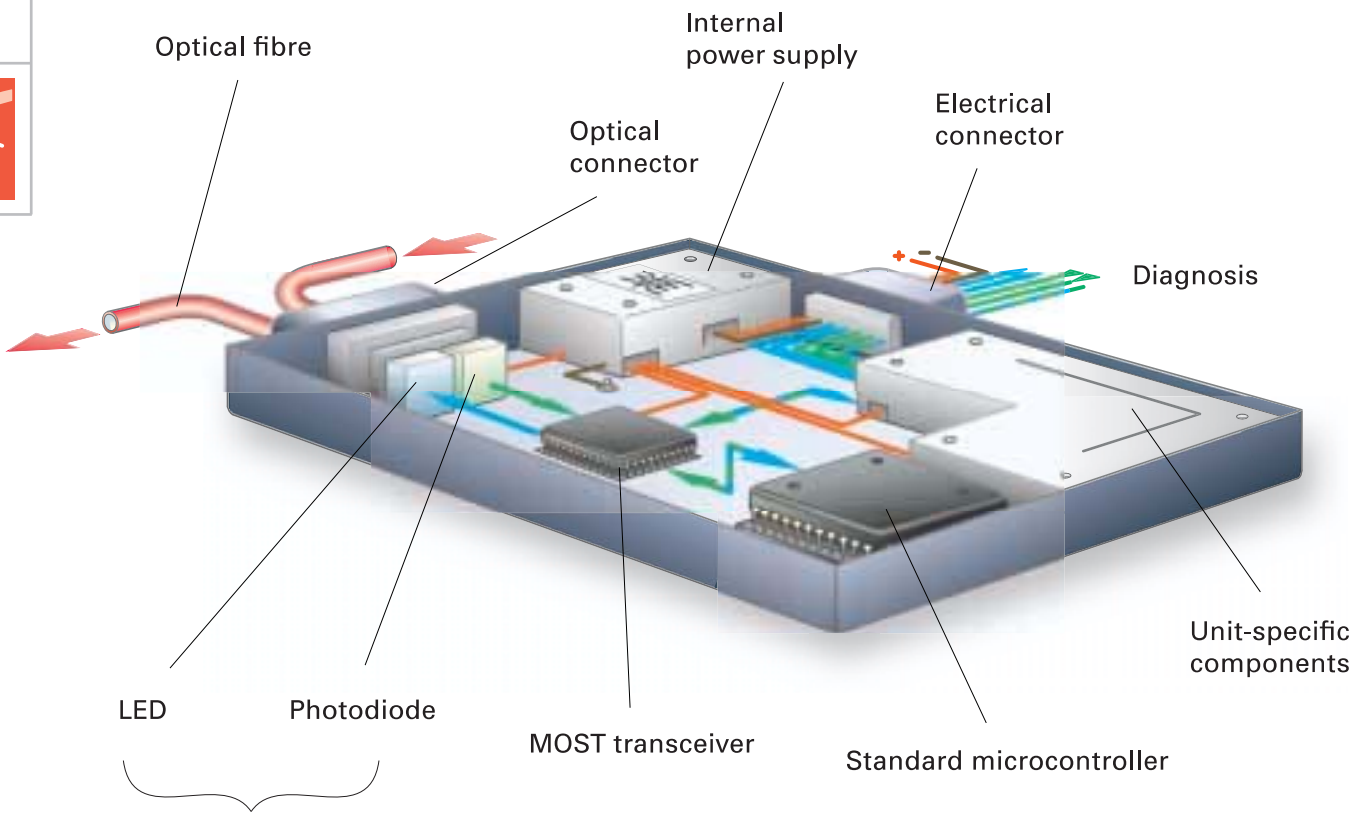
In comparison to radio waves, light waves have very short wavelengths. In addition, they neither generate nor are susceptible to electromagnetic interference waves.

These factors permit a high data transfer rate and a high level of interference immunity.



SSP286_003

Design of control units



Transmitter and receiver – Fibre Optical Transmitter (FOT)

SSP286_011

Components of control units in MOST bus

– Optical fibre - optical connector

  By way of this connector, the light signals pass into the control unit or the light signals generated are conveyed to the next bus user.

– Electrical connector

  This connector is responsible for the power supply, ring fault diagnosis (refer to Page 41 onwards) and input and output signals.

– Internal power supply

  The supply voltage fed into the control unit by the electrical connector is distributed to the components by the internal power supply system. This enables individual components in the control unit to be deactivated to reduce closed circuit current.

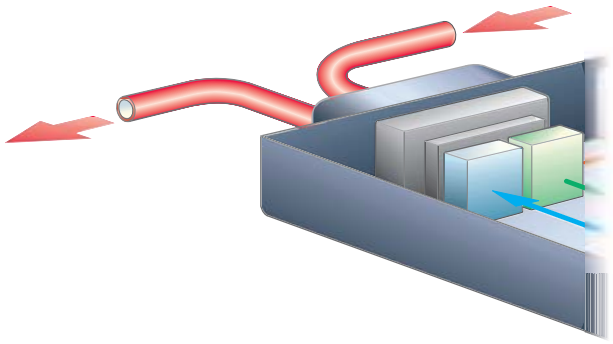
– Transmitter and receiver – Fibre Optical Transmitter (FOT)

  This consists of a photodiode and a light-emitting diode.
  Incoming light signals are converted by the photodiode into a voltage signal which is relayed to the MOST transceiver. The function of the light-emitting diode is to convert MOST transceiver voltage signals into light signals.

  The light waves generated have a wavelength of 650 nm and are visible as red light.

  The data are transmitted by means of light wave modulation.

  This modulated light is then conducted through the optical fibre to the next control unit.



SSP286_063



SSP286_004

– MOST transceiver

  The MOST transceiver consists of two components, namely the **trans**mitter and re**ceiver.**

  The transmitter conveys the messages to be transmitted to the FOT in the form of a voltage signal.

  The receiver accepts the voltage signals from the FOT and conveys the required data to the standard microcontroller (CPU) of the control unit.

  Non-required messages from other control units pass through the transceiver without data being conveyed to the CPU. The messages are transmitted in unaltered form to the next control unit.

– Standard microcontroller (CPU)

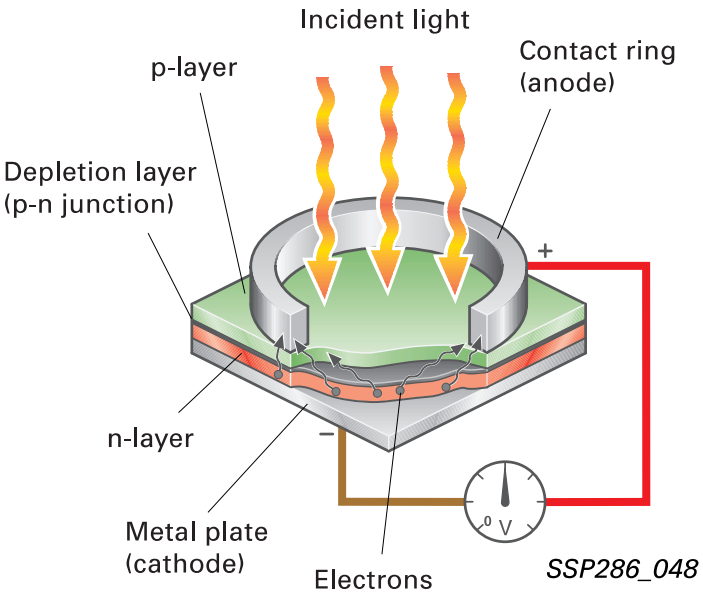
  The standard microcontroller (CPU) is the central processing unit of the control unit. It contains a microprocessor which controls all the major functions of the control unit.

– Unit-specific components

  These components are responsible for the implementation of functions specific to the control unit, e.g. CD drive, radio tuner.

Photodiode

This is designed to convert the light waves into voltage signals.



Design

The photodiode has a p-n junction, onto which light can be focused. On account of a heavily doped p-layer, the depletion layer extends almost exclusively into the n-layer.

There is a contact (anode) at the p-layer. The n-layer is applied to the metallic base (cathode).

Function

The energy associated with the penetration of light or infrared rays into the p-n junction results in the formation of free electrons and holes. These give rise to a flow of current across the p-n junction.

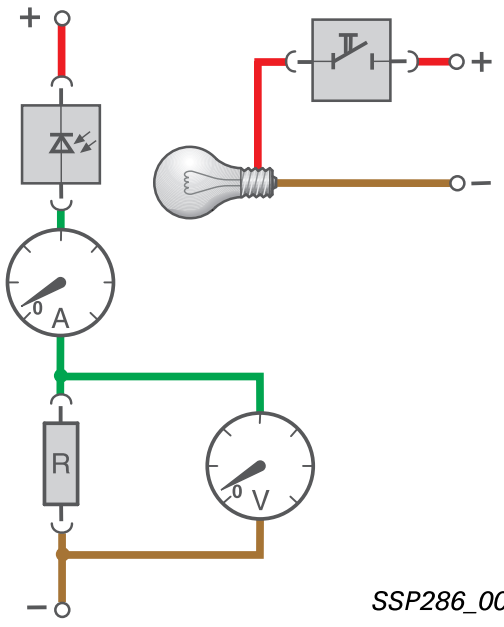
Consequently, the more light which strikes the photodiode the higher will be the current flowing through it.

This process is referred to as the internal photoelectric effect.

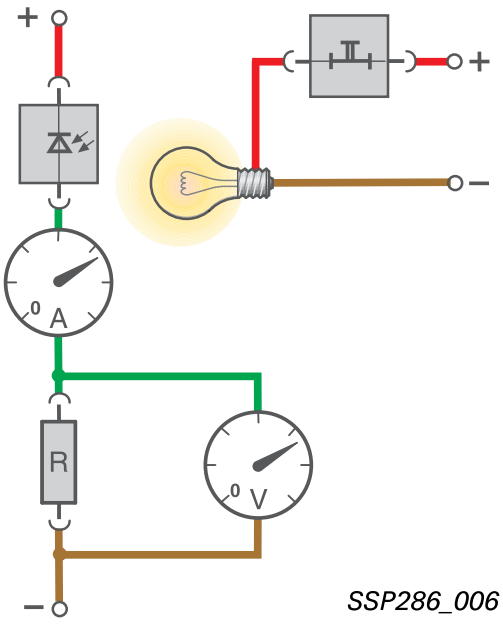
In reverse direction, the photodiode is connected in series with a resistor.

An increase in the current flowing through the photodiode on account of more light striking it increases the drop in voltage at the resistor. The light signal has thus been converted to a voltage signal.

Low incident light



High incident light



Optical fibre

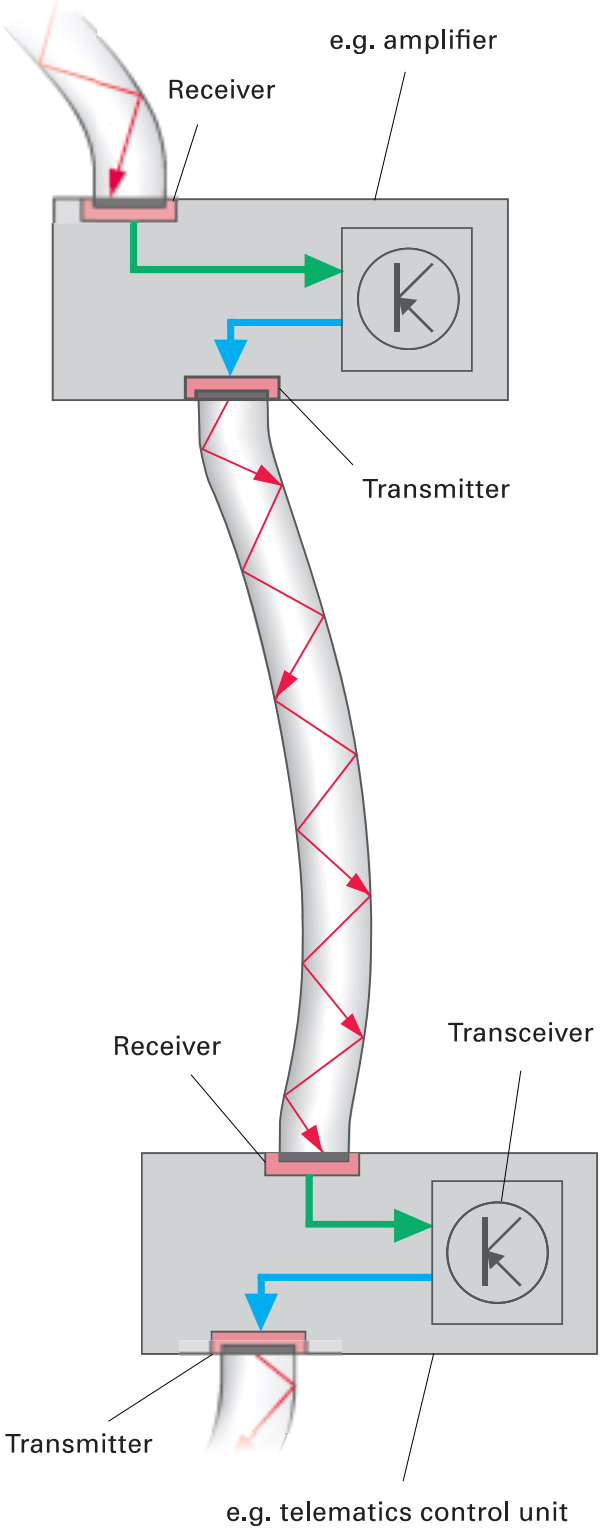
The optical fibre is designed to convey the light waves generated in the transmitter of one control unit to the receiver of another control unit.

Development of the optical fibre was based on the following criteria:

- Light waves travel in straight lines and cannot be bent. However, they have to be routed through bends in the optical fibre.
- The distance between transmitter and receiver may be several metres – Attenuation (refer to Page 27).
- The optical fibre must not be susceptible to damage caused by mechanical impact (vibration, assembly work).
- The optical fibre must operate reliably despite the great temperature fluctuations in the vehicle.

Requirements to be met by optical fibres used for transmitting light signals:

- The optical fibre must conduct the light waves with a low level of attenuation.
- The light waves have to be routed through bends in the optical fibre.
- The optical fibre must be flexible.
- The optical fibre must operate reliably in the temperature range between - 40 °C and 85 °C.



SSP286_020

Design of optical fibre

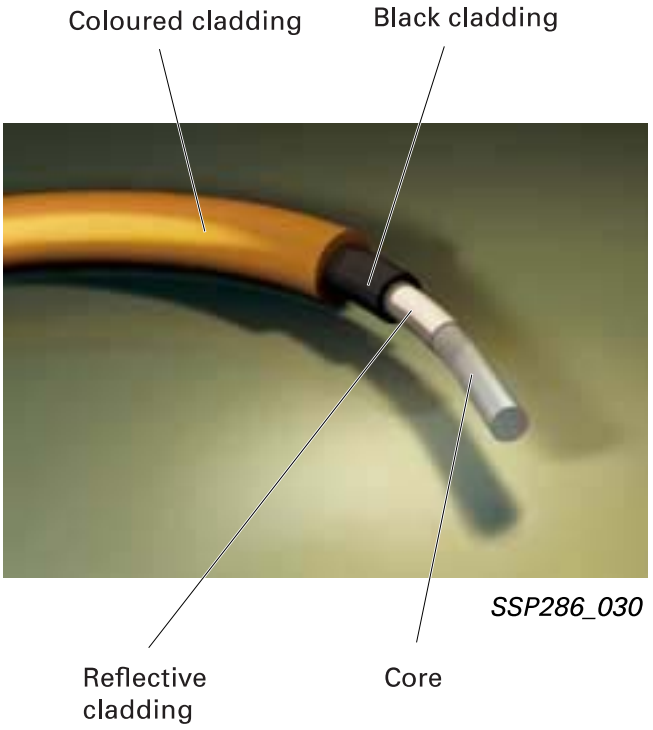
The optical fibre consists of several layers.

The core forms the central part of an optical fibre. It is made of polymethyl methacrylate and represents the actual light conductor, through which the light passes with virtually no losses by way of the total reflection principle. This principle is explained in greater detail in the following.

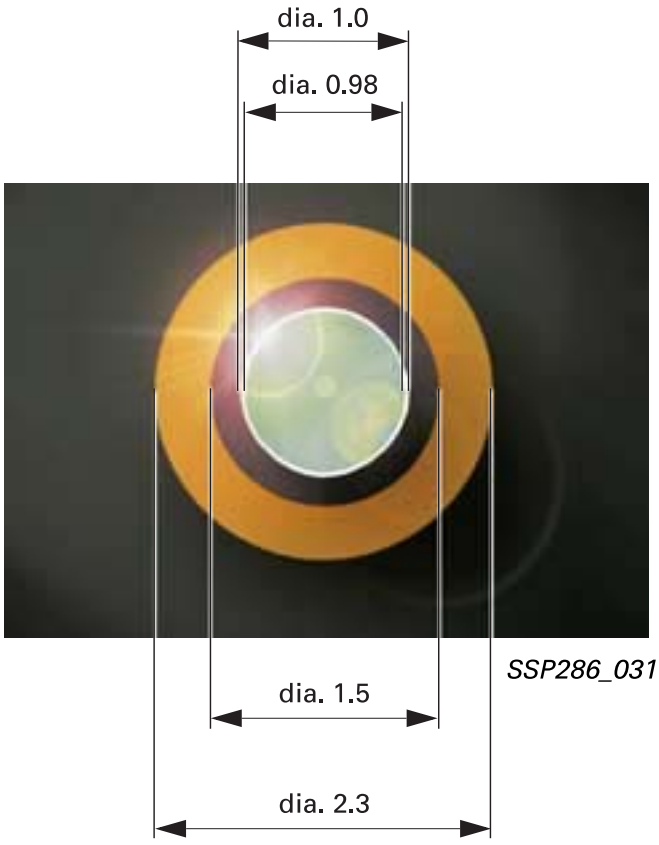
The optically transparent fluoropolymer cladding around the core is required for total reflection.

The black polyamide cladding protects the core against external incident light.

The coloured cladding is used for identification, protection against mechanical damage and thermal protection.



SSP286_030



SSP286_031

Transmission of light waves in optical fibre

Straight optical fibre

The optical fibre conducts some of the light waves in a straight line through the core.

Most of the light waves are conveyed in a zigzag pattern as a result of the total reflection occurring at the core surface.

Curved optical fibre

The total reflection occurring at the core cladding boundary causes the light waves to be reflected and thus conducted through the bend.

Total reflection

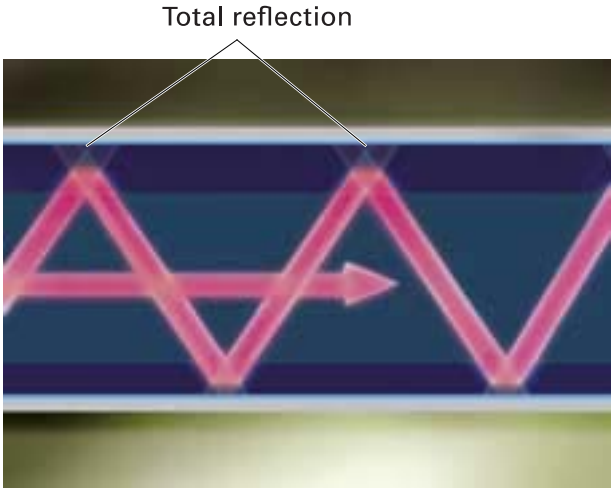
If a beam of light strikes a boundary layer between materials with higher and lower refractive indices at a shallow angle, the beam is fully reflected, i.e. total reflection takes place.

In an optical fibre, the material of the core has a higher refractive index than that of the cladding, with the result that total reflection takes place within the core.

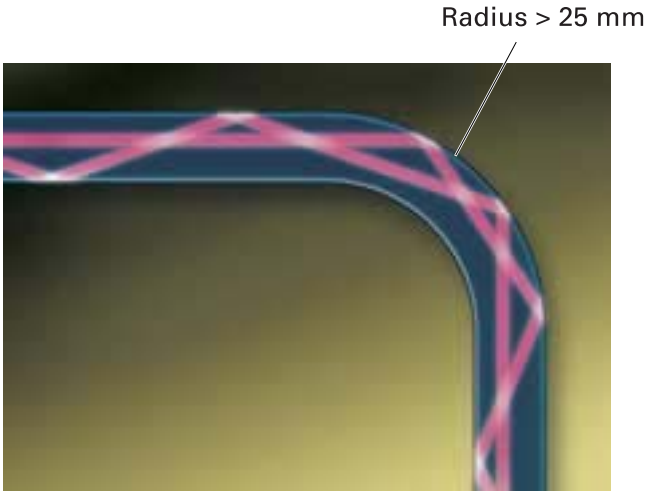
This effect is governed by the angle of the light waves striking the boundary from inside. If this angle becomes too steep, the light waves will leave the core and high losses will occur.

This situation is encountered if the optical fibre is excessively bent or kinked.

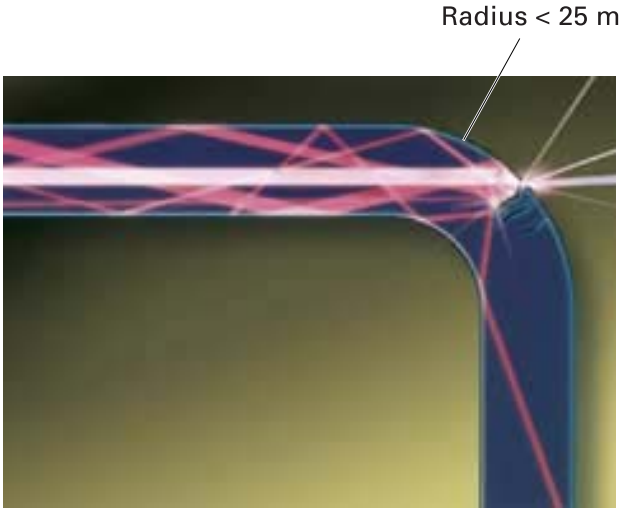
The bending radius of the optical fibre must not be less than 25 mm.



SSP286_032

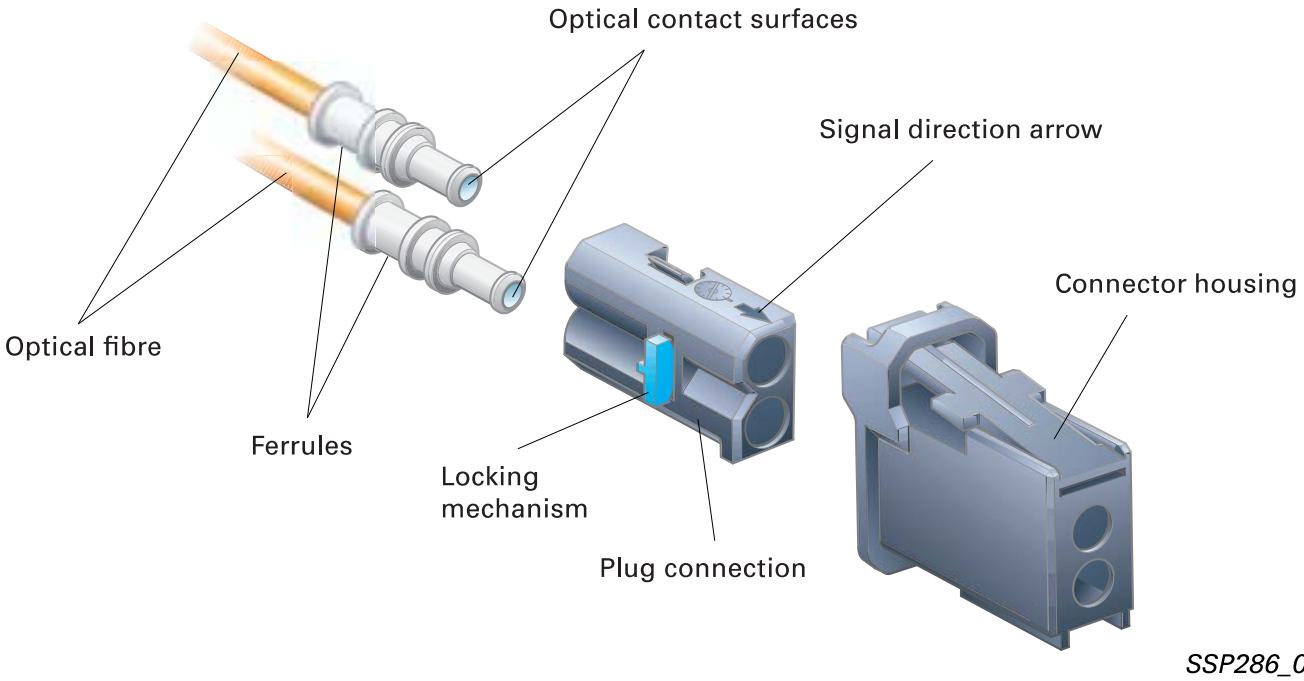


SSP286_033



SSP286_034

Connector



SSP286_035

Use is made of special optical connectors to link the optical fibres to the control units. A signal direction arrow on the plug connection indicates the input (to the receiver).

The connector housing creates the link with the control unit.

The light is transmitted by the end face of the core to the transmitter/receiver in the control unit.

At the optical fibre production stage, laser-welded plastic ferrules or crimp-type brass ferrules are fitted to secure the optical fibre in position in the connector housing.

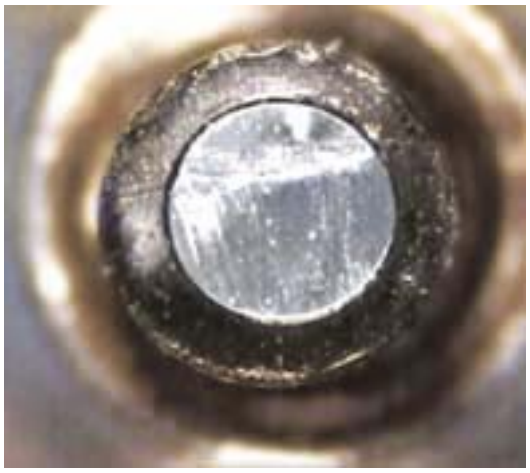
Optical end face

To minimise transmission losses, the end face of the optical fibre must be

- smooth
- perpendicular and
- clean.

This can only be achieved using a special cutting tool.

Dirt and scratches on the cut face cause higher losses (attenuation).



SSP286_081

Attenuation in optical bus

Assessment of the optical fibre condition involves measuring the attenuation.

A reduction in the power of the light waves during transmission is referred to as attenuation.

Attenuation (A) is given in decibels (dB).

A decibel is not an absolute quantity, but rather represents a ratio of two values.
This also explains why the decibel is not defined for specific physical quantities.
The decibel is also used, for example as a unit for expressing sound pressure or volume.

For attenuation measurement, this quantity is calculated from the logarithm of the ratio of transmission power to reception power.

Formula:

$$\text{Attenuation ratio (A)} = 10 * \lg \frac{\text{Transmission power}}{\text{Reception power}}$$

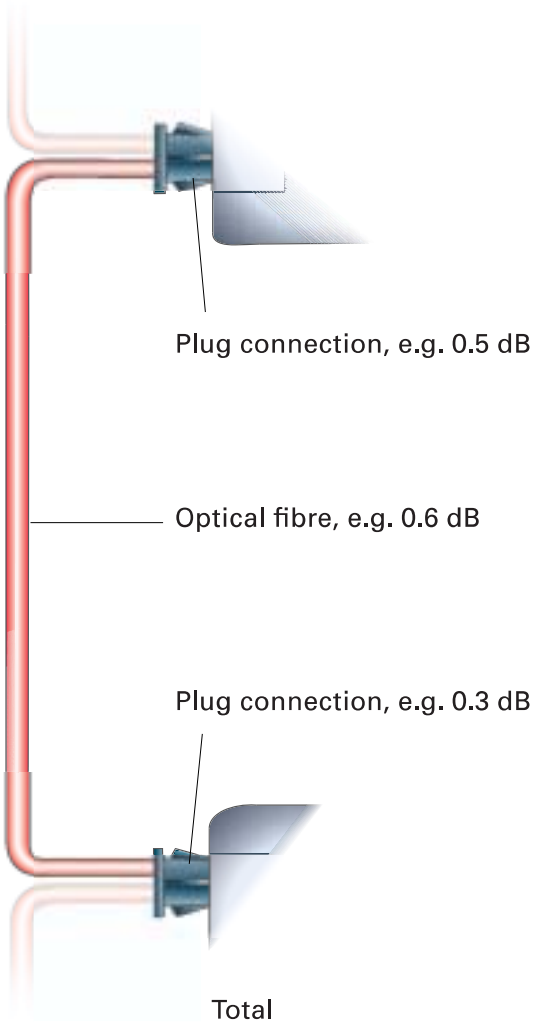
Example:

$$10 * \lg \frac{20\ \text{W}}{10\ \text{W}} = 3\ \text{dB}$$

This means that the light signal is reduced by half for an optical fibre with an attenuation ratio of 3 dB.

In other words, the higher the attenuation ratio, the poorer the signal transmission.

If several components are involved in the transmission of light signals, the attenuation ratios of the components can be added up to form a total attenuation ratio in the same way as the resistances of electrical components connected in series.



SSP286_045

As in the MOST bus each control unit re-transmits the light waves, only the total attenuation ratio between two control units is of significance.

Causes of increased attenuation in the optical data bus

1. Optical fibre bending radius too small
   Bending the optical fibre to a radius of less than 5 mm (kinking) obscures the core (comparable with bent perspex) at the bending point.
   The optical fibre has to be replaced.

2. Damage to optical fibre cladding.

3. End face scratched.

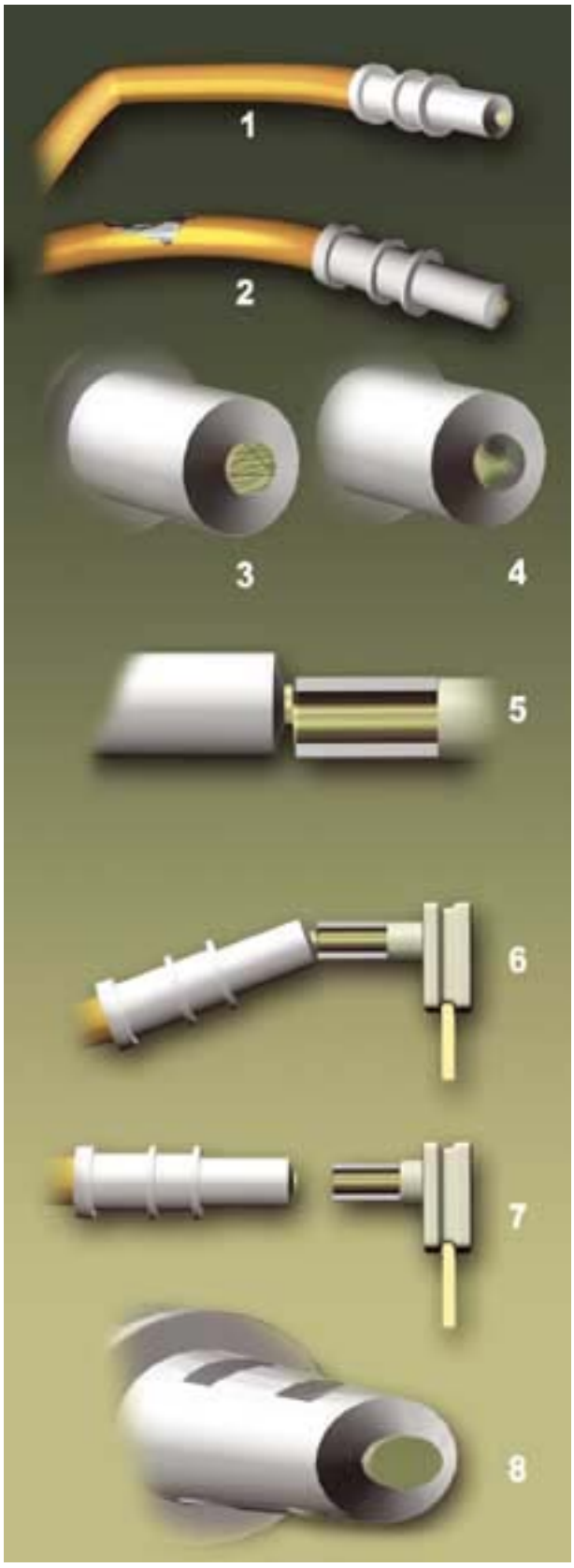
4. End face dirty.

5. End faces offset
   (connector housing broken).

6. End faces not in line
   (angle error).

7. Gap between end face of optical fibre and contact surface of control unit (connector housing broken or not engaged).

8. Ferrule not properly crimped.



SSP286_069

Optical fibre anti-kink sleeve

Fitting an anti-kink sleeve guarantees a minimum optical fibre radius of 25 mm.

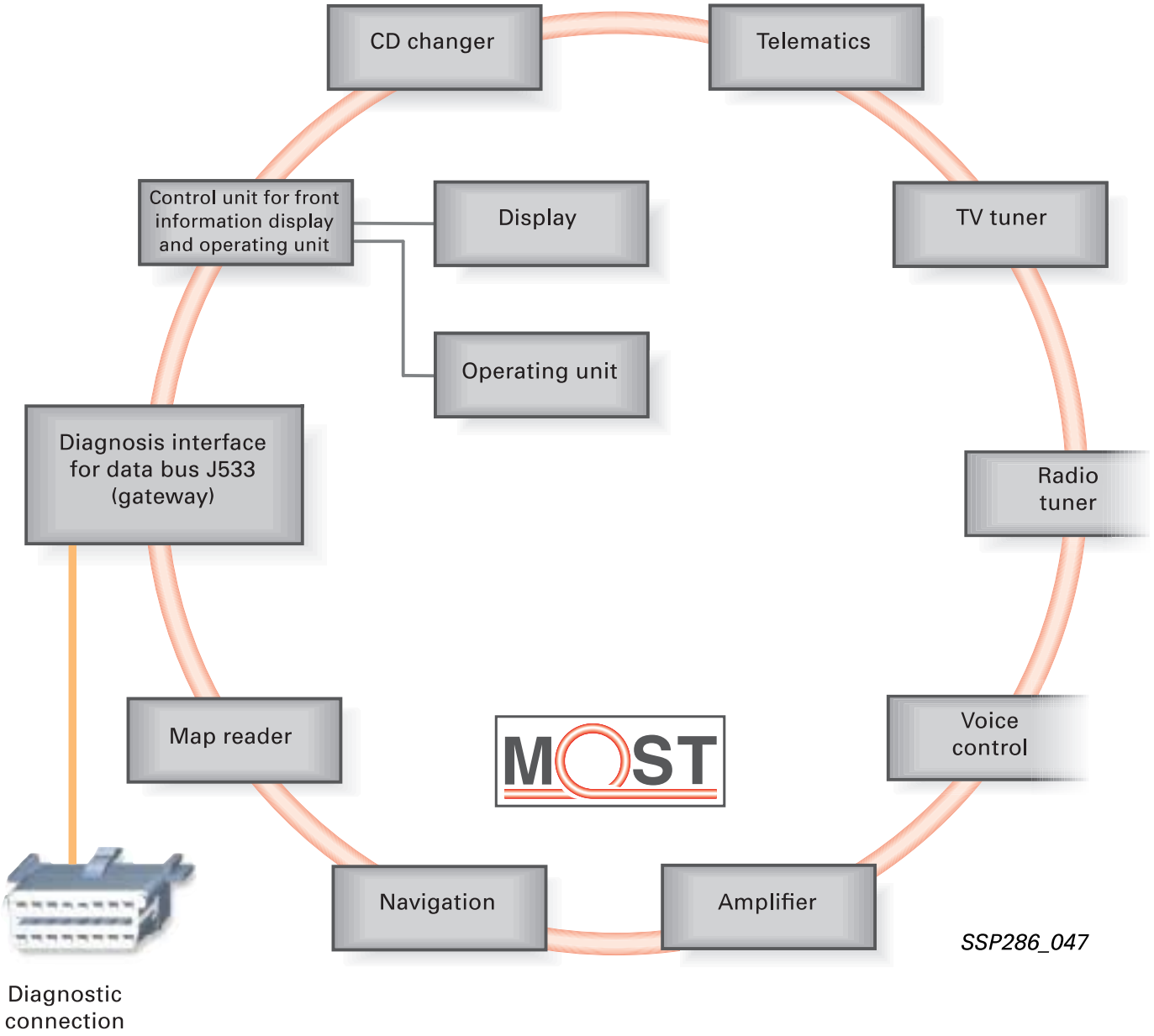


SSP286_087

Rules for handling optical fibres and their components

- Never employ thermal working and repair methods such as soldering, hot bonding or welding
- Never employ chemical and mechanical methods such as bonding and jointing
- Never twist together two optical fibre cables or an optical fibre cable and a copper wire
- Avoid cladding damage such as perforation, cutting or crushing: Do not stand or place objects on cladding, etc. when fitting in vehicle
- Avoid contaminating end face, e.g. with fluids, dust or other media; prescribed protective caps are only to be removed for connection or test purposes employing extreme care
- Avoid loops and knots when laying in vehicle; pay attention to correct length when replacing optical fibre

Ring configuration of MOST bus



Diagnostic connection

A distinguishing feature of the MOST bus system is its ring configuration.

The control units transmit data in one direction via an optical fibre to the next control unit in the ring.

This process continues until the data return to the control unit which originally transmitted them.

This completes the ring.

MOST bus system diagnosis is implemented by way of the data bus diagnosis interface and the diagnosis CAN.

System manager

Together with the diagnosis manager, the system manager is responsible for system administration in the MOST bus.

The diagnosis interface for data bus J533 (gateway) assumes the diagnosis manager functions in the Audi A8 ´03 (refer to Page 41).

The control unit for front information display and operating unit J523 implements the system manager functions.

Functions of system manager:

- Control of system statuses
- Transmission of MOST bus messages
- Management of transmission capacities

MOST bus system statuses

Sleep mode

There is no data exchange in the MOST bus. The units are switched to standby and can only be activated by an optical start pulse from the system manager.

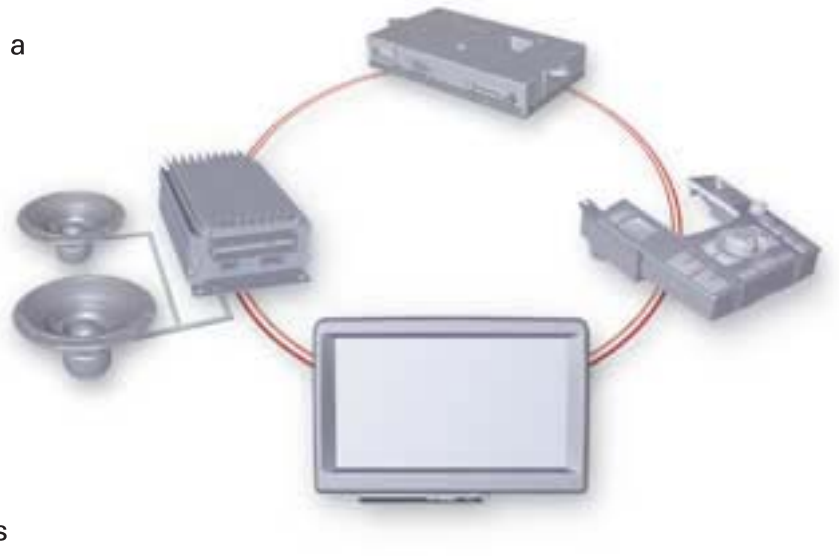
The closed-circuit current is reduced to a minimum.

Sleep mode activation conditions:

- All control units in MOST bus system indicate readiness to switch to sleep mode.
- No requests from other bus systems via the gateway.
- Diagnosis not active.

At a higher ranking level, the MOST bus system can be switched to sleep mode

- by the battery manager via the gateway in the event of starter battery discharge
- by activation of transport mode via the diagnosis tester



SSP286_066

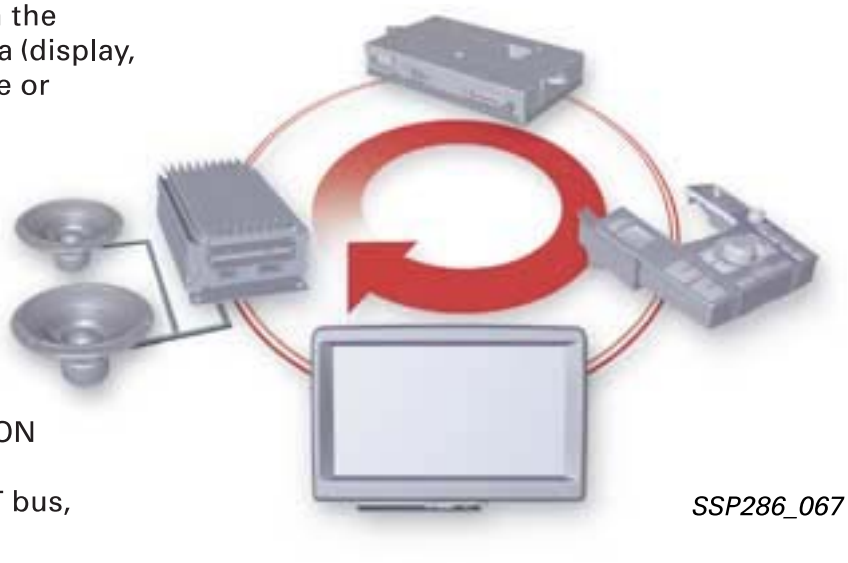
Standby mode

No functions are available to the user, i.e. the system gives the impression of being switched off. The MOST bus system is active in the background, however all output media (display, radio amplifier etc.) are either inactive or muted.

This mode is active on starting and during system run-on.

Activation of standby mode

- Activation by other data buses via gateway, e.g. unlocking/ opening of driver's door, ignition ON
- Activation by control unit in MOST bus, e.g. incoming call (telephone)



SSP286_067

Power ON

The control units are fully activated. Data are exchanged on the MOST bus. All functions are available to the user.

Prerequisites for Power ON mode:

- MOST bus system in standby mode
- Activation by other data buses via gateway e.g. S-contact, display active
- Activation by user function selection, e.g. via multimedia operating unit E380

Further information on system status activation can be found in the Self Study Programmes for the appropriate vehicle models.



SSP286_068

Frames

The system manager transmits the frames to the next control unit in the ring at a clock frequency of 44.1 kHz.

Clock frequency

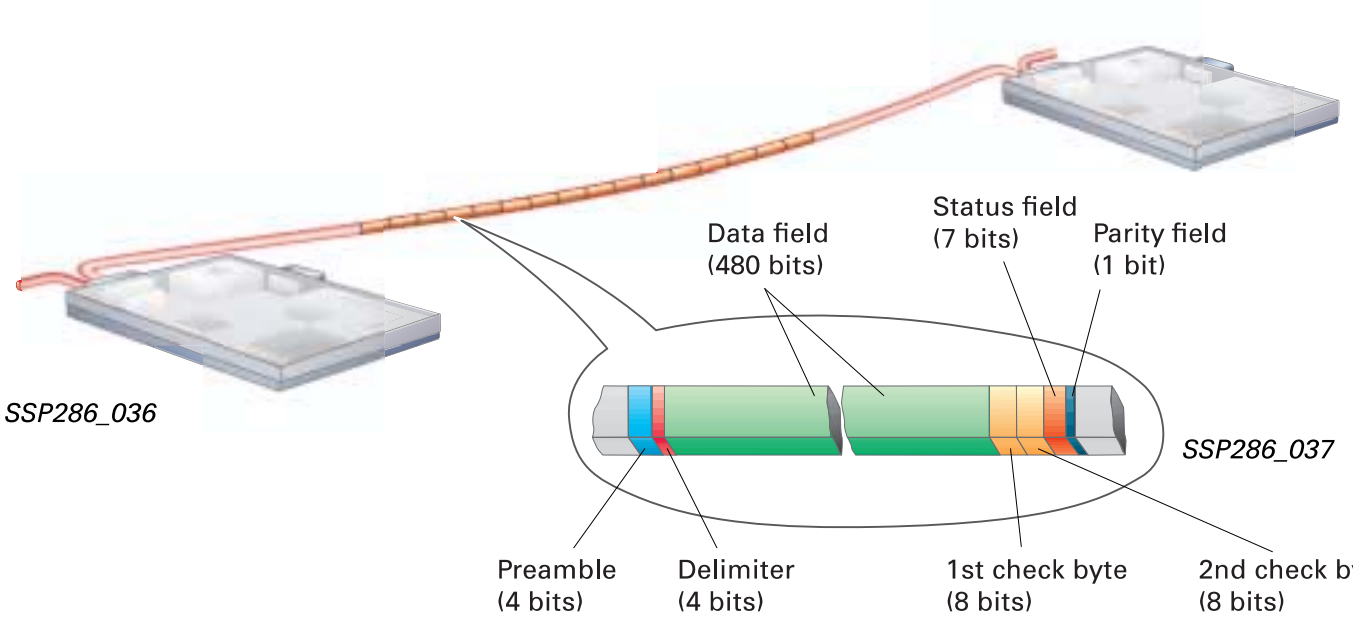
On account of the fixed time slot pattern, the clock frequency permits the transmission of synchronous data.

Synchronous data are used to carry information such as sound and moving images (video) which always has to be transmitted at the same intervals.

The fixed clock frequency of 44.1 kHz corresponds to the transmission frequency of digital audio units (CD, DVD player, DAB radio) and thus permits the connection of these units to the MOST bus.

The magnitude of a frame is 64 bytes, divided up as indicated below.

Structure of a frame



SSP286_036

SSP286_037

1 byte corresponds to 8 bits.

Frame areas

The **preamble** marks the start of a frame. Each frame in a block has a separate preamble.



SSP286_039

A **delimiter** creates a clear distinction between the preamble and the subsequent data fields.



SSP286_040

The **data field** is used by the MOST bus to transmit up to 60 bytes of user data to the control units.

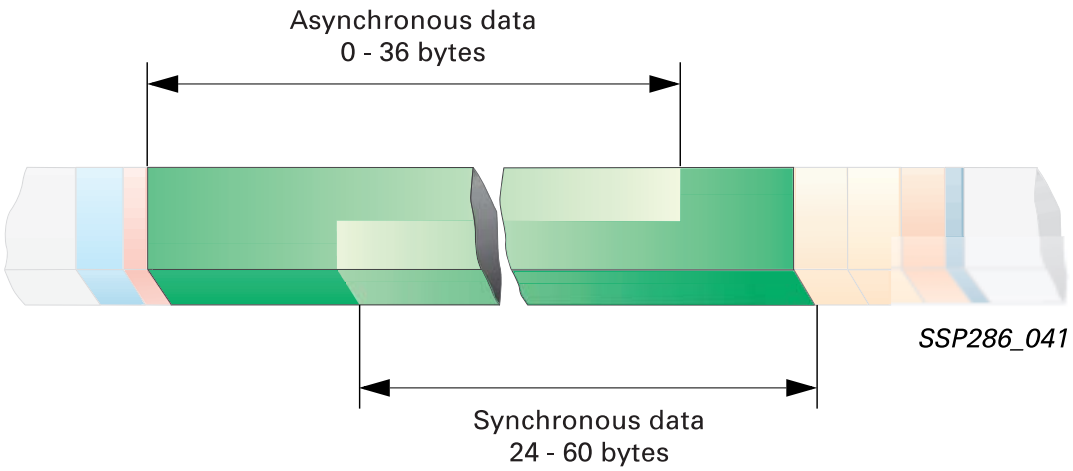
A distinction is made between two types of data:

- Audio and video in the form of synchronous data
- Images, information for calculation purposes and messages in the form of asynchronous data

The data field has a flexible structure. The proportion of synchronous data in the data field is between 24 and 60 bytes. The transmission of synchronous data has priority.

The asynchronous data are entered and thus transmitted to the receiver in packets of 4 bytes (quadlets) on the basis of the transmitter/receiver addresses (identifier) and the available asynchronous volume.

The corresponding data transfer processes are described in more detail on Page 38 onwards.



SSP286_041

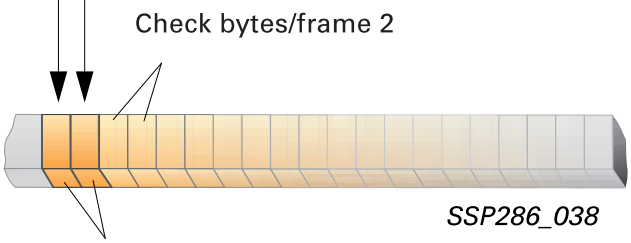
The two **check bytes** are used to transmit information such as

- Transmitter and receiver address (identifier)
- Control commands to receiver (e.g. amplifier setting up/down)



SSP286_042

The block **check bytes** are assembled in the control units to form a check frame. One block consists of 16 frames. The check frame contains control and diagnosis data to be transferred from a transmitter to a receiver. This is referred to as address-oriented data transfer.



SSP286_038

Example:

Transmitter – Control unit for front information display and operating unit

Receiver – Amplifier

Control signal – up/down

The **status field** of a frame contains frame transmission information for the receiver.



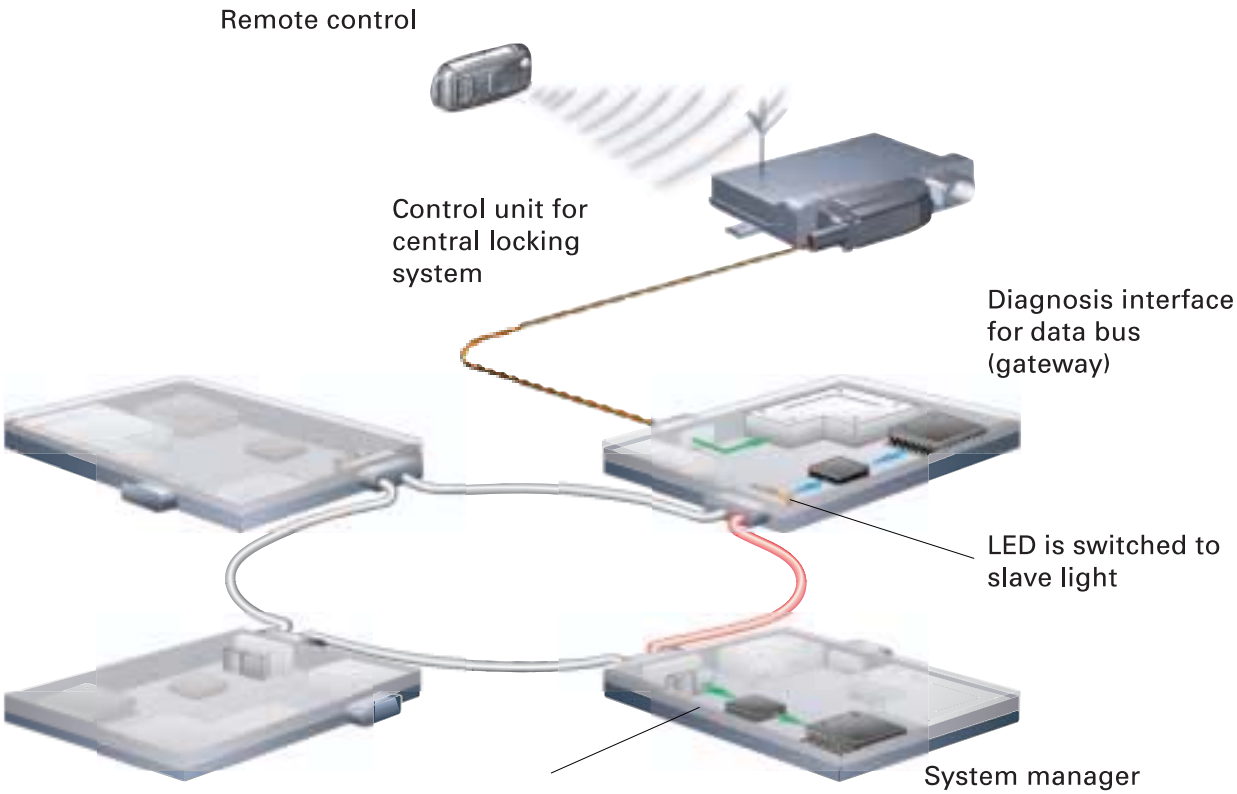
SSP286_043

The **parity field** is used for a final check that the frame is complete. The content of this field governs whether a transmission process is repeated.



SSP286_044

Operating sequences in MOST bus



System start (wake-up)

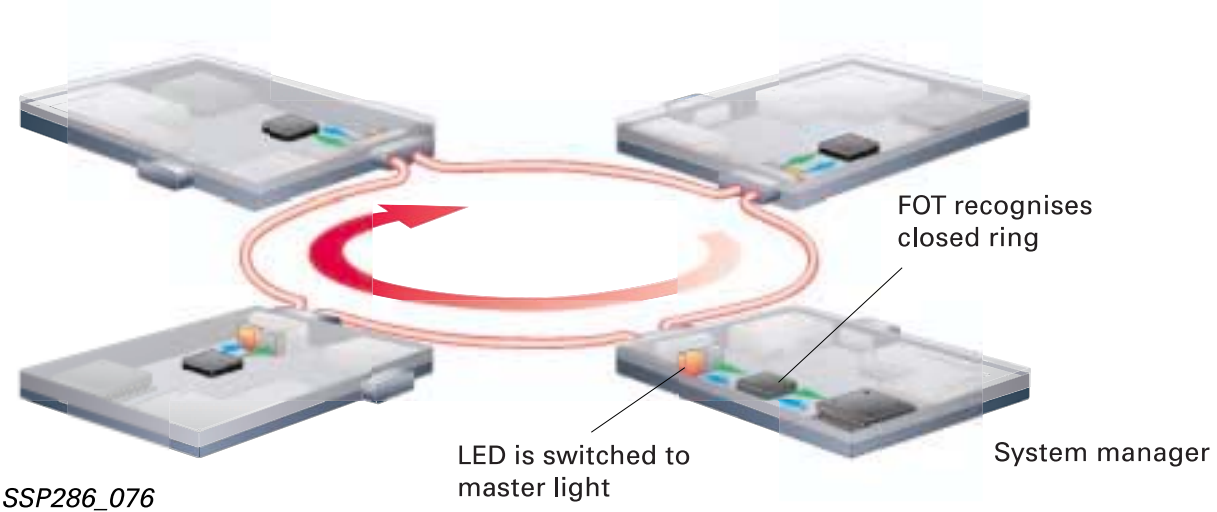
If the MOST bus is in sleep mode, the wake-up process initially switches the system to standby mode.

If one of the control units, with the exception of the system manager, wakes the MOST bus, it transmits specially modulated light – slave light – to the next control unit.

By way of the photodiode which is active in sleep mode, the next control unit in the ring receives the slave light and passes it on.

This process continues right through to the system manager. In the incoming slave light the manager recognises the prompt for system starting.

The system manager then transmits another specially modulated light – master light – to the next control unit. This master light is relayed by all control units. Reception of the master light in its FOT informs the system manager that the ring is complete and frame transmission commences.



SSP286_076

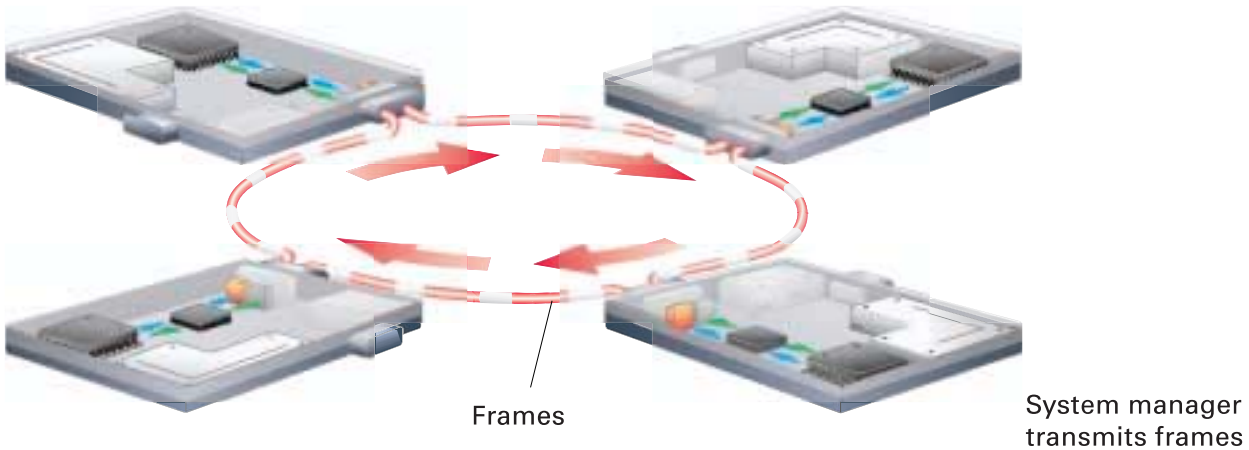
In the first frames the control units in the MOST bus are requested to provide identification.

Based on the identification, the system manager transmits the current sequence (actual configuration) to all control units in the ring. This permits address-oriented data transfer.

The diagnosis manager compares the reported control units (actual configuration) to a stored list of control units fitted (specified configuration).

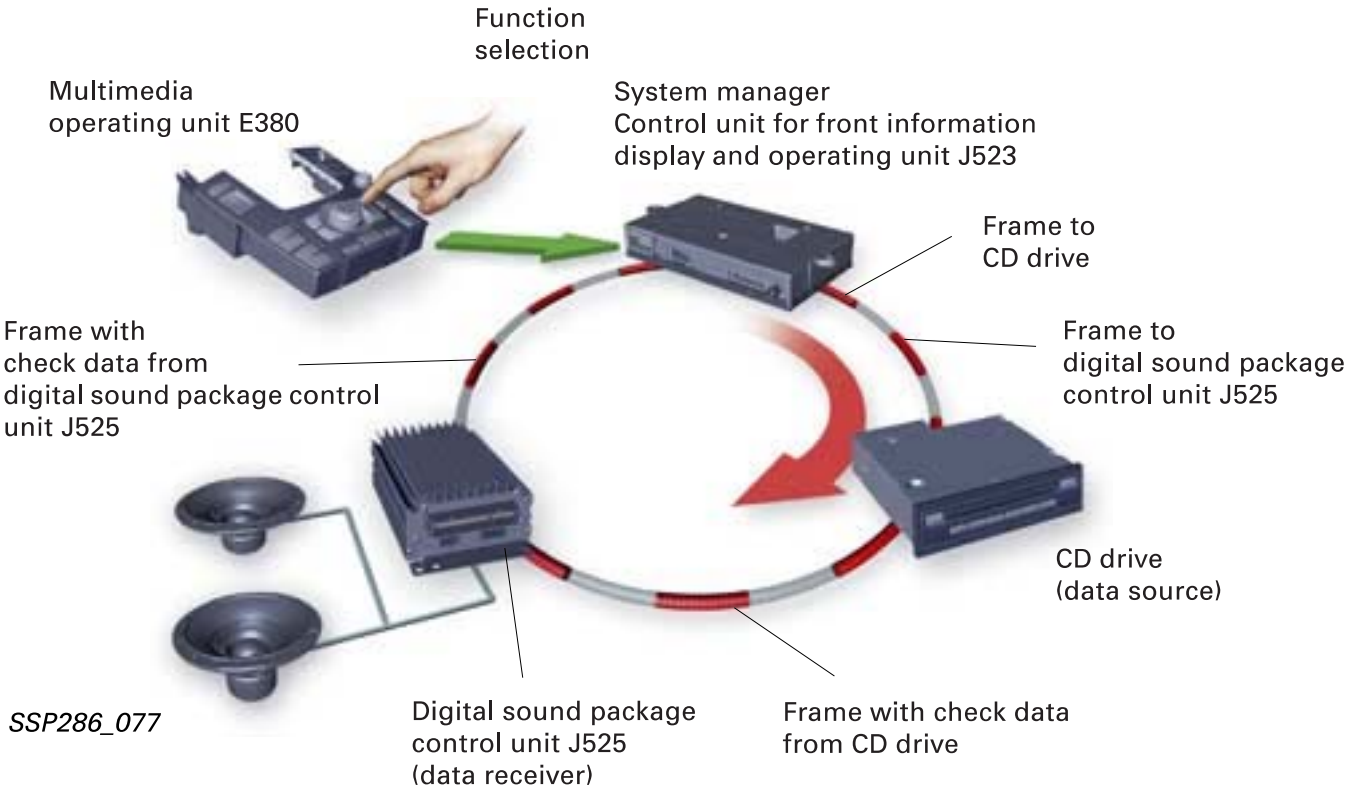
If the actual and specified configurations do not coincide, the diagnosis manager stores corresponding fault memory entries.

This completes the wake-up process and data transfer can commence.



SSP286_086

Audio and video transmission in the form of synchronous data



By way of explanation, synchronous data transfer is described on the basis of the mode of operation involved in playing a music CD in the Audi A8 '03.

With the aid of the multimedia operating unit E380 and the information display unit J685, the user selects the desired track on the music CD.

By way of a data wire, the operating unit E380 transmits the control signals to the control unit for front information display and operating unit J523 (system manager). Corresponding information can be found in the Self Study Programme 293 – Audi A8 ´03 Infotainment.

The system manager then inserts a message block (= 16 frames) with the check data into the frames constantly transmitted.

– Transmitter address:
  - Control unit for front information display and operating unit J523, position 1 in ring

– Receiver address of data source:
  - CD drive, position in ring (depends on equipment)

– Control commands:
  - Play track 10
  - Assign transmission channels

The CD drive (data source) determines which bytes in the data field are available for transmitting its data.

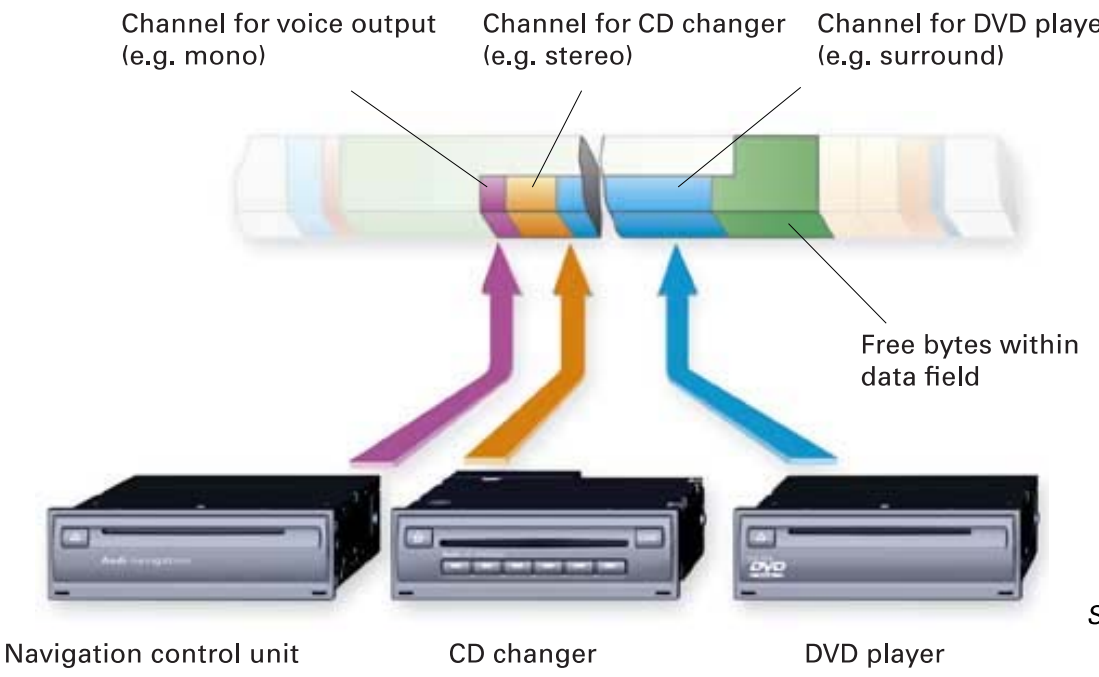
It then inserts a block with the check data.

– Transmitter address of data source:
  - CD drive, position in ring (depends on equipment)

– Receiver address of system manager:
  - Control unit for front information display and operating unit J523, position 1 in ring

– Control command:
  - Data transfer/music CD on channels 01, 02, 03, 04 (stereo))

Data management with synchronous transmission



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The control unit for front information display and operating unit J523 then uses a block with the check data

– Transmitter address:
  - Control unit for front information display and operating unit J523, position 1 in ring
– Receiver address:
  - Digital sound package control unit J525, position in ring (depends on equipment)
– Control commands:
  - Read out data channels 01, 02, 03, 04 and reproduce via speakers
  - Current sound settings such as volume, fader, balance, bass, treble, middle
  - Deactivate muting

to issue the instruction to the digital sound package control unit J525 (data receiver) to reproduce the music.

The music CD data are retained in the data field until the frame reaches the CD drive (i.e. the data source) again via the ring. The data are then replaced by fresh data and the cycle commences again.

This permits use of the synchronous data by all output units (sound package, headphone connections) in the MOST bus.

The system manager determines which unit is to use the data by transmitting the corresponding check data.

Transmission channels

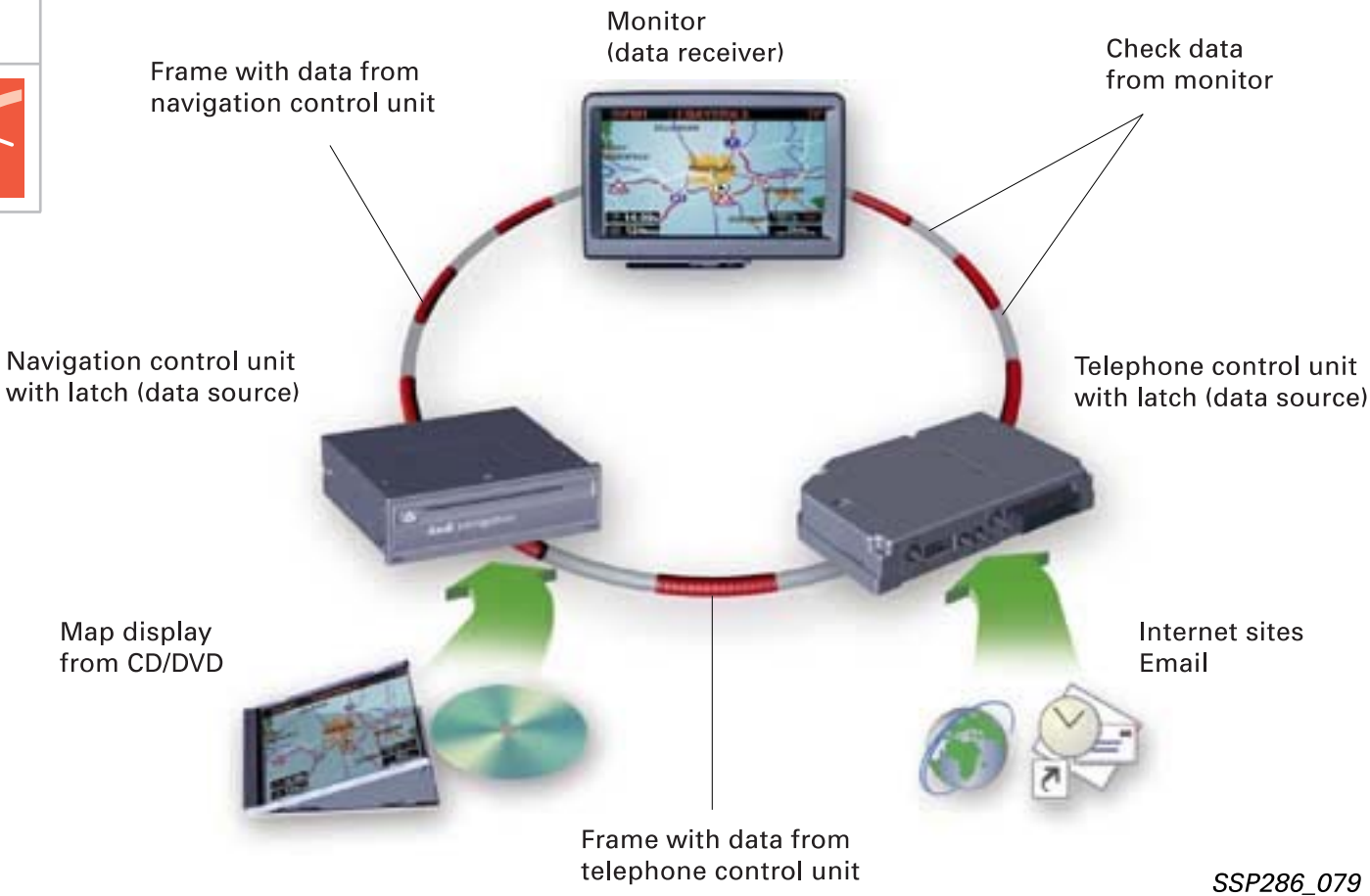
Audio and video transmission requires several bytes in each data field. The data source reserves a number of bytes in line with the type of signal. The bytes reserved are referred to as channels. One channel contains one byte of data.

Number of transmission channels

Signal	Channels/bytes
Mono	2
Stereo	4
Surround	12

This reservation of channels permits the simultaneous transmission of synchronous data from several data sources.

Transmission of data for images, messages and functions in the form of asynchronous data



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The data for

- Navigation system map display
- Navigation calculations
- Internet sites
- Email

are transmitted in the form of asynchronous data.
The asynchronous data sources transmit at irregular intervals.

For this purpose, each source stores its asynchronous data in a latch.

The data source then waits until it receives a message block with the address of the receiver.

The source enters the data into the free bytes in the data fields of this message block.

This takes place in packets (quadlets) of 4 bytes each.

The receiver reads the data packets in the data fields and processes the information.

The asynchronous data are retained in the data fields until the message block returns to the data source.

The data source extracts the data from the data fields and replaces them with fresh data if applicable.

Diagnosis

Diagnosis manager

In addition to the system manager, the MOST bus also has a diagnosis manager.

This is responsible for ring fault diagnosis and transmits the diagnosis data of the control units in the MOST bus to the diagnosis unit.

In the Audi A8 ´03, the diagnosis interface for data bus J533 implements the diagnostic functions.



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System malfunction

On account of the ring configuration, interruption of data transfer at a given MOST bus location is referred to as a ring break.

Possible causes of break in ring:

- Break in optical fibre
- Fault in power supply of transmitter or receiver control unit
- Defective transmitter or receiver control unit

Ring fault diagnosis must be performed to localise a break in the ring.
Ring fault diagnosis is part of the final control diagnosis routine of the diagnosis manager.

Consequences of break in ring:

- No audio and video reproduction
- No control and adjustment by way of multimedia operating unit
- Entry in diagnosis manager fault memory ("Break in optical data bus")

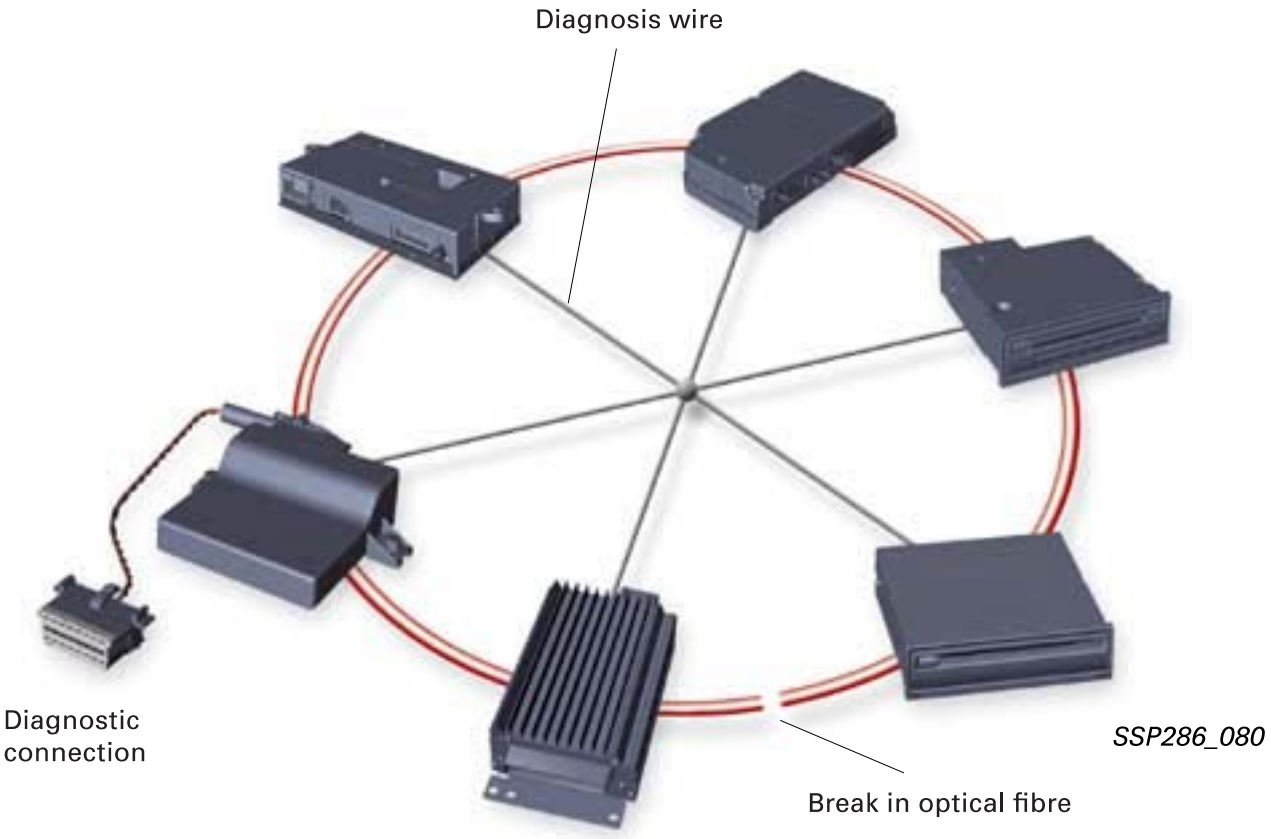
Ring fault diagnosis

Ring fault diagnosis wire

As a break in the ring prevents data transfer in the MOST bus, ring fault diagnosis is implemented with the aid of a diagnosis wire.

The diagnosis wire is linked by way of a central wiring connection to each MOST bus control unit.

MOST bus



After starting ring fault diagnosis, the diagnosis manager transmits a pulse via the diagnosis wire to the control units.

This pulse causes all control units to transmit light signals with the aid of their transmission unit in the FOT.

In this process, all control units check

- their power supply and internal electrical functions.
- Reception of light signals from preceding control unit in ring.

Each MOST bus control unit responds following a time period stipulated in its software.

The time period between start of ring fault diagnosis and control unit response enables the diagnosis manager to recognise which control unit has transmitted the response.

Content of response

Following start of ring fault diagnosis, the MOST bus control units transmit two items of information:

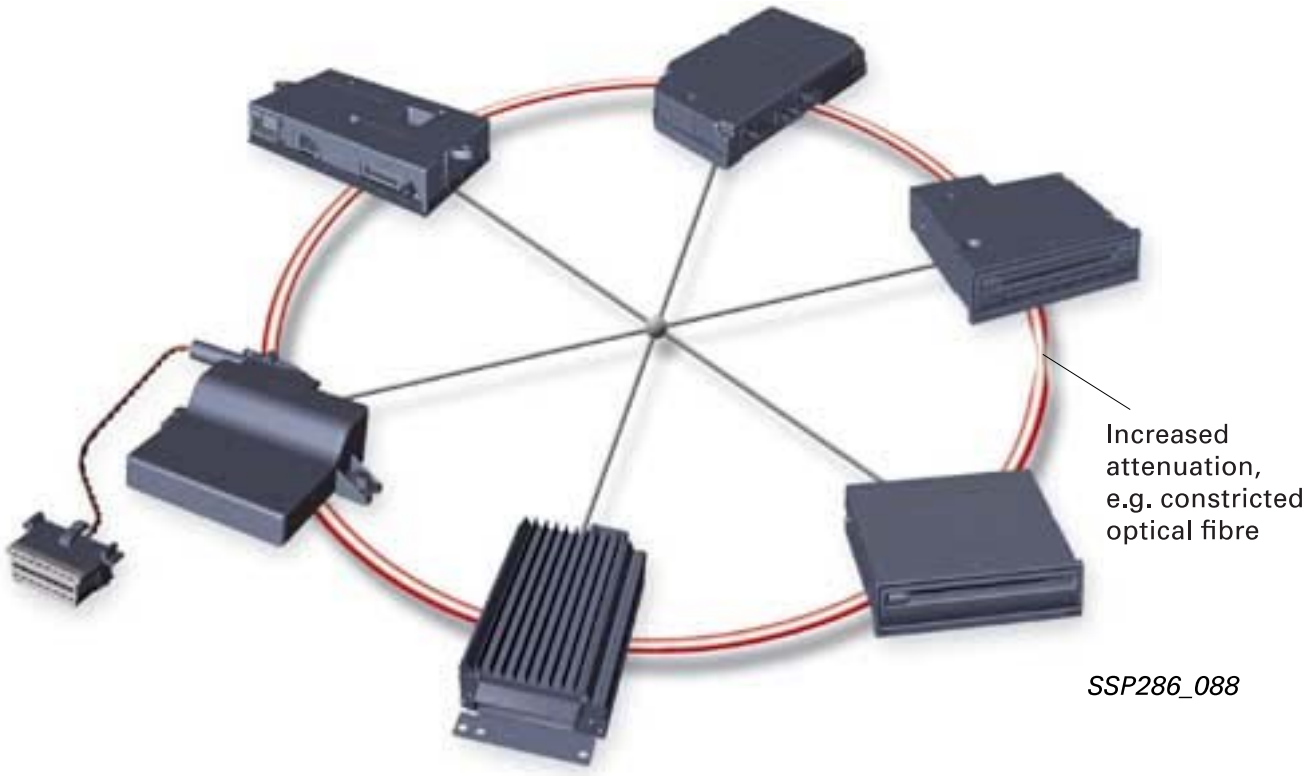
1. Control unit in proper electrical working order – i.e. electrical functions of control unit (e.g. power supply) are OK

2. Control unit in proper optical working order – its photodiode receives the light signal from the preceding control unit in the ring

These messages inform the diagnosis manager

- of any electrical faults in the system (fault in power supply)
- or of the control units between which there is a break in optical data transfer.

Ring fault diagnosis with increased attenuation



Ring fault diagnosis only permits detection of a break in data transfer.

The final control diagnosis function of the diagnosis manager additionally contains ring fault diagnosis with reduced light power for detection of increased attenuation.

The ring fault diagnosis process with reduced power corresponds to that described above.

However, the control units switch on their LEDs in the FOT with an attenuation of 3 dB, i.e. with light power reduced by half.

If the optical fibre is subject to increased attenuation, the light signal reaching the receiver is of insufficient strength. The receiver signals "optical problem".

The diagnosis manager thus recognises the fault location and issues a corresponding message in the assisted fault-finding of the diagnosis tester.