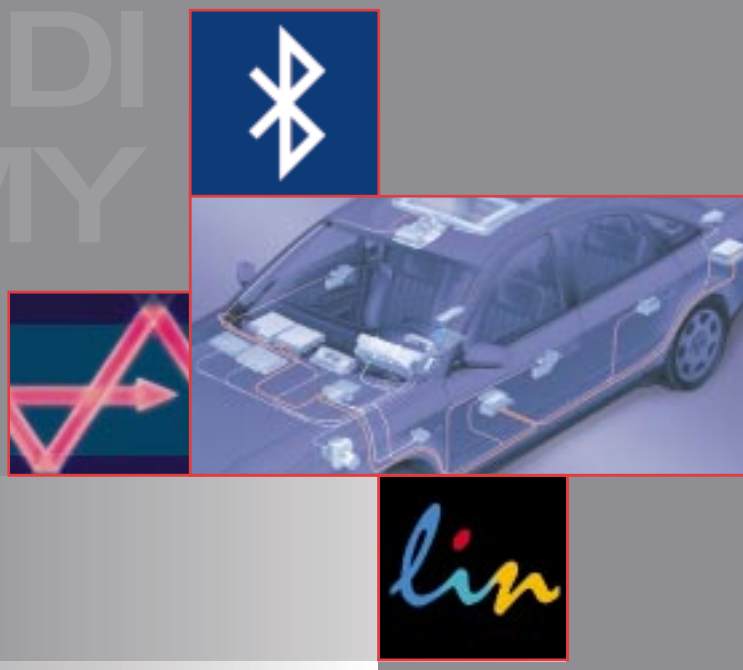
New Data Bus Systems

AUDI ACADEMY



Audi Academy

Self-Study Program
Course Number 971303

Audi of America, Inc.
Service Training
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Printed 12/2002
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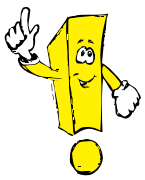
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New !



Important/Note!



The Self-Study Program provides you with information regarding designs and functions.

The Self-Study Program is not a Repair Manual.

For maintenance and repair work, always refer to the current technical literature.

Innovation

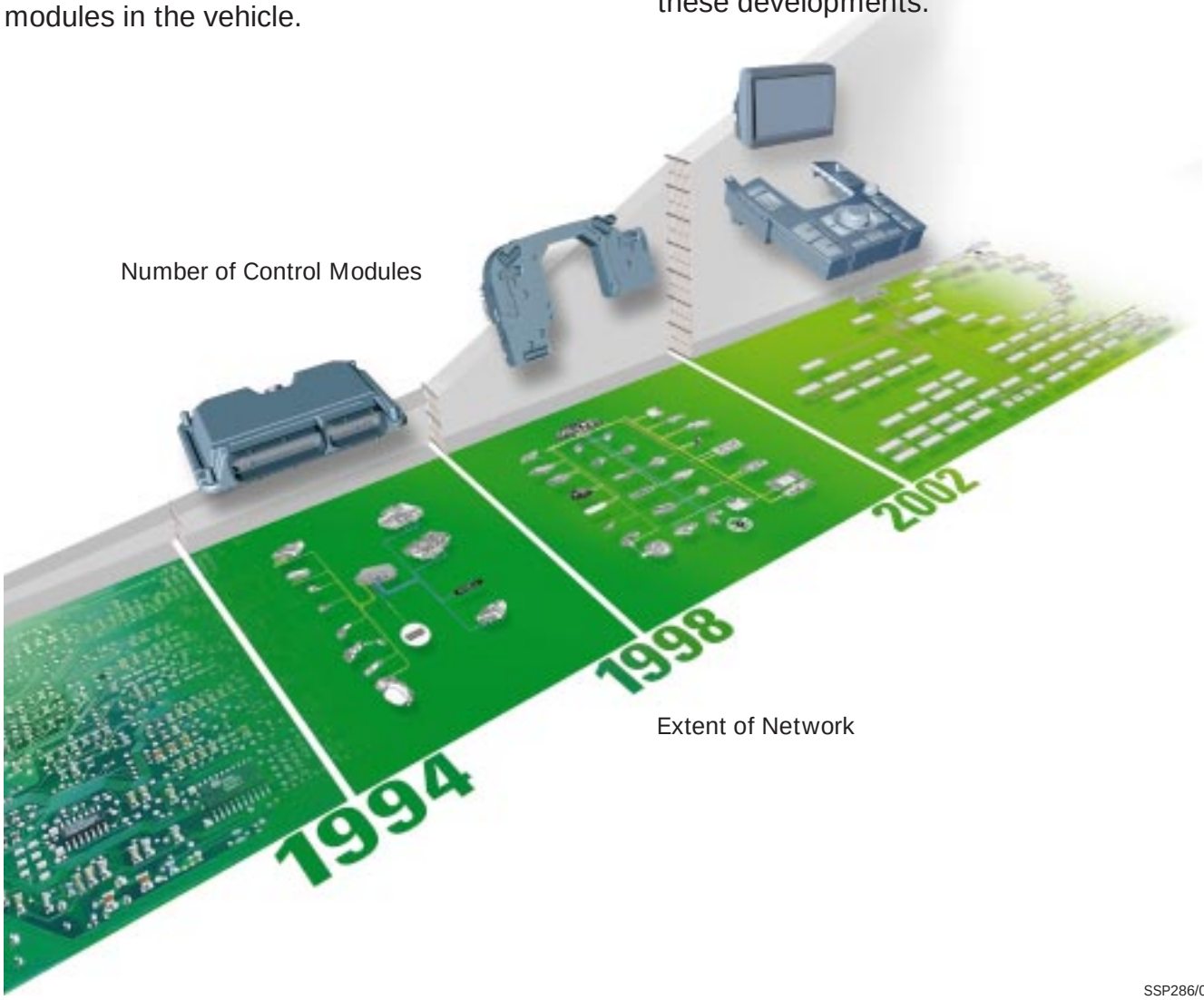
The demand for increases in functionality and comfort in automobiles stimulates an ever-increasing need for more and better vehicle electronic systems.

When the first Audi A8 was introduced in 1994, 15 control modules were sufficient to support all vehicle functions. The number of control modules used in the new 2003 Audi A8, has increased five-fold.

This increase in the use of electronics spurred a search for new ways to transmit data between the individual control modules in the vehicle.

The Audi introduction of the CAN data bus in the mid-nineties was a first and important step. However, the CAN data bus system strains against the limits of data transmission rates, especially for Infotainment applications.

To fill the need for rapid transmission of increasing amounts of information, data-transmission systems have been developed to suit the specific needs of the vehicle systems that they serve. Service and on-board diagnostics also profit from these developments.



SSP286/064

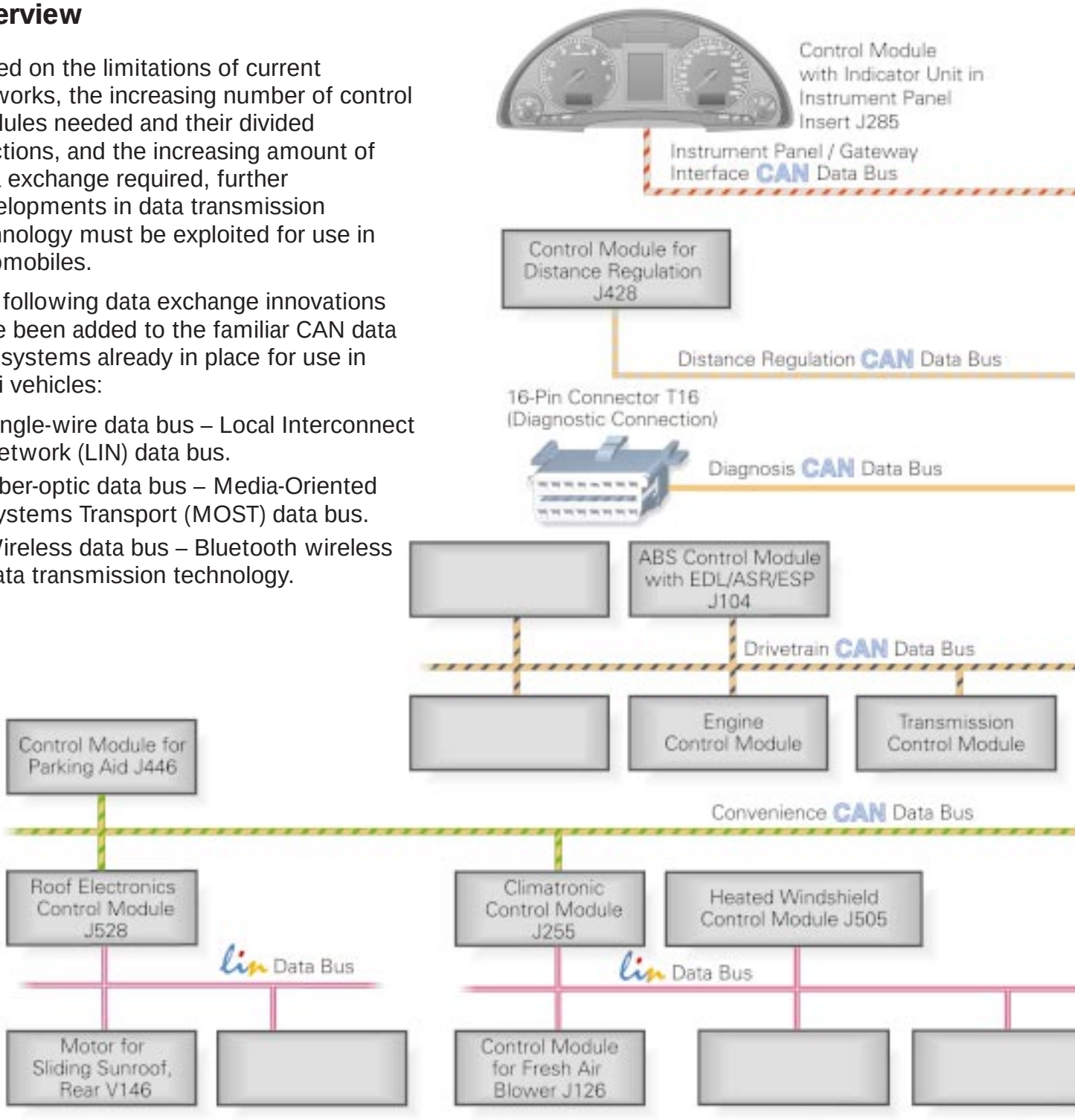
Introduction

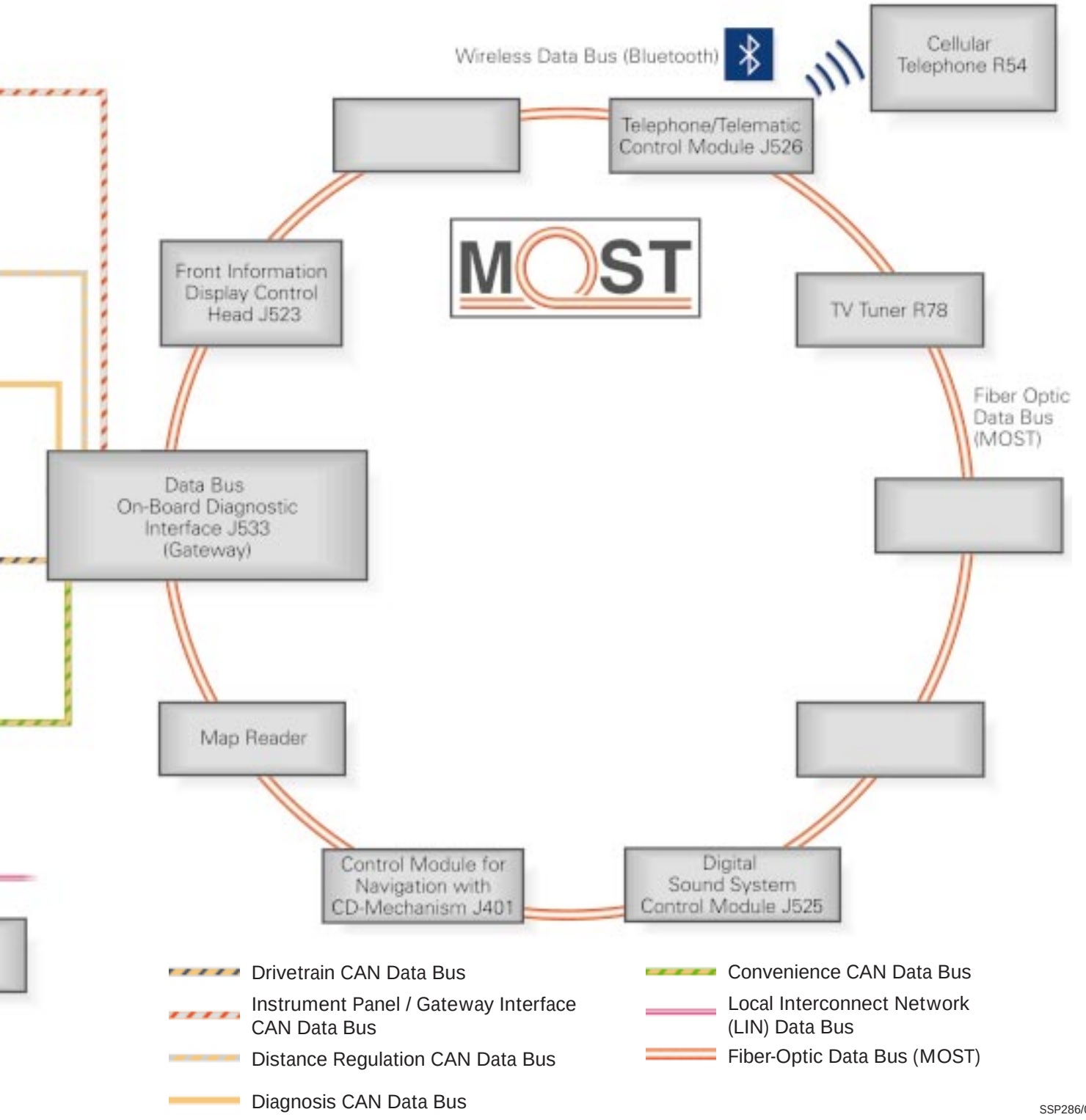
Overview

Based on the limitations of current networks, the increasing number of control modules needed and their divided functions, and the increasing amount of data exchange required, further developments in data transmission technology must be exploited for use in automobiles.

The following data exchange innovations have been added to the familiar CAN data bus systems already in place for use in Audi vehicles:

- Single-wire data bus – Local Interconnect Network (LIN) data bus.
- Fiber-optic data bus – Media-Oriented Systems Transport (MOST) data bus.
- Wireless data bus – Bluetooth wireless data transmission technology.




Wireless Data Bus (Bluetooth)
Cellular Telephone R54
Telephone/Telematic Control Module J526
MOST
Front Information Display Control Head J523
TV Tuner R78
Fiber Optic Data Bus (MOST)
Data Bus On-Board Diagnostic Interface J533 (Gateway)
Map Reader
Control Module for Navigation with CD-Mechanism J401
Digital Sound System Control Module J525
Drivetrain CAN Data Bus
Instrument Panel / Gateway Interface CAN Data Bus
Distance Regulation CAN Data Bus
Diagnosis CAN Data Bus
Convenience CAN Data Bus
Local Interconnect Network (LIN) Data Bus
Fiber-Optic Data Bus (MOST)

SSP286/001

Local Interconnect Network Data Bus

Introduction

The acronym “LIN” stands for “Local Interconnect Network.”

“Local interconnect” means that all control modules in an individual network are located within a limited vehicle area, such as the roof. This kind of network is also sometimes called a “local sub-system.”

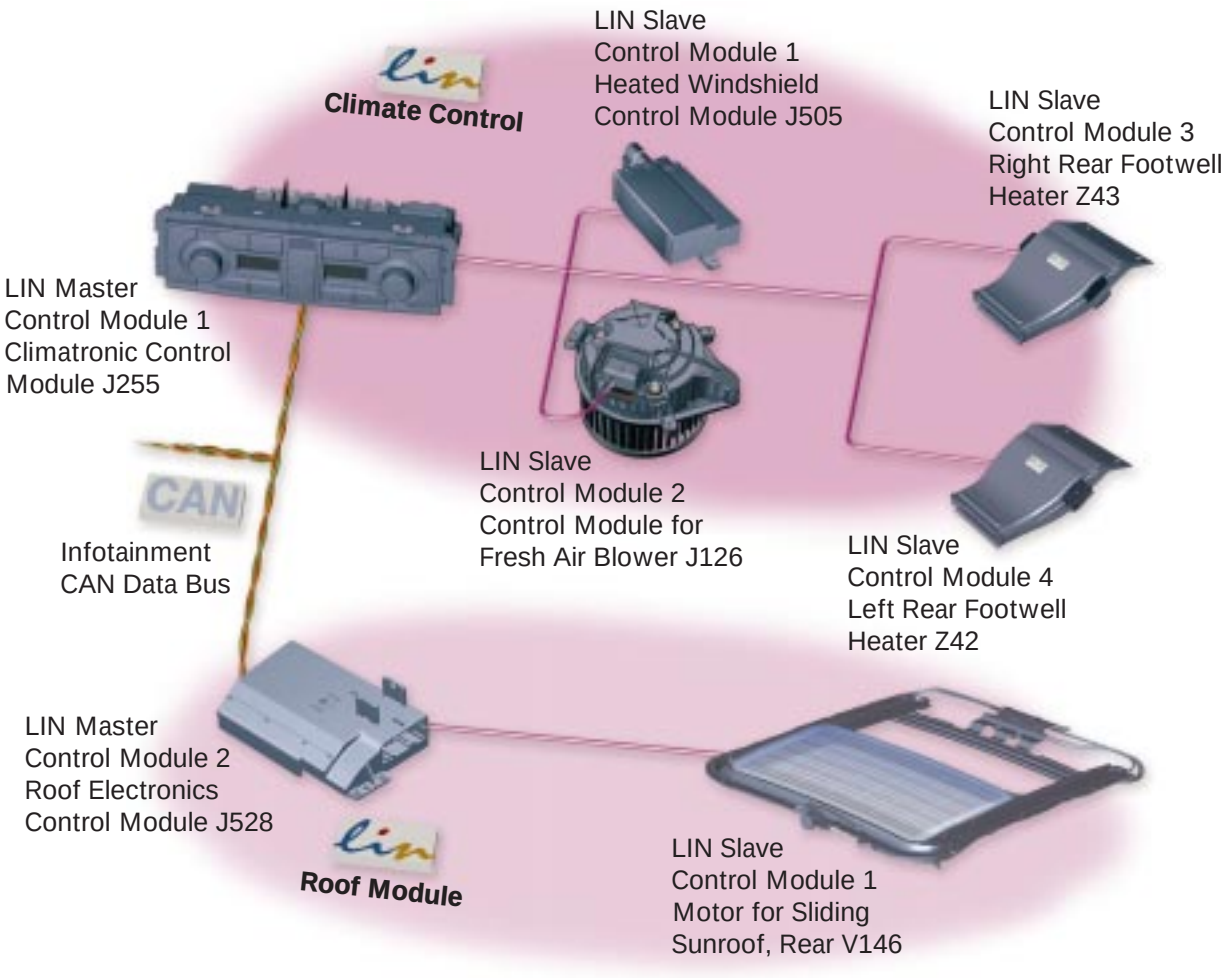
Local Interconnect Network

SSP286/013

The data exchange between the individual LIN systems in a vehicle is always controlled by a control module through the CAN data bus.

Each LIN data bus system functions as a single wire bus. The base color of the wire insulation is violet with an identifying stripe in an additional color. The wire gage is 0.35 mm. Shielding is not necessary.

Each LIN data bus system allows data exchange between a LIN master control module and up to 16 LIN slave control modules.



SSP286/014

LIN Master Control Modules

The control module in the LIN system that is connected to a CAN data bus performs the LIN master control module function.

The LIN master control module controls the data transfer and the data transfer speed. It also sends the message header.



For more information on message headers, please refer to page 10.

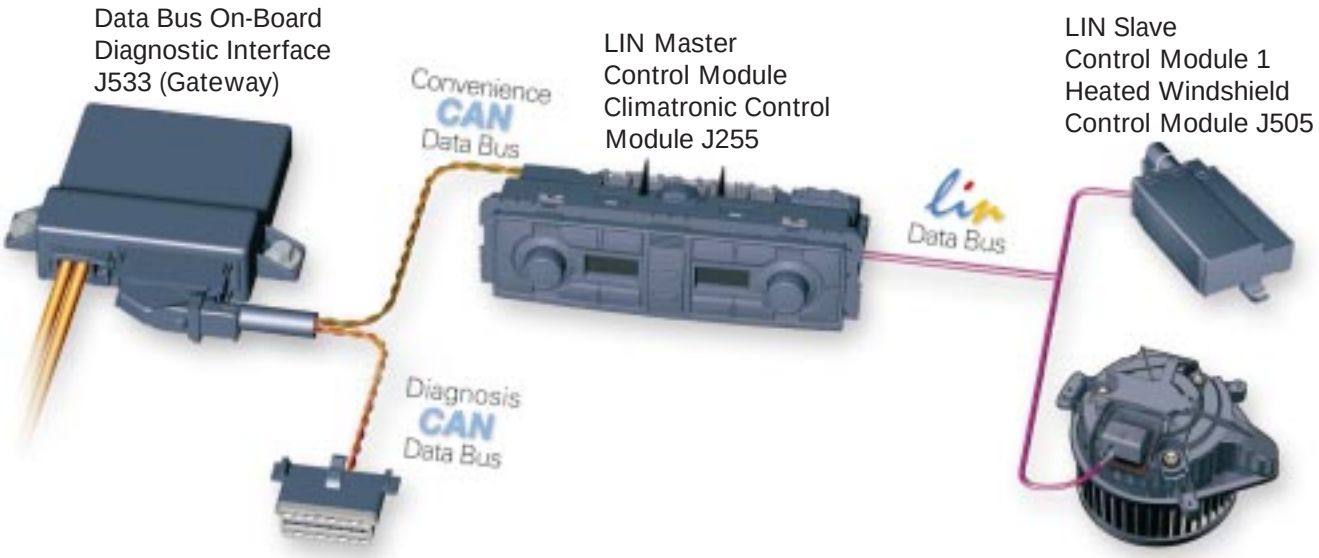
The software contains a cycle to control when and how often a message is sent on the LIN data bus.

The LIN master control module assumes the translation function between the LIN slave control modules of the local LIN data bus system and the associated CAN data bus.

The LIN master control module is the only control module in a LIN data bus system that is also connected to a CAN data bus.

The connected LIN slave control modules are diagnosed through the LIN master control module.

Example of LIN Interfaces



SSP286/017

Local Interconnect Network Data Bus

LIN Slave Control Modules

LIN slave control modules can be either individual control modules like the Control Module for Fresh Air Blower J126, or sensors and actuators like a Vehicle Inclination Sensor G384 or a Signal Horn for Alarm System H18, and all be components of a LIN data bus system.

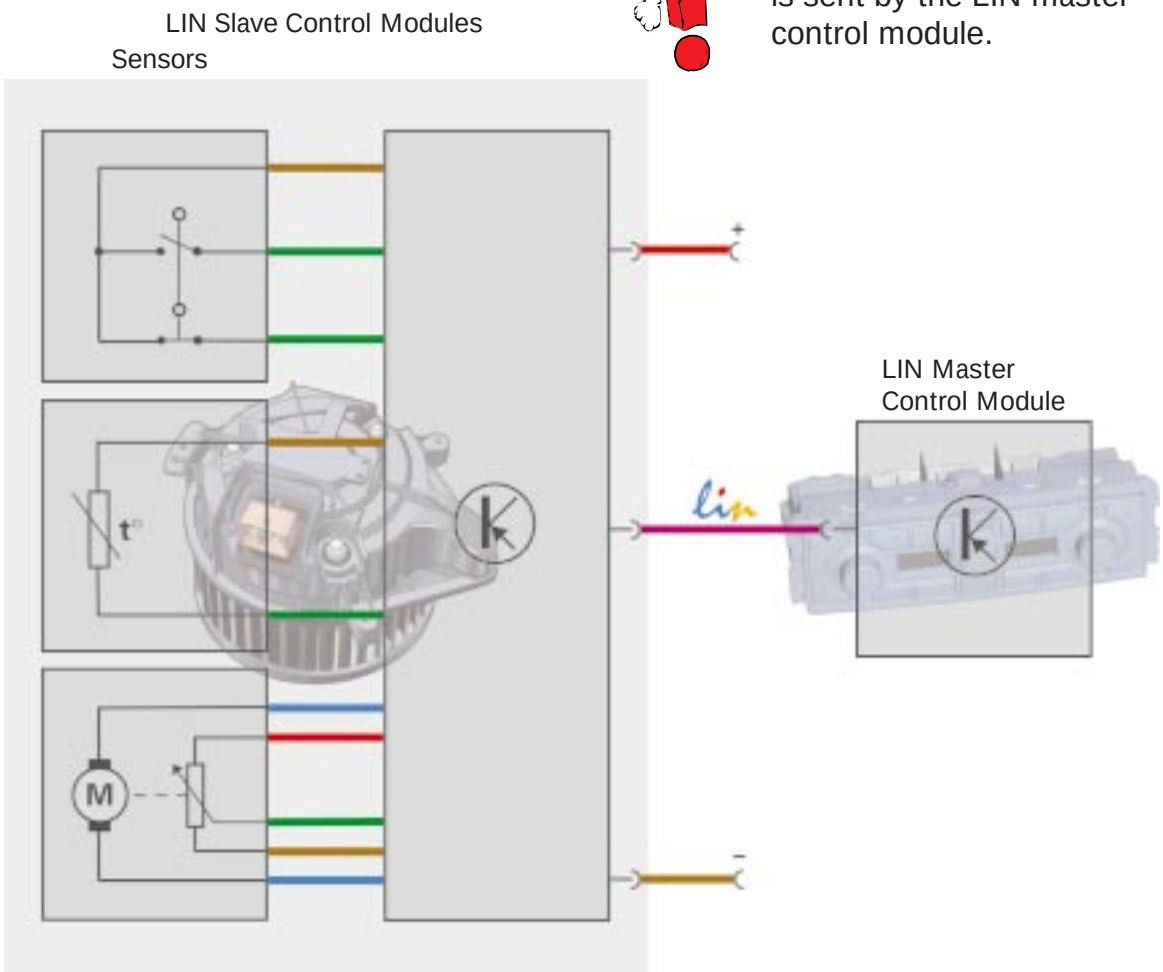
Electronics that evaluate the measured values are integrated in the sensors. Communication of these values is then accomplished on the LIN data bus in the form of a digital signal.

Only one pin is needed for several sensors and actuators at the socket of the LIN master control module.

The LIN actuators are intelligent electro-mechanical subsystems that receive their commands in form of LIN data signals from the LIN master control module. The actual condition of the actuators can be monitored by the LIN master control module. This allows comparison between actual and specified values.



The sensors and actuators only respond when a header is sent by the LIN master control module.

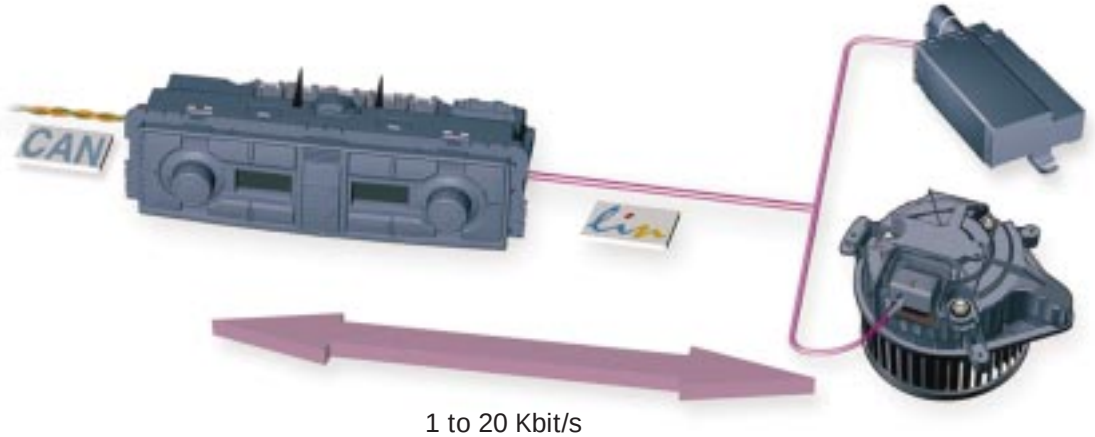


SSP286/070

Local Interconnect Network Data Bus

Data Transmission

The data transmission rate can be from 1 to 20 kilobits per second. A specific rate is programmed into the software of each LIN control module. This is at most approximately one-fifth of the data transmission rate of the convenience CAN data bus.



1 to 20 Kbit/s

SSP286/061

Signal

Recessive level

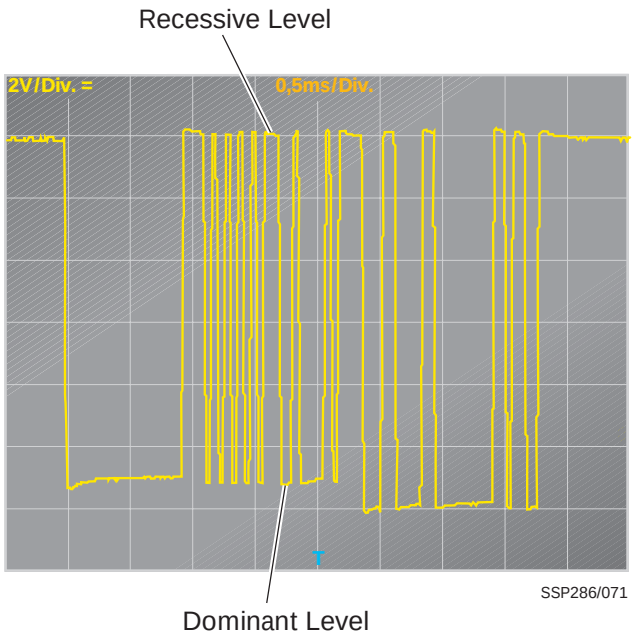
If no message or a recessive bit is sent on the LIN data bus, the voltage of the data bus wire is close to battery voltage.

Dominant level

To transmit a dominant bit on the LIN data bus, the data bus wire is switched to ground by a transceiver in the transmitter control module.

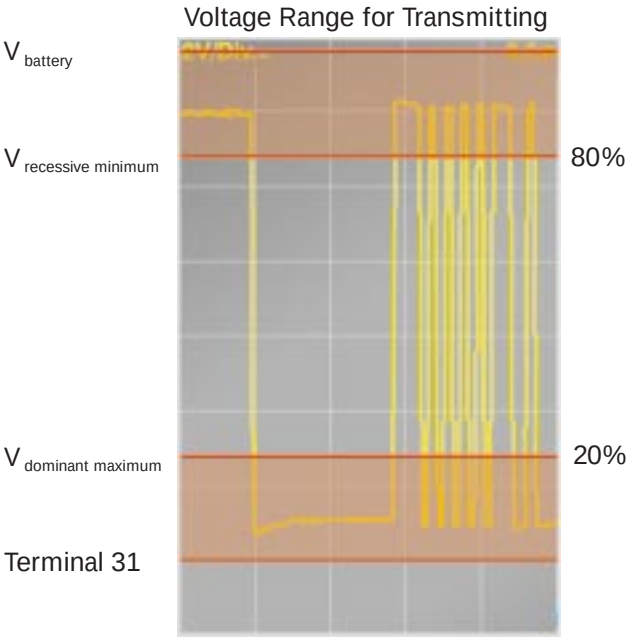


Because of different designs of transceivers in the control modules, differences in the dominant levels may be visible on the display.



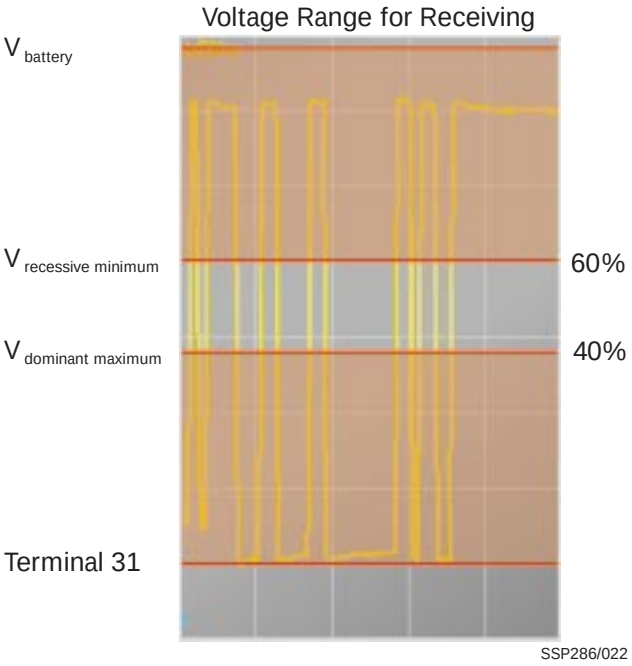
SSP286/071

Local Interconnect Network Data Bus



Transmission Reliability

By specifying tolerances for transmitting and receiving within the range of recessive and dominant levels, a stable data transfer is assured.



To be able to receive valid signals in spite of interference radiation, the specified voltage ranges are higher on the receiving side.

Messages

Message with Slave Answer

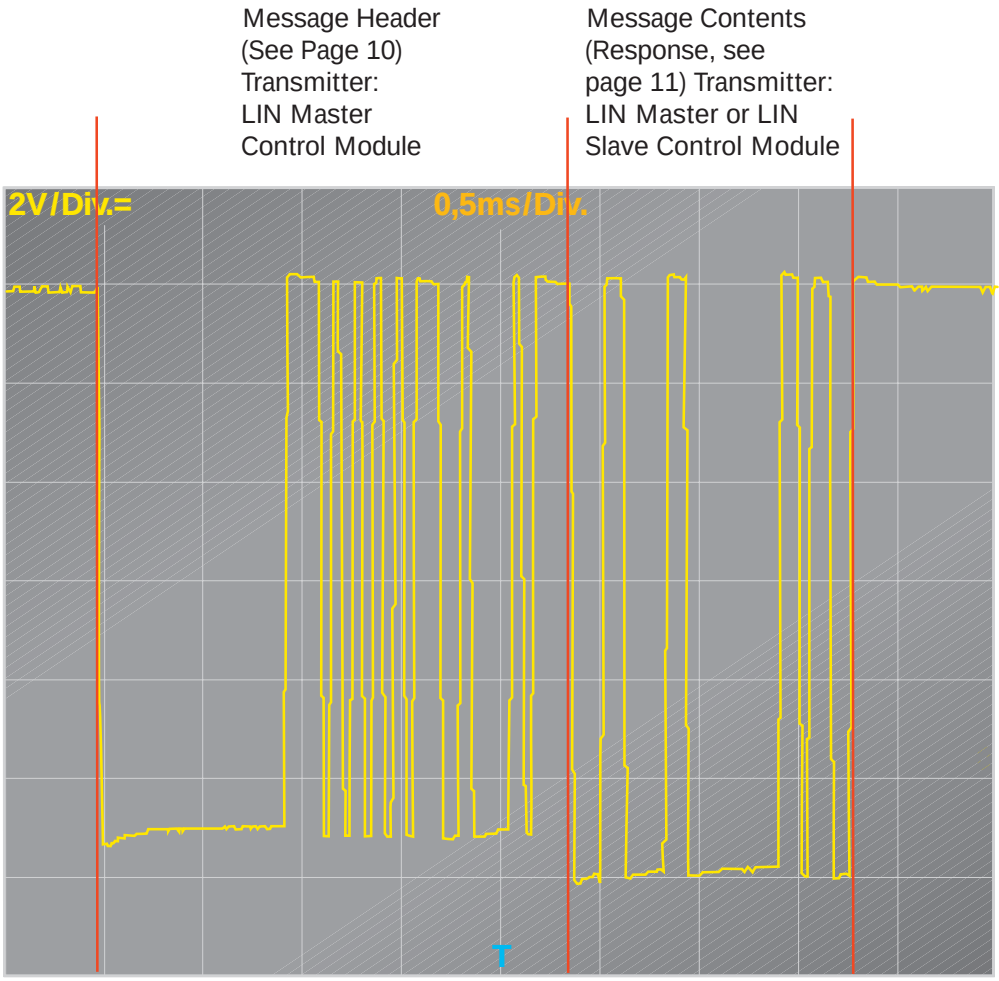
In the message header, the LIN master control module requests information such as switch conditions or measuring values from a LIN slave control module.

The LIN slave control module sends the information back to the LIN master control module in response.

Message with Master Instructions

Using an identifier in the message header, the LIN master control module can also request that the LIN slave control module process the data contained in its response.

The LIN master control module processes the data and sends the response.



Message Header

The LIN master control module transmits the header in cycles.

The header can be subdivided into four sections:

- Synchronization break
- Synchronization delimiter
- Synchronization field
- Identifier field

The **synchronization break** (synch break) is at least 13 bits long. It is sent with the dominant level.

The length of 13 bits is necessary to clearly inform the LIN slave control modules about the start of a message.

In the succeeding messages, a maximum of 9 dominant bits are transmitted one after the other.

The **synchronization delimiter** (synch delimiter) is at least 1 bit long and recessive (~$V_{battery}$).

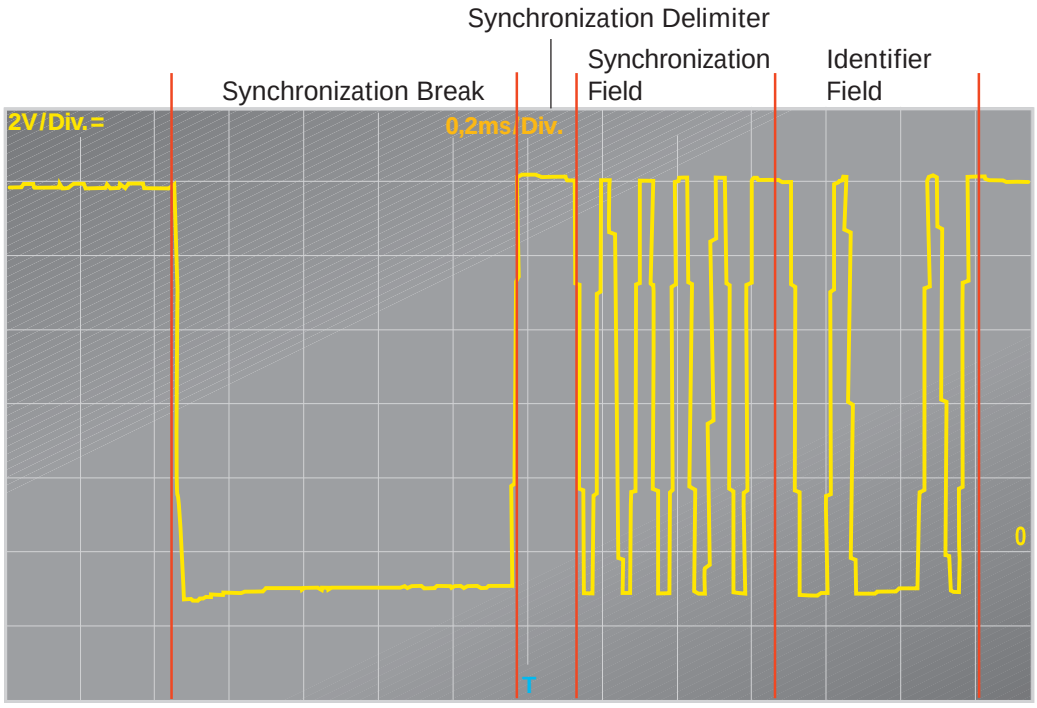
The **synchronization field** (synch field) consists of the bit rate 0 1 0 1 0 1 0 1 0 1.

Because of this bit rate, all LIN slave control modules can adapt to or synchronize with the system cycle of the LIN master control module.

The synchronization of all control modules is necessary for an error-free data exchange. Loosing the synchronization would cause the insertion of the bit values into the message at the receiving end. This would lead to errors in the data transfer.

The **identifier field** is 8 bits long. The first 6 bits contain the message identification and the number of data fields of the response (see page 12).
The number of data fields in the response may be between 0 and 8.

The last 2 bits contain the check-total of the first 6 bits for the identification of transmission errors. The check total is necessary to avoid the assignment of the identifier to a wrong message in case of a transmission error.

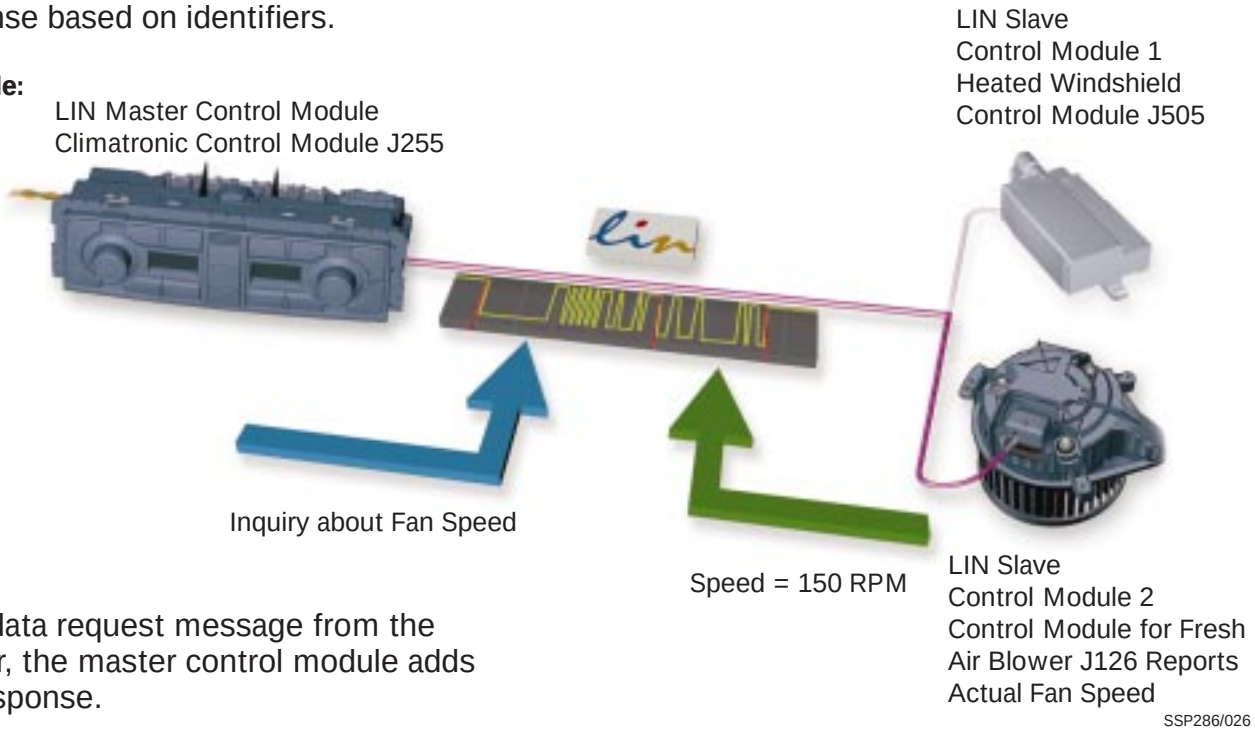


SSP286/073

Message Contents (Response)

The LIN slave control module adds information to a message with slave response based on identifiers.

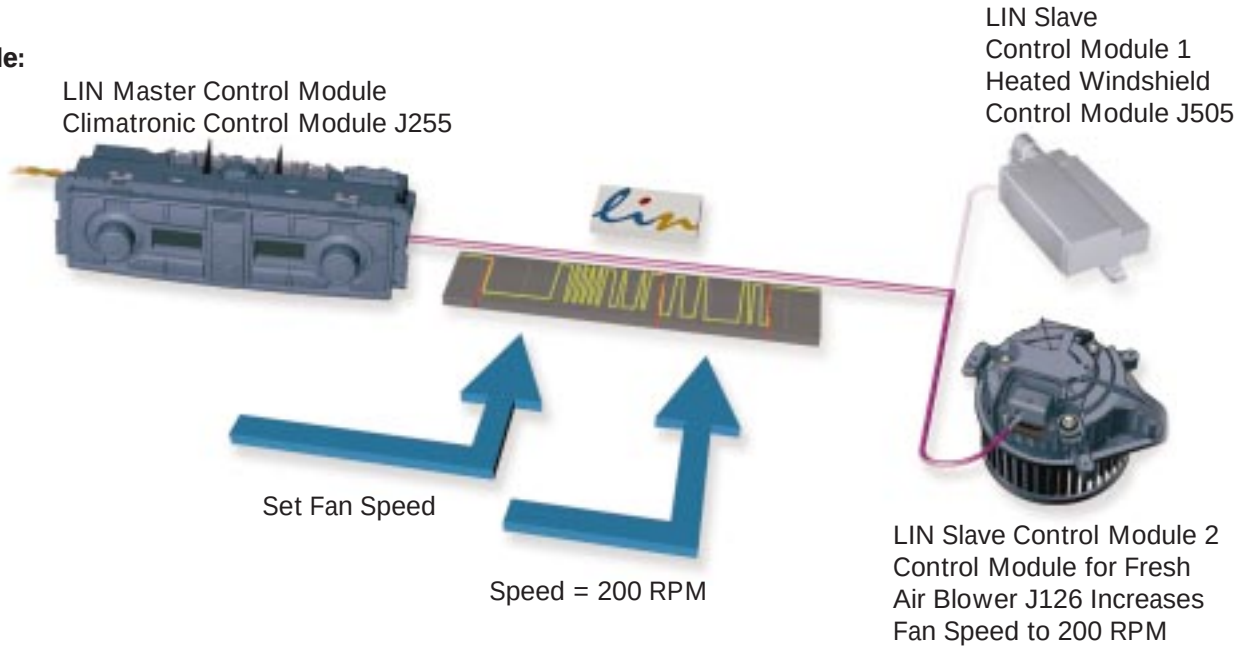
Example:



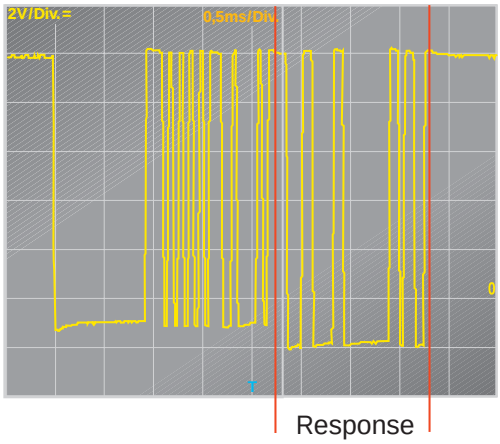
For a data request message from the master, the master control module adds the response.

Depending on the identifier, the applicable LIN slave control modules use the data to perform functions.

Example:

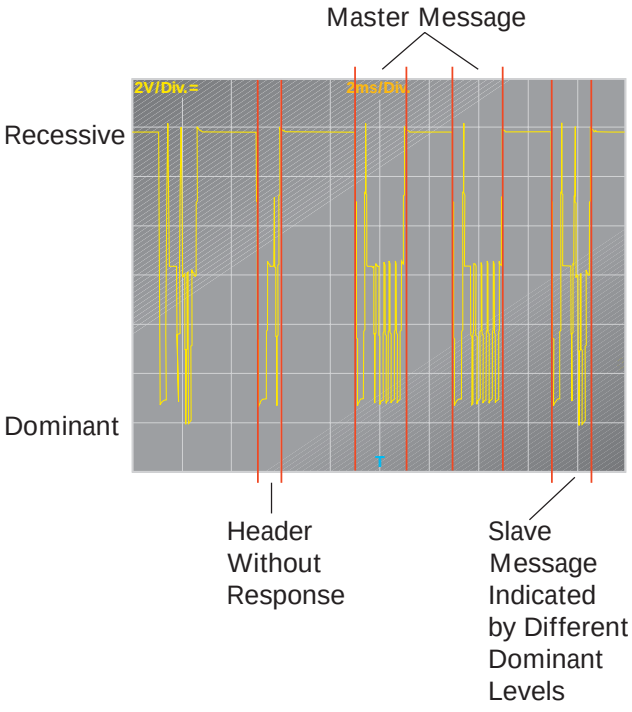


Local Interconnect Network Data Bus



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The response consists of 1 to 8 data fields. One data field consists of 10 bits. Each data field consists of one dominant start bit, a data byte that contains the information, and one stop bit. The start- and stop-bits are used for the after-synchronization to avoid transmission errors.



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Sequence of the Messages

The LIN master control module sends the headers as well as the responses to master messages on the LIN data bus according to a specified sequence and cycle.

Information that is used frequently is sent frequently.

The sequence of the messages can change depending on the prevailing conditions of the LIN master control module.

Example of prevailing conditions:

- Ignition on or off
- Diagnostics active or inactive
- Parking lights on or off

To reduce the variety of LIN master control modules, the LIN master control module sends the headers through the LIN data bus addressed to all of the applicable control modules for a fully equipped vehicle.

Since there may be control modules addressed that are not installed on a specific vehicle, headers for these messages will be shown on the oscilloscope without responses.

This does not affect the functioning of the system.

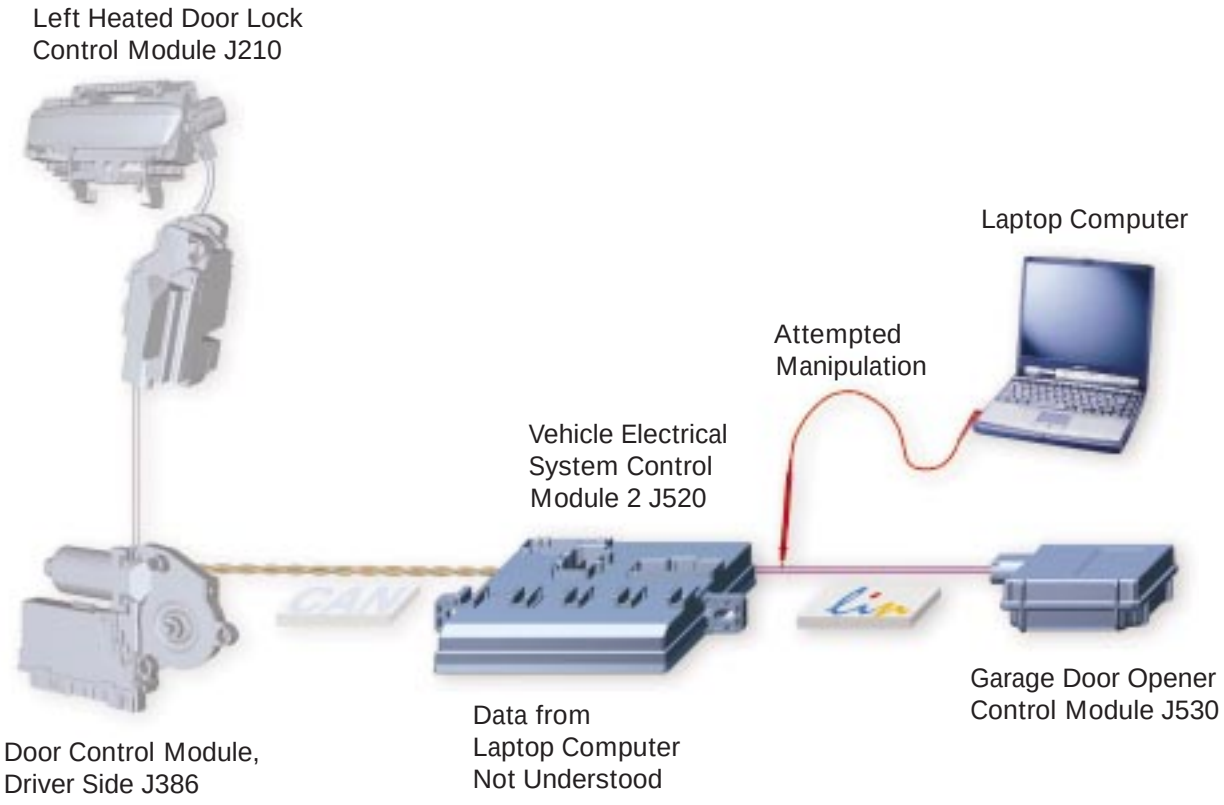
Theft Protection

Data transmission on the LIN data bus only occurs when a LIN master control module sends a header with the applicable identifier.

Manipulation through a LIN wire from outside the vehicle is impossible because of the complete control of all messages by the LIN master control modules. The LIN slave control modules can only answer.

For example, the doors cannot be opened by tapping into the LIN data bus because of this limitation.

With this arrangement, LIN slave control modules can also be installed on the outside of the vehicle. The Garage Door Opener Control Module J530 can be located in the front bumper for example, without compromising the security of the vehicle or the garage.



SSP286/065

Local Interconnect Network Data Bus

Diagnosis

The diagnosis of the LIN data bus system is done with the Address Word for the relevant LIN master control module.

The transfer of diagnostic data from the LIN slave control modules to the LIN master control module occurs on the LIN data bus.

All of the On-Board Diagnostic (OBD) functions are available for LIN control modules.

Example of Diagnosis Capabilities

Fault Location	Fault Text	Cause of Diagnostic Trouble Code (DTC)
LIN Slave Control Module Example: Fan Control	No signal / no communication	Failure of data transmission from the LIN slave control module within a specified time interval that is programmed into the software for the LIN master control module. • Break in wiring or short circuit. • Faulty voltage supply for the LIN slave control module. • Wrong part for LIN slave control module or LIN master control module. • Faulty LIN slave control module.
LIN Slave Control Module Example: Fan Control	Implausible signal	Fault in the check total. Incomplete transmission of the messages. • Electro-magnetic interference affecting the LIN wire. • Capacity and resistance changes of the LIN wire (such as moisture or contamination at the connector). • Software problem (wrong version).

Introduction

In addition to the well-known CAN data bus systems, a fiber-optic data bus system is installed for the first time in the 2003 Audi A8.

This data bus system is based on standards determined by Media-Oriented Systems Transport (MOST) cooperation. To establish these standards, several automobile manufacturers, their suppliers, and software manufacturers have joined together to make a unified system for rapid data transmission possible.

MOST
Media Oriented Systems Transport

SSP286/007

The MOST standards developed by this cooperative effort have resulted in a network specifically designed to relay media-oriented data. Contrary to what happens on a CAN data bus, the fiber-optic data bus based on the MOST protocol allows address-oriented messages to be sent to a specific recipient.

This technology is used in Audi vehicles for data transmission in the infotainment system.

The infotainment system offers a variety of modern information and entertainment media.



SSP286/008

Fiber-Optic Data Bus

Transmission Rates of Media

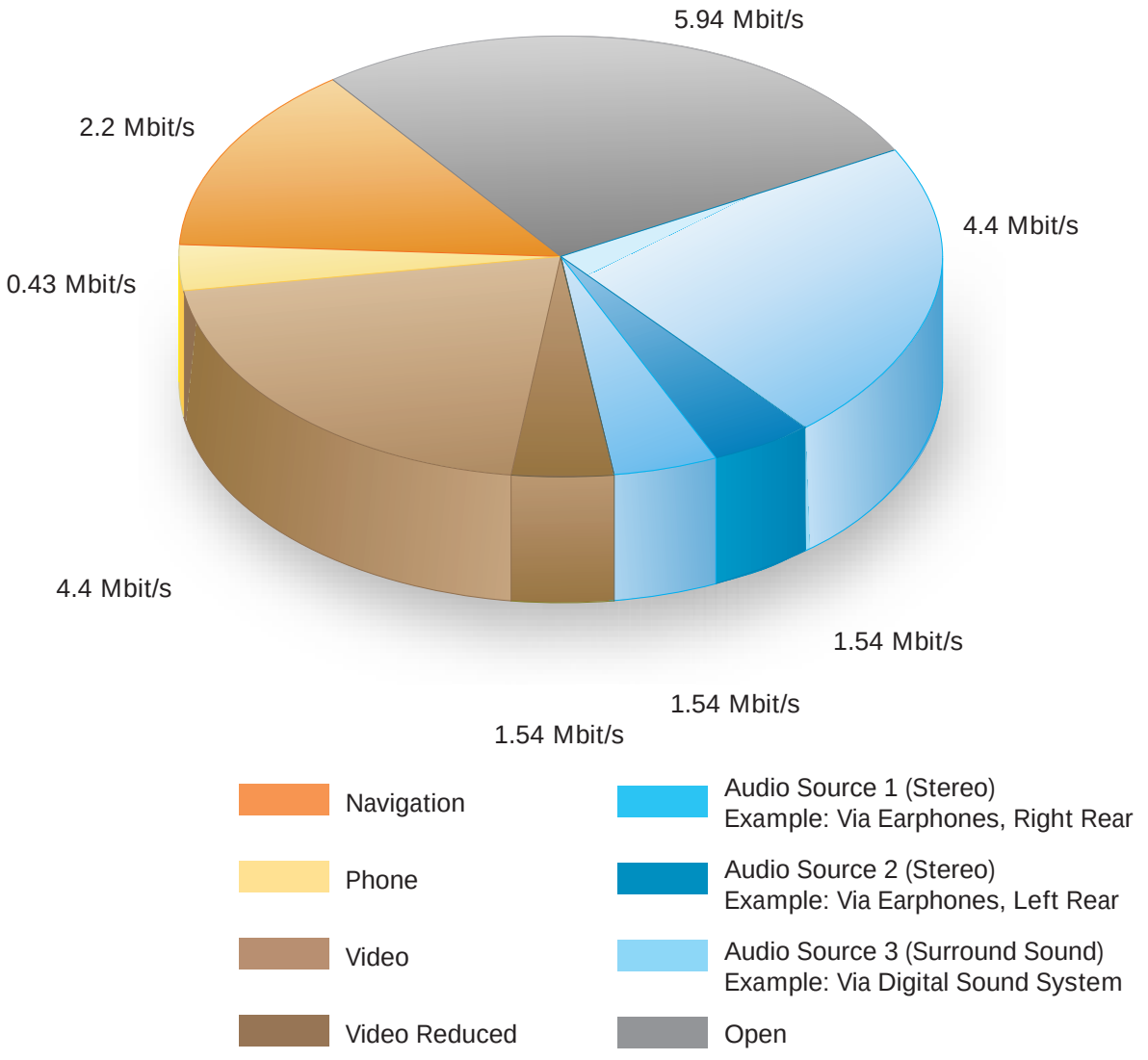
Optical data transfer makes complex infotainment systems possible because CAN data bus systems cannot transfer data fast enough and cannot handle the amount of data that is needed.

Using video and audio applications requires data transmission rates of many megabits per second.

The transmission of a digital TV signal alone requires a transmission speed of about 6 megabits per second.



The MOST fiber-optic data bus allows for transmission rates of 21.2 megabits per second.



SSP286/010

Fiber-Optic Data Bus

Until recently, information such as video and sound could only be transmitted as analog signals. This required additional wiring in vehicle wiring harnesses.

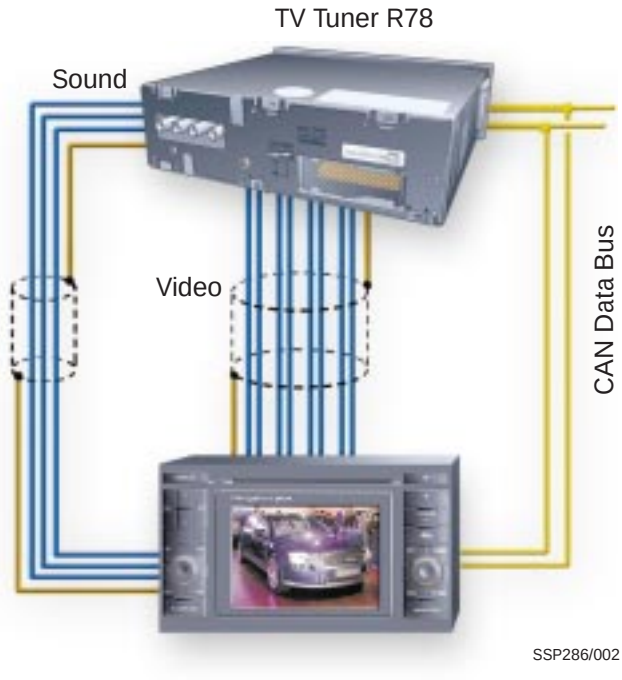
The data transfer of a CAN data bus system is restricted to a maximum speed of 1 megabit per second. This explains why only control signals can be transmitted using the CAN data bus.

Using the MOST fiber-optic data bus, the data exchange between the participating components is digital.

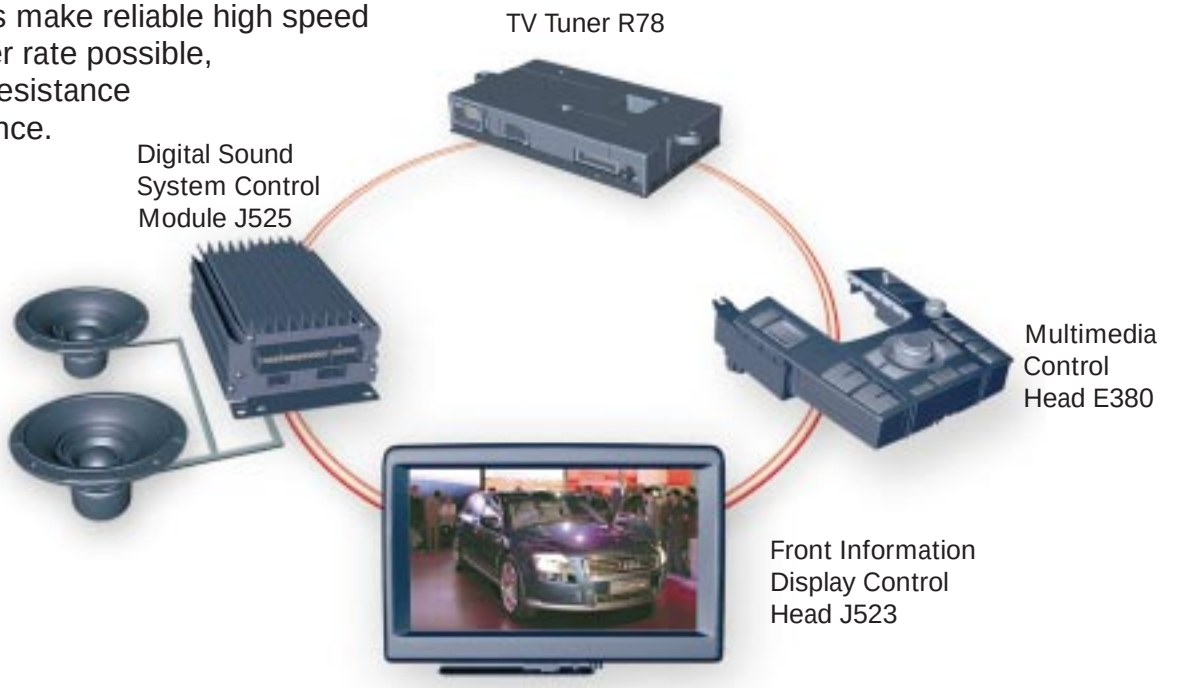
The data transfer using light waves allows for a much higher data transfer rate. It also saves wiring and reduces total vehicle mass.

In comparison with radio waves, light waves have very short wave lengths, they do not produce electro-magnetic interference waves, nor are they affected by them.

Light waves make reliable high speed data transfer rate possible, with good resistance to interference.



SSP286/002



SSP286/003

Fiber-Optic Data Bus

Control Module Design

Fiber-Optic Cable and Connector

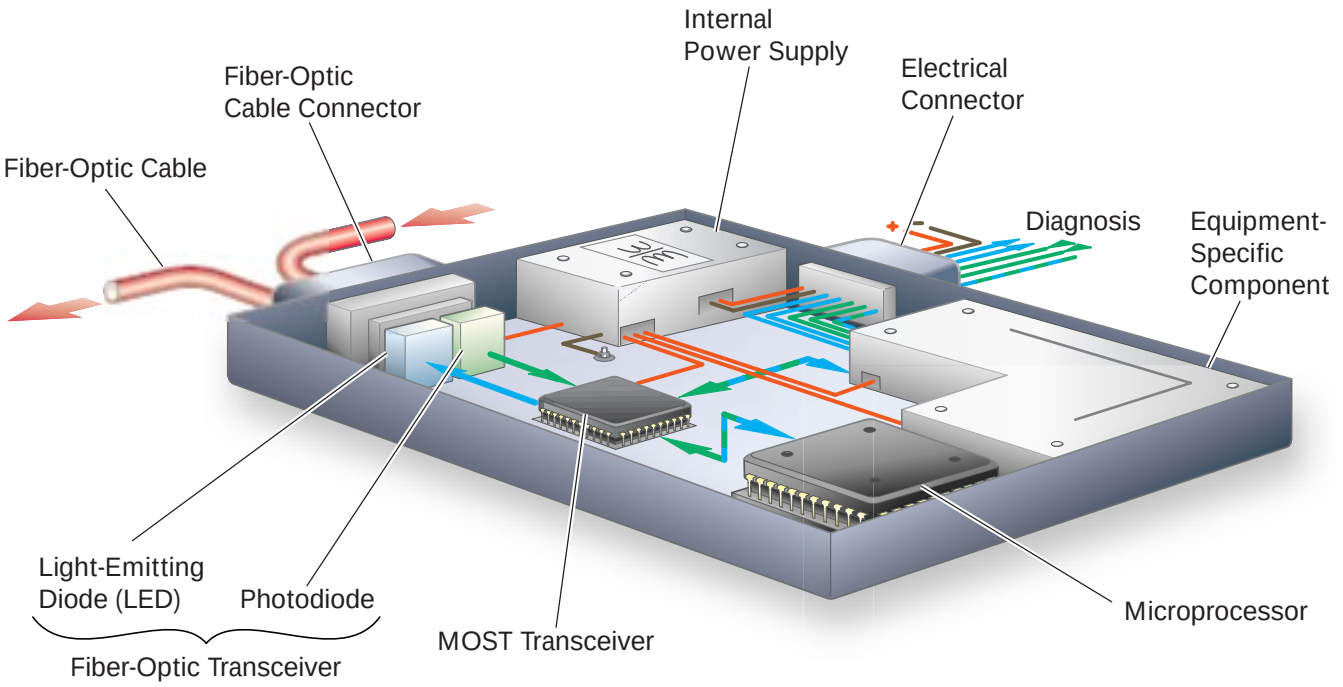
The light signals travel through these connectors to the control module or guide the produced light signals to the next component on the fiber-optic data bus.

Electrical Connector

The input and output signals to the control module are provided through this connector. It also provides the voltage supply for the ring break diagnosis (explained starting on page 44).

Internal Power Supply

The voltage supplied to the control module through the electrical connector is distributed by the internal power supply to the various control module internal components. The internal power supply can turn off these internal components to reduce power consumption when the control module is in the sleep mode.



SSP286/011

Fiber-Optic Transceiver

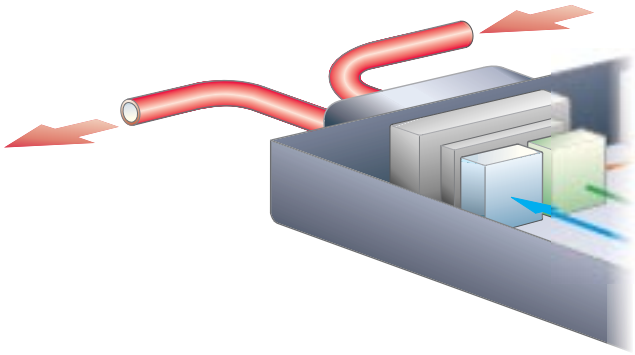
The fiber-optic transceiver uses a photodiode to change light signals received through the fiber-optic cable into a voltage that is then transmitted to the MOST transceiver in the control module.

It also uses a light emitting diode (LED) to convert voltage signals received from the control module MOST transceiver into light signals so that they can be passed on to the next control module in line on the fiber-optic data bus.

The produced light waves have a wavelength of 650 nanometers (nm) and are visible as red light.

The data are transmitted through modulation of the light waves.

This modulated light is transmitted to the next control module through the fiber-optic cable.



SSP286/063



SSP286/004

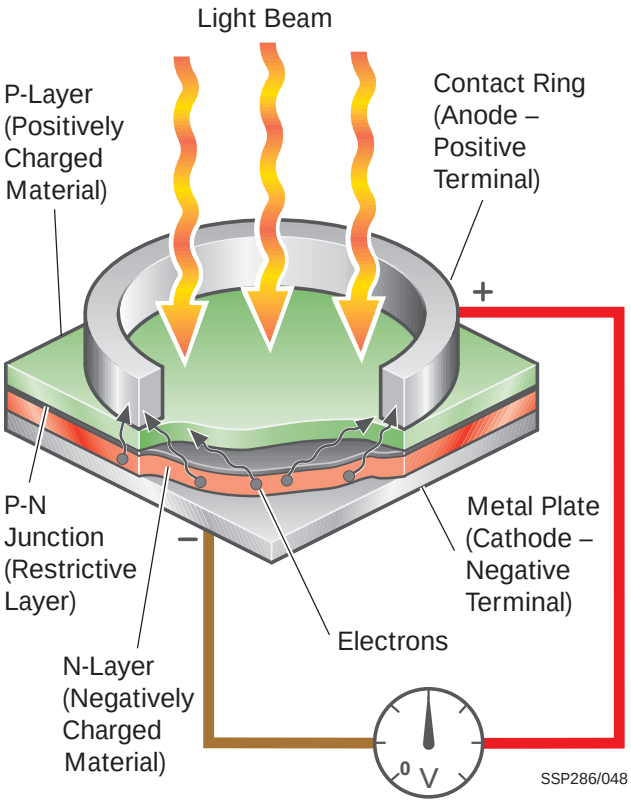
MOST Transceiver

As the name implies, the MOST transceiver consists of both a transmitter and a receiver.

The transmitter sends messages as voltage signals to the fiber-optic transceiver.

The receiver takes the voltage signals from the fiber-optic transceiver and transmits the needed data to the control module microprocessor.

Messages from other control modules that are not needed by this control module are guided through the transceiver without transmitting any data to the microprocessor. These unchanged messages are routed back through the fiber-optic transceiver and transmitted to the next control module.



Microprocessor

The microprocessor is the central processing unit for the control module. It controls all the important functions of the control module.

Equipment-Specific Component

The equipment-specific component controls functions that are unique to the individual control module, such as operating the CD-drive or the radio tuner.

Photodiode

The photodiode converts light waves into voltage signals.

Photodiode design

The photodiode has a P-N junction that is affected by light.

Because the P-layer (positively charged semiconductor material) is so heavily "doped" with the impurity that gives it its positive charge, the restrictive layer or depletion region at the P-N junction reaches almost into the N-layer (negatively charged semiconductor material).



The term **doped** or **doping** refers to the addition of impurities to the semiconductor material to give it an absence or excess of electrons, with the result of a positive or negative charge to the material.

A contact ring on the P-layer provides the anode or positive terminal of the photodiode.

The N-layer is applied to a metallic base plate that acts as the cathode or negative terminal.

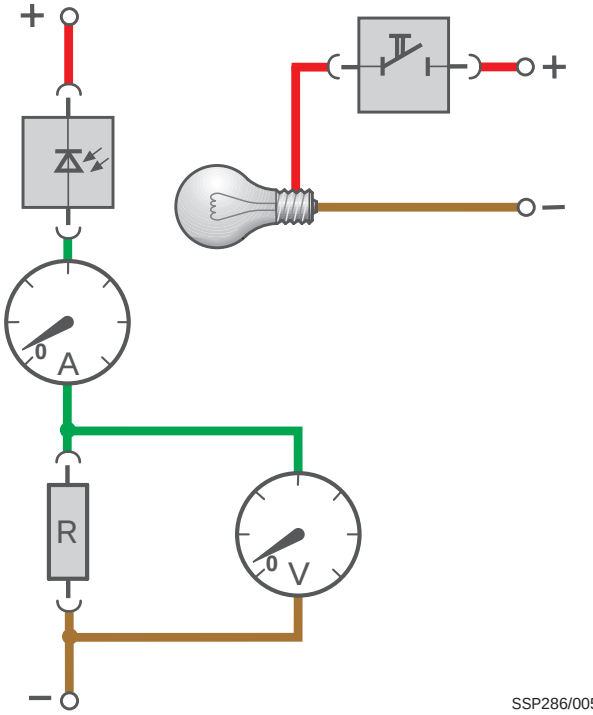
Photodiode Function

When visible light or infrared rays penetrate the P-N junction, the resulting free energy creates free electrons and holes nearby. These induce a voltage to pass through the P-N junction in direct proportion to the amount of light that is penetrating it.

This means, that the more light reaches the photodiode, the higher the voltage will be that flows through it.

This process is called the “internal photoelectric effect.”

Low Light Level

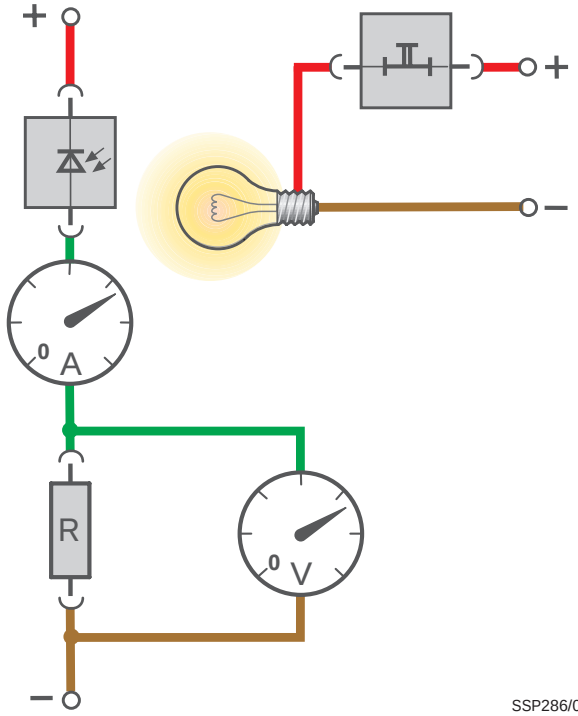


SSP286/005

The photodiode is connected in series with a resistor on the negative side in the direction of restriction.

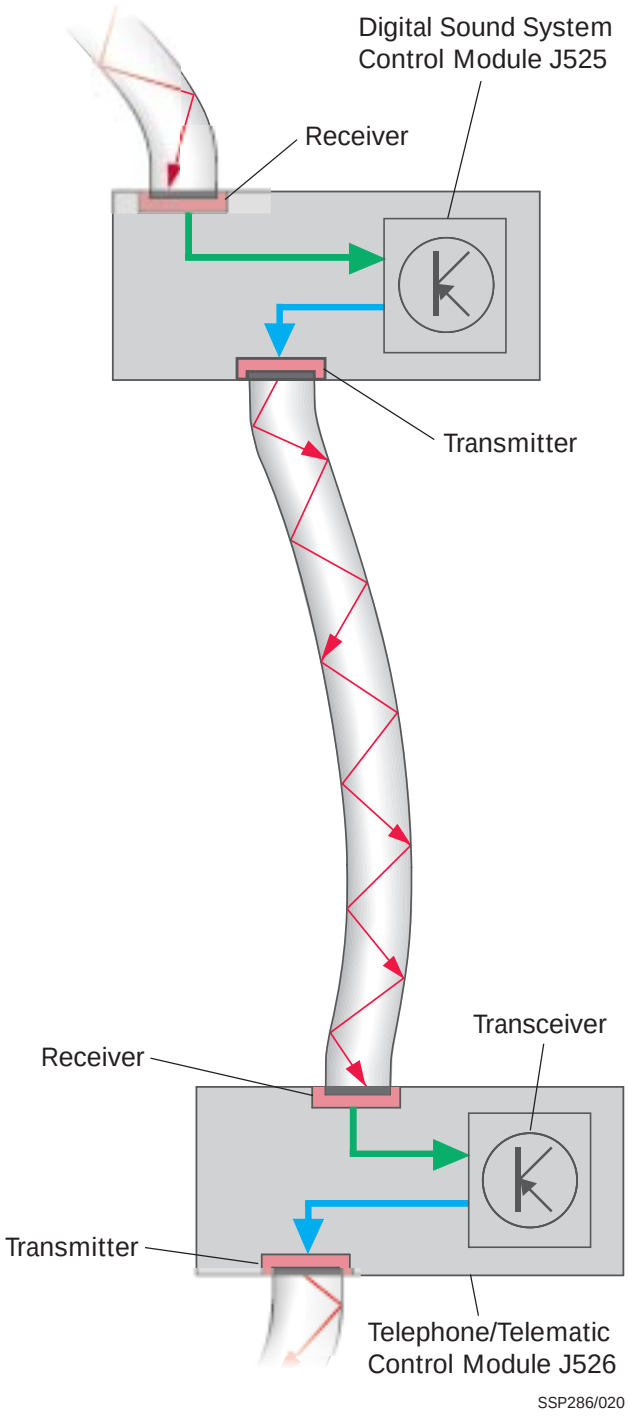
If the voltage through the photodiode increases because more light reaches it, the voltage drop across the resistor will also increase. The resulting changes in voltage effectively translate light signals to voltage signals.

Intense Light Level



SSP286/006

Fiber-Optic Data Bus



Fiber-Optic Cable

The fiber-optic cable is used to route the light waves produced by the transmitter of one control module to the receiver of another control module.

The following criteria had to be considered during the development of the fiber-optic cable:

- Light waves travel in straight lines and cannot be bent. The light waves however have to be guided through the bends of the fiber-optic cable.
- The distance between the transmitter and the receiver can be several yards, therefore attenuation can occur (see page 26).
- Mechanical stress, vibration, or repairs must not damage the fiber-optic cable.
- The function of the fiber-optic cable must be assured during high temperature fluctuations in the vehicle.

For these reasons, the fiber-optic cable must fulfill the following requirements:

- The fiber-optic cable must conduct the light wave with little attenuation.
- The light waves must be guided through the bends of the fiber-optic cable.
- The fiber-optic cable must be flexible.
- The function of the fiber-optic cable must be assured between -40°F and 185°F (-40°C to 85°C).

Fiber-Optic Cable Design

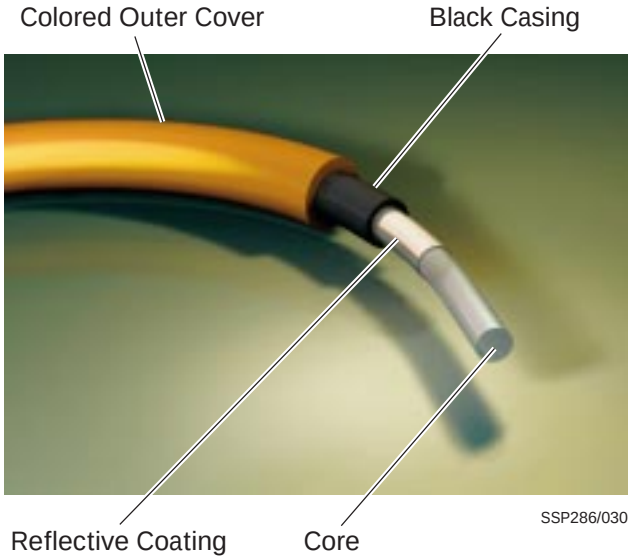
The fiber-optic cable has several layers.

The core is the main part of a fiber-optic cable. It consists of polymethylmethacrylate (PMMA), which is the actual fiber-optic cable. In it, the light travels according to the principle of total reflection with almost no loss.

The optically transparent reflective coating around the core is needed for total reflection.

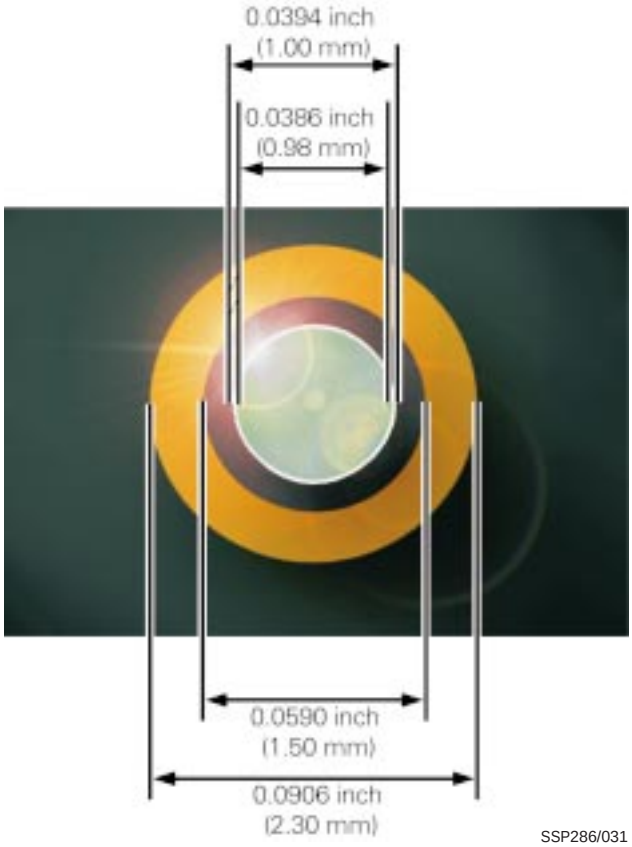
The black casing made from polyamide protects the core from outside light.

The colored outer cover is for identification, protection against outside damage, and insulation against temperature.



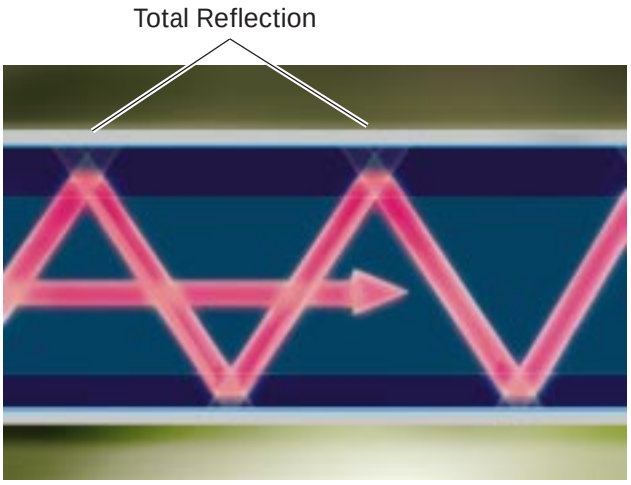
SSP286/030

Fiber-Optic Cable Diameter

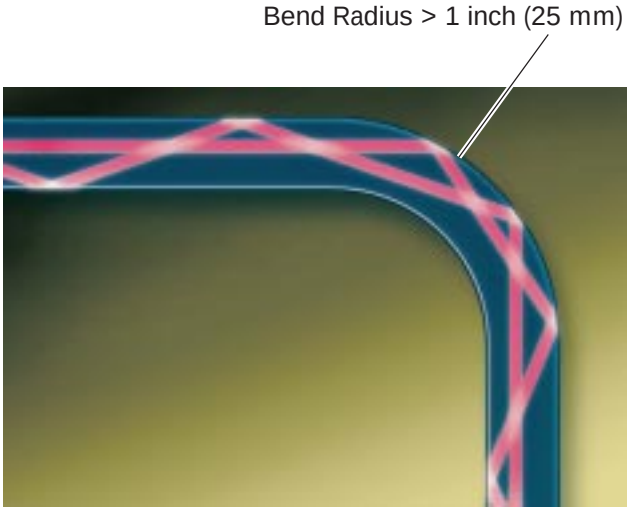


SSP286/031

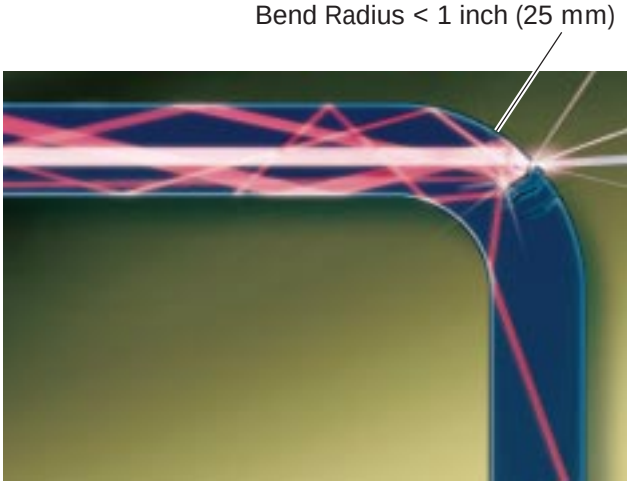
Fiber-Optic Data Bus



SSP286/032



SSP286/033



SSP286/034

Transmission of Light Waves in Fiber-Optic Cables

Straight fiber-optic cable

The fiber-optic cable guides part of the light waves in a straight line through the core.

The largest part of the light waves are guided through the fiber-optic cable in a zigzag line according to the principle of total reflection against the surface of the core.

Bent fiber-optic cable

The light waves are reflected by total reflection at the borderline of the core coating and with that are guided through the bend.

Total reflection

When a light wave strikes a boundary layer between a dense and an optically thin material at a low angle, the beam will be reflected completely, causing total reflection.

The core in the fiber-optic cable is the optically dense material and the coating the optically thin material. That way the total reflection occurs on the inside of the core.

This reflection depends on the angle of the light wave as it hits the boundary layer. If this angle is too acute, the light waves will leave the core and higher loss will result.

This condition occurs when the fiber-optic cable is bent too much or is kinked.



The bend radius of the fiber-optic cable must not be less than 1 inch (25 mm).

Connectors

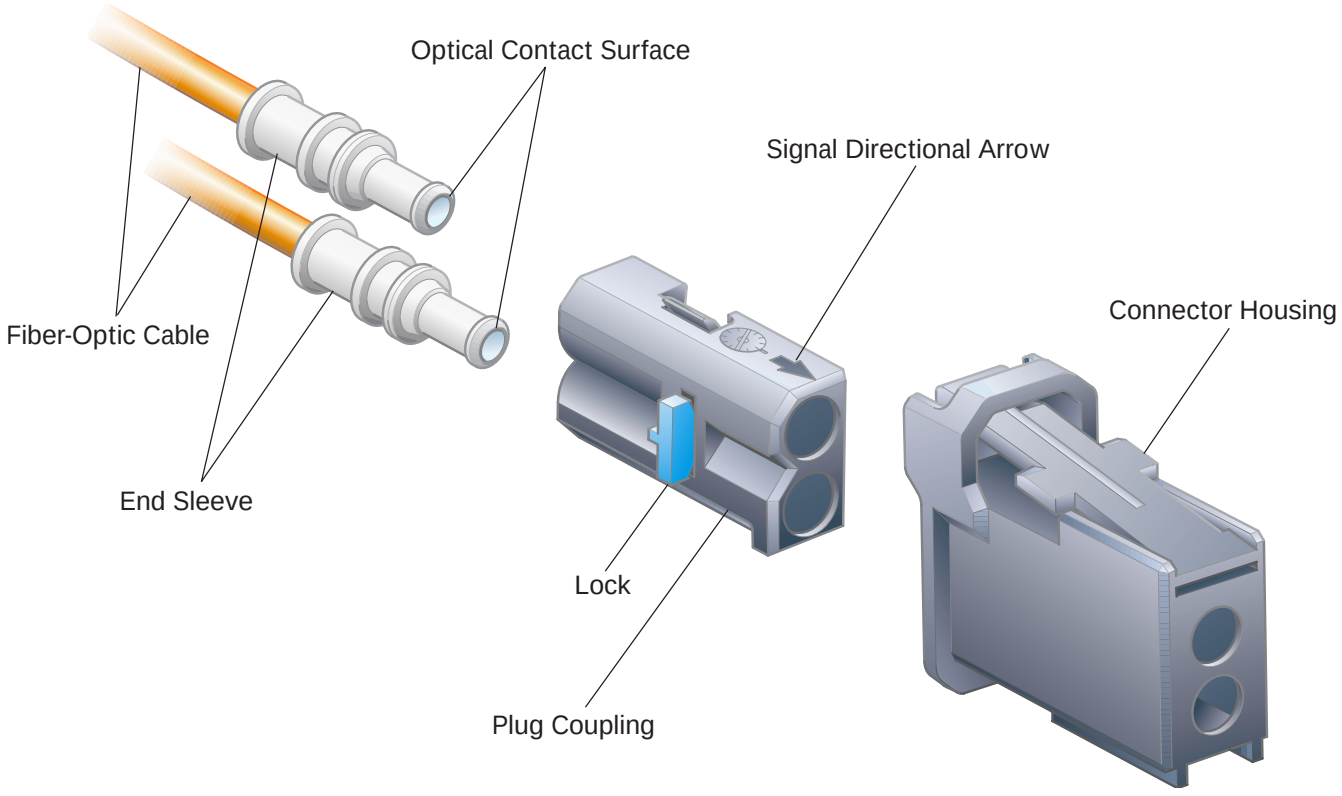
To be able to connect fiber-optic cables to control modules, special optical connectors are used.

There are arrows on the connector plug coupling to indicate the signal direction.

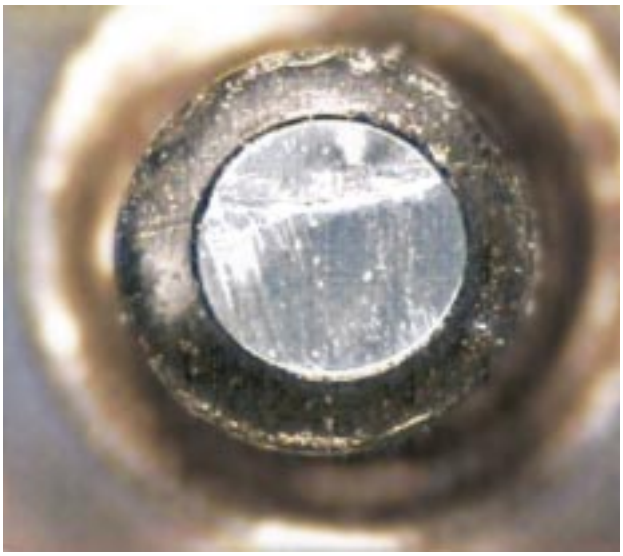
The connector housing serves as the connection to the control module.

The transfer of light occurs between the face surface of the core and the transmitter/receiver of the control module.

End sleeves are welded by laser or brass end sleeves are crimped onto the cable ends to enable connection of the fiber-optic cables to the connector plug couplings.



SSP286/035



SSP286/081

Optical face surface

Contamination and scratches on the face surface of the fiber-optic cable increase signal losses (attenuation).

To produce a transfer of light waves with no loss, the face surface must be:

- Smooth
- Perpendicular
- Clean

This condition can only be assured by using a special cutting tool.

Attenuation in the Fiber-Optic Data Bus

A reduction in the amount or intensity of the light waves as they are routed through the fiber-optic cable is a reduction in signal.

To evaluate the efficiency of a fiber-optic cable, the signal loss must be measured.



This signal loss is referred to as **attenuation.**

The attenuation (A) is measured in decibels (dB).

A decibel is not an absolute value but a ratio of two values. This is the reason that a decibel is not defined as a physical value. For example, the decibel unit is used to establish acoustic pressure or sound volume.

To measure attenuation, it is calculated from the logarithm of the ratio of the transmitter output versus the receiver output.

Formula:

$$\text{Attenuation value (A)} = 10 \times \log \frac{\text{Transmitter Output}}{\text{Receiver Output}}$$

Example:

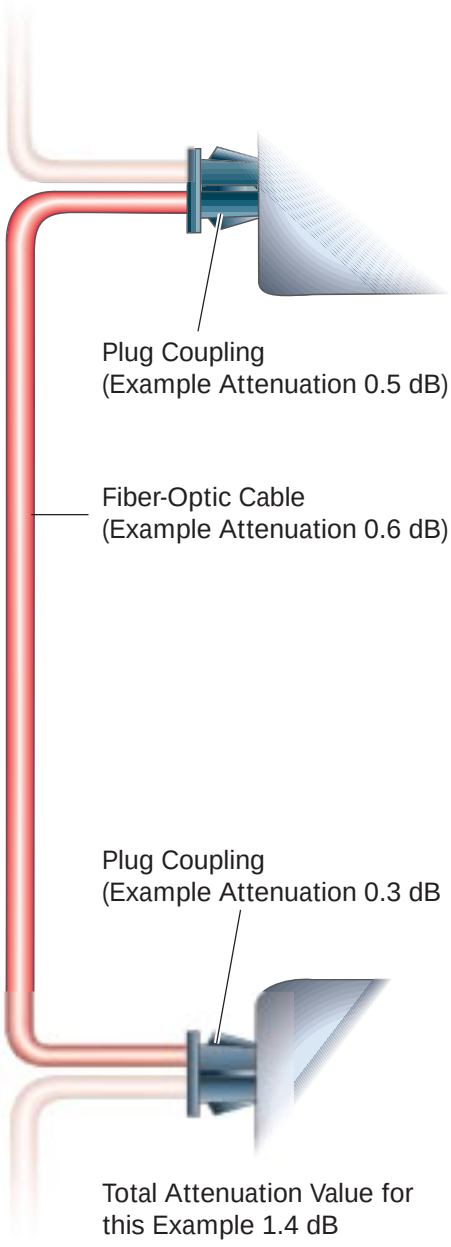
$$10 \times \log \frac{20\ \text{W}}{10\ \text{W}} = 3\ \text{dB}$$

This means that for a fiber-optic cable with an attenuation value of 3 dB, the light signal will be reduced by half.

If several components are involved in the transmission of light signals, the attenuation values can be added to a total attenuation value, similar to the resistance of electrical components that are connected in series.

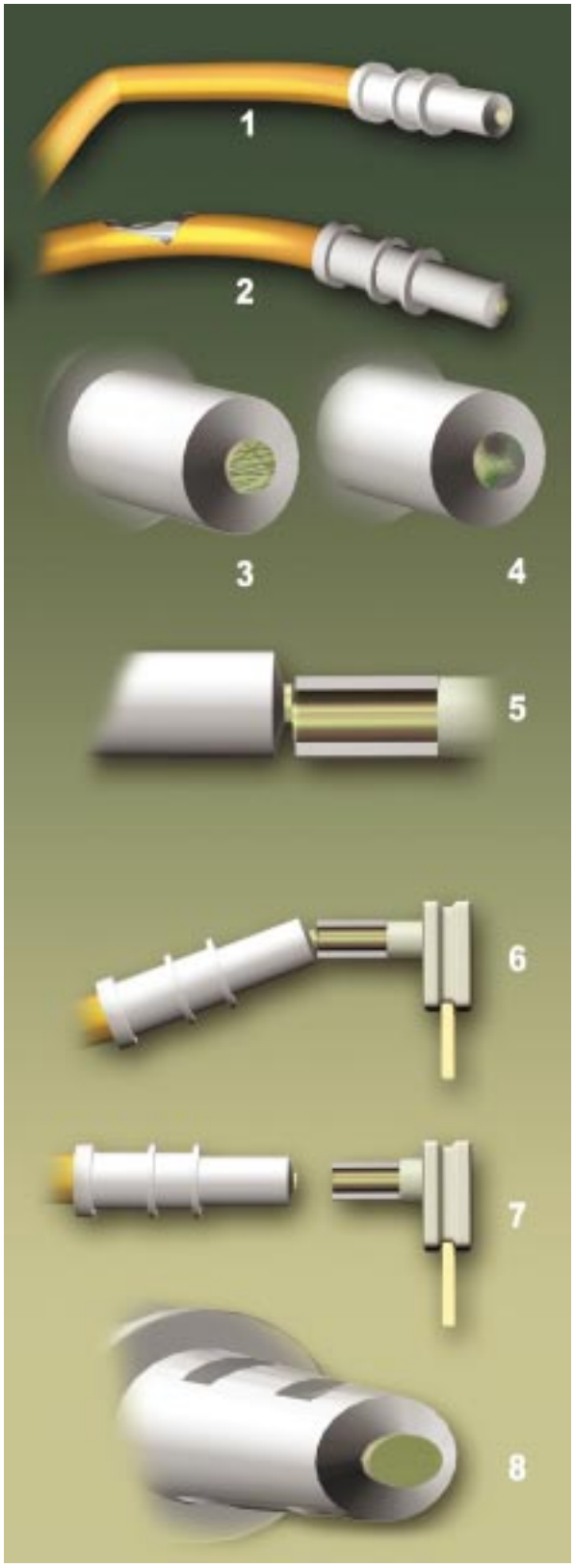


Since every control module in the MOST fiber-optic data bus always transmits anew, only the total attenuation value between two control modules is of any significance.



SSP286/045

Fiber-Optic Data Bus



SSP286/069

Causes for increased attenuation in the fiber-optic data bus

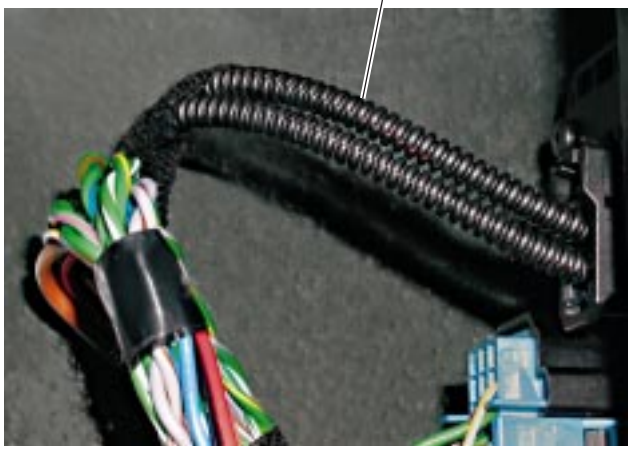
1. The bending radius of the fiber-optic cable is below the specified limit. If the fiber-optic cable was kinked or bent by more than a radius of 1 inch (25 mm), clouding will appear in the core similar to the clouding appearing in sharply bent Plexiglas. In such cases the fiber-optic cable must be replaced.
2. The casing of the fiber-optic cable was damaged.
3. The face was scratched.
4. The face is contaminated.
5. The faces are offset (connector housing broken).
6. The faces are positioned on a bias (angle fault).
7. There is a gap between the face of the fiber-optic cable and the contact face of the control module (connector housing broken or not locked).
8. The end sleeve is not properly crimped.

Fiber-Optic Cable Handling



The fiber-optic cables and their components must be handled with extreme care.

- Do not crush the fiber-optic cable. Avoid damage to the casing such as perforating, cutting, pinching, etc. Do not step on fiber-optic cables or place objects on them.
- Do not kink or bend the fiber-optic cable to a radius of less than 1 inch (25 mm). By installing kink protection (corrugated pipe), a bending radius of more than 1 inch (25 mm) is assured during installation.
- Be mindful of tie-down and contact points, and use the correct length when routing fiber-optic cables in the vehicle.
- Prevent contamination of the face surface with liquids, dust, fuels, etc. Do not remove the protective cap from the end of the fiber-optic cable until just before testing or installation. If the protective cap is missing, you may have to replace the fiber-optic cable with another new one that has been properly protected.
- Do not apply thermal treatment or repair methods to fiber-optic cables that involve soldering, heat bonding, or welding.
- Do not employ chemical or mechanical methods to connect fiber-optic cables such as gluing or butt joints.
- Do not twist two fiber-optic cables together or one fiber-optic cable with a copper wire.



SSP286/087

Fiber-Optic Data Bus

Ring Structure of the Fiber-Optic Data Bus

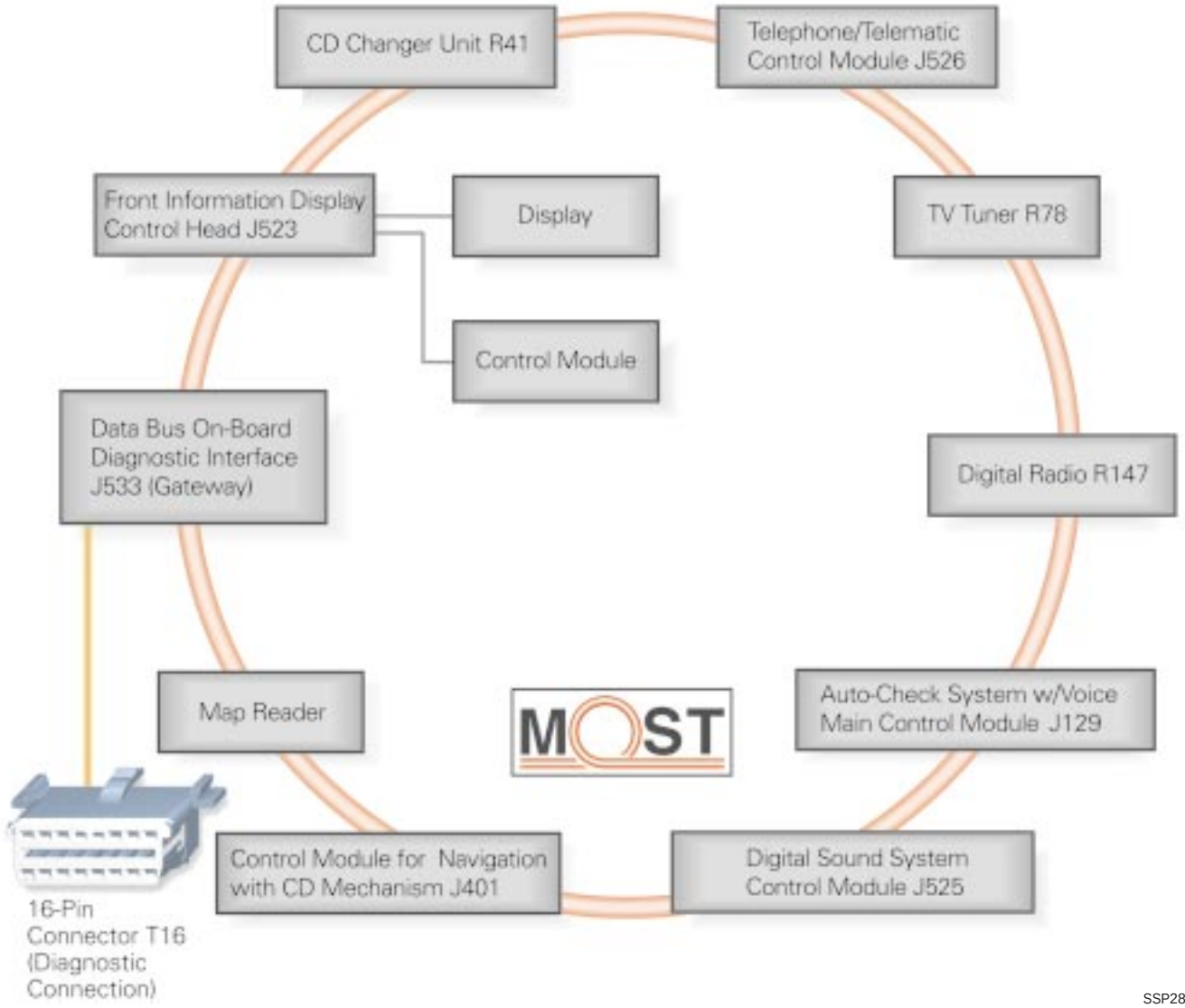
An important feature of the MOST fiber-optic data bus system is its circular arrangement in the form of a ring.

The control modules send data in one direction on a fiber-optic cable to the next control module in the ring.

This procedure is repeated until the data is again received by the control module that sent the data in the first place.

This way the ring closes.

The diagnosis of the MOST fiber-optic data bus system is performed through the Data Bus On-Board Diagnostic Interface J533 (Gateway) and diagnosis CAN data bus to the 16-Pin Connector T16 (Diagnostic Connection).



SSP286/047

System Manager

The system manager is responsible for the system management in the MOST fiber-optic data bus. The system manager is supported by the diagnosis manager

The Data Bus On-Board Diagnostic Interface J533 (Gateway) assumes the diagnosis management function in the Audi A8 (see page 44).

The Front Information Display Control Head J523 is responsible for the system management function.

The system manager is responsible for:

- Control of the system conditions.
- Transmitting messages of the MOST fiber-optic data bus.
- Control of the transmission capacities.

MOST Fiber-Optic Data Bus System Conditions

Sleep Mode

In the sleep mode there is no data exchange on the system. The components are ready but can only be activated by a start impulse from the system manager through the fiber-optic data bus.

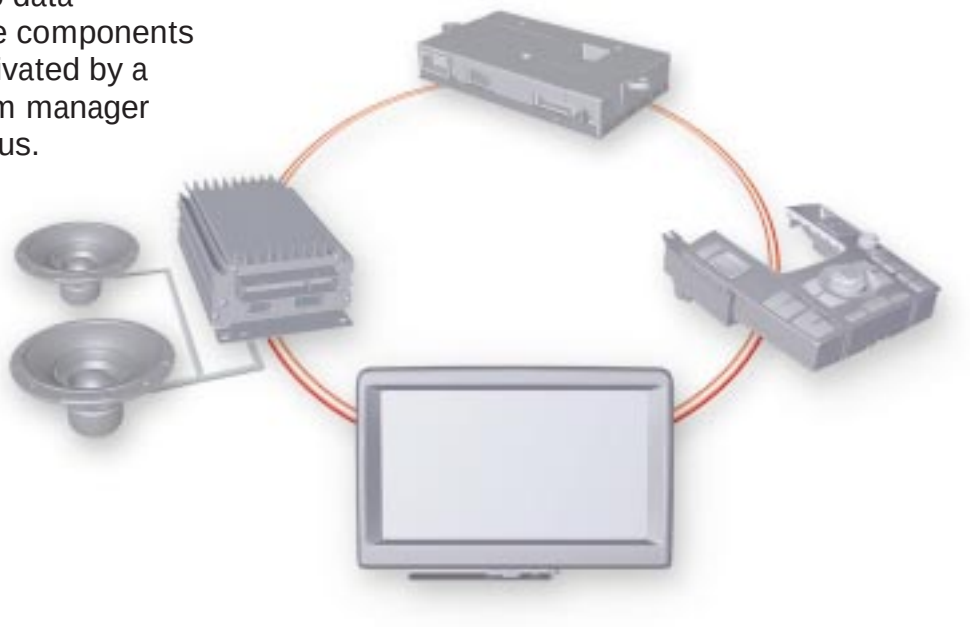
The sleep mode voltage is reduced to a minimum.

Conditions for activating the sleep mode:

- All control modules in the system signal their readiness to switch to the sleep mode.
- There is no request from other bus systems via the Data Bus On-Board Diagnostic Interface J533 (Gateway).
- Diagnosis is not active.

Overriding the above conditions, the system can be switched to the sleep mode by:

- The Battery Monitoring Control Module J367 via the Data Bus On-Board Diagnostic Interface J533 (Gateway) during discharge of the starter battery.
- When the transport mode is activated via the Vehicle Diagnosis, Test and Information System VAS 5051.



SSP286/066

Fiber-Optic Data Bus

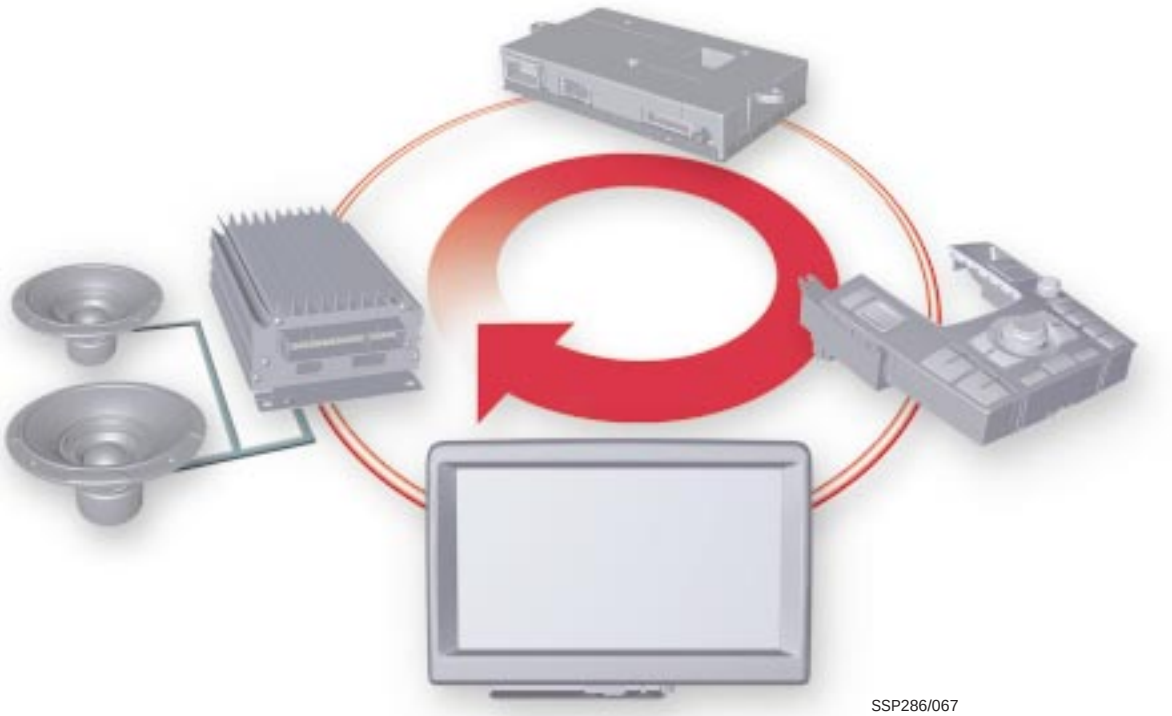
Standby Mode

In this mode there is no service offered to the operator. It seems as if the system is turned off. However, the system is active in the background. All output media (display, radio amplifier, etc.) are either inactive or are switched to the standby mode.

The system is in standby mode during the after-run period and when the vehicle is being started.

Activation of the standby mode:

- Can be triggered by other data buses via the Data Bus On-Board Diagnostic Interface J533 (Gateway), by unlocking and opening the driver's door, or turning the ignition on.
- Can occur through a control module in the MOST fiber-optic data bus, for instance by an incoming phone call.



SSP286/067

Power On

In the power-on mode, all control modules are turned on. Data exchange occurs on the MOST fiber-optic data bus. All functions are available for the operator.

Conditions for activating the power-on mode:

- The MOST fiber-optic data bus system is in standby mode.
- Activation through other data buses via the Data Bus On-Board Diagnostic Interface J533 (Gateway), for example S-contact, display active.
- Activation triggered by a function selection by the operator, such as from the Multimedia Control Head E380.

Further information about activation conditions is available in Self-Study Programs that apply to the specific vehicle.



SSP286/068

Fiber-Optic Data Bus

Message Frames

The system manager (Front Information Display Control Head J523) transmits message frames to the next control module in the fiber-optic data bus ring at a **duty cycle frequency** of 44.1 kHz.

The stability of this duty cycle frequency allows the transmission of synchronous data.

Synchronous data transmit information such as digital audio and video signals that must always be sent in the same time intervals.

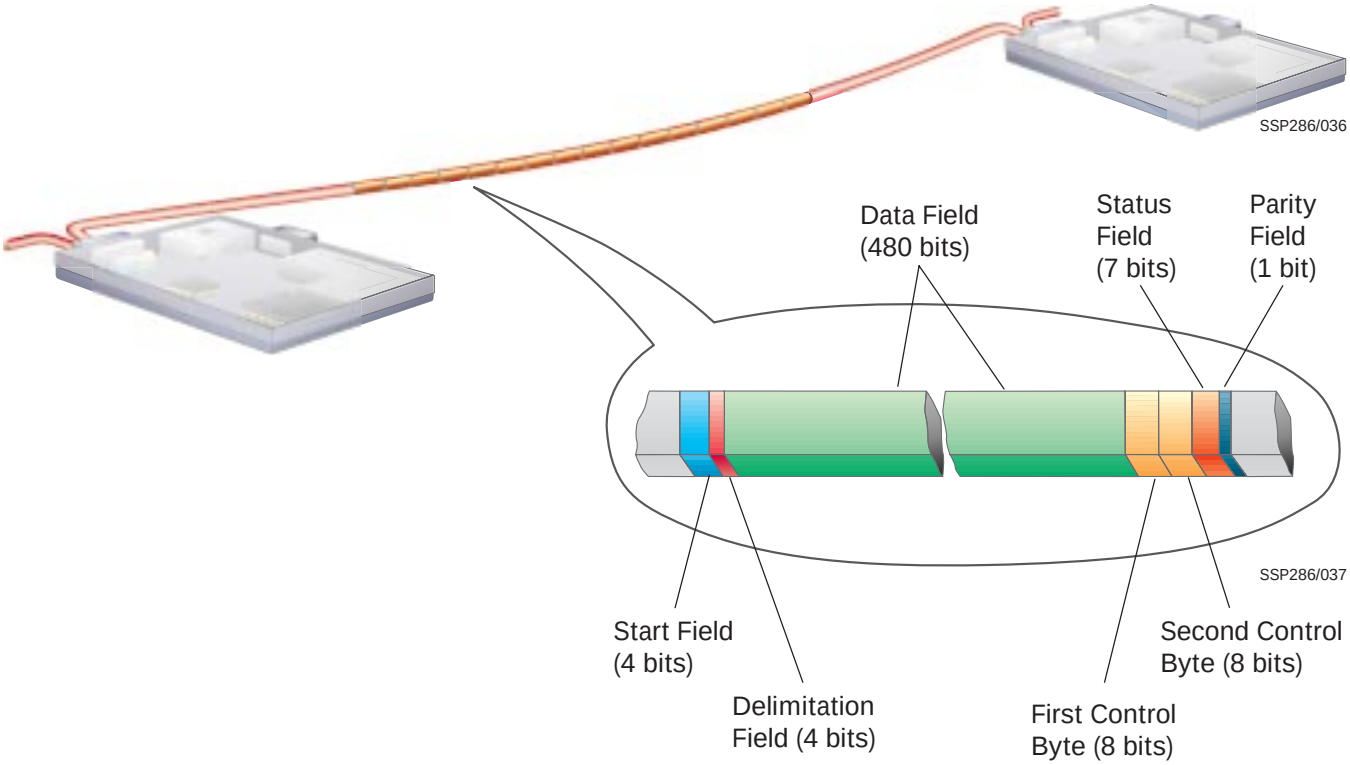
The stable duty cycle frequency of 44.1 kHz corresponds with the transmission frequency of digital audio and video equipment such as CD Changer Unit R41, Video Recorder / DVD Player R129, and Digital Sound System Control Module J525. This allows the integration of such equipment into the MOST fiber-optic data-bus system.

Construction of a Message Frame

A message frame is 64 bytes long and subdivided into sections.



One byte contains eight bits.





SSP286/039



SSP286/040

Sections of a Message Frame

The **start field**, also called the preamble, marks the beginning of a frame. Each frame of a block has its own start field.

A **delimitation field** is used to clearly separate the start field from the following data fields.

In the **data field**, the MOST fiber-optic data bus transmits up to 60 bytes of usable data to the control modules.

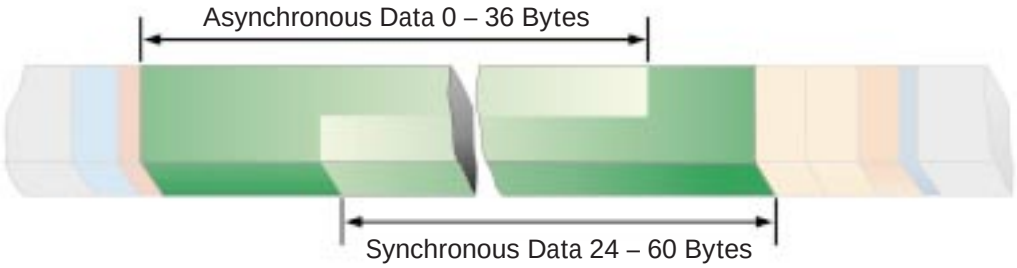
There are two data types in a message frame:

- Sound and video as synchronous data.
- Pictures, information for calculation, and text, as asynchronous data.

The partition of the data field between the two data types is flexible. The portion of synchronous data in the data field is between 24 and 60 bytes. The transmission of synchronous data has priority over asynchronous data.

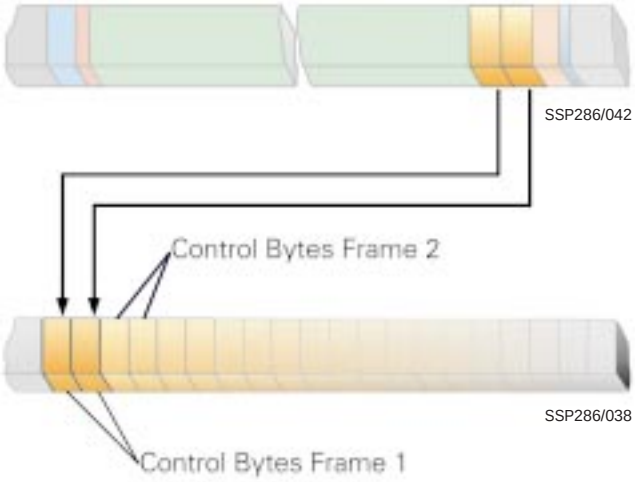
Asynchronous data are registered depending on the transmitter and receiver addresses (identifiers), and the available asynchronous portion, in packages of four bytes which are then sent to the receiver.

The sequence of the applicable data transmission is further described starting on page 40.



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Fiber-Optic Data Bus



With the two **control bytes**, the following information is transmitted:

- The transmitter and receiver address (identifier).
- The control commands to the receiver (such as to an amplifier for increasing or decreasing the volume).

The control bytes of a block are assembled in the control modules to make up a control frame. A block consists of 16 frames. The control frame contains control and diagnostic data for sending the data from one transmitter to a receiver. This is called "address-oriented data transmission."

Example:

- Transmitter – Front Information Display Control Head J523.
- Receiver – Digital Sound System Control Module J525.
- Control signal – increase or decrease volume.



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



The **parity field** is used to check the frame for a last time for completeness. The contents of this field determine whether a transmission process is going to be repeated.

Function Flow in the MOST Fiber-Optic Data Bus

System Start (Wake-Up)

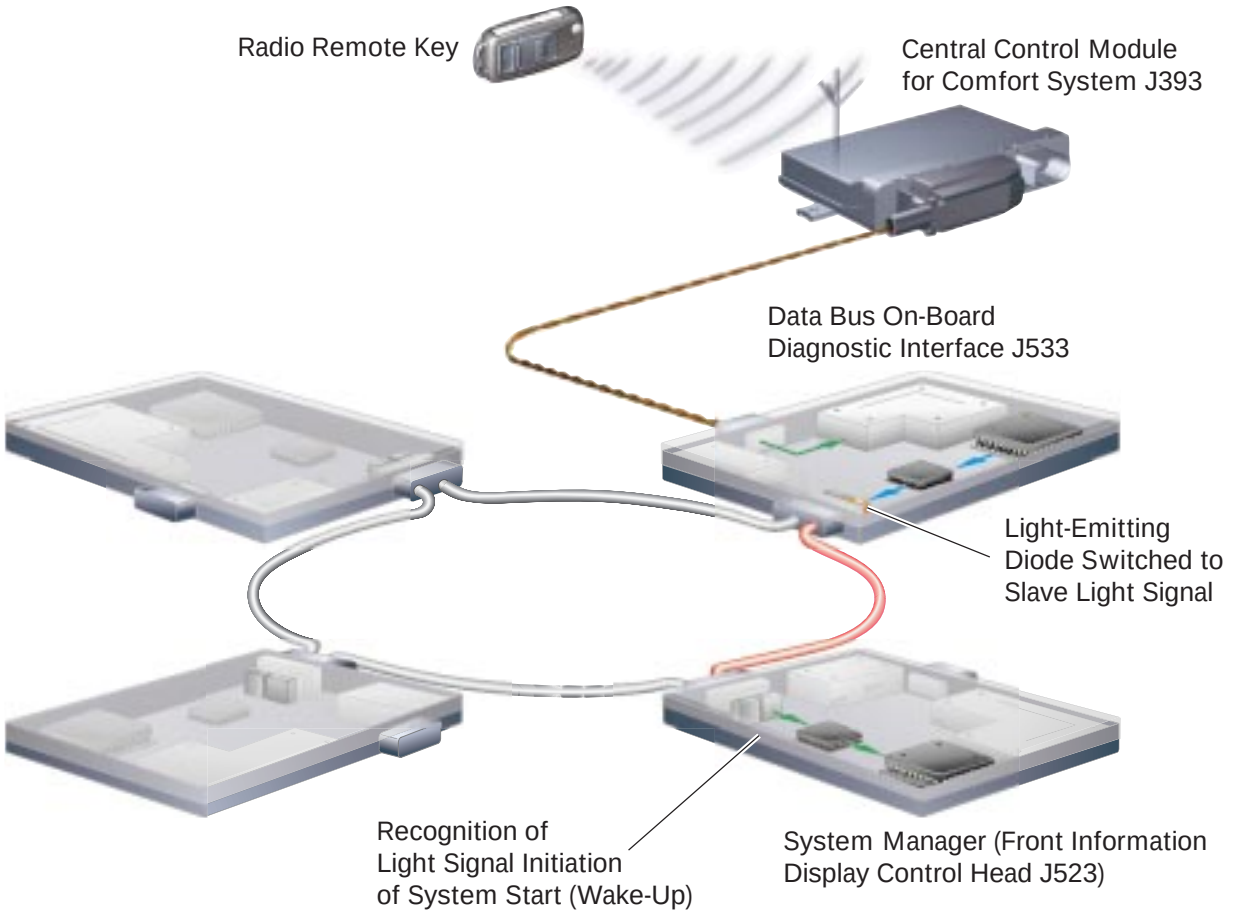
If the MOST fiber-optic data bus is in the sleep mode, the system is first switched to standby mode by the wake-up procedure.

If a control module other than the system manager wakes the system, it sends a specifically modulated light signal, the slave light signal, to the next control module.

The next control module in the ring receives the slave light signal by the active photodiode and passes it on.

This process continues until the signal arrives at the system manager.

The system manager recognizes the arrival of the slave light signal as a command to start the system.



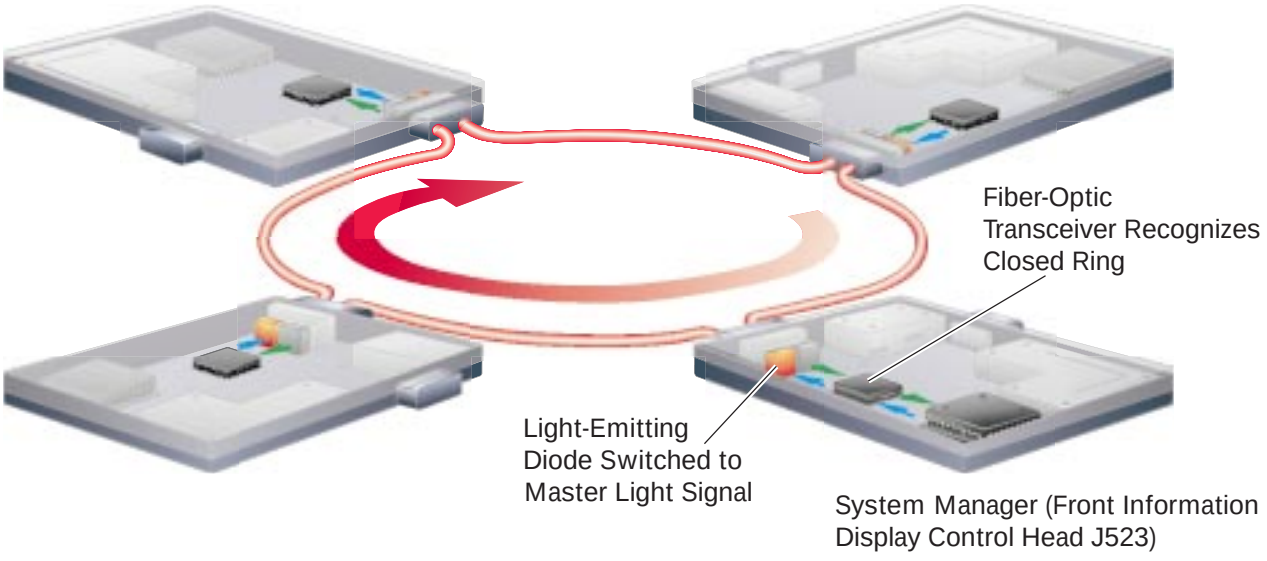
SSP286/046

Fiber-Optic Data Bus

In response to this signal, the system manager sends a different specifically modulated light signal, the master light signal, to the next control module in the ring.

This master light signal is transmitted by each control module in turn.

When the system manager receives the master light signal back at its fiber-optic transceiver, it recognizes that the fiber-optic data bus ring has been closed and starts transmitting the message frame.



SSP286/076

In the first message frame, the control modules in the MOST fiber-optic data bus are asked to identify themselves.

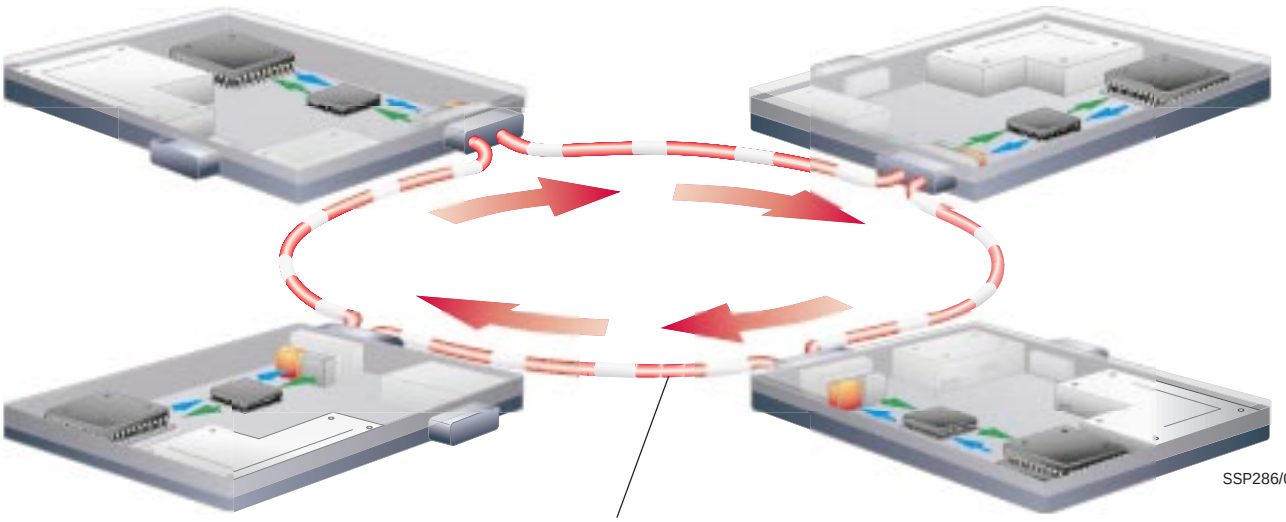
Following the identification cycle, the system manager sends the current sequence (actual configuration) to all control modules in the ring.

This makes address-oriented data transmission possible.

The diagnosis manager compares the reported control modules (actual configuration) with a stored list of the installed control modules (specified configuration).

If the actual configuration does not match the specified configuration, the diagnosis manager (Data Bus On-Board Diagnostic Interface J533) stores the applicable Diagnostic Trouble Code (DTC).

At this point the wake-up procedure is concluded and data transmission can begin.



Transmission of Sound and Video as Synchronous Data

Synchronous data transmission is explained here using a function of the 2003 Audi A8 audio system as an example: playing a music CD.

The operator selects the desired title (10 in this example) on the music CD from the Multimedia Control Head E380 and the Front Information Display Control Head Control Module J685.

The Multimedia Control Head E380 transmits the control data over a data connection to the system manager (Front Information Display Control Head J523).

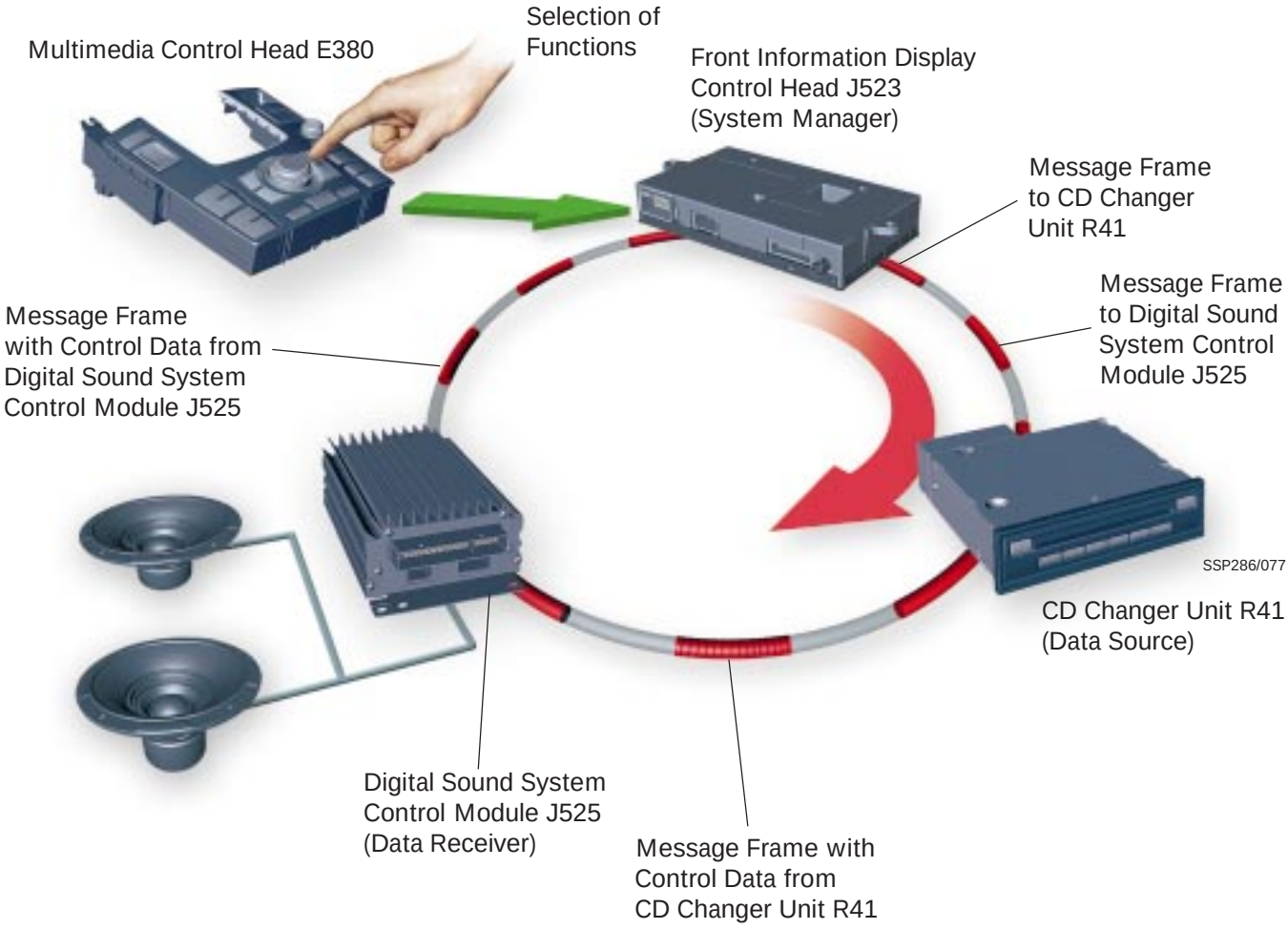
The system manager then adds the continuously sent frames to a message block (16 frames) with the control data:

- Transmission address:
  - — Front Information Display Control Head J523, position 1 on the MOST fiber-optic data bus ring.
- Receiver address of the data source:
  - — CD Changer Unit R41, position on the ring depending on installed options.
- Control commands:
  - — Play title 10.
  - — Assign transmission channels.

The CD Changer Unit R41 (the data source) decides which bytes in the data field are available for the transmission of CD drive data.

Then it adds a block with the following control data:

- Transmission address of the data source:
  - — CD Changer Unit R41, position on the ring depending on installed options.
- Receiver address of the system manager:
  - — Front Information Display Control Head J523, position 1 on the ring.
- Control command:
  - — Data transmission music CD on channels 01, 02, 03, 04 (stereo).


Multimedia Control Head E380
Selection of Functions
Front Information Display Control Head J523 (System Manager)
Message Frame to CD Changer Unit R41
Message Frame to Digital Sound System Control Module J525
Message Frame with Control Data from Digital Sound System Control Module J525
SSP286/077
CD Changer Unit R41 (Data Source)
Digital Sound System Control Module J525 (Data Receiver)
Message Frame with Control Data from CD Changer Unit R41

Fiber-Optic Data Bus

Data Management During Synchronous Transmission

The Front Information Display Control Head J523 then commands the Digital Sound System Control Module J525 to play the music by using a block with the following control data:

- Transmission address:
  - — Front Information Display Control Head J523, position 1 on the MOST fiber-optic data bus ring.
- Receiver address:
  - — Digital Sound System Control Module J525, position on the ring depending on installed options.
- Control commands:
  - — Read data channels 01, 02, 03, 04 and deliver through the loudspeakers.
  - — Use current sound adjustments, such as volume, fader, balance, base, treble, middle.
  - — Turn off mute.

The data of the music CD remain in the data field until the frame reaches the CD Changer Unit R41 (the data source) again on the ring.

This makes the use of synchronous data possible for each performance device (sound package, earphone connections) on the MOST fiber-optic data bus.

As the system manager, Front Information Display Control Head J523 assigns which one of the devices uses the data based on the applicable control data.

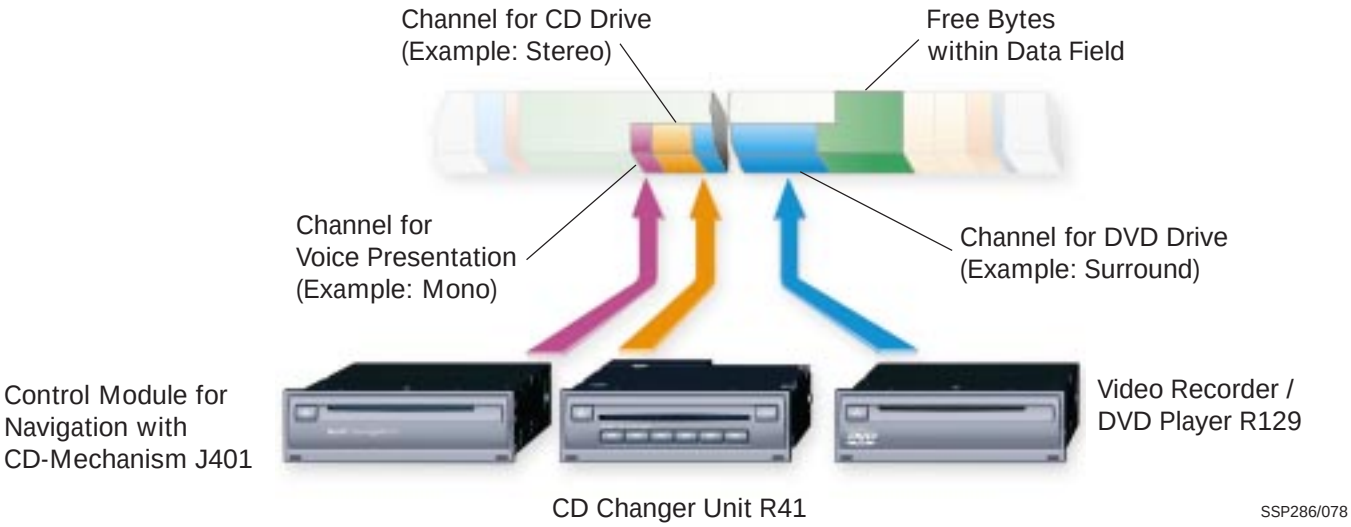
Transmission channels

The transmission of sound or video requires several bytes in each data field. The data source reserves a number of bytes according to the kind of data. The reserved bytes are called “channels.” Each channel contains one byte of data.

Number of transmission channels

Signal	Channels (Bytes)
Mono	2
Stereo	4
Surround	12

Reserving these channels makes it possible to simultaneously transmit synchronous data from several data sources.



Transmission of Data for Pictures, Text, and Functions as Synchronous Data

The following data are transmitted as asynchronous data:

- Map displays of the navigation system.
- Navigation calculations.
- Internet web sites.
- E-mail.

The sources of asynchronous data send them at irregular time intervals.

For this reason, each source saves its asynchronous data in an intermediate memory.

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

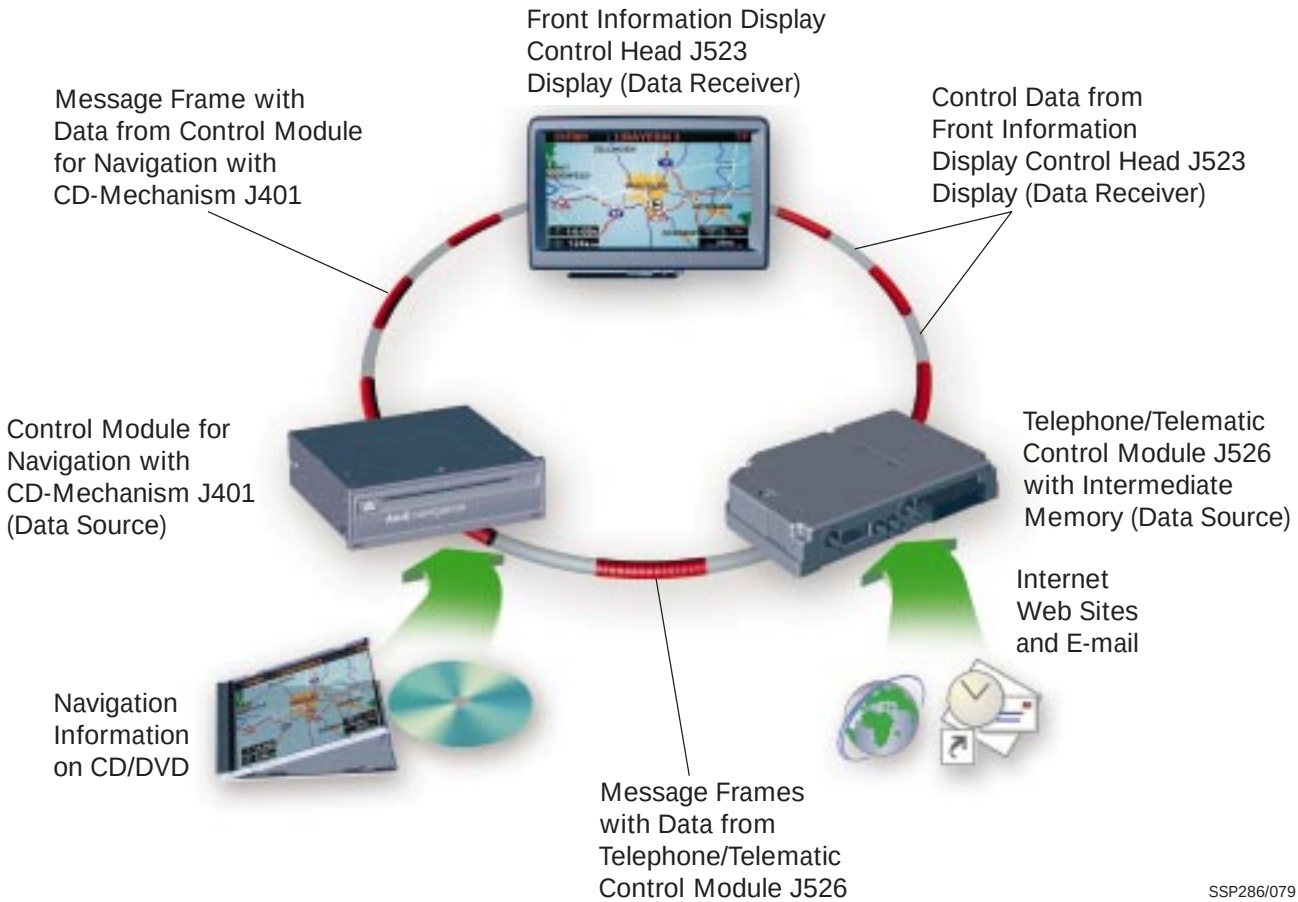
In this message block, the source enters the data in the free bytes in the data fields.

This is done in packages of four bytes each (quadlets).

The receiver reads the data packages in the data fields and uses the information.

The asynchronous data stay in the data fields until the message block again reaches the data source.

The data source selects the data from the data fields and if necessary, replaces them with new ones.



Diagnosis

Diagnosis Manager

In addition to the system manager, the MOST fiber-optic data bus has a diagnosis manager.

The diagnosis manager performs a diagnosis of the fiber-optic data bus ring and transmits the diagnosis data of the control modules in the ring to the scan tool.

The diagnosis function for fiber-optic data bus in the 2003 Audi A8 is performed by Data Bus On-Board Diagnostic Interface J533.



SSP286/057

System Failure

If the transmission of data in the fiber-optic data bus is interrupted, it is referred to as a "ring break" because of its ring structure.

Reasons for a ring break can include:

- Interruption of the fiber-optic cable.
- Faulty voltage supply of the transmitter or receiver control module.
- Faulty transmitter or receiver control module.

To localize a ring break, a ring break diagnosis must be performed. The ring break diagnosis is part of the output diagnostic test mode of the diagnosis manager.

Consequences of a ring break are:

- Failure of sound and video reception.
- Failure of control and adjustment using the Front Information Display Control Head J523.
- The Diagnostic Trouble Code (DTC) entered in the diagnosis manager is "Optical data bus interruption."

Ring Break Diagnosis

Wiring for ring break diagnosis

Because data transmission in the MOST fiber-optic data bus is not possible in case of a ring break, the diagnosis must be performed using a diagnosis wire.

The diagnosis wire is connected to every control module in the fiber-optic data bus ring from a central connection.

How ring break diagnosis works

After ring break diagnosis is initiated, the diagnosis manager sends an impulse to the control modules over the diagnosis wire.

In response to this impulse, all the control modules in the ring use the transmitters in their fiber-optic transceivers to send light signals through the fiber-optic cable.

At the same time all control modules check:

- Their **voltage supply** and **internal electrical functions.**
- The **receipt of the light signals** from the previous control module in the ring.

Each control module connected to the MOST fiber-optic data bus answers according to timing programmed into the software.

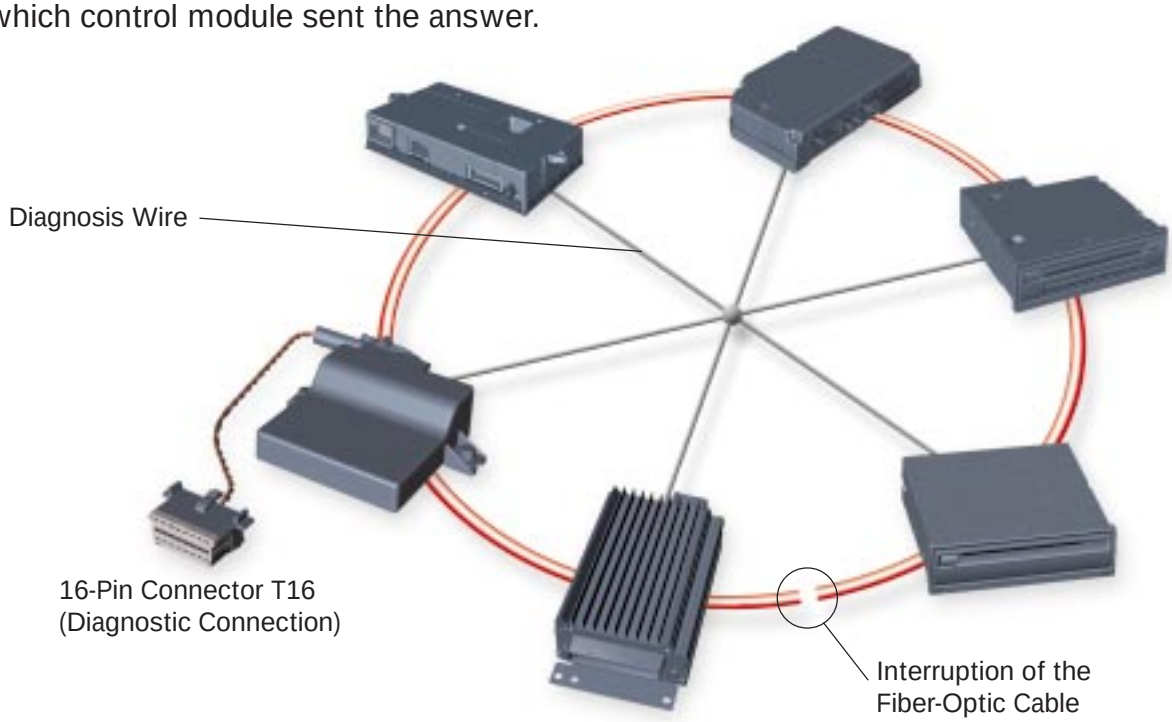
Using the timing between the start of the ring break diagnosis and receipt of the answer, the diagnosis manager recognizes which control module sent the answer.

The control modules connected to the MOST fiber-optic data bus send two messages after the start of the ring break diagnosis:

- **Control module is electrically OK** means that the electrical functions of the control module, such as the voltage supply are OK.
- **Control module is optically OK** means that it receives the light signal through its photodiode from the control module that precedes it in the ring.

From this information the diagnosis manager can recognize:

- Whether there is an electrical fault in the system (voltage supply faulty).
- Between which of the control modules the optical data transmission is interrupted.



SSP286/080

Fiber-Optic Data Bus

Ring break diagnosis with increased attenuation

The previously described ring break diagnosis process can only detect an interruption of the data flow.

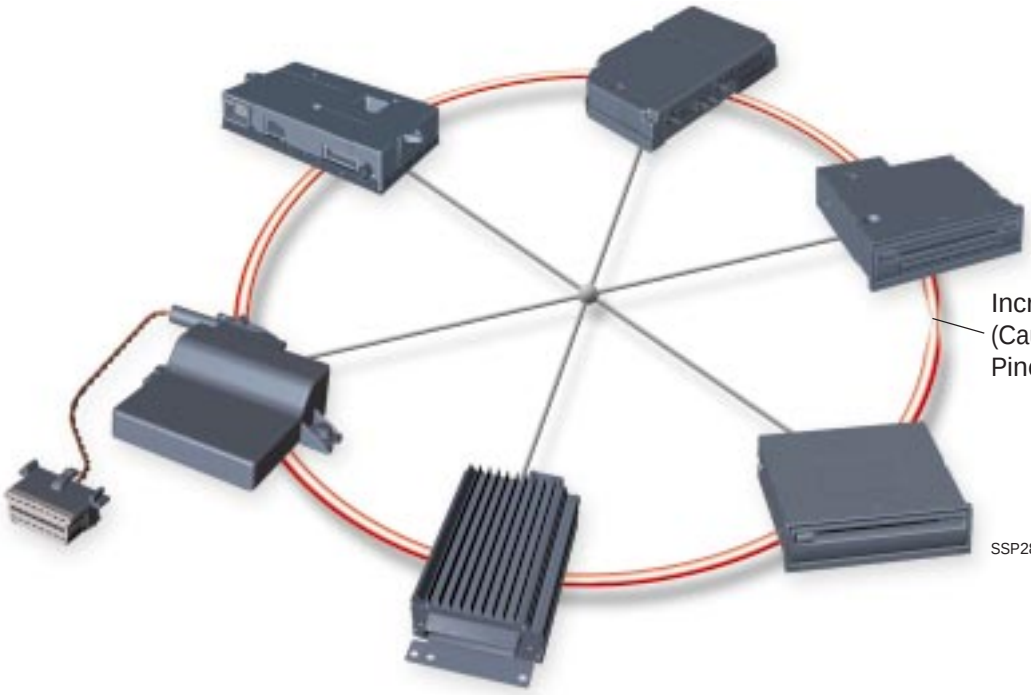
The output diagnostic test mode of the diagnosis manager (Data Bus On-Board Diagnostic Interface J533) can also perform a ring break diagnosis with reduced light output to recognize a reduction in the amount or intensity of the light waves as they are routed through the fiber-optic cable (increased attenuation).

The process of the ring break diagnosis with reduced output is similar to the one described for interrupted data flow.

However, in this case the control modules switch the LEDs in their fiber-optic transceivers to an attenuation of 3 dB, or to half of their normal light output.

If the fiber-optic cable has an increased attenuation, the light signal is too weak as it reaches the receiver. The receiver then reports "Optics not OK."

From this signal the diagnosis manager recognizes the fault location and produces an appropriate message in the "Guided fault-finding" mode of the scan tool.



Introduction

In the modern business world as well as in private life, mobile communication and information is becoming more and more important.

A person often uses more than one mobile device such as a mobile telephone, a personal digital assistant, or a laptop computer.

The exchange of information between these mobile devices was possible in the past only through hard-wired electrical connection or wireless infrared connection.

These non-standardized connections took up valuable space and the devices were complicated to operate.

The Bluetooth technology takes up less space and reduces the complexity of operating these devices. It enables mobile devices of various manufacturers to be connected through a standardized radio transmission.

This technology is used for the first time in the 2003 AUDI A8 for the wireless connection between the cordless Cellular Telephone R54 and the Telephone/Telematic Control Module J526.



At a later date other applications are planned for the vehicle user:

- Installation of a second phone in the rear passenger compartment.
- Connection of laptop computers, smart phones, and notepads to the internet for transmission of information and entertainment.
- Reception and transmission of e-mail using a laptop computer or personal digital assistant.
- Transmission of addresses and phone numbers from a laptop or personal digital assistant to the multimedia interface system.
- The hands-free operation of mobile phones without additional cable adapters.
- Use of Bluetooth technology in other vehicle systems (remote operation of the auxiliary heater for example).

What is Bluetooth?

The Swedish company Ericsson promoted the development of a standardized short distance radio transmission system – the Bluetooth technology.

In response to this initiative, many companies have joined in the development of this technology. Today the Bluetooth Special Interest Group consists of more than 2000 companies, including telecommunications, data processing, equipment, and vehicle manufacturers.

The name “Bluetooth” comes from the Viking King Harald Blåtand. During the tenth century he united Denmark and Norway and had the nickname “Bluetooth.”

Because this transmission system connects diverse information and data processing devices as well as mobile phones, the resulting good communication reflects the philosophy of King Harald. That’s the reason it was called Bluetooth.



SSP286/084

Design and Function

The Bluetooth technology enables wireless connection of various mobile devices from different manufacturers using a standardized radio transmission.

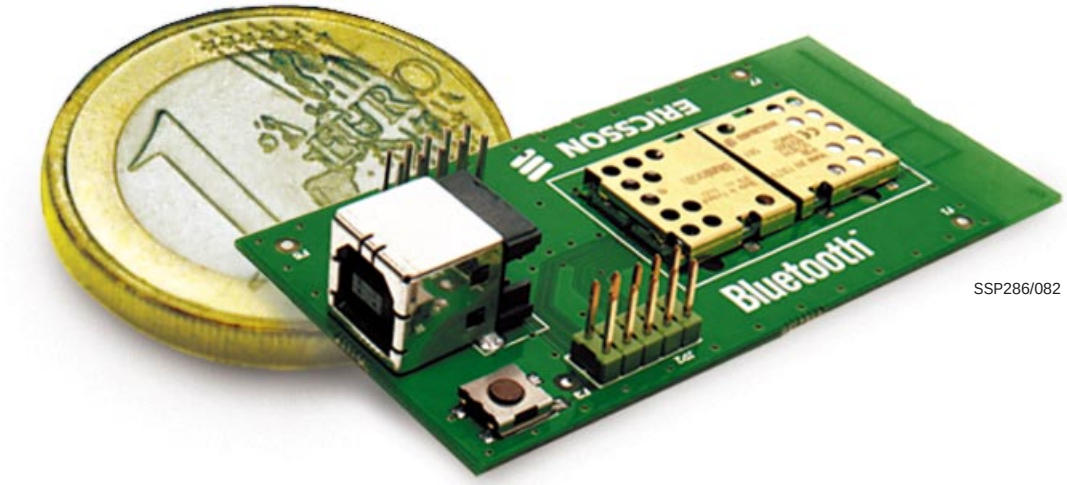
In selected mobile devices, short-range transceivers (transmitters and receivers) are either directly installed or integrated using an adapter (example PC-card, universal service bus, etc.).

The radio transmission occurs in the 2.40 GHz to 2.48 GHz frequency range that is available worldwide. Transmitting on this band does not require a license and is free of charge.

The very short wave length of this frequency makes it possible to integrate the following into the Bluetooth module:

- The antenna (Bluetooth Antenna R152).
- The control and encryption.
- The entire transmission and receiver technology.

The small size of the Bluetooth module allows its installation into small electronic devices.



SSP286/082

The Bluetooth data transmission rate is up to 1 megabit per second. These devices can transmit up to three language channels at the same time.

Bluetooth transmitters normally have a range of about 33 feet (10 meters). In special applications with amplifiers, transmission ranges of up to about 330 feet (100 meters) are possible.

The data transmission works with no complicated adjustments.

As soon as two Bluetooth devices meet, they automatically establish a connection. Before that can happen, the devices must be adapted once by entering a PIN-number.

With entering the PIN-number, small transmission cells are formed, called “piconets,” to help with the organization of data.

A piconet offers room for a maximum of eight active Bluetooth devices. Each device can belong to several piconets at the same time.

In each piconet, one device assumes the master function. The Telephone/Telematic Control Module J526 is the Bluetooth master in the 2003 Audi A8.

- The master establishes the connection.
- The other devices synchronize with the master.
- Only the device that received a data package from the master may send an answer.

To prevent chaos in the construction of a piconet, adjustments can be made to every device to determine whether it will communicate with another device or not.

Each device has an address that is 48 bits long and is unique worldwide. This makes it possible to clearly identify more than 281 trillion devices.

Shared Operating Frequencies

Data transmission in the Bluetooth system is done using radio waves within a frequency range of 2.40 GHz to 2.48 GHz.

This frequency range is used also by other devices:

- Garage door openers
- Microwave ovens
- Medical devices

Interference Reduction Measures

The Bluetooth technology employs special measures to reduce the interference caused by other devices operating on the same frequencies.

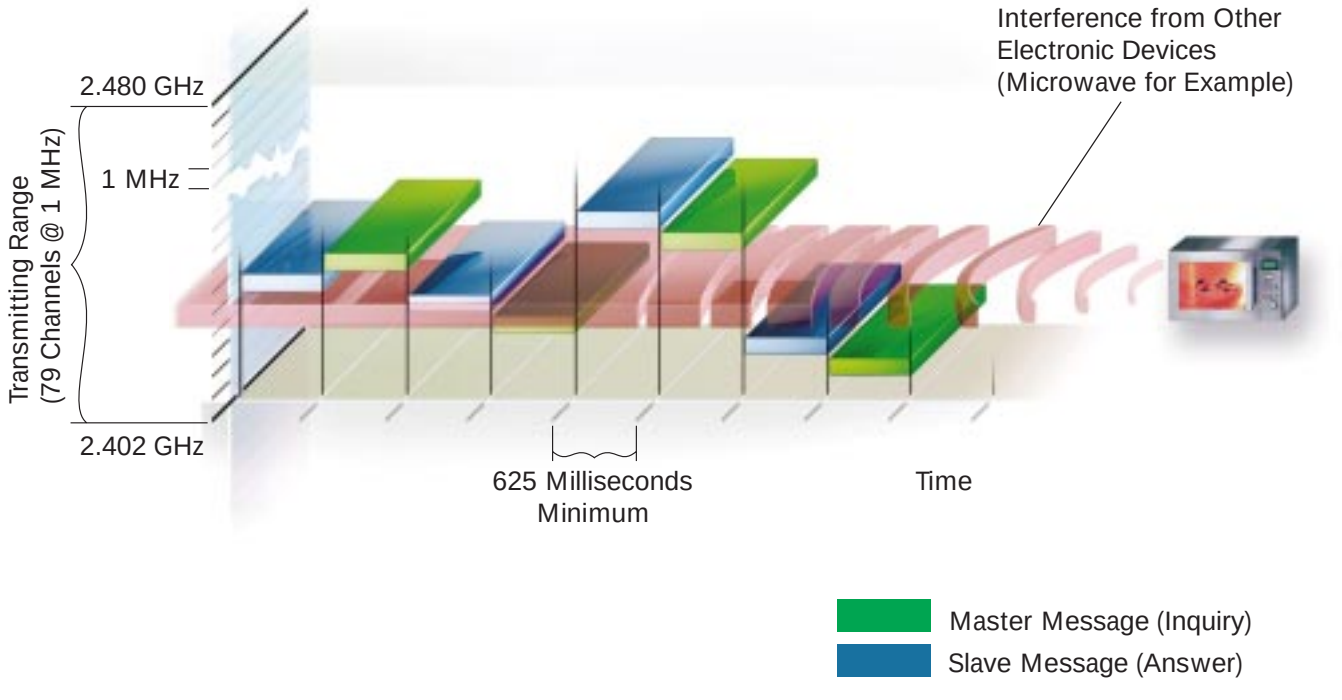
The Bluetooth control module:

- Divides the data into short and flexible data packages. They have a duration of about 625 milliseconds.
- Checks the completeness of the data packages using a check total of 16 bits.
- Automatically repeats the transmission of faulty data packages.
- Uses robust language coding. The language is converted into digital signals.

The Bluetooth transmitter module:

- Changes the transmitting and receiving frequencies at random, 1600 times per second. This is called “frequency hopping.”

Function



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Data Security

In the development of the Bluetooth technology, the cooperating manufacturers placed great value on the protection of the transmitted data against manipulation and unauthorized access.

The data are encrypted using an encryption key that is 128 bits long.

The receiver is checked for authenticity with a key of 128 bits. The devices use a secret password that is used for participants to recognize each other.

The key is newly created for every connection.

Since the range is limited to about 33 feet (10 meters), a manipulation must occur within this range. This also increases data security.

These same measures also increase security against outside interference and manipulation of the data flow.

By additional use of elaborate encrypting methods, diverse security levels, and network protocols, the equipment manufacturers can increase data security even further.

Diagnosis

The diagnosis of the Bluetooth connection is performed using the Address Word of the master control module.



The Telephone/Telematic Control Module J526 is the Bluetooth master in the 2003 Audi A8.
Address Word 77 – Phone
Address Word 75 – Emergency call module

The Bluetooth connection between the Cordless Cellular Telephone R54 in the 2003 Audi A8 and the Telephone/Telematic Control Module J526 is monitored by the Bluetooth Antenna R152.

If an interruption in the connection to the Bluetooth Antenna R152 occurs, the following Diagnostic Trouble Code (DTC) is put into memory:

“Bluetooth antenna – no signal / no communication”

In the measured value blocks the portable devices that are connected to the master control module can be shown in detail:

- The number of devices.
- The device number.
- The field strength of the radio connection.

In the adaptation of the Bluetooth master, the Bluetooth function can be turned on or off. This may be necessary during air transport of the vehicle or operation of the vehicle in a country that does not allow the use of Bluetooth frequencies.

Overview

The diagnosis CAN data bus is used for the data exchange between the diagnostic scan tool and the control modules installed in the vehicle.

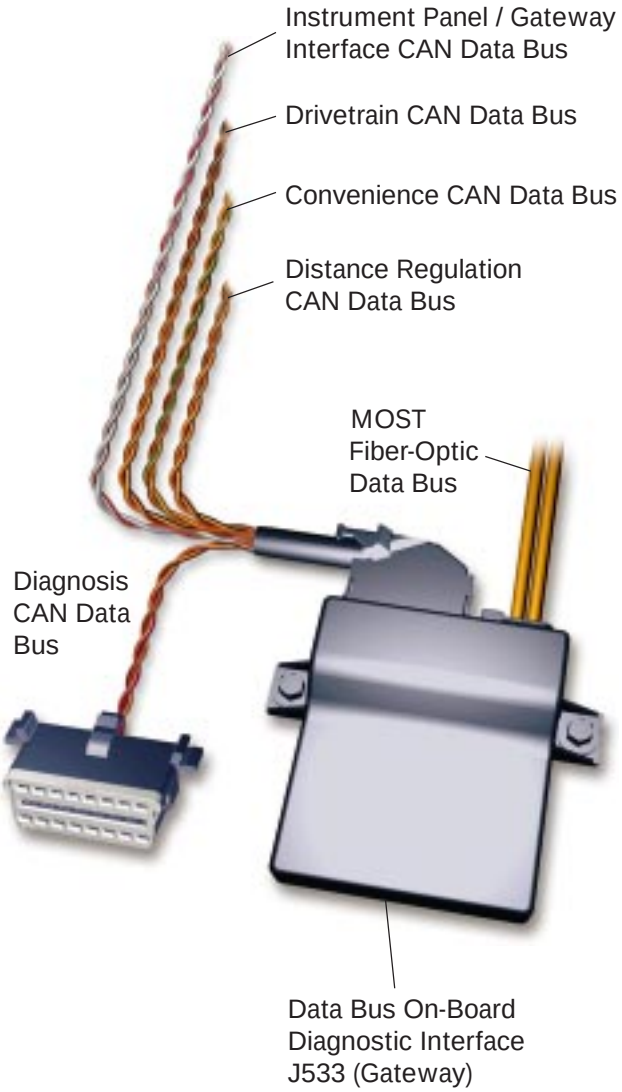


The K-wires or L-wires are no longer used, with the exception of emission-related control modules.

The diagnosis is performed with the Vehicle Diagnosis, Test and Information System VAS 5051 or the Vehicle Diagnosis and Service Information System VAS 5052.

The transfer of the control module diagnosis data is accomplished by means of the applicable data bus systems to the Data Bus On-Board Diagnostic Interface J533 (gateway).

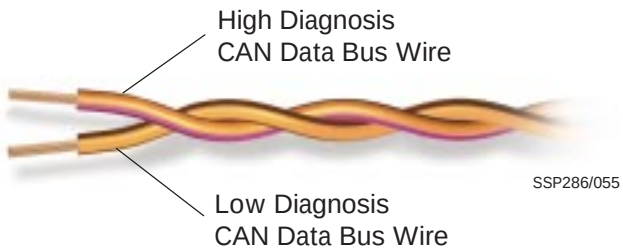
Taking advantage of the rapid data transmission through the diagnosis CAN data bus and the gateway function, the diagnostic scan tool is able to show the status of installed components and their fault status.



The diagnosis CAN data bus uses two unshielded and twisted wires, each with a diameter of 0.35 mm.

The low diagnosis CAN data bus wire is orange/brown and the high diagnosis CAN data bus wire is orange/violet.

The data transfer occurs at a transfer speed of 500 kilobits per second in the full duplex mode. That means that data can be transmitted in both directions at the same time.



Diagnosis CAN Data Bus

Diagnosis can be done under the following conditions:

Number	Diagnosis	Condition		Remarks
1	Initiation	When ignition is turned ON	Yes	Wake-up of the control module via the diagnosis CAN is not possible.
		When ignition is turned OFF	Yes, but not in sleep mode	
2	Execution	When ignition is turned ON	Yes	
		When ignition is turned OFF	Yes, but no writing procedures (i. e. coding of the control module)	
3	End	Cancel by turning ignition OFF	No	



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To initiate diagnosis on the vehicle, one of these new diagnostic cables is required:

VAS 5051/5A – 9.8 ft (3 m)

or

VAS 5051/6A – 19.7 ft (6 m)

These new diagnostic cables can also be used with diagnosis systems using K-wires or L-wires.



SSP286/051



The latest version of the software is needed for diagnosis:

VAS 5051 – Basic software 3.0 for diagnosis via CAN.

VAS 5052 – Basic software.

With the changes of the basic software there will be new functions and changes of the user/system interface.

Extension of Addressing Forms

In addition to directly addressing individual control modules, it is now possible to address them in groups. This allows the DTC memories of several control modules to be read at the same time.

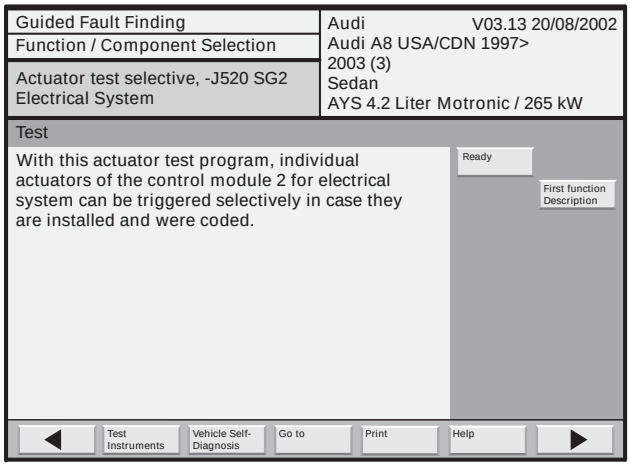
Therefore, the reading of DTC memories can be done much faster.

Selective Output Diagnostic Test Mode Test

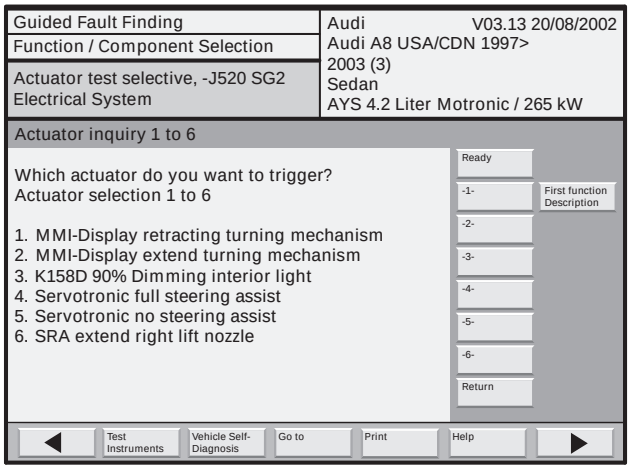
The selective output diagnostic test mode test allows for direct activation of actuators without staying within a particular sequence.

The simultaneous display of measured value block control modules is also possible when checking switches and sensors.

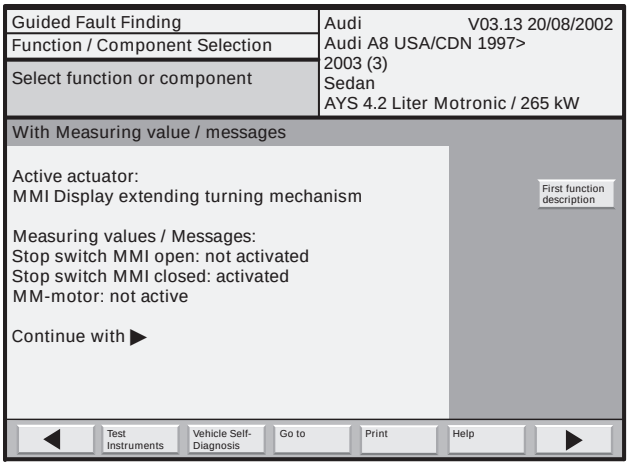
These innovations open new possibilities in guided troubleshooting.



SSP286/089



SSP286/090



SSP286/091

Example:

The illustration shows the selective output diagnostic test mode test for checking the display mechanism of the Vehicle Electrical System Control Module 2 J520 in the 2003 Audi A8.



SSP286/052

Pin assignment at the 16-Pin Connector T16 (Diagnostic Connection)

Pins not listed are not currently in use.

Pin	Wiring
1	Terminal 15
4	Ground
5	Ground
6	High Diagnosis CAN Data Bus
7	K-Wire
14	Low Diagnosis CAN Data Bus
15	L-Wire
16	Terminal 30

Knowledge Assessment

An on-line Knowledge Assessment (exam) is available for this SSP.

The Knowledge Assessment may or may not be required for Certification.

You can find this Knowledge Assessment at:

www.accessaudi.com

From the accessaudi.com homepage:

- Click on the “ACADEMY” Tab
- Click on the “Academy Site” Link
- Click on the ”CRC Certification” Link

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