

BOSCH

Automotive Handbook

6th
EDITION

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Foreword to the 6th Edition

The history of the automobile's development is also an impressive documentation of technical innovations. New systems and detail enhancements make driving even safer and more comfortable, and continue to reduce the environmental impact by engine emissions and manufacturing processes. The 6th Edition of the "Automotive Handbook" reflects this development by including a number of new subjects and complete revisions of existing sections. Compared with the previous edition, the handbook has grown by about 270 pages.

The "Automotive Handbook" is an important reference work with worldwide distribution due to its up-to-date sections that are worded concisely. It is intended to provide an insight into the modern state of automotive technology for engineers and technicians, as well as those who are interested in technical matters.

The authors in the 6th Edition are experts from the Bosch corporation, universities, and the automotive industry. They have completely revised the contents of this handbook, brought it up-to-date, and expanded it with new subjects. We would like to take this opportunity of thanking all those involved for their cooperation.

In more than seven years the Automotive Handbook has grown from a calendar insert of 96 pages to an extensive work now with over 1,200 pages. In the meantime its circulation in several languages total more than a million copies.

The new edition has a revised page layout to provide better navigation for the reader. The left page title indicates the generic subject, while the right page title is the chapter heading. The redesigned and extended table of contents now contains all chapters and sections. This will help the reader to search for subjects more easily.

The Editors

For your information

The following subjects have been added since the 6th Edition:

Hydrostatics ● Fluid mechanics ● Mechatronics ● Coating systems ● Frictional joints ● Positive or form-closed joints ● Engine lubrication ● Emission reduction systems ● Diagnosis ● Truck brake management as a platform for truck driver assistance systems ● Analog and digital signal transmission ● Mobile information services ● Fleet management ● Multimedia systems ● Development methods and application tools for electronic systems ● Sound design ● Vehicle wind tunnels ● Environmental management ● Workshop technology.

The following subjects have been totally revised and restructured:

Basic equations used in mechanics ● Threaded fasteners ● Springs ● Air filtration ● Exhaust-gas measuring techniques ● Engine management for spark-ignition (SI) engines (including Motronic engine management) ● Diesel-engine management ● Car radio with auxiliary equipment ● Vehicle antennas ● Mobile and data radio ● Passenger-car driver-assistance systems.

The following subjects have been updated, expanded and restructured:

Acoustics ● Heat ● Electronics ● Substances ● Materials ● Corrosion ● Tribology ● Lubricants ● Fuels ● Antifreeze and brake fluid ● Chemicals ● Heat treatment ● Motor-vehicle dynamics ● Motor-vehicle requirements ● Internal-combustion engines ● Engine cooling ● Battery chargers ● Exhaust-gas system ● Alternative spark-ignition engine drive systems ● Hybrid drives ● Drivetrain ● Suspension ● Wheels ● Tires ● Braking systems ● Braking systems for passenger cars and commercial vehicles ● Vehicle stabilization systems for passenger cars and commercial vehicles ● Vehicle bodies for passenger cars and commercial vehicles ● Lighting technology (with cornering headlamps) ● Instrumentation ● Driver information system ● Trip recorders ● Parking systems ● Navigation systems ● Traffic-control engineering ● Electromagnetic compatibility ● Occupant safety systems ● Comfort and convenience systems ● Starter batteries ● Alternators ● Starting systems.

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Integrated analog circuits

- Basic structures:
- Stabilized-voltage supply, stabilized-current supply, differential amplifier components, switching elements, potential shift, output stages.
- Application-oriented classes:
- Operational amplifiers (OP), voltage regulators, comparators, timers, converters, interface circuits.
- Special analog ICs:
- Voltage references, wideband amplifiers, analog multipliers, function generators, phase-lock circuits, analog filters, analog switches.

Integrated digital circuits

The spectrum ranges from LSI (simple logic chips) through to ULSI (memories, microcomponents).

Several conditions must be met before logic chips can be combined within a single system: The power supply, logic level, the circuit speed, and the signal transit time must all be identical. This requirement is met within the respective circuit families.

The most important are:

- Various bipolar types (e.g. TTL: Transistor-Transistor-Logic)
- MOS logic, in particular CMOS logic

MOS and CMOS chips make up more than 99% of the production of integrated digital circuits. Bipolar logic circuits are only used in exceptional cases. Here, too, CMOS devices are taking their place more and more.

Semiconductor memories

Data storage includes the following operations: recording (writing, entering), storage (data storage in the narrow sense), retrieval, and readout. The memory operates by exploiting physical properties that facilitate unambiguous production and recognition of two opposed states (binary information). In semiconductor memories, the states produced are "conductive/non-conductive" or "charged/discharged"; the latter state relies on special properties in the silicon/silicon oxide or silicon nitride/metal junction. In future magnetic memory chips (FDRAM) will also be used. They have small ferromagnetic areas integrated on the chip. The direction of the magnetic field is used to store information.

Semiconductor memories are divided into the two main categories of "volatile" and "non-volatile". Virtually all of them are manufactured according to CMOS technology.

- Volatile memories (short-term memories) can be read and over written any number of times, and are therefore referred to as RAMs (Random Access Memories); the information content is lost when the power supply is switched off.

- Non-volatile memory chips (long-term memories) retain their data even when the power supply is switched off; they are also referred to as ROMs (Read-Only Memory).

The chart on the facing page shows the relationships and classification of the most common types of memory chip.

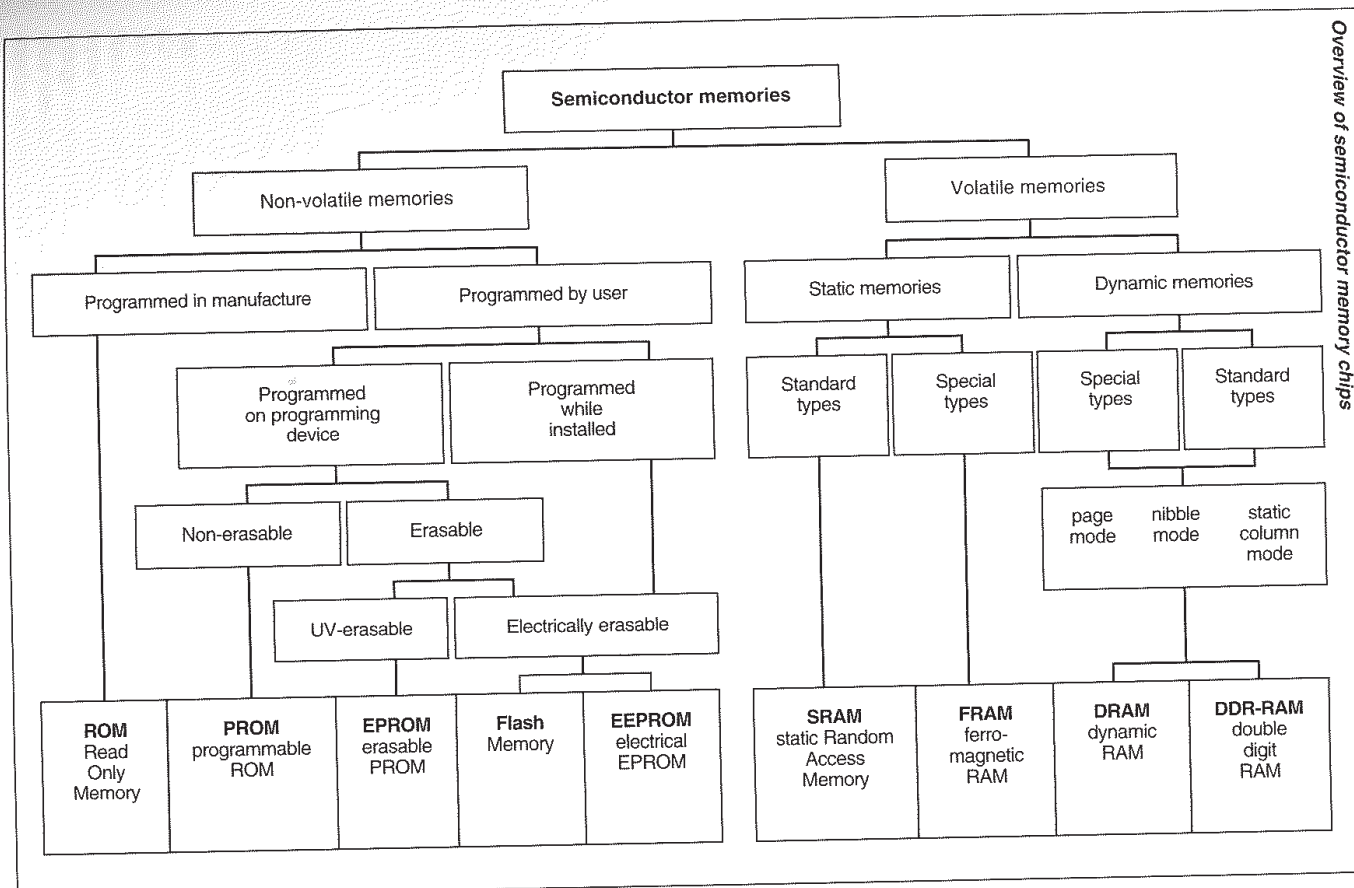
Microprocessors and microcomputers

The microprocessor represents the integration of a computer's central processing unit on a single chip. Microprocessor design seeks to avoid individualization, and the face of large-scale integration, and the units can be programmed to meet the varied requirements associated with specific operating conditions. There are two different main groups of processor. A PC (Personal Computer) uses CISC processors (CISC: Complete Instruction Set Computing). These processors are very versatile and user-programmable. A WS (work station) normally uses RISC processors (RISC: Reduced Instruction Set Computing). These processors are very much faster for the specific tasks frequently associated with WS use, but are significantly slower for all other tasks. A microprocessor cannot operate by itself: it always acts as part of a microcomputer.

A microcomputer consists of:

- Microprocessor serving as CPU (central processing unit). The microprocessor contains the controller and the arithmetic-logic unit. The arithmetic and logic unit performs the operations indicated by its name, while the controller ensures implementation of the commands stored in the program memory.
- Input and output units (I/O), which control data communication with the peripherals.

Overview of semiconductor memory chips



In order to prevent injuries caused by airbags or fatalities to "out-of-position" occupants or to small children in child seats with automatic child-seat detection, it is essential that the front airbags are triggered and inflated in accordance with the particular situations. The following improvement measures are available for this purpose:

1. **Deactivation switches.** These switches can be used to deactivate the driver or passenger airbag. The airbag function states are indicated by special lamps.

2. In the U.S., where there are currently approx. 160 fatalities caused by airbags, attempts are being made to reduce aggressive inflation by introducing "depowered airbags". These are airbags whose gas-inflator power has been reduced by 20...30%, which itself reduces inflation speed, inflation severity and the risk of injury to "out-of-position" occupants. "Depowered airbags" can be depressed more easily by large and heavy occupants, i.e. they have a reduced energy-absorption capacity. It is therefore essential – above all with regard to the possibility of severe frontal impacts – for occupants to fasten their seat belts. In the U.S., the "low-risk" deployment method is currently preferred. This means that, in "out-of-position" situations, only the first front-airbag stage is triggered. In heavy impacts, the full gas-inflator output can then be brought into effect by triggering both inflator stages. Another way of implementing "low-risk" deployment with single-stage inflators and controllable deflation vents is to keep the deflation valve constantly open.

3. **"Intelligent airbag systems".** The introduction of improved sensing functions and control options for the airbag inflation process, with the accompanying improvement in protective effect is intended to result in a gradual reduction in the risk of injury. Such functional improvements are:

- Impact severity detection by improvements in the deployment algorithm or the use of one or two upfront sensors (see the system diagram in "Restraint System Electronics") installed in the ve-

hic's crumple zone (e.g. on the radiator cross-member). These are acceleration sensors which facilitate early detection of impacts that are difficult to sense conventionally, e.g. ODB (Offset Deformable Barrier) crashes, offset against soft crash barriers), pole or under-ride impacts. They also allow an assessment of the impact energy.

- Self-belt usage detection
- Occupant presence, position and weight detection
- Seat-position and backrest-inclination detection
- Use of front airbags with two-stage gas inflators or with single-stage gas inflators and pyrotechnically triggered gas-discharge valves (see also "low-risk" deployment method)
- Use of seat-belt tighteners with occupant-weight-dependent belt-force limiters
- CAN bus networking of the occupant-protection system for communication and synergy utilization of data from "slow" sensors (switches) in other systems (data on vehicle speed, brake operation, seat-belt buckle and door-switch status) and for activation of warning lamps and transmission of diagnostic data.

For transmission of emergency calls after a crash and for activation of "secondary-safety systems" (hazard-warning signals, central-locking release, fuel-supply pump shutoff, battery disconnection, etc.) the "crash output" is used (see figure "Airbag control unit 9").

Side airbag

Function

Side impacts make up approx. 30% of all accidents. This makes the side collision the second most common type of impact after the frontal impact. An increasing number of vehicles are therefore being fitted with side airbags in addition to seat-belt tighteners and front airbags. Side airbags, which inflate along the length of the roof lining for the purposes of head protection are designed to cushion the occupants and protect them from injury in the event of a side impact (e.g. inflatable tubular systems, window bags, inflatable curtains) or from the door or the seat backrest (thorax bags, upper body protection).

Operating concept

Due to the lack of a crumple zone, and the minimum distance between the occupants and the vehicle's side structural components, it is particularly difficult for side airbags to inflate in time. In the case of severe impacts, therefore, the time needed for impact detection and activation of the side airbags must be approx. 5...10 ms and the time needed to inflate the approx. 12 l thorax bags must not exceed 10 ms.

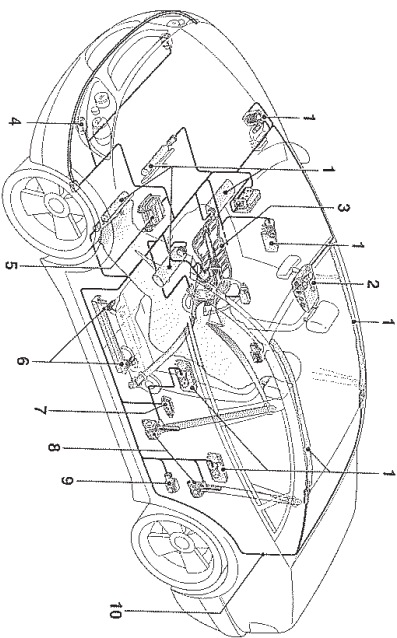
Bosch offers the following option to meet the above requirements: an instrument-cluster ECU, which processes the input signals of peripheral (mounted at suitable points on the body), side-sensing acceleration sensors, and which can trigger side airbags as well as the seat-belt tighteners and the front airbags.

Components

Acceleration sensors

Acceleration sensors for impact detection are integrated directly in the control unit (seat-belt tighteners, front airbag), and mounted in selected positions on both sides of the vehicle on supporting structural components such as seat cross-members, sills, B and C-pillars (side airbags) or in the crumple zone at the front of the vehicle (upfront sensors for "intelligent airbag systems"). The precision of these sensors is crucial in saving lives. Nowadays, those acceleration sensors are surface-micromechanical sensors consisting of fixed and moving finger structures and spring pins. A special process is used to incorporate the "spring/mass system" on the surface of a silicon wafer. Since the sensors only have low working capacitances (≈ 1 pF), it is necessary to accommodate the evalua-

Electronic impact-protection system "Restraint System Electronics" (RSE)
1 Airbag with gas inflator, 2 Vision™ passenger-compartment camera, 3 OC mat, 4 Upfront sensor, 5 Central control unit with integral rollover sensor, 6 Bolt™, 7 Peripheral pressure sensor (PPS), 8 Seat-belt tightener with propellant charge, 9 Peripheral acceleration sensor (PAS), 10 Bus architecture (CAN).



Biometric systems

Function

"Biometric systems" have the task of determining or confirming the identity of persons on the basis of "biometric" features.

At present about ten biometric processes are known, including

- fingerprint identification,
- face identification,
- iris identification, and
- voice identification.

Biometric systems in motor vehicles

Fingerprint identification is becoming established in automotive applications since criminology has developed a fundamental understanding of the techniques of fingerprint distinction.

As fingerprint identification will in future replace passwords on computers, in time-management and access-control systems, and on mobile phones as well, the development of sensors and algorithms has already become widespread. Due to the confined space available on board a motor vehicle, there is also limited space for installing the sensor.

Biometric features

Biometric features are features that are uniquely characteristic to a particular person. They may either be physiological features (such as the pattern of a fingerprint) or behavioral characteristics (such as the way a person walks or writes his/her signature).

The advantage of biometric systems is, firstly, for the greater convenience of the user. Since biometric features are part of a person's individuality, they are carried by the person at all times, i.e. they cannot be forgotten or lost. There is no need to carry a key or a transponder card.

Secondly, they offer the advantage of an attainable enhancement in security. Since biometric features are intrinsic and unique to a particular individual, they can neither be deliberately given to others nor stolen in the traditional sense of the word. Therefore, a high level of reliance can be placed on whether the vehicle really is being driven by a known driver.

Enrollment

In order to be able to recognize a user, a biometric system must first of all learn the fingerprint pattern of that person. This process is known as "enrollment". It involves the user placing his/her finger on a fingerprint sensor that generates a grayscale image (typical size: 64,000...96,000 pixels at a resolution of 8 bits/pixel).

Using signal-processing algorithms, a processor calculates the characteristics features within that image, e.g. branches or nodal points in the line pattern. The biometric system then stores these features - but not as an actual fingerprint pattern - in a permanent database, typically in an EEPROM memory (capacity requirement: 250...600 bytes per fingerprint).

When the biometric system checks a person's fingerprint pattern the next time, it again identifies the characteristic features of the fingerprint and then searches the database for a matching set of features. If it finds a match, the person is recognized as an authorized user.

Typical applications

Many vehicles already have programmable seat-adjustment functions. The control panel typically has three numbered memory buttons, which can be assigned to three different drivers, and a teach-in button. The drivers of the vehicle will have to select a memory button for each driver and then remember which button contains their own settings. The number of drivers that can use the system is limited by the number of memory buttons.

The use of a biometric system significantly enhances the level of personalized convenience. A fingerprint sensor replaces the memory buttons for the programmable seat-adjustment system. Instead of pressing a memory button to recall his/her personal settings, the driver places a finger on the sensor.

Since biometric features are intrinsic to a particular individual, the biometric system can always identify a particular driver reliably and apply the correct personal settings.

If a previously unknown driver places his/her finger on the sensor to store his/her personal settings, the biometric system automatically performs an enrollment sequence and then memorizes the current settings. Once a driver is known to the biometric system, only the current settings are stored.

The advantage for the user lies in the simplified human-machine interface. Users no longer have to agree on the allocation of memory buttons, nor do they have to remember which button is theirs. In addition, the maximum number of users is not limited to the number of memory buttons available. Ultimately, the number of users is limited by the biometric system's memory capacity for user identities and personal settings.

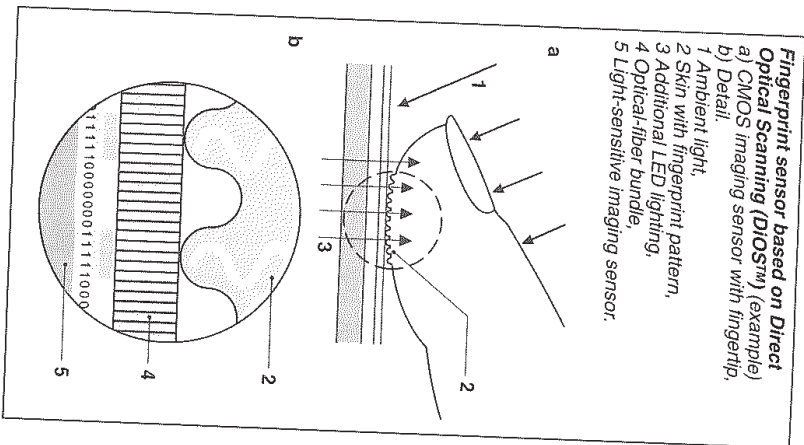
Personalization can be extended beyond seat-adjustment, mirror-adjustment and steering-column adjustment functions. Theoretically, all configurable vehicle systems can be connected to the biometric personalization system. It could be conceivable to personalize air-conditioning and automatic-transmission settings (sports/economy). For the radio, a set of personal favorite stations and preferred volume and tone settings could be selected, while there could be a list of favorite destinations for the navigation system. Similarly, if the vehicle has configurable displays, a driver's personal preferences for the display elements could be recalled.

In the case of self-teaching assistance systems which adapt to the driver's driving patterns, the "last known settings" regarding driver characteristics could be retrieved by the personalization system before starting off.

Biometric systems can also be used even before starting the engine as a means of implementing a vehicle immobilizer and for vehicle access. Vehicles equipped with this technology could then be driven entirely without the use of keys. With regard to the use as a vehicle immobilizer, it has not yet been definitively demonstrated that the same degree of security is attainable as with the present transponder-based immobilizers.

For vehicle-access applications, the sensors for identifying the fingerprint pattern would have to be integrated in the vehicle's outer skin. The technical challenge is then to design a sufficiently resilient sensor system that is adequately protected against external conditions so that effective usability is guaranteed at all times - including in winter.

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Driving-assistance systems

Critical driving situations

On average, someone dies every minute somewhere in the world as a result of a traffic accident. Bosch pursues the aim of reducing the frequency and the severity of accidents by developing active and passive driving-assistance systems. Driving-assistance systems aim to make the vehicle capable of perceiving its surroundings, interpret them, identify critical situations, and assist the driver in performing driving maneuvers. The object is, at best, to prevent accidents completely and, at worst, to minimize the consequences of an accident for those concerned.

In critical driving situations, fractions of a second are often decisive in determining whether an accident occurs or not. According to various studies, approximately 60% of rear-end collisions and virtually a third of frontal impacts could have been avoided if the driver had reacted only half a second earlier. Every second accident at an intersection could be prevented by faster driver reaction.

At the end of the 1980s, when the vision of highly efficient and partially automated road traffic was presented as part of the "Prometheus" project, the electronic components for this task was not in existence. However, the highly sensitive

sensors and extremely powerful microcomputers now available have brought the "sensitive" vehicle a step nearer to realization. Sensors scan the vehicle's surroundings, and systems generate warnings based on the objects identified, or directly perform the maneuvers required. All this takes place at those decisive fractions of a second faster than even a fully attentive and experienced driver would be capable of.

Causes of accidents and possible action

In 2000 a total of more than 91,000 people were killed in road-traffic accidents in Europe, the U.S.A. and Japan. The resulting cost to the various national economies totaled more than € 600 billion.

The fact that the capabilities of many motorists are overburdened by the complexities of road-traffic situations is borne out by recent statistics – in Germany, for example, there were 2.37 million road accidents in 2001, 375,345 of which resulted in personal injury. In nine out of ten cases, the cause was human error.

A statistical analysis of accident causes outside built-up areas in Germany (see figure) shows more than a third of the total number are caused by drivers changing lanes or unintentionally failing to keep in lane. Systems which can see the "blind spot" and lane-change alarms offer a means of reducing the number of acci-

dents caused in this way. About another third of accidents result from "rear-ending" and frontal collisions.

Collision-warning systems can represent a first line of defense in combating such accidents. A second level can be provided by collision-avoidance systems which actively intervene in the control of the vehicle. A first step in this direction has already been taken through the development of ACC (Adaptive Cruise Control, see P. 1058 and P. 1060).

Accidents involving pedestrians and at intersections have a high level of complexity. Only networked sensor systems with scenario-interpretation capabilities can master such complicated accident situations. This is one of the issues currently occupying researchers.

Applications

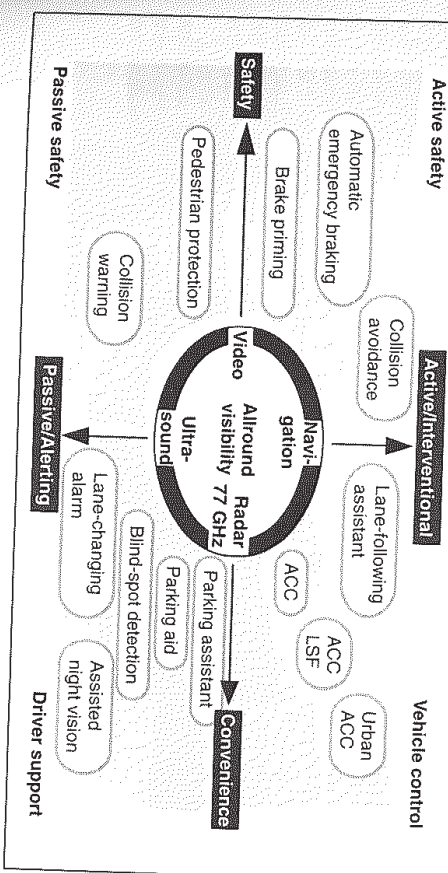
Driving-assistance systems with multiple applications (see figure) can be divided in:

- safety systems aimed at preventing accidents, and
- comfort and convenience systems with the long-term aim of "semi-automated driving".

A further distinction is made between:

- active systems which intervene in vehicle dynamics, and
- passive, i.e. informative systems, which do not intervene in vehicle control.

Safety and convenience functions based on allround-visibility sensors

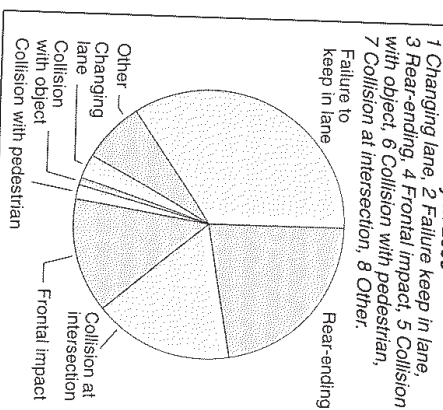


Convenience and safety functions

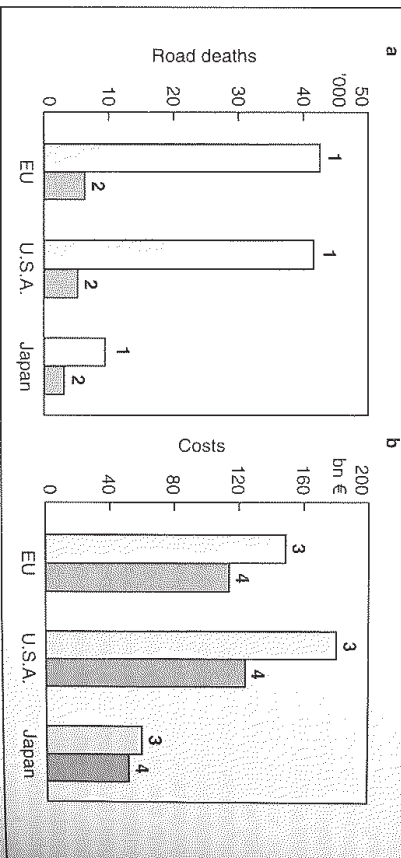
Passive safety (lower left quadrant of diagram) consists of features for lessening the consequences of accidents, such as precrash functions and pedestrian-protection features.

Systems for driver support without intervention in vehicle control represent precursor to vehicle-handling functions. Such systems merely warn the driver of recommended maneuvers.

Causes of accidents outside built-up areas in Germany in 2000



Fatalities (a) and cost to the economy (b) resulting from road-traffic accidents in 1998
1 Total fatalities (thousands), 2 Pedestrian fatalities, 3 Personal injury, 4 Damage to property.



Virtual safety shield

Close-range sensors can form a "virtual safety shield" around the vehicle. It can be used to implement a number of functions. The signals from that safety shield firstly warn the driver of potentially dangerous situations, and secondly, it acts as a data source for safety and convenience systems. Even the driver's "blind spot" can be monitored by these sensors.

Video sensors

Video sensors perform a major role in driving-assistance systems because they specifically assist with the interpretation of visual information (object classification). In the near future, Bosch will be able to offer this type of sensor for use in vehicles. This will open the way for a wide range of new functions.

Rear-end video sensors (in their simplest form) can assist the ultrasound-based Parkpilot system during parking maneuvers.

Greater benefit is offered by a rear-end camera if the detected objects can be interpreted by image-processing software and the driver is alerted in critical situations. Such a situation might be one where an intended lane change would be dangerous because a vehicle is approaching fast in the outside lane.

The use of a front-end camera is necessary to implement functions for night-vision enhancement, for instance. To this end, the system illuminates the road ahead of the vehicle with infrared light. A display shows the image recorded by an infrared-sensitive camera. Visibility is enhanced for the driver without dazzling oncoming vehicles, and obstructions and hazards can be identified more quickly in the dark.

A day-and-night sensitive front-end camera allows several assistance functions. For example, Bosch is currently developing systems for lane-detection and road-sign recognition based on this technology.

The "lane-detection system" can identify the lane boundaries and the lane direction ahead. If the vehicle is about to move out of its lane unintentionally, the system alerts the driver. At a later stage, Bosch is planning to expand lane detection into a lane-following assistance system which can move the vehicle back to

its lane by actively turning the steering wheel. Combined with ACC, this will make an ideal system for relieving driver stress in stop-and-go traffic.

Another function that makes use of data from the video sensor is "road-sign recognition". This system is capable of recognizing ("reading") road signs (e.g. speed-limit or no-overtaking signs). The instrument cluster then displays the last road signs recognized.

The front-end camera also assists the ACC sensor by providing the capability of not only measuring the distance from an object, but of classifying it as well. By combining the video system with long-range radar, there are synergistic benefits – the visible range of the ACC is extended significantly, and object detection is even more reliable.

Video technology will initially be used in information-providing driving-assistance systems. Current video sensors are still a long way from initiating the capabilities of the human eye in terms of resolution, sensitivity and light-intensity response. However, advanced methods of image processing combined with recently developed dynamic imaging sensors already demonstrate the enormous potential of these sensors.

CMOS technology with nonlinear luminance conversion will be capable of covering a very wide range of brightness dynamics and will be far superior to conventional CCD sensors. Since the brightness of images in the automotive environment is not controllable, the dynamic range of conventional imaging sensors is inadequate; for this reason, highly dynamic imagers are required.

The video signals from the camera in a video system are transmitted to an image processor which extracts individual image features (see figure and schematic diagram). This information can also be sent over a data bus to other ECUs or information units (HMI: Human Machine Interface), where it can be used as the basis for initiating intervention in vehicle control or for driver information.

Sensor-data fusion

To ensure that assistance functions are as fault-resistant as possible but remain capable of detecting and classifying several objects simultaneously, the signals of multiple sensors must be combined and analyzed. Sensor-data fusion allows systems to create an overall, realistic picture of the vehicle's surroundings. In this way, information about the vehicle's surroundings is much more reliable than if it was detected by individual sensors.

Future driving-assistance systems will incorporate the functions of gradually more sensors and actuators and will have more complex connections to other vehicle systems. Bosch is developing all the components and functions based on the "Cartronic" system architecture (see P. 1066) and intends to network all control and regulation tasks in the vehicle. It consists of a clearly structured function architecture and modular software with open, standardized interfaces.

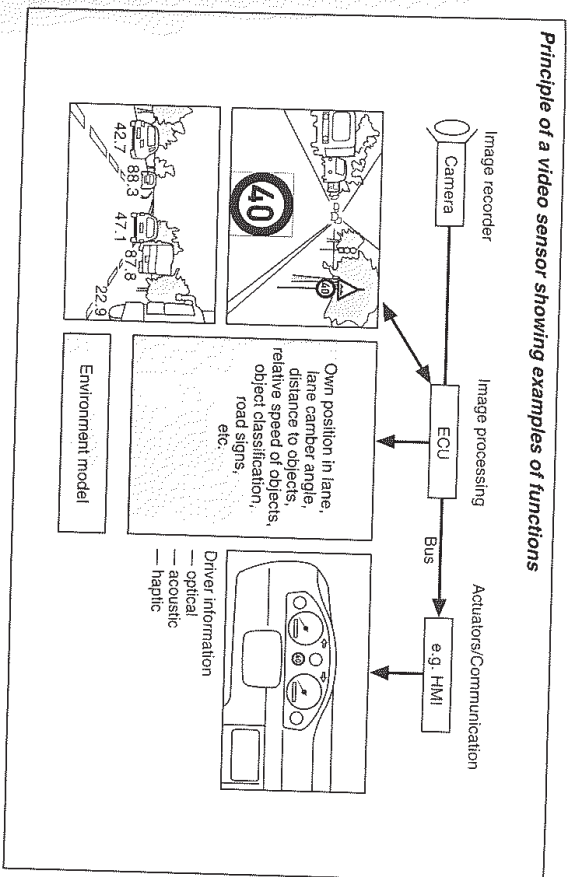
Summary and outlook

The development of sensors for detecting the vehicle's surroundings is progressing at a fast pace. New functions are quickly being integrated according to their relevance to safety and convenience.

Close-range sensors represent the next milestone in this development. They will form a "virtual safety shield" around the vehicle and provide the signals that will firstly alert the driver to potentially critical situations, and secondly act as a data source for active safety and convenience systems.

At the same time (and as the high-performance sensor chips become available for volume production), video sensors will enter the world of automotive technology and open up a multiplicity of opportunities. This will open up the way for information systems that are based on highly complex image analysis using high-performance processors and which can be used as data sources by several driving-assistance systems.

Principle of a video sensor showing examples of functions



Data processing and communication networks in motor vehicles

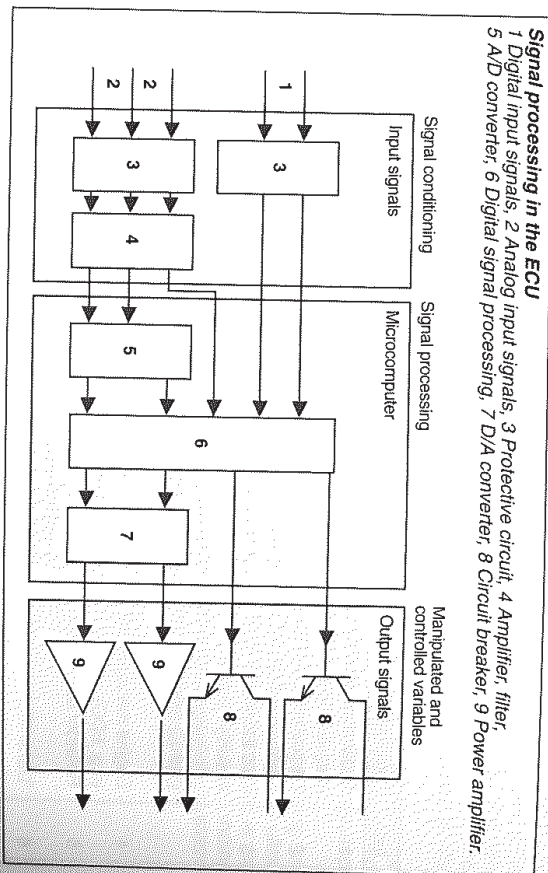
Requirements

Highly sophisticated state-of-the-art open-loop and closed-loop control concepts are essential for meeting the demands for function, safety, environmental compatibility and convenience associated with the wide range of automotive subsystems installed in modern-day vehicles. Sensors monitor reference and controlled variables, which an electronic control unit (ECU) then converts to the signals required to adjust the final-control elements/actuators. The input signals can be analog (e.g. voltage characteristic at pressure sensor), digital (e.g. switch position) or pulse-shaped (i.e. information content as a function of time, e.g. engine-speed signal). These input signals are processed after appropriate conditioning (filtering, amplification, pulse-shape modification) and converted (analog/digital), preferably by digital signal-processing methods.

With modern semiconductor technology, powerful microcomputers can be integrated on relatively few chips together with their accompanying program and data memories, and special peripheral circuits designed specifically for real-time applications.

Modern vehicles are equipped with 20 to 60 electronic control units, e.g. for engine management, Antilock Braking System (ABS), and transmission-shift control. Improved performance and additional functions are obtained by synchronizing the processes controlled by the individual ECUs and by mutual real-time adaptation of the respective parameters. An example of this type of function is traction control (TCS), which reduces the drive torque if the driving wheels spin.

Originally, data exchange between the ECUs (in the example cited above, ABS/TCS and engine management) took place via separate wires. However, this type of point-to-point connection is only suitable for a limited number of signals. The introduction of automotive-compatible communication networks for serial transmission of information and data between ECUs has expanded the data transfer capabilities and represents the logical development of autonomous "microcomputers" in motor vehicles.



Electronic control unit (ECU)

ECUs developed for use in motor vehicles all have a similar design. Their structure can be subdivided in the conditioning of input signals, the logic processing of these signals in the microcomputer, and the output of logic and power levels as regulation or control signals (see figure).

Digital input signals

Detect a switch position or digital sensor signals (e.g. rotational-speed pulses from a Hall-effect sensor).

Analog input signals

Signals from analog sensors (lambda sensor, pressure sensor).

Pulse-shaped input signals

Signals from inductive wheel-speed sensors. After signal conditioning, they are then processed as digital signals.

Initial conditioning of input signals

Protective circuits (passive: R and RC circuits; active: special surge-proof semiconductor components) are used to limit the voltage of the input signals to acceptable levels (operating voltage of the microcomputer). Filters remove most of the superimposed noise from the useful signals, which are then amplified to the microcomputer's input voltage.

Signal processing

ECUs generally process signals in digital form. Rapid, periodic, real-time signals are processed in hardware modules specifically designed for the particular function. Results, e.g. a counter reading or the time of an event, are sent in registers to the CPU for further processing. This procedure substantially reduces the CPU's interrupt-response time (μ s range).

The amount of time available for calculations is determined by the controlled system (e.g. milliseconds in the case of engine management). The software contains the actual control algorithms. Depending on the data, almost any logical operation can be implemented, and any data records can be stored and processed in the form of parameters, characteristic curves, or multidimensional pro-

gram maps. For more complex requirements in the field of image processing, the use digital-signal processors (DSP) is becoming more widespread.

Manipulated and controlled variables

Manipulated and controlled variables in the output module provide the required signals or power levels for peripheral actuators (e.g. electric motors for seat adjustment, power windows or power-assisted steering). Circuit breakers and amplifiers raise the microcomputer's output-signal levels (0...5 V, a few mA) to the power levels required for the actuators concerned (e.g. up to 100 A for short periods for engine cooling).

Architecture

The structural building blocks are assembled in hardware platforms or modular kits by using identical components (chipssets). These modules are also increasingly used for multiple applications (e.g. engine management for gasoline and diesel engines).

The same procedure is also suitable for function modules for control algorithms, which then become modular, reusable components within the overall system. Essentially, there are two elements that are important for implementing this type of methodology transfer:

- A concept for configuring and structuring functionality within the vehicle (CARTRONIC).
- Communication networks over which ECUs can interchange information.

The building plan for assembling functions, network hardware and software is referred to as the architecture. System architecture describes the entirety of the structural and dynamic characteristics of distributed systems.

Multimedia systems

Multimedia means the combination of different media. All known media are interconnected and are available for use.

Various sound and information sources, and communication installations can form a common mobile driver-information system consisting of radio, cassette player, CD player, phone, navigation and traffic telematics equipment, and even computer, video player, and TV.

Multimedia broadcasting

The digital audio broadcasting systems developed in recent years (DAB, DRM) allow the transmission of any type of data at high bit rates so that the radio of the past is currently developing into a genuine multimedia system for the future. It permits transmission of audio data (music, news), textual information (messages), and video data (from individual images through to TV broadcasts). With such capabilities, DAB becomes DMB (Digital Multimedia Broadcasting). This is illustrated by the following conceivable examples:

Traffic and travel information

Traffic and travel information may encompass the following services:

- Traffic announcements may be transmitted as audio (synthetic voice), or as text, or map extracts (on a display).
- TMC or TPEG-coded traffic announcements may be transmitted for navigation devices, thus allowing dynamic route guidance. In addition, updated digital road maps may be transmitted to ensure that route guidance by navigation systems is based on information that is completely up-to-date.
- Travel guides may use maps to provide directions to vacation destinations, or to business appointments, and offer information about the locality, the hotel, (photos, room prices, and vacancies), local events, parking facilities (with details of parking lots with free spaces), filling stations, timetables, local stores, etc. Along with the information about the "Points of Interest" (POI), details of their location (references) may also be

transmitted so that the navigation system can locate them automatically without any driver input.

Transmission of text and images

Text data is an extension of radio broadcasts, and may contain a large amount of additional information, such as title and composer of a music track currently being played, information about the present station tuned, including phone number/address to request additional information, or even an electronic program listing. The DAB standard offers the following modes for transmitting text:

- Station name and type.
- Dynamic label for the station, the speed of the label is controlled by the transmitting station.
- Interactive text pages in HTML or XML format, which can be displayed in various formats.

Mobile Internet

Combination with mobile communication media, such as GSM and UMTS, permits interaction with servers on the Internet so that interactive services can be offered. Wireless Application Protocol (WAP) is the name of the internationally established protocol which links the two worlds together.

The aim is to integrate the various communication elements such as navigation system, car tuner, mobile radiocommunications, digital audio broadcasting, and Internet.

For mobile access to the Internet from a motor vehicle (or on board a train), it must be possible to receive over the air interface, even when traveling at high speeds. In addition, there is certainly a challenge in meeting the demands for consistent Internet-access quality while moving between city and rural surroundings, with the resulting wide variations in transmission conditions.

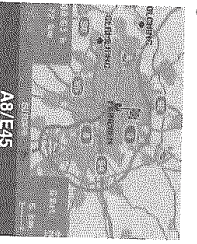
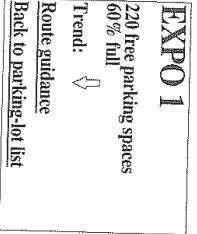
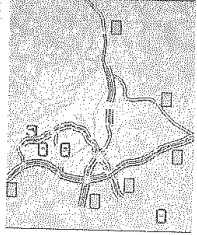
The Internet is an open medium or marketplace for users and information providers and has a wide variety of services for the mobile consumer. International bodies, such as the Open Mobile Alliance (OMA), the World Wide Web Consortium (W3C), or the International Engineering Task Force (IETF) define interfaces and protocols so that the new services can be used anywhere at any time:

- A hotel or restaurant may encode its geographical coordinates on its website so that they can be accessed by a navigation system. This would then direct the driver automatically to the desired destination. A reservation inquiry could be made and confirmed in advance over the mobile radiocommunications channel.
- Vehicle functions, such as remote diagnosis and remote maintenance support, could connect automatically to a service center via the Internet in case of a breakdown or accident. The service center would then produce a diagnosis of the vehicle's condition, and accompany the vehicle to the workshop, or inform the breakdown assistance or emergency services.

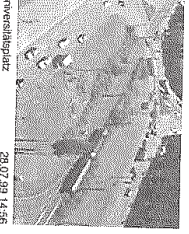
- Future traffic management systems will take account of traffic flow in city areas as well. The number of organizations involved will be so large that coordination over the Internet will become necessary, as this is the medium accessible to everyone. Traffic flow in selected areas will be shown online on graphical displays, or will be distributed in machine-readable form as network lists. The navigation system will then be able to use this information to compute the best route.

- In addition, other specially prepared services may be accessible over the Internet. This includes e-mails, e-commerce, or news, weather, and sports announcements, or online transactions with banks, hotels, cinemas, or travel agents.
- With the ever shorter development cycles in the fields of information and communications technology, software updates via the Internet will allow the longer-lasting components of motor vehicles to be kept up-to-date.

Mobile Internet services (examples)
a) Traffic-holdup maps (with forecast), b) Parking information and parking guidance system, c) Dynamic navigation, d) Public transport information, e) Camera shots of traffic situation, f) Information about events.



Agendaplatz			
Time	Departure	Destination	
1	01.06.00 12:22	Stuttgart	
2	01.06.00 13:06	Stuttgart	
3	01.06.00 13:15	Langerbach	
4	01.06.00 13:20	Langerbach	



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