Bosch Professional
Automotive Information

Robert Bosch GmbH *Ed.*

Bosch Automotive Electrics and Automotive Electronics

Systems and Components, Networking and Hybrid Drive

5th Edition

Springer Vieweg

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Foreword

In recent decades, the development of the motor vehicle has been marked by the introduction of electronics. At first, electronic systems were used to control the engine (electronic fuel-injection systems), then electronic components entered the domain of driving safety (e.g. antilock brake system, ABS). More recently, completely new fields of application have emerged in the areas of driving assistance, infotainment and communication as a result of continuous advancements in semiconductor technology. Consequently, the proportion of electrics and electronics in the motor vehicle has continuously increased.

A typical feature of many of these new systems is that they no longer perform their function as standalone systems but operate in interaction with other systems. If the flow of information between these systems is to be maintained, the electronic control units must be networked with each other. Various bus systems have been developed for this purpose. Networking in the motor vehicle is a topic that receives comprehensive coverage in this book.

Powerful electronic systems not only require information about operating states, but also data from the vehicle's surroundings. Sensors therefore play an important role in the area of automotive electronics. The number of sensors used in the motor vehicle will continue to rise.

The complexity of the vehicle system is set to increase still further in the near future. To guarantee operational reliability in view of this complexity, new methods of electronics development are called for. The objective is to create a standardized architecture for the electrical system/electronics that also offers short development times in addition to high reliability for the electronic systems.

Besides the innovations in the areas of comfort/convenience, safety and infotainment, there is a topic that stands out in view of high fuel prices and demands for cutting CO_2 emissions: fuel consumption. In the hybrid drive, there is great potential for lowering fuel consumption and reducing exhaust-gas emissions. The combination of internal-combustion engine and electric motor enables the use of smaller engines that can be operated in a more economically efficient range. Further consumption-cutting measures are start/stop operation and the recuperation of brake energy (recuperative braking). This book addresses the fundamental hybrid concepts.

The traditional subject areas of automotive electrical systems are the vehicle electrical system, including starter battery, alternator and starter. These topics have been revised for the new edition. New to this edition is the subject of electrical energy management (EEM), which coordinates the interaction of the alternator, battery and electrical consumers during vehicle operation and controls the entire electrical energy balance.

The new edition of the "Automotive Electric/Automotive Electronics" technical manual equips the reader with a powerful tool of reference for information about the level of today's technology in the field of vehicle electrical systems and electronics. Many topics are addressed in detail, while others – particularly the electronic systems – are only presented in overview form. These topics receive in-depth coverage in other books in our series.

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Electrical and electronic systems in the vehicle

The amount of electronics in the vehicle has risen dramatically in recent years and is set to increase yet further in the future. Technical developments in semiconductor technology support ever more complex functions with the increasing integration density. The functionality of electronic systems in motor vehicles has now surpassed even the capabilities of the Apollo 11 space module that orbited the Moon in 1969.

Overview

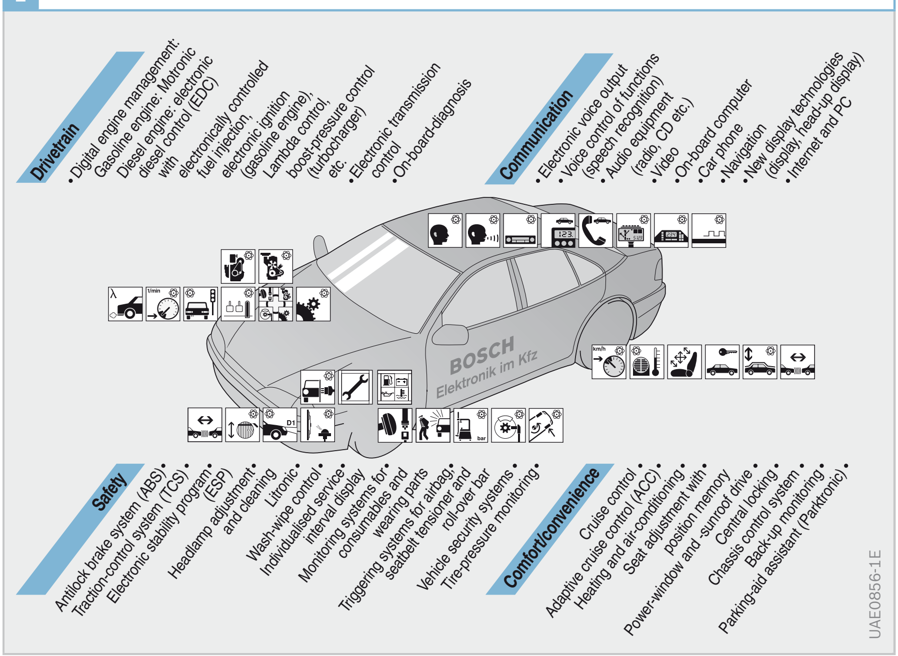
Development of electronic systems

Not least in contributing to the success of the vehicle has been the continuous string of innovations which have found their way into vehicles. Even as far back as the 1970s, the aim was to make use of new technologies to help in the development of safe, clean and economical cars. The pursuit of economic efficiency and cleanliness was closely linked to other customer benefits such as driving pleasure. This was characterized by the European diesel boom, upon which Bosch had such a considerable influence. At the same time, the development of the gasoline engine with gasoline direct injection, which would reduce fuel consumption by comparison with intake-manifold injection, experienced further advancements.

An improvement in driving safety was achieved with electronic brake-control systems. In 1978, the antilock brake system (ABS) was introduced and underwent continual development to such an extent that it is now fitted as standard on every vehicle in Europe. It was along this same line of development that the electronic stability program (ESP), in which ABS is integrated, would debut in 1995.

The latest developments also take comfort into account. These include the hill hold control (HHC) function, for example, which makes it easier to pull away on uphill gradients. This function is integrated in ESP.

1 Electronics in the motor vehicle



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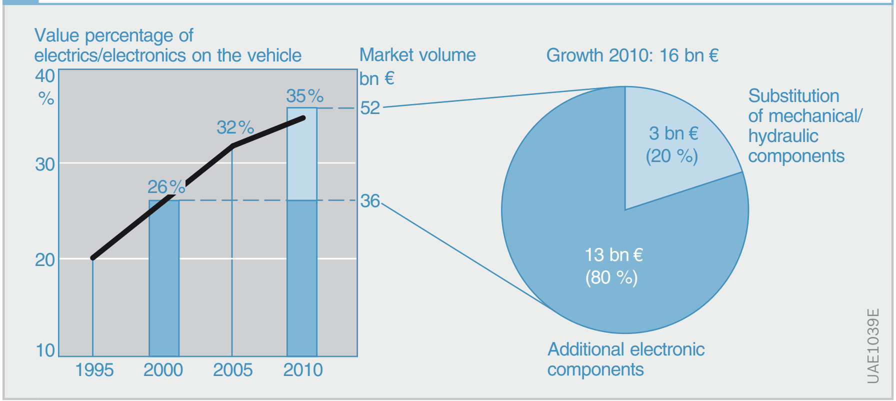
2 Market volumes of electrics/electronics in Europe (estimates)



Many kinds of new functions appear in conjunction with driver-assistance systems. Their scope extends far beyond today's standard features such as Parkpilot or electronic navigation systems. The aim is to produce the "sensitive vehicle" that uses sensors and electronics to detect and interpret its surroundings. Tapping into ultrasound, radar and video sensor technologies has led to solutions that play an important role in assisting the driver, e.g. through improved night vision or distance control.

Value creation structure for the future

The latest studies show that the production costs of an average car will increase only slightly by 2010 despite further innovations. No significant value growth for existing systems is expected in the mechanics/hydraulics domain despite the expected volume growth. One reason here being the electrification of functions that have conventionally been realized mechanically or hydraulically. Brake control systems are an impressive example of this change. While the conventional brake system was characterized more or less completely by mechanical components, the introduction of the ABS brake-control system was accompanied by a greater proportion of electronic components in the form of sensor technology and an electronic control unit. With the more recent developments of ESP, the additional functions, such as HHC, are almost exclusively realized by electronics.

Even though significant economies of scale are seen with the established solutions, the value of the electrics and electronics will increase overall (Fig. 1). By 2010, this will amount to a good third of the production costs of an average vehicle. This assumption is based not least on the fact that the majority of future functions will also be regulated by electrics and electronics.

The increase in electrics and electronics is associated with a growth in software. Even today, software development costs are no longer negligible by comparison with hardware costs. Software authoring is faced with two challenges arising from the resulting increase in complexity of a vehicle's overall system: coping with the volume and a clearly structured architecture. The Autosar initiative (Automotive Open Systems Architecture), in which various motor vehicle manufacturers and suppliers participate, is working towards a standardization of electronics architecture with the aim of reducing complexity through increased reusability and interchangeability of software modules.

Task of an electronic system

Open-loop and closed-loop control

The nerve center of an electronic system is the control unit. Figure 3 shows the system blocks of a Motronic engine-management system. All the open-loop and closed-loop algorithms of the electronic system run inside the control unit. The heart of the control unit is a microcontroller with the program memory (flash EPROM) in which is stored the program code for all functions that the control unit is designed to execute.

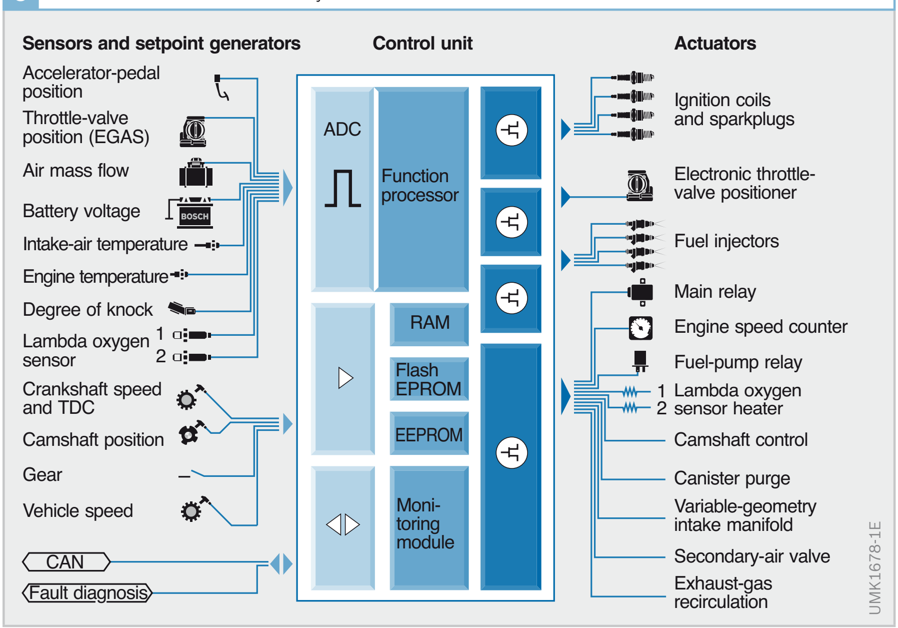
The input variables for the sequence control are derived from the signals from sensors and setpoint generators. They influence the calculations in the algorithms, and thus the triggering signals for the actuators. These convert into mechanical variables the electrical signals that are output by the microcontroller and amplified in the output stage modules. This could be mechanical energy generated by a servomotor (power-window unit), for example, or thermal energy generated by a sheathed-element glow plug.

Communication

Many systems have a mutual influence on each other. For example, it may sometimes be necessary to not only have the electronic stability program carry out a braking intervention in the event wheel spin but also to request that the engine-management system reduce torque and thus counteract wheel spin. Similarly, the control unit for the automatic transmission outputs a request to the engine-management system to reduce torque during a gearshift and thereby promote a soft gear change. To this end, the systems are networked with each other, i.e. they are able to communicate with each other on data buses (e.g. CAN, LIN).

In a premium-class vehicle, there may be up to 80 control units performing their duties. The examples below are intended to give you an insight into the operating principle of these systems.

3 Function modules of an electronic system



Motronic engine-management system

"Motronic" is the name of an engine-management system that facilitates open- and closed-loop control of gasoline engines within a single control unit.

There are Motronic variants for engines with intake-manifold injection (ME Motronic) and for gasoline direct injection (DI Motronic). Another variant is the Bifuel Motronic, which also controls the engine for operation with natural gas.

System description

Functions

The primary task of the Motronic engine-management system is:

- To adjust the torque desired and input by the driver depressing the accelerator pedal
- To operate the engine in such a way as to comply with the requirements of ever more stringent emission-control legislation
- To ensure the lowest possible fuel consumption but at the same time
- To guarantee high levels of driving comfort and driving pleasure

Components

Motronic comprises all the components which control and regulate the gasoline engine (Fig. 1, next page). The torque requested by the driver is adjusted by means of actuators or converters. The main individual components are:

- The electrically actuated throttle valve (air system): this regulates the air-mass flow to the cylinders and thus the cylinder charge
- The fuel injectors (fuel system): these meter the correct amount of fuel for the cylinder charge
- The ignition coils and spark plugs (ignition system): these provide for correctly timed ignition of the air-fuel mixture present in the cylinder

Depending on the vehicle, different measures may be required to fulfill the requirements demanded of the engine-management system (e.g. in respect of emission characteristics, power output and fuel consumption). Examples of system components able to be controlled by Motronic are:

- Variable camshaft control: it is possible to use the variability of valve timing and valve lifts to influence the ratio of fresh gas to residual exhaust gas and the mixture formation
- External exhaust-gas recirculation: adjustment of the residual gas content by means of a precise and deliberate return of exhaust gas from the exhaust train (adjustment by the exhaust-gas recirculation valve)
- Exhaust-gas turbocharging: regulated supercharging of the combustion air (i.e. increase in the fresh air mass in the combustion chamber) to increase torque
- Evaporative emission control system: for the return of fuel vapors that escape from the fuel tank and are collected in an activated charcoal canister

Operating variable acquisition

Motronic uses sensors to record the operating variables required for the open and closed-loop control of the engine (e.g. engine speed, engine temperature, battery voltage, intake air mass, intake-manifold pressure, Lambda value of the exhaust gas).

Setpoint generators (e.g. switches) record the adjustments made by the driver (e.g. position of the ignition key, cruise control).

Operating variable processing

From the input signals, the engine ECU detects the current operating status of the engine and uses this information in conjunction with requests from auxiliary systems and from the driver (accelerator-pedal sensor and operating switches) to calculate the command signals for the actuators.

1 Components used for open-loop electronic control of a DI-Motronic system (example of a naturally aspirated engine, λ = 1)

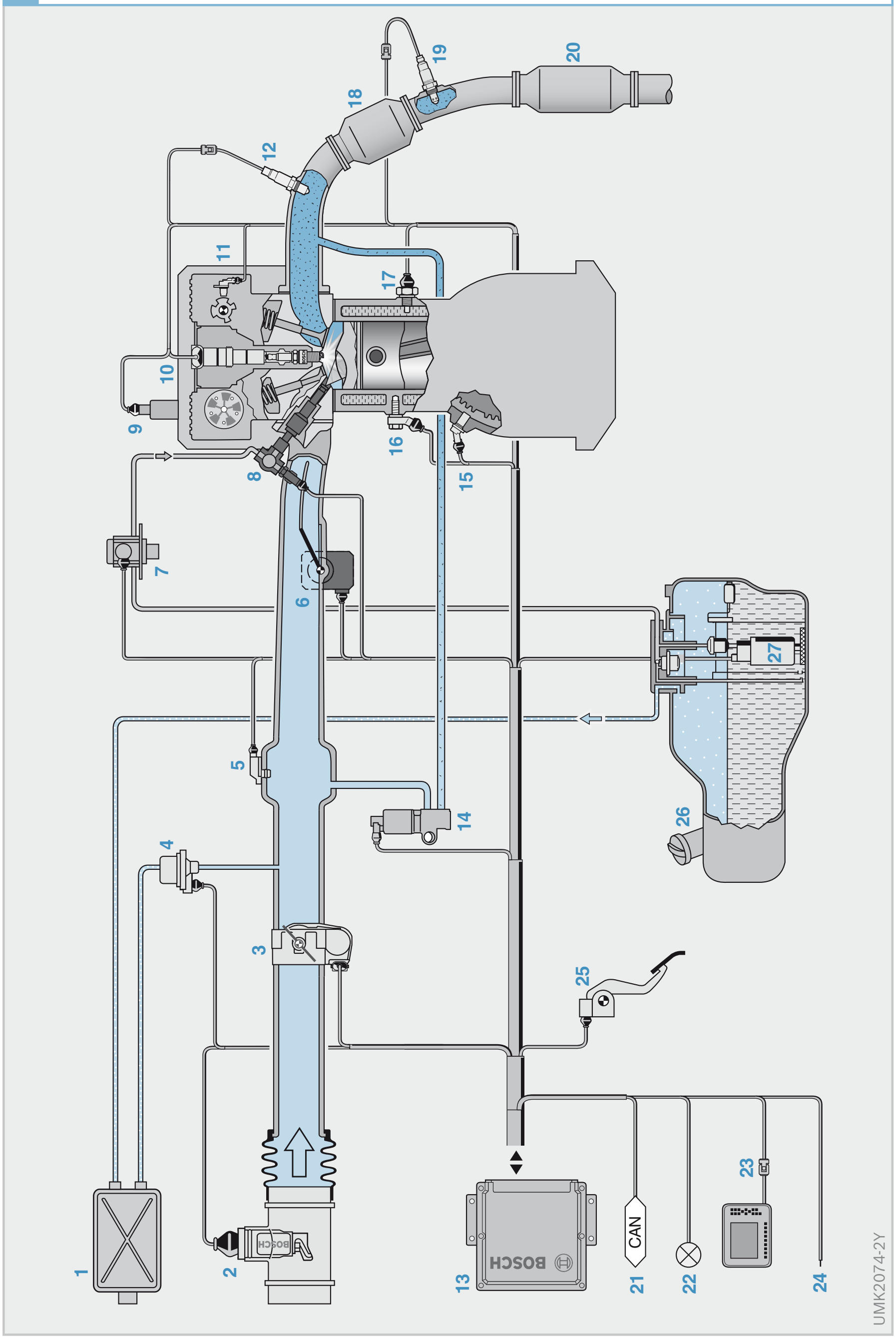


Fig. 1

1 Activated charcoal canister
2 Hot-film air-mass meter
3 Throttle device (ETC)
4 Canister-purge valve
5 Intake-manifold pressure sensor
6 Swirl control valve
7 High-pressure pump
8 Rail with high-pressure fuel injector
9 Camshaft adjuster
10 Ignition coil with spark plug
11 Camshaft phase sensor
12 Lambda oxygen sensor (LSU)
13 Motronic ECU
14 EGR valve
15 Speed sensor
16 Knock sensor
17 Engine-temperature sensor
18 Primary catalytic converter
19 Lambda oxygen sensor
20 Primary catalytic converter
21 CAN interface
22 Diagnosis lamp
23 Diagnosis interface
24 Interface with immobilizer control unit
25 Accelerator-pedal module
26 Fuel tank
27 Fuel delivery module with electric fuel-supply pump