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 • Developments 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 in 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: Re-duced 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.

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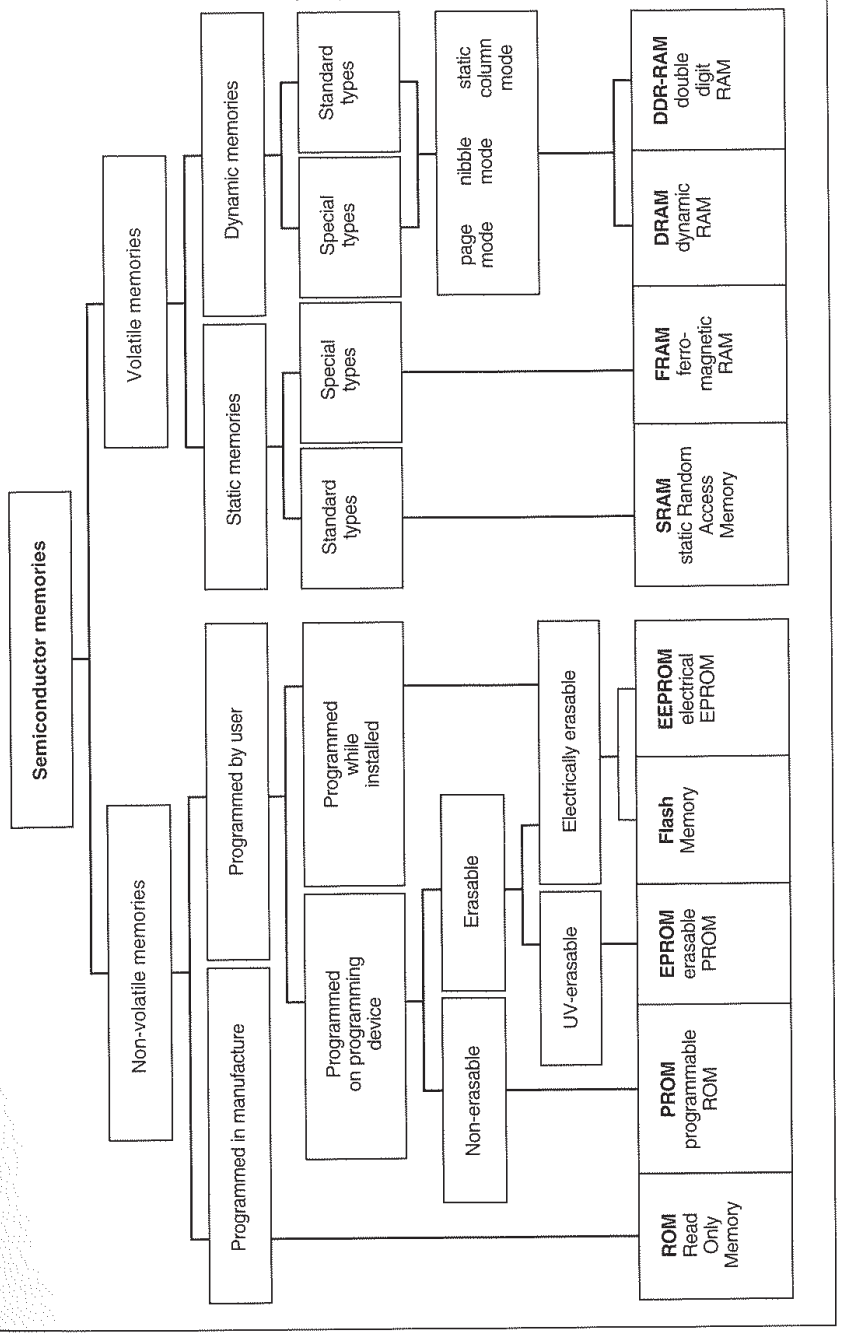
Overview of semiconductor memory chips



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- Program memory which provides permanent storage for the operating program (user program), thus ROM, PROM, or EPROM.
- Data memory for the data being run at any given time. This data changes continuously; thus, the storage medium for this application is the RAM. Part of the RAM (cache) is integrated on the microcomputer since CPU speed would otherwise be drastically reduced due to the high data rates, and there would be no use in deploying a high-speed processor if the required data were always sent over external buses. SRAMs are always used in these cases owing to the low access times required.
- Clock generator and power-supply system.
- The bus system links the individual elements in a microcomputer.
- A clock generator makes sure that all the operations in the microcomputer take place within a specified timeframe.
- Logic circuits are chips that carry out special tasks, such as program interrupts, inserting intermediate programs, etc.
- The periphery includes input/output devices and external memories, e.g. the main memory (DRAM) or the hard disk.

The main components of a microcomputer are normally combined as separate components on printed-circuit boards. "Single-chip" computers are becoming used more and more for simpler tasks, e.g. internet access in wireless communications, which is a growing trend, or functions integrated on a single silicon chip (SoC: System on a Chip). The performance of these high-integration systems is limited by the relatively small amount of RAM which can be accommodated at reasonable expense on the chip.

A microcontroller includes at least the CPU function, read-only memory (ROM, EPROM, or EEPROM), input/output capability (I/O), and random-access memory (RAM) on a single chip. In some cases, analog functions are only integrated on the chip. In contrast to a microcomputer, the controller reacts with a specified program that provides particular output values depending on the input information. It is used to control self-governing systems, e.g. engine management.

The transputer is a special type of microprocessor which is especially useful for building parallel computer networks. In addition to the standard microprocessor components, the chip is also equipped with communications and processing hardware.

It has at least four serial bidirectional transmission channels (links), allowing extremely high-speed (> 1 Gbit/s per link) communications with many other transputers. As communications are completely asynchronous, distributed networks do not require a common clock circuit. Each link has its own DMA controller; once initialized by the CPU, it can carry out data transmission on its own. Thus, processing and communication are essentially parallel operations. Of particular significance are the extremely short process switchover and interrupt-response times of $\ll 1$ µs. The transputer does not need a real-time operating system for this; instead, it has the necessary processing commands directly in its command set.

The transputer operates as a communication node within the parallel network, meaning that it serves as both computer and communications interface. The transputer can therefore be employed to avoid one of the gravest liabilities of many parallel systems, which is the inherent need to share a common bus. Maximum-performance computers are therefore built using transputers.

Application-specific ICs

Application-specific IC (ASIC: Application Specific Integrated Circuits or also ASSP: Application Specific Standard Product) are only designed for a single application, as opposed to standard ICs. ASICs are produced for, and sold only to, one customer. ASSPs are application-specific ICs which are sold to several customers for the same application. Both are the result of a successful cooperation between users who share special system experience, and producers who possess suitable technologies. The essential advantages of ASICs: fewer components, lower system costs, increased reliability, more difficult to copy.

The ASIC family is generally classified according to the development method which has been selected: chip-mounted circuitry, constructed from individual function elements (full-custom IC), provides the best results with regard to operation and packaging density. It is, however, only suited for large-volume applications (time and expense).

Standardized basic circuit functions (developed and tested in advance) represent one step towards rationalizing the development process. The circuits are incorporated in cells of varying sizes (ROM, RAM, computer core, or individualized, application-specific circuit groups). Depending on the number of available application-specific cells, this method can be employed to reduce development times without sacrificing efficient exploitation of the chip surface.

The next stage is the use of standardized, relatively complex basic functions which are developed in advance in standard cells of the same height and variable width. They are available in the form of cell libraries. These standard cells are automatically placed in series and then automatically connected with polysilicon and aluminum conductors. A dual or triple-layer metallic coating can be applied to achieve even better utilization of the surface area.

Gate arrays are predeveloped as far as the transistor/gate connection, and are manufactured in advance, leaving only the final masking operations for later completion. The connection with the application-specific circuit is then automatic. Rationalization is achieved by providing standard circuits for frequent basic computer functions (similar to a cell library). Special gate arrays designed for specific applications have particular advantages (e.g. pure computer-oriented digital circuits under the general conditions usual for computers).

Programmable logic devices (PLD) – completely preassembled transistor arrays – are programmed by the user in the same way as a special-application PROM. PLDs thus provide system developers with the option of producing silicon breadboard circuits within a short period of time. The production of complex systems in silicon is becoming increasingly important, as it allows the production of practical working models in the development phase.

Smart-power ICs

Automotive and industrial systems rely upon electronics to govern numerous final-control elements and other loads. Circuit-breakers must be capable of assuming auxiliary functions extending beyond the control of circuit power: driver circuits for activating switching transistors, protective circuits for excess current, overvoltage, overtemperature, and fault acknowledgments in case of incorrect operation. Such bipolar or MOS-technology power ICs are generically termed smart-power ICs.

Film and hybrid circuits, MCM

Film circuits

The integrated film circuit features passive circuit elements – these include capacitors and inductors, as well as conductor tracks, insulators, and resistors. An integrated film circuit is produced by applying the layers which contain these elements to a substrate carrier. The terms "thin-film" and "thick-film" circuit derive from the fact that the film thickness was originally the determining factor for tailoring to specific performance characteristics; present technology employs a variety of manufacturing techniques to achieve the same end.

Thin-film circuits

Integrated film circuits on which the individual layers are applied to glass or ceramic substrates, usually in a vacuum coating process. Advantages: fine structures (to approx. 10 µm) provide high circuit-element density, extremely good HF characteristics, and low-noise resistor elements. On the minus side are the relatively high manufacturing costs.

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Automotive Handbook

All about automotive engineering in a pocketbook

The 6th edition has been completely revised.
Here are some of the contents you can expect:

Spark-ignition engine management (revised and updated)
Vehicle safety systems for passenger cars
(with new ABS and ESP functions)
Driver-assistance systems
Dynamics of lateral motion (basic principles for ESP)
On-Board Diagnosis, OBD (legal regulations and implementation)
Electronic commercial-vehicle brake management as the platform for driver-assistance systems
Analog and digital signal transmission
Multimedia systems
Development methods and processes (hardware and software development tools, sound design, vehicle wind tunnels)
Environmental management

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