

Introduction to Automotive Electronics

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Key concepts, components, and functional blocks that enable modern vehicles to operate safely, efficiently, and intelligently.

1. Overview

Aspect	Description
Definition	Application of electronic devices and systems to control, monitor, and improve vehicle functions.
Purpose	Enhance safety, comfort, performance, fuel efficiency, emissions control, and infotainment.
Trend	Growing integration of software, sensors, and connectivity ? “software?defined vehicles.”

2. Core Functional Areas

Functional Area	Main Tasks	Typical Sub?systems
Powertrain Control	Engine/ motor management, transmission shifting, hybrid energy flow	Engine Control Unit (ECU), Transmission Control Module (TCM), Motor Controller
Chassis & Safety	Braking, stability, steering assistance	ABS/ESC controllers, ESP, Adaptive Cruise Control, Lane?Keep Assist
Body & Comfort	Lighting, climate, seat adjustment, door/window operation	Body Control Module (BCM), HVAC controller, Power Window modules
Infotainment & Connectivity	Audio/video, navigation, smartphone integration, telematics	Head?unit, CAN gateway, Telematics Control Unit (TCU)
Advanced Driver? Assistance Systems (ADAS)	Perception, decision?making, automated driving functions	Radar/Lidar sensors, Camera processors, Fusion ECU

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3. Key Electronic Components

Component	Function	Typical Technology
Microcontroller / ECU	Executes control algorithms, handles I/O	ARM Cortex-M, PowerPC, automotive-grade MCUs
Sensors	Convert physical phenomena to electrical signals	Hall-effect (wheel speed), MAP (manifold pressure), O ₂ , LiDAR, cameras
Actuators	Convert electrical commands into mechanical motion	Fuel injectors, solenoids, electric motors, stepper motors
Power Devices	Switch or regulate high currents/voltages	MOSFETs, IGBTs, DC-DC converters
Communication Interfaces	Transfer data between modules	CAN, LIN, FlexRay, Ethernet, MOST, SPI, UART
Memory	Store firmware, calibration data, logs	Flash, EEPROM, RAM (volatile)
Display & UI	Present information to driver/passengers	LCD, OLED, TFT, HUD (head-up display)

4. Automotive Networks

Network	Bandwidth	Typical Use	Characteristics
CAN (Controller Area Network)	125 kbps – 1 Mbps	Powertrain, chassis, body	Robust, deterministic, message-oriented
LIN (Local Interconnect Network)	20 kbps	Low-cost peripheral devices (window motors, seat adjusters)	Single-master, slave nodes
FlexRay	10 Mbps – 20 Mbps	Time-critical systems (advanced chassis, safety)	Dual-channel, deterministic, fault-tolerant
Automotive Ethernet	100 Mbps – 1 Gbps	High-bandwidth ADAS, infotainment, OTA updates	IP-based, scalable

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Network	Bandwidth	Typical Use	Characteristics
MOST (Media Oriented Systems Transport)	25?Mbps – 150?Mbps	Audio/video streaming, infotainment	Synchronous, low? latency

5. Power Architecture

1. **Battery (12?V or 48?V)