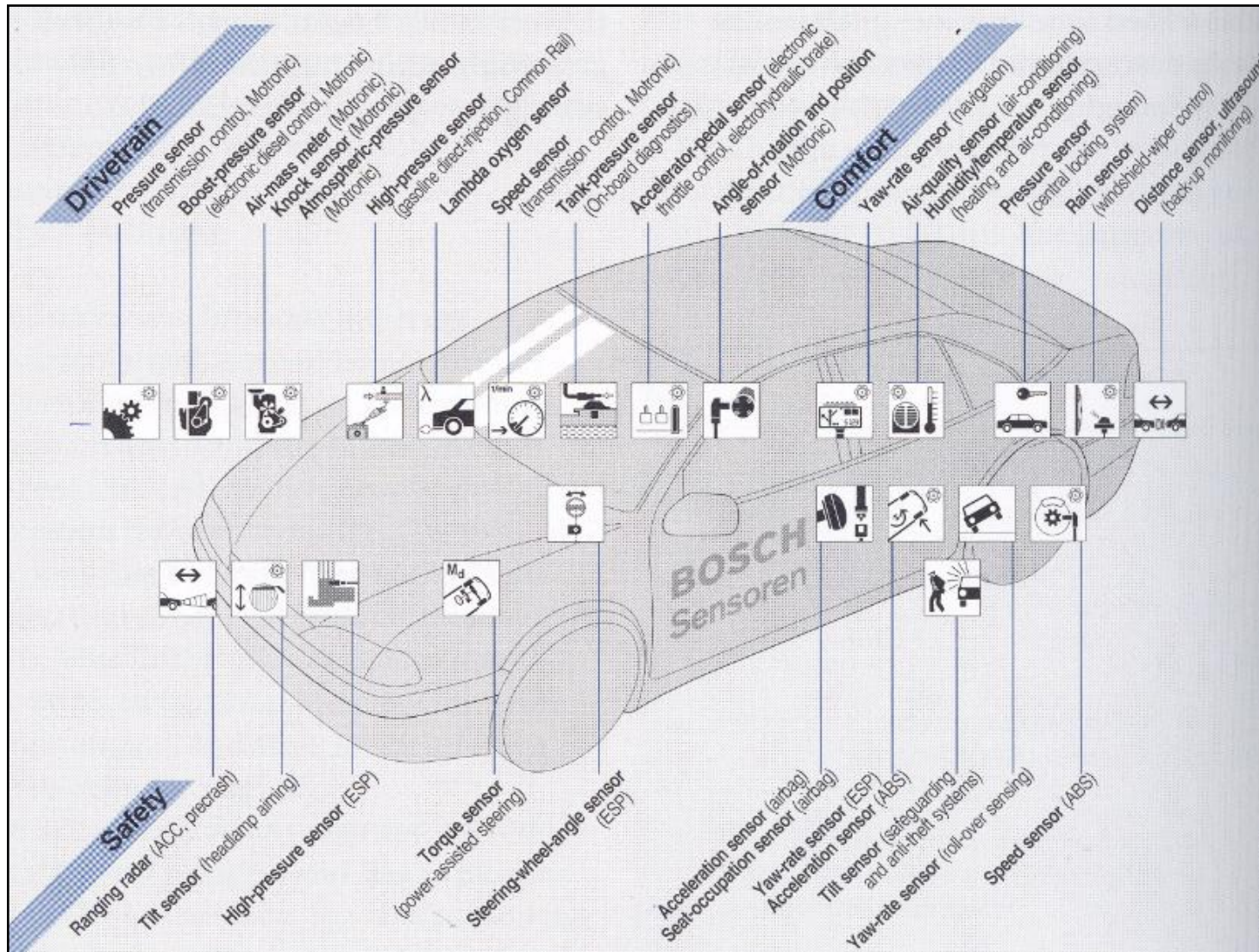




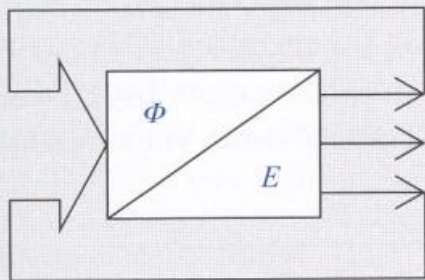
Увод у сензоре на возилима



1 Areas in which sensors are used

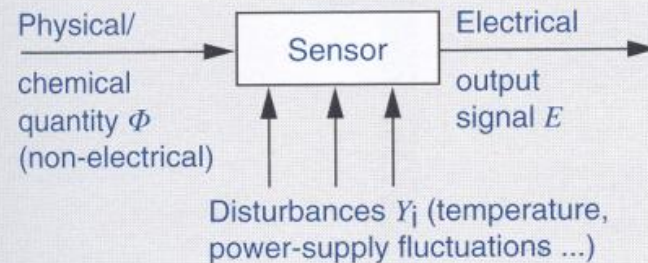
Typical features	Primary standards	Precision measurement	Industrial measurement	Consumer technology
Accuracy	10^{-11} to 10^{-7}	2 to $5 \cdot 10^{-4}$	2 to $5 \cdot 10^{-3}$	2 to $5 \cdot 10^{-2}$
Costs	€ 100 k to € 1 m	€ thousands	€ hundreds	€ 1 to 10
Units/year	single figures	approximately 10	100 to 1 k	10 k to 10 m
Use	– Research – Testing of secondary normals	– Calibration	– Process instrumentation – In-process measurement	– Auto electronics – Building services

2 Sensor symbol



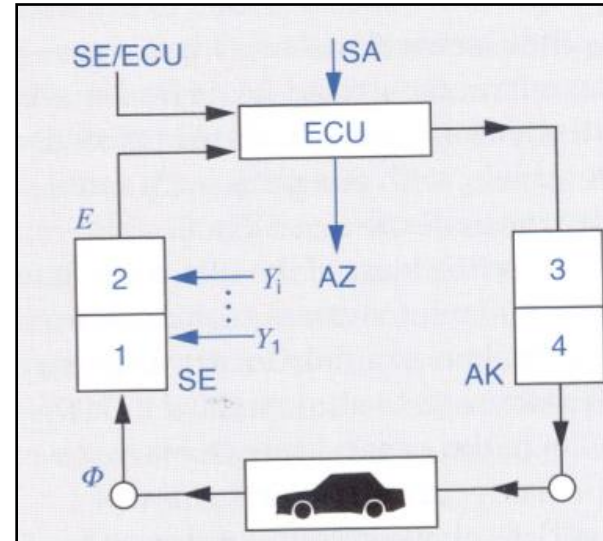
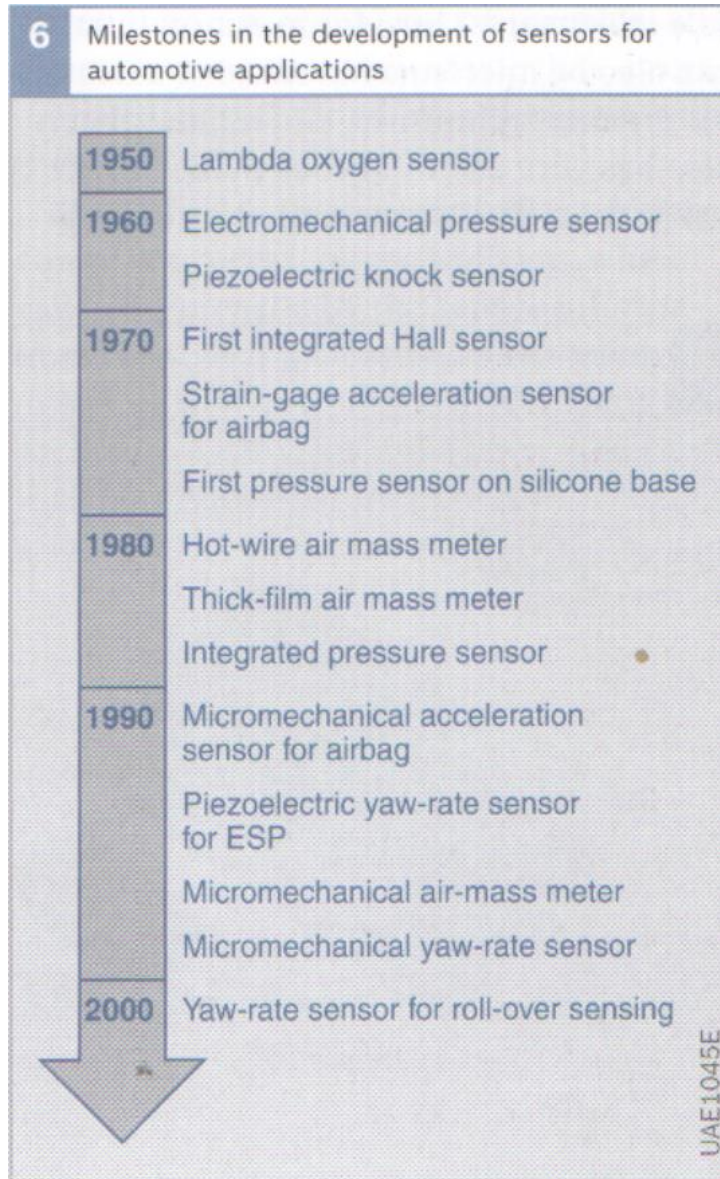
UAE0815Y

3 Basic sensor function



LAE0913E

Примена сензора на возилима



- 1 Measuring sensors
- 2 Adapter circuit
- 3 Driver circuit
- 4 Actuators
- AK Actuator
- AZ Display
- SA Operating switch
- SE Sensors
- ECU Control unit
- Φ Physical variable
- E Electrical variable
- Y_i Disturbances

Подела сензора на возилима

- према намени
- према карактеристикама
- према типу излазног сигнала

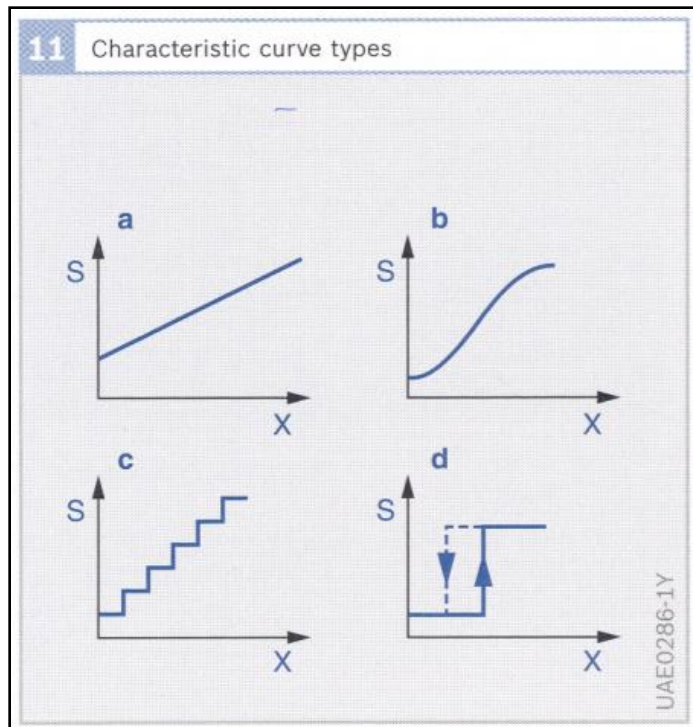


Fig. 11

S Output signal
X Measured variable

- a Continuous, linear
- b Continuous, nonlinear
- c Discontinuous, multi-step
- d Discontinuous, two-step (with hysteresis)

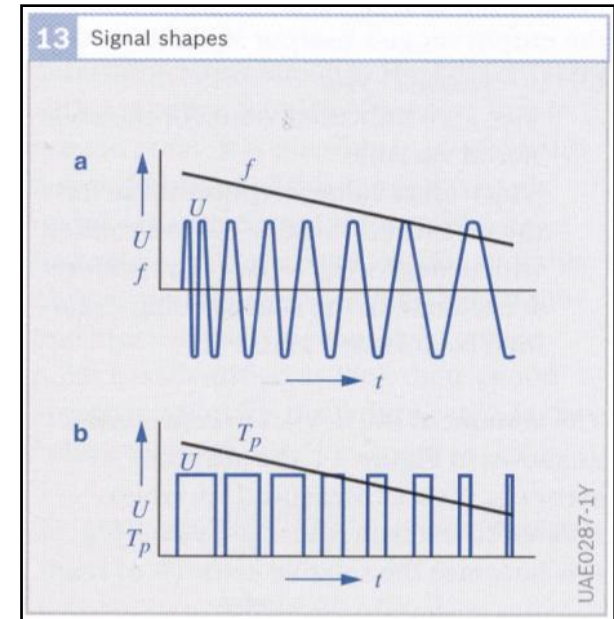
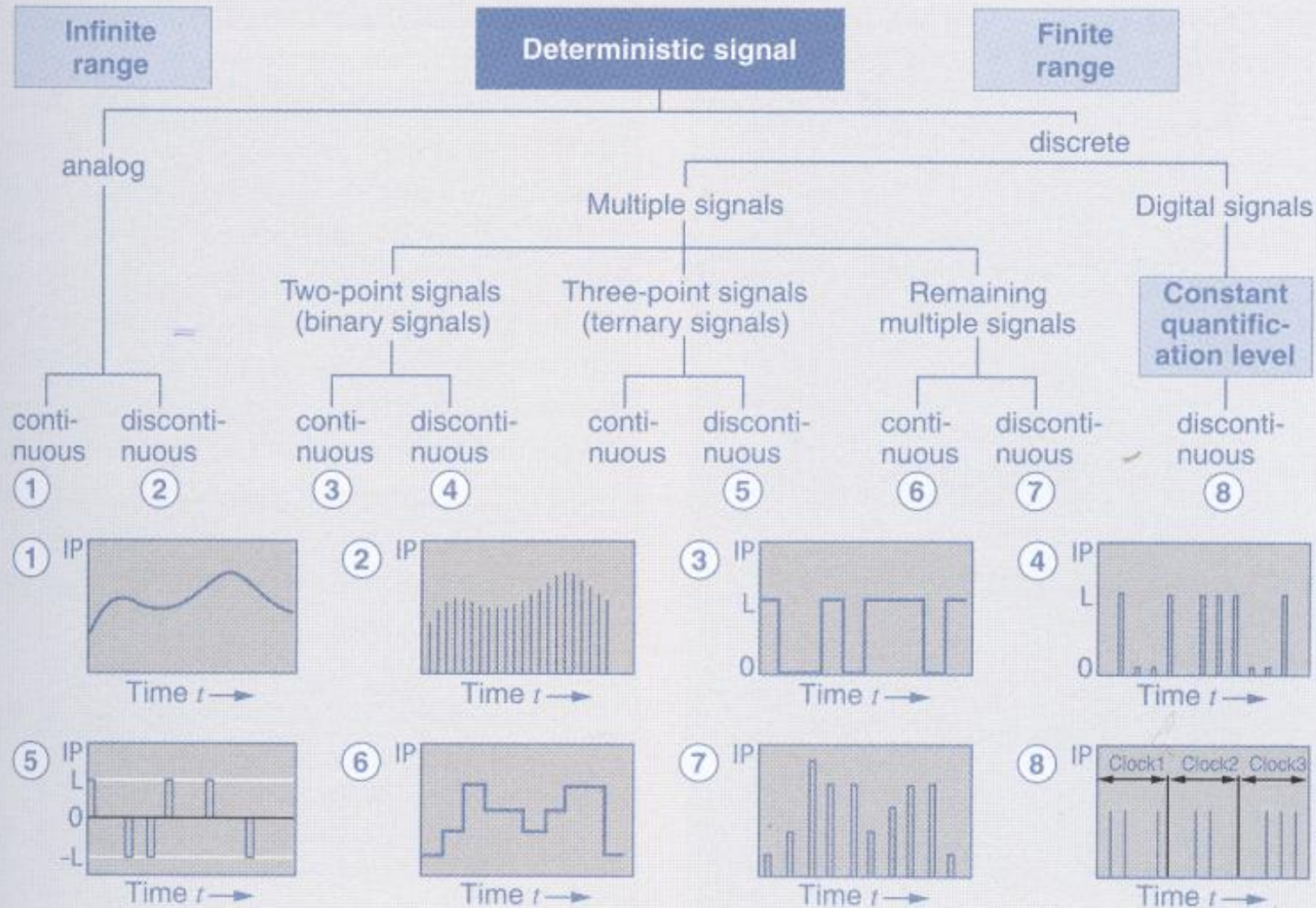


Fig. 13

- a Output signal U , information parameter: frequency f
- b Output signal U , information parameter: pulse duration T_p

12 Classification of the determined signals according to the information parameter (IP) with examples



UAE1047E

Типови грешака

14 Characteristic curves and error graph for a sensor

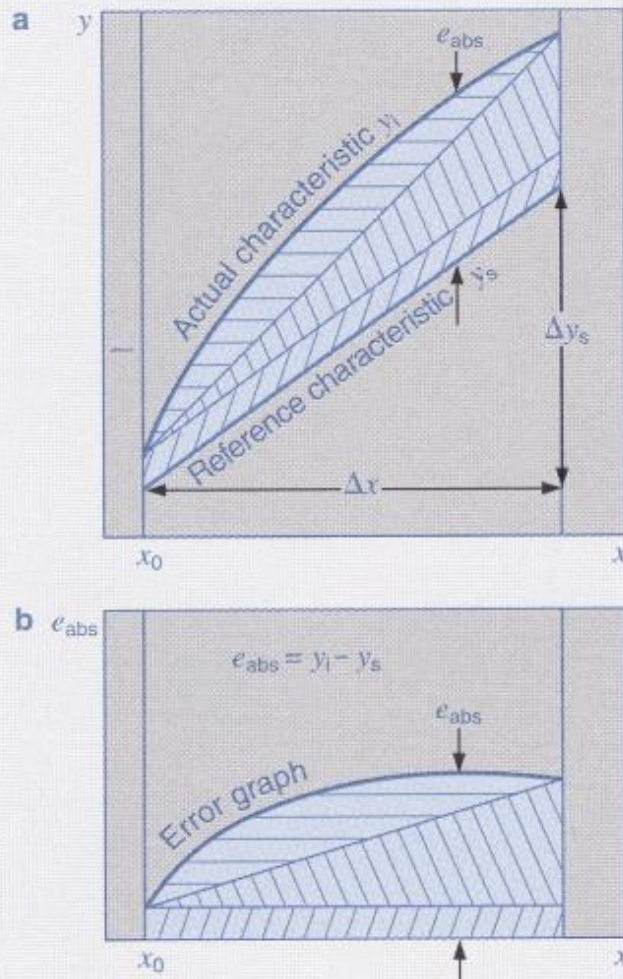


Fig. 14

- a Actual and reference characteristic
- b Error graph

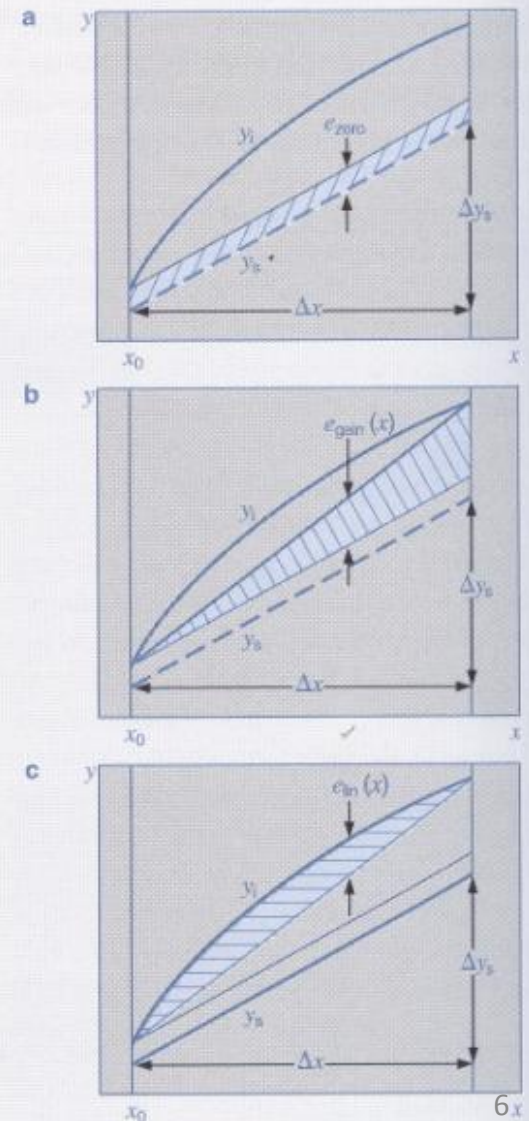
y Measured variable
 x Output signal
 Δx Measuring range
 e Error (deviation)

Fig. 15

- a Zero error
- b Gradient error
- c Linearity error

y Measured variable
 x Output signal
 Δx Measuring range
 e Error

15 Subdivision of the total error



Поузданост сензора

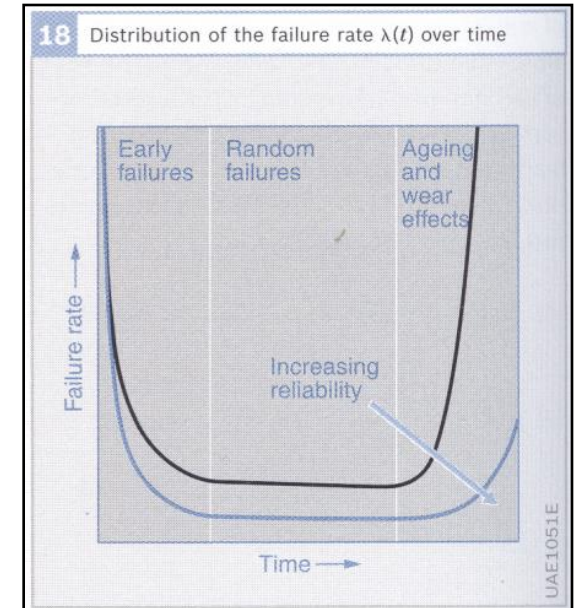
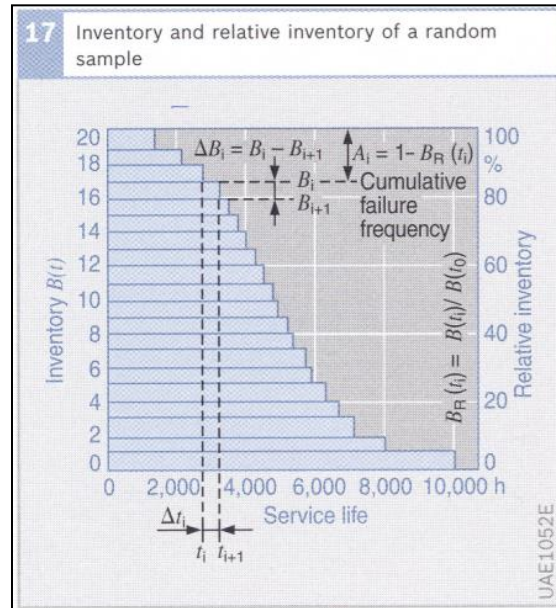
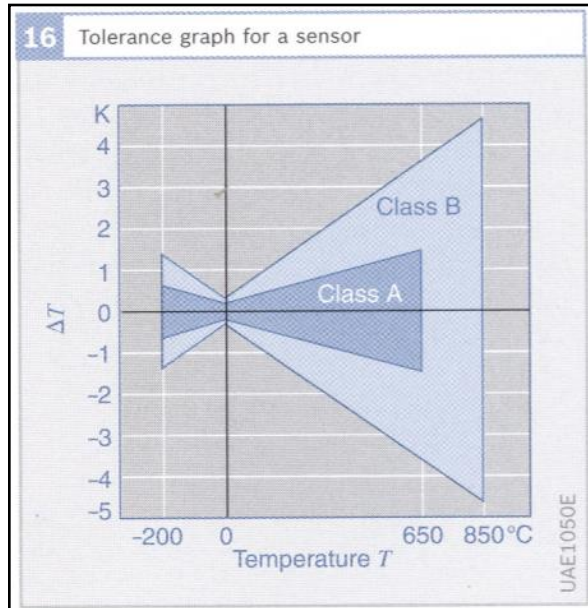


Fig. 16
Tolerance graph
illustrated on the
example of a resistance
temperature sensor

Fig. 17
Observation for a
random sample of
 $N = 20$ sensors;
mean service
life $T_M = 4,965$ h.

Захтеви и трендови код сензора на возилима

3 Reliability requirements on vehicle systems

Warranty target: 150,000 km/10 years

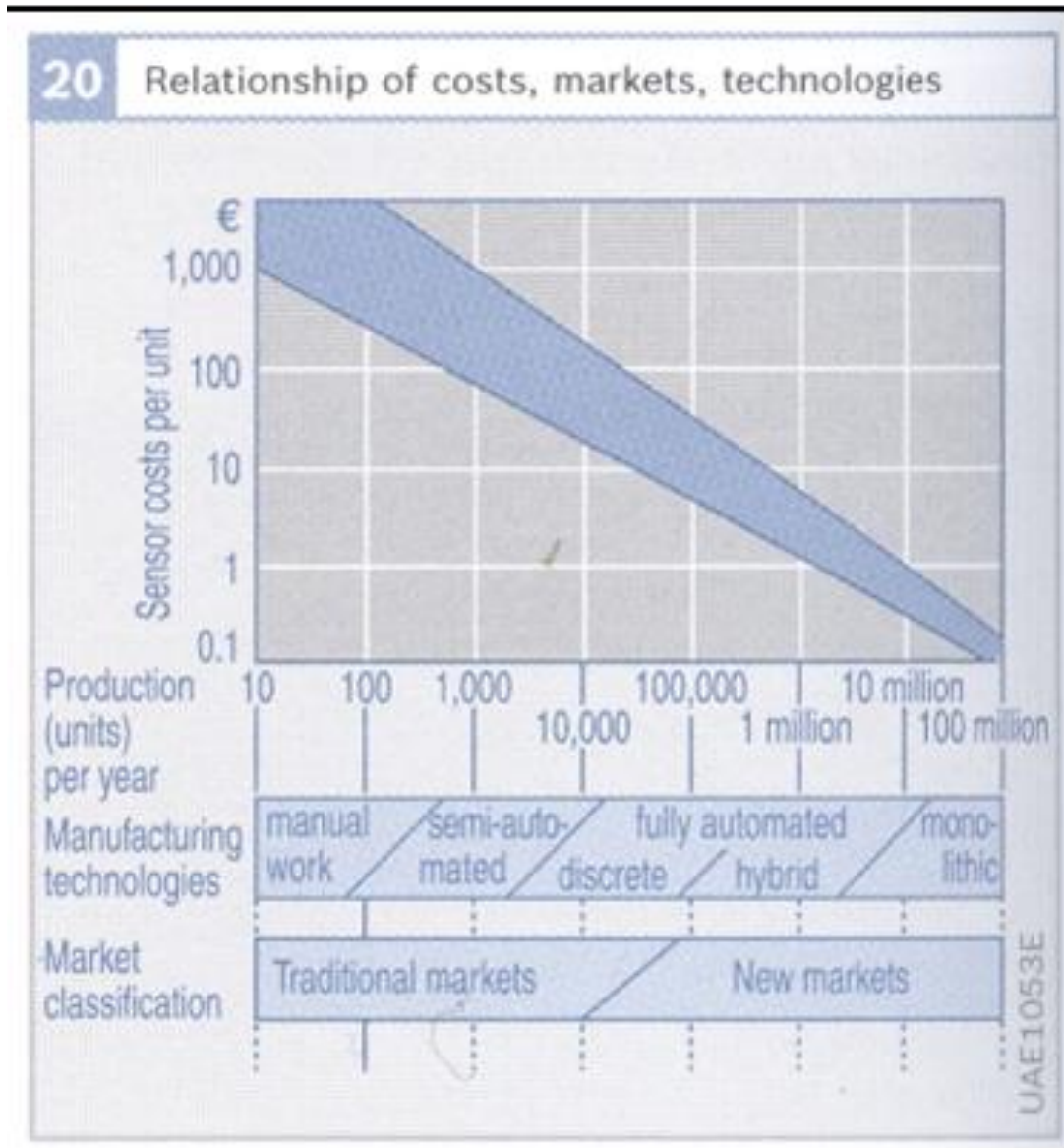
→ ECU failure rate (field)	< 50 ppm
→ ECU failure rate (0 km)	< 15 ppm
→ Failure rate of modules and sensors	< 10 ppm
→ ASIC failure rate	< 3 ppm
→ IC failure rate	<< 1 ppm
→ Failure rate of discrete components	< 0.5 ppm
→ <i>For comparison</i> Mobile phone	~ 5,000 ppm

19 Principal requirements on vehicle sensors

Vehicle sensor	Requirement
Rational mass production	← Low costs
Robust, proven technology	← High reliability
Appropriate packaging technology	← Extremely severe operating conditions
Appropriate miniaturization technologies	← Low space requirement
On-site error compensation	← High-level accuracy

SAE1013-1E

Ниска цена производње



Тешки радни услови

- механички (вибрације, удари)
- климатски (темп. влага)
- хемијски (гориво, мот. уље, електролит, со)
- електомагнетни (зрачење, линијска интерференција, напонски скокови)

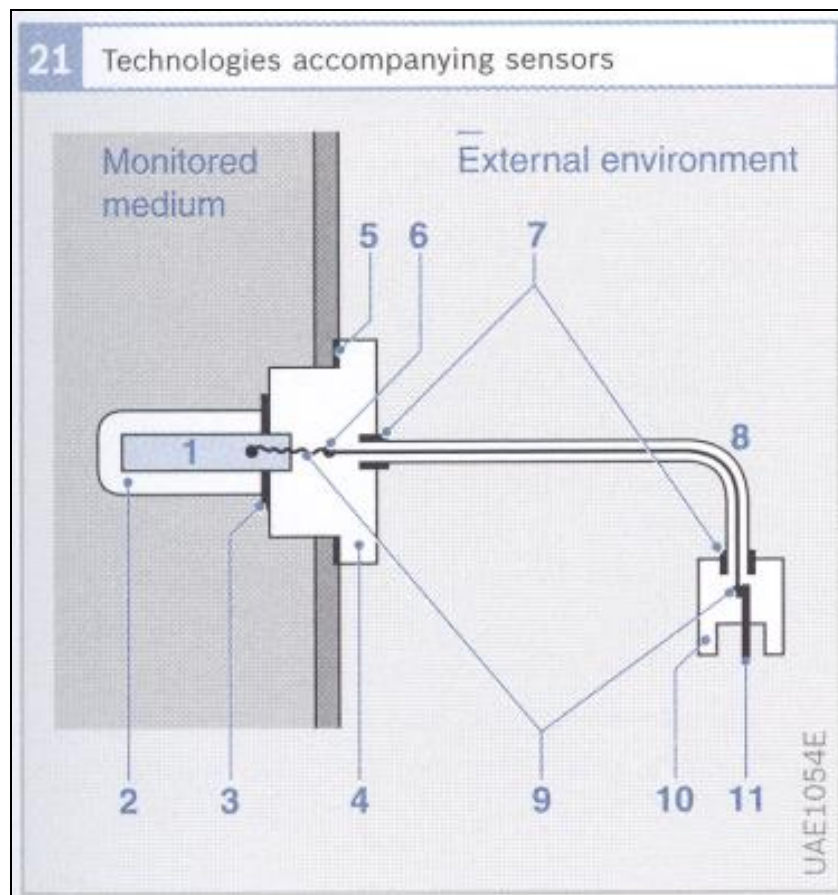
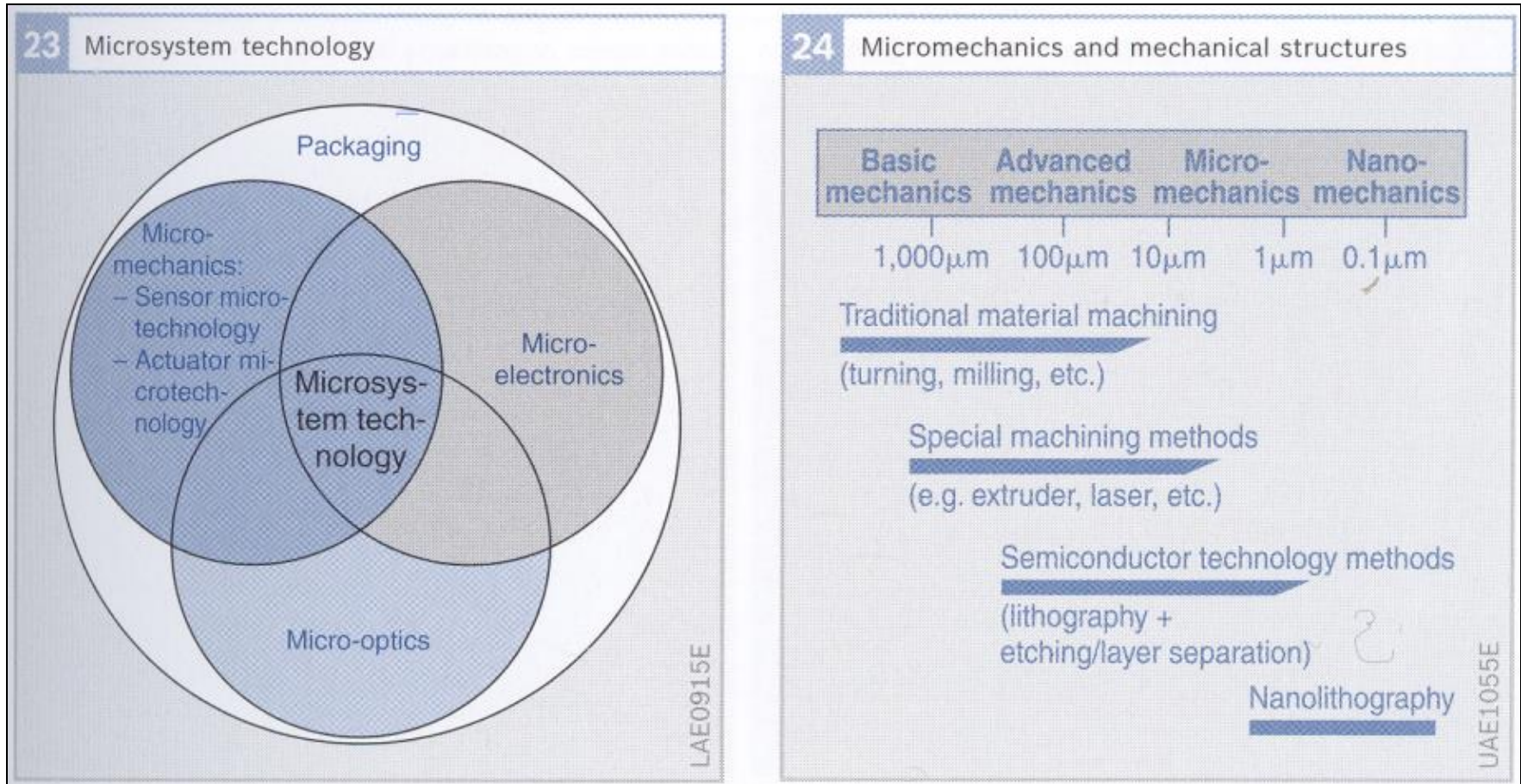


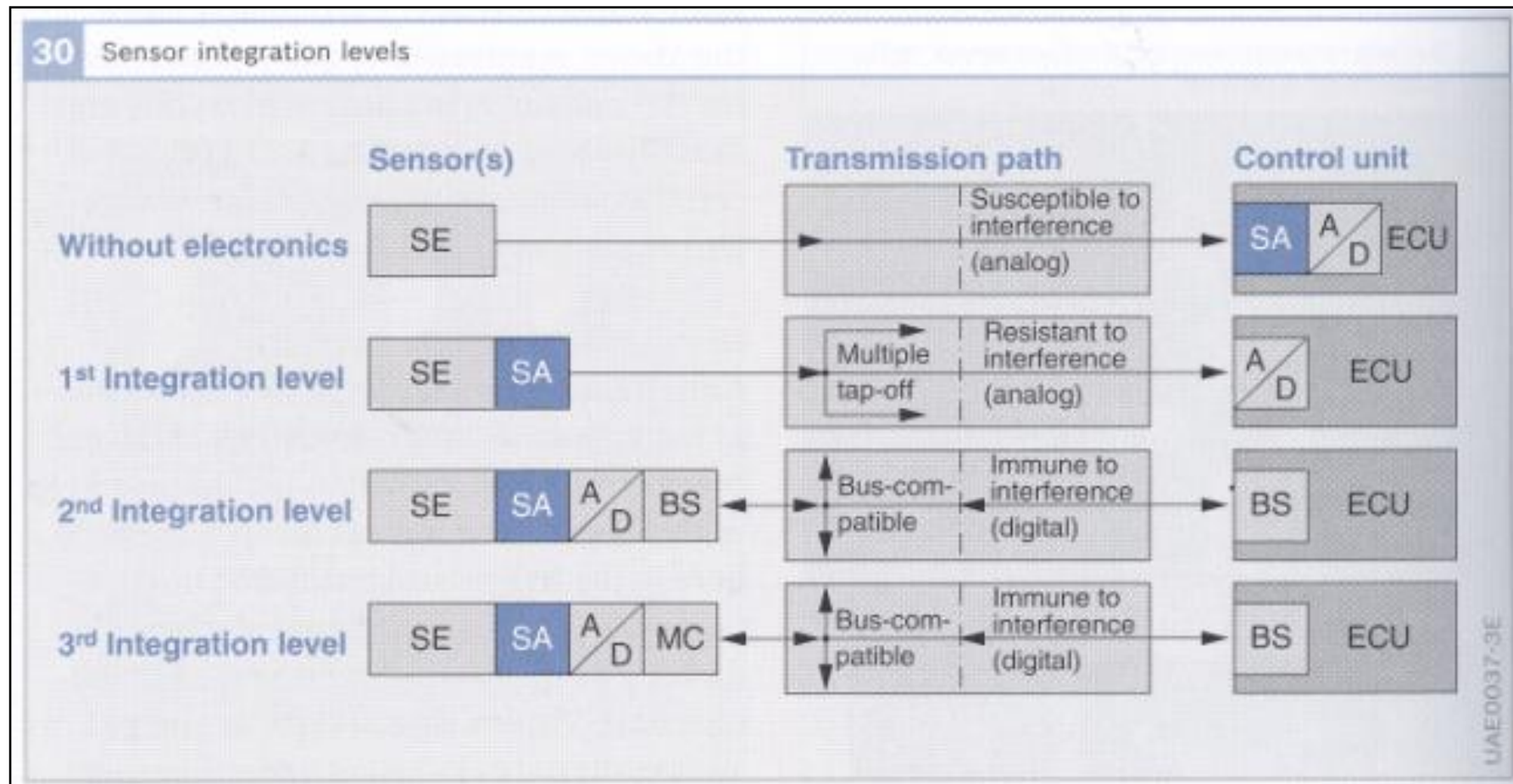
Fig. 21

- 1 Sensor
- 2 Protective sleeve (coating)
- 3 Seal
- 4 Mount
- 5 Seal, mounting
- 6 Data point
- 7 Seal, strain relief
- 8 Insulation (flexible)
- 9 Contacts
- 10 Plug housing
- 11 Plug contact

Мали габарити (минијатуризација)



Висока точност



Преглед физикалних основа сензора

4 Physical effects for sensors		
Physical effect	Example	As at: Series production ¹ / Development ²
Resistive effects (dependency of electrical resistance):		
Influence of temperature on metallic and semiconductor materials	NTC and thin-film resistors for the measurement of air and engine temperature	S
Length or angular proportionality of resistors (potentiometer sensors)	Accelerator-pedal and throttle-valve sensor, fuel tank level	S
(In plane) tension or pressure dependency (piezoresistive): strain-gage resistors	High-pressure sensors (e.g. common rail, ABS): metal diaphragm,	S
	low pressure sensors (silicon diaphragm),	S
	force sensor	D
Vertical pressure dependency (out of plane)		
Magnetic field dependency (magnetoresistive): semiconductor (magnetoresistors), AMR ³ thin metal layers (e.g. NiFe, also in barber's pole form), GMR ⁴ sensors (nanolayers)	Speed or delivery angle measurement in diesel distributor injection pumps	S/D
Light dependency: semiconductor photoresistors	Rain sensor, dirt sensor for headlight cleaning, automatic headlights, automatic low-beams	S
Inductive effects (effects of Faraday's law)		
Induction voltage sensors (alternator): movement in the magnetic field	Wheel, camshaft, engine speed, needle lift (injection nozzle)	S
Wiegand effect	Speed of rotation	D
Variation in inductance as a result of the positional change of a ferromagnetic coil core	Solenoid armature sensor	D
Variation in inductance as a result of field limiting conductive elements (eddy current)	Semi-differential short-circuiting ring sensor (diesel pump load sensor)	S

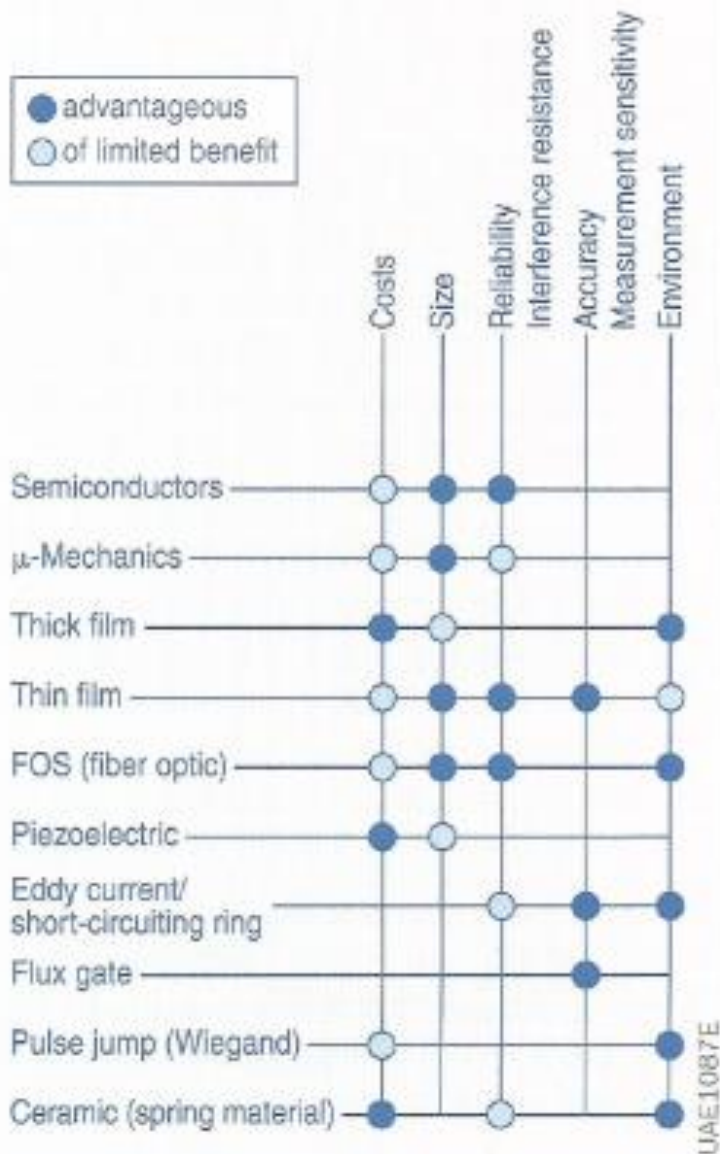
Table 4

- ¹) Series production, at RB or competitors, possible also already phased out
- ²) Development possibly also concluded and in reserve
- ³) AMR = Anisotrop Magneto Resistive
- ⁴) GMR = Giant Magneto Resistive

Physical effect	Example	As at: Series production ¹ / Development ²
Variation of the degree of transformer coupling (by electrical or magnetic conductive elements)	Full-differential short-circuiting ring sensor	D
Variation in inductance or of the degree of transformer coupling (by magneto-elastic conductive elements)	Load bolt (Hitchtronik), braking force	S D
Saturation core sensors (e.g. Foerster probe)	Compass sensor	S
Capacitive effects (influence)		
Capacitance change as a result in change in plate distance and degree of cover	Micromechanical acceleration sensors, e.g. for airbag, ESP, MM2 yaw-rate sensor, pressure sensor	S S D
Capacitance change as a result in a change of the relative dielectric constant	Oil grade, humidity sensors	S S
Capacitance change as a result of change in the electrolyte level with a dielectric medium	Fuel tank level	D
Charge generating effects		
Piezoelectric effect (quartz, piezoceramics)	Knock sensor, airbag sensor, DRS1 yaw-rate sensor	S S
Pyroelectric effect	IR sensor (dynamic)	D
Photoelectric charge generation	CCD and CMOS imaging sensor (also IR range)	D

Voltage generating, galvanic effects		
Hall effect (out-of-plane sensitivity, semiconductor material)	Hall switch (ignition), wheel and engine speed, acceleration sensor (ABS, 2g), front passenger weight detection (iBolt™), ARS1,2 (accelerator pedal etc.)	S
Pseudo-Hall effect (in-plane sensitivity, metal thin film)	LWS2 and LSW4 steering-angle sensors	S
Electrolytic diffusion probes (doped Zr oxide ceramic)	Lambda oxygen sensors	S
Thermocouple, thermopile	IR sensor (Bolometer)	D
Photoelectric and fiber-optic effects		
Photoelectric cells, photodiodes, phototransistors (also in IR range)	Rain sensor, dirt sensor for headlight cleaning, automatic headlights, automatic low beams	S
Medium-dependent absorption	Soot particles, humidity	D
Extrinsic and intrinsic fiber-optic effects: influence on intensity, interference (influencing phases), influencing polarization; e.g. microbending effect	Finger protection (windows, sliding sunroof), pedal force, collision	D
Thermal effects		
Resistor cooling as a function of the flow velocity, of the medium, of the density or fill level of a medium	HFM air-mass sensors,	S
	analysis,	-
	concentration,	-
	fill level (fuel tank)	D
Wave propagation effects		
Sound waves: propagation time effects (echo sounding), superposition with medium speed, Doppler effect (moving source/receiver)	Parking-aid assistant,	S
	volume flow rate,	D
	speed over the ground	S
Light waves: total reflection on boundary surfaces, optical resonators (color analysis)	Rain sensor,	S
	fiber-optic finger protection,	D
	fill level (analog, limit value),	D
Sagnac effect	yaw rate: fiber and laser gyroscopes,	D
Propagation time	lidar (light wave radar)	D
Electromagnetic radiation: Doppler, FMCW, propagation time radar	ACC distance sensor	S

32 Selection of suitable sensor technologies



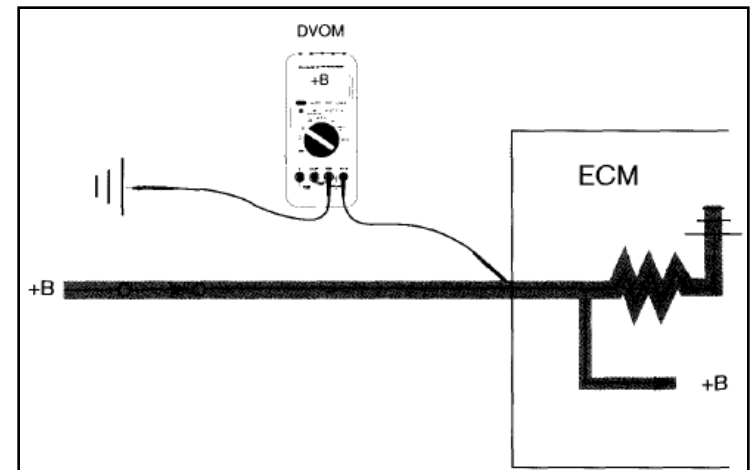
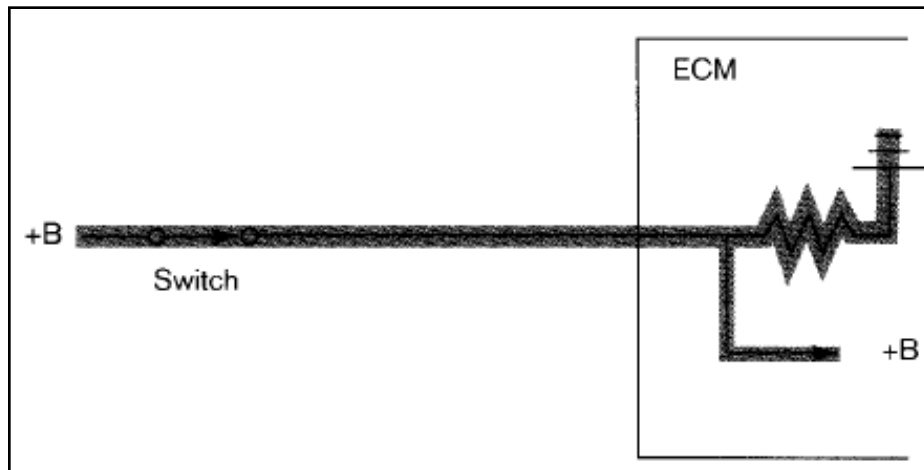
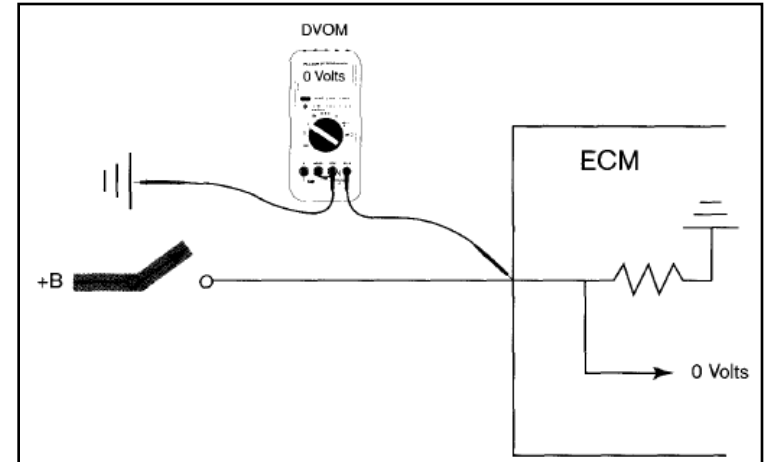
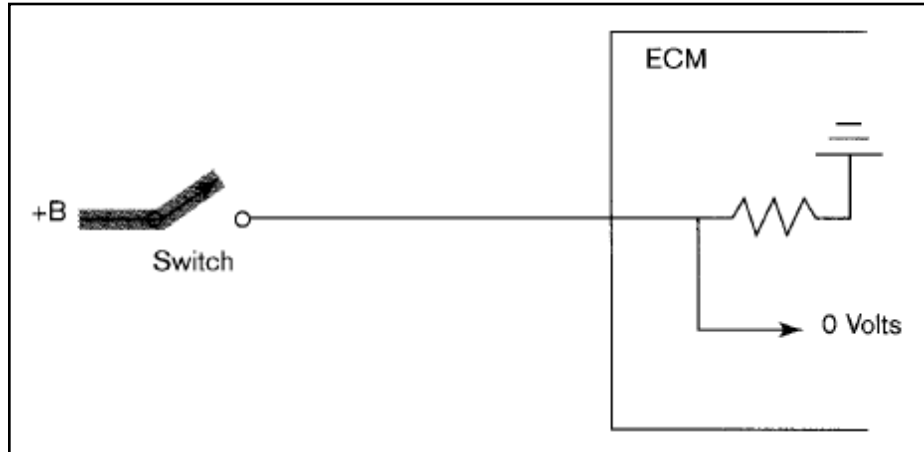
Преглед сензорских технологија

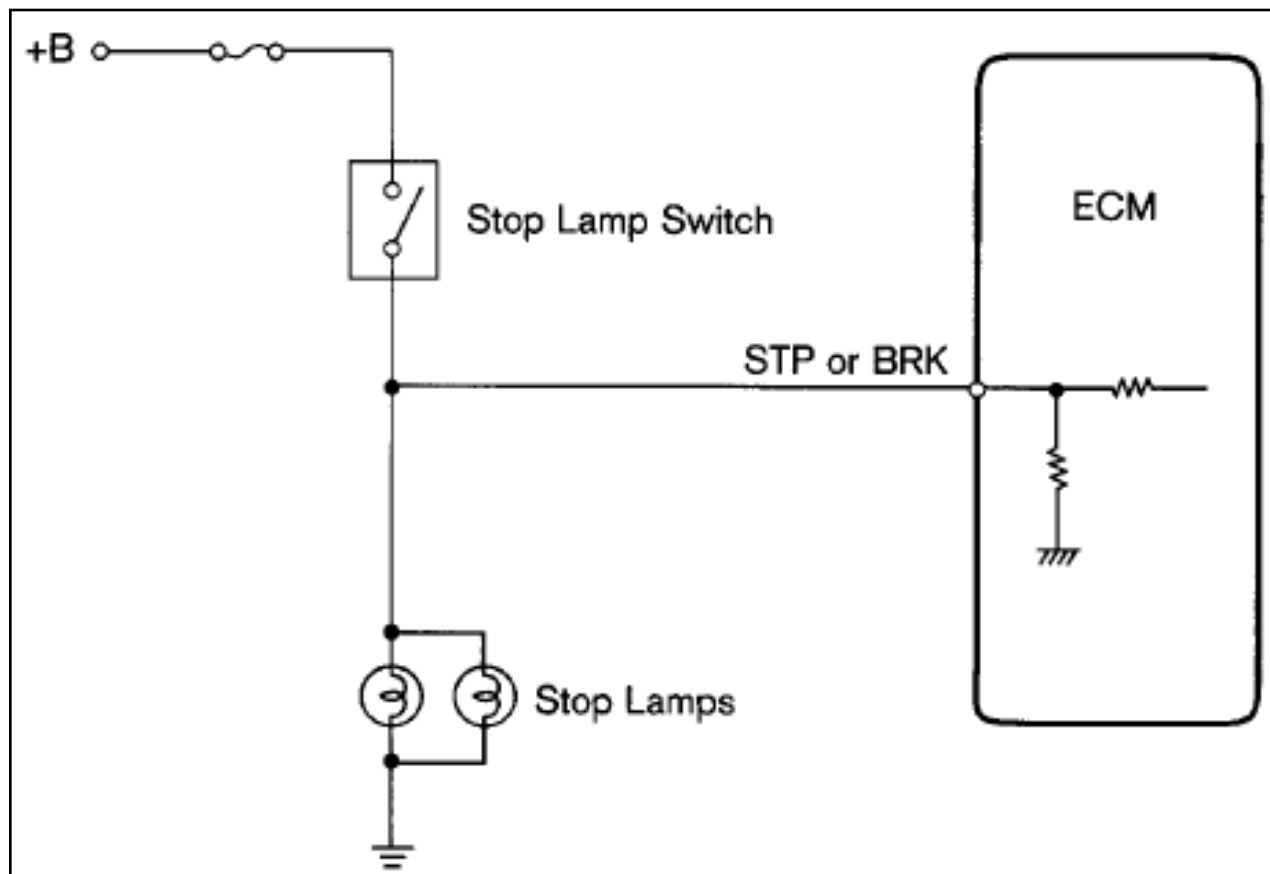
Различите сензорске технологије за коришћење мерних ефеката су блиско повезане са изабраним концептом мерења.

Тај избор првенствено зависи од захтева који се постављају при мерењу одређене величине:

- цена
- величина
- поузданост,
- тачност
- околина

Прекидач-давач мода

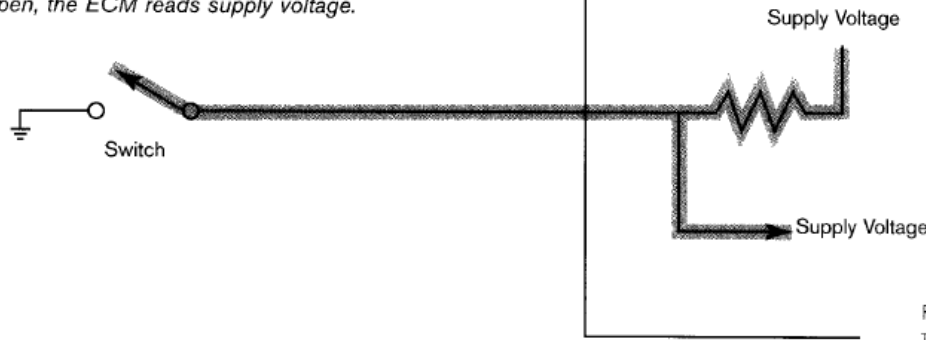




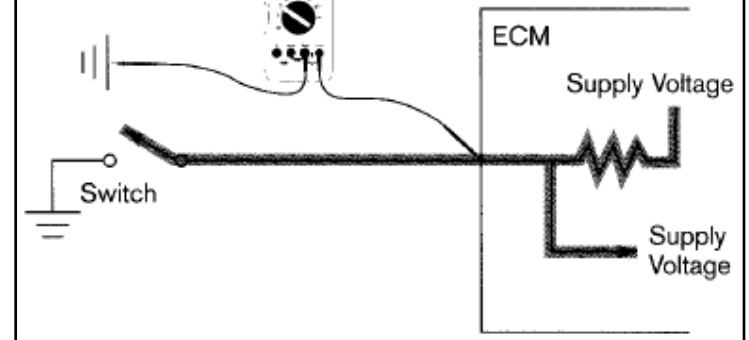
СЕНЗОРИ И АКТУАТОРИ

ECM

On a ground side switch circuit with switch open, the ECM reads supply voltage.

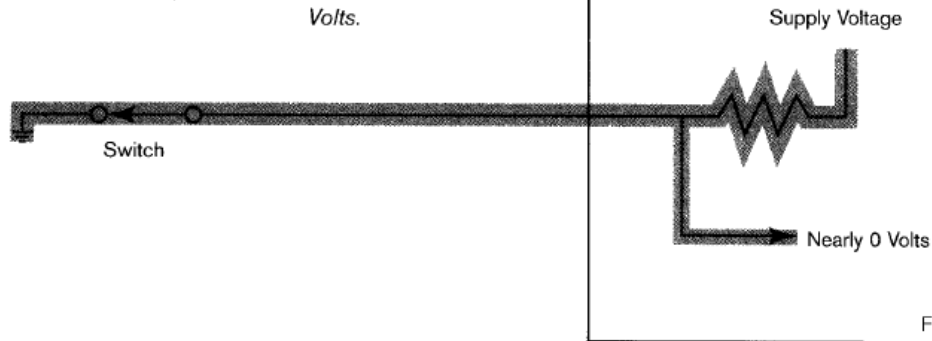


DVOM



ECM

When the switch closes, the ECM reads 0 Volts.



DVOM

