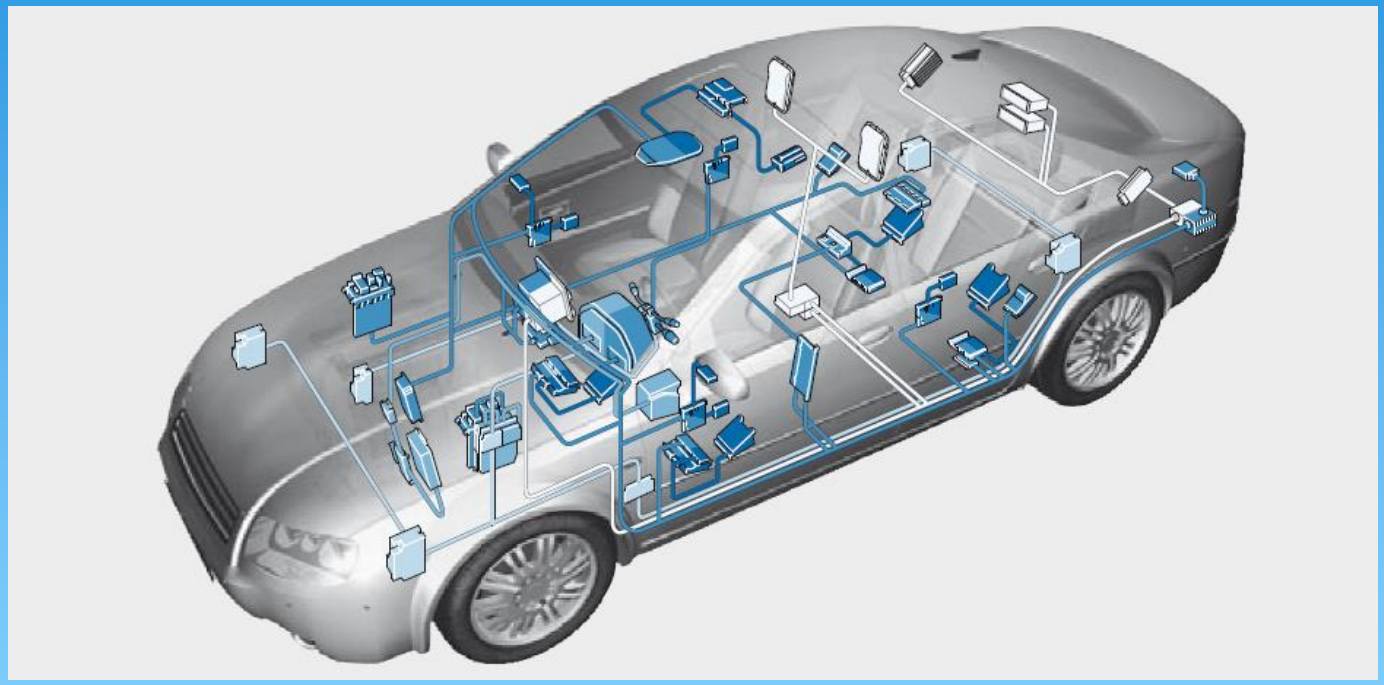
Automotive Network

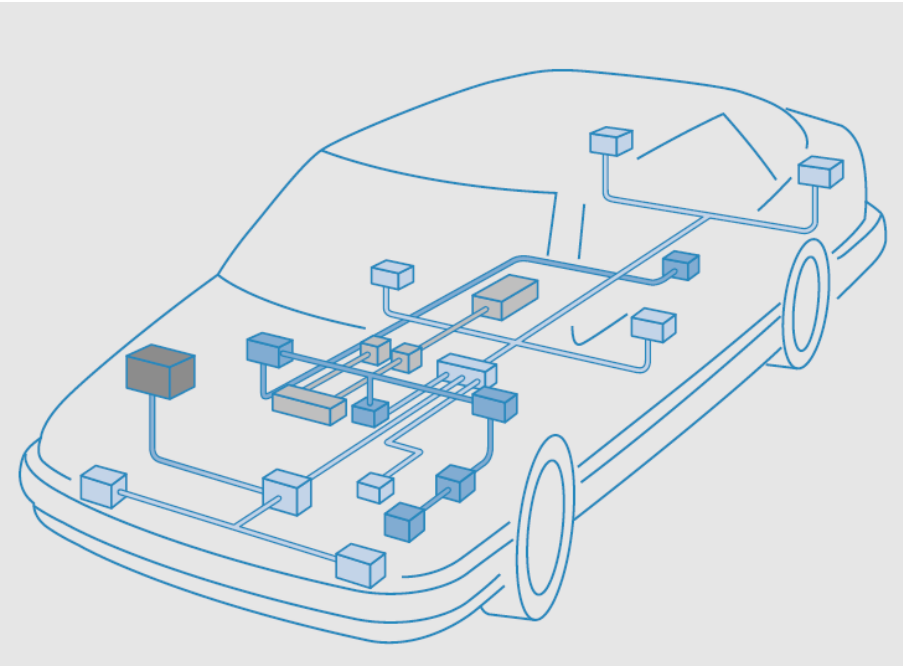


کاربرد شبکه در خودروها

ویرایش چهارم – بهمن 98

تهیه و تنظیم : بهروز خطیبی

فهرست



تهیه و تنظیم : بهروز خطیبی

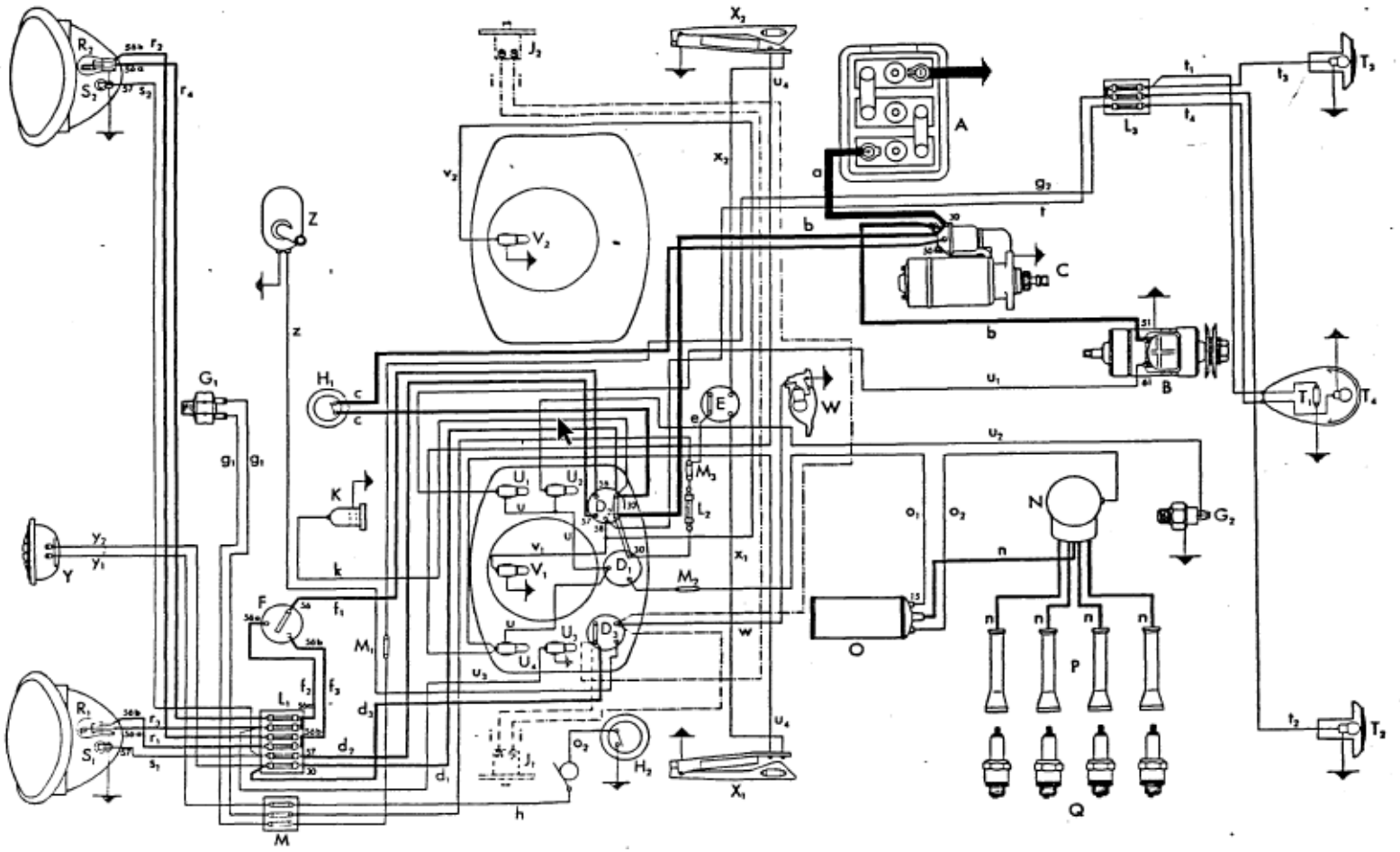
Why Vehicle need Network

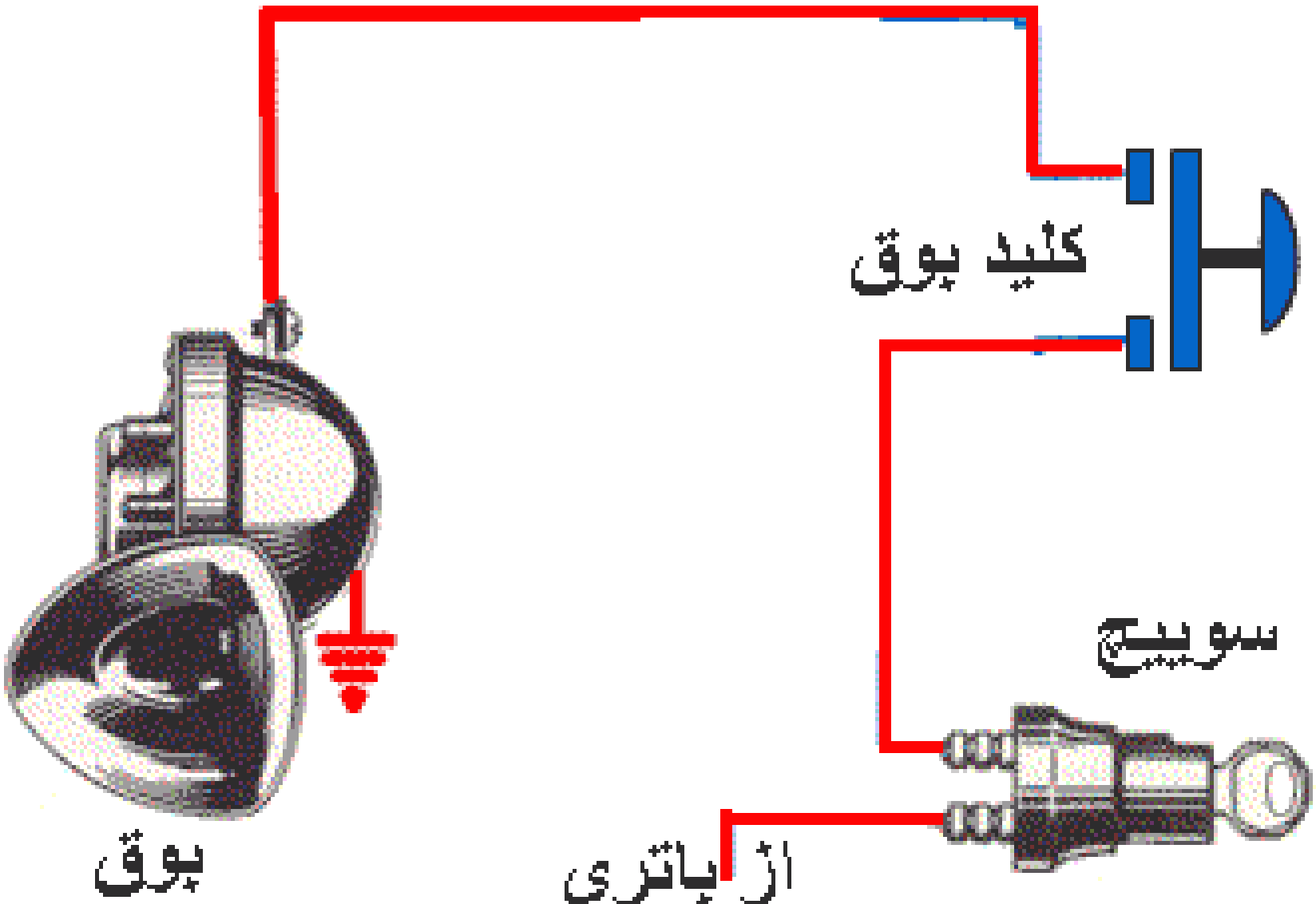
یا

چی شد که شبکه (در خودرو ها) لازم شد

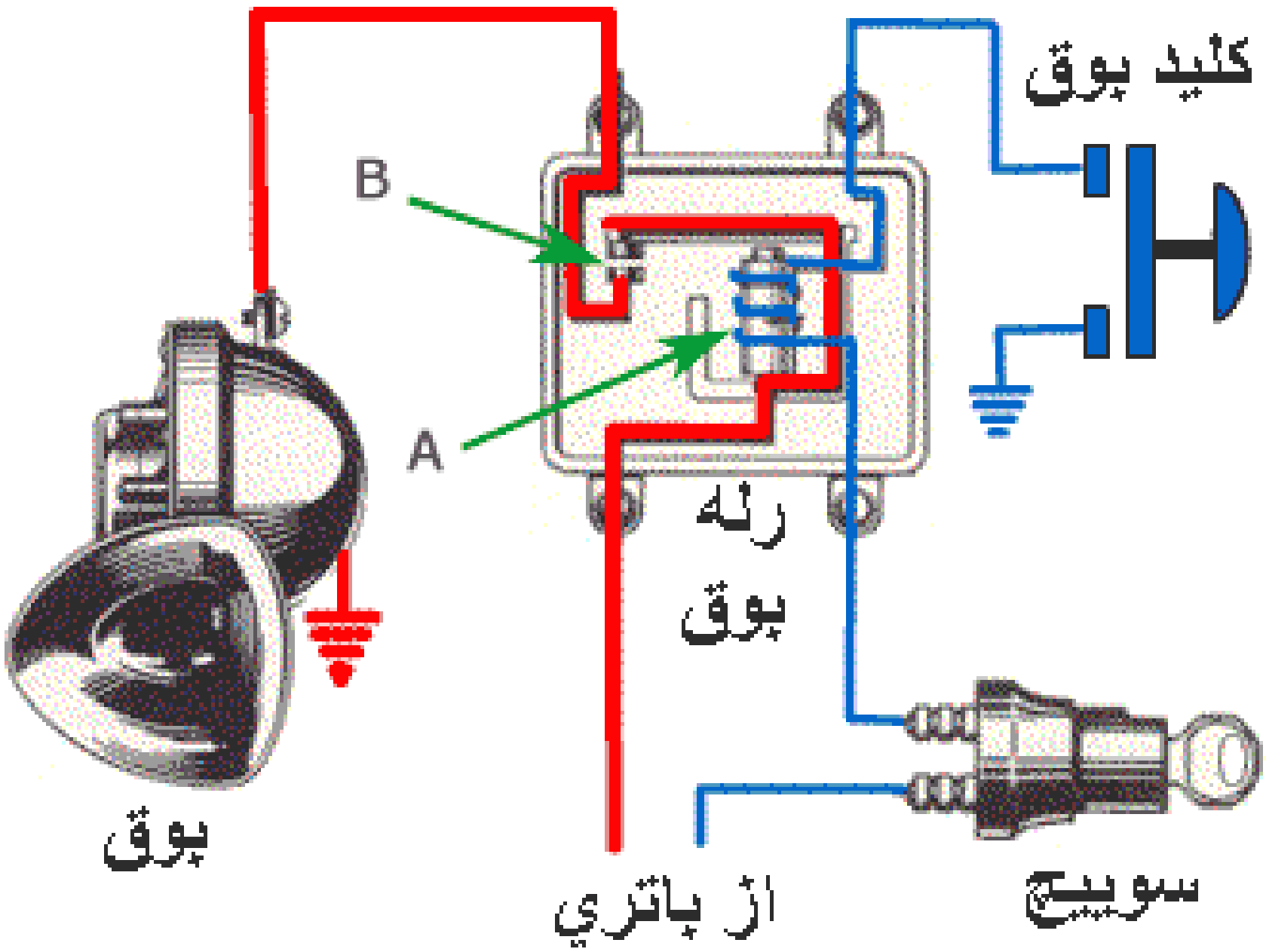
تهیه و تنظیم : بهروز خطیبی

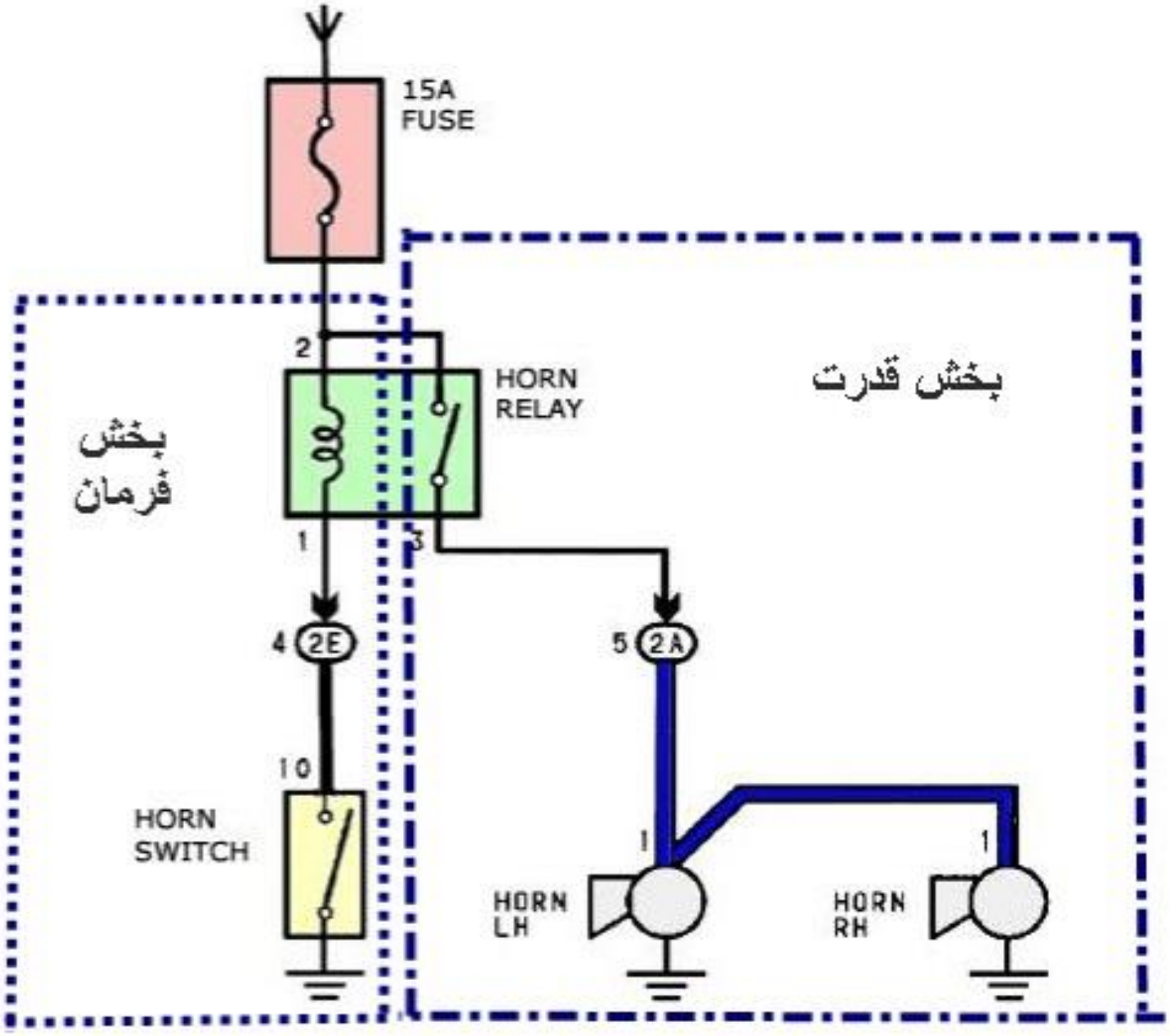
Elektrischer Schaltplan (Volkswagen)

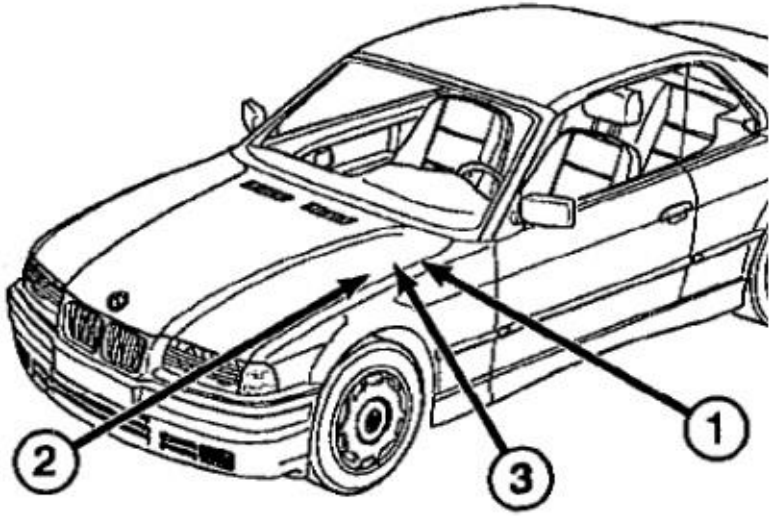


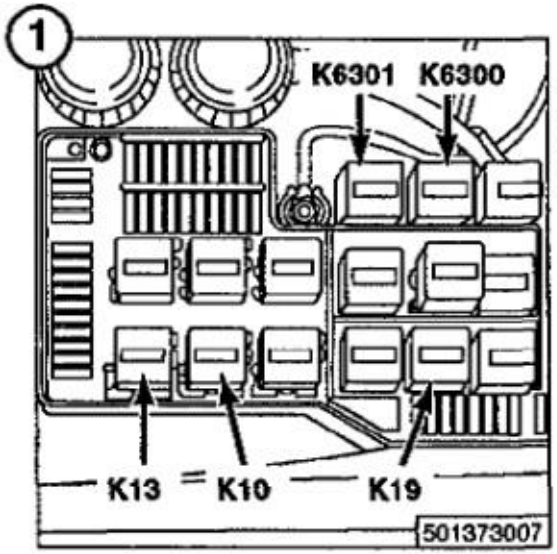


تهیه و تنظیم : بهروز خطیبی




15A
FUSE
2
HORN
RELAY
بخش قدرت
بخش
فرمان
1
3
4
2E
5
2A
10
HORN
SWITCH
1
1
HORN
LH
HORN
RH





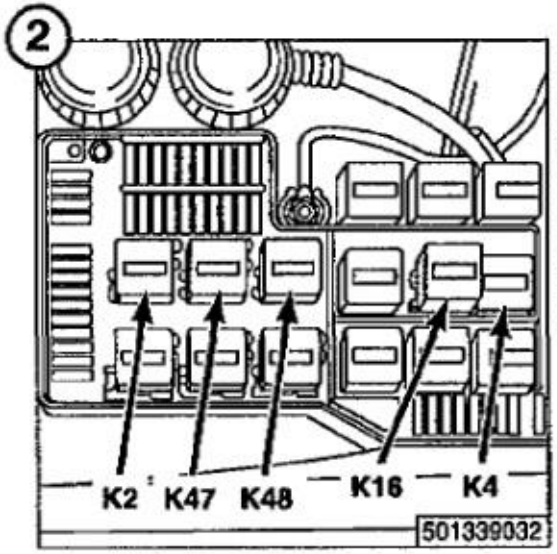
K10
ABS RELAY

K6300
ENGINE CONTROL
MODULE RELAY

K13
REAR DEFOGGER
RELAY

K6301
CYL. 1–6 FUEL
PUMP RELAY

K19
COMPRESSOR
CONTROL RELAY



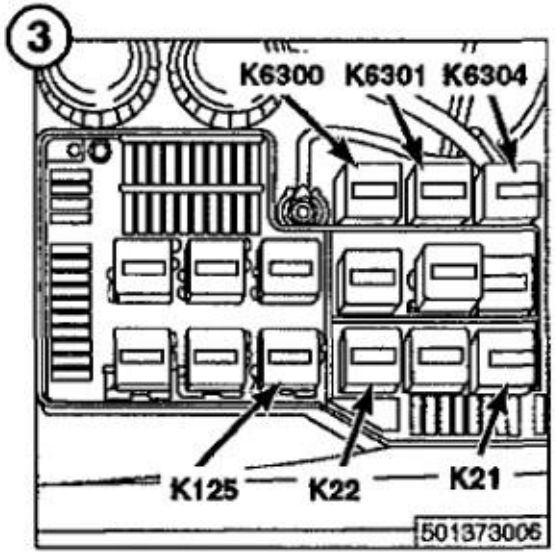
K2
HORN RELAY

K47
FRONT FOG LIGHT
RELAY

K4
BLOWER RELAY

K48
LOW BEAM LIGHT
RELAY

K16
HAZARD FLASHER
RELAY



K6301
CYL. 1–6 FUEL
PUMP RELAY

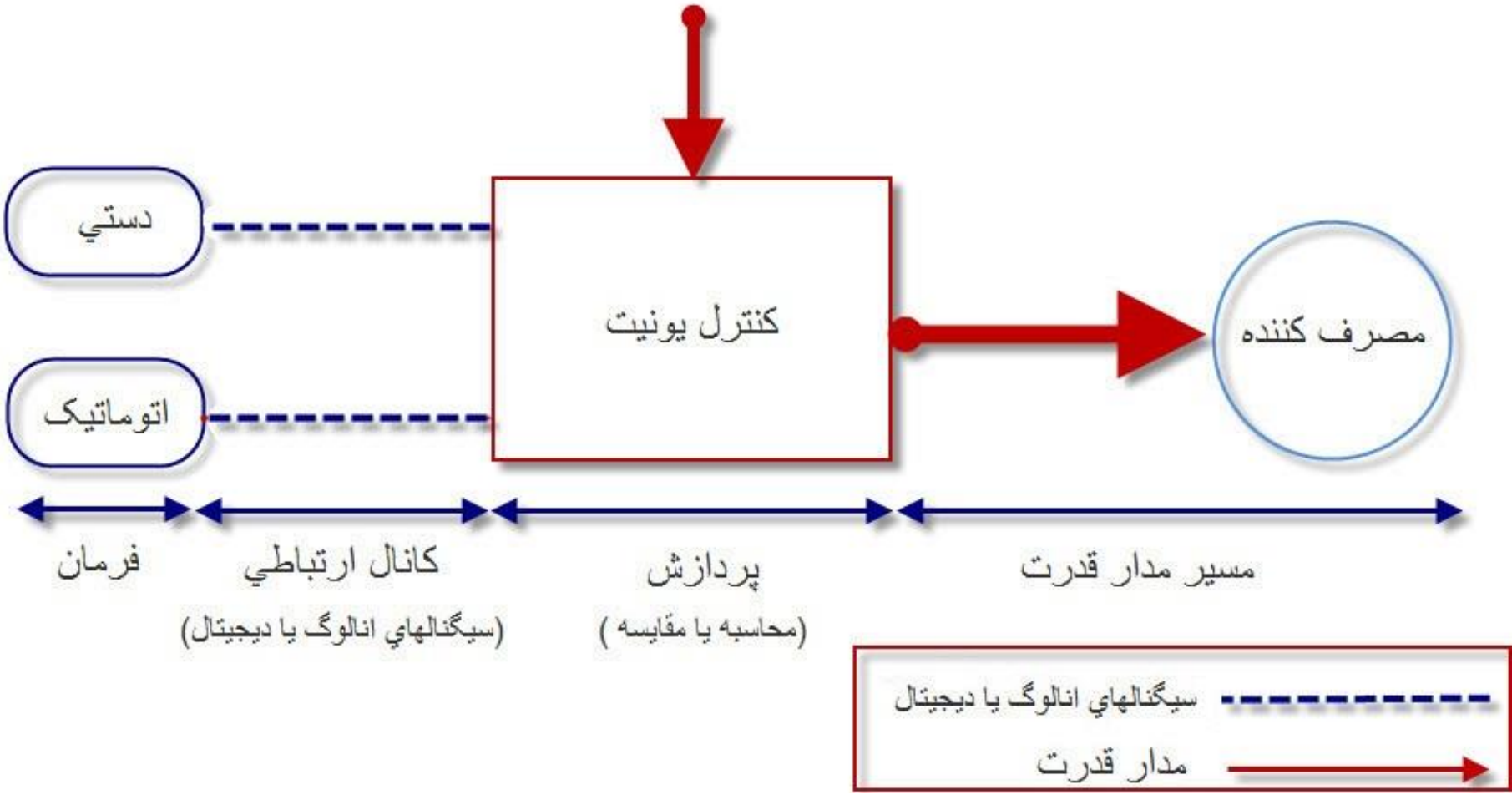
K22
HIGH SPEED
RELAY

K6300
ENGINE CONTROL
MODULE RELAY

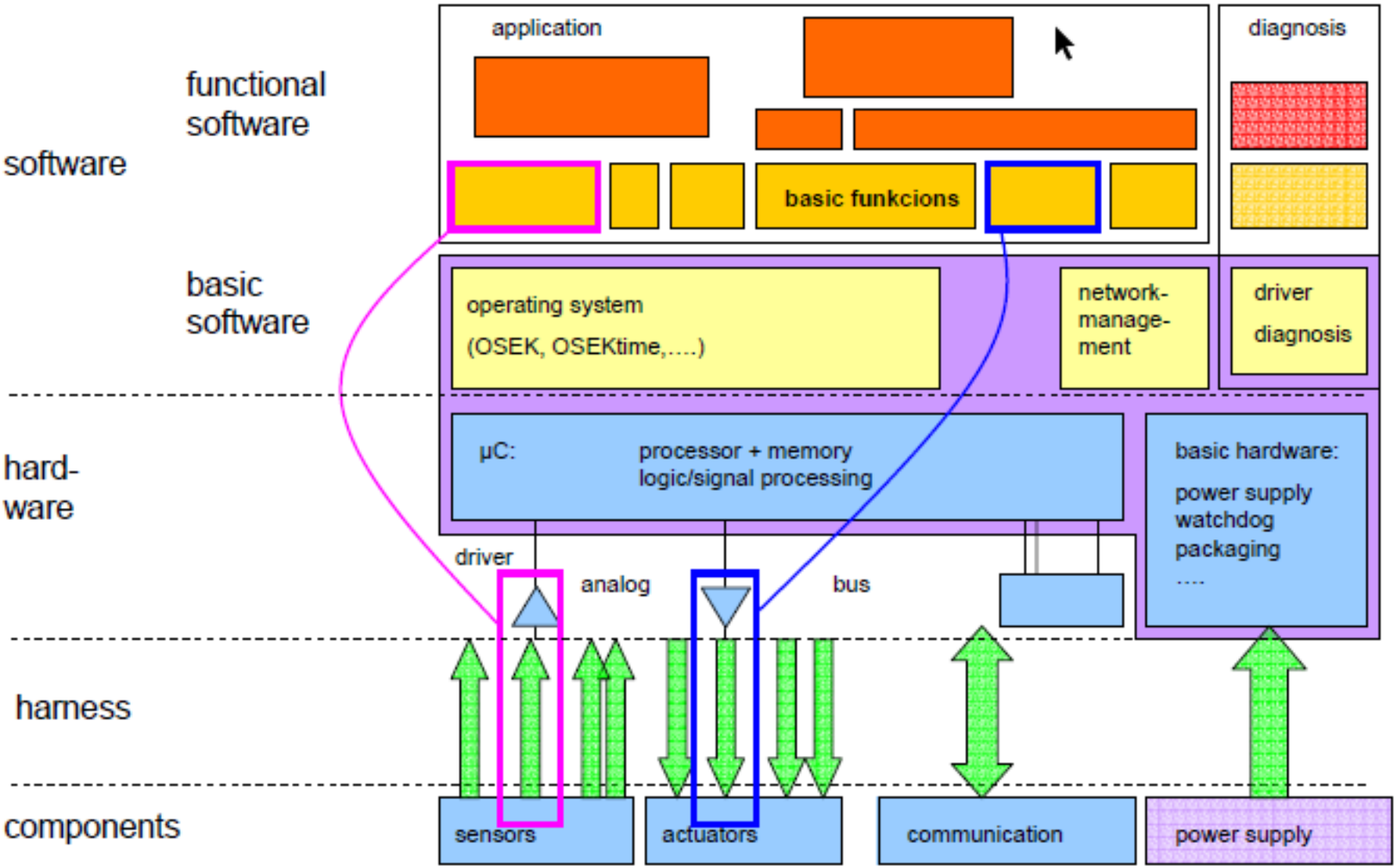
K125
ABS PUMP MOTOR
RELAY, TIMED

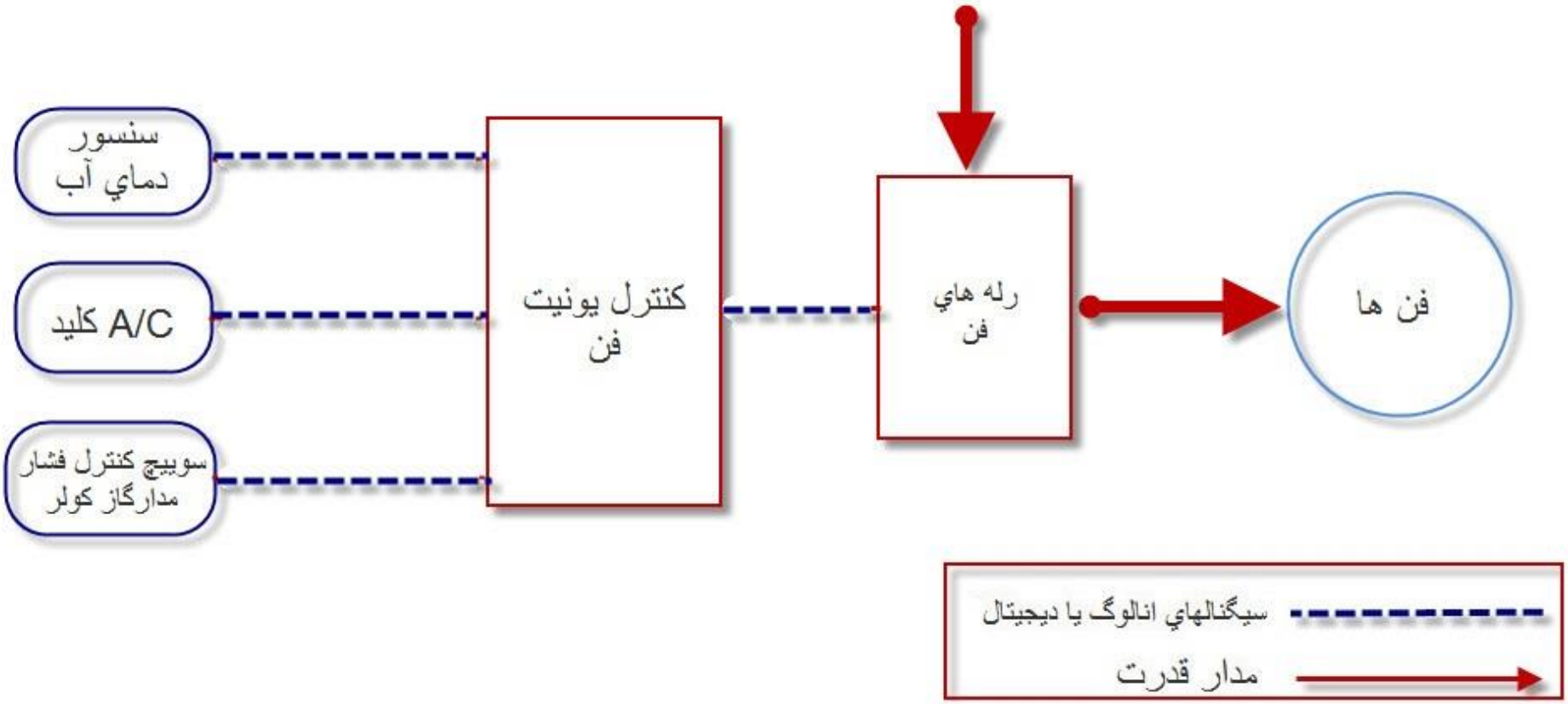
K21
NORMAL SPEED
RELAY

K6304
SECONDARY AIR
PUMP RELAY


دستي
اتوماتيک
کنترل يونيت
مصرف کننده
فرمان
کانال ارتباطي
(سيگنالهاي انالوگ يا ديجيتال)
پردازش
(محاسبه يا مقايسه)
مسير مدار قدرت
سيگنالهاي انالوگ يا ديجيتال
مدار قدرت

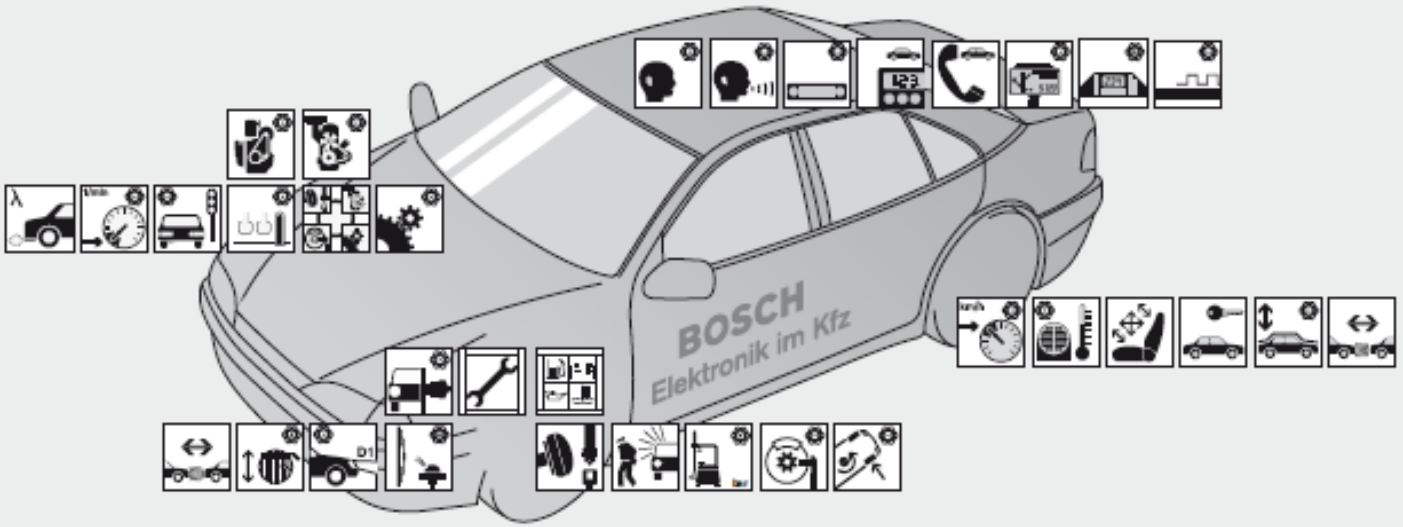
ECU and system architecture




سنسور دماي آب
کليد A/C
سوييچ کنترل فشار مدارگاز کولر
کنترل يونيت فن
رله هاي فن
فن ها
سيگنالهاي انالوگ يا ديجيتال
مدار قدرت

- Current middle and upper class vehicles carry 80 .. 100 networked Electronic Control Units (ECUs)

1 Electronics in the motor vehicle



Drivetrain

- Digital engine management: Gasoline engine: Motronic Diesel engine: electronic diesel control (EDC) with electronically controlled fuel injection, electronic ignition (gasoline engine), Lambda control, boost-pressure control (turbocharger) etc.
- Electronic transmission control
- On-board-diagnosis

Communication

- Electronic voice output
- Voice control of functions (speech recognition)
- Audio equipment (radio, CD etc.)
- Video
- On-board computer
- Car phone
- Navigation
- New display technologies (display, head-up display)
- Internet and PC

Safety

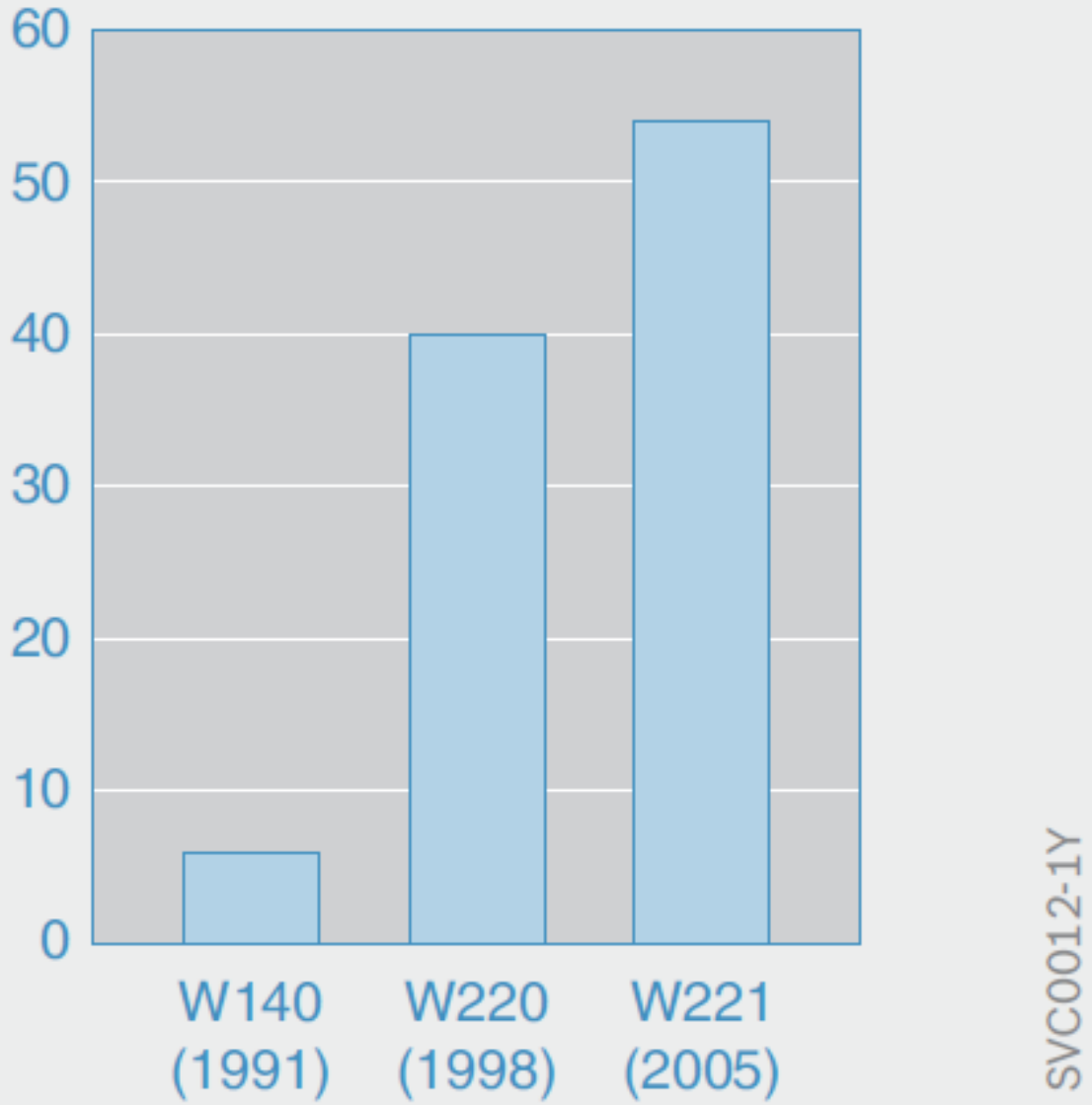
- Antilock brake system (ABS)
- Traction-control system (TCS)
- Electronic stability program (ESP)
- Headlamp adjustment and cleaning
- Litronic
- Wash-wipe control
- Individualised service interval display
- Monitoring systems for consumables and wearing parts
- Triggering systems for airbag, seatbelt tensioner and roll-over bar
- Vehicle security systems
- Tire-pressure monitoring

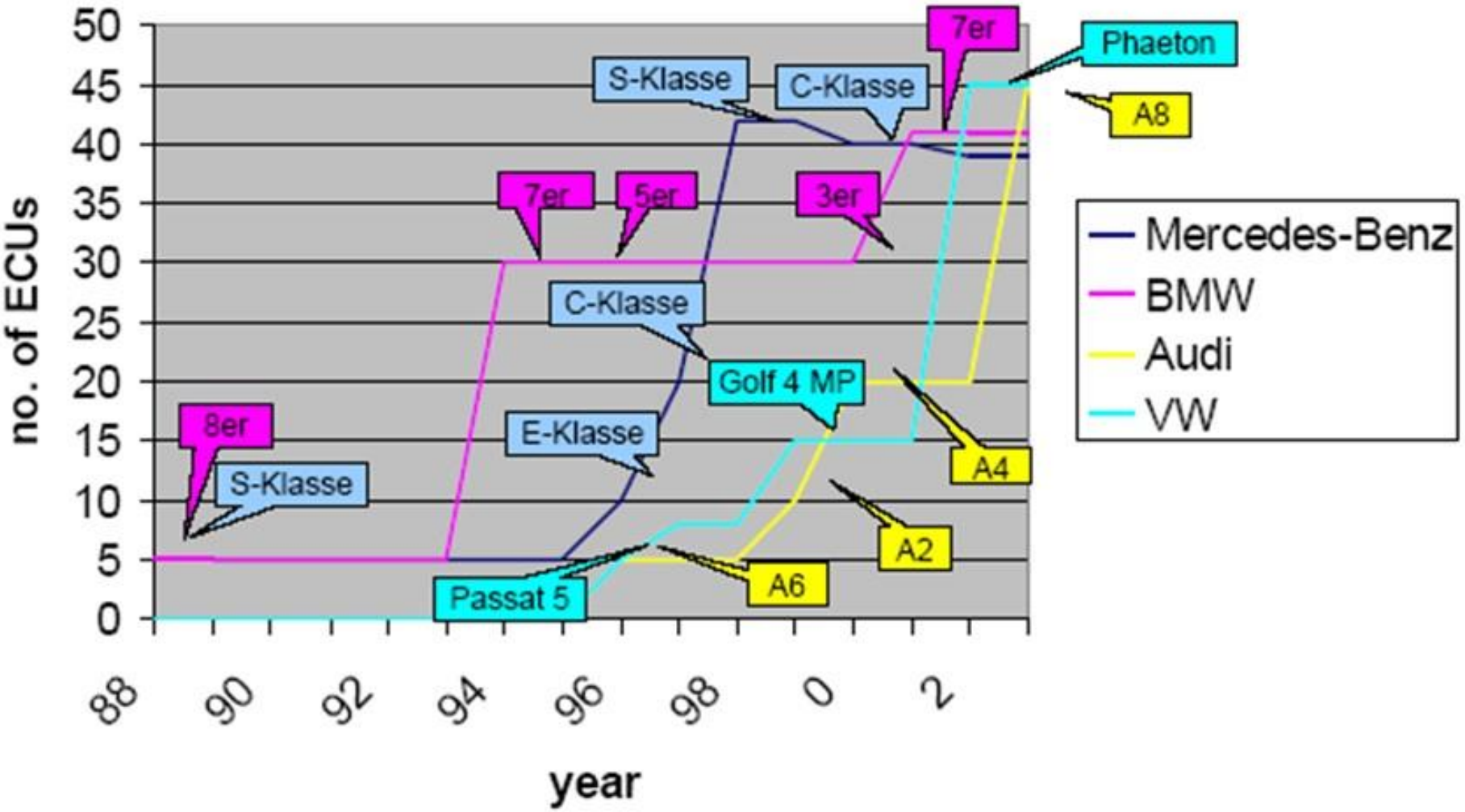
Comfort/convenience

- Cruise control
- Adaptive cruise control (ACC)
- Heating and air-conditioning
- Seat adjustment with position memory
- Power-window and -sunroof drive
- Central locking
- Chassis control system
- Back-up monitoring
- Parking-aid assistant (Parktronic)

UAE0856-1E

2 Number of control units in the Mercedes S-class that are networked via CAN




no. of ECUs
50
45
40
35
30
25
20
15
10
5
0
88
90
92
94
96
98
0
2
year
8er
S-Klasse
7er
5er
3er
S-Klasse
C-Klasse
7er
Phaeton
A8
C-Klasse
Golf 4 MP
E-Klasse
A4
A2
Passat 5
A6
Mercedes-Benz
BMW
Audi
VW

VW Phaeton:

- 11.136 electrical parts in total

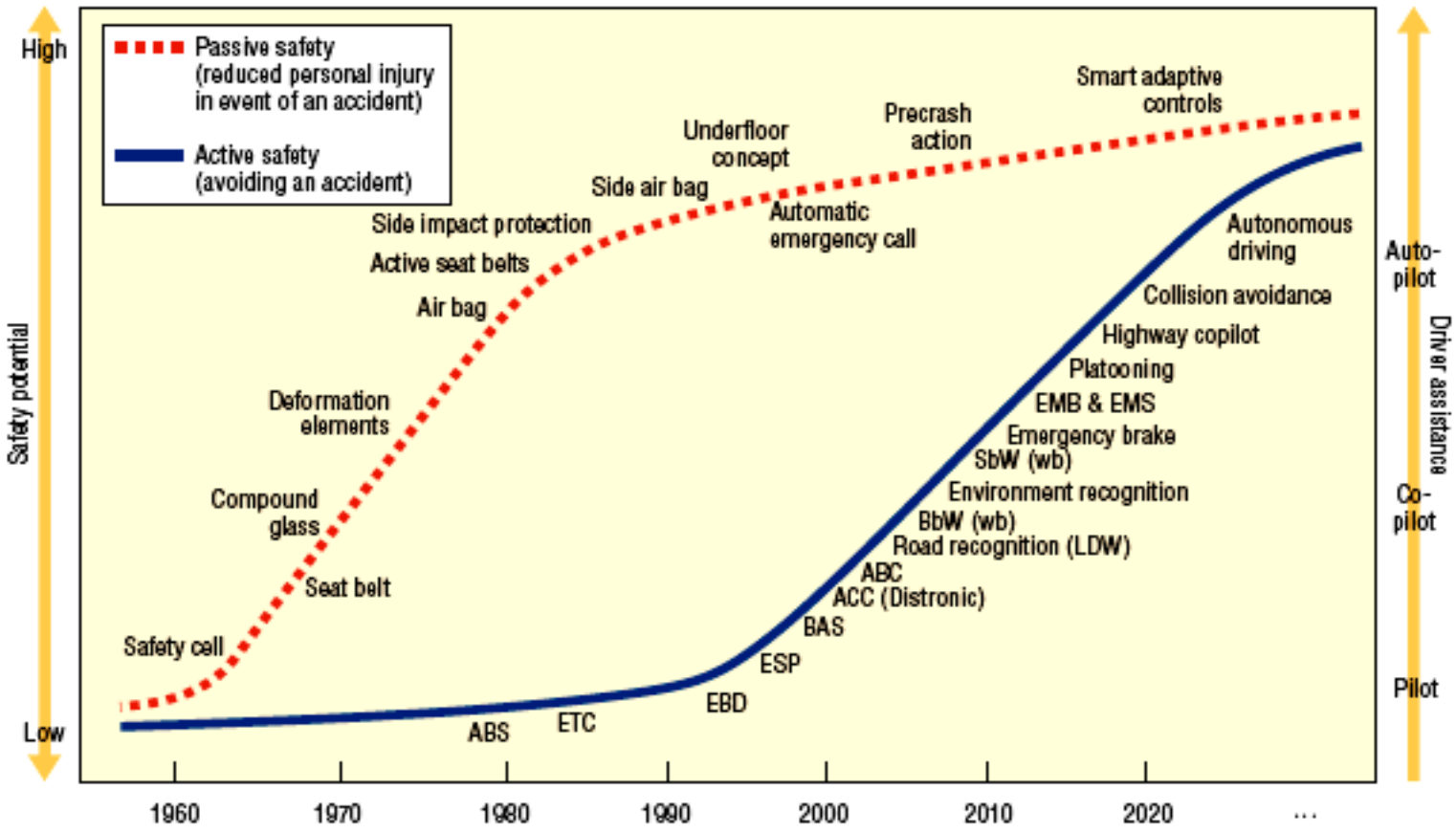
communication:

- **61 ECUs in total**
- external diagnosis for 31 ECUs via serial communication
- optical bus for high bandwidth Infotainment-data
- **sub-networks** based on proprietary serial bus
- **35 ECUs** connected by **3 CAN-busses**

sharing

- appr. **2500 signals**
- in **250 CAN messages**

Increasing of ECSs is mandatory !!!

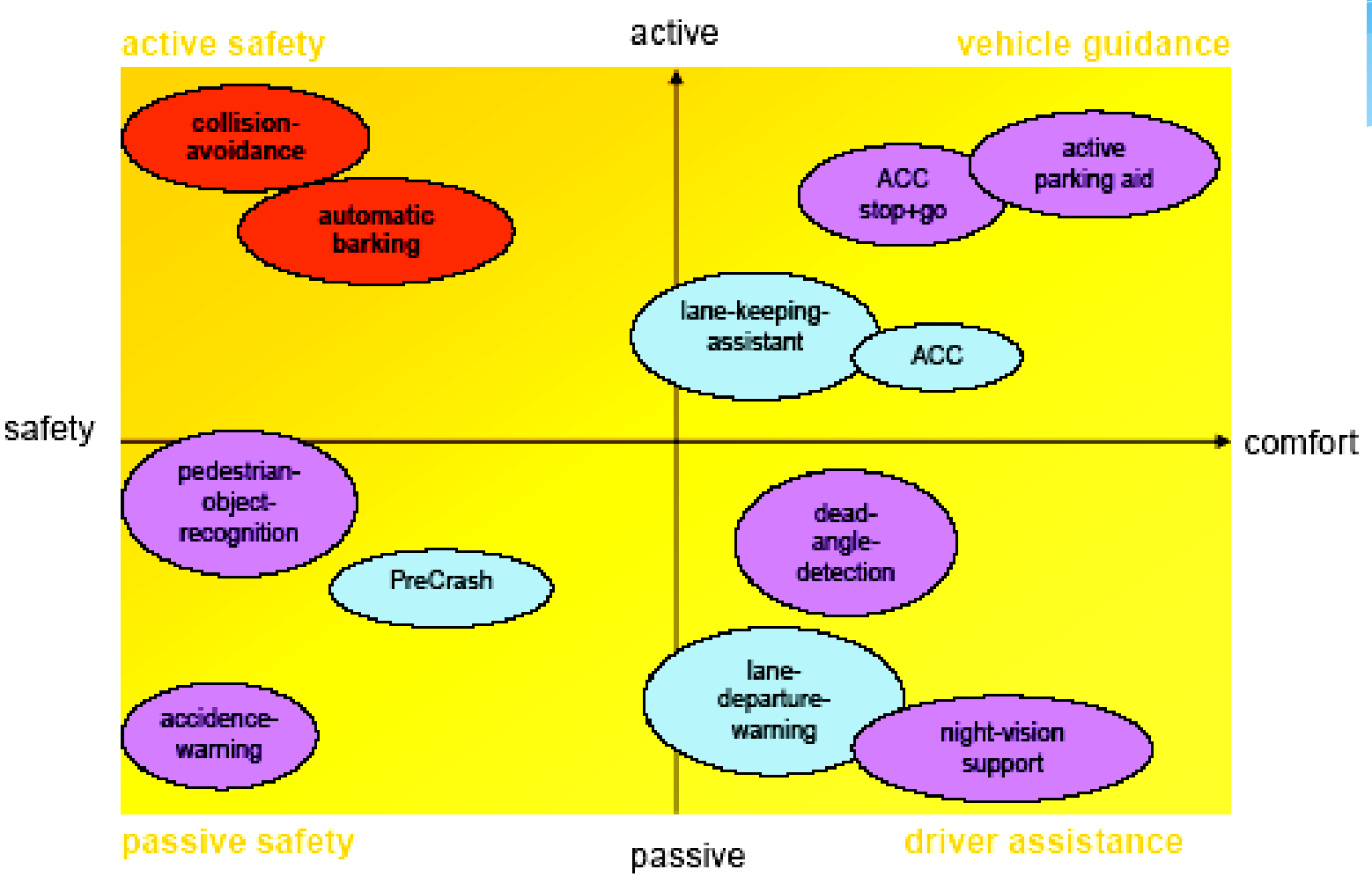


ABC	Active body control	EBD	Electronic brakeforce distribution
ABS	Antilock brake system	EMB	Electromechanical brakes
ACC	Adaptive cruise control	EMS	Electromechanical steering
BAS	Brake assist system	ESP	Electronic stability program
BbW	Brake by wire	ETC	Electronic traction control
CA	Collision avoidance	SbW	Steer by wire
DbW	Drive by wire	(wb)	with mechanical backup

Evolution of automotive electronics

	1960	1970	1980	1990	2000	2010
Drivetrain	• Ignition	• Fuel Injection	• Enginecontrol Otto	• Valve control • Diesel pump • Slip control	• FSI • Pumpe-Düse-ECU • 32bit Controller • Hybrid	• electromagn. Valves? Fuel cell •
Chassis			• ABS • controlled Damping	• ESP • Bremsassistent	• Autom. Cruise Control • ACC Stop+go • Lenkhilfe • Überlagerungslenkung • skyhook-control • Wankausgleich	• elektrohydr. Brake • brake-by-wire? • autom.emerg. stop • UVF? • steer-by-wire?
Safety			• Airbag		• 2step Airbags • byteflight • precrash	• Pedestrian Protect.
Comfort	• intervall Wiper		• Climate control	• Xenon-lights	• Keyless Entry• advanced frontlighting • 2Motor-Wiper	
Power+Wirung	• 12V		• CAN	• D2B .watercooled.Generator • • elektron. ZE	• MOST,LIN • TTP/Flexray • Startergenerator • APU? • power module • 42V?.	
Information	• Radio		• Trip computer	• Sound systems • TV Satellite radio• • GSM • GPS Navigation	• Infotainment • DAB • bluetooth • UMTS • Internet	• Veh.-Veh.-Comm.

GOAL ?


active safety
active
vehicle guidance
collision-avoidance
automatic barking
ACC stop+go
active parking aid
lane-keeping-assistant
ACC
safety
comfort
pedestrian-object-recognition
PreCrash
dead-angle-detection
lane-departure-warning
night-vision support
accidence-warning
passive safety
passive
driver assistance

تهیه و تنظیم : بهروز خطیبی

سنسورهاي دماي آب

مديريت سوخت رساني و جرقه

کنترل یونیت فن یا رله هاي فن

نشاندهنده دماي آب موتور

تهیه و تنظیم : بهروز خطیبی

Analog – Digital

Open loop - Close loop

Node

BUS

Protocol

Gateway

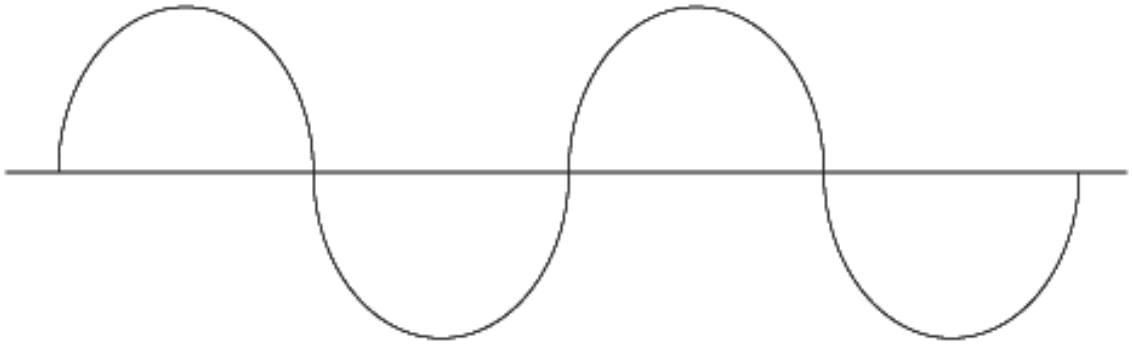
Master-slave

Multi-master

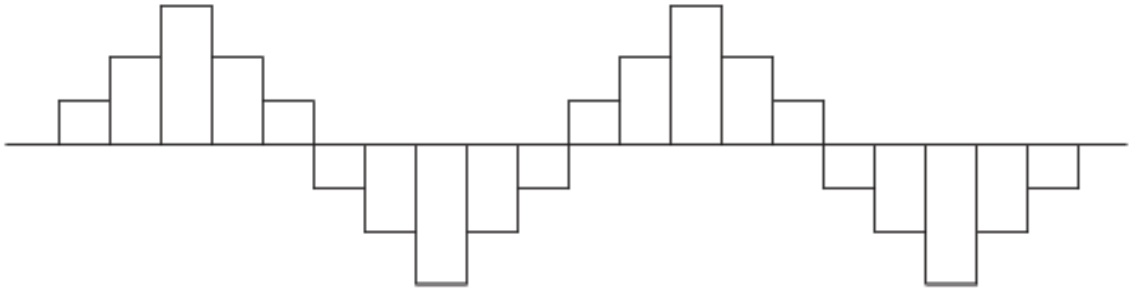
Topology

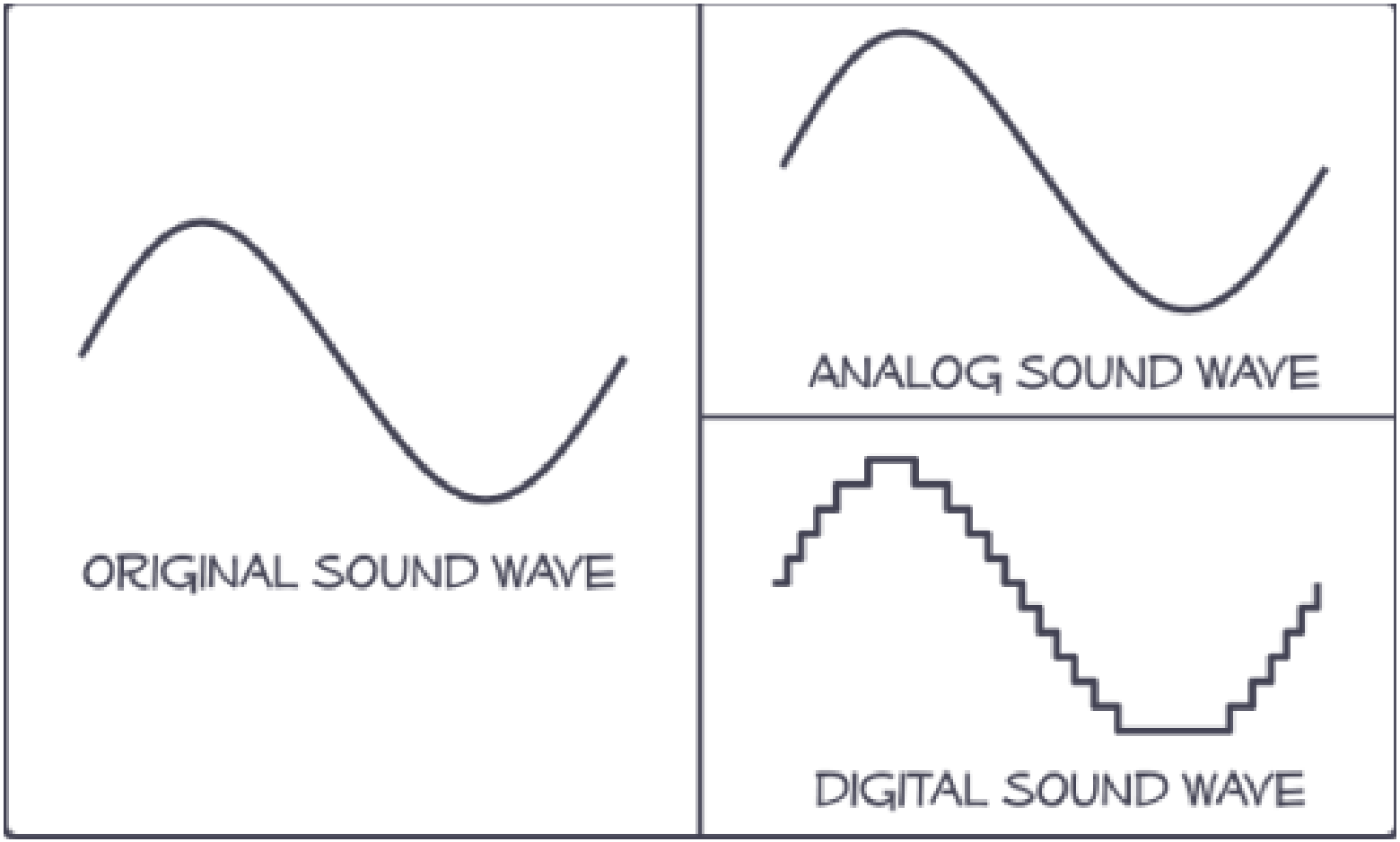
تهیه و تنظیم : بهروز خطیبی

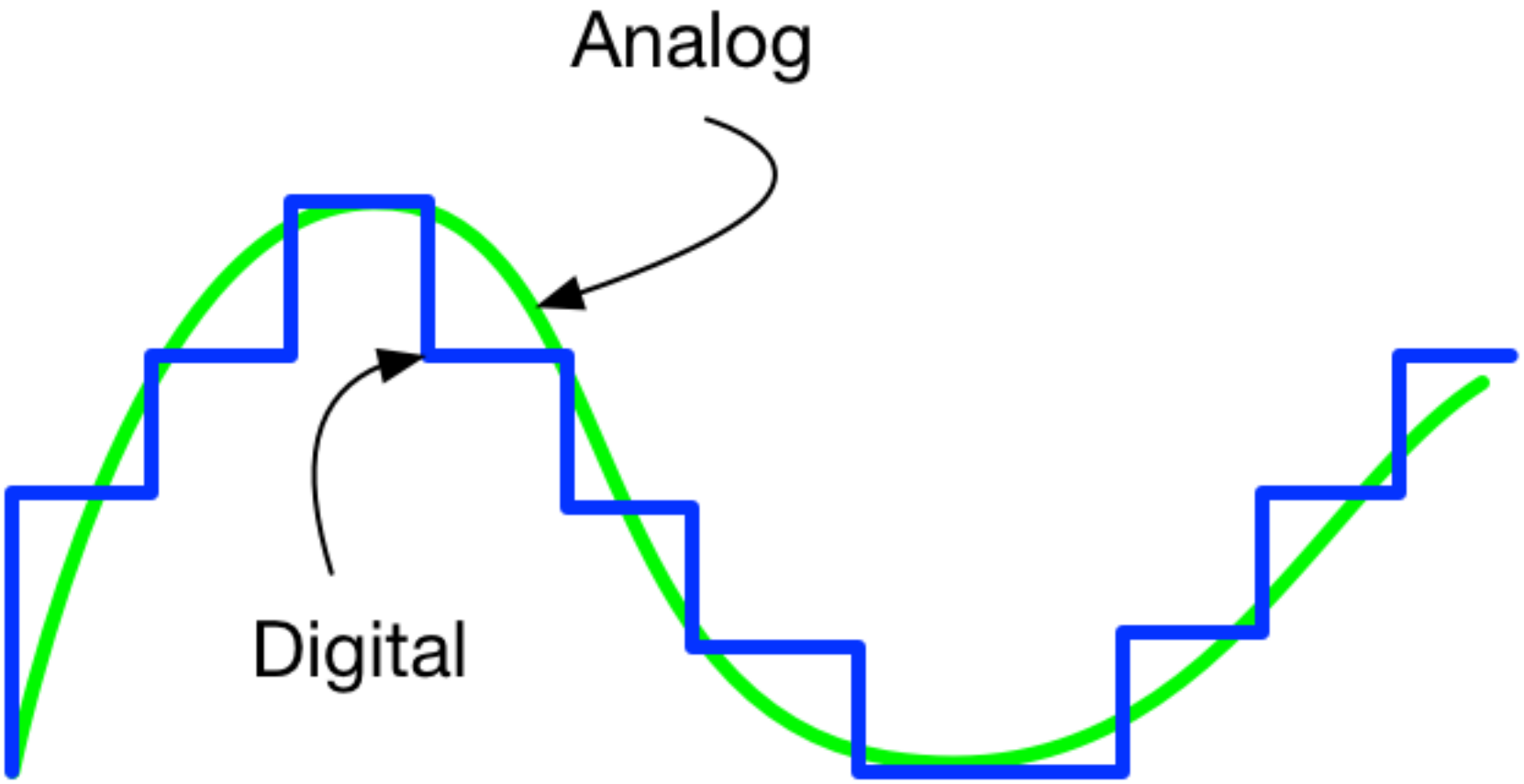
Analog

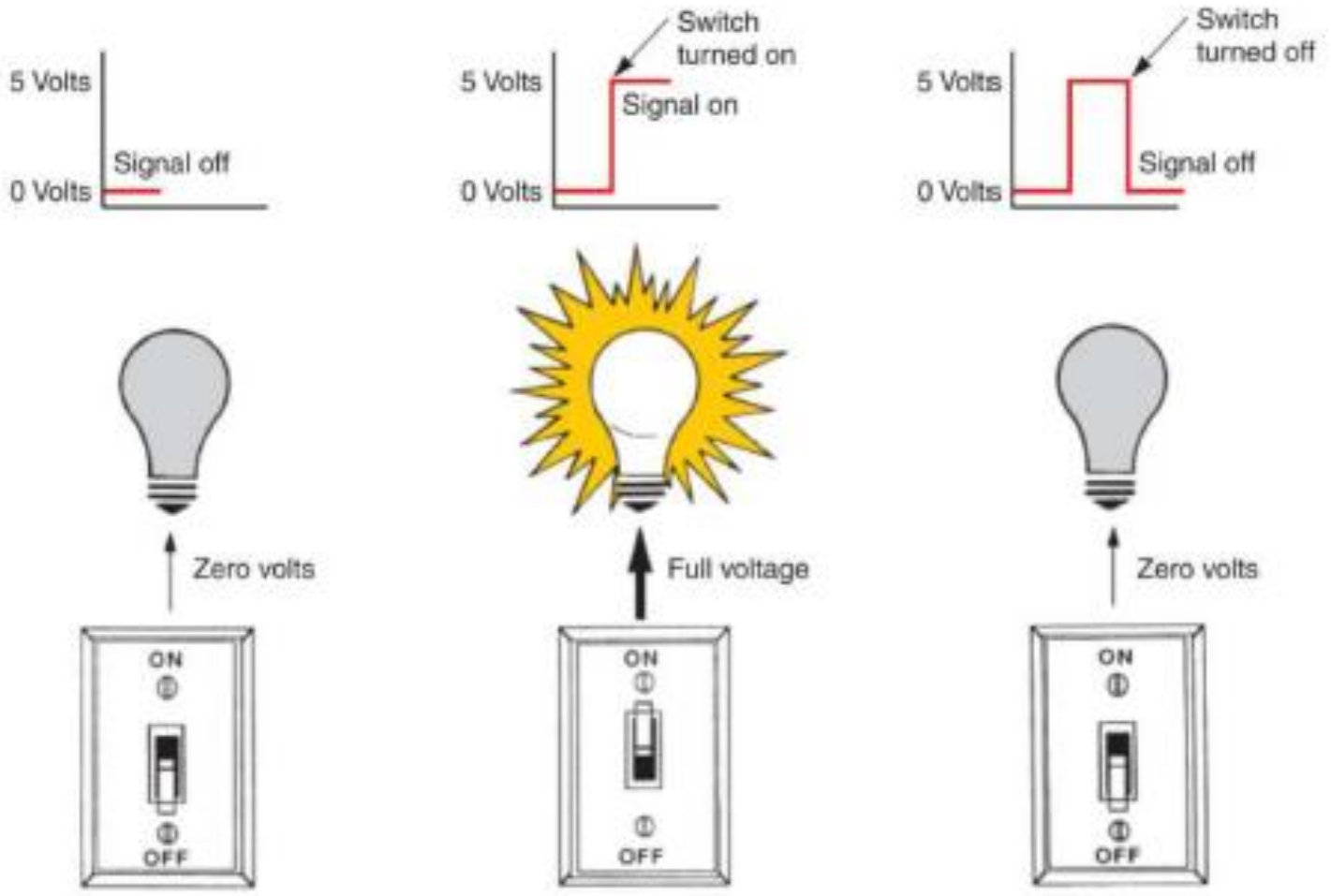


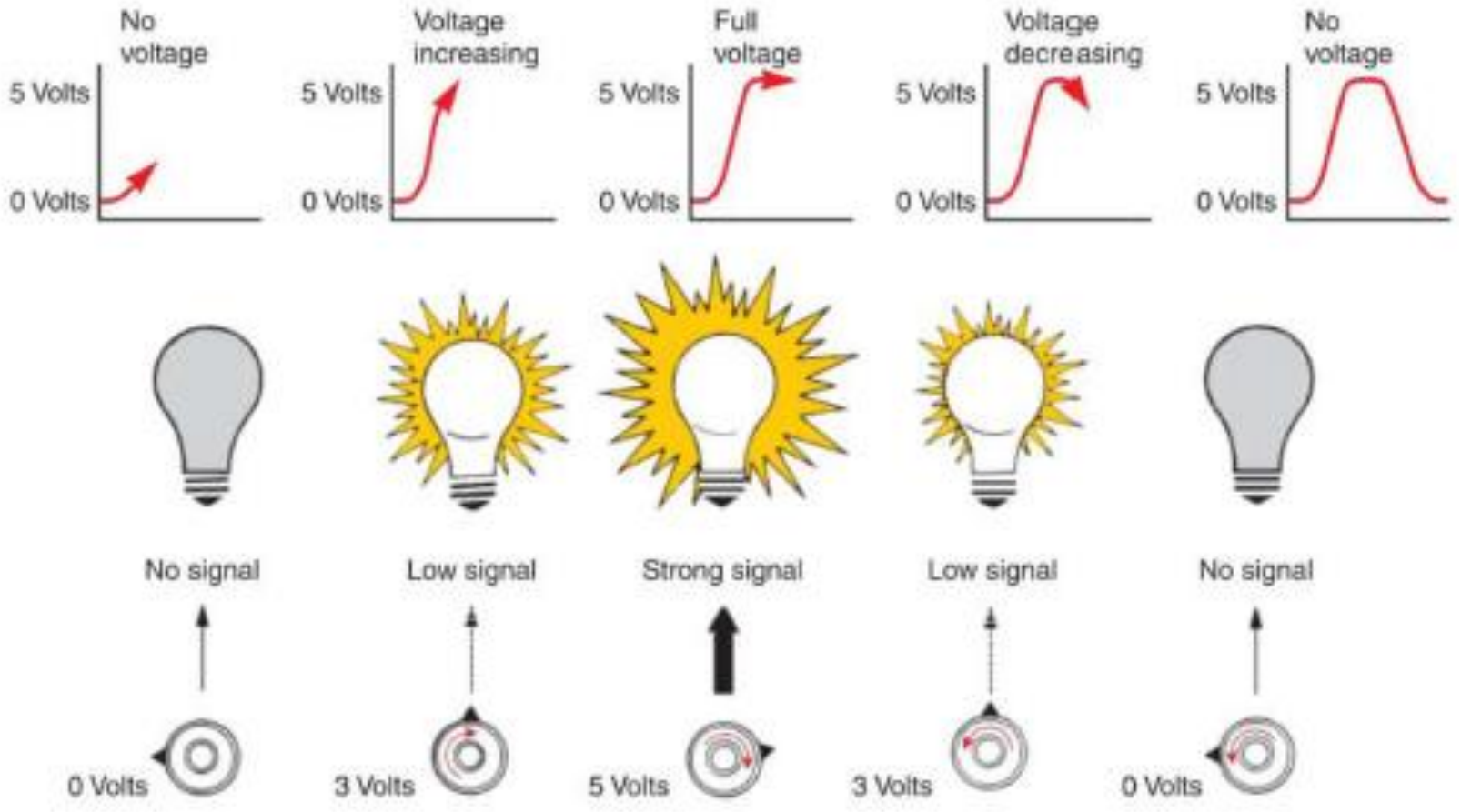
Digital

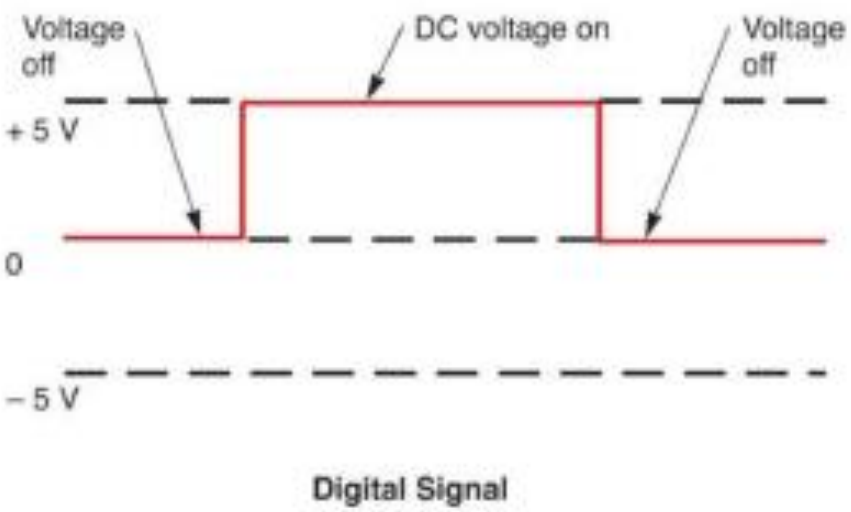



ORIGINAL SOUND WAVE
ANALOG SOUND WAVE
DIGITAL SOUND WAVE

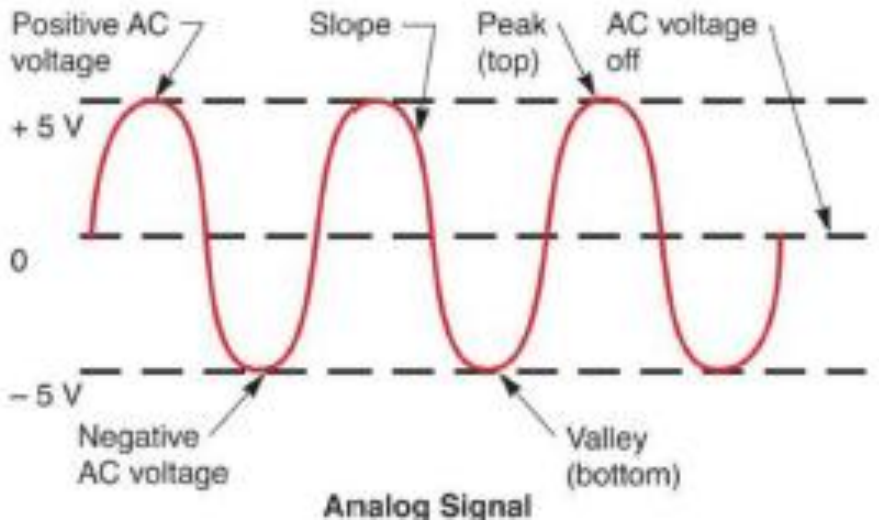

Analog
Digital


5 Volts
0 Volts
Signal off
Switch turned on
5 Volts
0 Volts
Signal on
Switch turned off
5 Volts
0 Volts
Signal off
Zero volts
ON
OFF
Full voltage
ON
OFF
Zero volts
ON
OFF
A

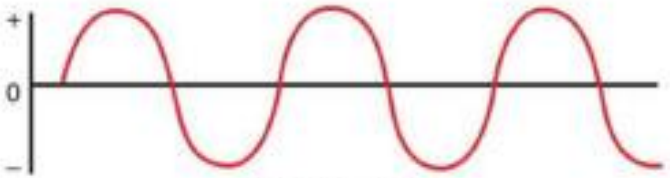

No voltage
5 Volts
0 Volts
Voltage increasing
5 Volts
0 Volts
Full voltage
5 Volts
0 Volts
Voltage decreasing
5 Volts
0 Volts
No voltage
5 Volts
0 Volts
No signal
Low signal
Strong signal
Low signal
No signal
0 Volts
3 Volts
5 Volts
3 Volts
0 Volts
B



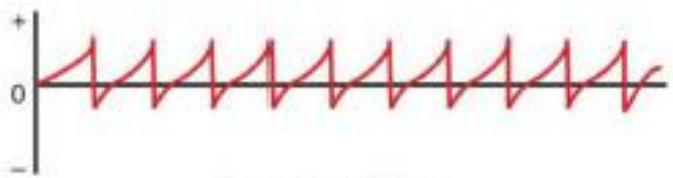
Digital Signal



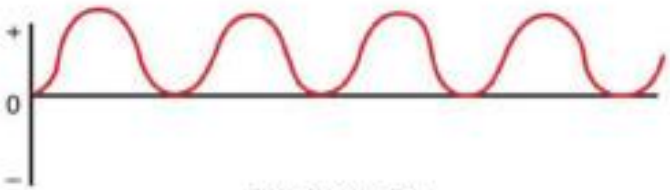
Analog Signal



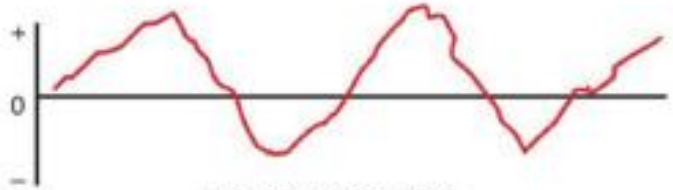
AC Sine Wave



Pulse Signal Wave



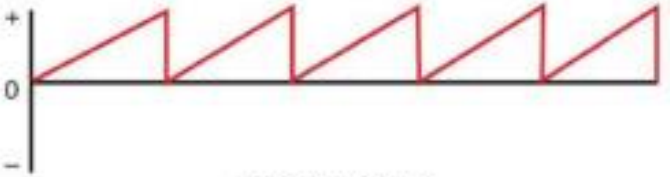
DC Sine Wave



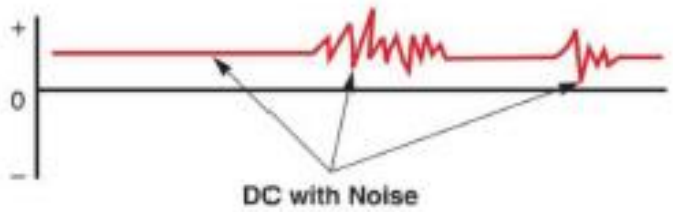
Complex Sine Wave

DC Square Wave

Voice Waves

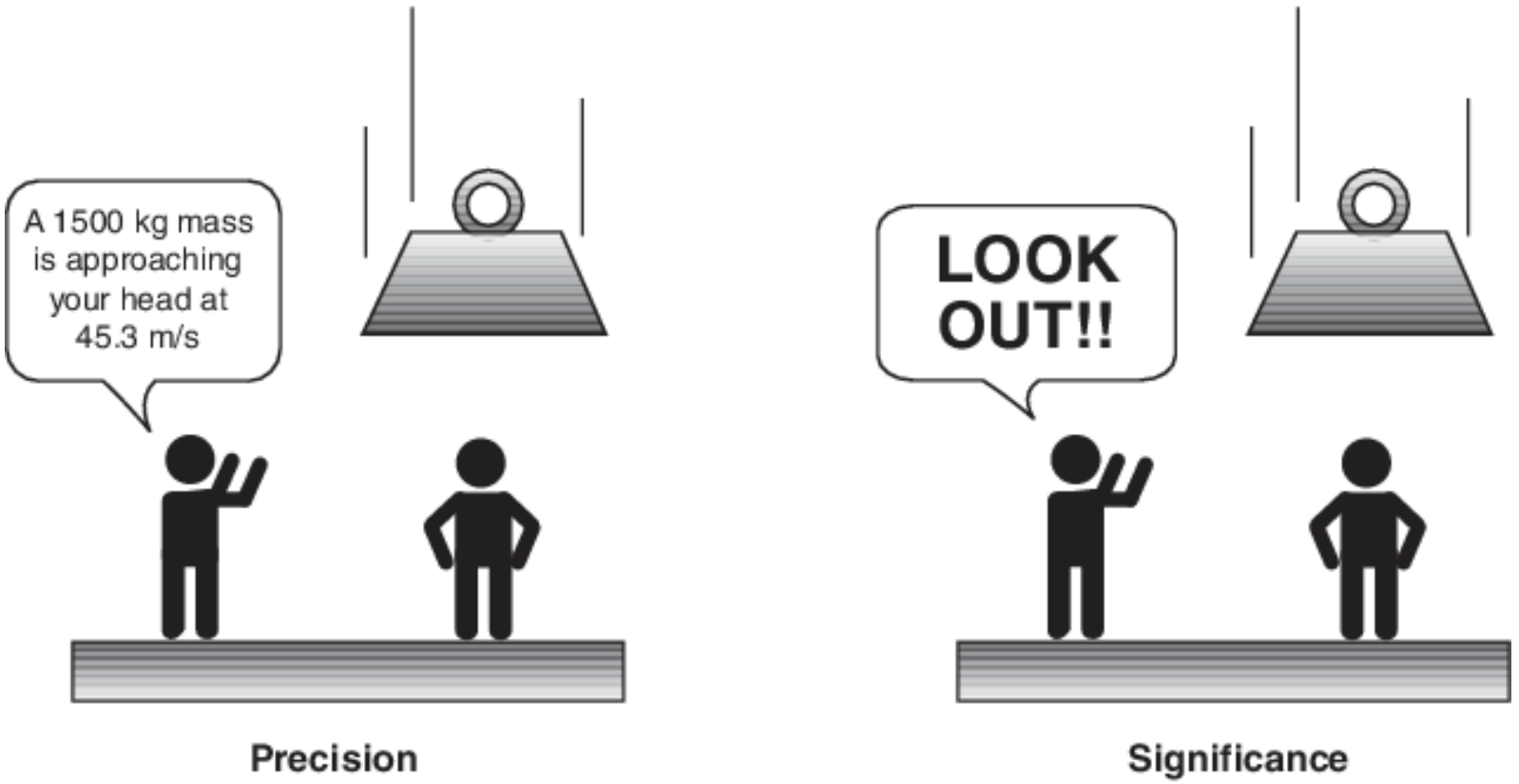


DC Ramp Wave

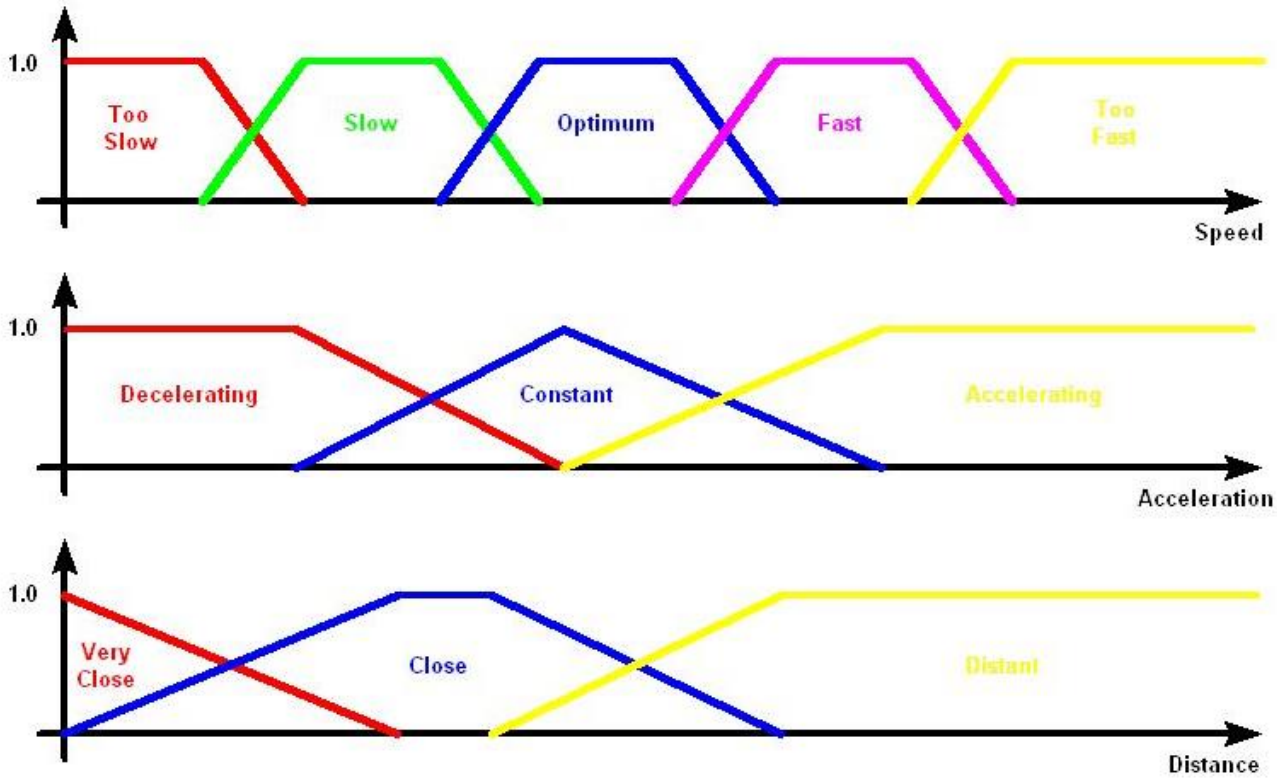


DC with Noise

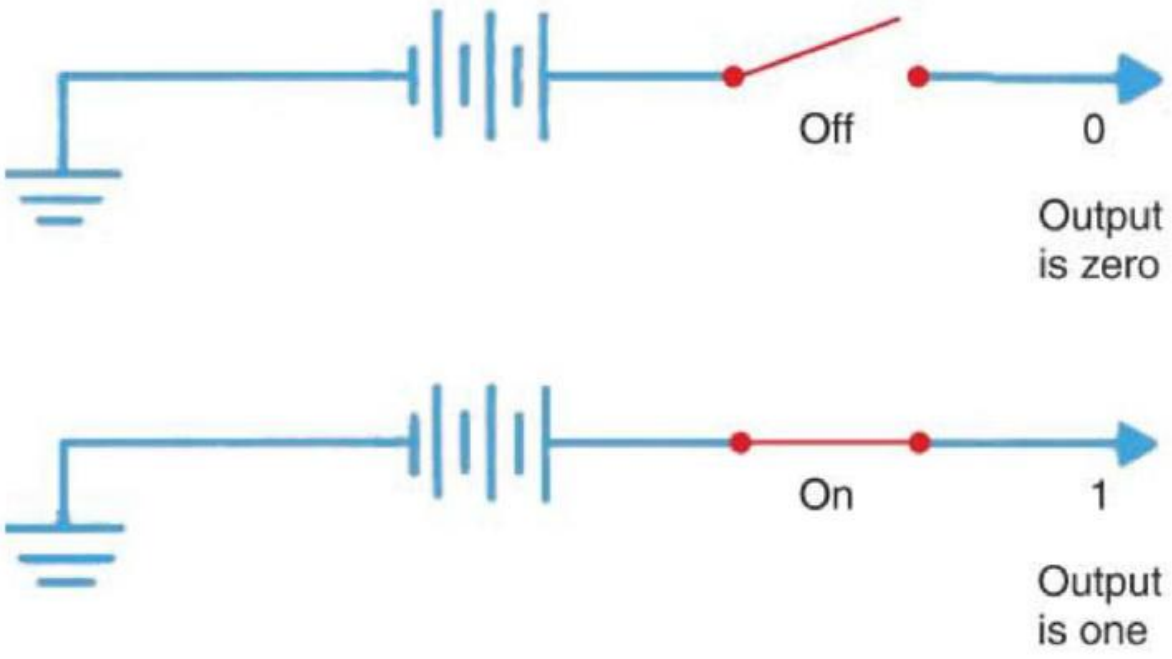
Precision and Significance in the Real World



Fuzzy Logic Example



منطق فازی : در سال پروفسور لطفی زاده در سال 1965 به دنیا معرفی شد.

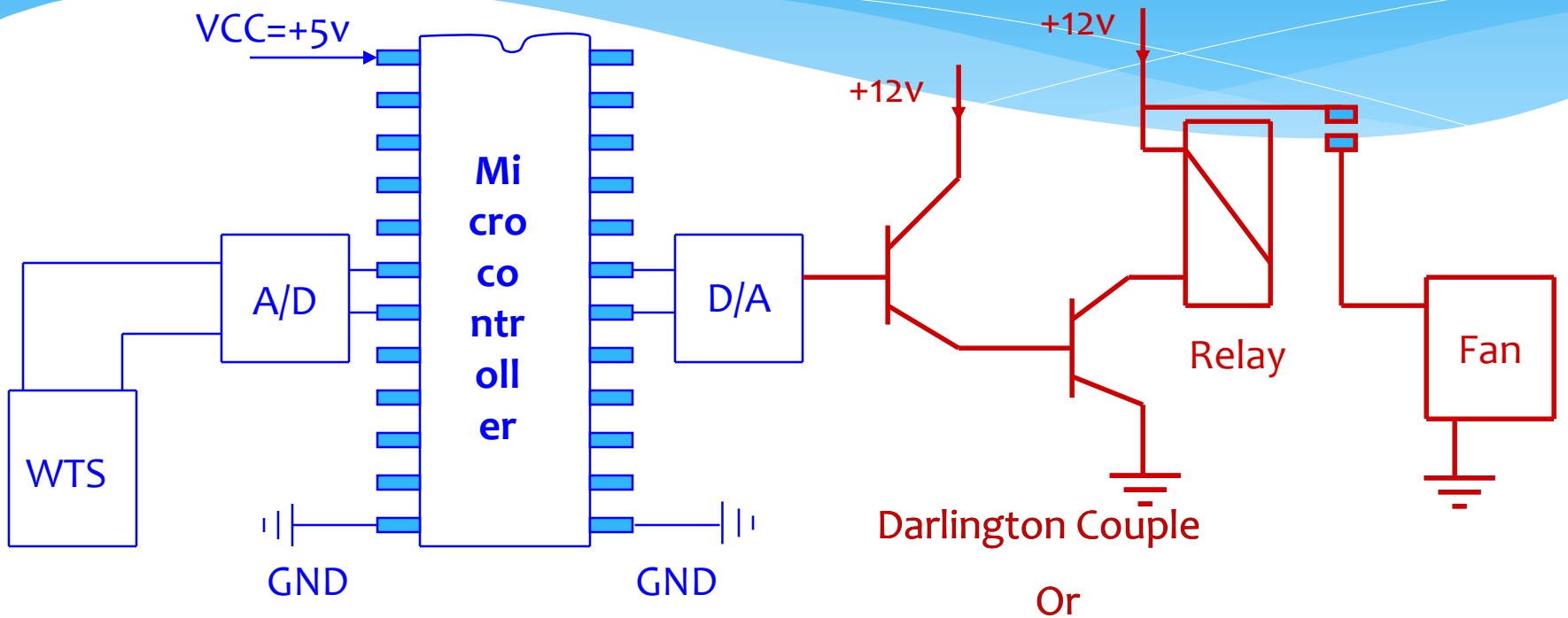


Goodheart-Willcox Publisher

Figure 23-2. Since electronic components can be either on or off, the binary numbering system is ideal for digital logic and computer circuits. The binary system has only two numbers, zero and one, which represent off and on conditions.

Microcontroller

It can programmed by software like Code Vision



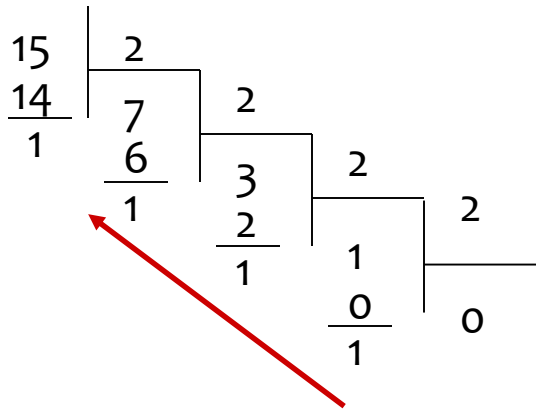
Control Unit

Power Unit

A/D & D/A Converter

A/D Converter

15 = 1111



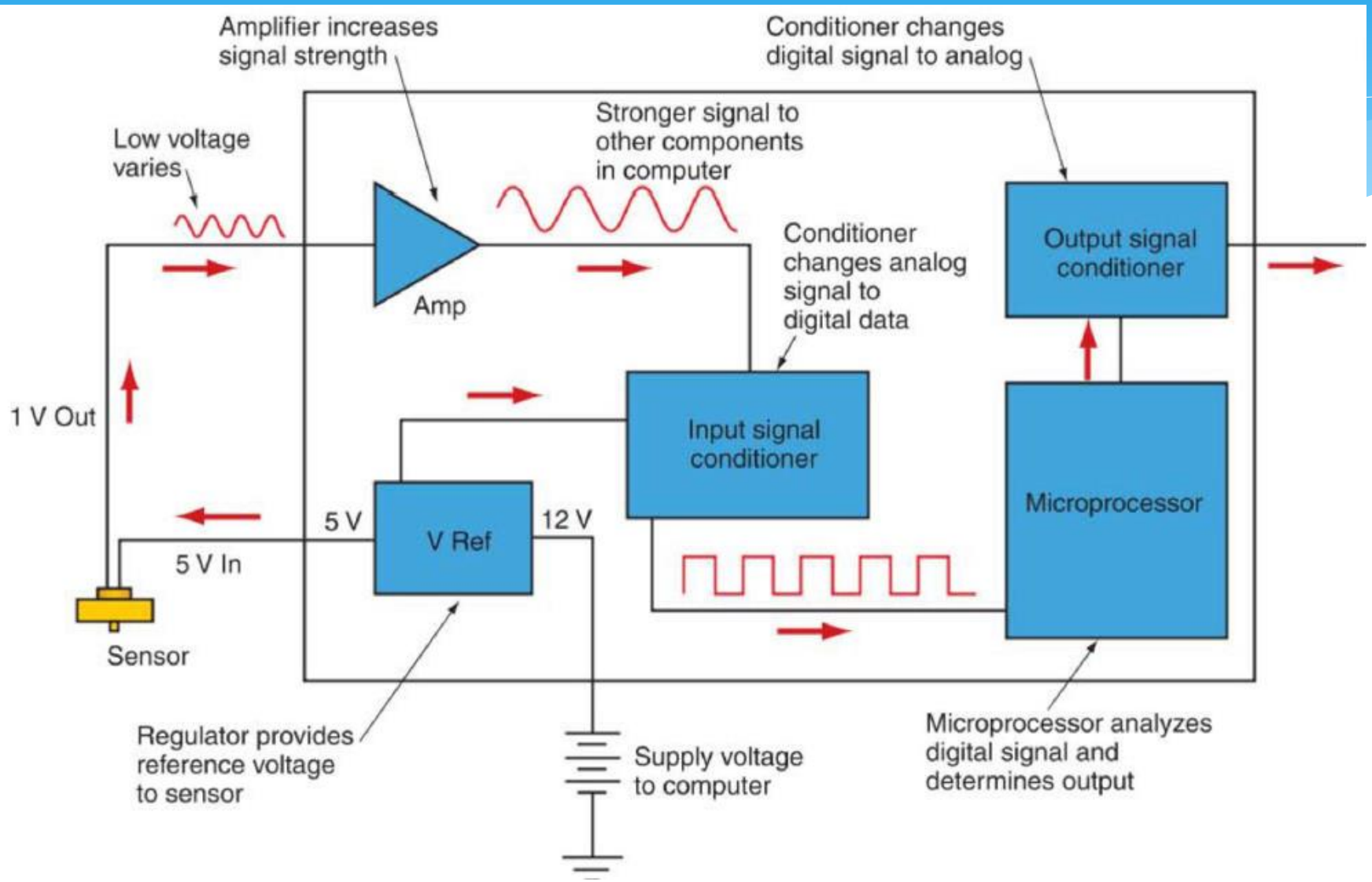
D/A Converter

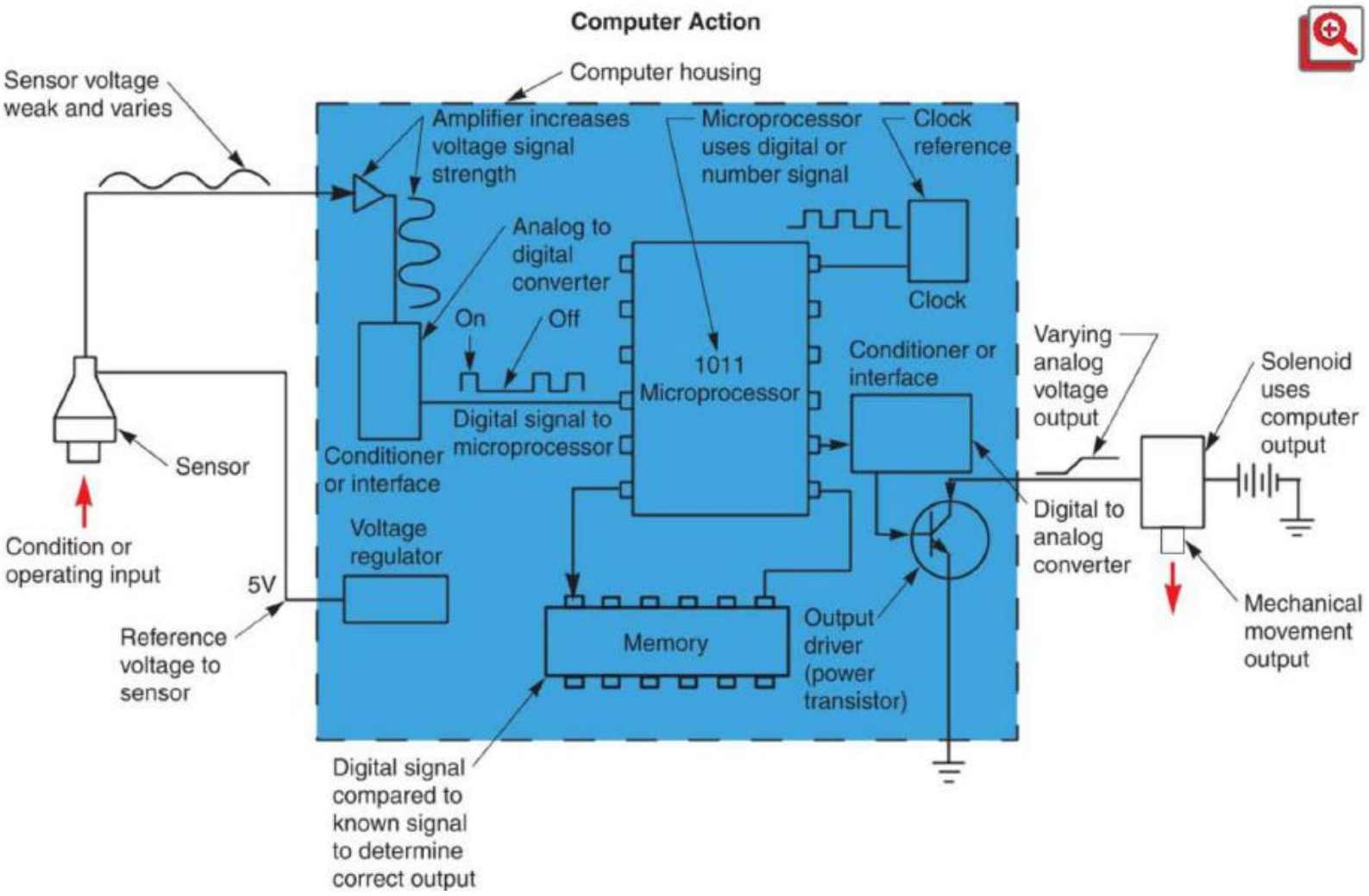
1111

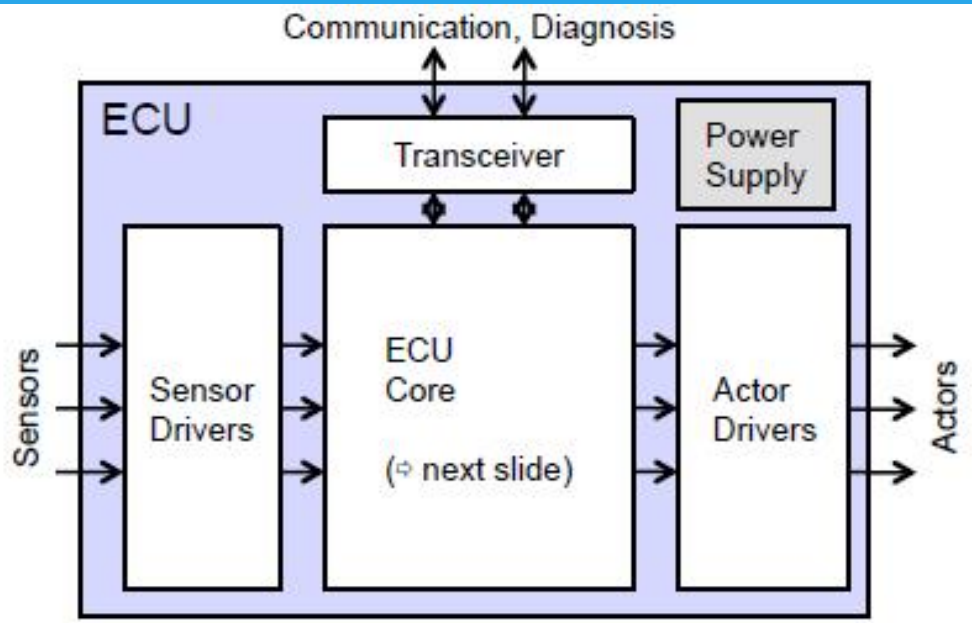
$$1*2^0+1*2^1*1*2^2+1*2^3=15$$

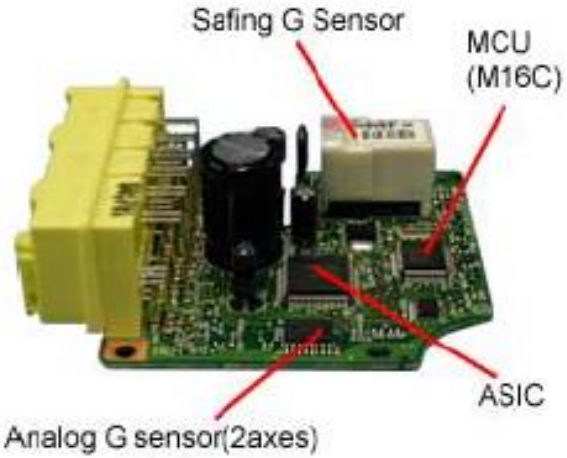
تهیه و تنظیم : بهروز خطیبی

Decimal number	Binary number code 8 4 2 1	Binary to decimal conversion
0	0 0 0 0	= 0 + 0 + 0 + 0 = 0
1	0 0 0 1	= 0 + 0 + 0 + 1 = 1
2	0 0 1 0	= 0 + 0 + 2 + 0 = 2
3	0 0 1 1	= 0 + 0 + 2 + 1 = 3
4	0 1 0 0	= 0 + 4 + 0 + 0 = 4
5	0 1 0 1	= 0 + 4 + 0 + 1 = 5
6	0 1 1 0	= 0 + 4 + 2 + 0 = 6
7	0 1 1 1	= 0 + 4 + 2 + 1 = 7
8	1 0 0 0	= 8 + 0 + 0 + 0 = 8

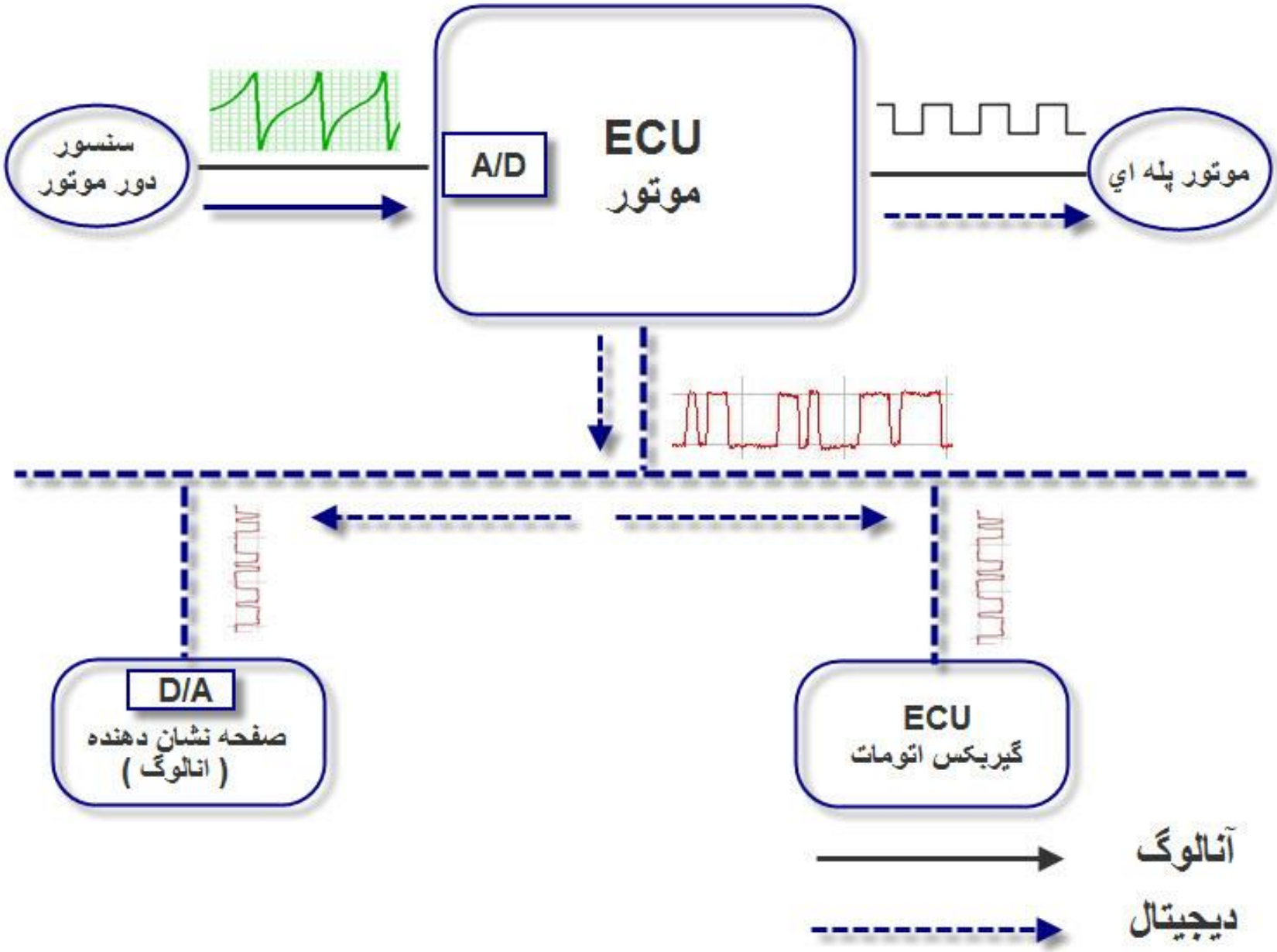



Computer Action
Computer housing
Sensor voltage weak and varies
Amplifier increases voltage signal strength
Microprocessor uses digital or number signal
Clock reference
Analog to digital converter
On
Off
Clock
1011 Microprocessor
Conditioner or interface
Varying analog voltage output
Solenoid uses computer output
Digital signal to microprocessor
Conditioner or interface
Sensor
Condition or operating input
Voltage regulator
5V
Reference voltage to sensor
Memory
Output driver (power transistor)
Digital to analog converter
Mechanical movement output
Digital signal compared to known signal to determine correct output



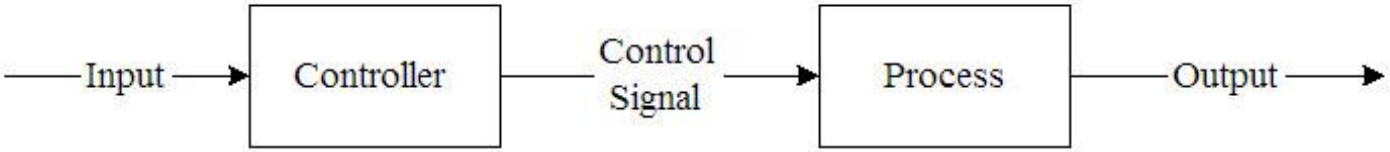


Images: Mitsubishi Electric

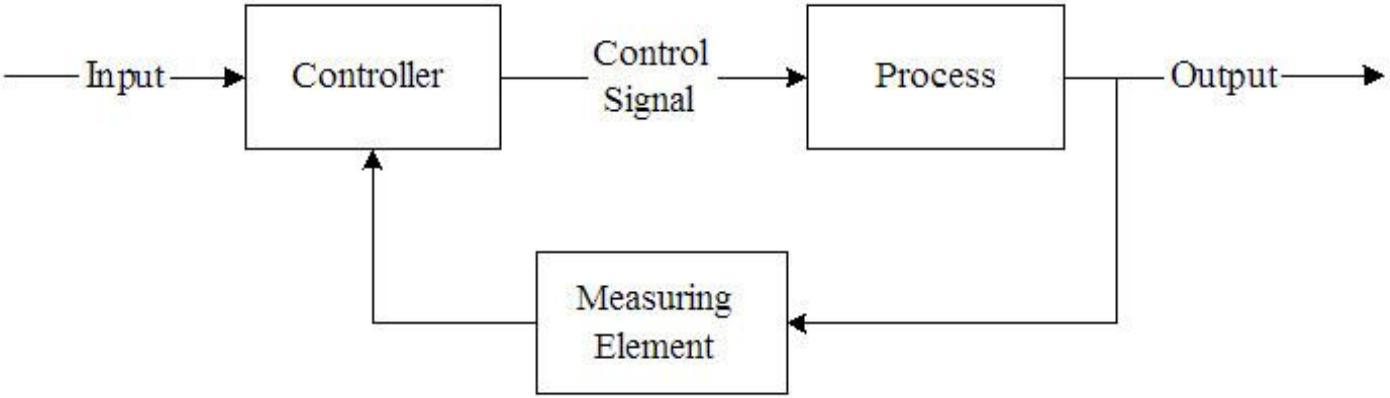


تهیه و تنظیم : بهروز خطیبی

Open Loop Control (OLC) & Close Loop Control (CLC)



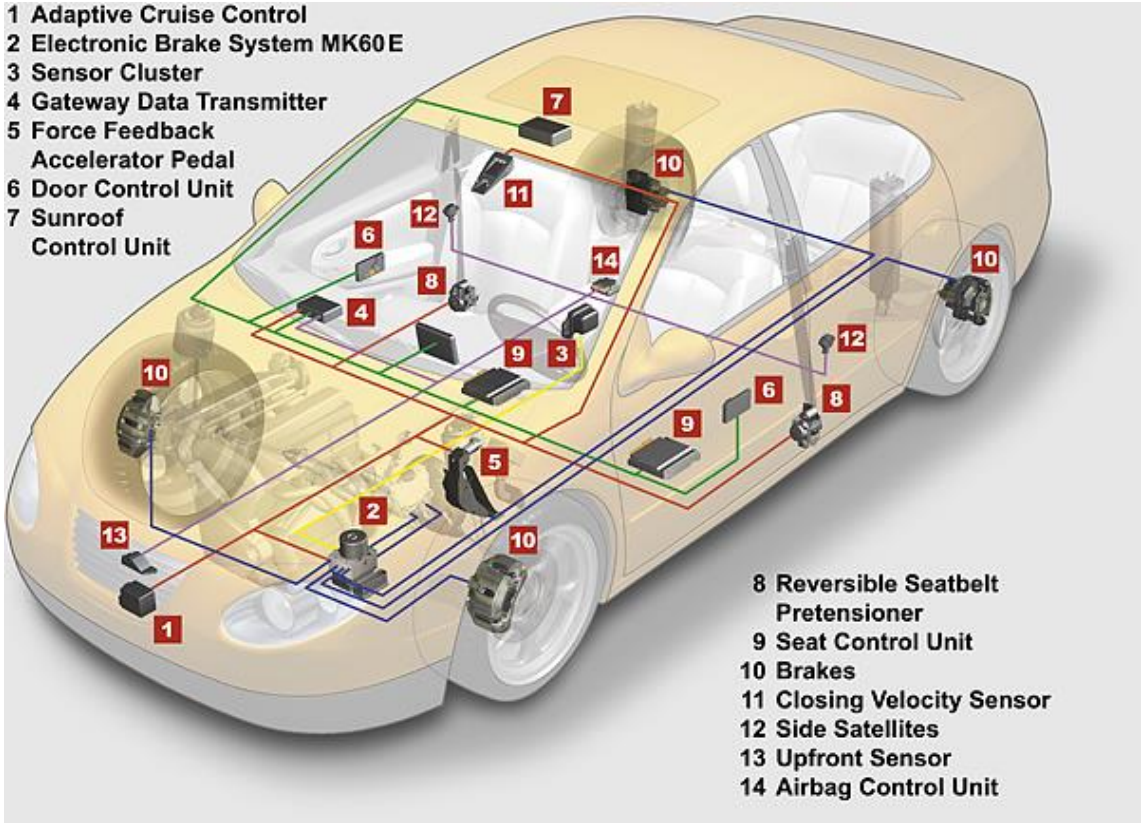
Open Loop System



Closed Loop System

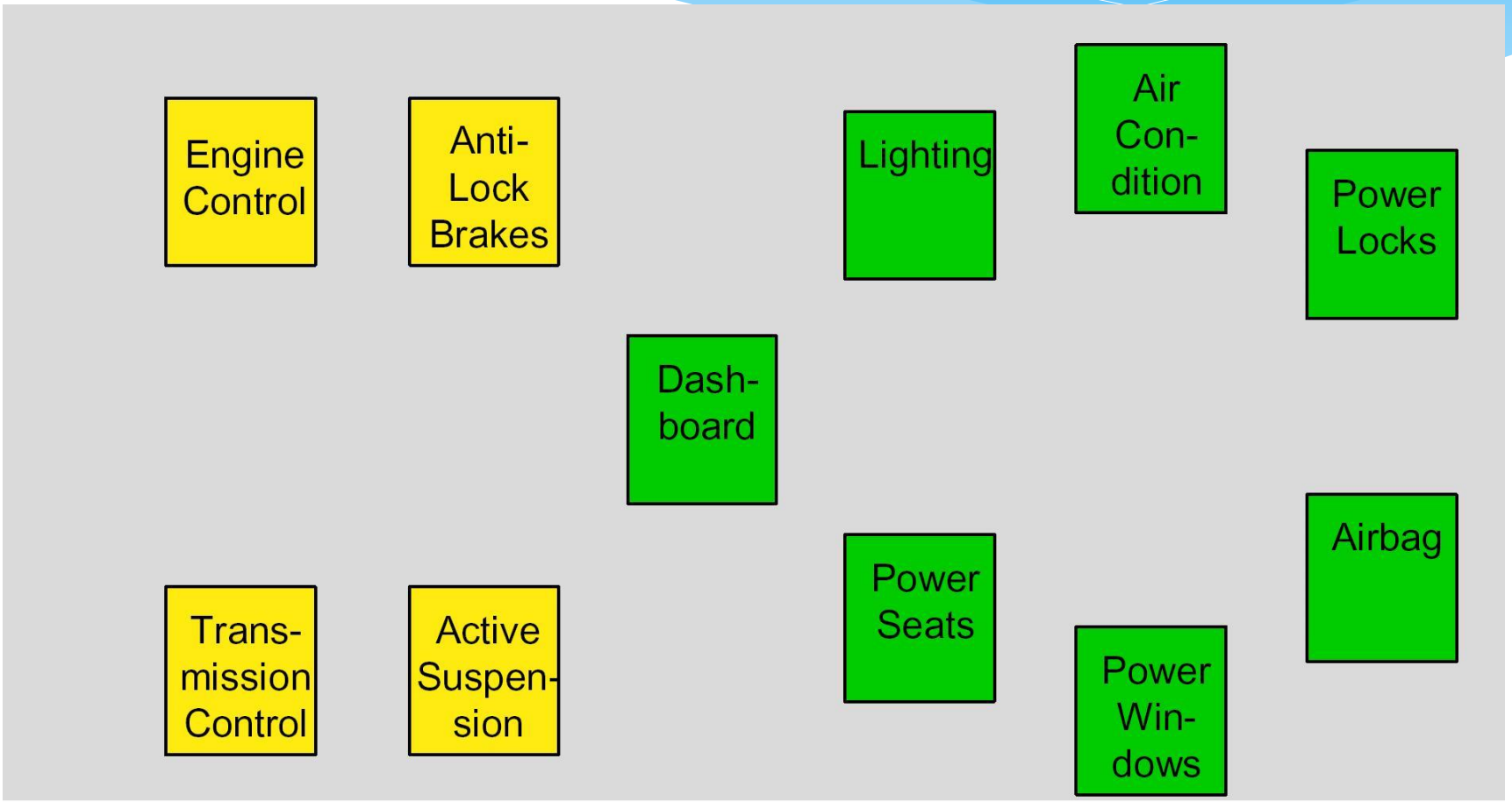
Node:
واحد های کنترل در یک شبکه نود میگویند

توجه : هر گره در شبکه نیز نود خوانده می شود



---NODE----

Some ECUs are used in the vehicle



BUS

به صورت کلی به مفهوم کانال ارتباطی شبکه

نوعی ارتباط سیمی (هندسه شبکه)

تهیه و تنظیم : بهروز خطیبی

Protocol's

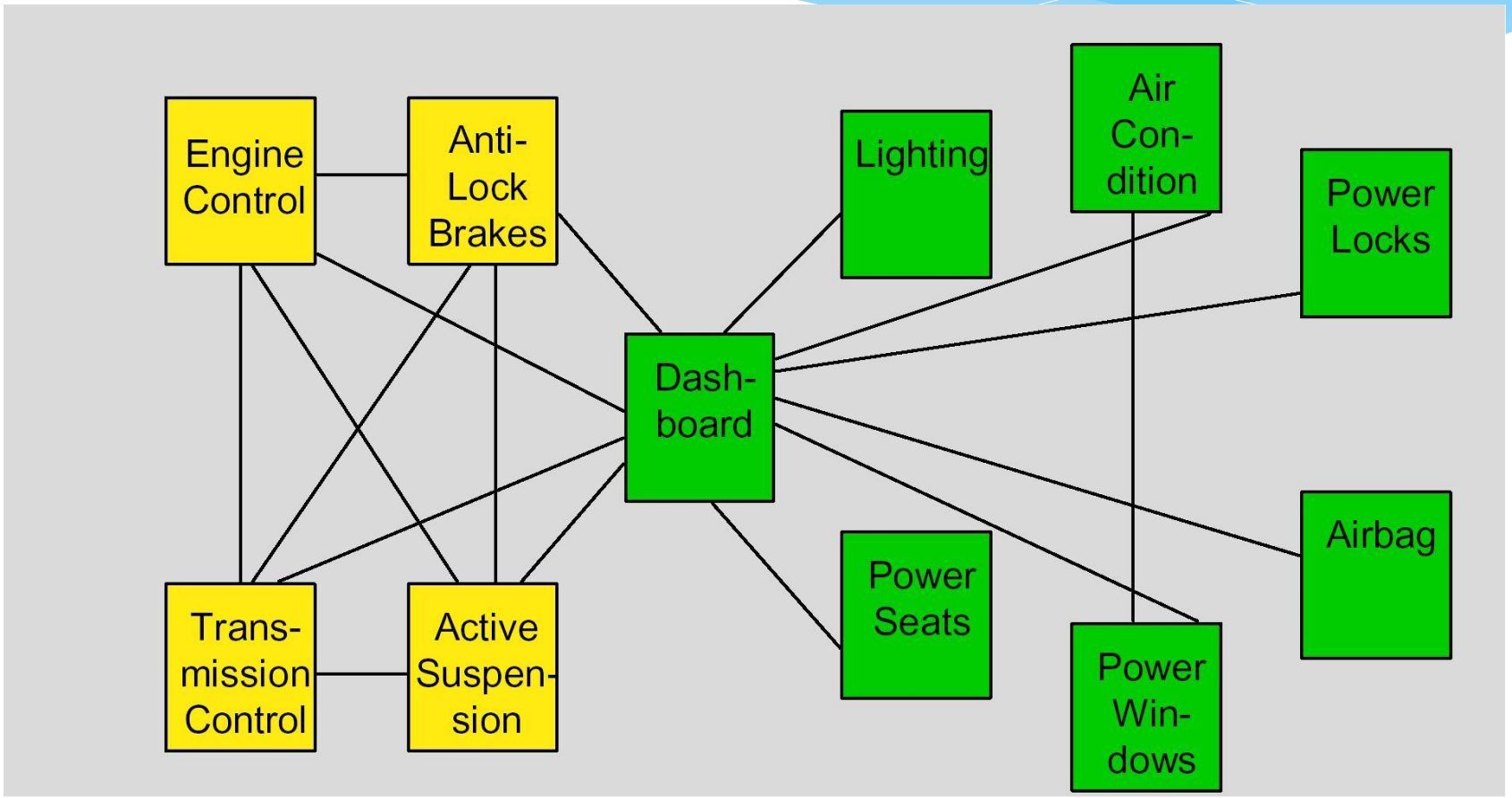
مجموعه قوانین سخت افزاری و نرم افزاری در یک شبکه

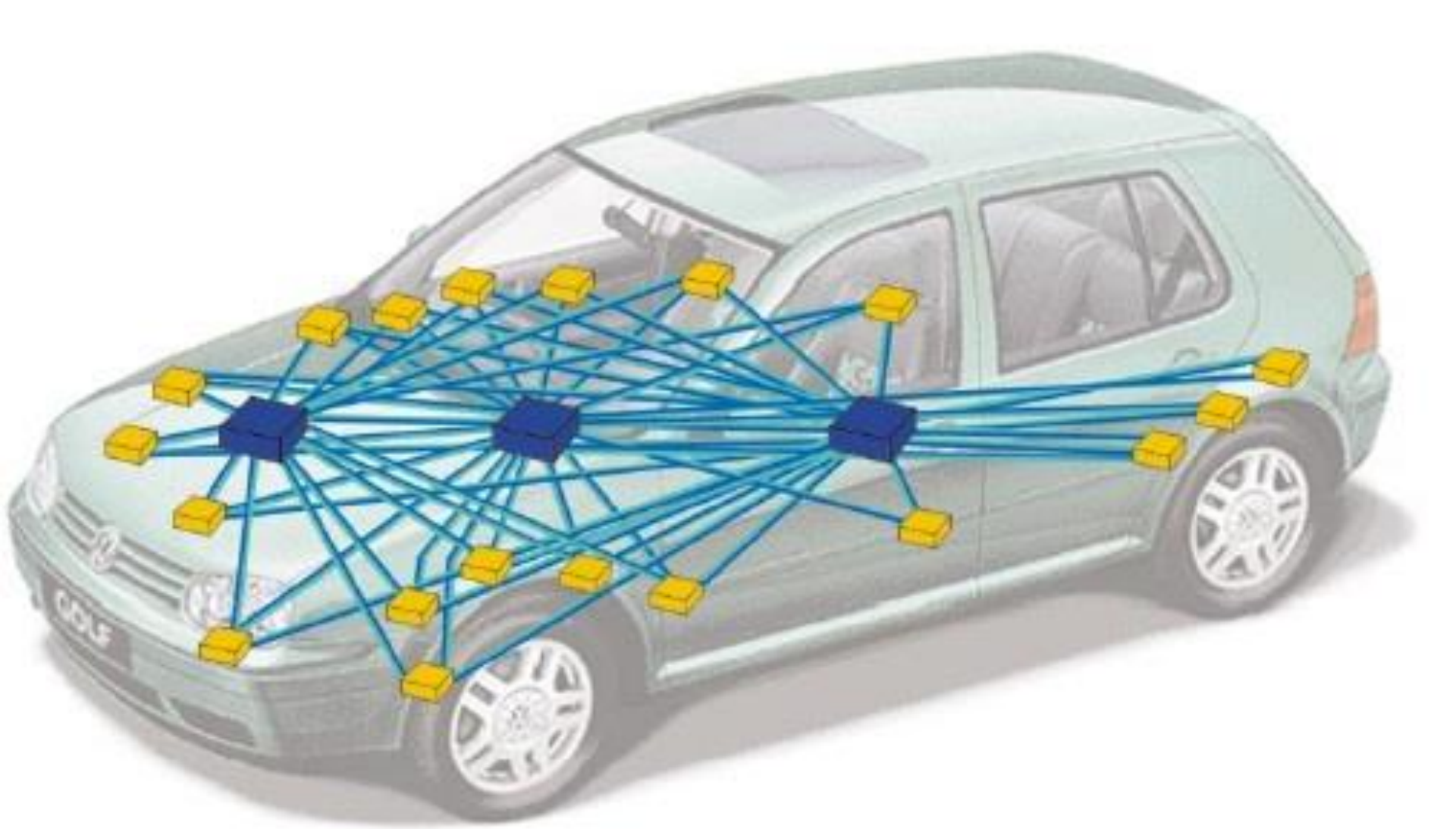
پروتکل

نامیده میشود

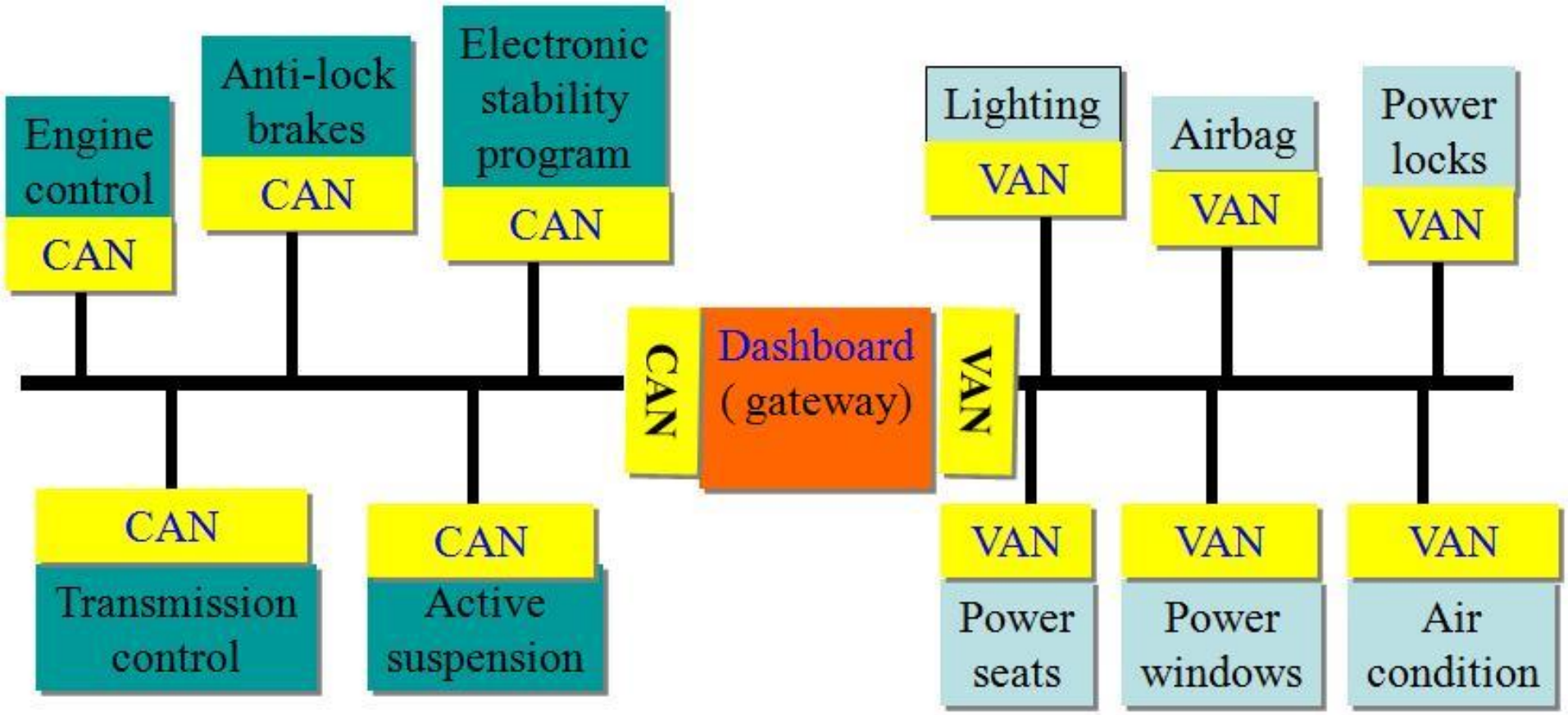
تهیه و تنظیم : بهروز خطیبی

Traditional Network connection

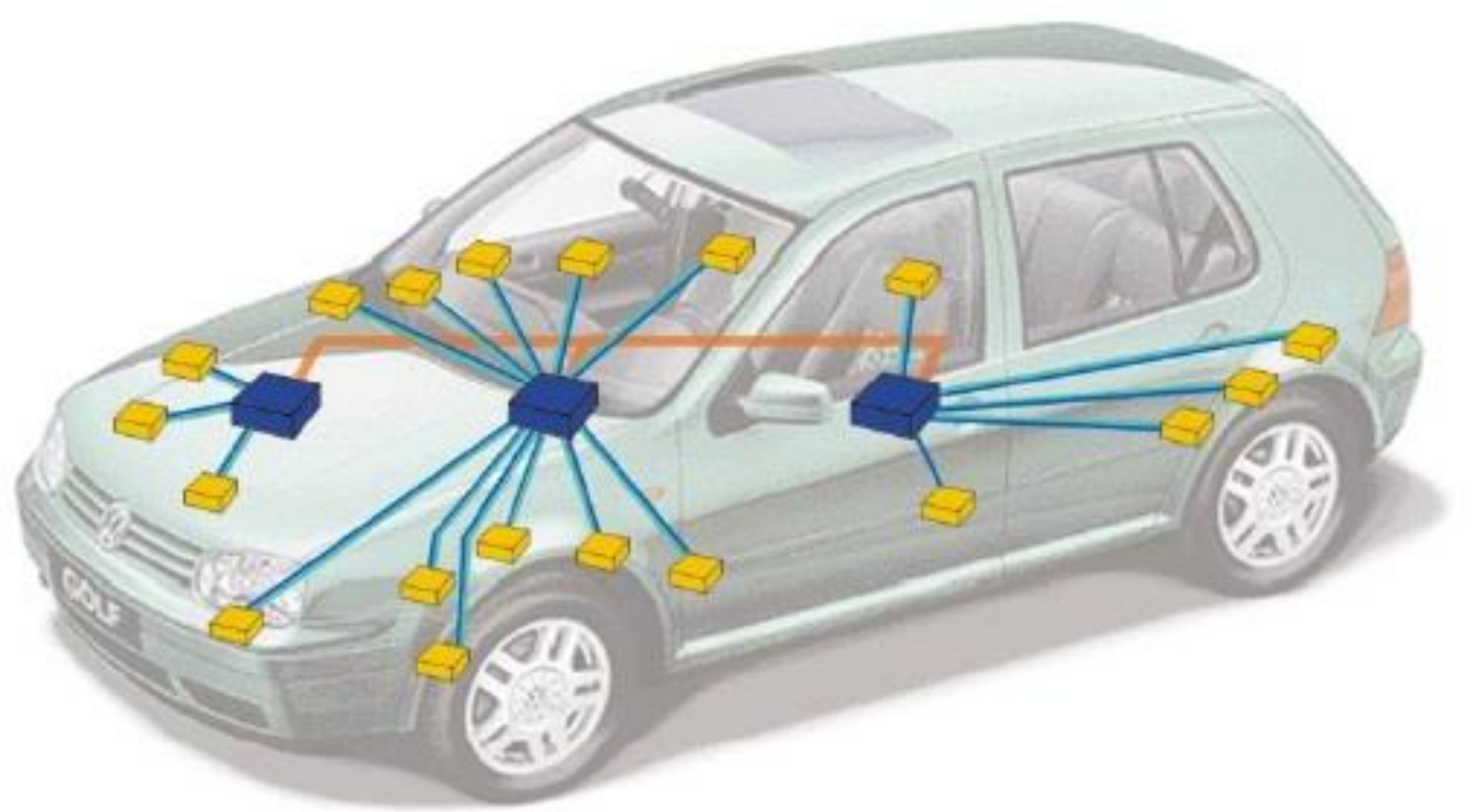




Today Network connection

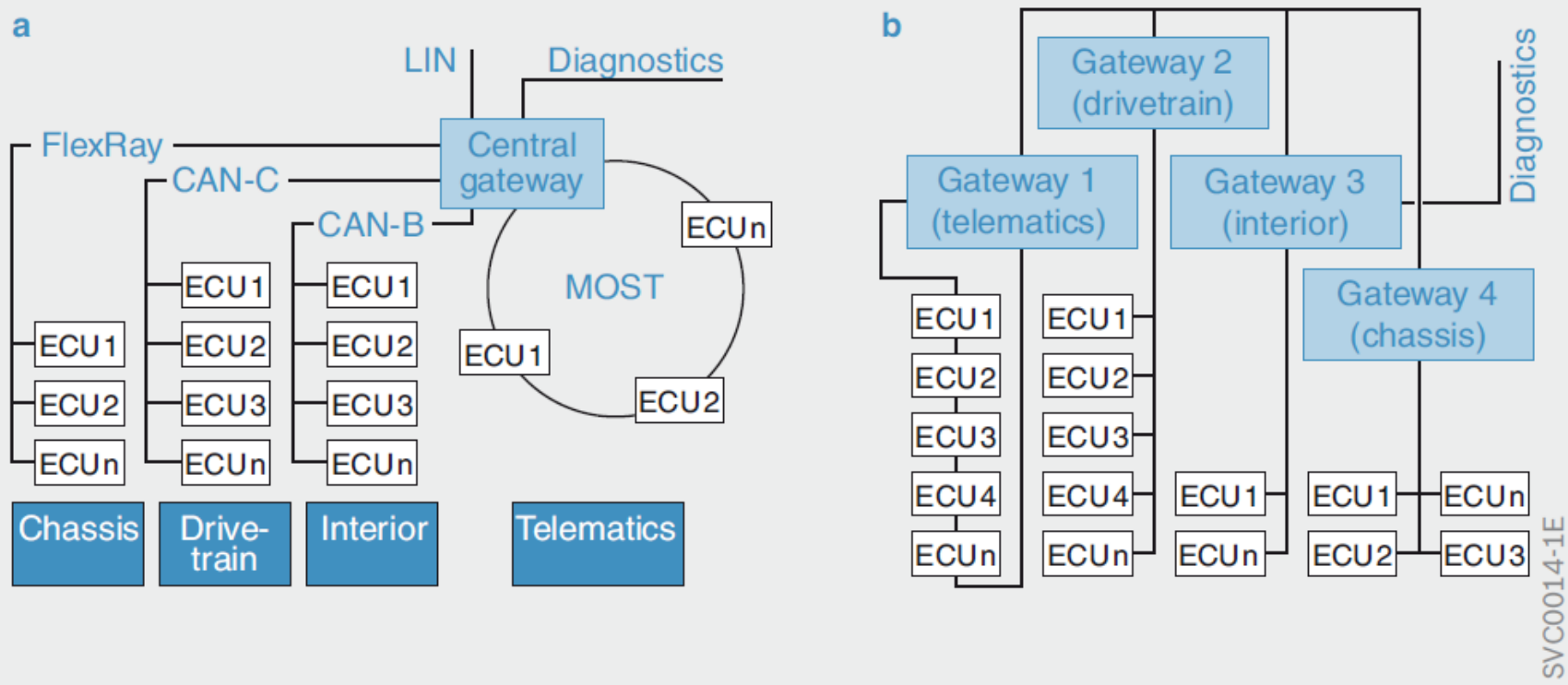


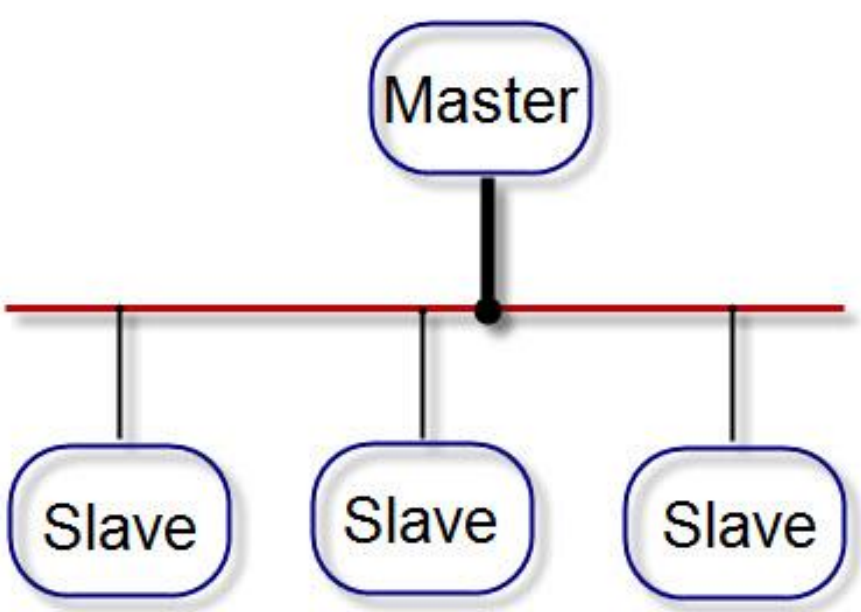
تهیه و تنظیم : بهروز خطیبی



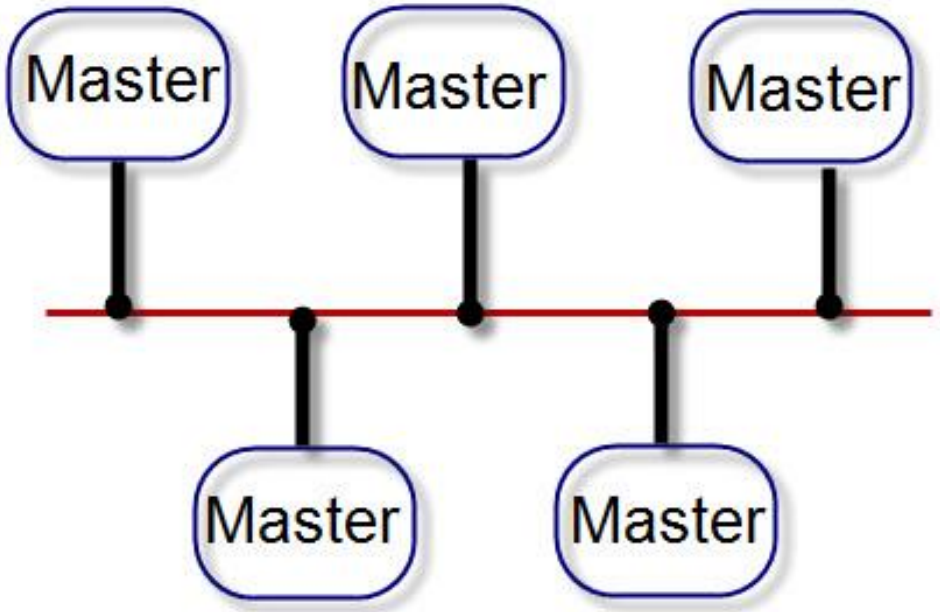
تهیه و تنظیم : بهروز خطیبی

4 Gateway structures

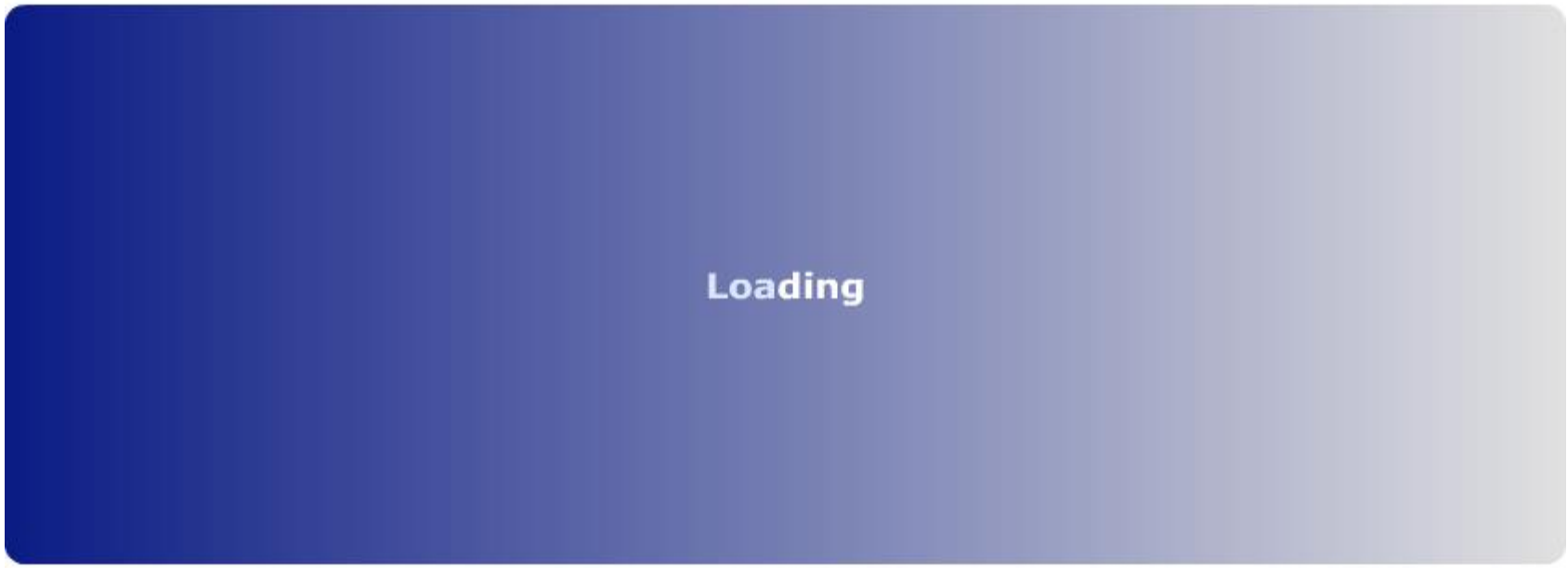


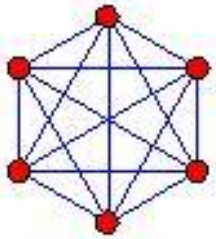

Master
Slave
Slave
Slave

(b)

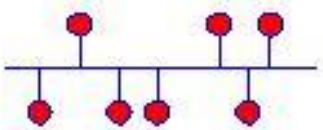

Master
Master
Master
Master
Master

(a)

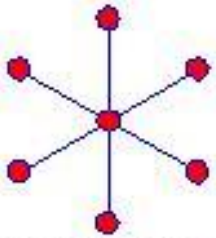

Loading



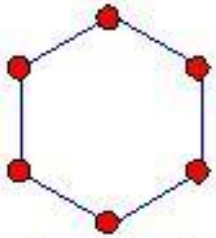
a) Fully Connected Topology



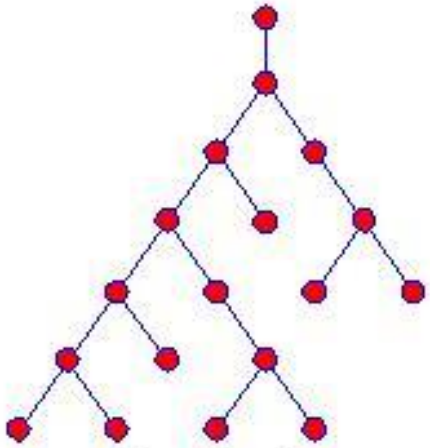
b) Bus Topology



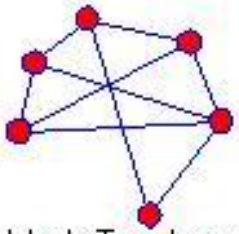
c) Star Topology



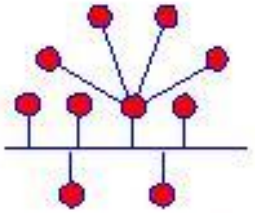
d) Ring Topology



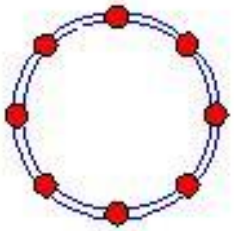
e) Tree Topology



f) Mesh Topology



g) Hybrid Topology
(example: combination of
Star topology and Bus topology)



h) Dual Ring Topology

i) Linear Topology

Nodes ● —— Branches

Network type

دسته بندی از نظر نوع اتصال

دسته بندی از نظر روش اتصال

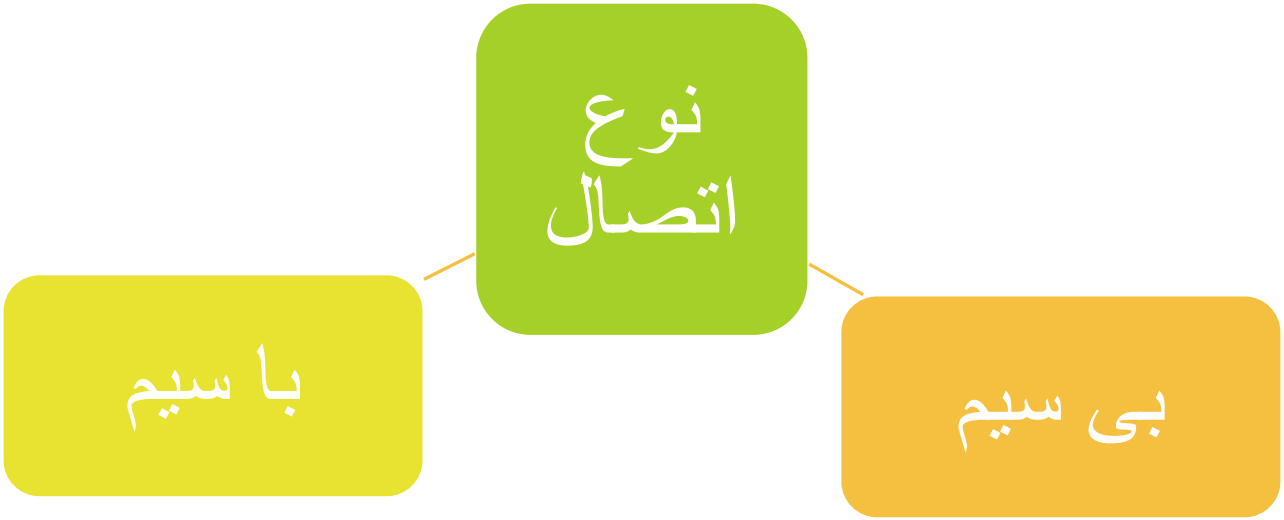
دسته بندی از نظر نوع مالتی پلکس

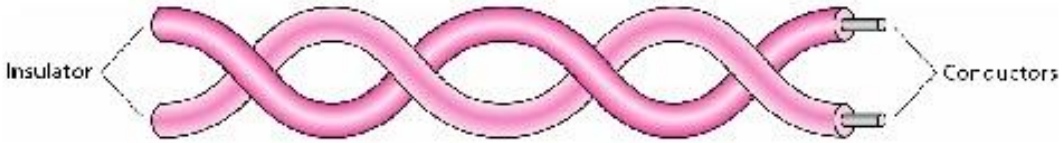
دسته بندی از نظر سرعت SAE

دسته بندی از نظر هندسه شبکه -توپولوژی

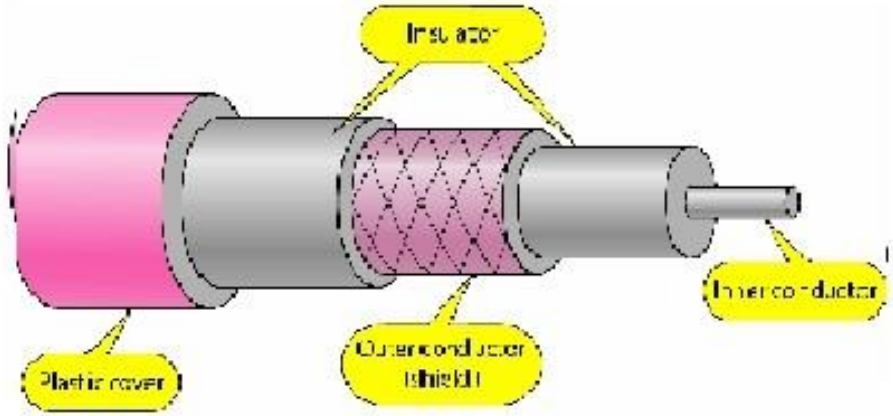
دسته بندی از نظر نوع پروتکل

تهیه و تنظیم : بهروز خطیبی

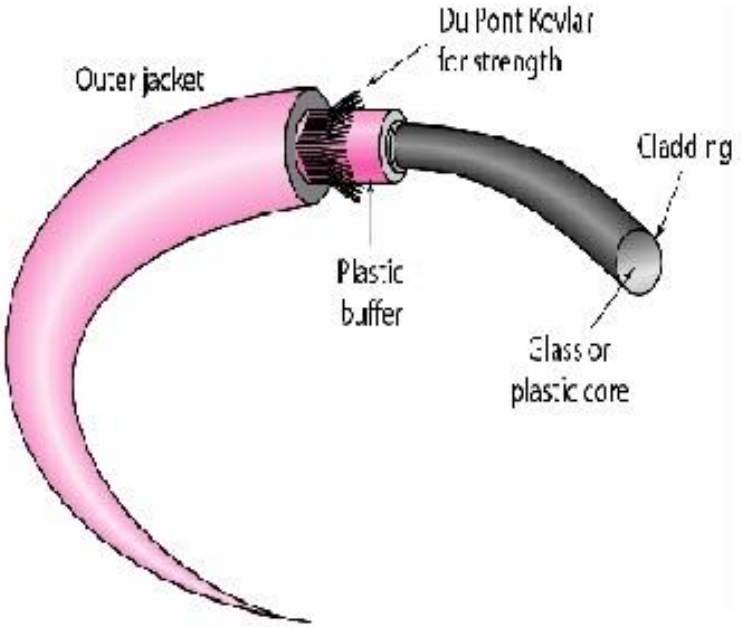

نوع
اتصال
با سیم
بی سیم


Insulator
Conductors

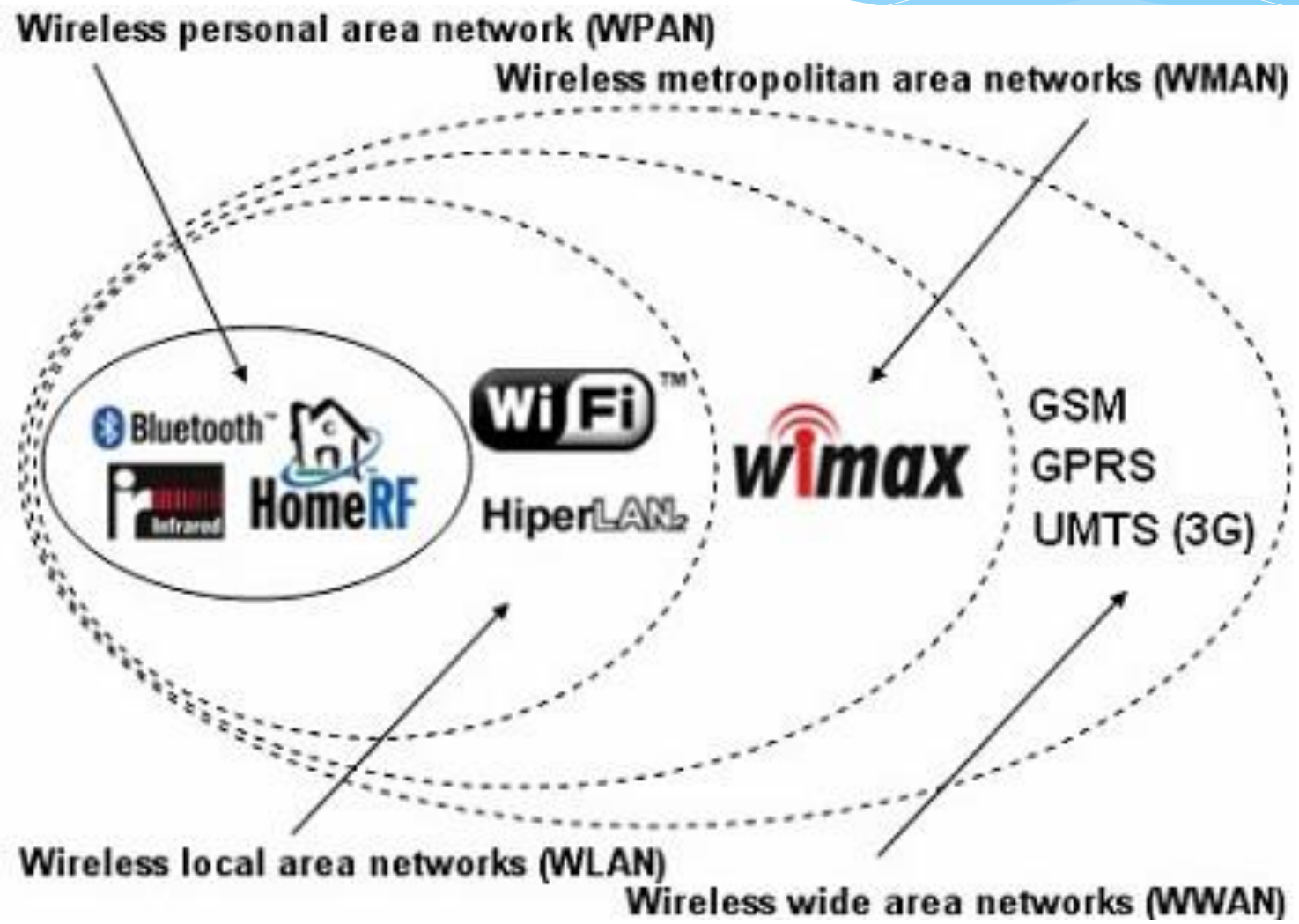
a

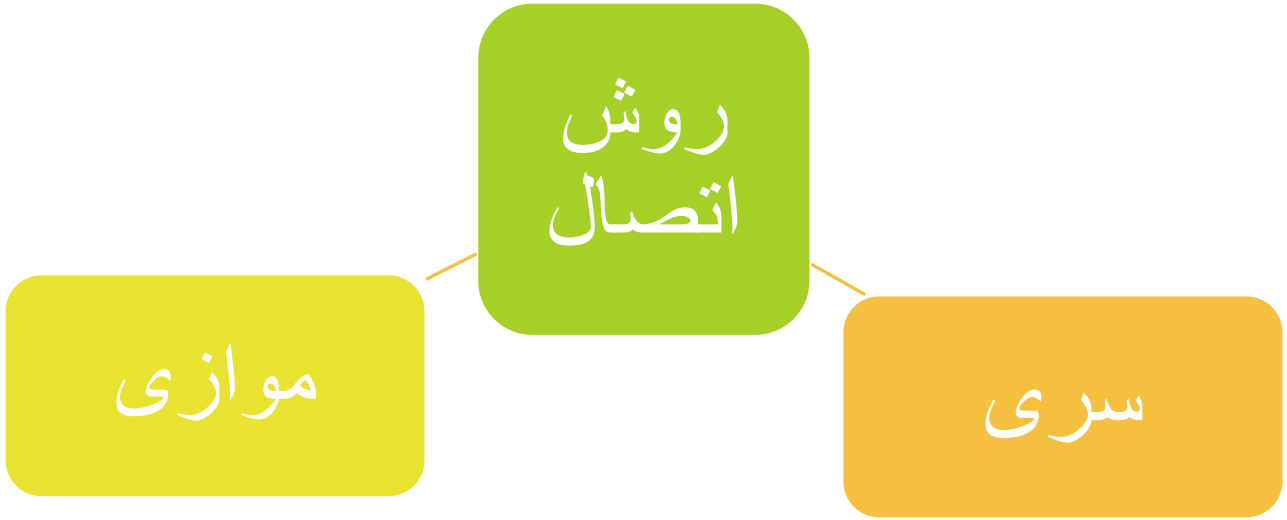

Insulator
Inner conductor
Plastic cover

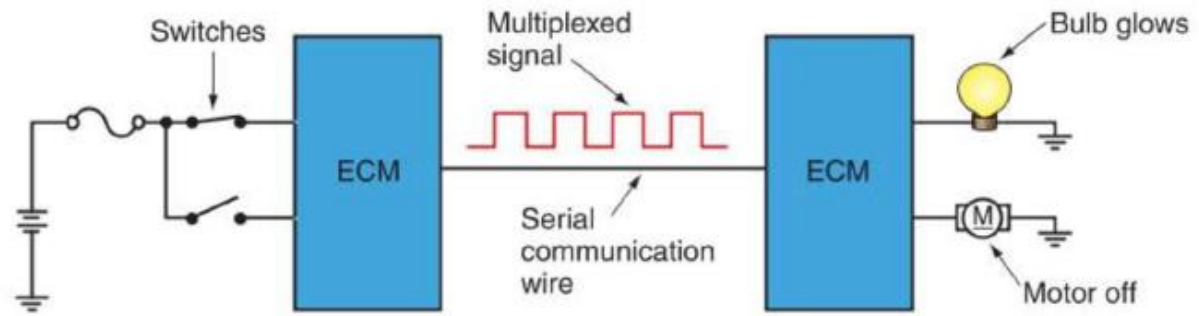
b


Du Pont Kevlar
for strength
Outer jacket
Cladding
Plastic
buffer
Glass or
plastic core

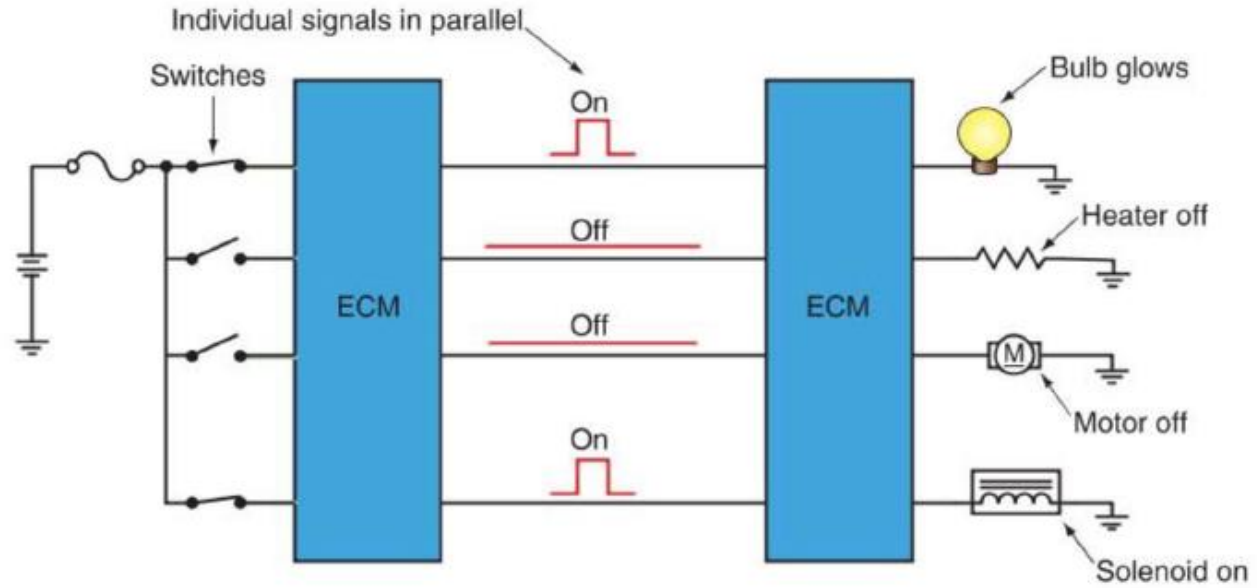
c


Wireless personal area network (WPAN)
Wireless metropolitan area networks (WMAN)
Bluetooth
Infrared
HomeRF
Wi Fi
HiperLAN
wimax
GSM
GPRS
UMTS (3G)
Wireless local area networks (WLAN)
Wireless wide area networks (WWAN)

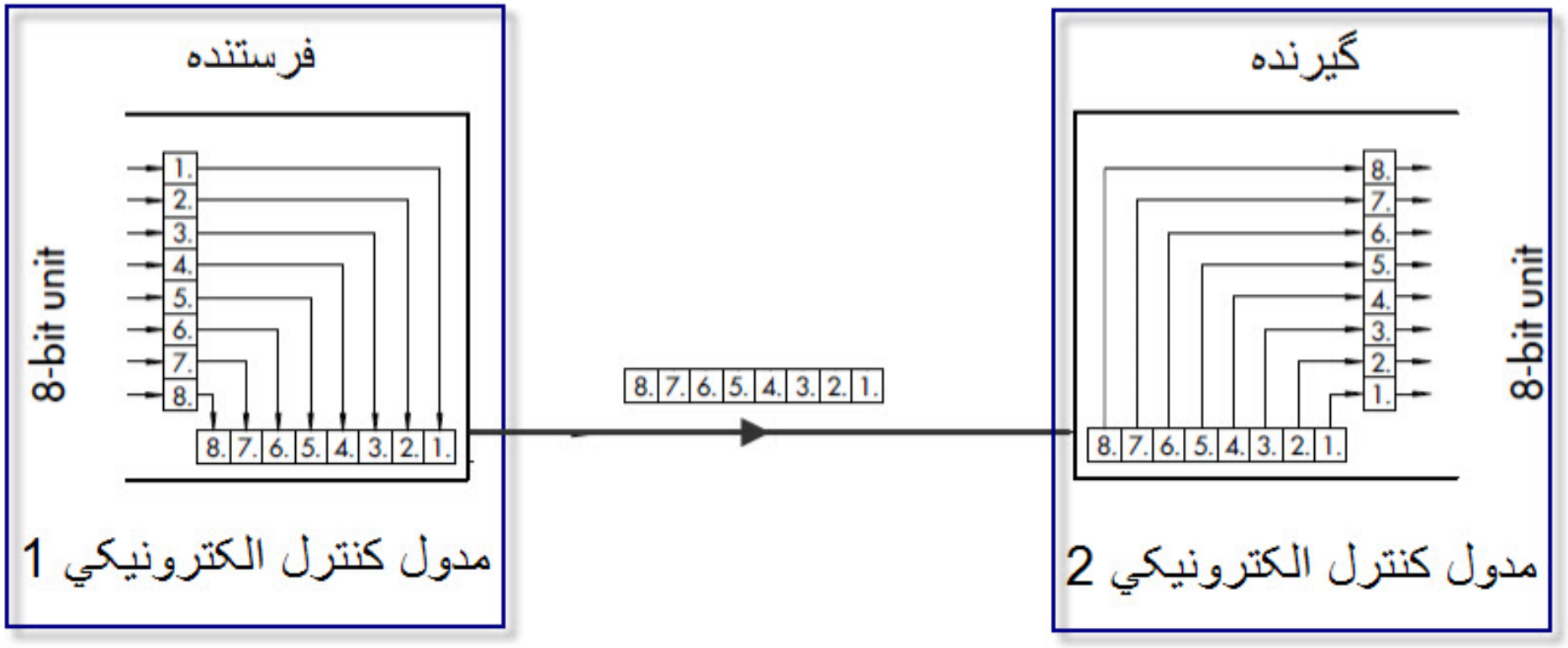

روش اتصال
موازی
سری

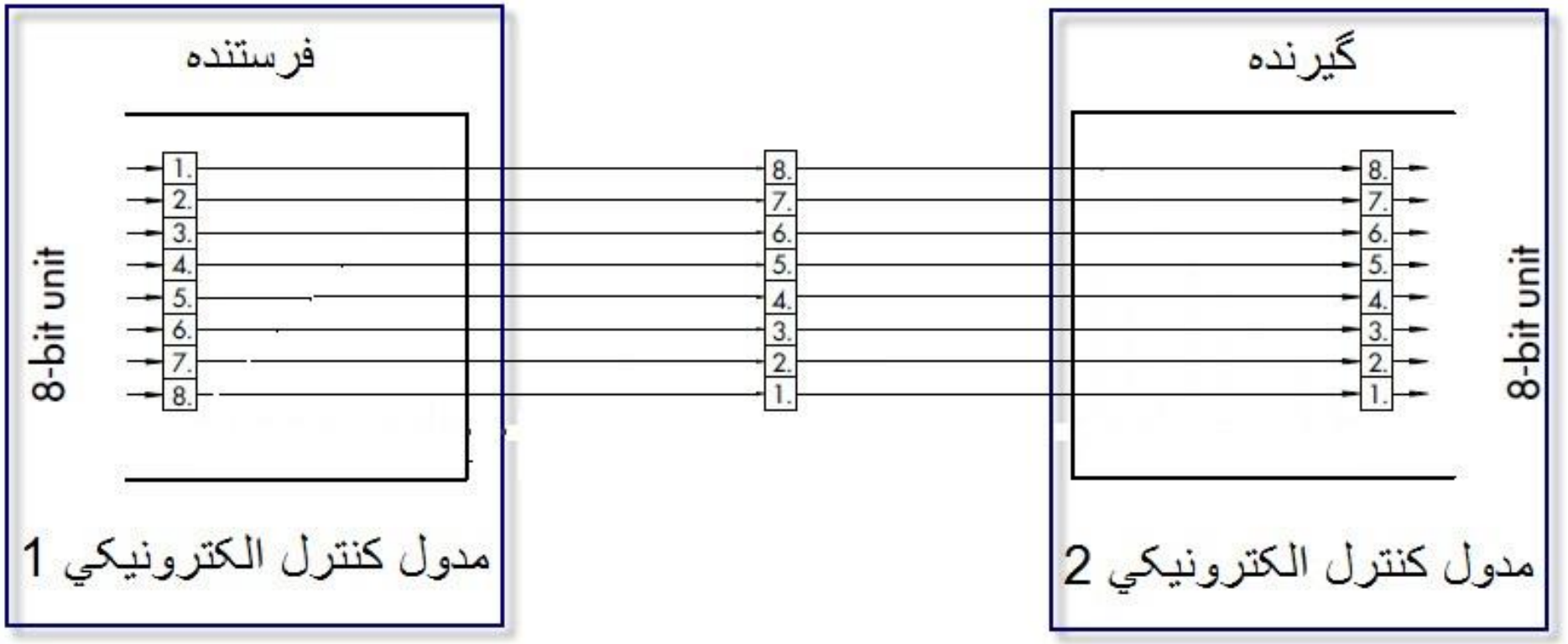


A **Serial (Multiplexed) Communication**

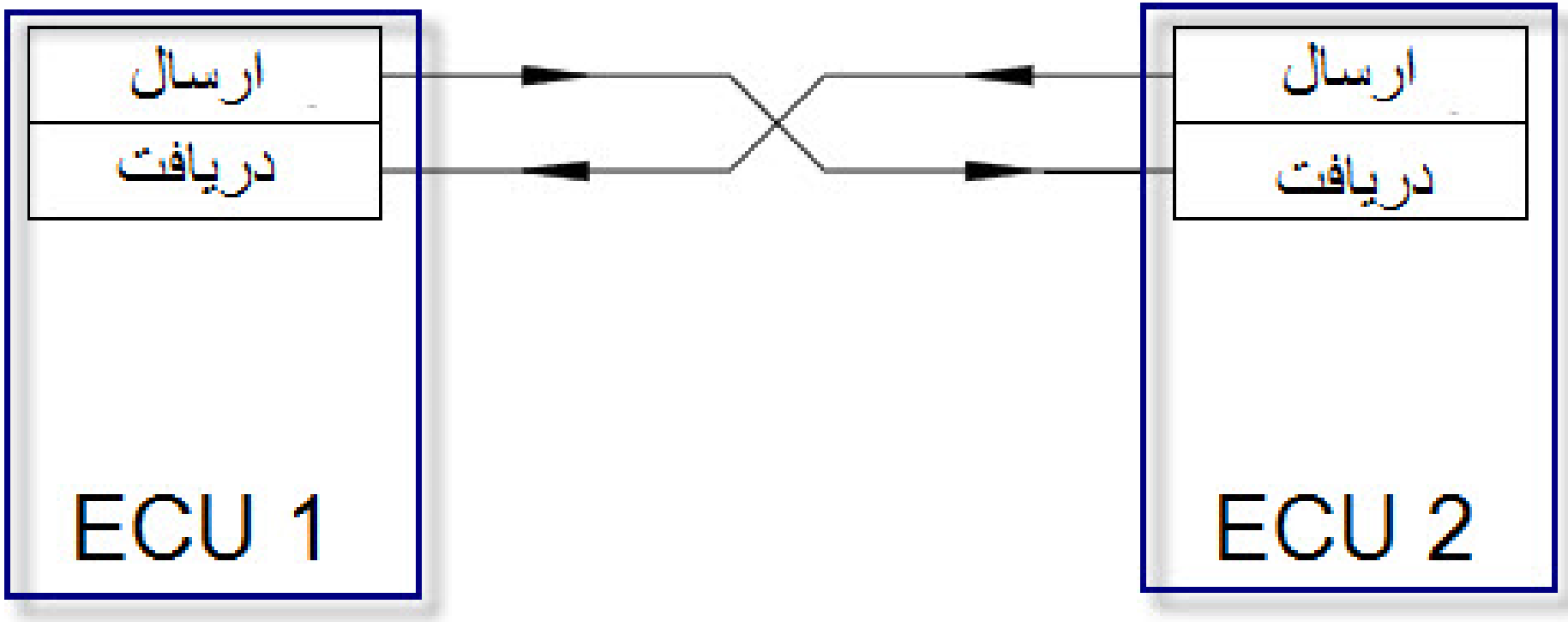


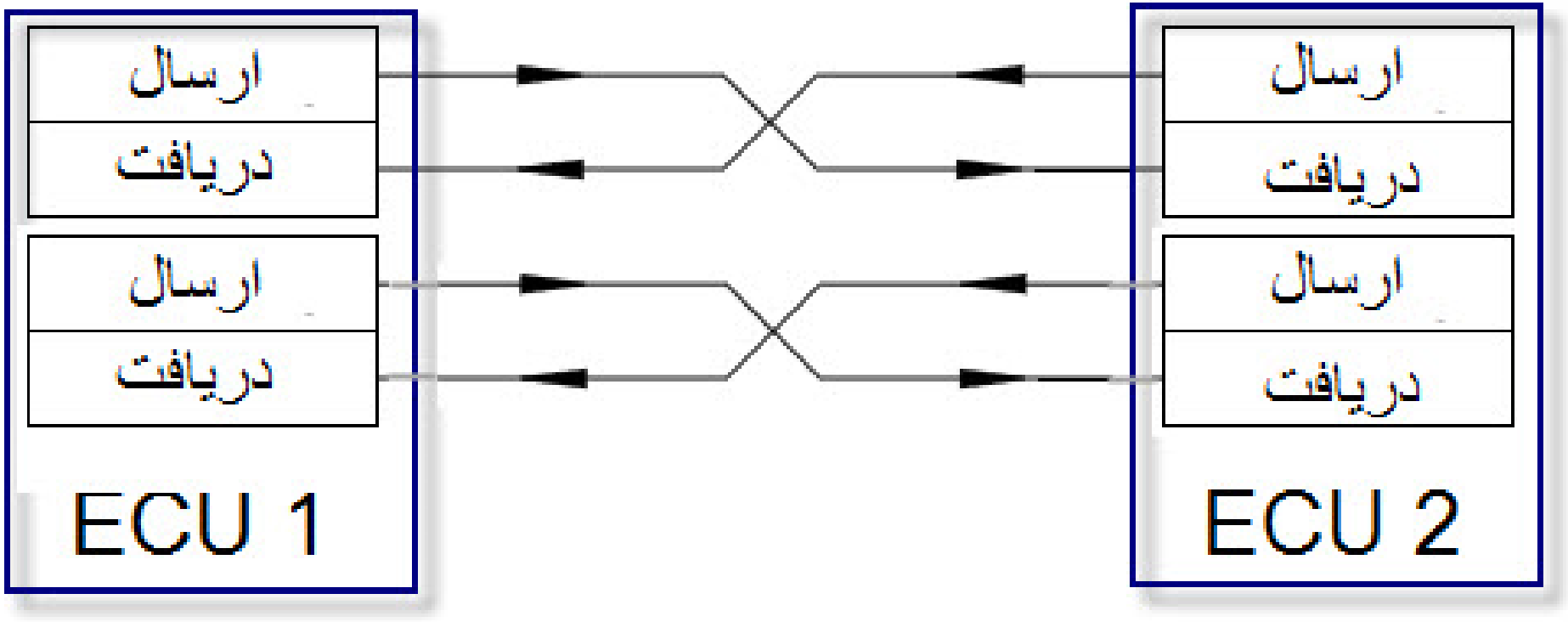
B **Parallel Communication**

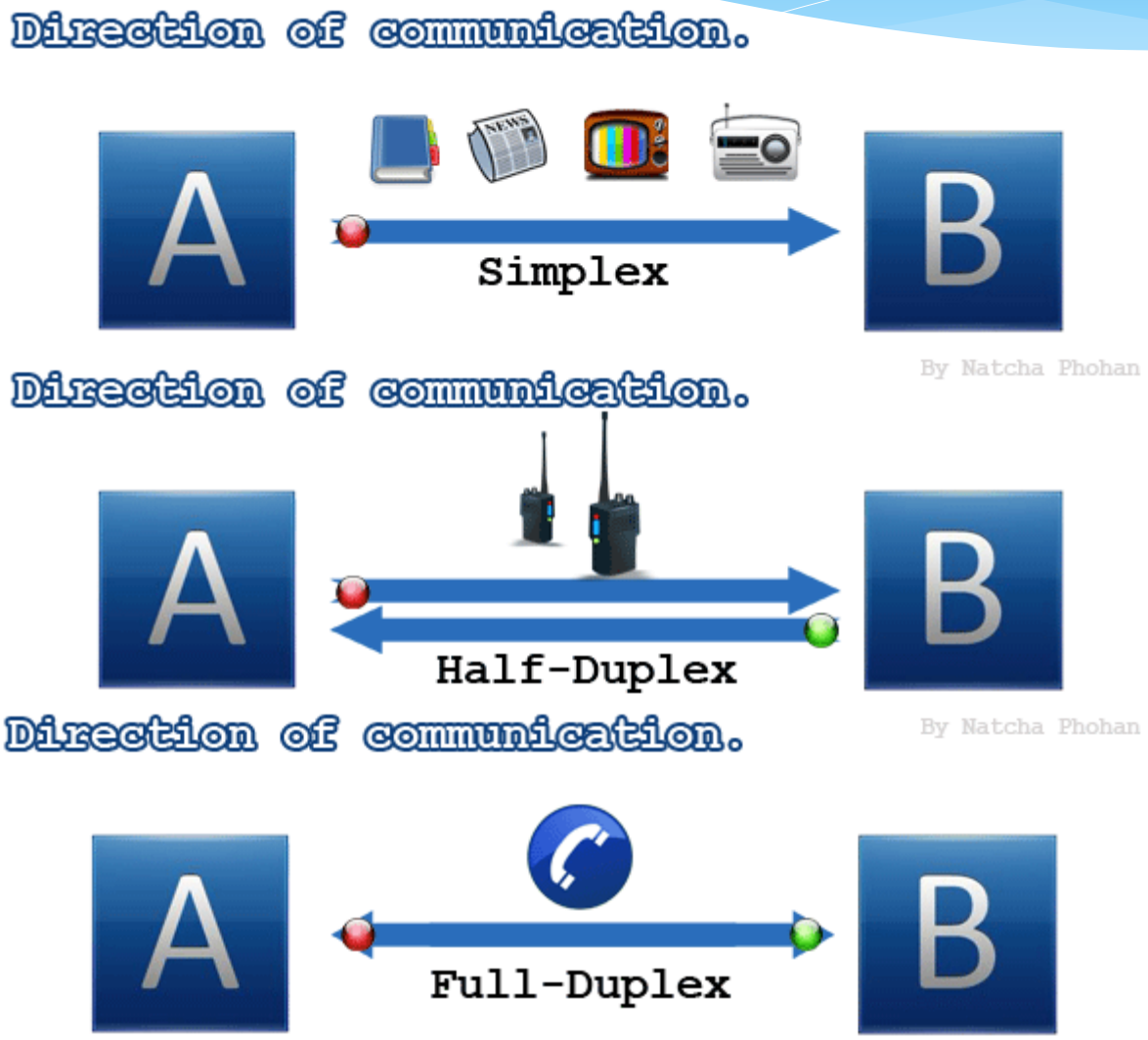

فرستنده
8-bit unit
1.
2.
3.
4.
5.
6.
7.
8.
8. 7. 6. 5. 4. 3. 2. 1.
مدول کنترل الکترونیکی 1
8. 7. 6. 5. 4. 3. 2. 1.
گیرنده
8-bit unit
8.
7.
6.
5.
4.
3.
2.
1.
8. 7. 6. 5. 4. 3. 2. 1.
مدول کنترل الکترونیکی 2

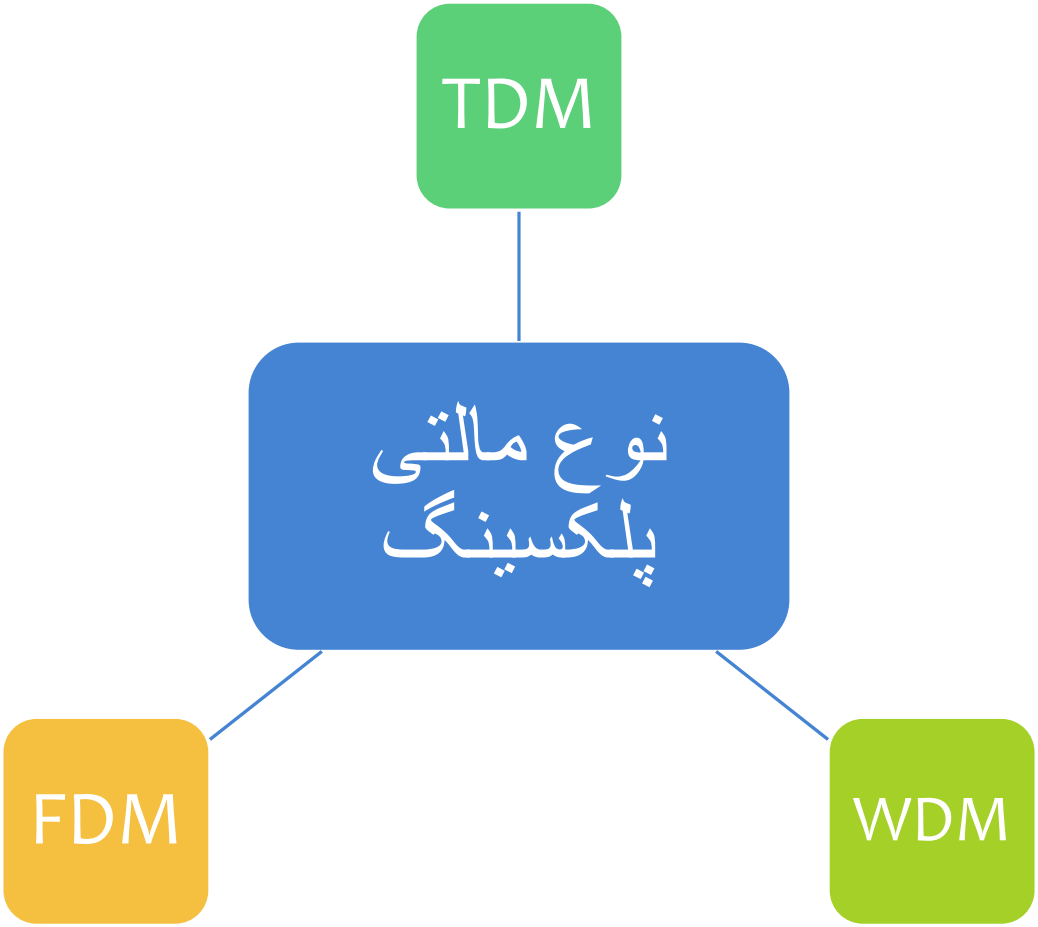


تهیه و تنظیم : بهروز خطیبی

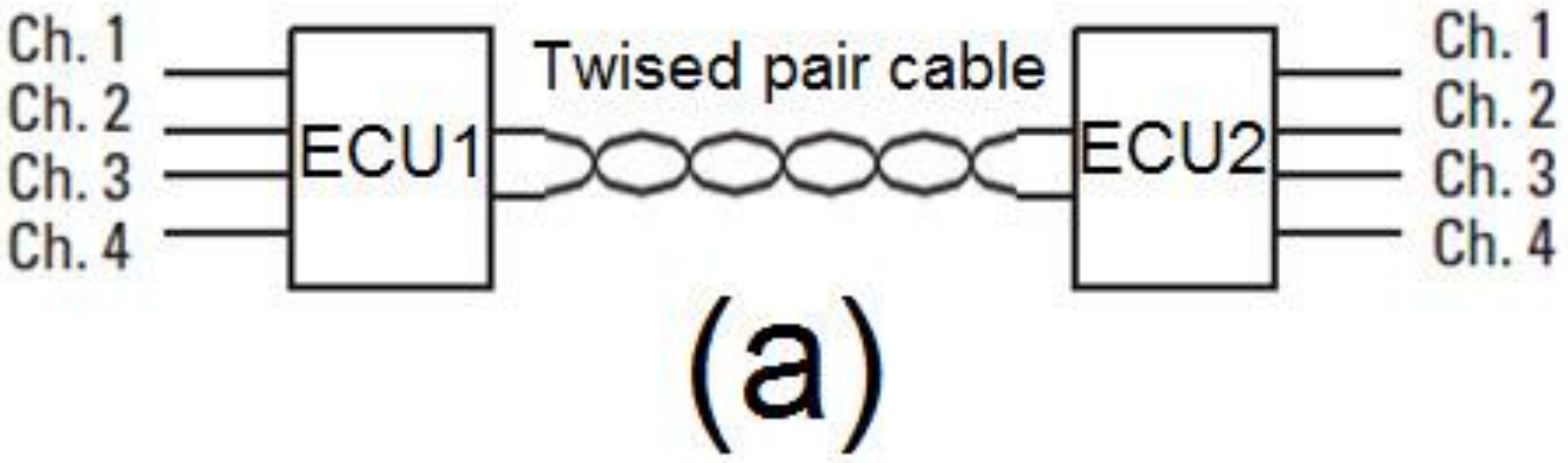

ارسال
دریافت
ECU 1
ارسال
دریافت
ECU 2


ارسال
دریافت
ارسال
دریافت
ECU 1
ارسال
دریافت
ارسال
دریافت
ECU 2

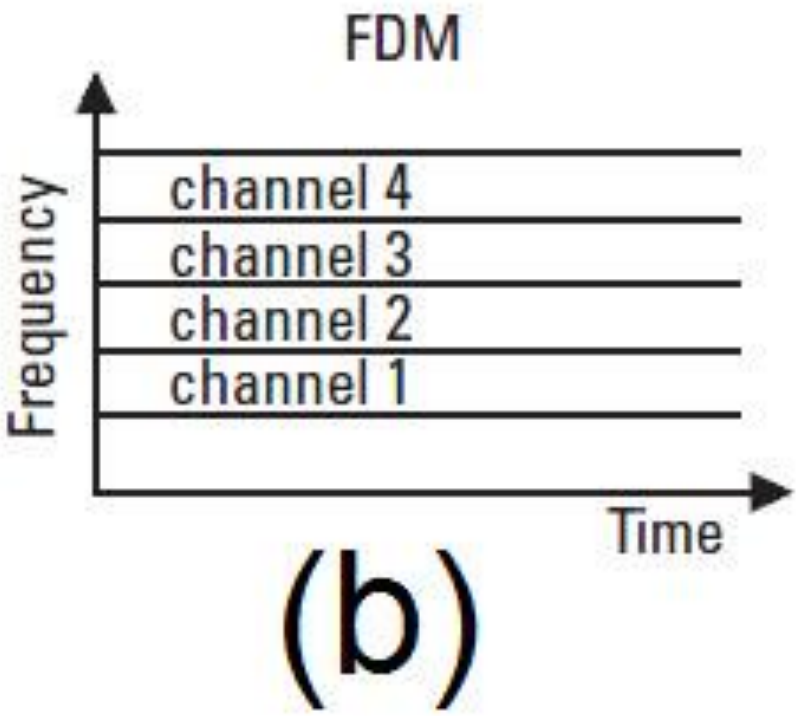

Direction of communication.
A
NEWS
B
Simplex
By Natcha Phohan
Direction of communication.
A
B
Half-Duplex
By Natcha Phohan
Direction of communication.
A
B
Full-Duplex
By Natcha Phohan


TDM
نوع مالتی پلکسینگ
FDM
WDM

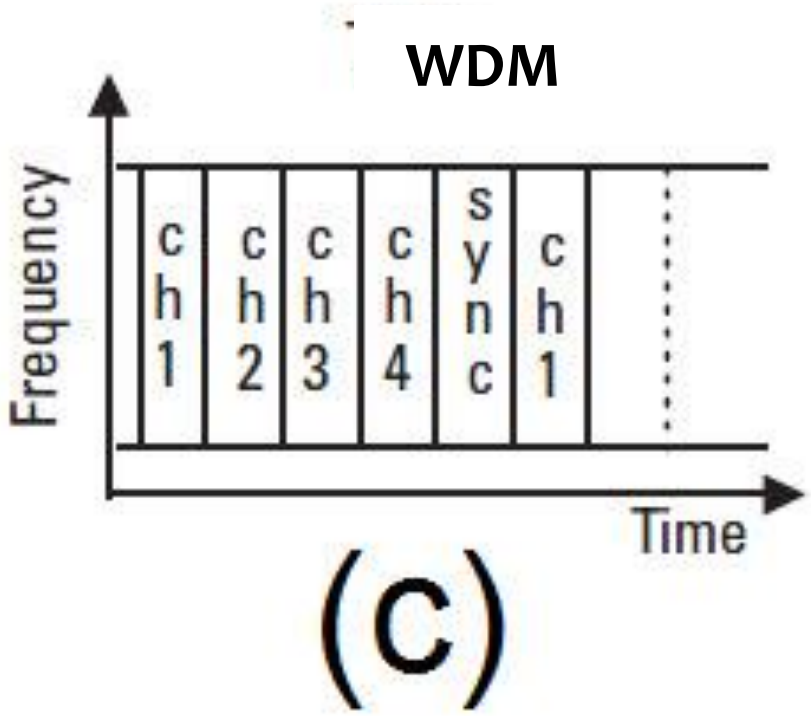
TDM



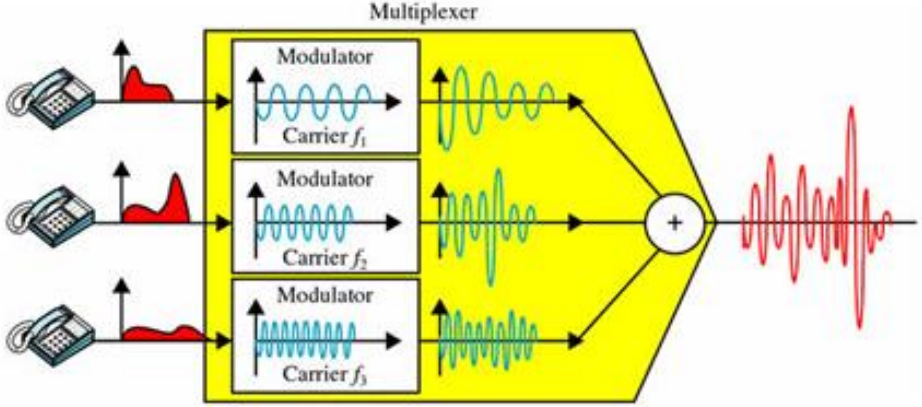
(a)



(b)



(c)

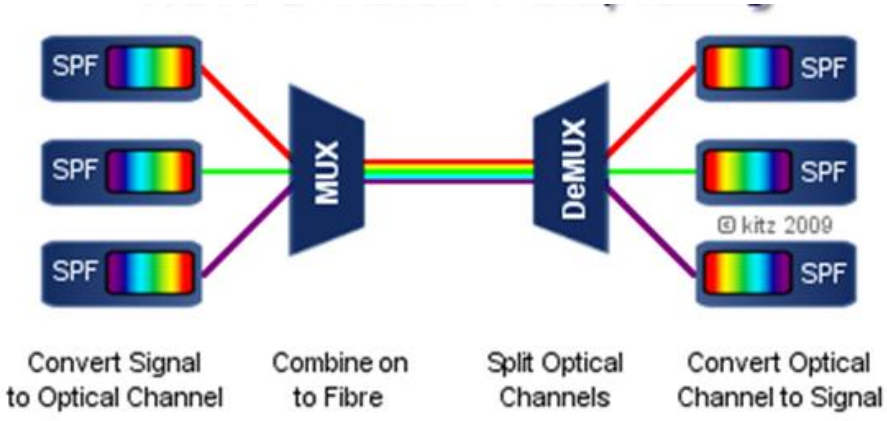


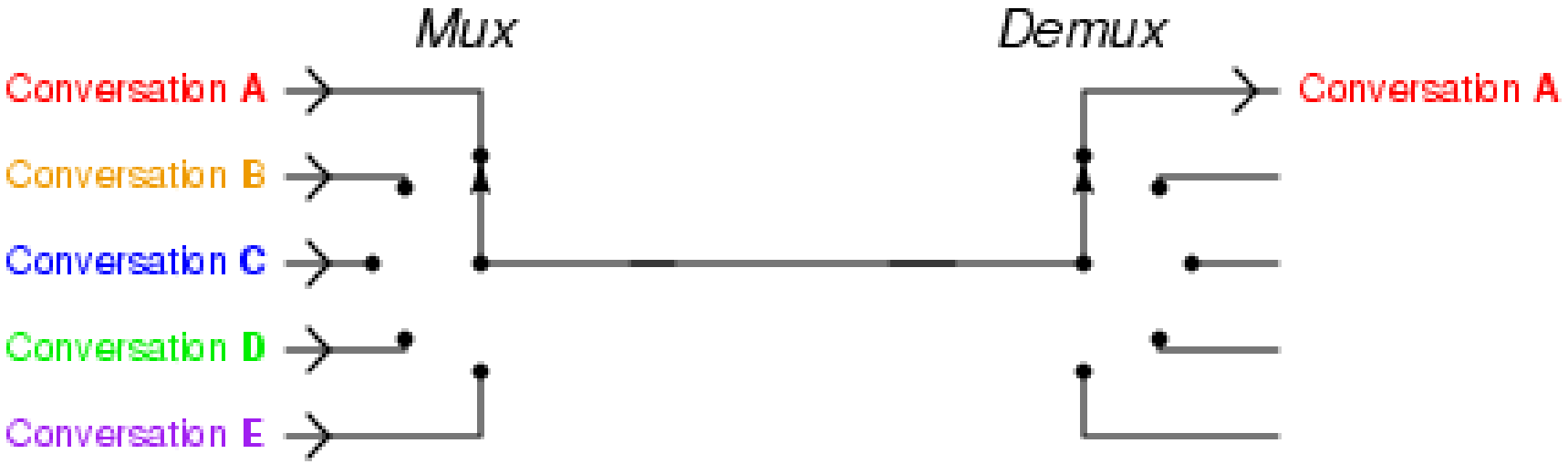
FDM

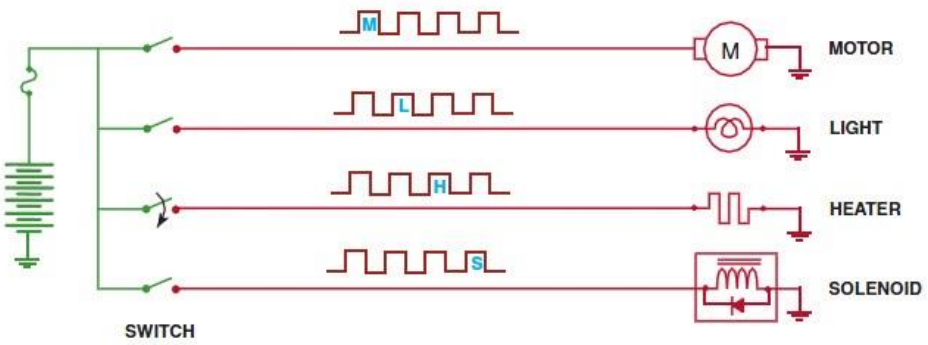
Frequency division Multiplexing

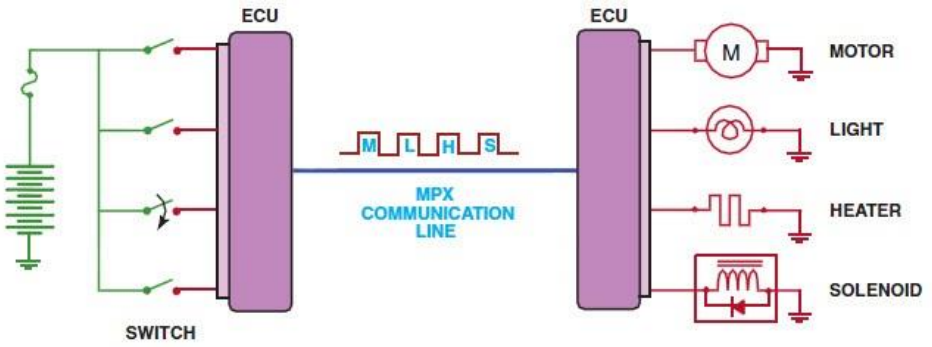
WDM

Wave division Multiplexing



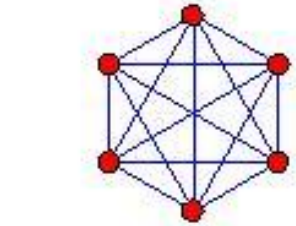

Mux
Demux
Conversation A
Conversation B
Conversation C
Conversation D
Conversation E
Conversation A



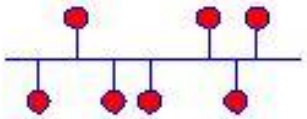


تهیه و تنظیم : بهروز خطیبی

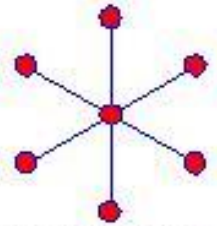
Networks Topology



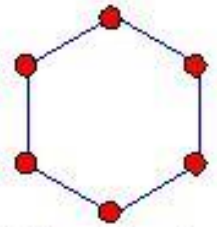
a) Fully Connected Topology



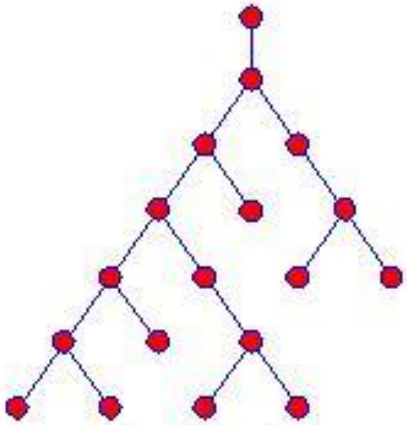
b) Bus Topology



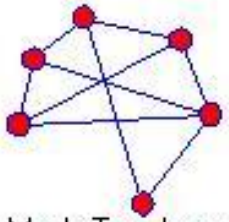
c) Star Topology



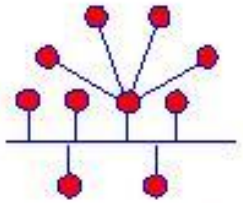
d) Ring Topology



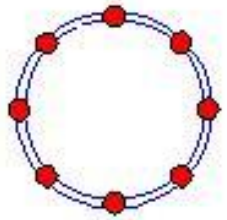
e) Tree Topology



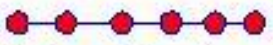
f) Mesh Topology



g) Hybrid Topology
(example: combination of
Star topology and Bus topology)

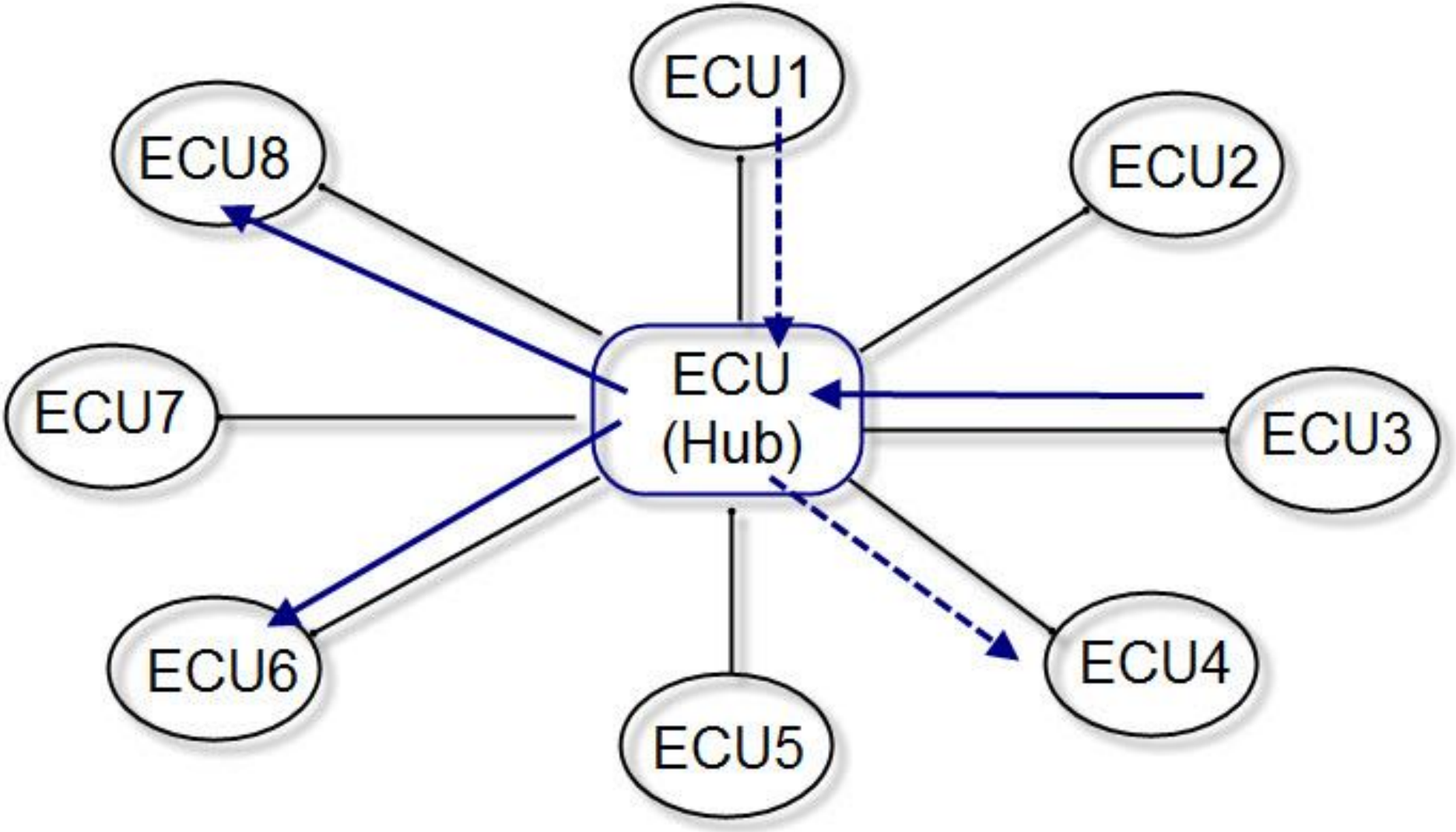


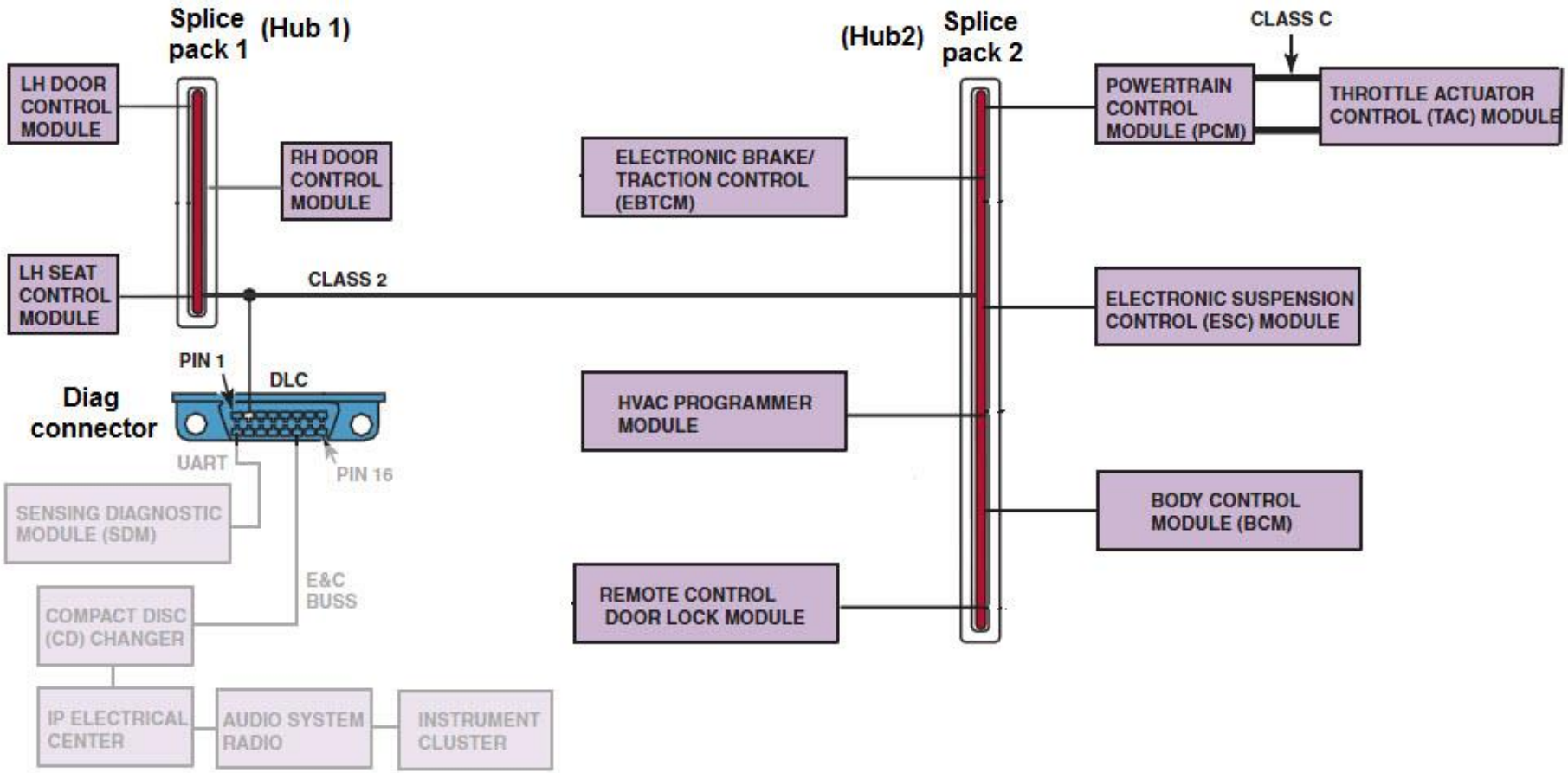
h) Dual Ring Topology



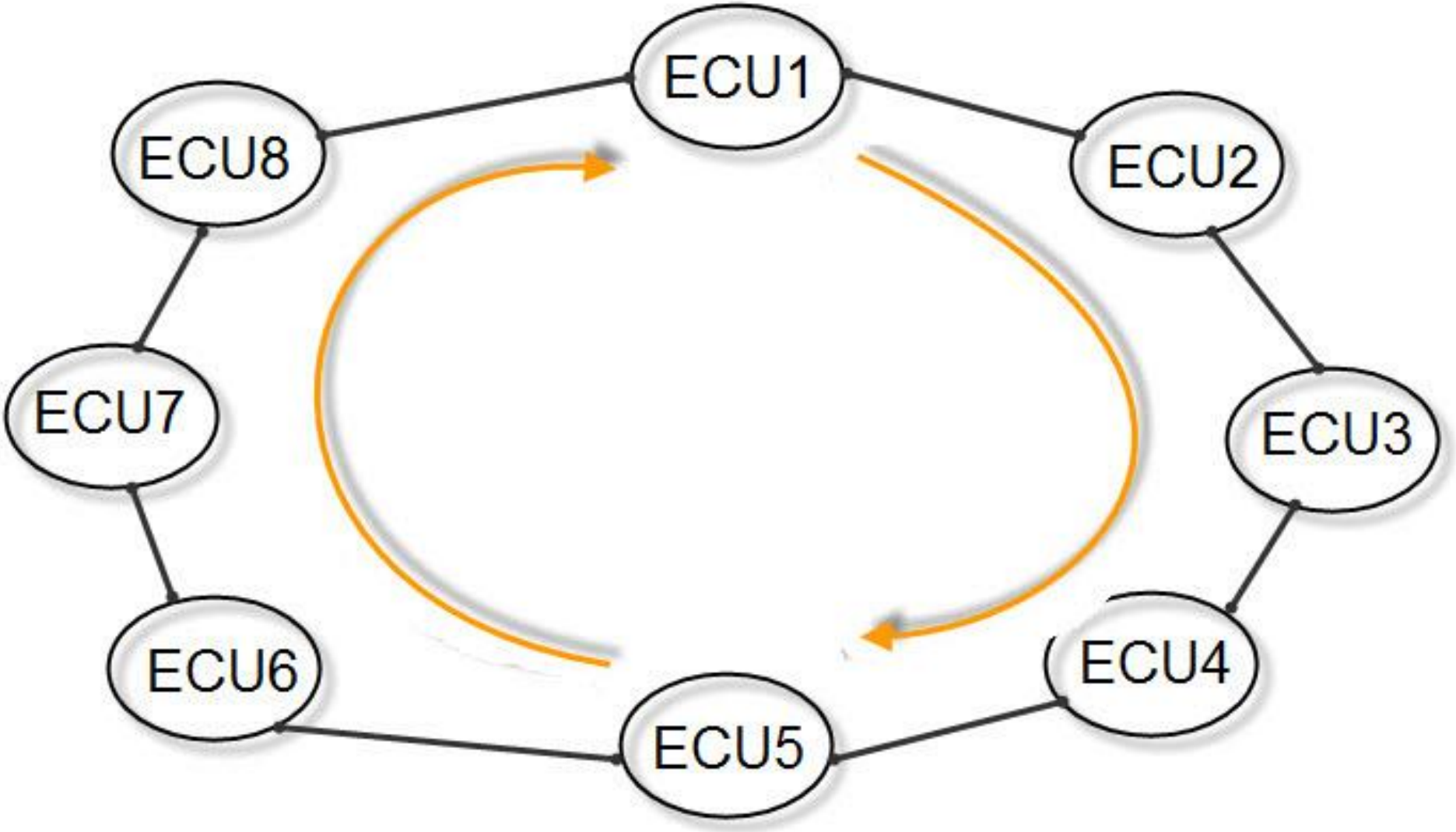
i) Linear Topology

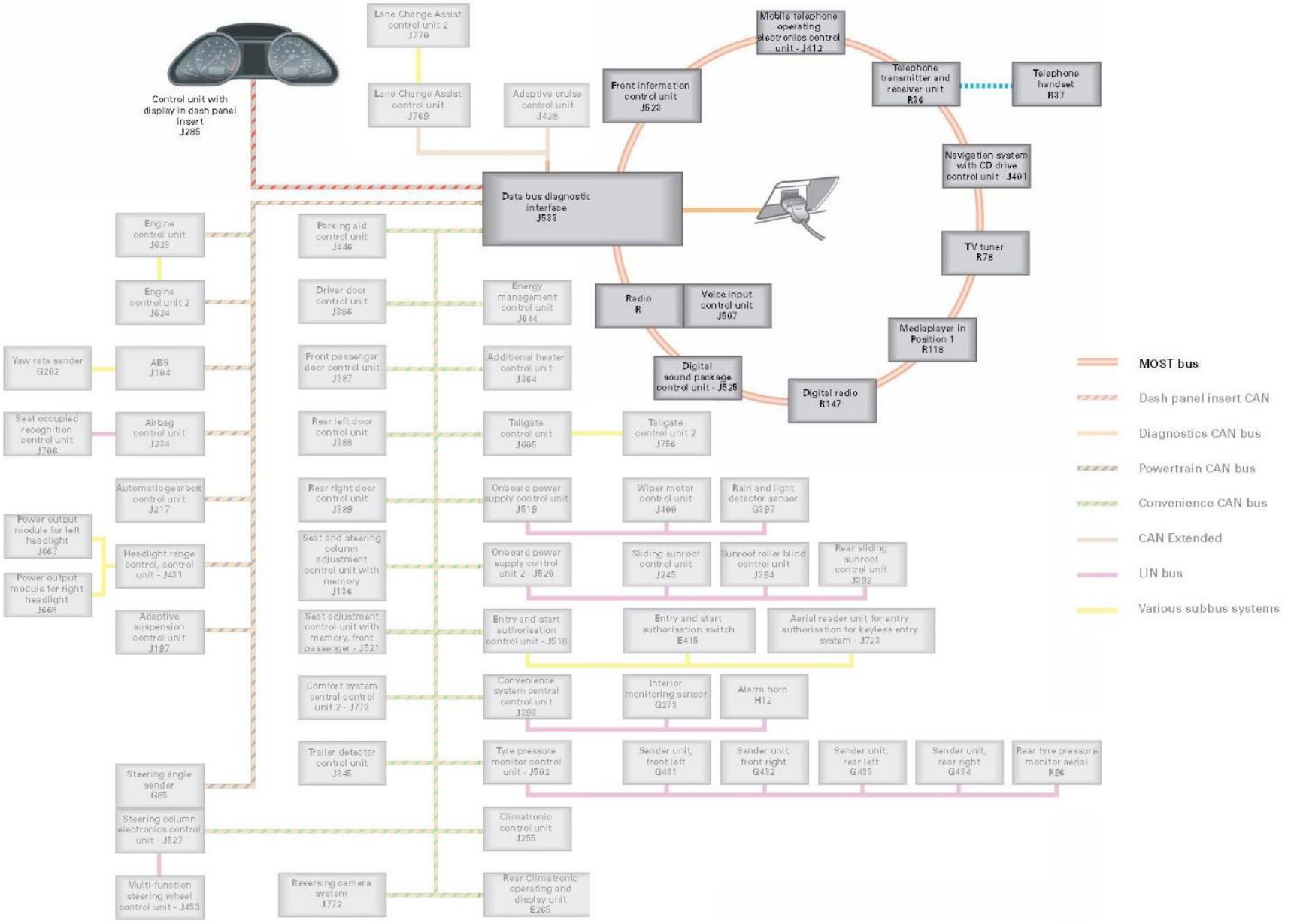
Nodes ● —— Branches

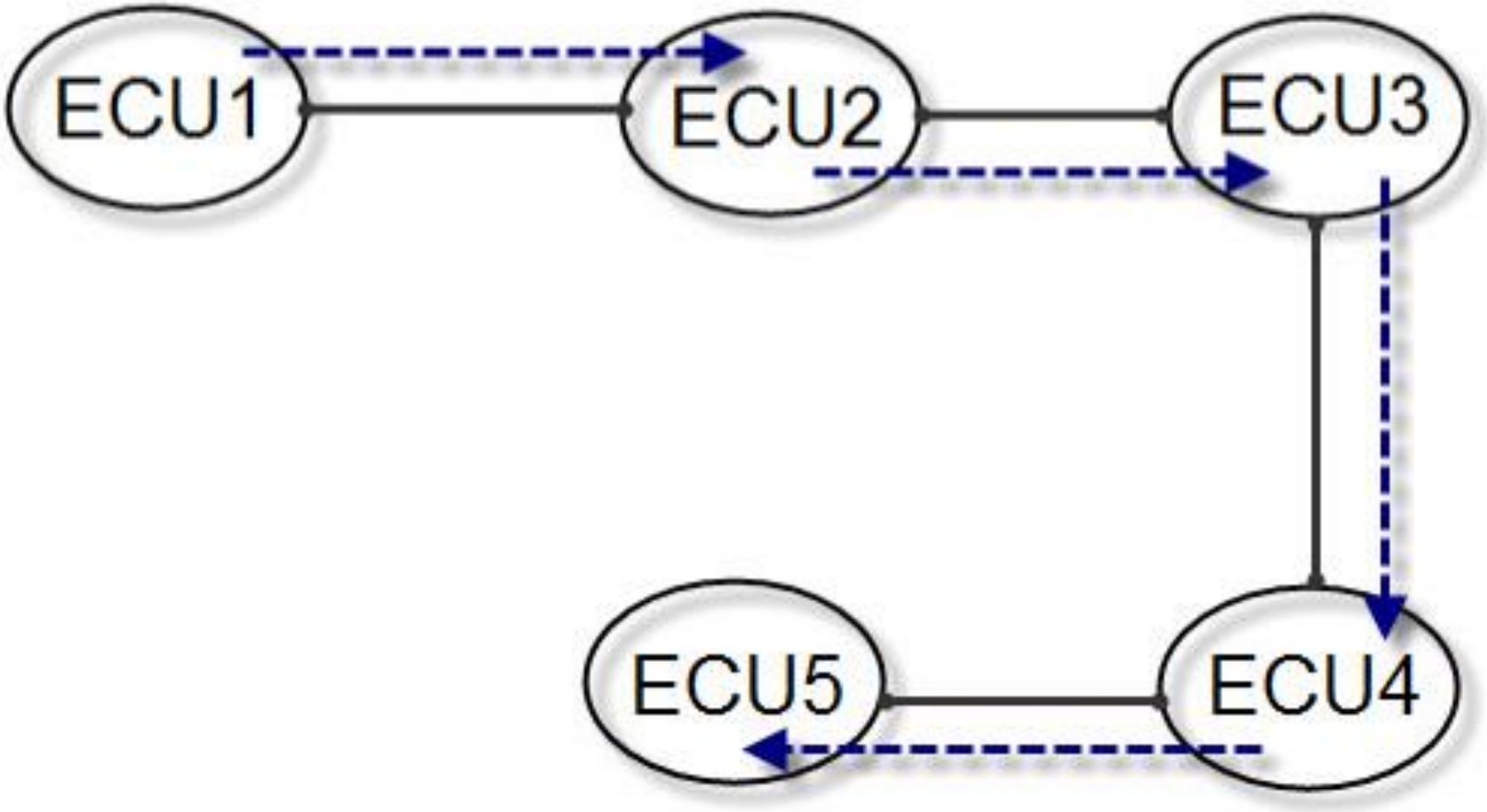

ECU1
ECU2
ECU3
ECU4
ECU5
ECU6
ECU7
ECU8
ECU
(Hub)

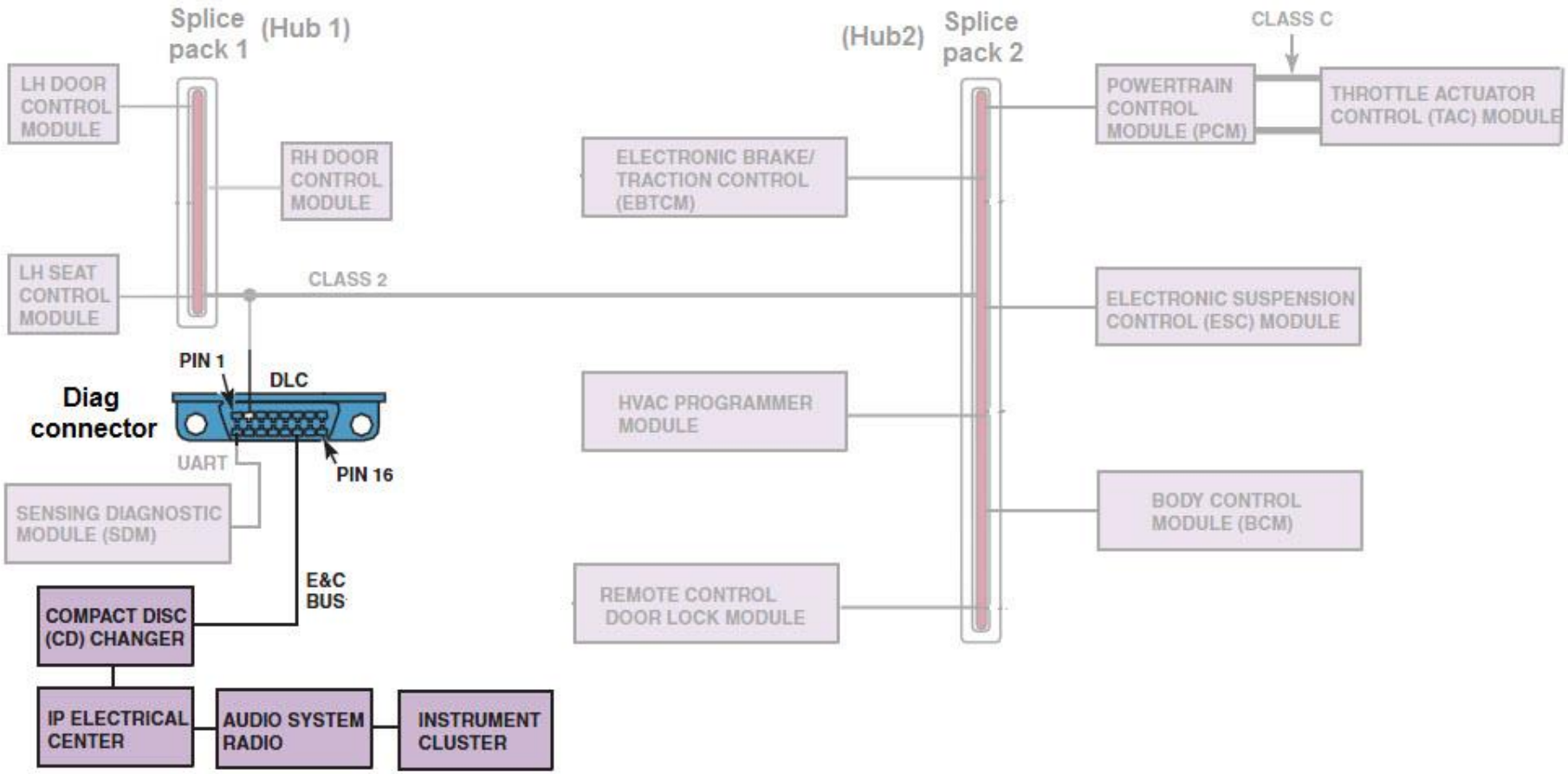


تهیه و تنظیم : بهروز خطیبی

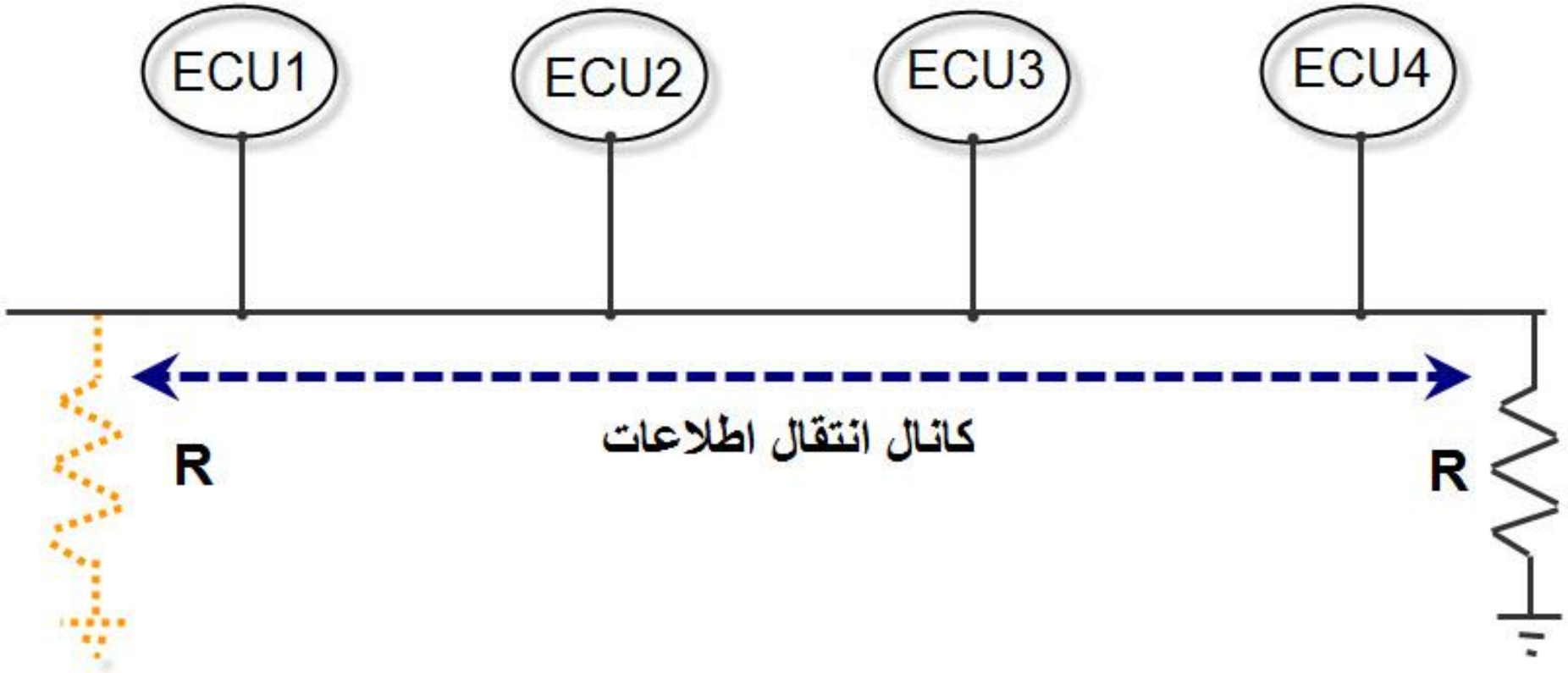

ECU1
ECU2
ECU3
ECU4
ECU5
ECU6
ECU7
ECU8

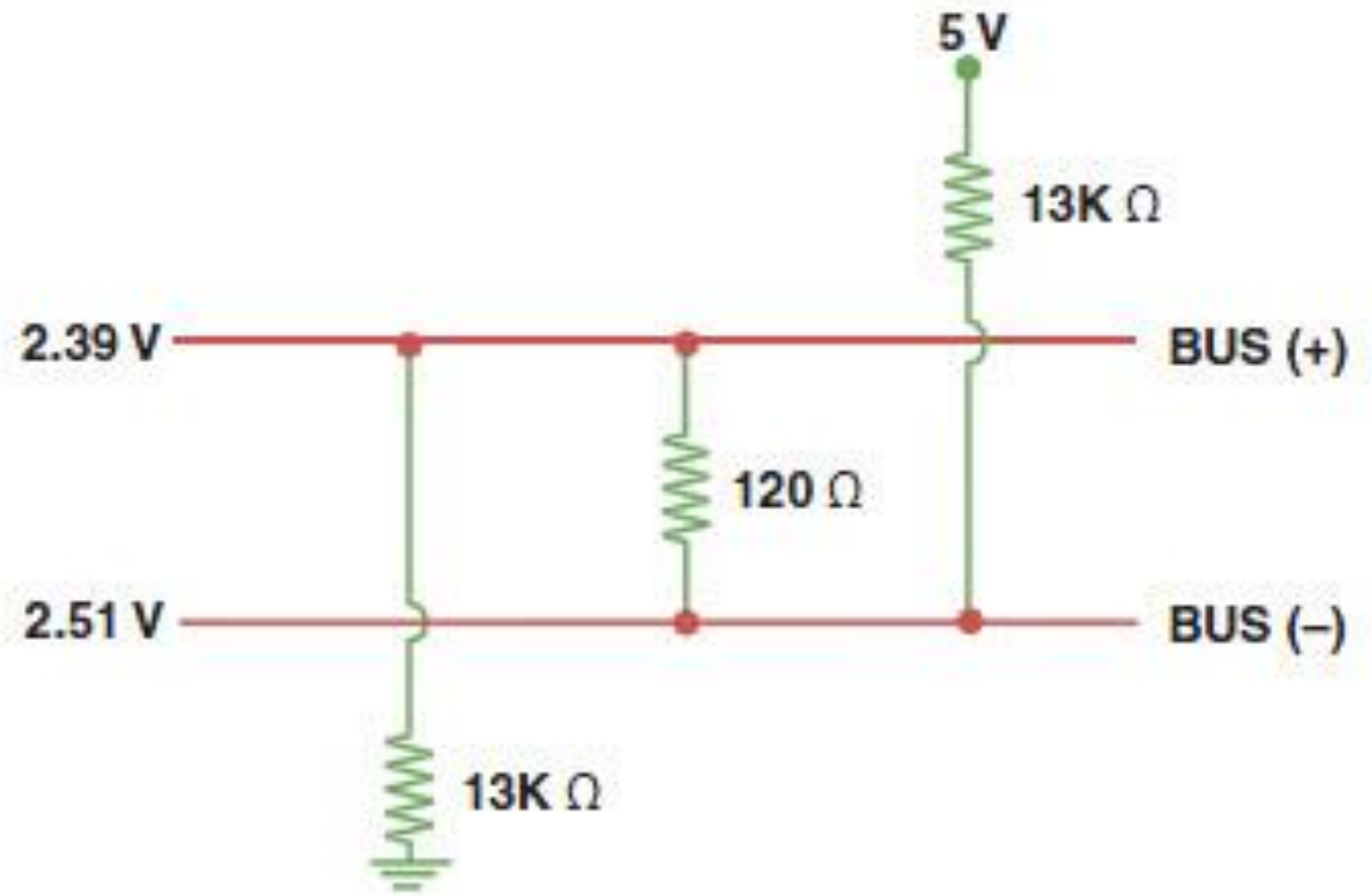


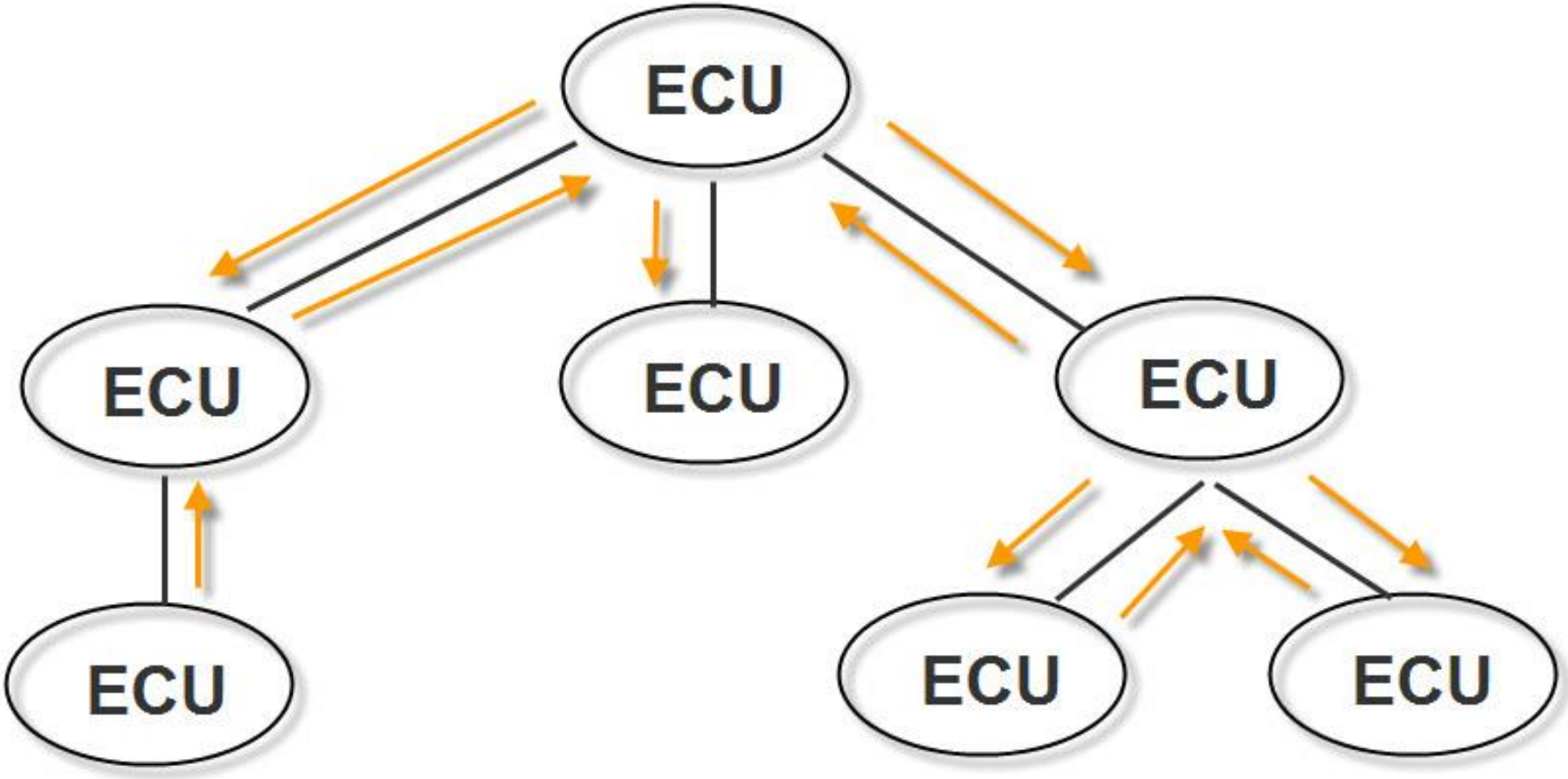

ECU1
ECU2
ECU3
ECU4
ECU5



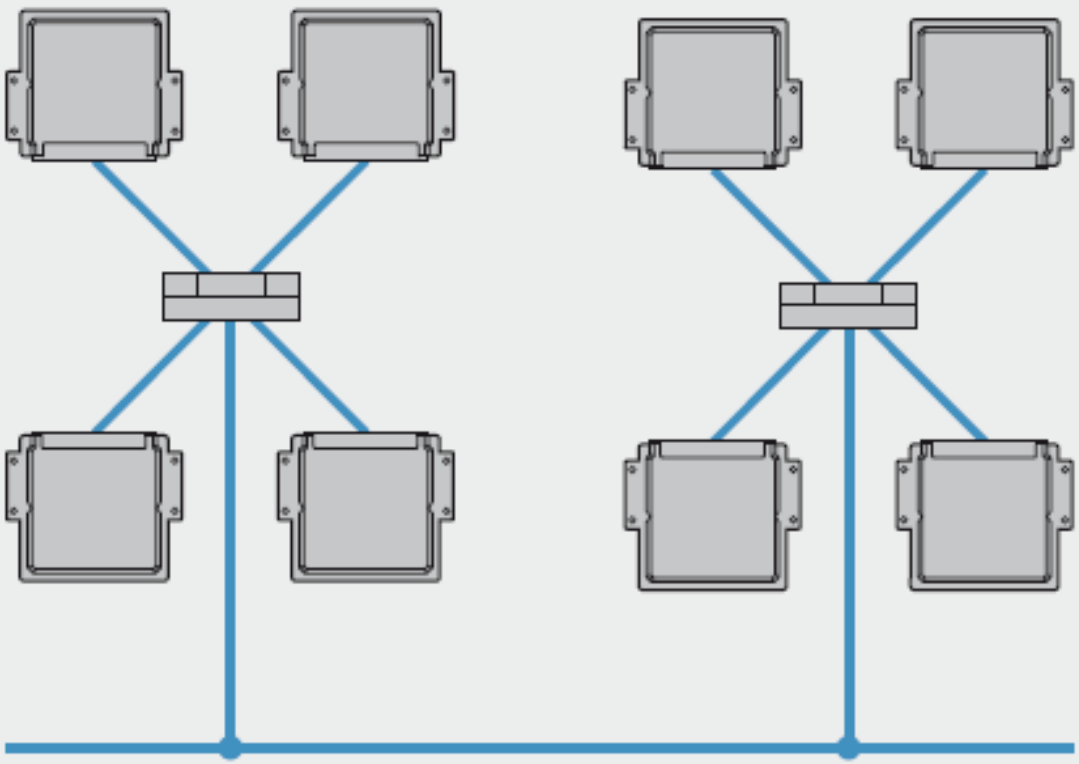
تهیه و تنظیم : بهروز خطیبی


ECU1
ECU2
ECU3
ECU4
R
کانال انتقال اطلاعات
R

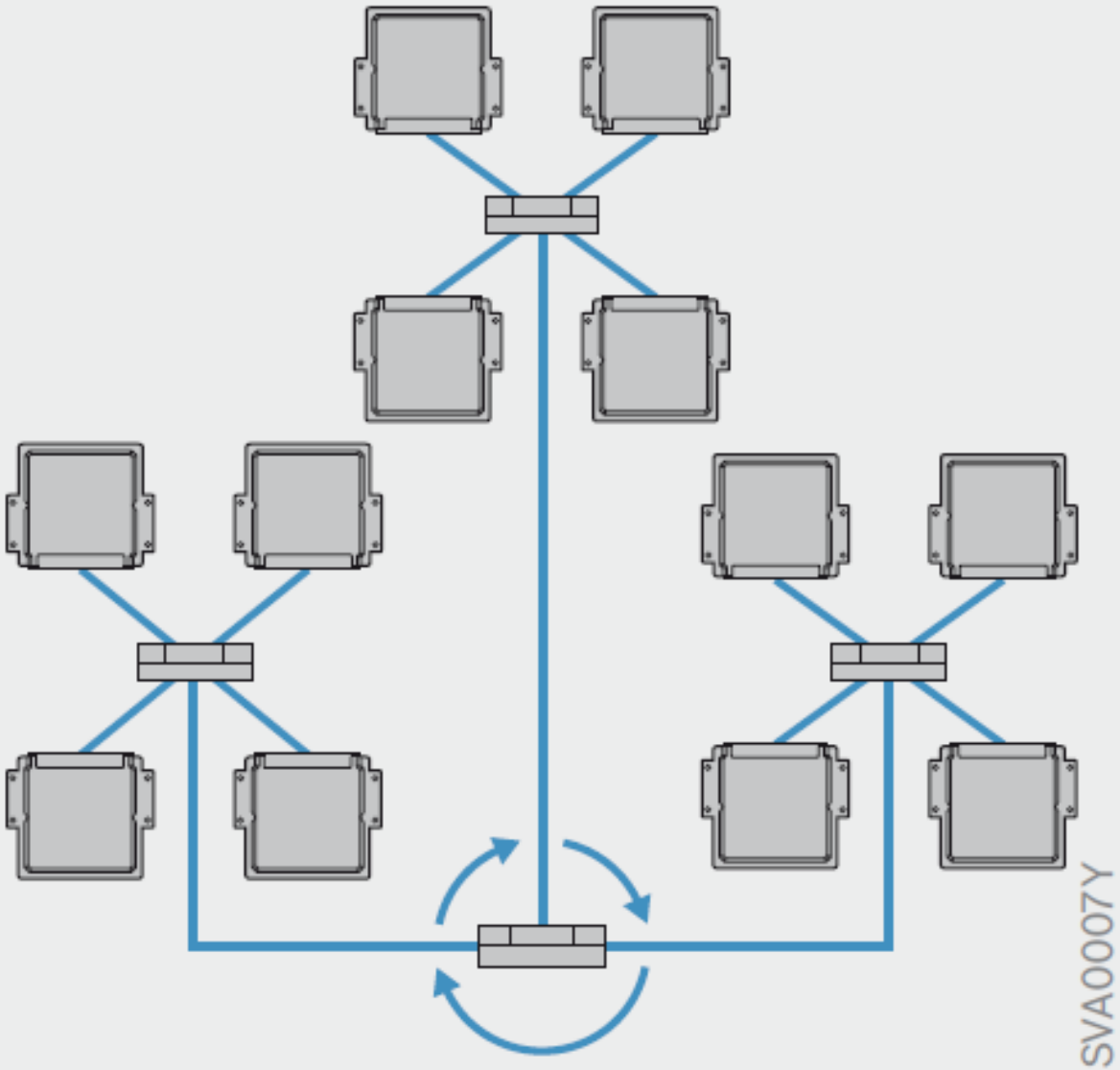

5 V
13K Ω
2.39 V
BUS (+)
120 Ω
2.51 V
BUS (–)
13K Ω


ECU
ECU
ECU
ECU
ECU
ECU
ECU

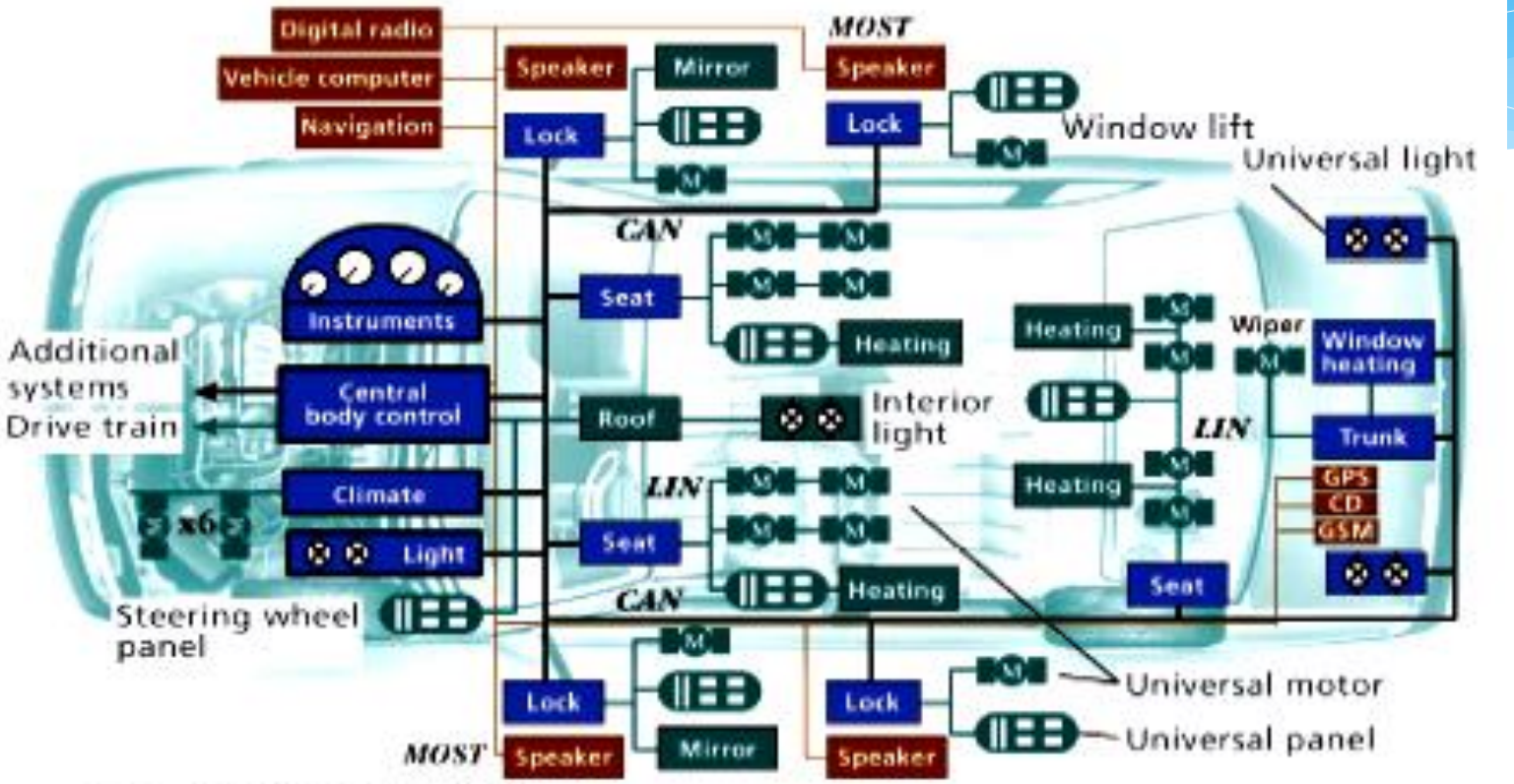
6 Star bus topology



7 Star ring topology



Sample

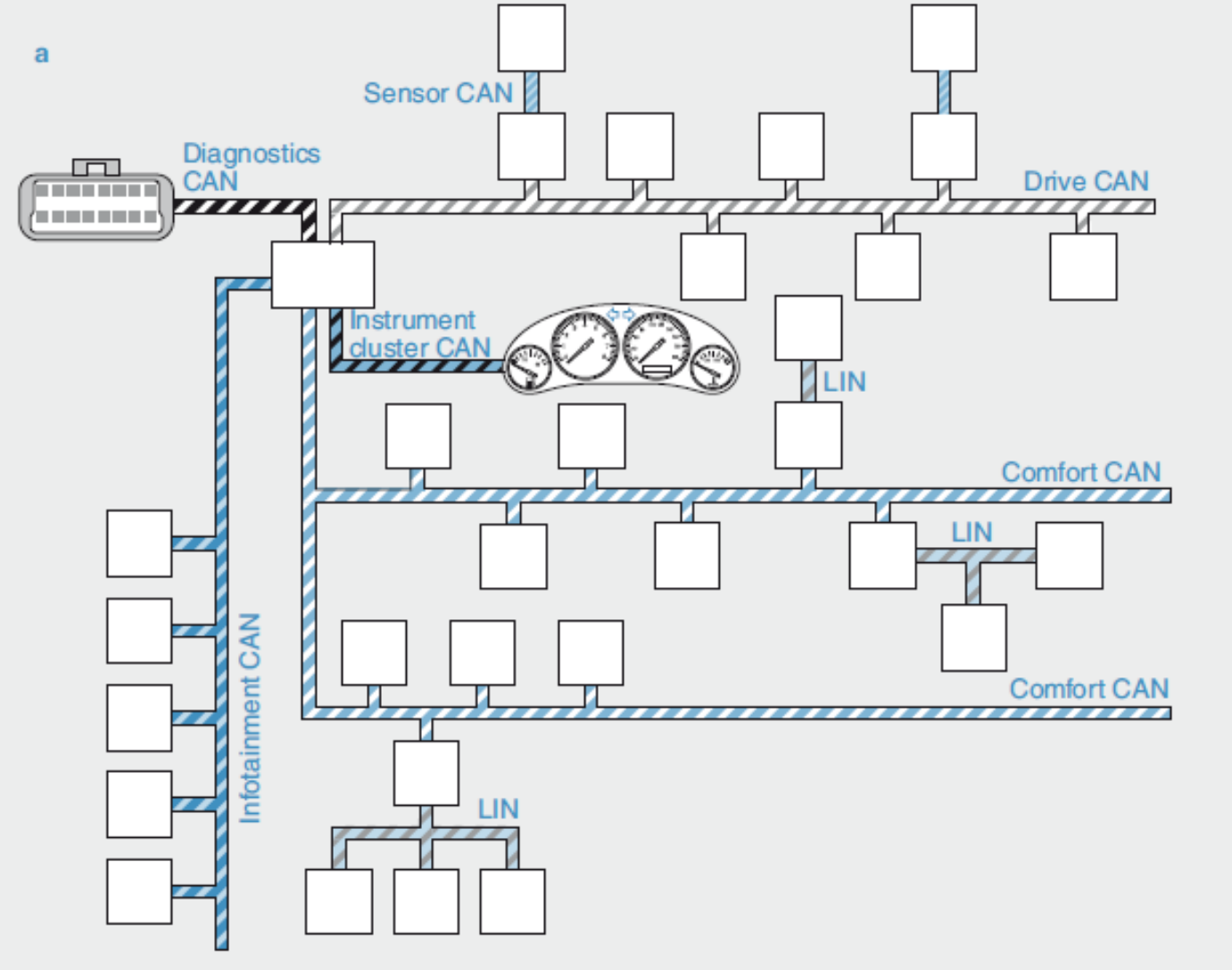


CAN Controller area network
GPS Global Positioning System
GSM Global System for Mobile Communications
LIN Local interconnect network
MOST Media-oriented systems transport

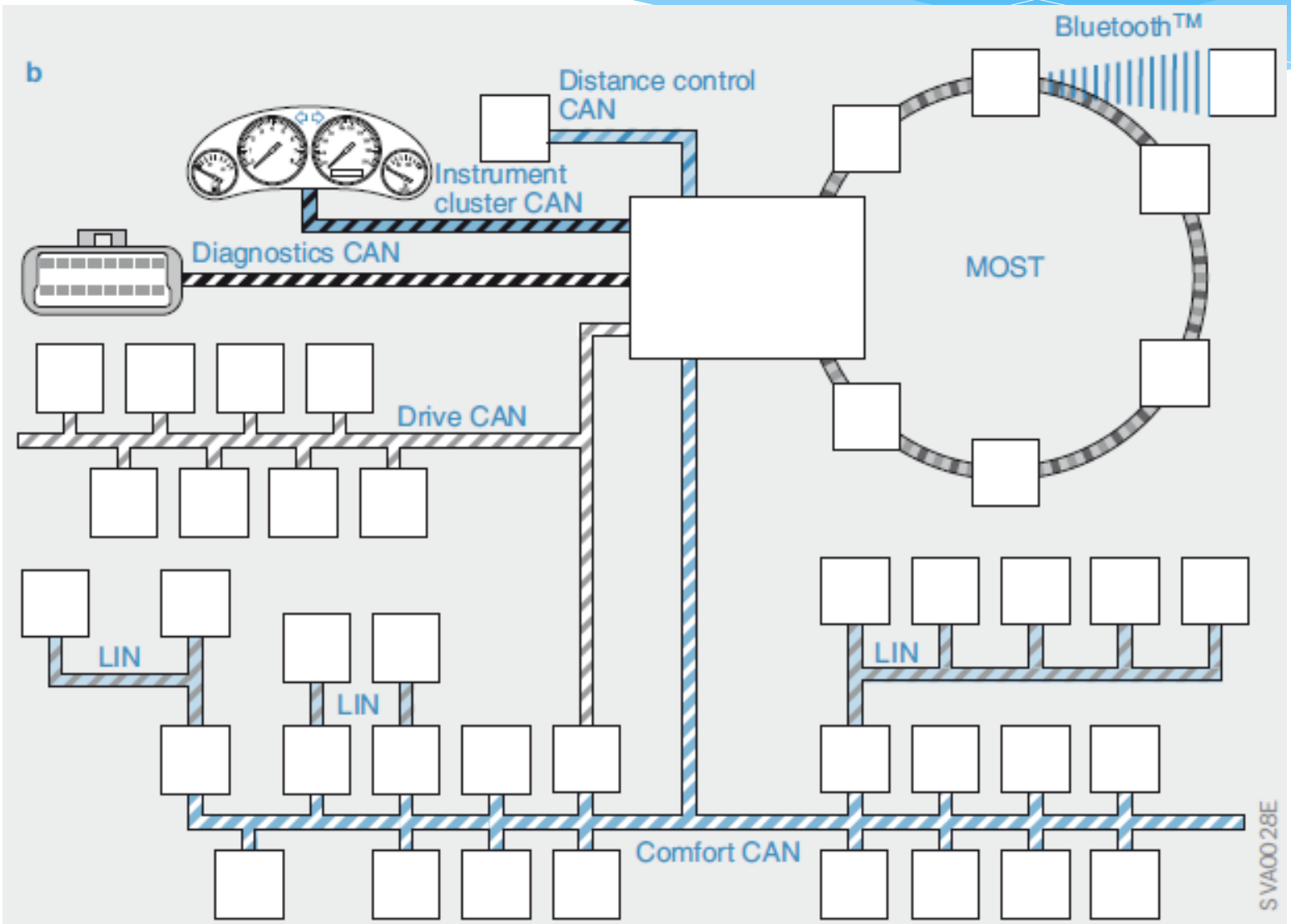
VOLVO
XC90

تهیه و تنظیم : بهروز خطیبی

Sample

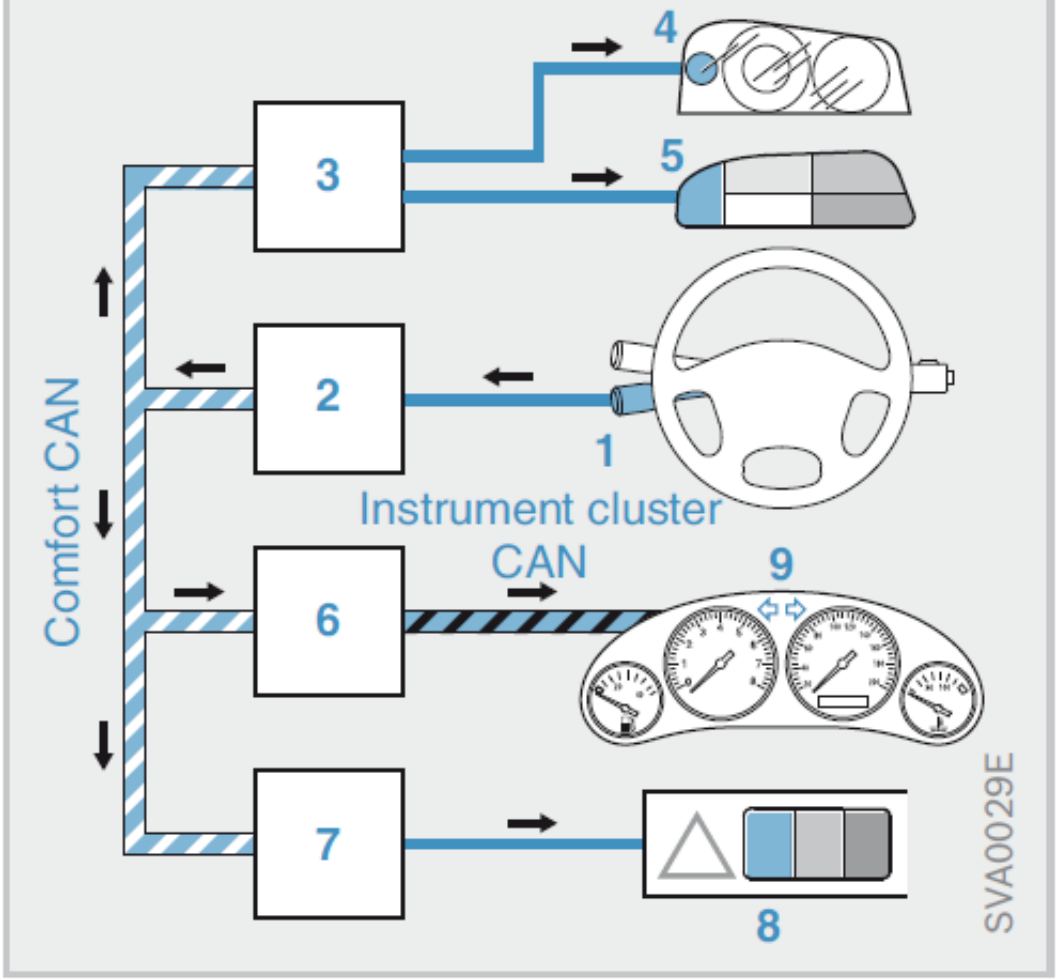

a
Sensor CAN
Diagnostics CAN
Drive CAN
Instrument cluster CAN
LIN
Comfort CAN
LIN
Comfort CAN
Infotainment CAN
LIN

Sample


b
Bluetooth™
Distance control CAN
Instrument cluster CAN
Diagnostics CAN
MOST
Drive CAN
LIN
LIN
LIN
Comfort CAN
SVA00028E

1 Turn signal lever
2 Steering column control unit
3 Vehicle electrical system control unit
4, 5 Turn-signal lamp
6 Gateway
7 Trailer recognition control unit
8 Turn-signal lamp on trailer
9 Instrument cluster

6 Data transfer during turn signaling



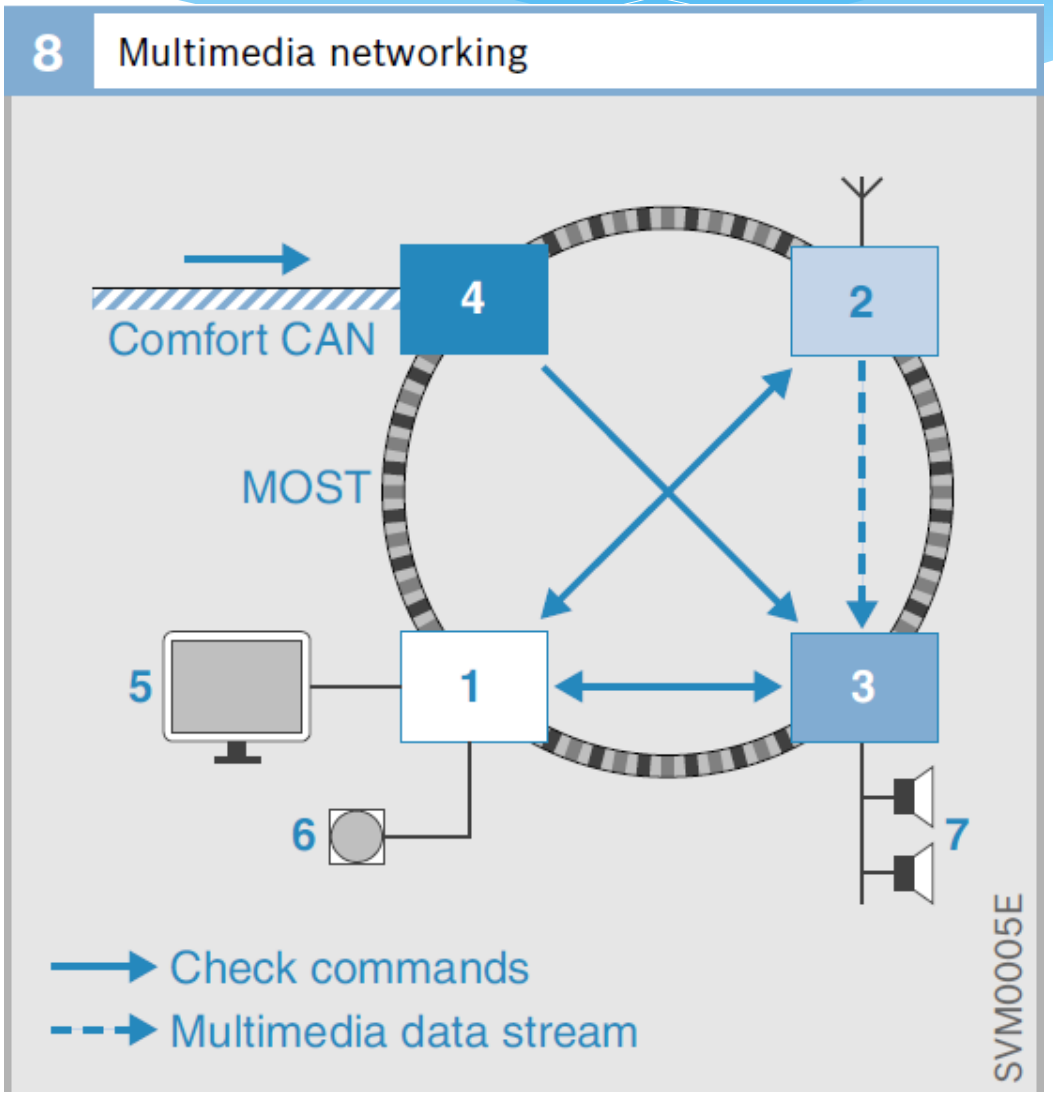
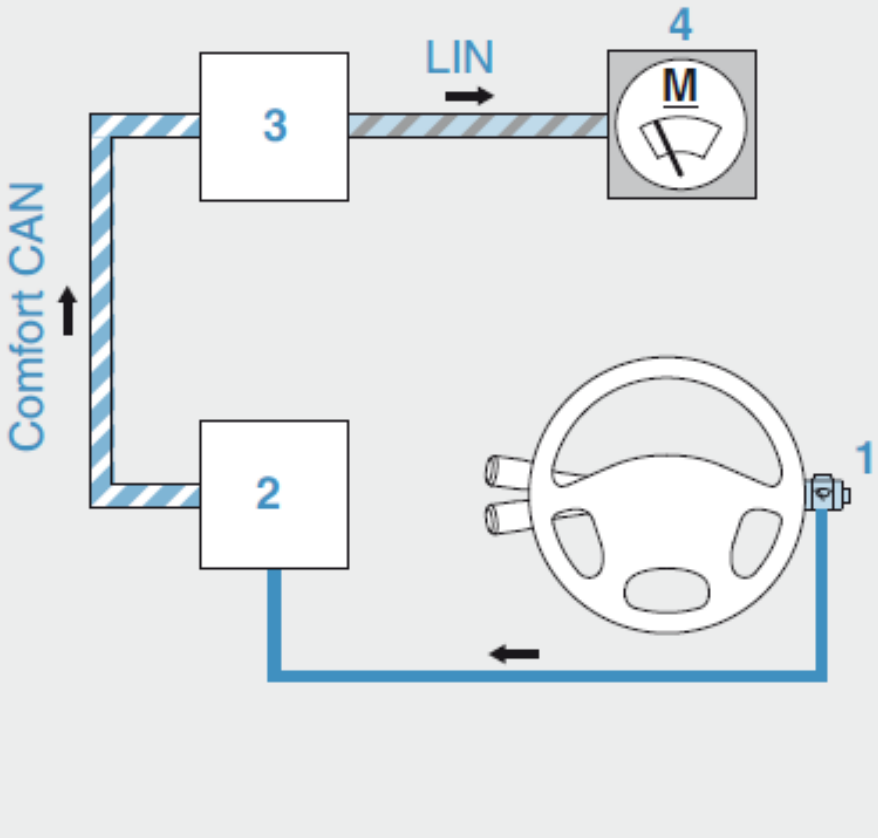


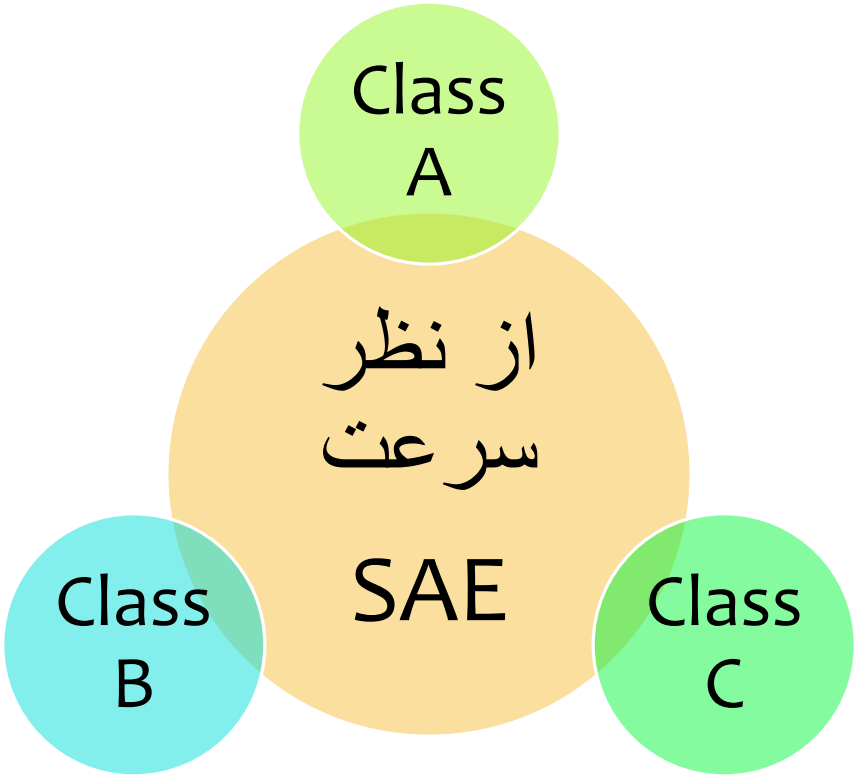
Fig. 8

1 Head unit
2 Radio tuner
3 Amplifier
4 CAN/MOST gateway
5 Screen
6 Control element
7 Speakers

1 Windshield wiper lever
2 Steering column control unit
3 Vehicle electrical system control unit
4 Wiper motor

7 Data transfer during windshield wiper operation




Class A
از نظر سرعت
SAE
Class B
Class C

کلاس های اصلی

Class A	
Transfer rates	Low data rates (up to 10 kBit/s.)
Applications	Actuator and sensor networking
Representative	LIN

Class B	
Transfer rates	Average data rates (up to 125 kBit/s.)
Applications	Complex mechanisms for error handling, control unit networking in the comfort functions
Representative	Low speed CAN

Class C	
Transfer rates	High data rates (up to 1 MBit/s.)
Applications	Real-time requirements, control unit networking in the drive and running gear functions
Representative	High speed CAN

نام پروتکل	UART(ALDL)	SINEBUS	E & C	I^2C	SAE J1708	ACP	BEAN	LIN
استفاده کننده	GM	DELCO	GM	PHILIPS	TMC - ATA	FORD	TOYOTA	Motorola
کاربرد	GENERAL & DIAGNOSTICS	AUDIO	GENERAL		CONTROL & DIAGNOSTICS	AUDIO CONTROL	BODY CONTROL & DIAGNOSTICS	SMART SENSORS
روش اتصال	SINGLE WIRE	SINGLE WIRE	SINGLE WIRE	TWISTED PAIR	TWISTED PAIR	TWISTED PAIR	SINGLE WIRE	SINGLE WIRE
روش کد گذاری	NRZ	SAM	PWM	AM	NRZ	NRZ	NRZ	NRZ
نوع ارتباط	MASTER/ SLAVE	MASTER/ SLAVE	CONTENTION		MASTER/ SLAVE	MASTER/ SLAVE	CONTENTION	MASTER/ SLAVE
نحوه تعیین خطا	8-bit CS	NONE	PARITY	ACK bit	8-bit CS	8-bit CS	8-bit CRC	8-bit CS
طول اغاز پیام	16 BITS	2 BITS	11 - 12 BITS		16 BITS	12 - 24 BITS	25 BITS	2 BITS/BYTE
طول پیام	0 - 85 BYTES	10 - 18 bits	1 - 8 BITS			6 - 12 BYTES	1 - 11 BYTES	8 BYTES
هم پوشانی	Variable	75 %	Variable	45 %	Variable	25 %	28 %	2 BYTES
نیاز به دریافت پاسخ	NO	NO	NO		NO	NO	NO	NO
سرعت انتقال	8192 b/s	66.6 KHz – 200 KHz	1000 b/s	1 - 100 Kb/s	9600	9600 b/s	10 Kb/s	20 Kb/s
بیشترین طول	Not Specified	10 METERS	20 METERS	Not Specified	Not Specified	40 METERS	Not Specified	40 METERS
ماکزیمم نود ها	10		10			20	20	16
µ NEEDED?	YES	NO	YES		YES	YES	YES	NO
حالت خواب /بیدار	NO	NO	NO		NO	NO	NO	
H/W AVAIL?	YES	NO	YES		YES	YES	YES (?)	NO
هزینه	LOW	LOW	LOW		MEDIUM	LOW	LOW	LOW

تهیه و تنظیم : بهروز خطیبی

نام پروتکل :	SINGLE-WIRE CAN (SWC)	CAN 2.0 ISO 11898-1,2,3 ISO 11992 J2284	J1850 ISO 11519-4			SAE J 1939	VAN ISO 11519-3
استفاده کننده	SAE/ISO	BOSCH/SAE/ISO	GM	FORD	CHRYSLER	TMC - ATA	PSA peugeot citroen
کاربرد	DIAGNOSTICS	CONTROL & DIAGNOSTICS	GENERAL & DIAGNOSTICS	GENERAL & DIAGNOSTICS	GENERAL & DIAGNOSTICS	CONTROL & DIAGNOSTICS	GENERAL & DIAGNOSTICS
روش اتصال	SINGLE WIRE	TWISTED PAIR	SINGLE WIRE	TWISTED PAIR	SINGLE WIRE	TWISTED PAIR	TWISTED PAIR
روش کد گذاری	NRZ-5 MSb first	NRZ-5 MSb first	VPW MSb first	PWM MSb first	VPW MSb first	NRZ-5 MSb first	Manchester
نوع ارتباط	CONTENTION	CONTENTION	CONTENTION	CONTENTION	CONTENTION	CONTENTION	CONTENTION
نحوه تعیین خطا	CRC	CRC	CRC	CRC	CRC	CRC	CRC
طول اغاز پیام	11 BITS	11 or 29 BITS	32 BITS	32 BITS	8 BITS	29 BITS	29 BITS
طول پیام	0-8 BYTES	0-8 BYTES	0-8 BYTES	0-8 BYTES	0-10 BYTE	8 BYTES	0-10 BYTE
اضربوشتی	9.9 %	9.9 % - 22 %	33.3 %	33.3 %	8.3 %	9.9 % - 22 %	
نیاز به دریافت پاسخ	NO	NO	Optional Normally NO	Optional Normally YES	Optional Normally YES	NO	NO
سرعت انتقال	33.33 Kb/s 83.33 Kb/s	10 Kb/s to 1 Mb/s	10.4 K b/s	41.6 K b/s	10.4 K b/s	250 Kb/s	125 K b/s
بیشترین طول	30 METERS	Not Specified 40 (Typical)	35 METERS (5 Meters for scan tool)	35 METERS (5 Meters for scan tool)	35 METERS (5 Meters for scan tool)	40 METERS	
ماکزیمم نود ها	16	Not Specified 32 (Typical)	32	32	32	30 FOR STP 10 FOR UTP	
µ NEEDED?	YES	YES	YES	YES	YES	YES	YES
حالت خواب /بیدار	YES	NO	YES	NO	NO	NO	YES
H/W AVAIL?	NO	YES	YES	YES	YES	YES	
هزینه	LOW	MEDIUM	LOW	LOW	LOW	MEDIUM	MEDIUM

	BUS NAME		
نام پروتکل	CAN 2.0 ISO 11898 ISO 11519-2 ISO 11992 J2284 J1939	SAE J1939	Intellibus
استفاده کننده	BOSCH/SAE/ISO	TMC - ATA	Boeing/SAE
کاربرد	CONTROL & DIAGNOSTICS	CONTROL & DIAGNOSTICS	CONTROL & DIAGNOSTICS
روش اتصال	TWISTED PAIR	TWISTED PAIR	TWISTED PAIR
روش کد گذاری	NRZ-5 MSb first	NRZ-5 MSb first	Manchester Bi-phase
نوع ارتباط	CONTENTION	CONTENTION	Master/Slave
نحوه تعیین خطا	CRC	CRC	CRC, Parity
طول اغاز پیام	11 or 29 BITS	29 BITS	16 - 48 Bits
طول پیام	0-8 BYTES 11 or 29-bit ID	MOST ARE 8 BYTES 29-bit ID	0 - 32 Bytes
هم پوشانی	9.9 % - 22 %	9.9 % - 22 %	28% - 75%
نیاز به دریافت پاسخ	NO	NO	Optional
سرعت انتقال	10 Kb/s to 1 Mb/s	250 Kb/s	12.5 Mb/s
بیشترین طول	Not Specified 40 (Typical)	40 METERS	30 METERS
ماکزیمم نود ها	Not Specified 32 (Typical)	30 W/ SHIELDED TWISTED PAIR 10 W/ UNSHIELDED TP	64
µ NEEDED?	YES	YES	NO
حالت خواب /بیدار	NO	NO	YES
H/W AVAIL?	YES	YES	FPGA
هزینه	MEDIUM	MEDIUM	MEDIUM

کلاس های خاص

Class C+	
Transfer rates	Extremely high data rates (up to 10 MBit/s.)
Applications	Real-time requirements, control unit networking in the drive and running gear functions
Representative	FlexRay

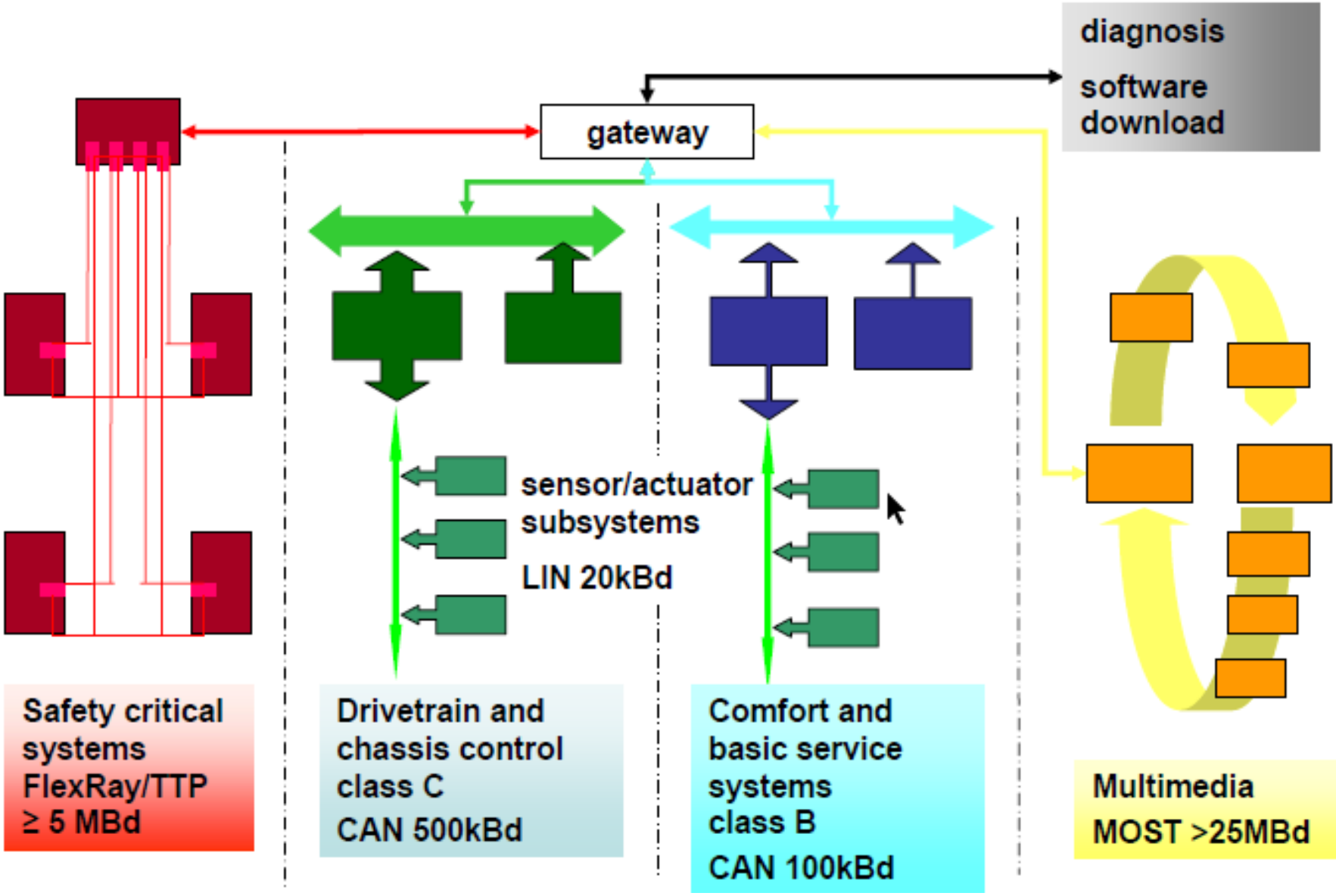
Class D	
Transfer rates	Extremely high data rates (> 10 MBit/s.)
Applications	Control unit networking in the telematics and multi-media functions
Representative	MOST

	BUS NAME					
نام پروتکل	ISO 15765	J1850 ISO 11519-4			ISO/DIS 9141 ISO/DIS 9141-2	KEYWORD XX
استفاده کننده	ISO	GM	FORD	CHRYSLER	WORLD	Various
کاربرد	EMISSIONS DIAGNOSTICS	GENERAL & DIAGNOSTICS	GENERAL & DIAGNOSTICS	GENERAL & DIAGNOSTICS	DIAGNOSTICS ONLY	DIAGNOSTICS
روش اتصال	TWISTED PAIR	SINGLE WIRE	TWISTED PAIR	SINGLE WIRE	SINGLE WIRE	1-WIRE
روش کد گذاری	NRZ	VPW MSb first	PWM MSb first	VPW MSb first	NRZ (strt, 7D, P, stop) LSb first	NRZ
نوع ارتباط	CONTENTION	CONTENTION	CONTENTION	CONTENTION	TESTER/SLAVE	MASTER/ SLAVE
نحوه تعیین خطا	CRC	CRC	CRC	CRC	PARITY (odd)	x-bit CS
طول اغاز پیام	11 and 29-BITS	32 BITS	32 BITS	8 BITS	Not Specified	16 BITS
طول پیام	8 BYTES	0-8 BYTES	0-8 BYTES	0-10 BYTE	Not Specified	0 - 85 BYTES
هم پوشانی	About 50%	33.3 %	33.3 %	8.3 %	Variable	Variable
نیاز به دریافت پاسخ	NO	Optional Normally NO	Optional Normally YES	Optional Normally YES	NO	NO
سرعت انتقال	250 or 500 Kb/s	10.4 K b/s	41.6 K b/s	10.4 K b/s	<10.4 Kb/s	5 b/s - 10.4 Kb/s
بیشترین طول	40 METERS	35 METERS (5 Meters for scan tool)	35 METERS (5 Meters for scan tool)	35 METERS (5 Meters for scan tool)	Limited by total impedance to ground	Not Specified
ماکزیمم نود ها	32	32	32	32	Limited by total impedance to ground	10
µ NEEDED?	YES	YES	YES	YES	YES	YES
حالت خواب /بیدار	YES	YES	NO	NO	NO	NO
H/W AVAIL?	YES	YES	YES	YES	YES	YES
هزینه	LOW	LOW	LOW	LOW	LOW	LOW

نام پروتکل	IDB-C	Intellibus	MOST	SmartWireX	MML	USB	IEEE 1394
استفاده کننده	SAE	Boeing/SAE	Oasis	C&C	DELCO	Commercial	IEEE
کاربرد	Aftermarket Entertainment	CONTROL & DIAGNOSTICS	Stream Data & Control	STREAM DATA & CONTROL	STREAM DATA & CONTROL	PC DEVICES	PC DEVICES
روش اتصال	2-Wire	TWISTED PAIR	Optical	TWISTED PAIR	OPTICAL FIBER	SHIELDED TWISTED PAIR	SHIELDED TWISTED PAIR
روش کد گذاری	NRZ	Manchester Bi-phase	BiPhase	PWM	NRZ	NRZ	NRZ
نوع ارتباط	Token-slot	Master/Slave	Master/Slave	Master/Slave	Master/Slave	Contention	Contention
نحوه تعیین خطا	15-bit CRC	CRC, Parity	CRC	Parity	CORRECTING (optional)	CRC	CRC
طول اغاز پیام	11 BITS	16 - 48 Bits			1 BYTE		
طول پیام	8 BYTES	0 - 32 Bytes			1 - 200+ BYTES		
هم پوشانی	~ 32 BITS	28% - 75%			5 - 10 %	25 %	25 - 30 %
نیاز به دریافت پاسخ	1 ACK BIT	Optional	No	No	No		
سرعت انتقال	250 Kb/s	30 Mb/s	25 Mb/s	tbd kb/s	110 Mb/s	12 Mb/s	98 - 393 Mb/s
بیشترین طول	TBD	30 METERS	TBD	150 METERS	10 METERS		72 METERS
ماکزیمم نود ها	16	64	24	50	16	127	16
µ NEEDED?	YES	NO	YES	YES	YES	YES	YES
حالت خواب /بیدار	YES	YES	YES	YES	YES	NO	NO
H/W AVAIL?	NO	FPGA	YES	YES	NO	YES	YES
هزینه	LOW	LOW	HIGH	HIGH	HIGH	MEDIUM	MEDIUM

تهیه و تنظیم : بهروز خطیبی

Communication system architecture

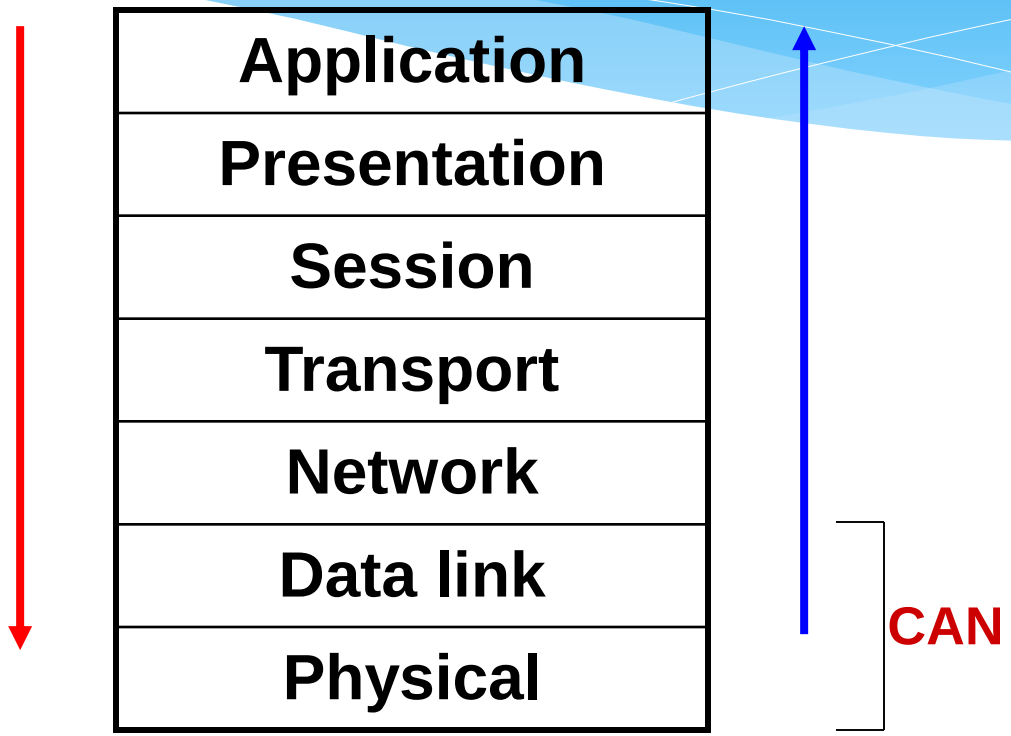


	CAN-C high-speed CAN	CAN-B low-speed CAN	LIN	TTP
Definition	Controller area network	Controller area network	Local interconnect network	Time-triggered protocol
Bus type	Conventional bus	Conventional bus	Conventional bus	Conventional and optical bus
Domains	Drivetrain	Comfort/ convenience	Comfort/ convenience	Safety-related networking
Applications	Engine management, transmission control and ABS/ESP networking	Body and comfort and convenience electronics networking	Low-cost expansion of CAN bus for simple applications in the comfort and convenience electronics area	Networking in safety-related environments such as brakes, steering, railway signal boxes or aircraft landing gear
Most frequently used topology	Linear bus	Linear bus	Linear bus	Star topology
Data transfer rate	10 kbit/s to 1Mbit/s	Max. 125 kbit/s	Max. 20 kbit/s	Unspecified, typ. 10 Mbit/s
Max. number of nodes	10	24	16	Unspecified
Control mechanism	Event-driven	Event-driven	Time-driven	Time-driven
Bus lines	Copper conductors (twisted pair)	Copper conductors (twisted pair)	Copper conductor (single wire)	Copper conductors (twisted pair)
Deployment	in all vehicles	in all vehicles	in all vehicles	Premium class vehicles, aircraft, rail control systems
Standard	ISO 1198	ISO 11519-2	LIN consortium	TTA group
SAE classification	Class C	Class B	Class A	Drive-by-wire

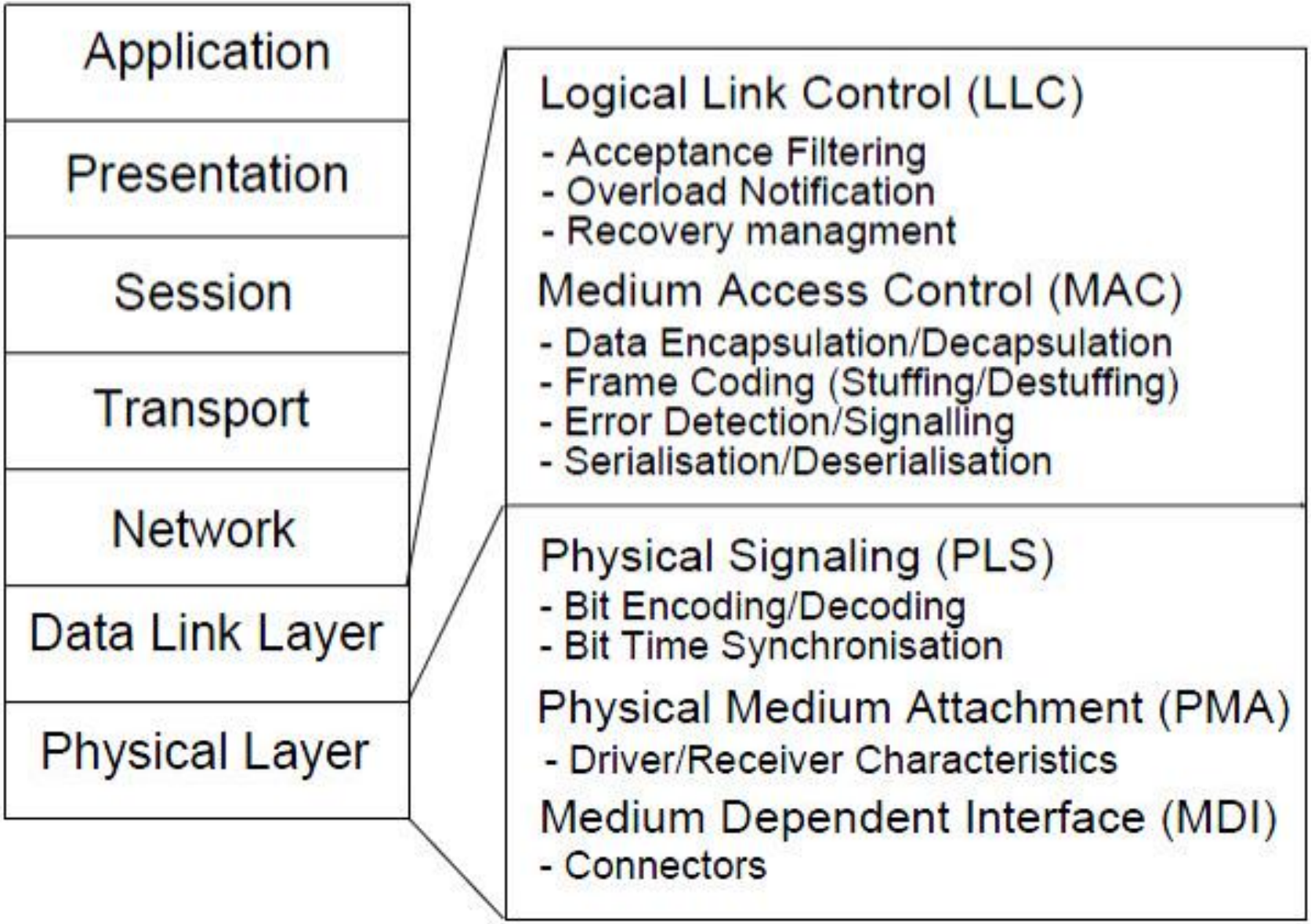
	MOST Bus	Bluetooth	Flexray
Definition	Media oriented systems transport	Proprietary name (Danish king)	Proprietary name
Bus type	Optical bus	Wireless	Conventional and optical bus
Domains	Multimedia and Infotainment	Multimedia and Infotainment	Deployment across all domains
Applications	Transmission of control, audio and video information	Data transfers over short distances, e.g. mobile phone integration in the infotain-ment system	A network system for use in safety-related and simple applications
Most frequently used topology	Ring topology	Network topology (radio)	Star topology
Data transfer rate	Max. 22.5 Mbit/s	Max. 3 Mbit/s (v2.0) Max. 723 kbit/s (v1.2)	Typ. 10 Mbit/s Max. 20 Mbit/s
Max. number of nodes	64	8 active (up to 256 passive)	Theoretically up to 2,048 Max. 22 per passive bus/star
Control mechanism	Time and event-driven	Event-driven	Time and event-driven
Bus lines	Plastic or glass optical waveguides	Electromagnetic radio waves	Copper conductors (twisted pair)
Deployment	Premium class vehicles made by European manufacturers	All vehicles, connection be-tween multimedia equipment and infotainment system	Pilot application
Standard	MOST cooperation	Bluetooth SIG	Flexray consortium
SAE classification	Mobile Media	Wireless	Drive-by-wire

Information layers

ISO Reference layer



In the best conditions is used all layers in spite of it’s used less layers . CAN=1,2


Application
Presentation
Session
Transport
Network
Data Link Layer
Physical Layer
Logical Link Control (LLC)
- Acceptance Filtering
- Overload Notification
- Recovery managment
Medium Access Control (MAC)
- Data Encapsulation/Decapsulation
- Frame Coding (Stuffing/Destuffing)
- Error Detection/Signalling
- Serialisation/Deserialisation
Physical Signaling (PLS)
- Bit Encoding/Decoding
- Bit Time Synchronisation
Physical Medium Attachment (PMA)
- Driver/Receiver Characteristics
Medium Dependent Interface (MDI)
- Connectors

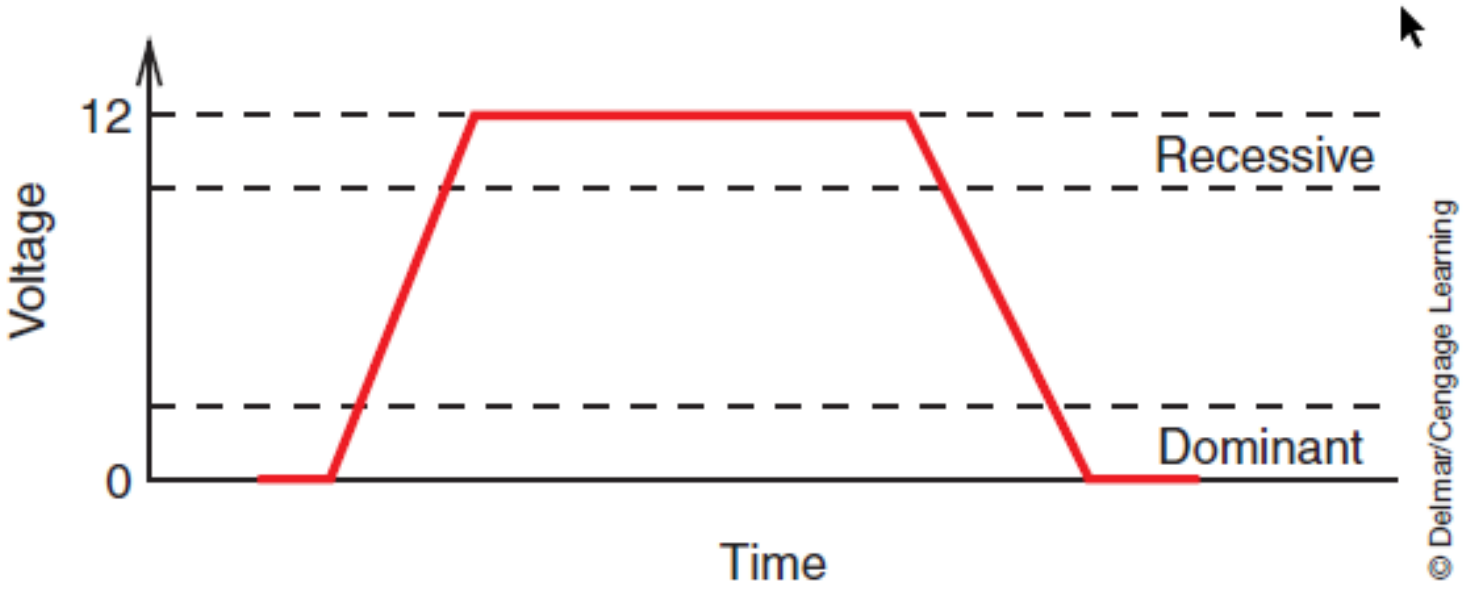


FIGURE 11-20 Voltages of the LIN bus.

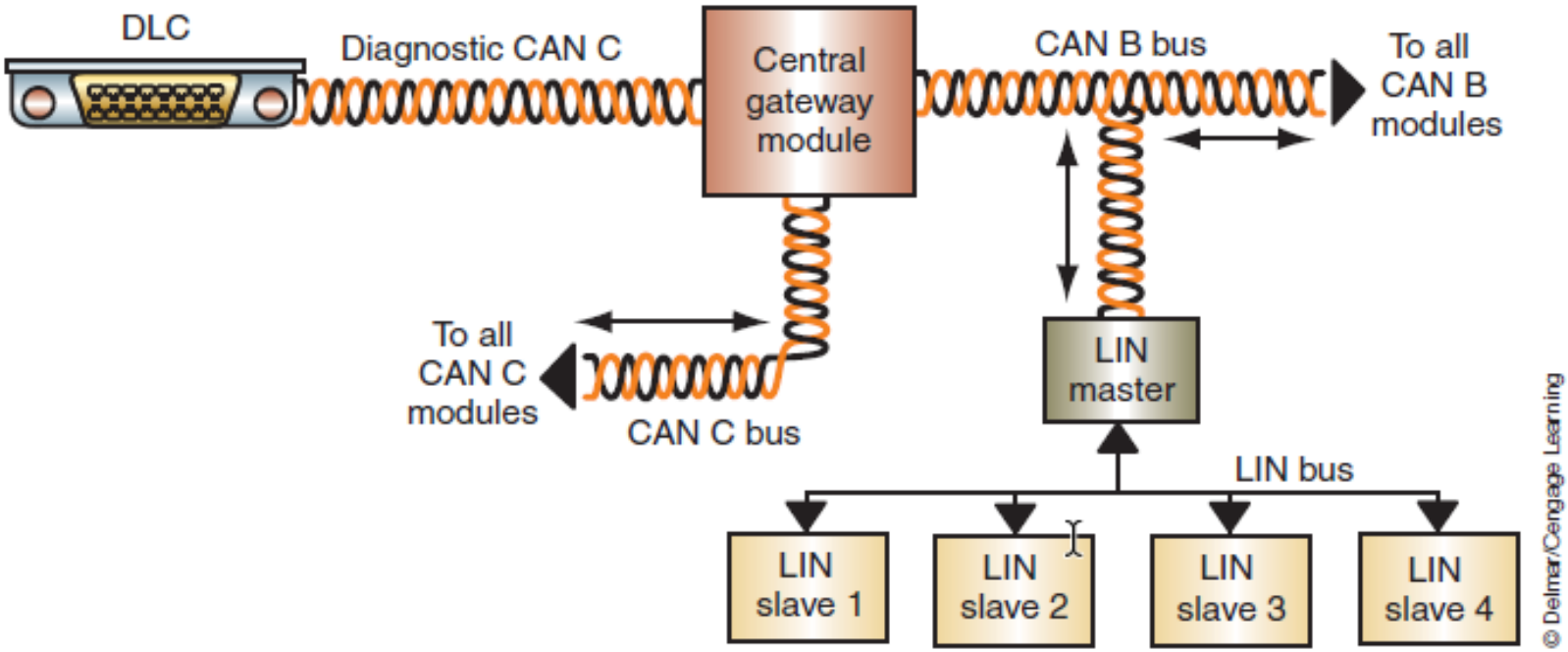


FIGURE 11-19 **The LIN master communicates messages from the slaves onto the CAN bus.**

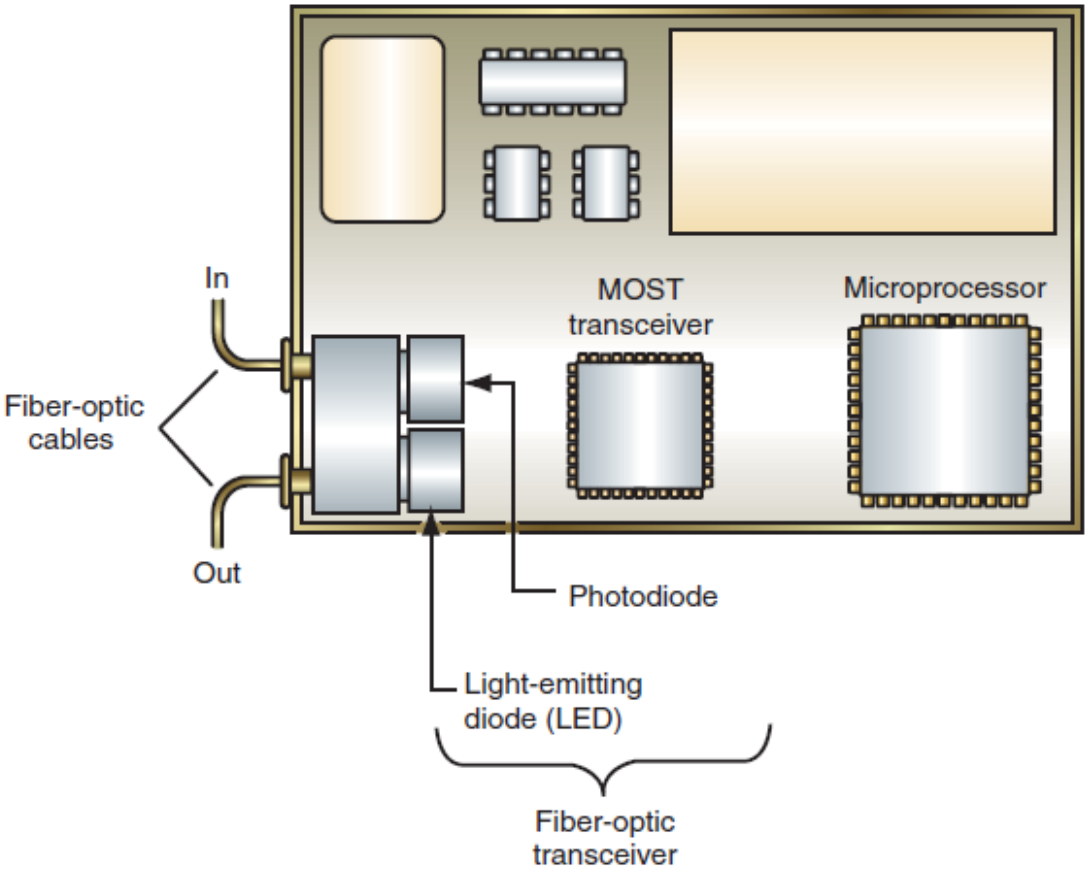


FIGURE 11-21 **Typical MOST data system controller components.**

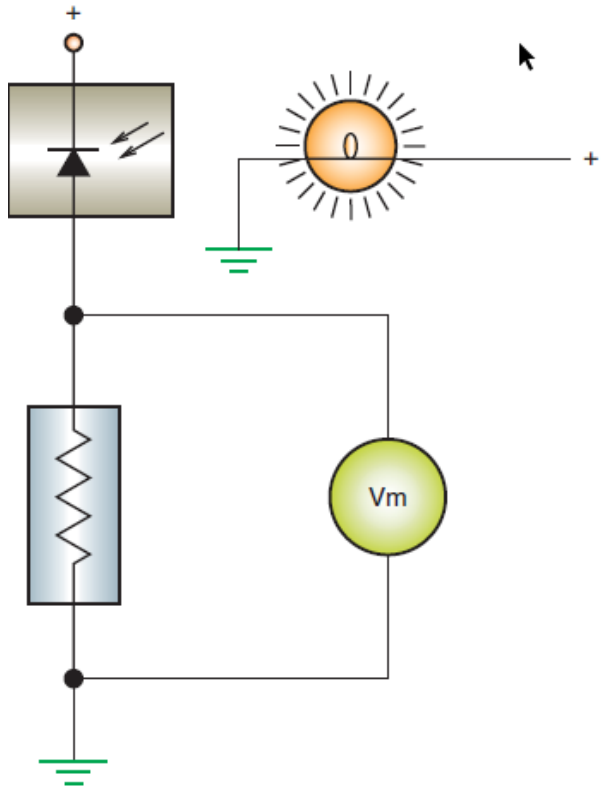


FIGURE 11-22 **The voltage drop over the resistor changes in relation to the amount of light applied to the photodiode.**

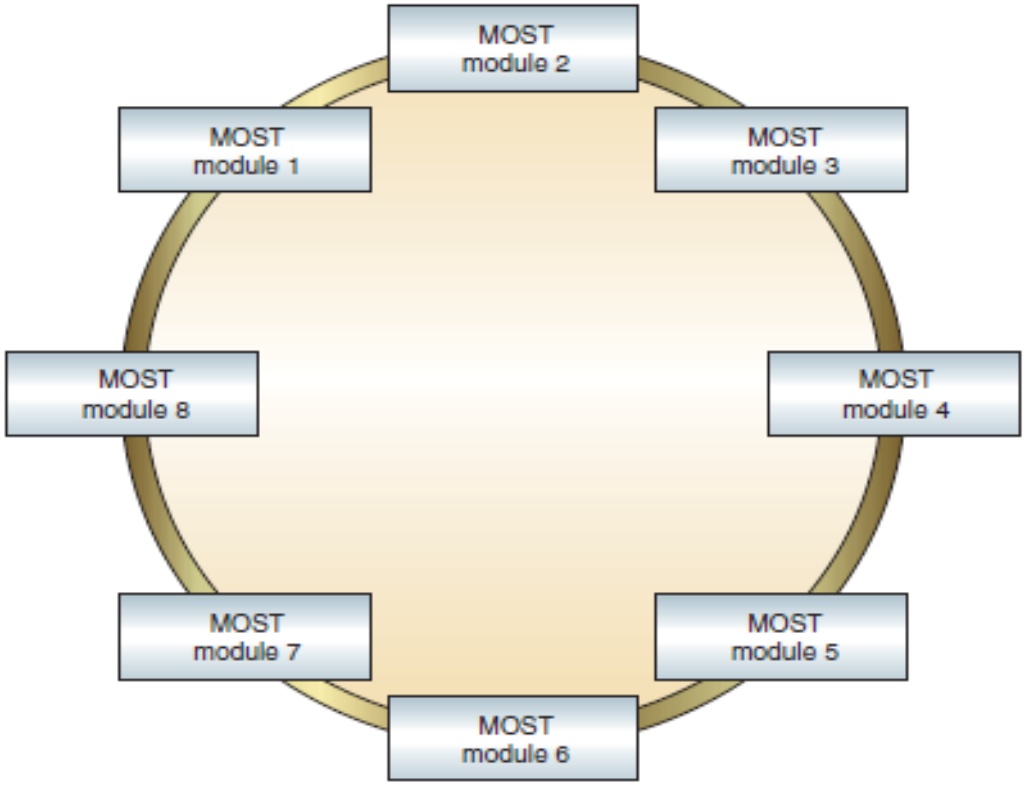


FIGURE 11-23 **The MOST data system transfers data in a single direction through the use a ring configuration.**

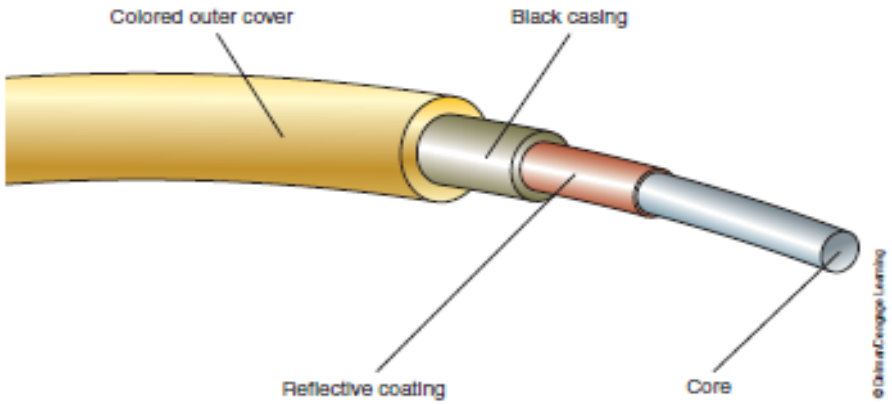


FIGURE 11-24 **Fiber optic cable construction.**

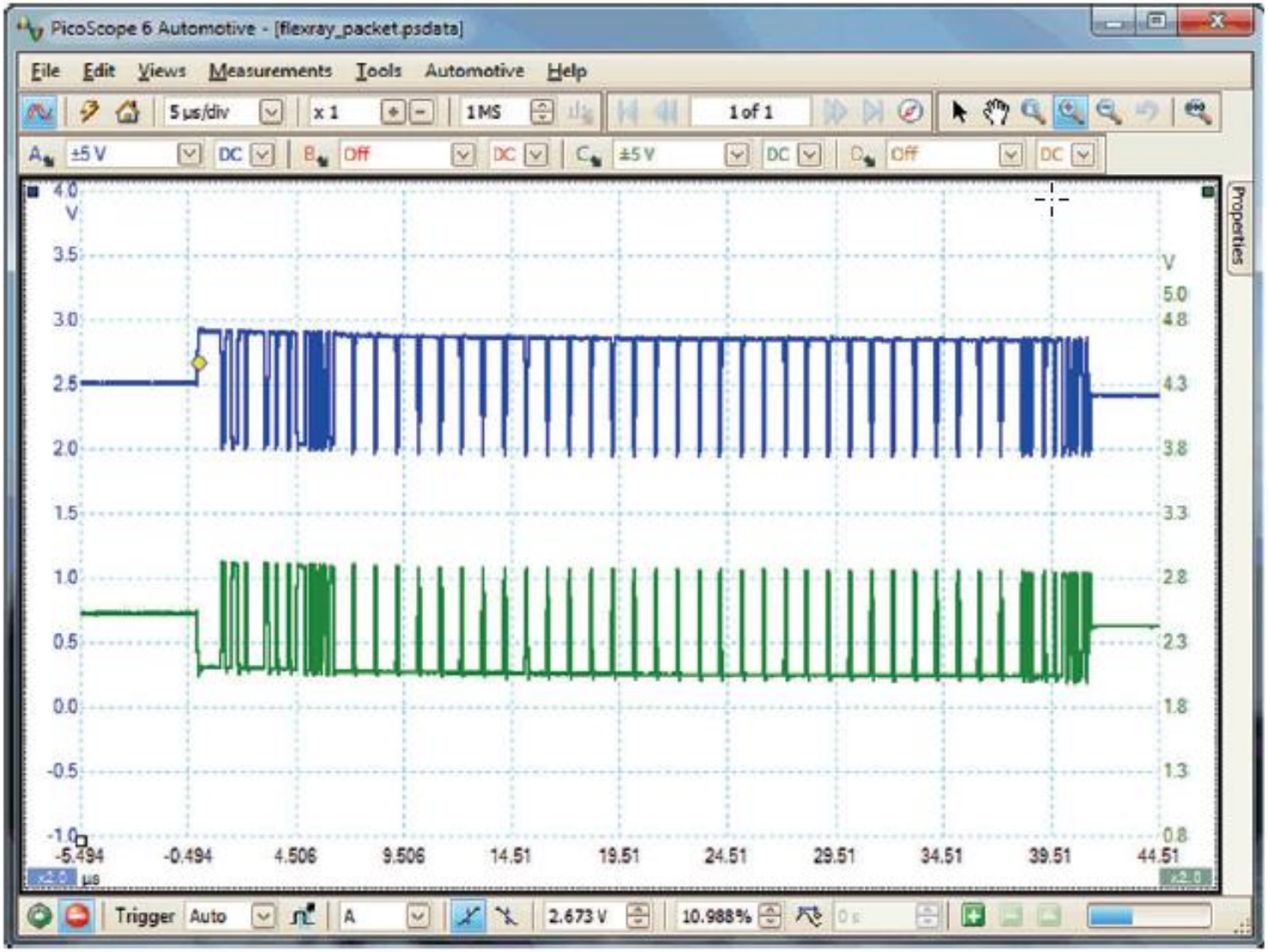


Figure 4.72 FlexRay signal

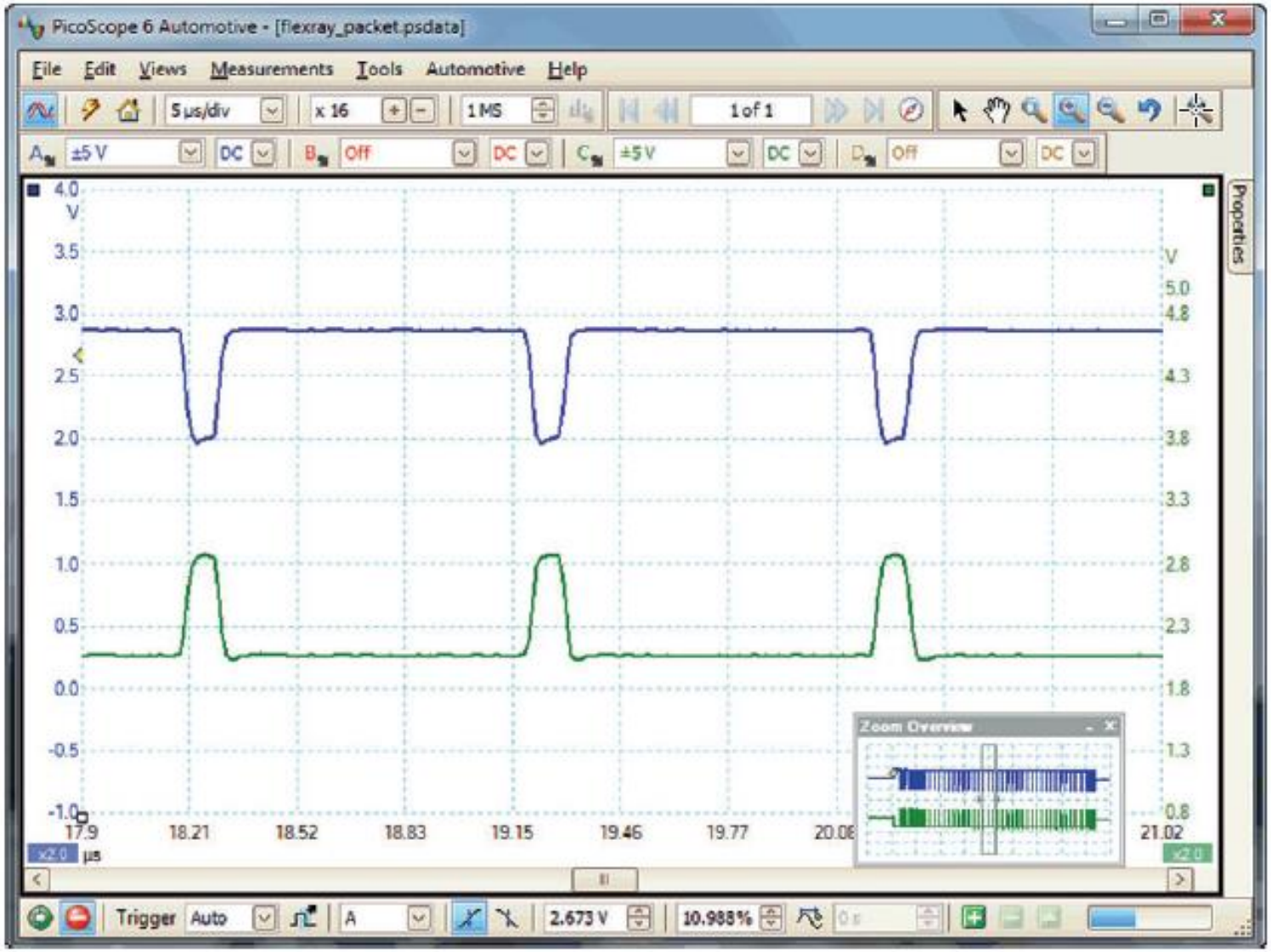


Figure 4.73 A closer view of a FlexRay signal

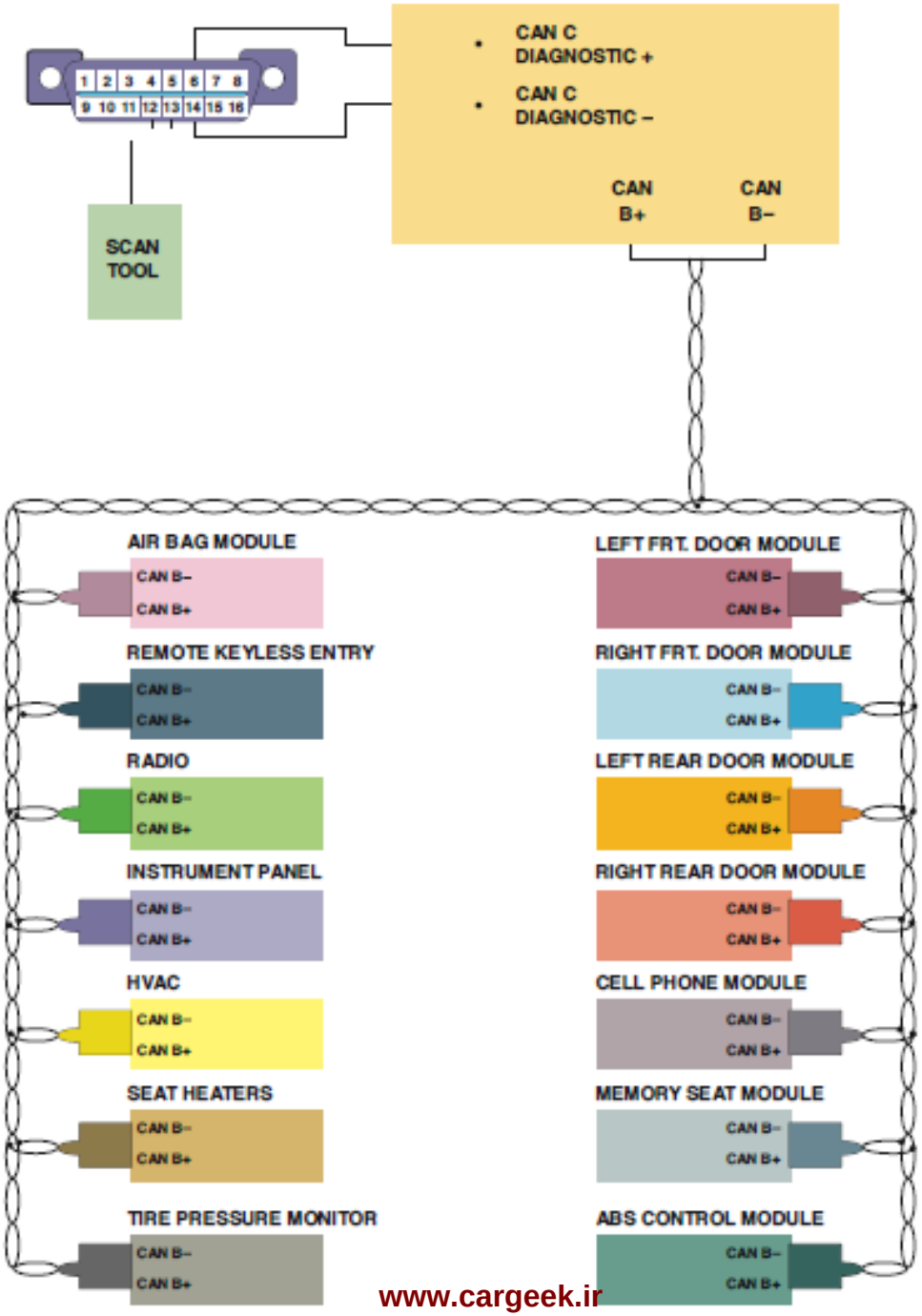
CAN (Controller Area Network)

* It equals SAE Class C and has speed up to1 Mb/s.

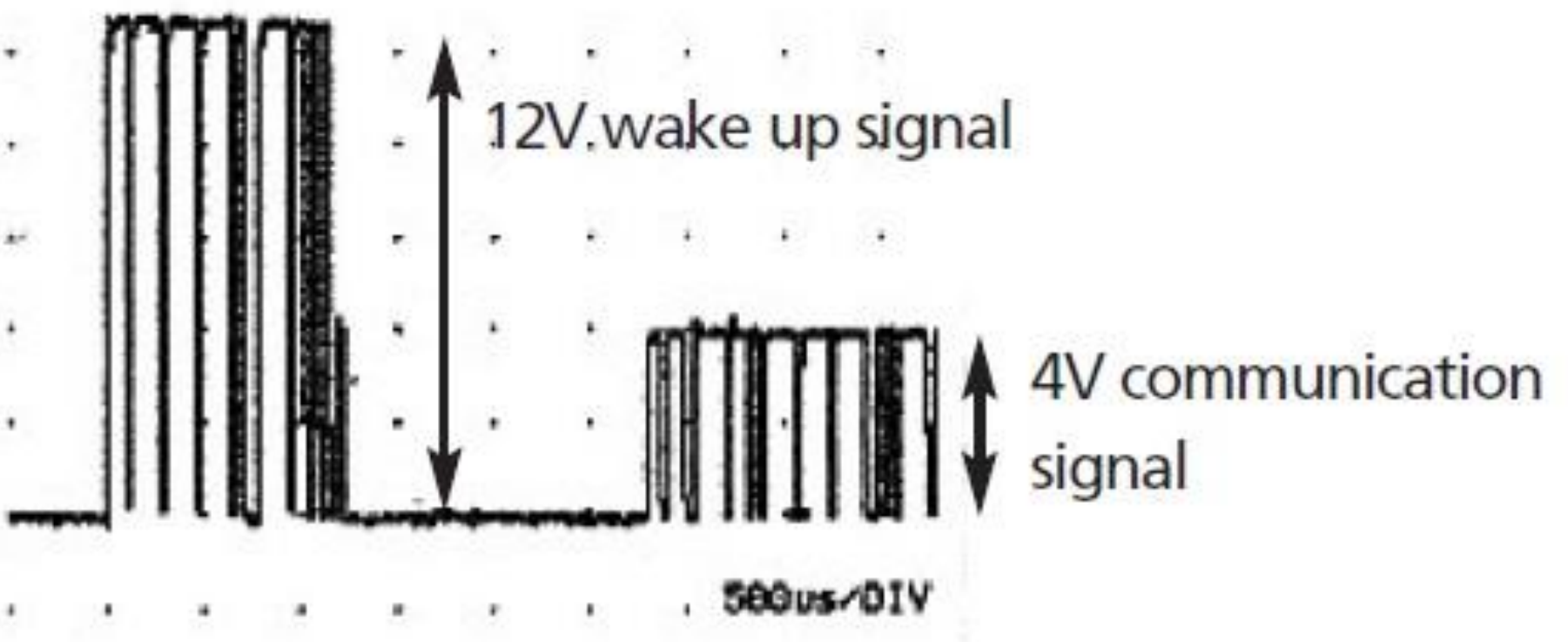
Basic CAN = J 1939

CAN (500Kb/s) = J 2284-500

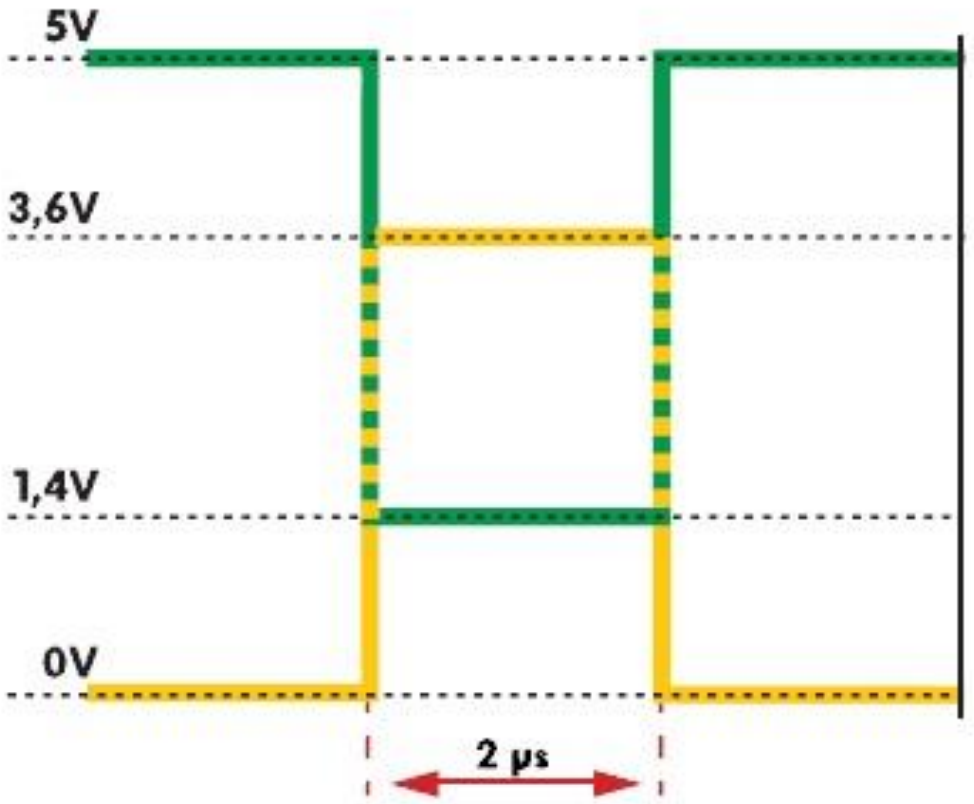
CAN Single Wire = J 2411



CAN LOW SPEED (one wire)



(CAN B)-Medium speed



In a **dominant** state, the **CAN low wire** drops to **approx.** 1.4V.

In a **recessive** state, the **CAN high wire** is at approx. **0V** and the **CAN low wire** is at approx. **5V.**

In a **dominant** state, the **CAN high wire** is at approx. **3.6V.**

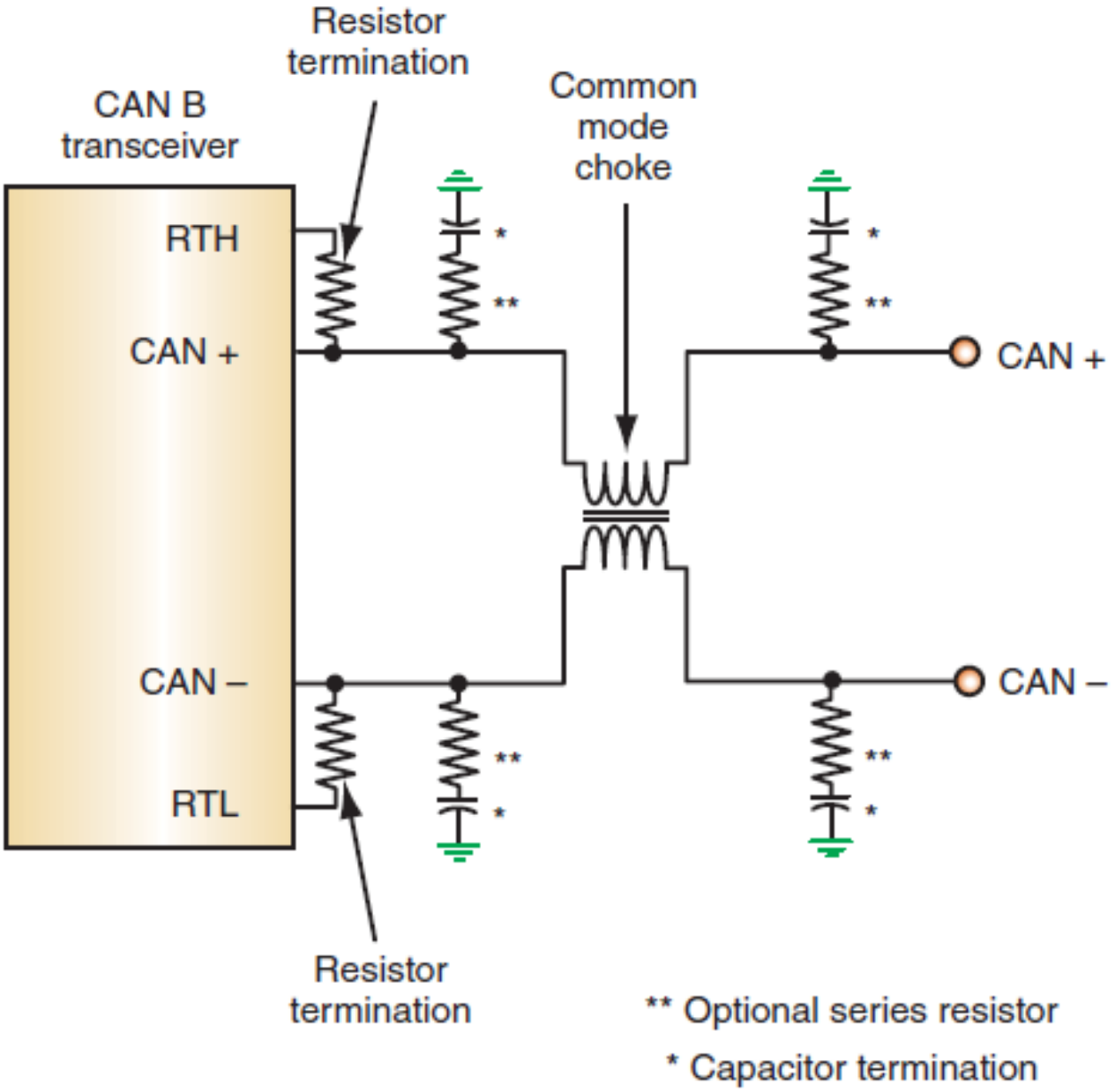
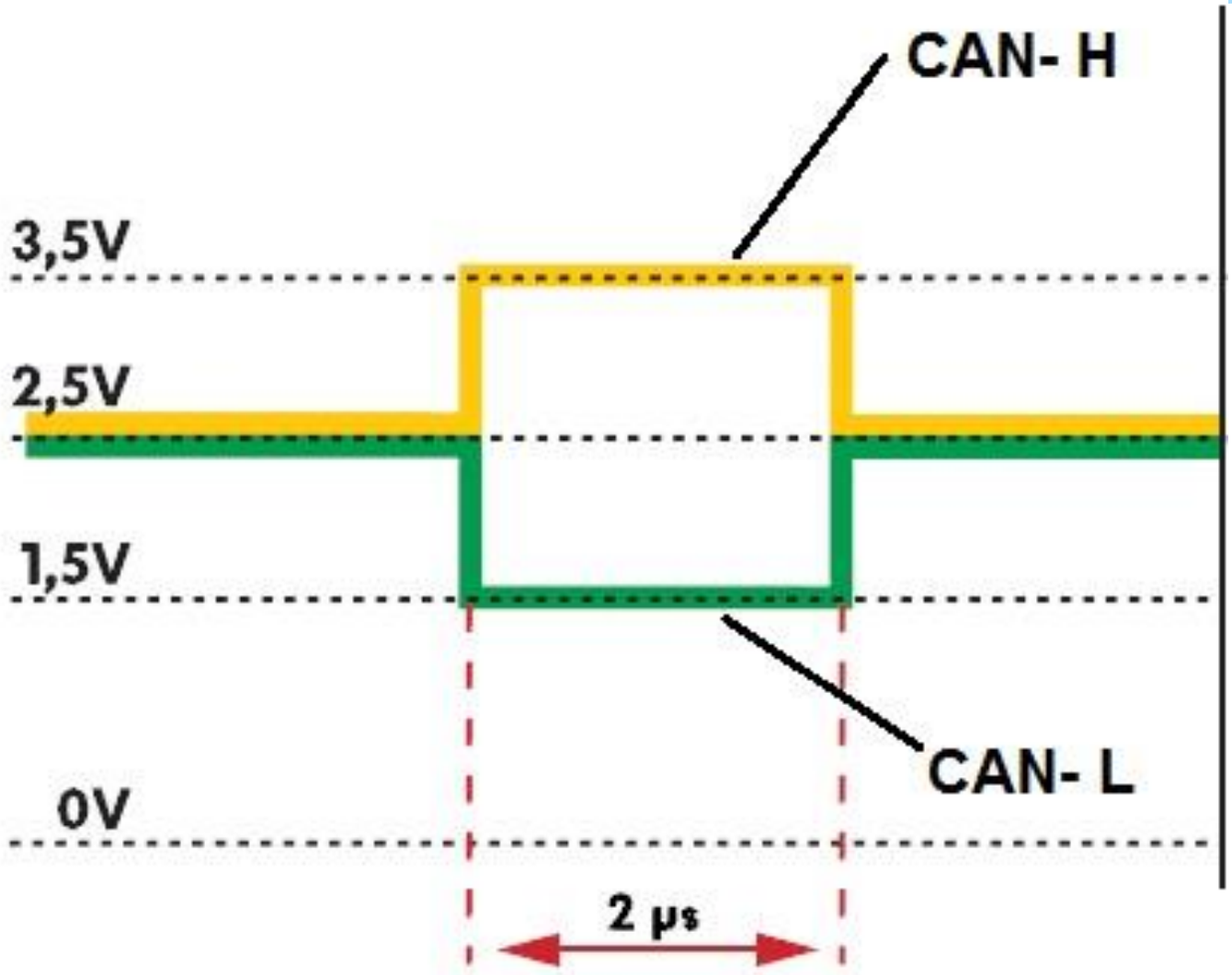


FIGURE 11-18 **CAN B bus module termination resistance.**

CAN High SPEED



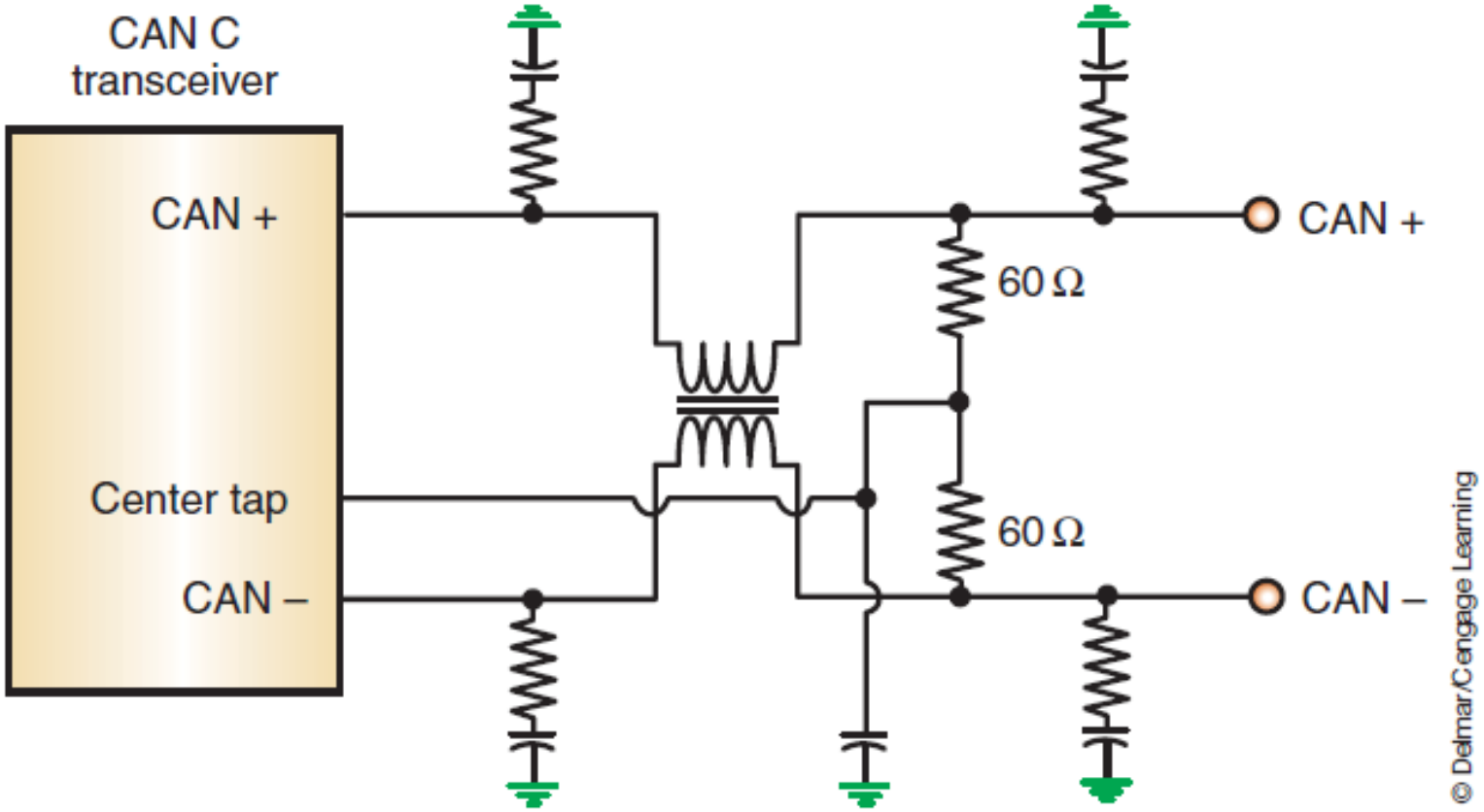
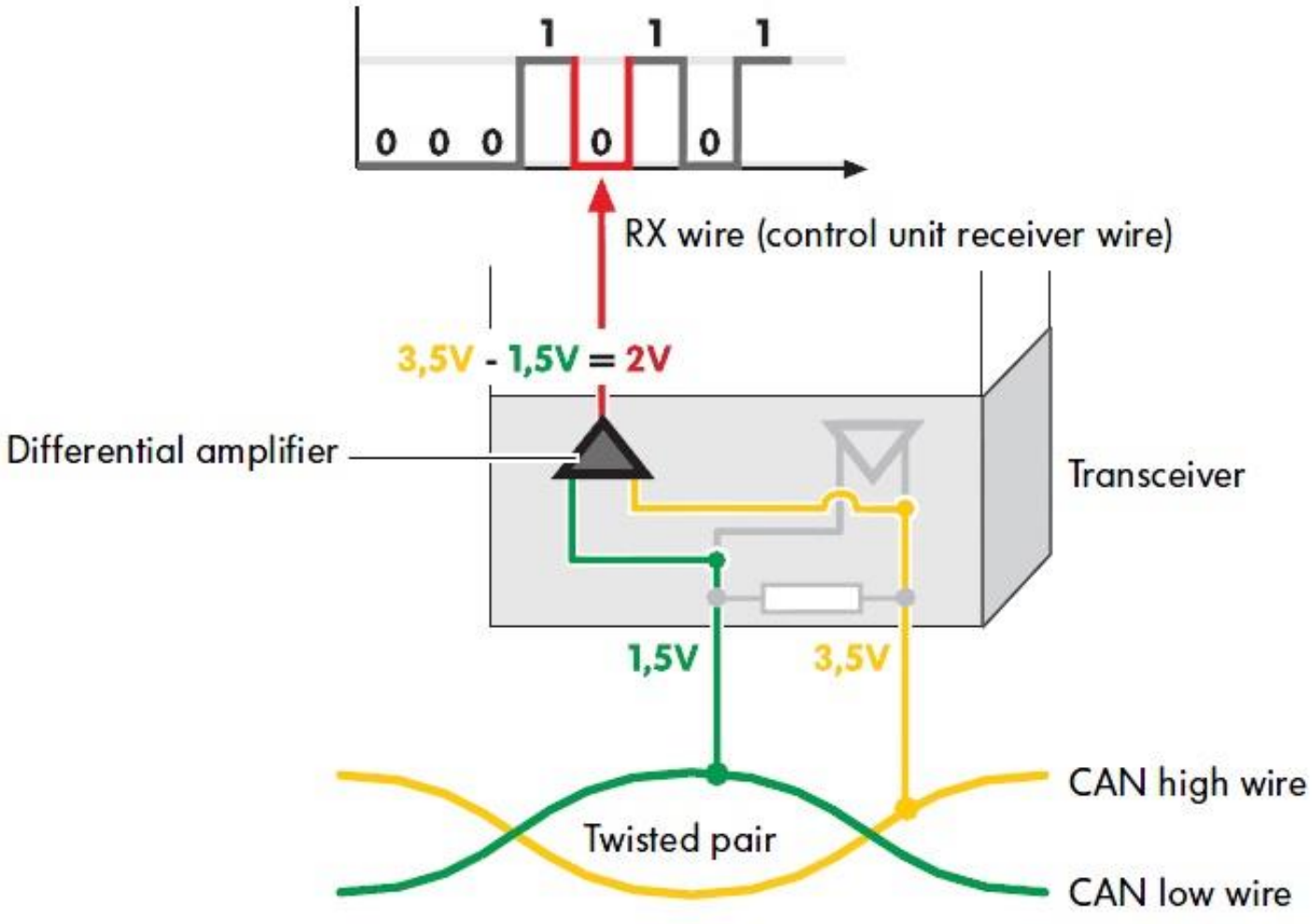
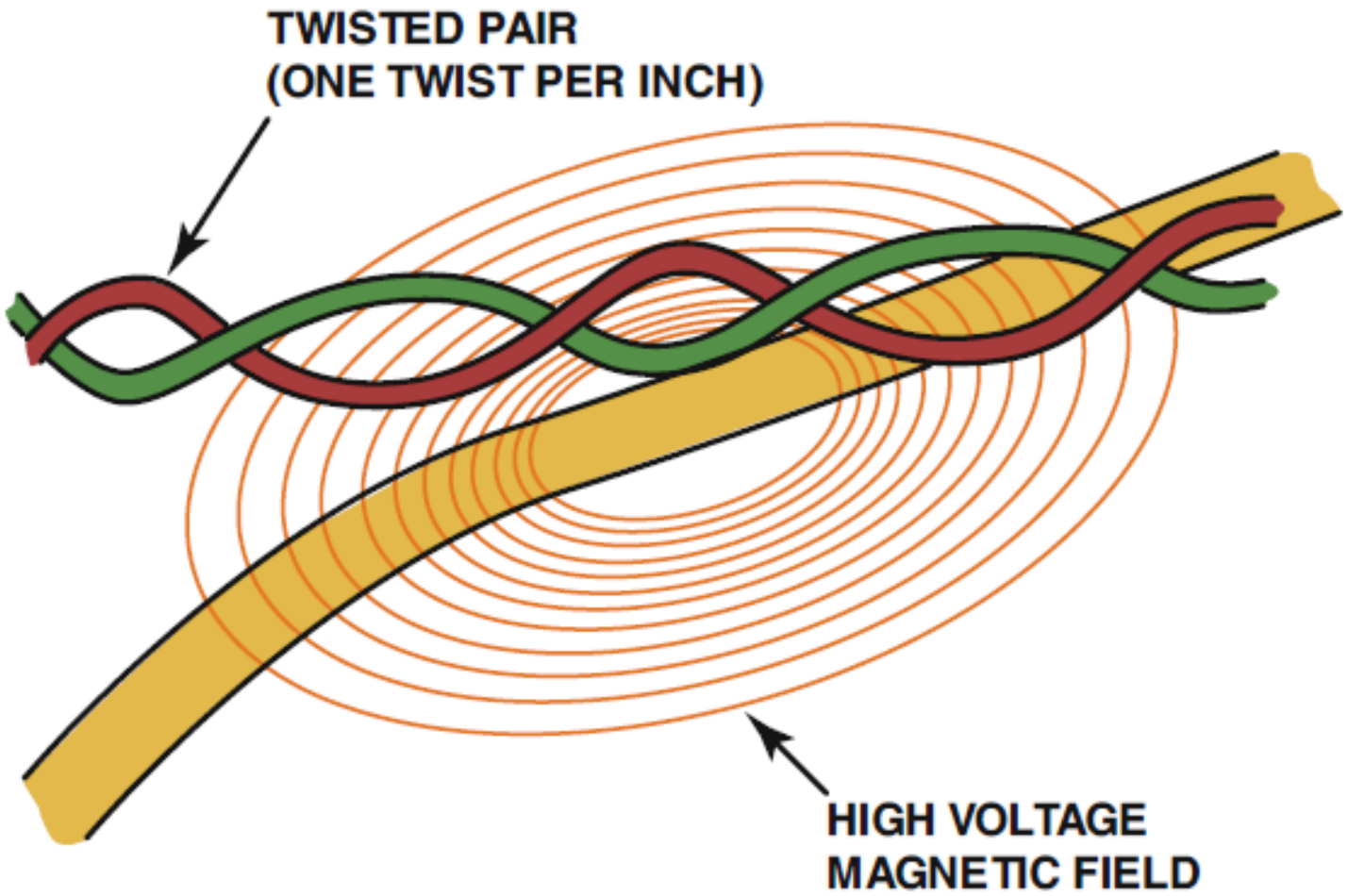


FIGURE 11-16 Termination resistance of a CAN C module.


1 1 1
0 0 0 0 0
RX wire (control unit receiver wire)
3,5V - 1,5V = 2V
Differential amplifier
Transceiver
1,5V
3,5V
CAN high wire
Twisted pair
CAN low wire

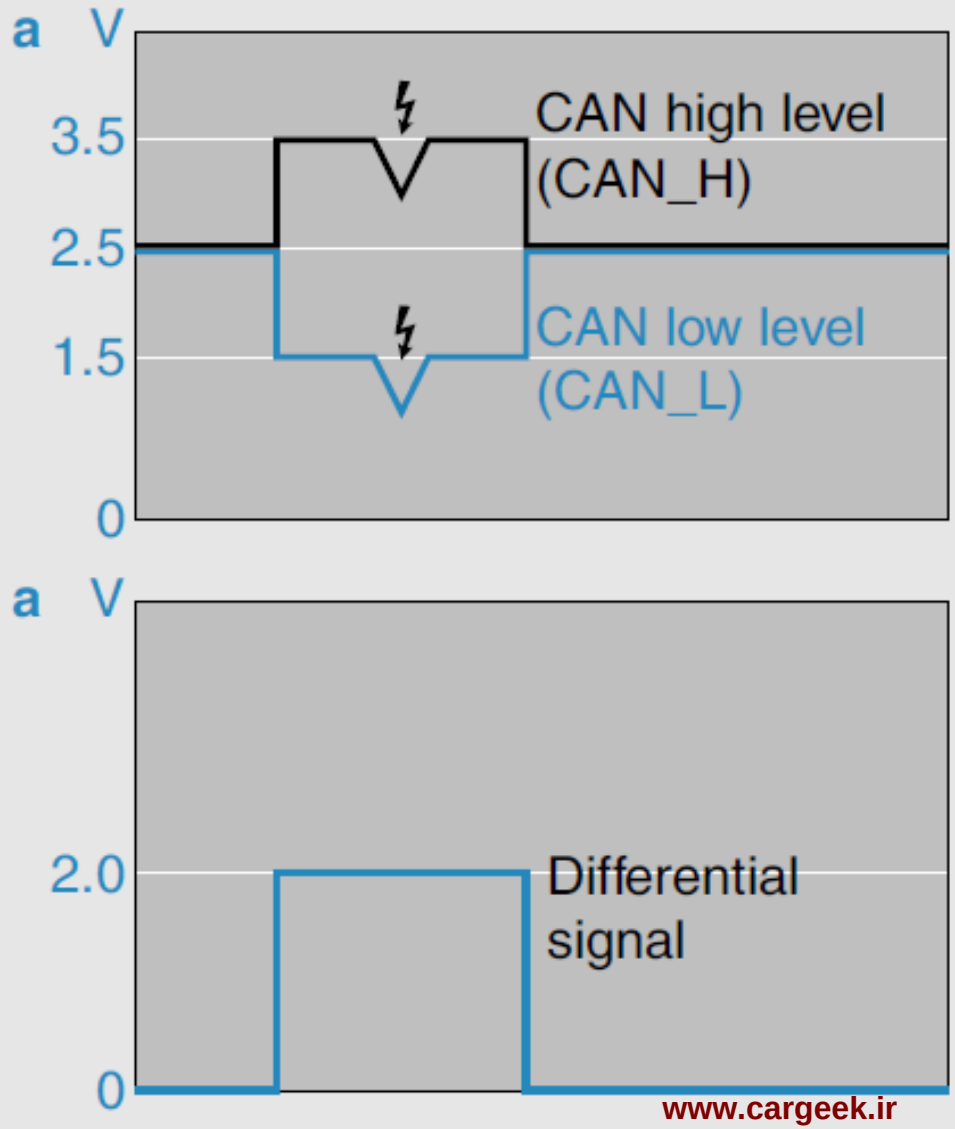

TWISTED PAIR
(ONE TWIST PER INCH)
HIGH VOLTAGE
MAGNETIC FIELD

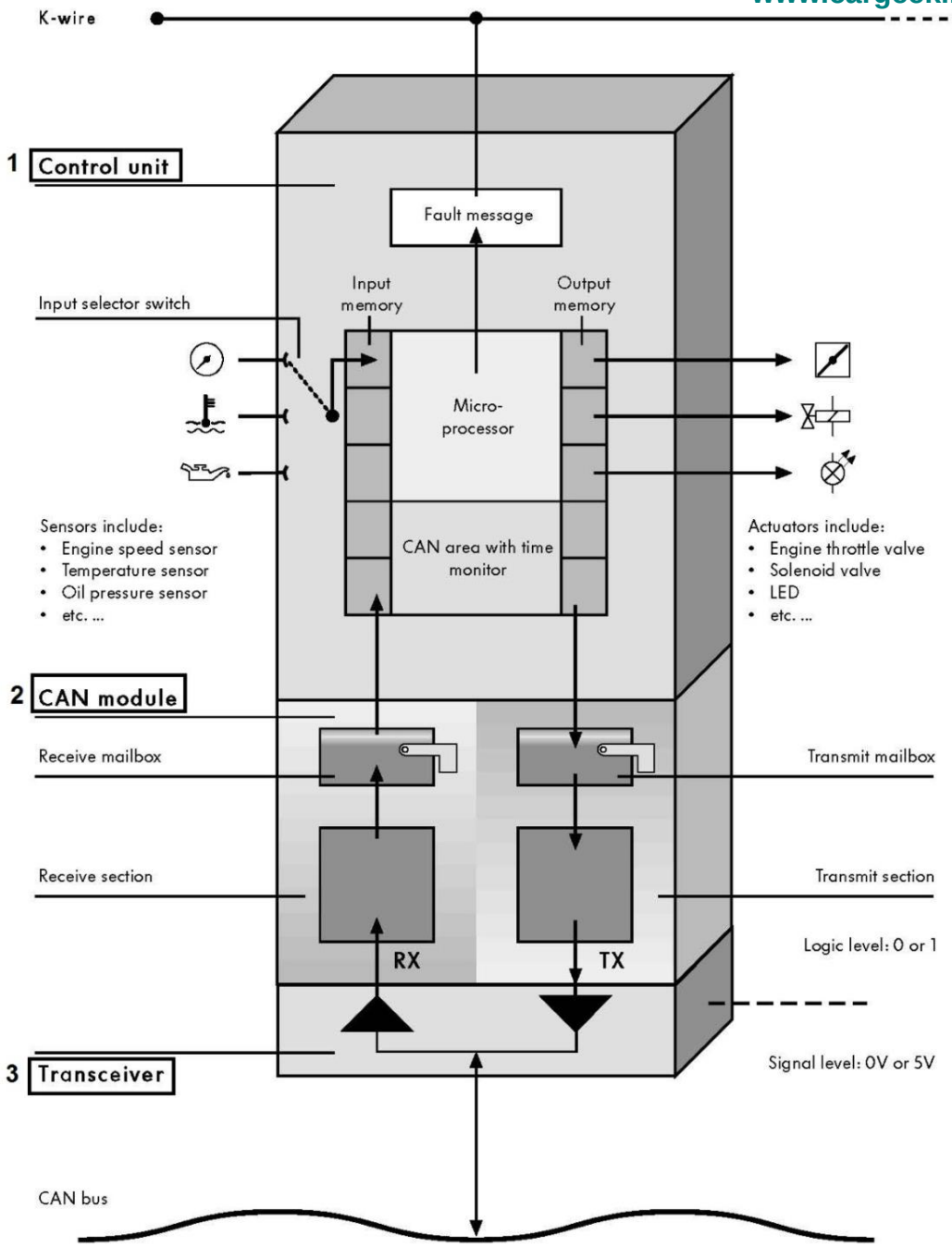
روش های عمومی پارازیت گیری

- استفاده از سیگنال های دیجیتال
- استفاده از سیم شیلد
- با استفاده از IC های هوشمند و فیلتر ها
- روش تفاضلی

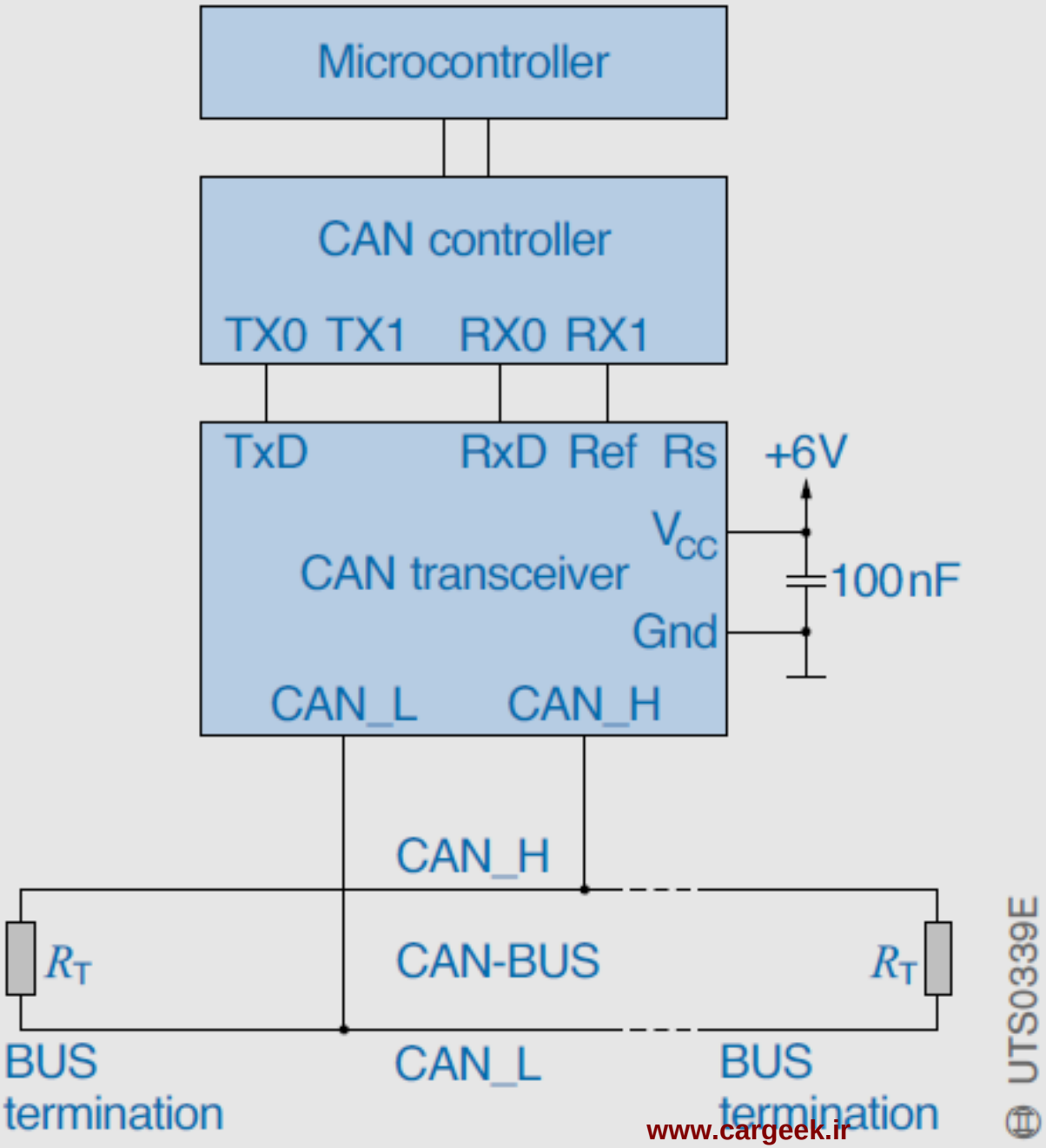
تهیه و تنظیم : بهروز خطیبی

3 Filtering out interference on the CAN bus

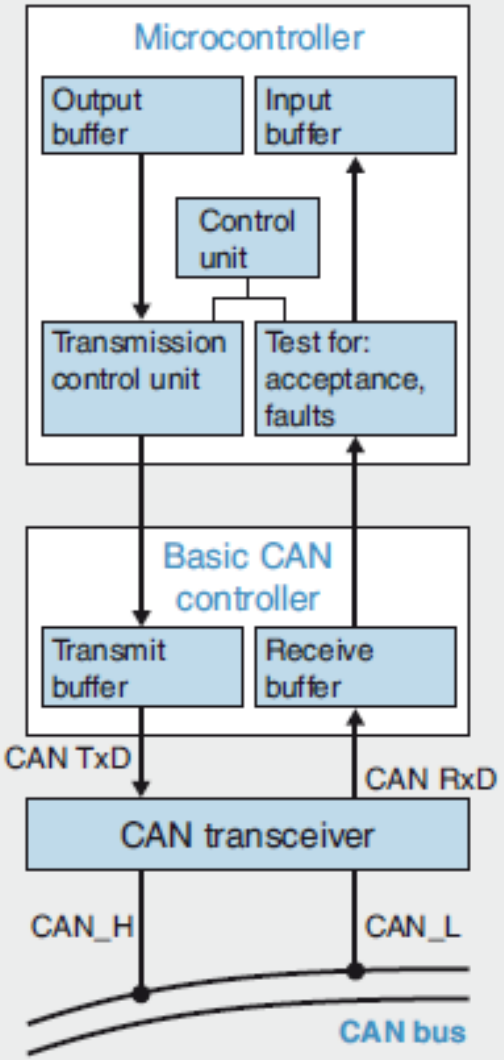




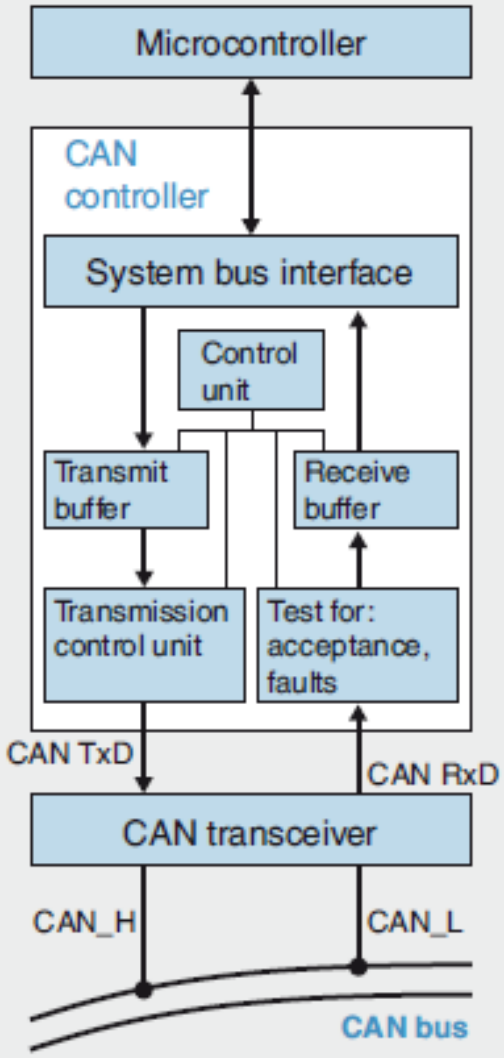
تهیه و تنظیم : بهروز خطیبی

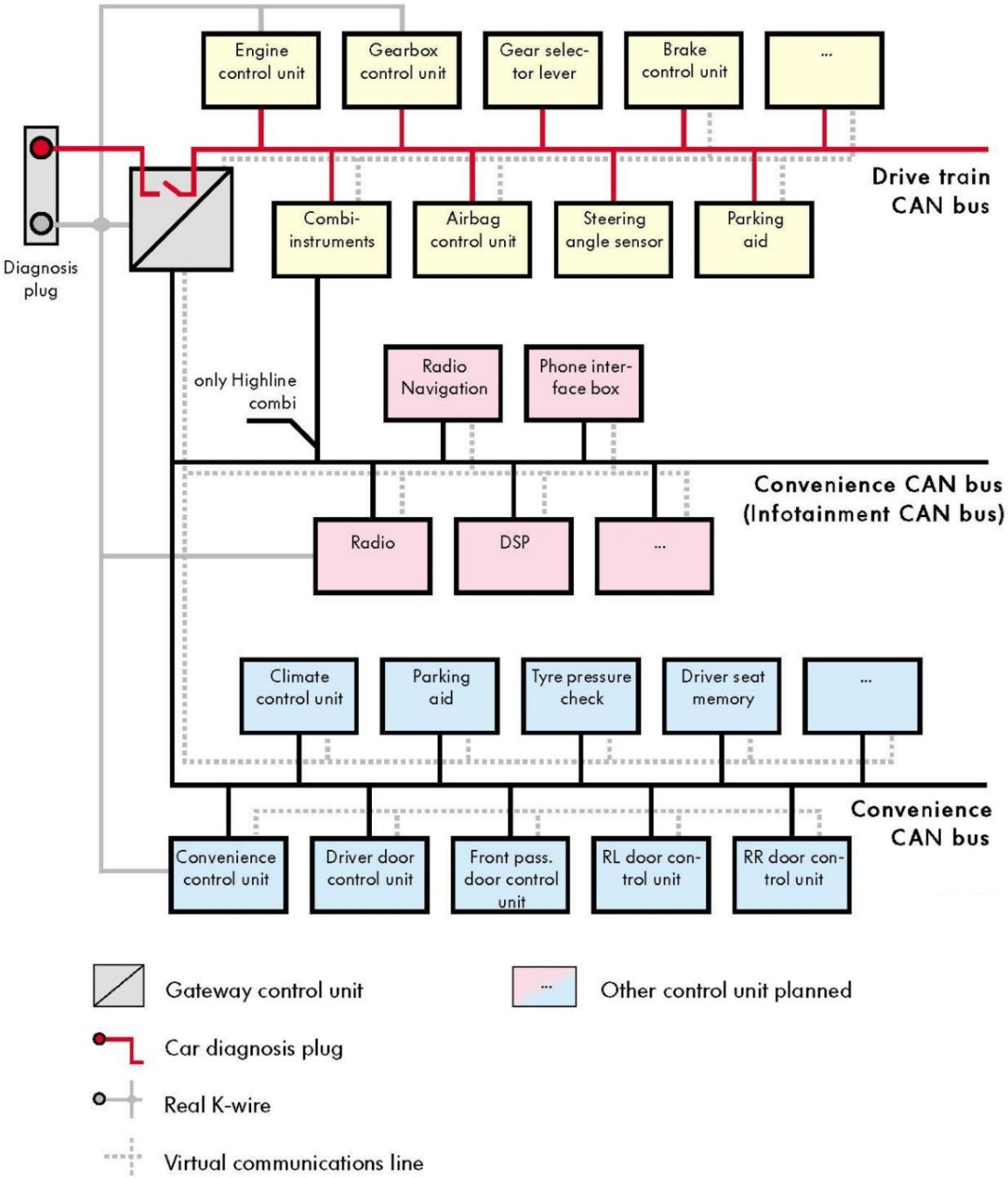


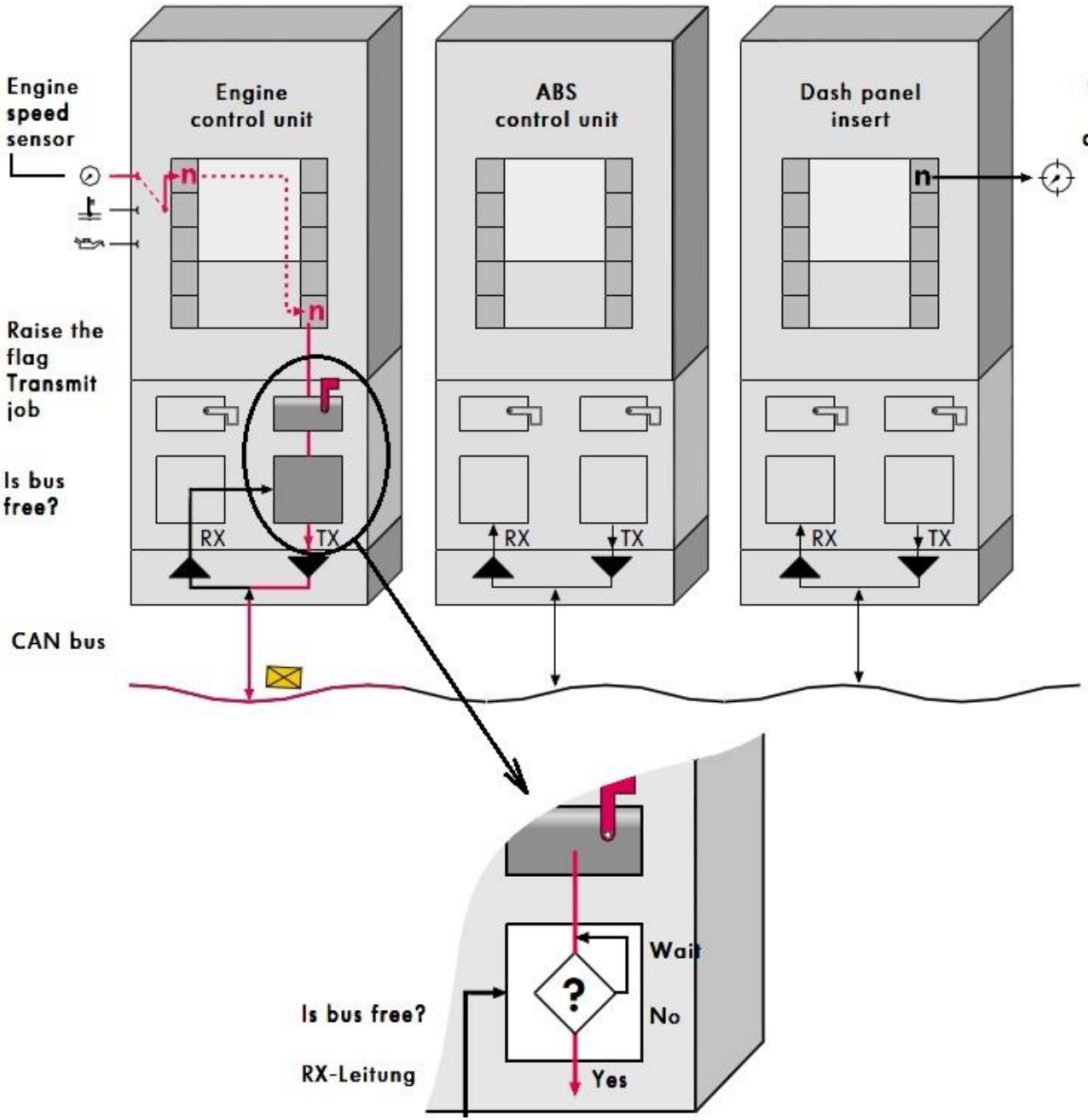
10 Basic-CAN module

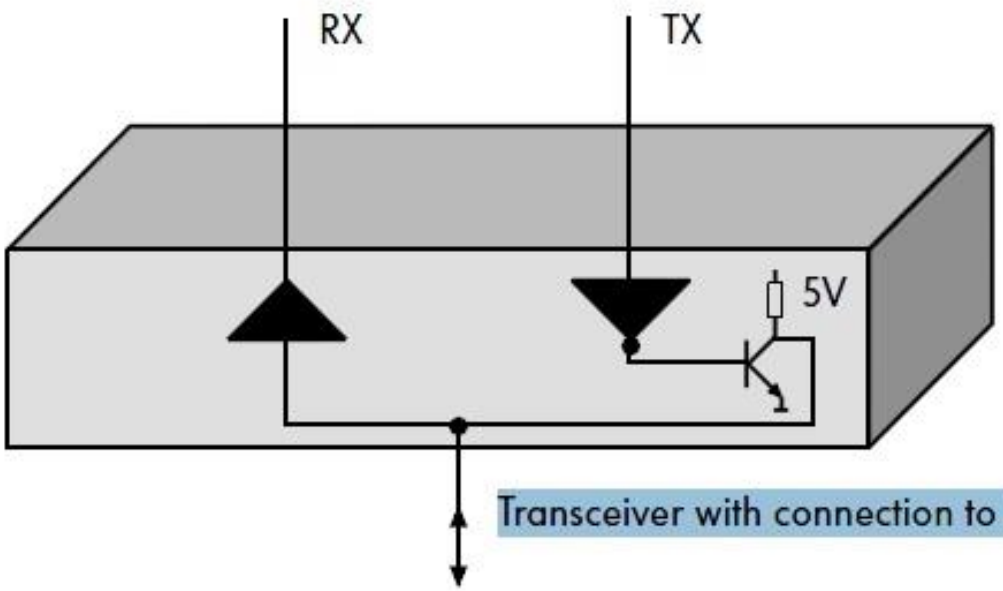


11 Full-CAN module

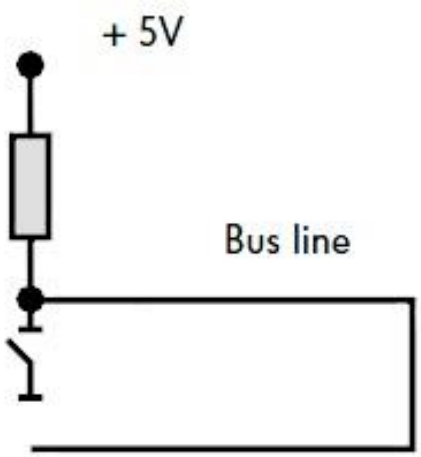




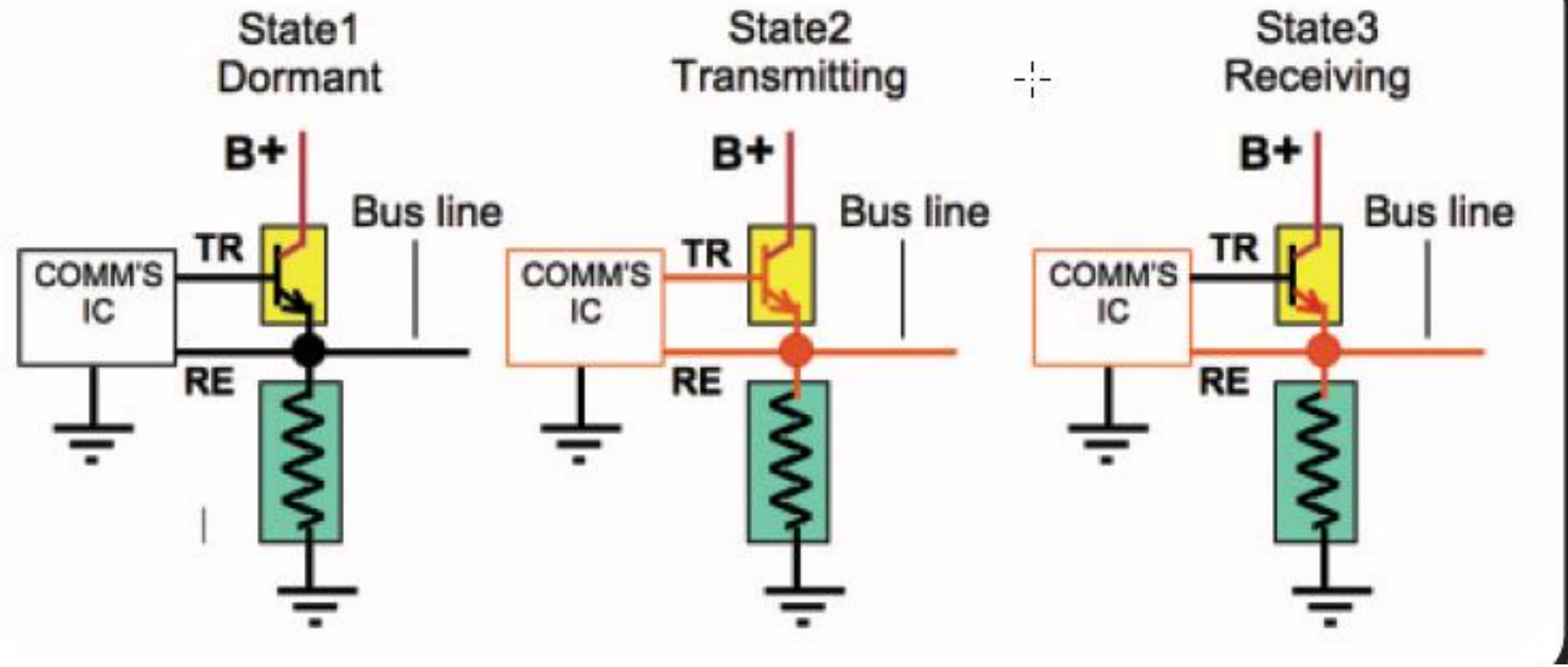


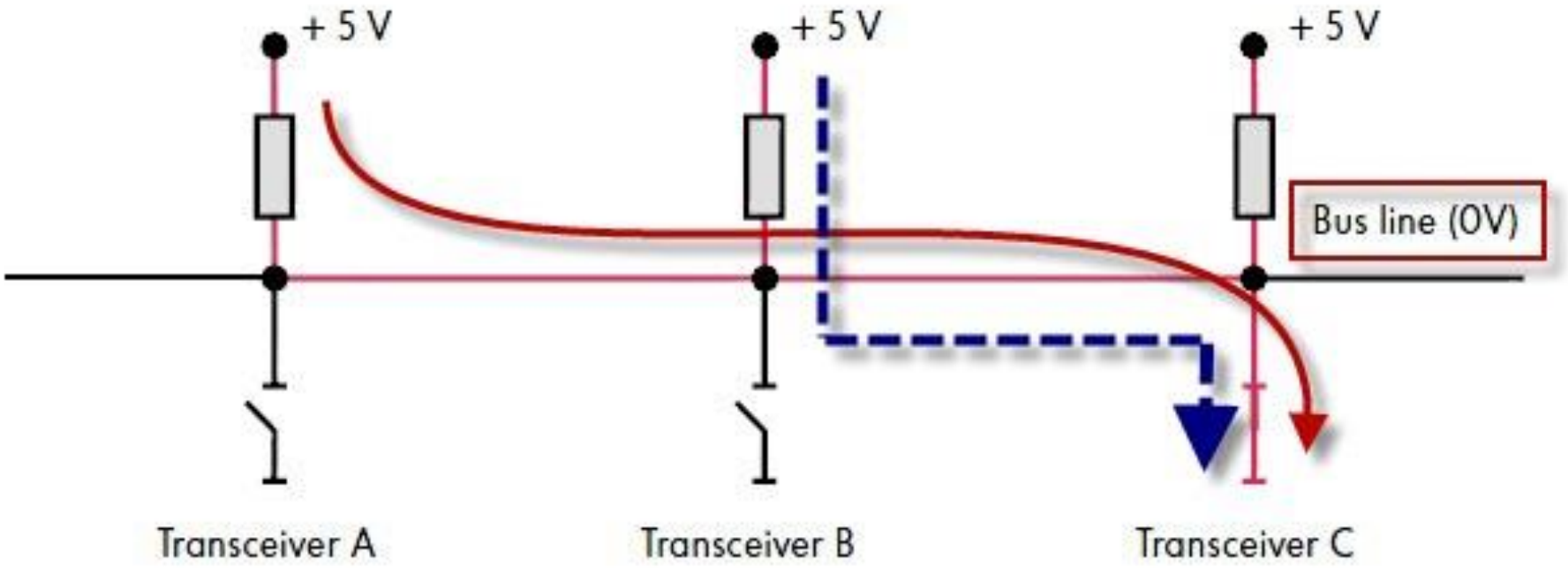


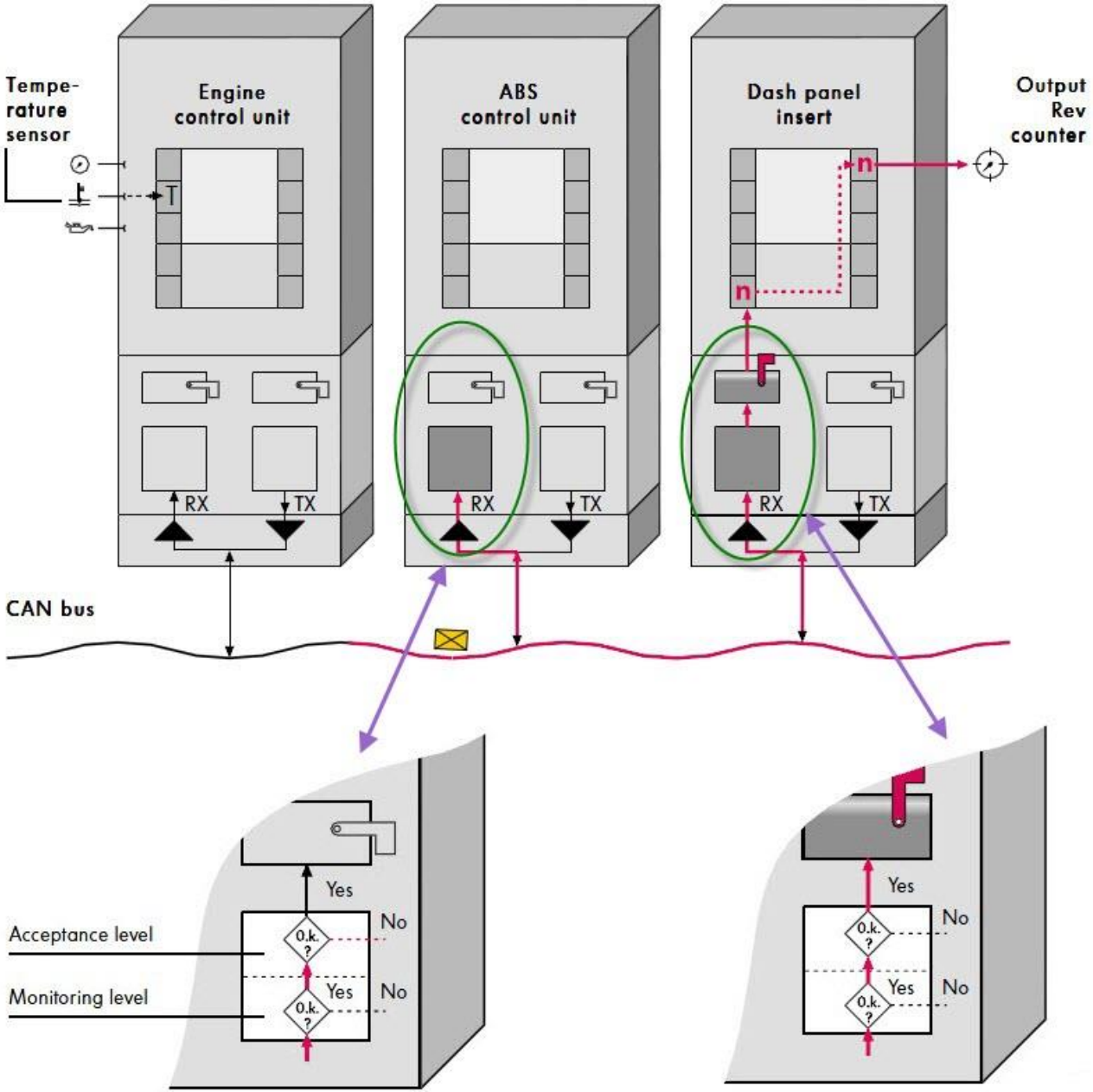
Transceiver with connection to TX line

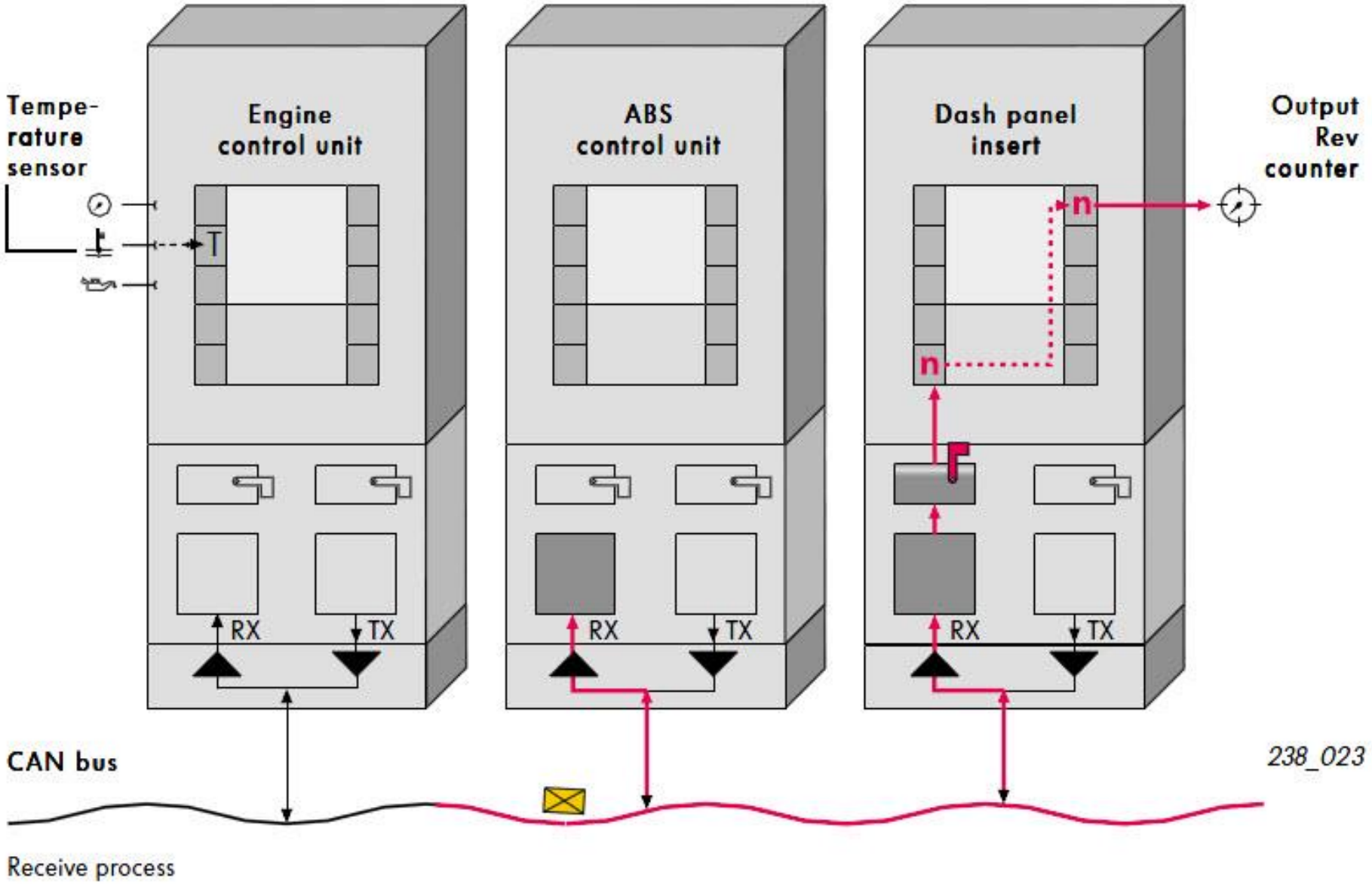


Block diagram with one switch


State1
Dormant
B+
Bus line
TR
COMM'S
IC
RE
State2
Transmitting
B+
Bus line
TR
COMM'S
IC
RE
State3
Receiving
B+
Bus line
TR
COMM'S
IC
RE

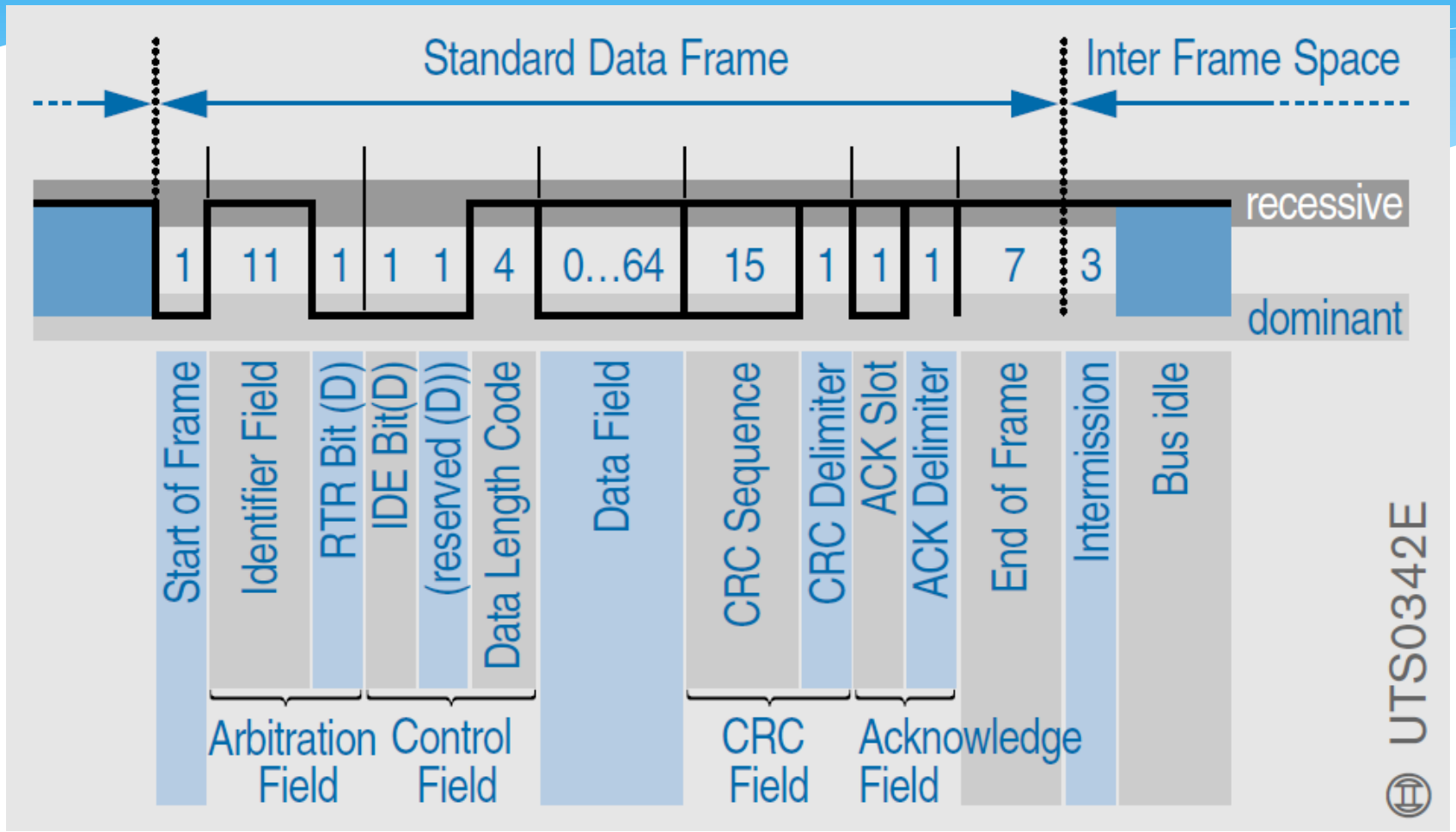

+ 5 V
+ 5 V
+ 5 V
Bus line (0V)
Transceiver A
Transceiver B
Transceiver C





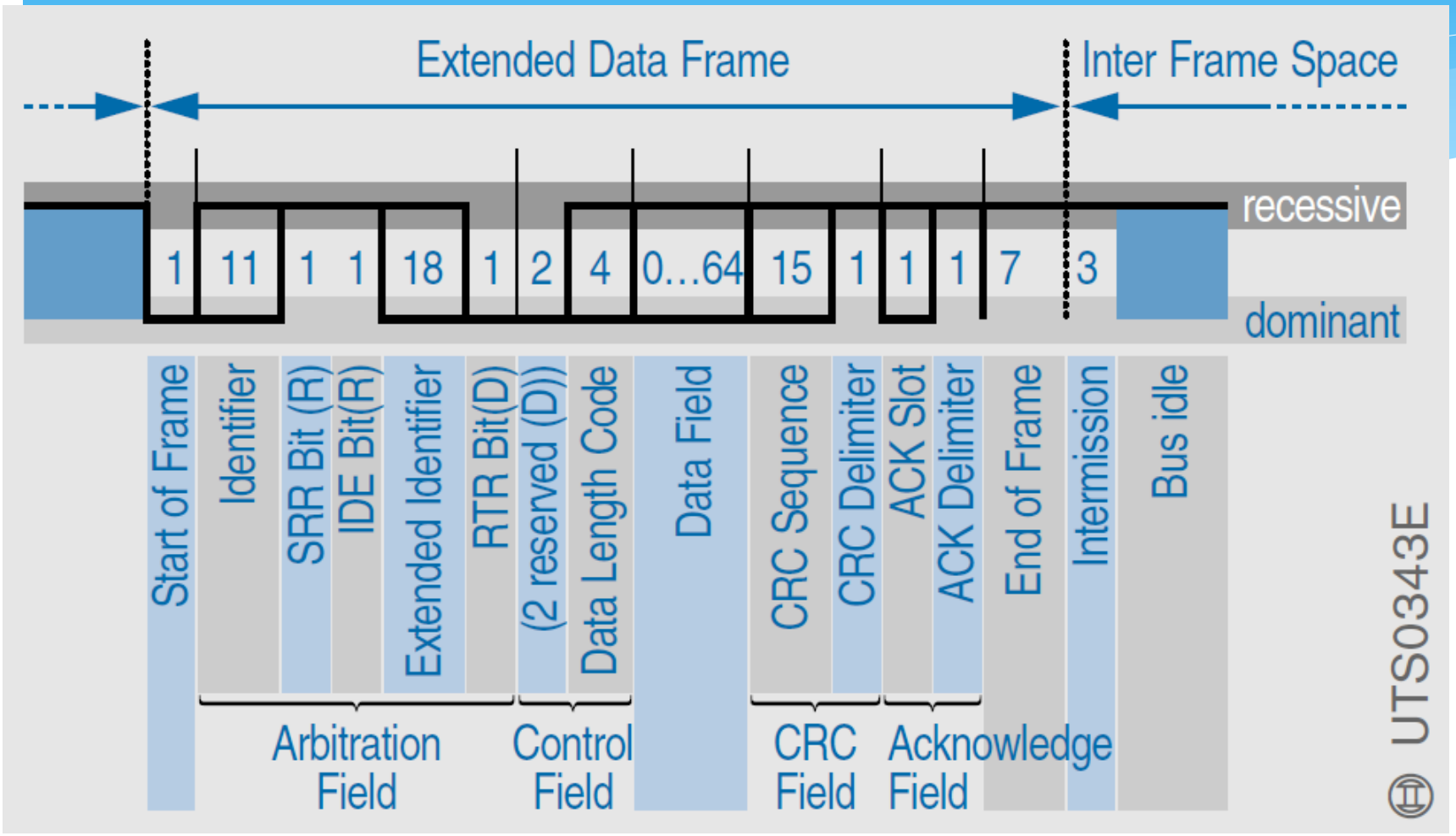
Receive process

CAN standard Data Frame



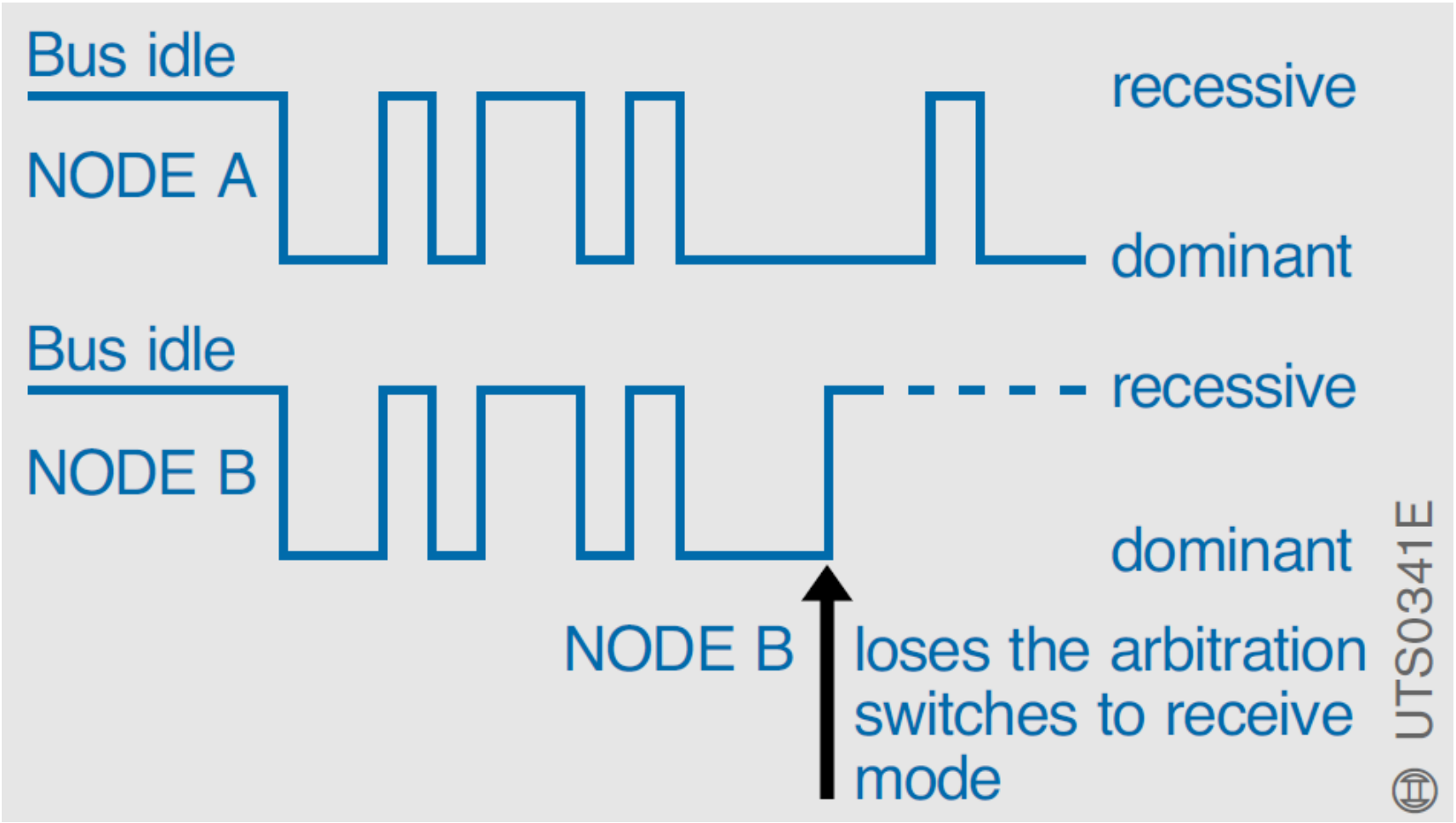
تهیه و تنظیم : بهروز خطیبی

CAN Extended(Developed) Data Frame



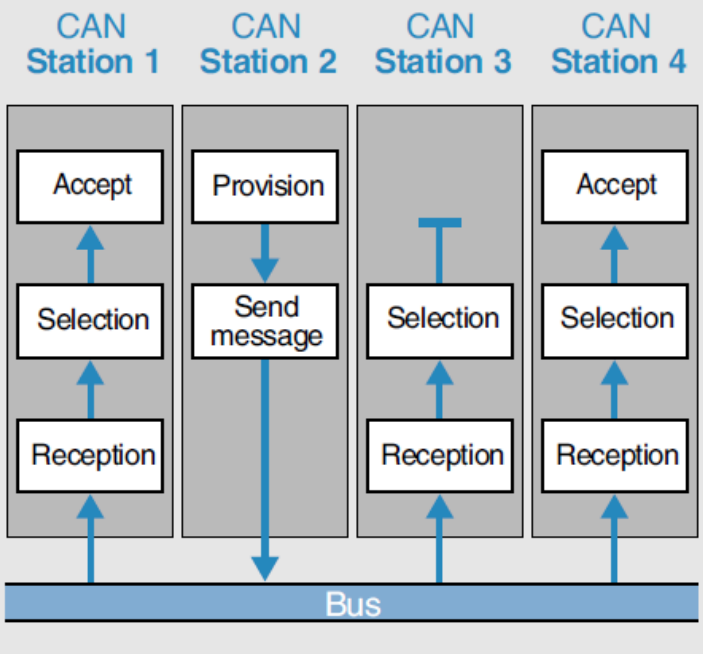
تهیه و تنظیم : بهروز خطیبی

Arbitration

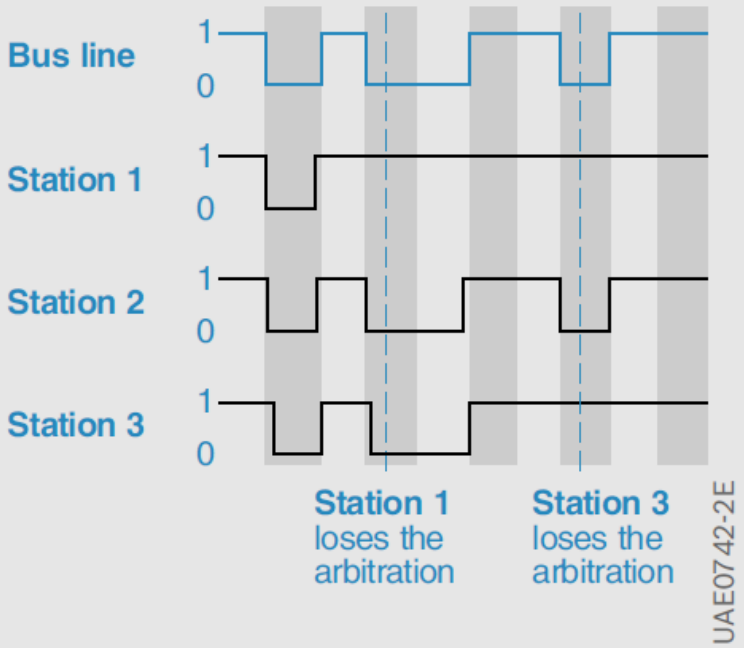


Arbitration

7 Addressing and message filtering (acceptance check)

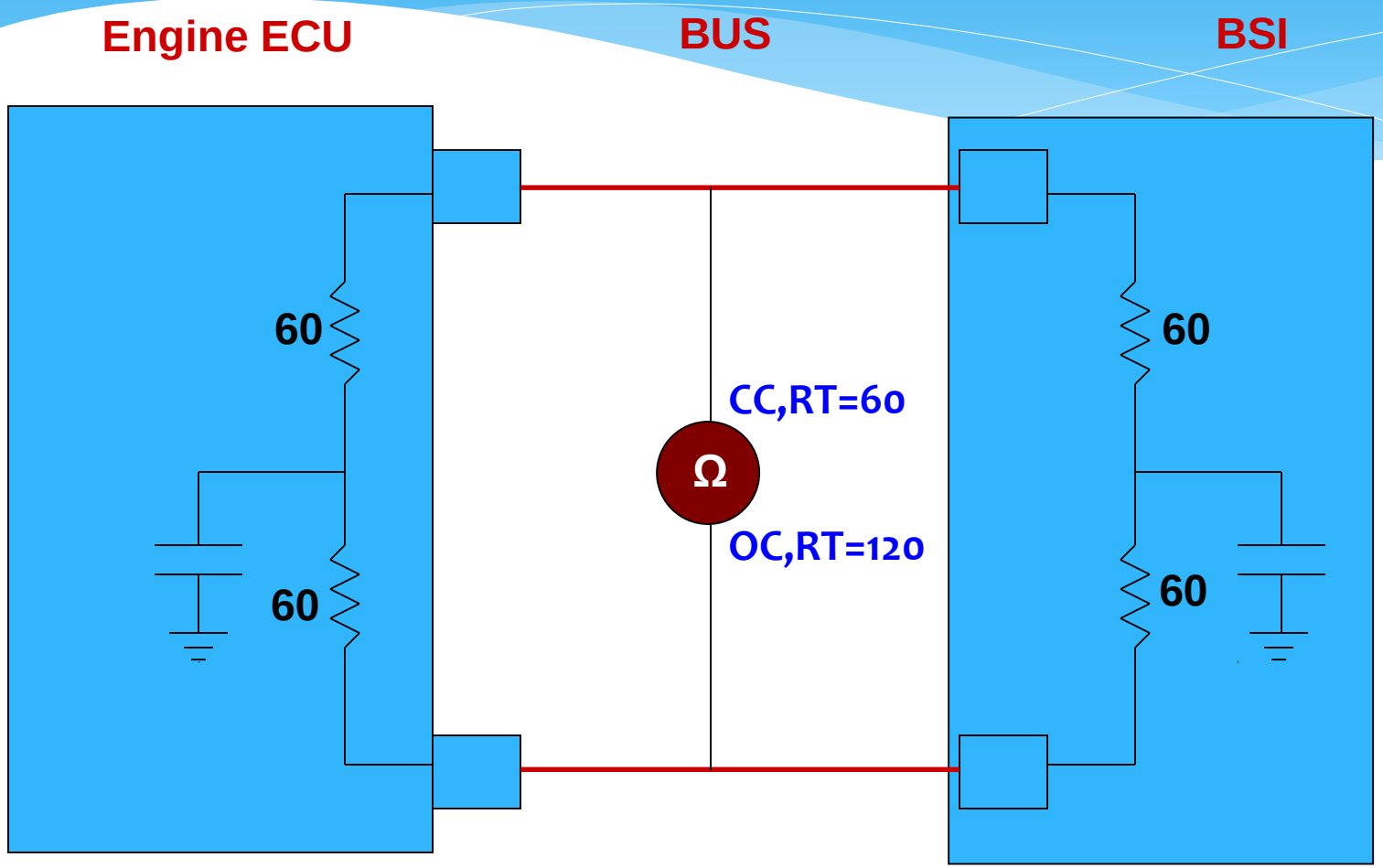


8 Bit arbitration



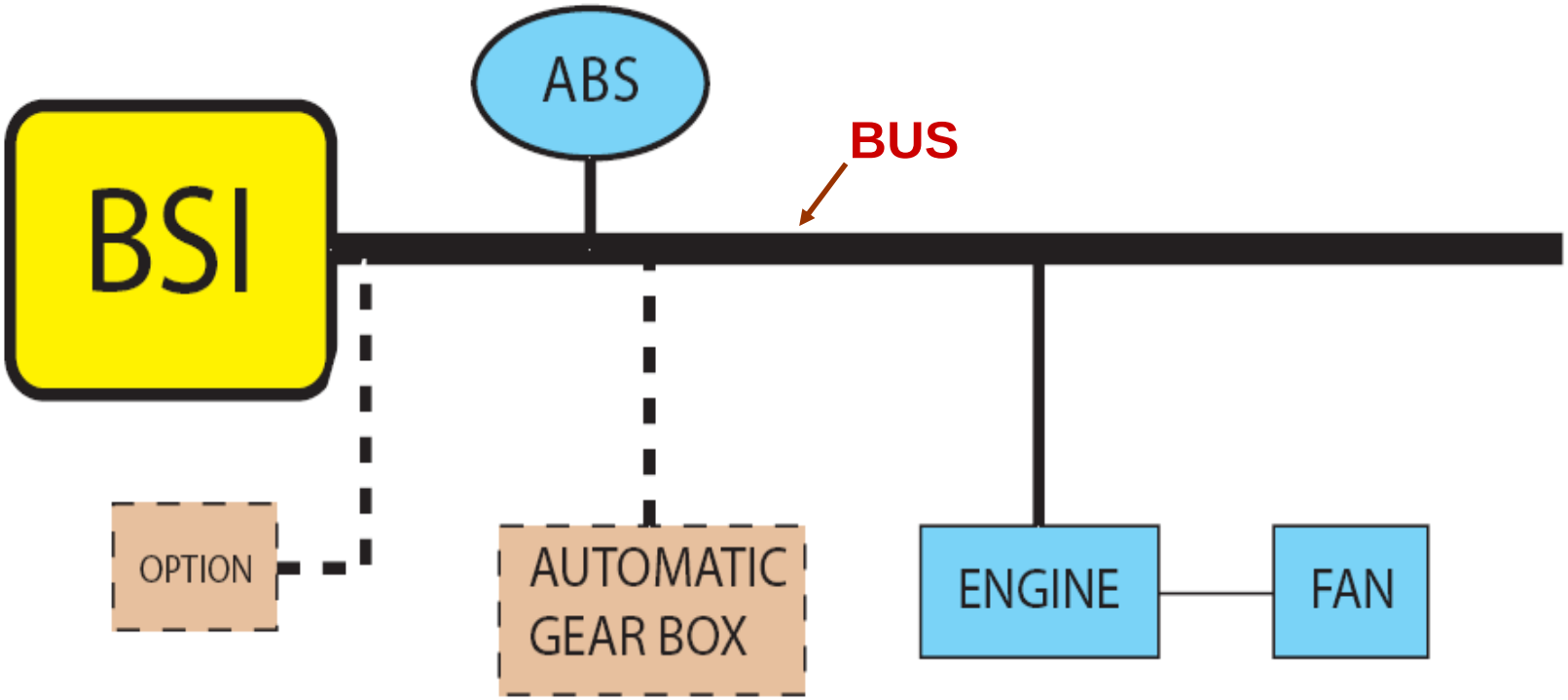
CAN Construction

We need at least 5 mins switched off for going to asleep and doing it.



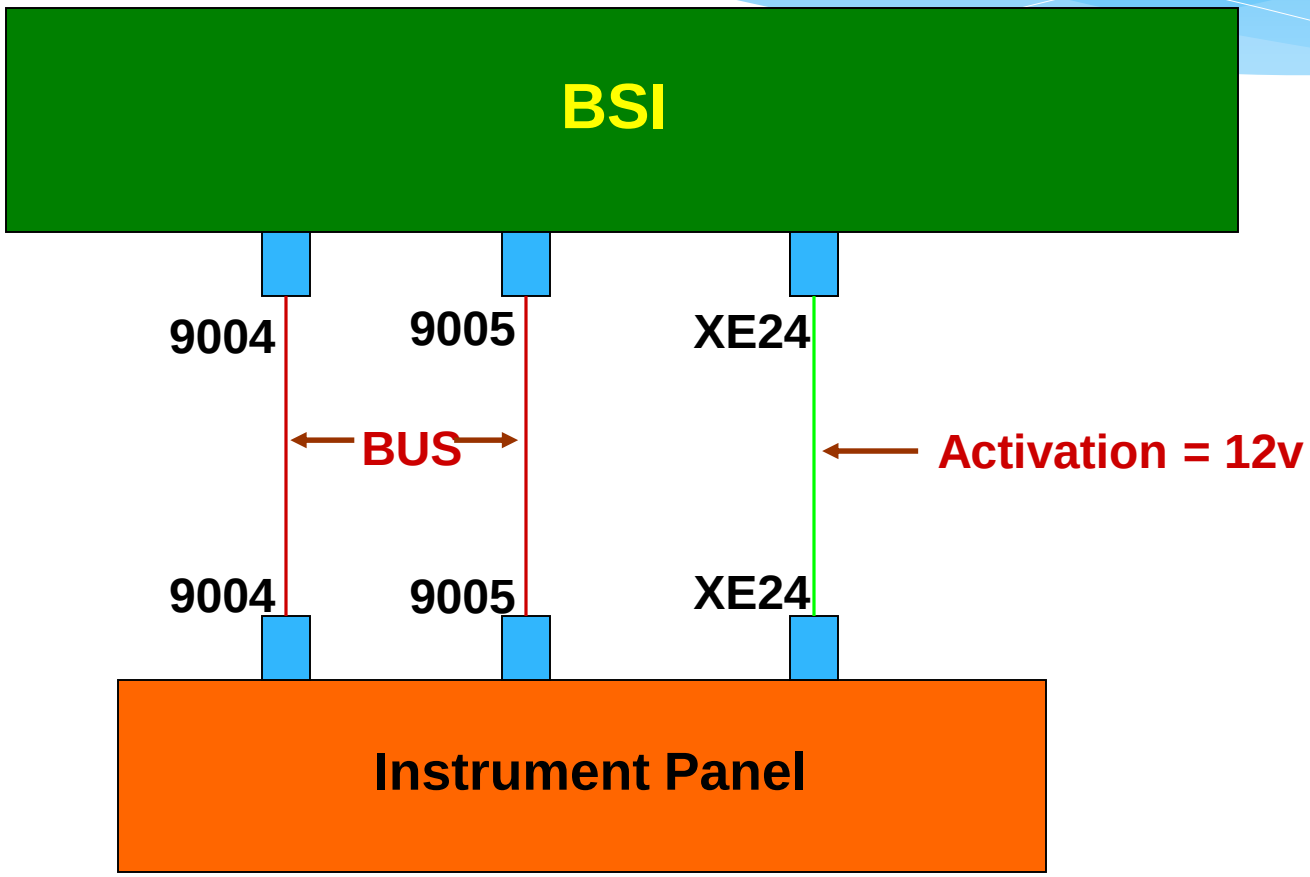
Preventing interferences of reflection of electrical, optical or audio waves.

CAN in Peugeot 206



VAN Construction

It can support up to 17 ECUs



Message construction in VAN

Start: Start of frame (10 bits)

Identifier: Identify of priority (12 Bits)

Com: Command and Control(4 bits)

Information: (28 bits)

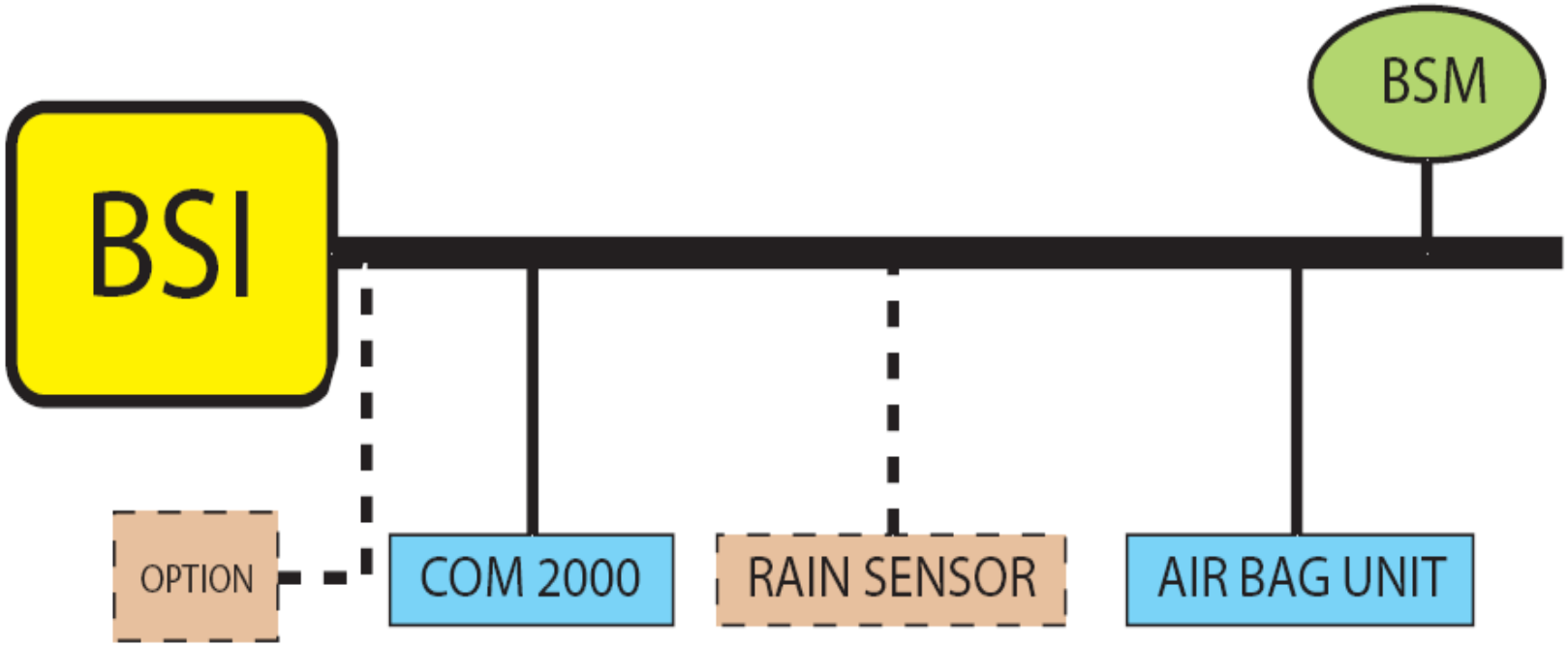
Control: Control

End data: End data

Ack: Acknowledgement

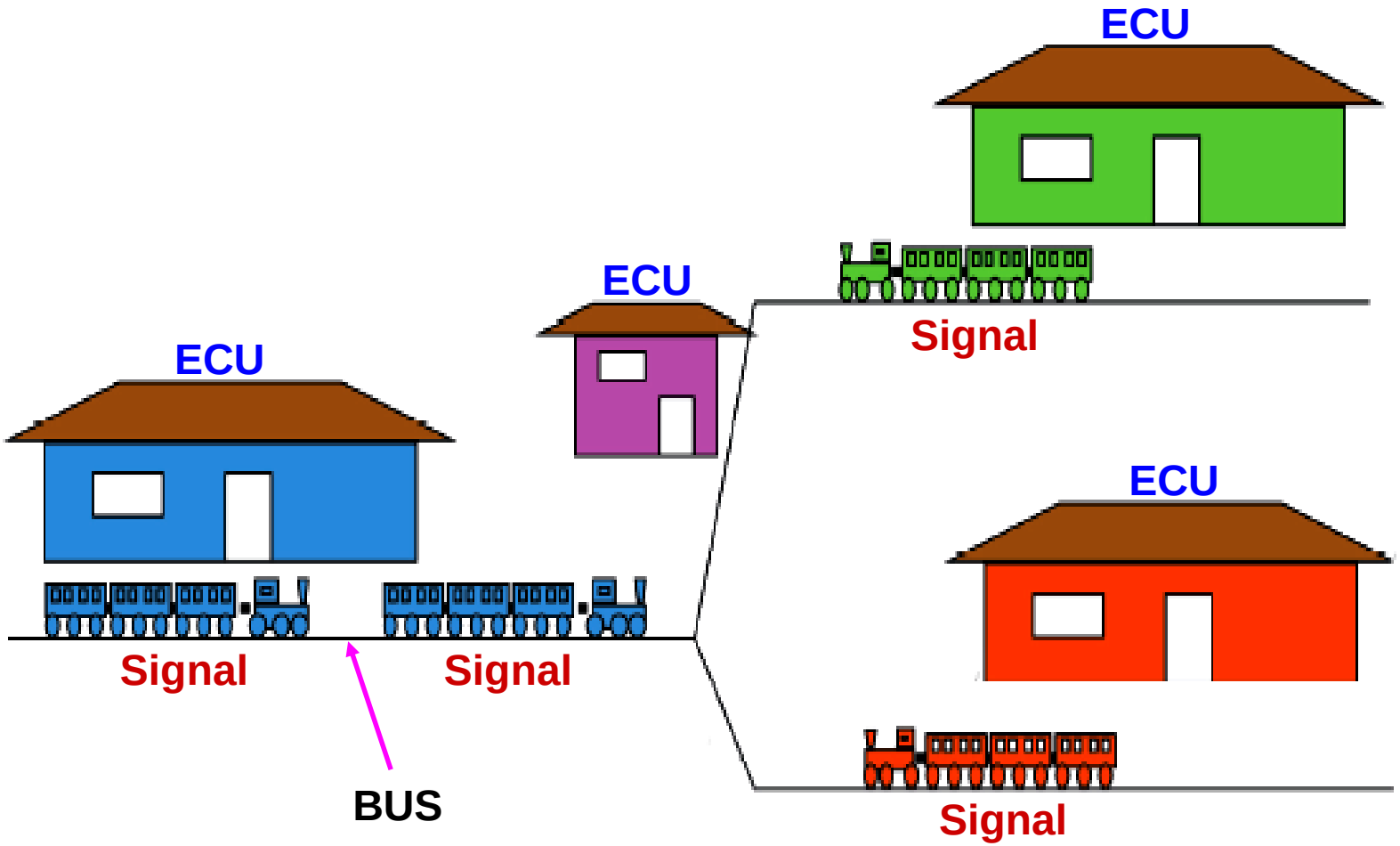
End: End of frame

VAN Body1



Multiplex

Sending several signals through a wire



Continued of XC90

Powertrain and chassis

TCM: Transmission control module
ECM: Engine control module
BCM: Brake control module
BSC: Body sensor cluster
SAS: Steering angle sensor
SUM: Suspension module
AUD: Audio module

Infotainment/Telematics

MP1,2: Media players 1 and 2
PHM: Phone module
MMM: Multimedia module
SUB: Subwoofer
ATM: Antenna tuner module

Body electronics

CEM: Central electronic module
SWM: Steering wheel module
DDM: Driver door module
REM: Rear electronic module
SWM: Steering wheel module
DDM: Driver door module
PDM: Passenger door module
REM: Rear electronic module
CCM: Climate control module
ICM: Infotainment control
UEM: Upper electronic module
DIM: Driver information module
AEM: Auxiliary electronic

Continued of XC90

+ It’s used 40 ECUs.

+CAN1 : (TCM, ECM, BCM, etc.) and has a communication rate of 500 kbps.

+CAN2 : (DDM, PDM, CCM, etc.) and has a communication rate of 125 kbps.

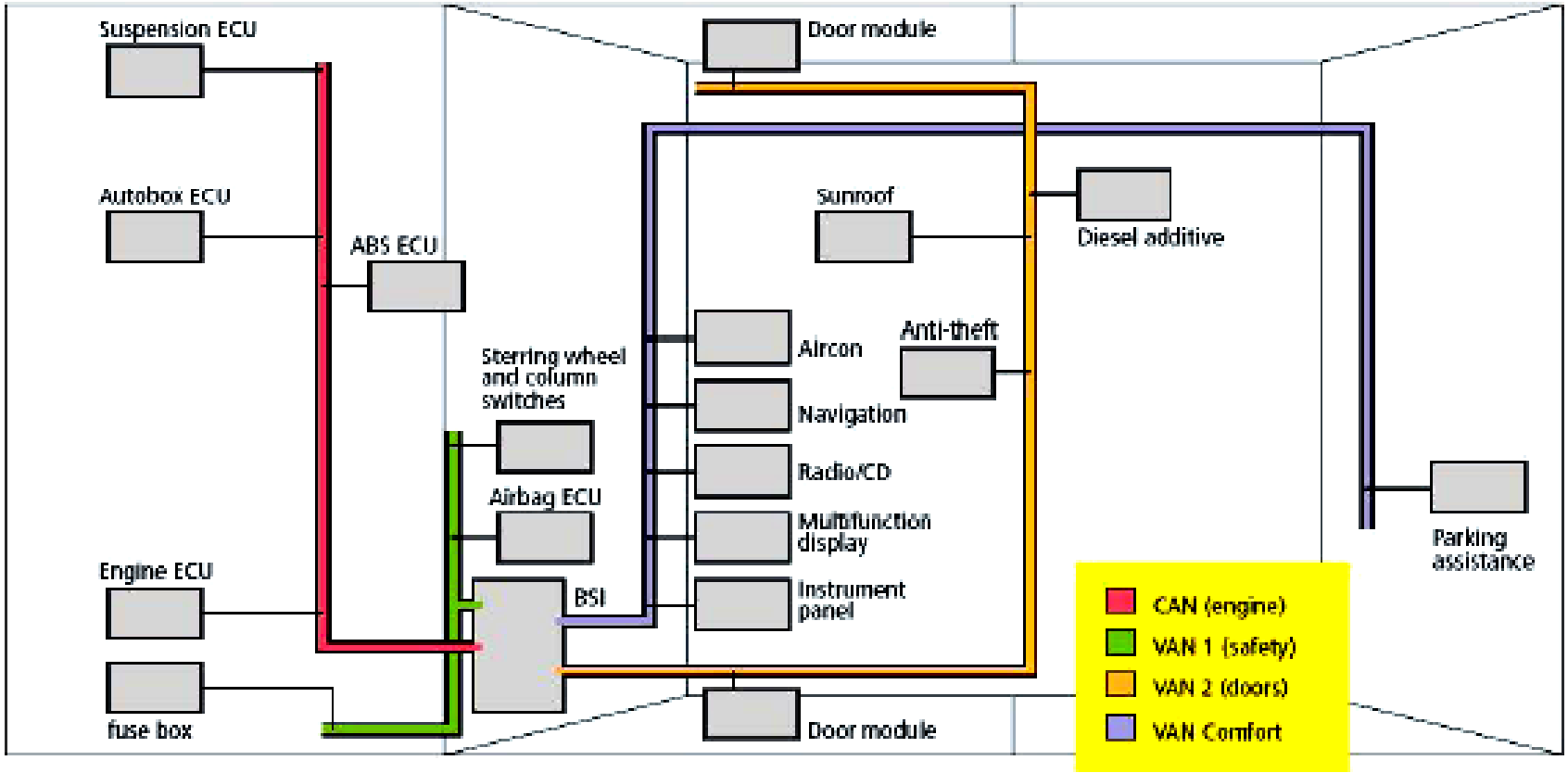
+The central electronic module (CEM) is an ECU that acts as a gateway between the two CAN buses.

+A media oriented system transport (MOST) network defines networking for infotainment and telematics subsystems. It consequently connects ECUs for multimedia, phone, and antenna

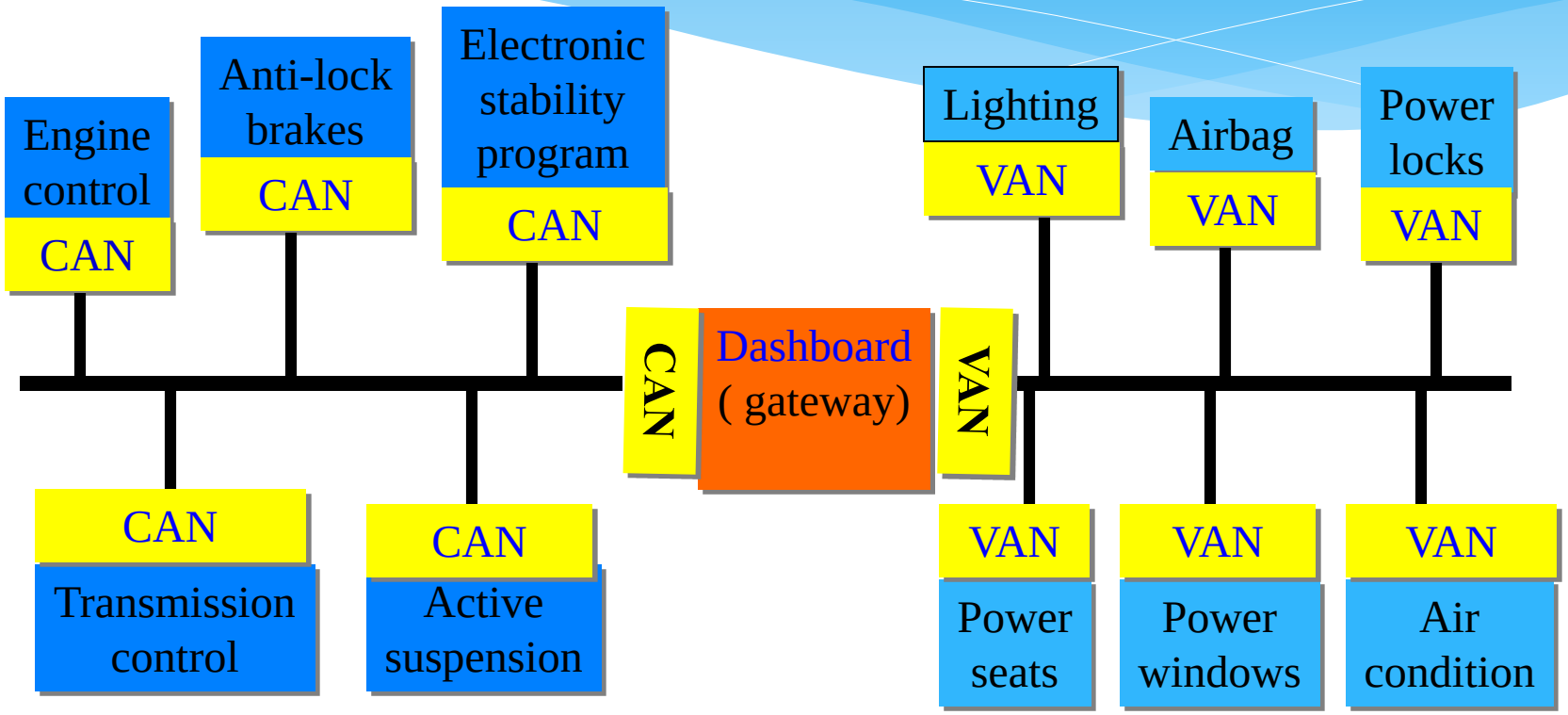
+Finally, local interconnect networks (LINs) are used to connect slave nodes into a subsystem

Smple1: Citroën C5

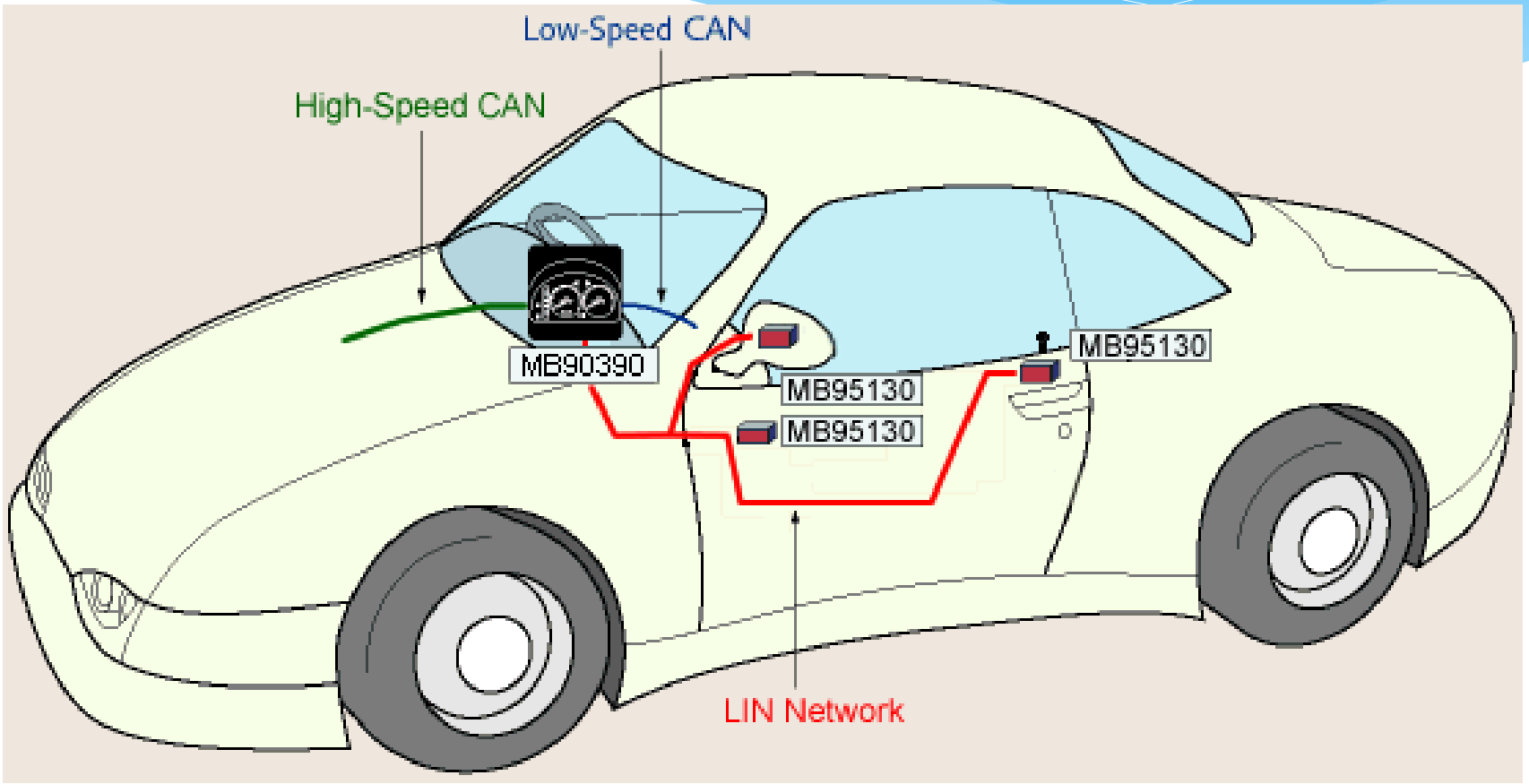
Buses in the C5



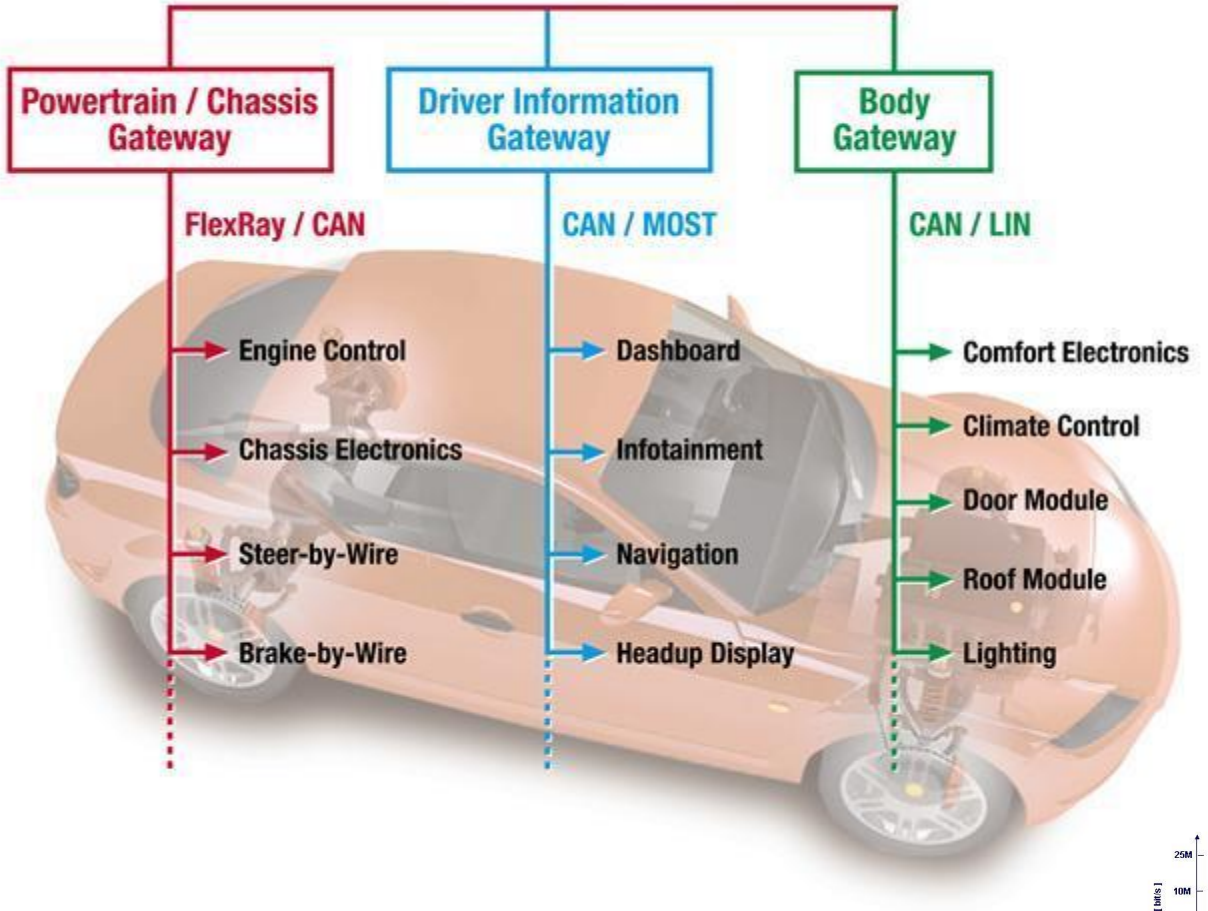
BUS استفاده از دو یکی CAN دیگری VAN

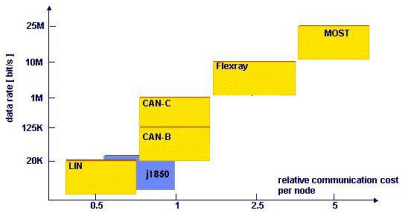


بیشترین کاربرد شبکه LIN و نمایش آن

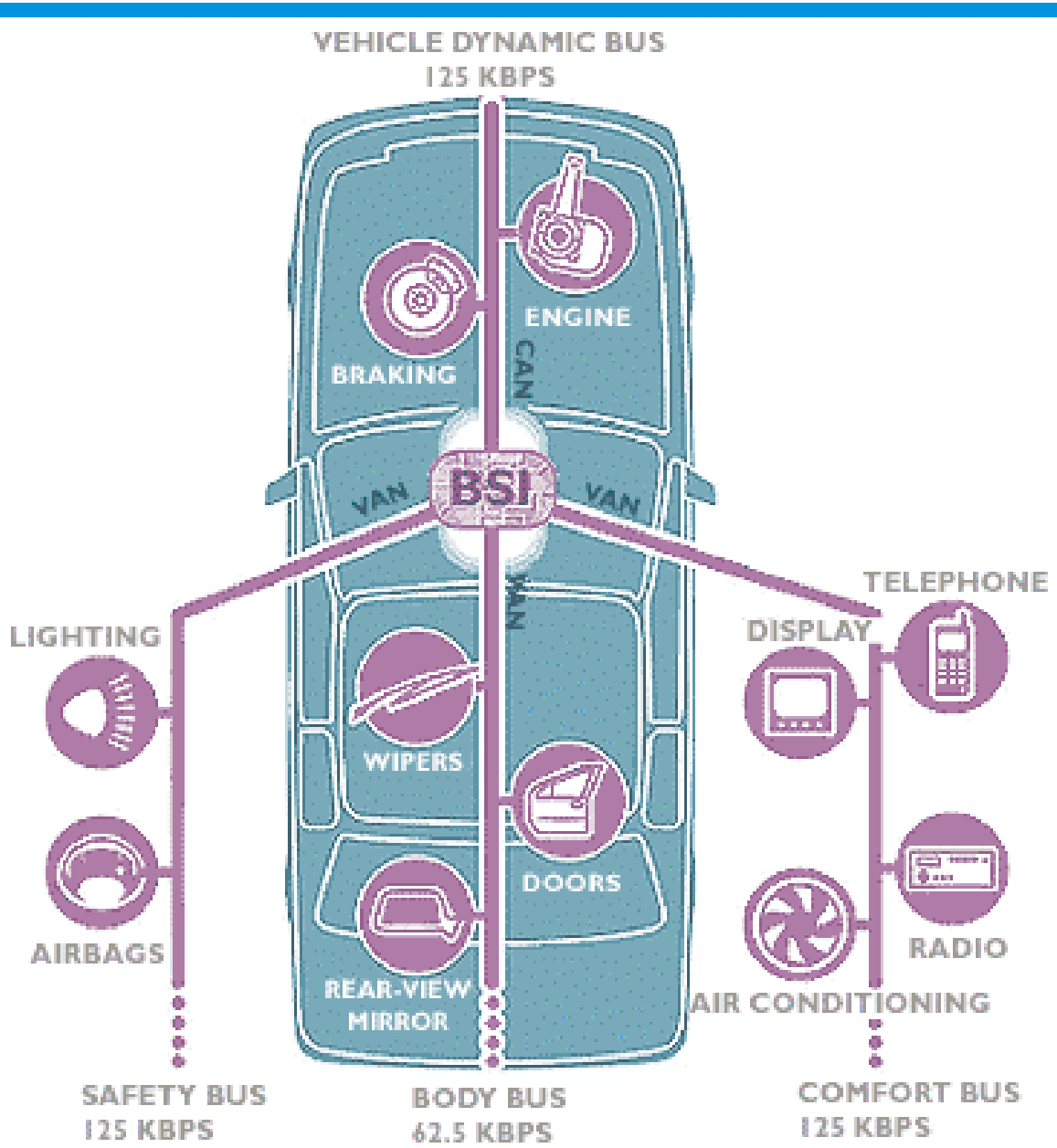


استفاده های معمول از CAN,MOST,LIN,FlexRay





تهیه و تنظیم : بهروز خطیبی



پژو

استفاده از BUS 4

3 شبکه VAN

1 شبکه CAN

شبکه از نوع CAN

BCM

4WD

0004

keyless start

ECM

ABS

TCM

Diagnosis protocols

History

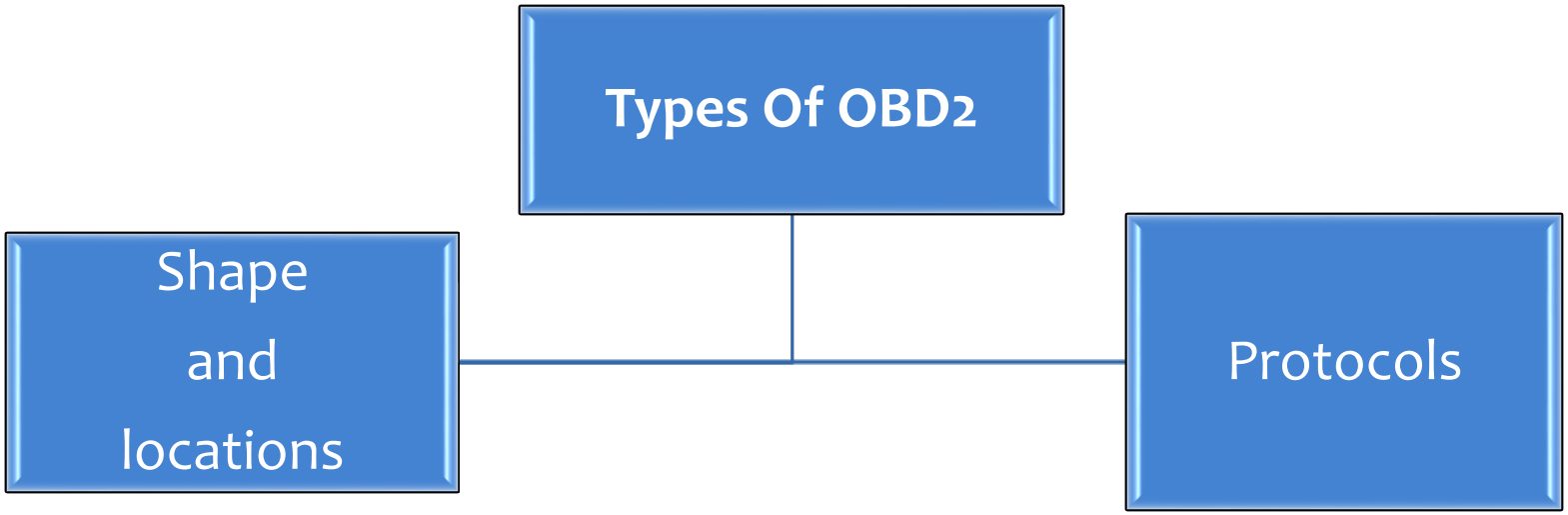
YEAR	NAME	Propose
1970's	California Air Resources Board (**CARB**)	healthy air quality for people
	Environmental Protection Agency (**EPA**),	
	Society of Automotive Engineers (**SAE**)	
1985 (1991)	on-board diagnostic(**OBD**)	emission system diagnostics
1989 (1996)	on-board diagnostic (**OBD II**)	drivability and emission system diagnostics
2001	European on-board diagnostics (**EOBD**)	
2006	Enhanced On-Board Diagnostics (**EOBD II**)	access additional data and parameters than OBD II

OBD vs OBD II

	OBD1	OBD2
Introduction	1991	1996
Nature	Semi-automatic self-diagnostic system	Fully automatic self-diagnostic system
Function	Access ECU and diagnose sensors and actuators	Access ECU and diagnose sensors and actuators
Standardization	Not standardized	Standardized on all vehicles made from 1996
Application	Californian standard	Federal standard
Interface	Manufacturer-specific	Universal

تهیه و تنظیم : بهروز خطیبی

Types Of OBD2



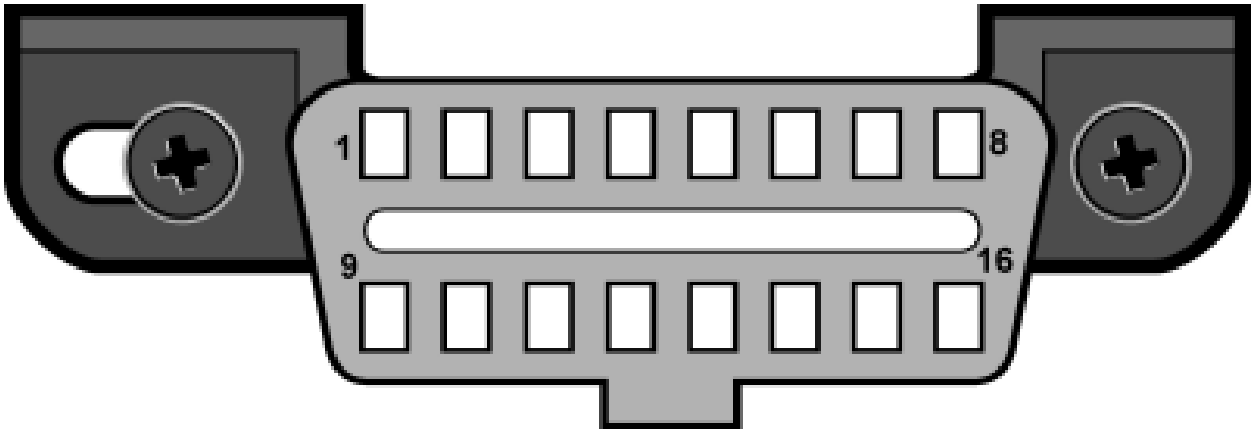
Types Of OBD2 Shape & Location

* There are two types of diagnostic link connectors (**DLCs**) defined by ***SAE J1962*** - **Type A** and **Type B.**

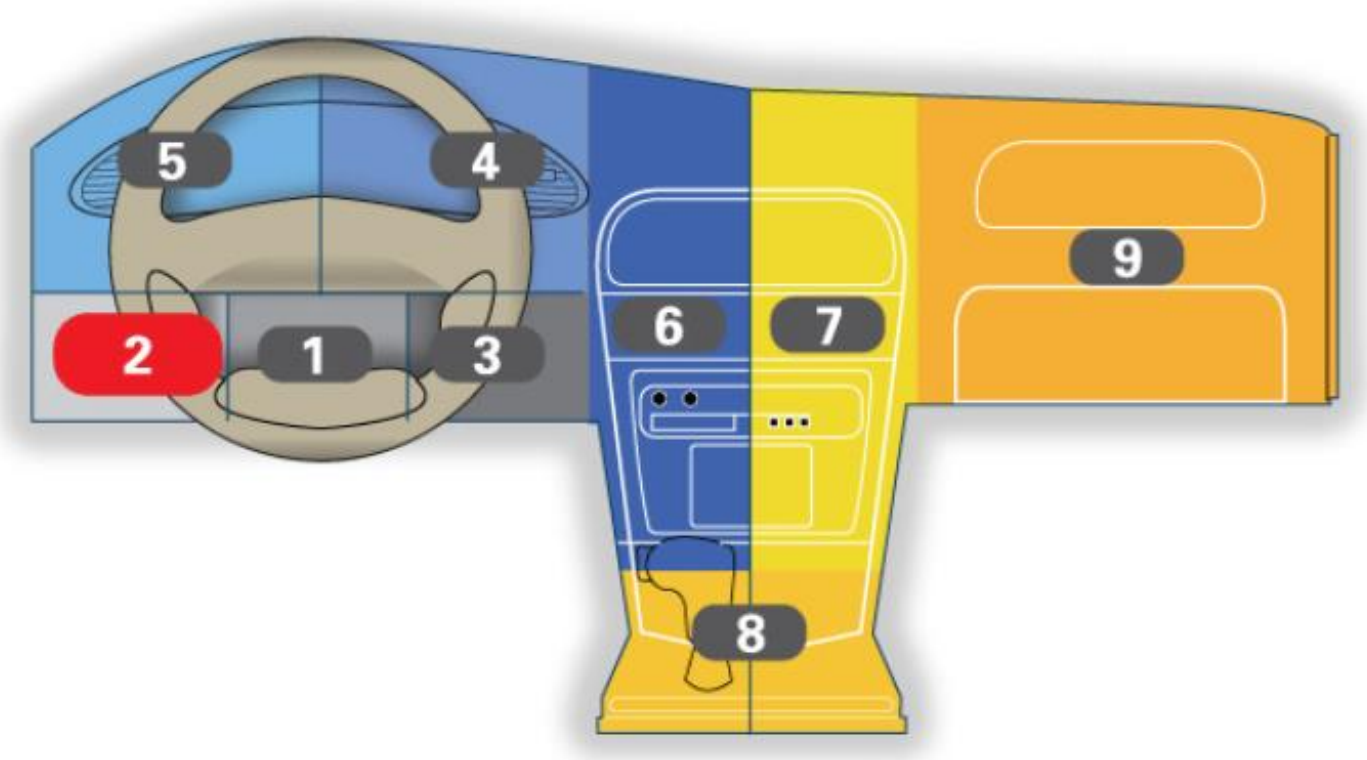
* . The main difference between the two connectors is in the shape of the alignment tab.

Type A
(J1962 - Vehicle Connector-12 V)

* **Location** - According to J1962, Type A DLC "shall be located in the passenger or driver's compartment in the area bounded by the driver's end of the instrument panel to 300 mm (~1 ft) beyond the vehicle centerline, attached to the instrument panel and easy to access from the driver's seat. The preferred location is between the steering column and the vehicle centerline."



OBD II port location
12 V- type A



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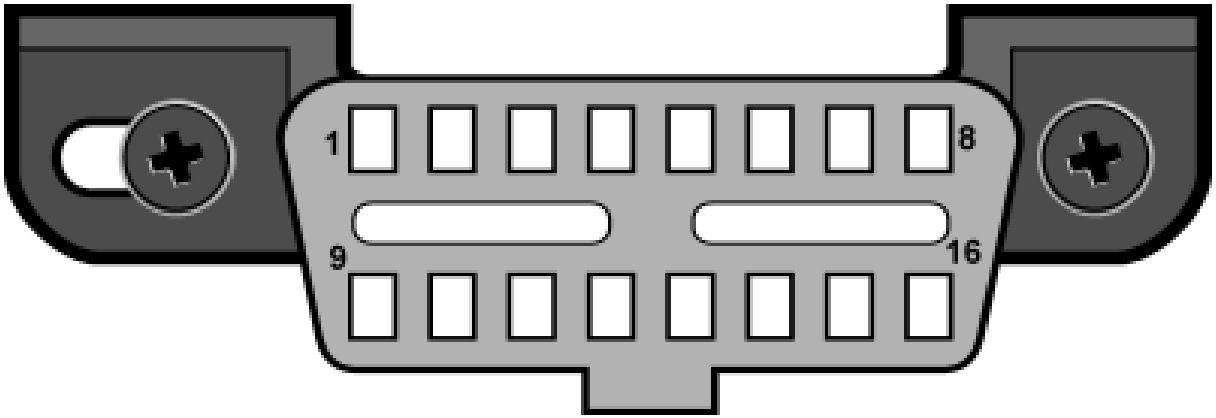
OBD II port location

Type B
(J1962 -Vehicle Connector -24 V)

* Type B DLC "shall be located in the passenger or driver's compartment in the area bounded by the driver's end of the instrument panel, including the outer side, and an imagined line 750 mm (~2.5 ft) beyond the vehicle centerline. It shall be attached to the instrument panel and easy to access from the driver's seat or from the Co-drivers seat or from the outside. The vehicle connector shall be mounted to facilitate mating and unmating."



Types Of OBD2 Protocols

There are 5 protocols in the OBD2 system and a car will normally only use 1 of them

PROTOCOLS

J1850 PWM (pulse width modulation) used by Ford Motor Company and Mazda

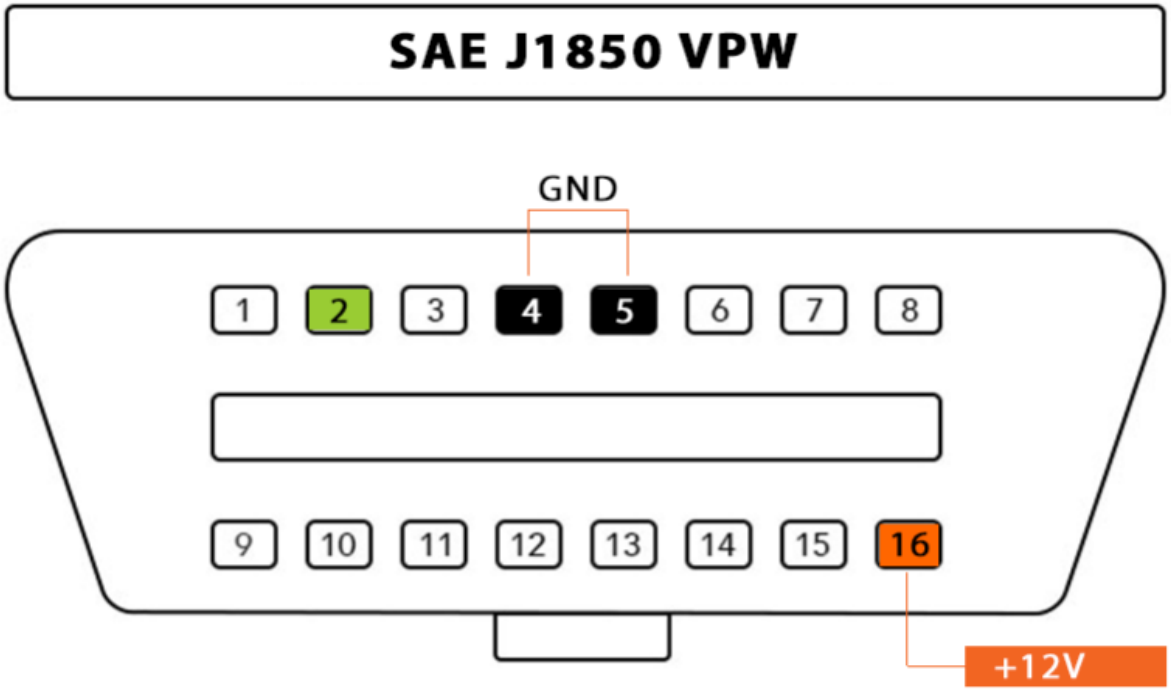
J1850 VPW (variable width modulation) used by General Motors and in light trucks

ISO9141-2 = older protocol in Chrysler, European, and Asian vehicles between 2000-2004

ISO14230-4 KWP2000 (keyword protocol 2000) commonly used in cars from 2003

ISO 15765-4 CAN-BUS = first introduced in 2004 then mandatory in all vehicles from 2008

SAE J1850 VPW

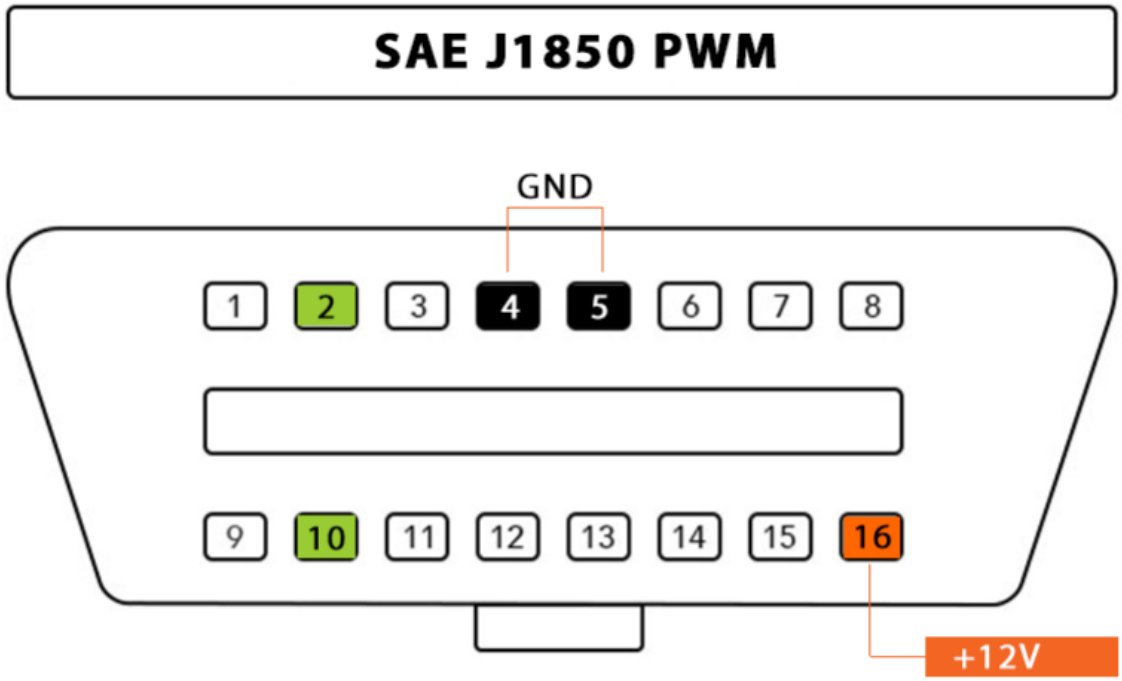


J1850 VPW must have pins 2, 4, 5, and 16, but not 10
Pin 2: BUS+ signal

B	class
10.4kb/s	speed
GM	company
2007	Used
Single	wire

SAE J1850 PWM

(Common Motors utilize this protocol)



J1850 PWM must have pins 2, 4, 5, 10 and 16
Pin 2: BUS+ signal
Pin 10: BUS- signal

B	class
40.6kb/s	speed
Ford	company
2007	Used
Pair	wire

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PWM
(SAE J1850)

pulse-width modulated

- most DW busses and some SW busses
- all bits (zeros and ones) will be the same length
- With this type of binary code, a binary one is usually a high-voltage pulse (which may be 21/2 V, 5 V, or 6 to 8 V) and a binary zero is a low-voltage pulse (zero volts or even a negative voltage

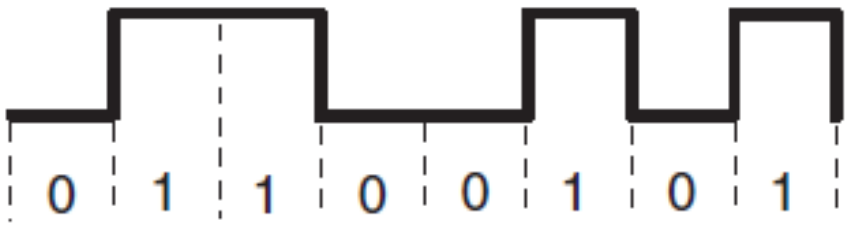


Figure 9–4 Pulse-width-modulated serial data is formed from binary code in which all bits of information

VPW
(SAE J1850)

variable pulse width

- SW busses use

- a binary one may be represented as a short, high-voltage pulse, but it may also be represented as a long, low-voltage pulse. Conversely, a binary zero may be represented as a short, low-voltage pulse or a long, high-voltage pulse.

- that the wave forms not truly vertical at the bits' edges, but, rather, the edges are slanted. This allows the nodes on the data bus to distinguish between serial data and an induced voltage from a nearby circuit, which would tend to be more vertical at the edges.

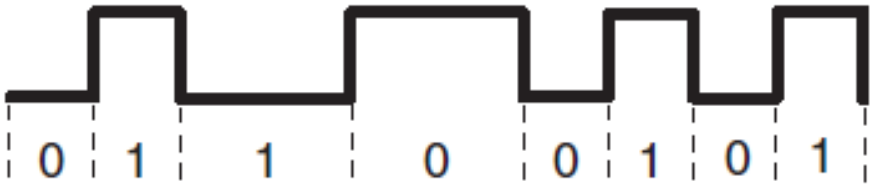
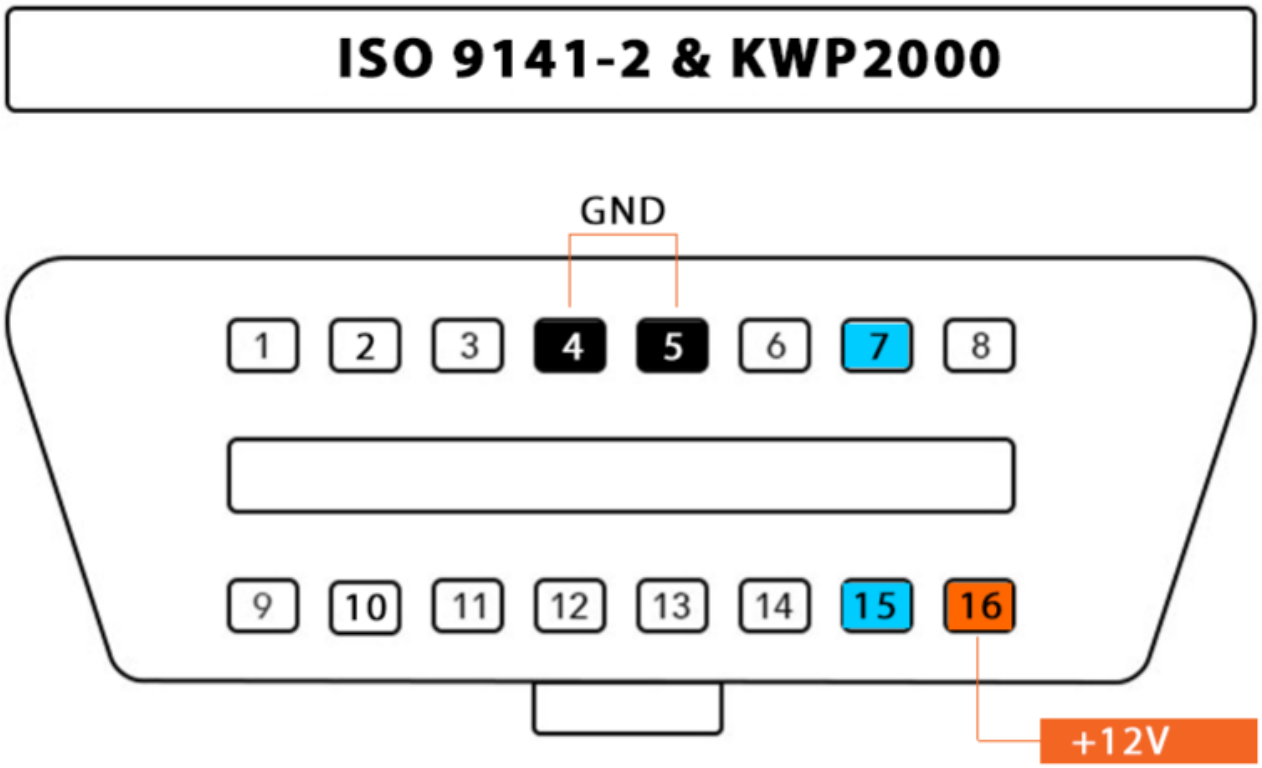


Figure 9–5 Variable-pulse-width serial data is formed from binary code in which bits of information are of different lengths. © Cengage Learning 2012

ISO 9141-2
(Asian, Chrysler, and European cars)



ISO 9141-2 must have pins 4, 5, 7, 15 and 16
Pin 7: K-line bidirectional for communication
Pin 15: L-line undirectional for waking up the ECU

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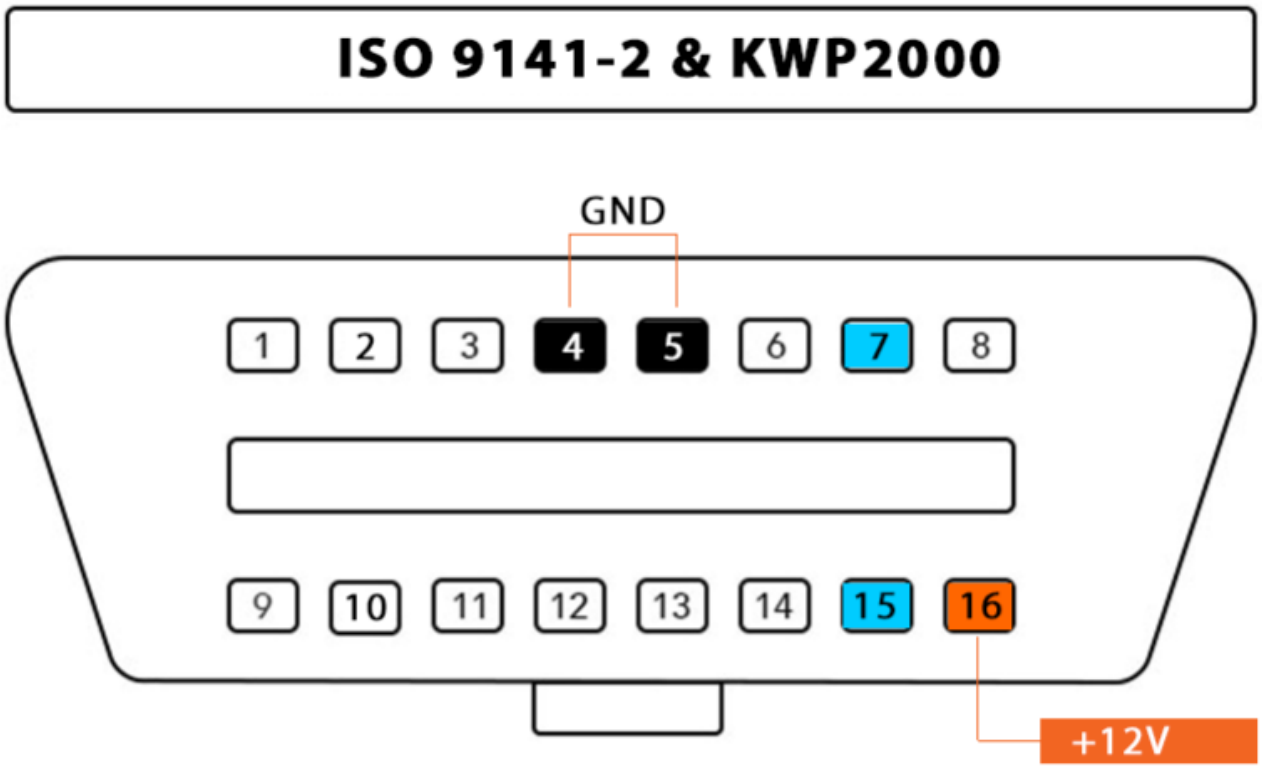
ISO 14230 (KWP2000)

(Asian vehicles)



ISO 9141-2 must have pins 4, 5, 7, 15 and 16
Pin 7: K-line bidirectional for communication
Pin 15: L-line undirectional for waking up the ECU

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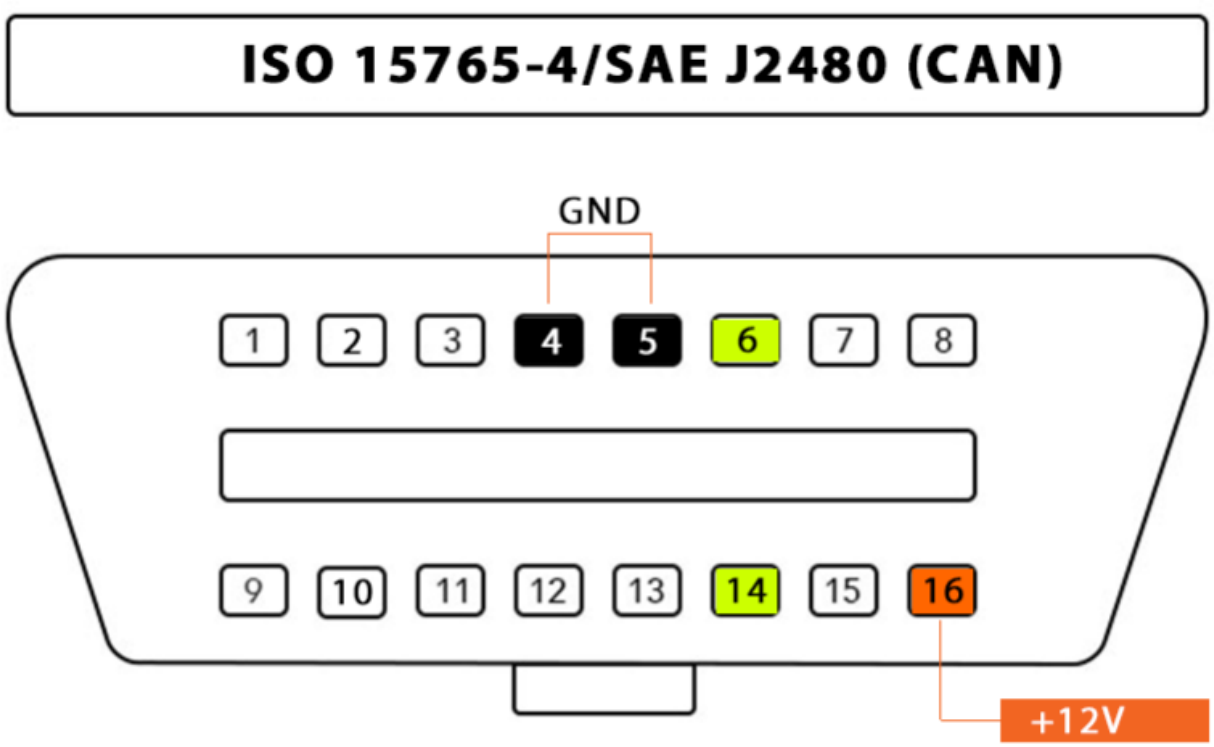
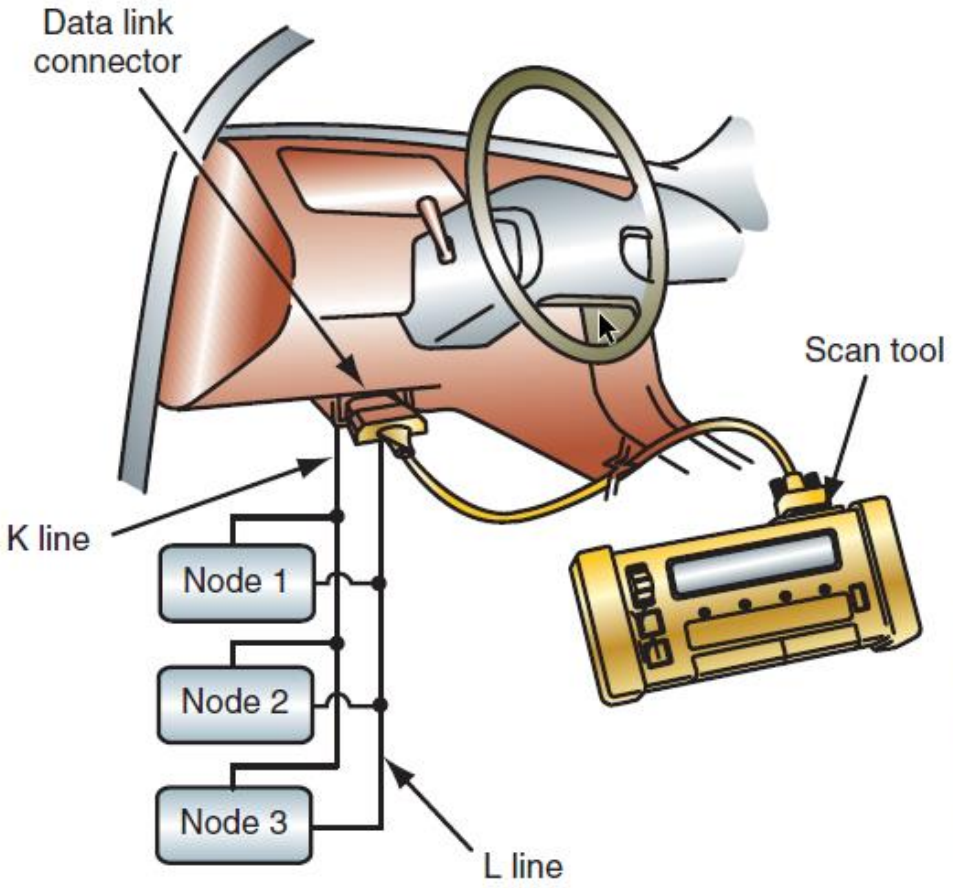
ISO 15765-4/SAE J2480 (CAN)
(many vehicles made after 2008)



ISO 15765 (CAN) must have pins 4, 5, 6, and 14
Pin 6: CAN high
Pin 14: CAN low

ISO 9141-2, ISO 14230 (KWP2000)



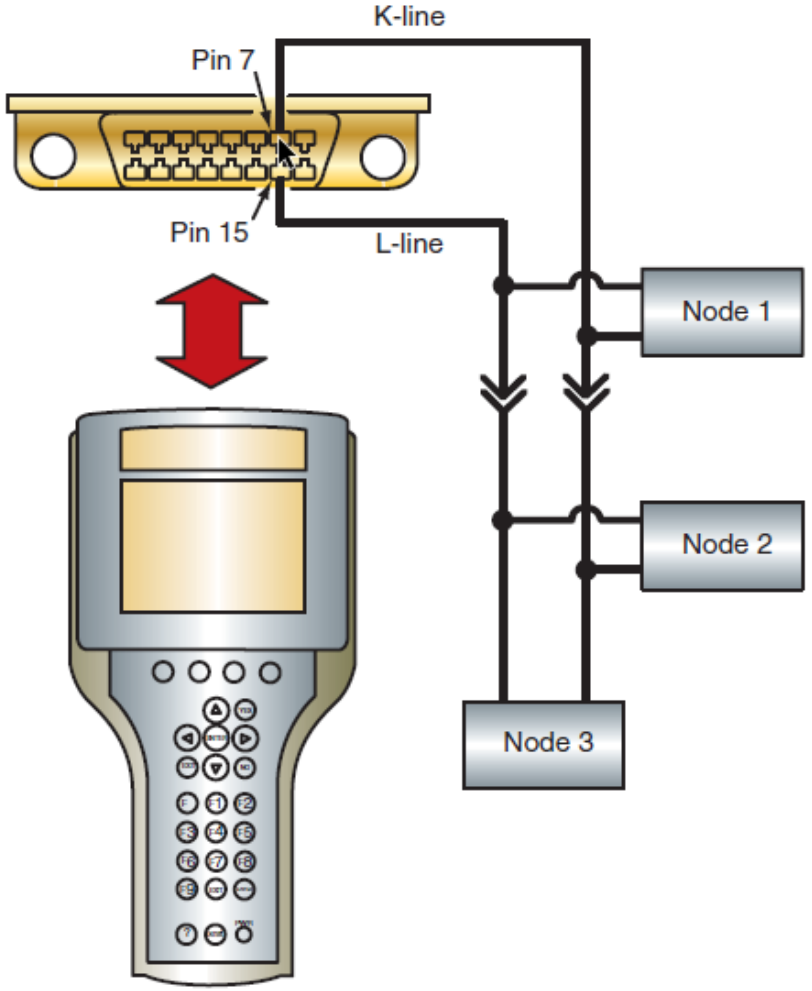


FIGURE 11-2 The two-wire ISO 9141-2 data bus used for diagnostic purposes.

ISO 9141-2, ISO 14230 (KWP2000)

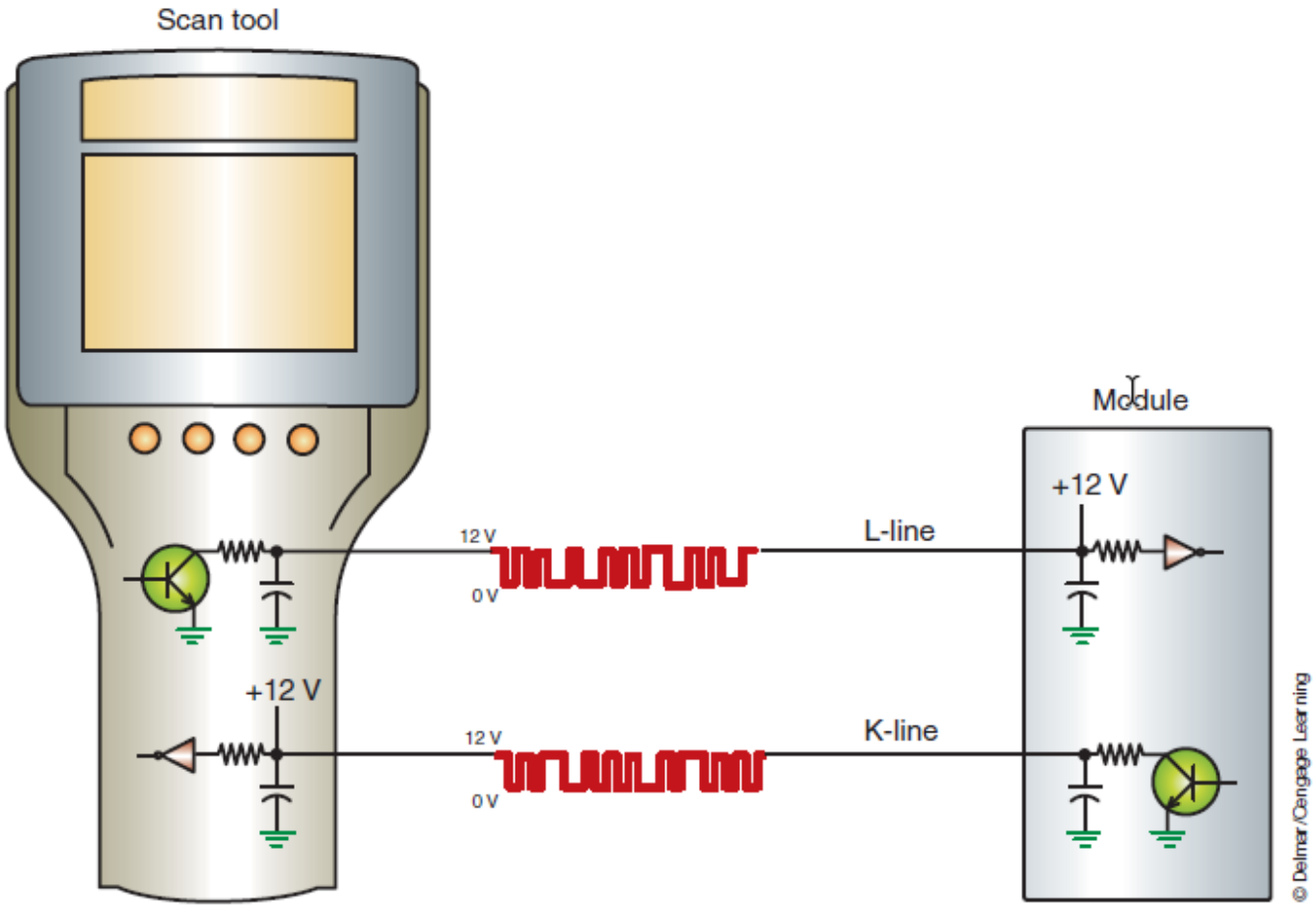


FIGURE 11-3 The K-line transmits data from the module to the scan tool and an L-line receives data from the scan tool.

پروتکل ارتباط با دستگاه عیب یاب ISO-K Bus

* خودرو هایی که از پروتکل ISO –K bus برای ارتباط با دستگاه عیب یاب استفاده می کنند برای دریافت DTC احتمالا از پایه های دیگری نیز در ترمینال OBD استفاده می کنند. پایه اصلی pin شماره 7 است

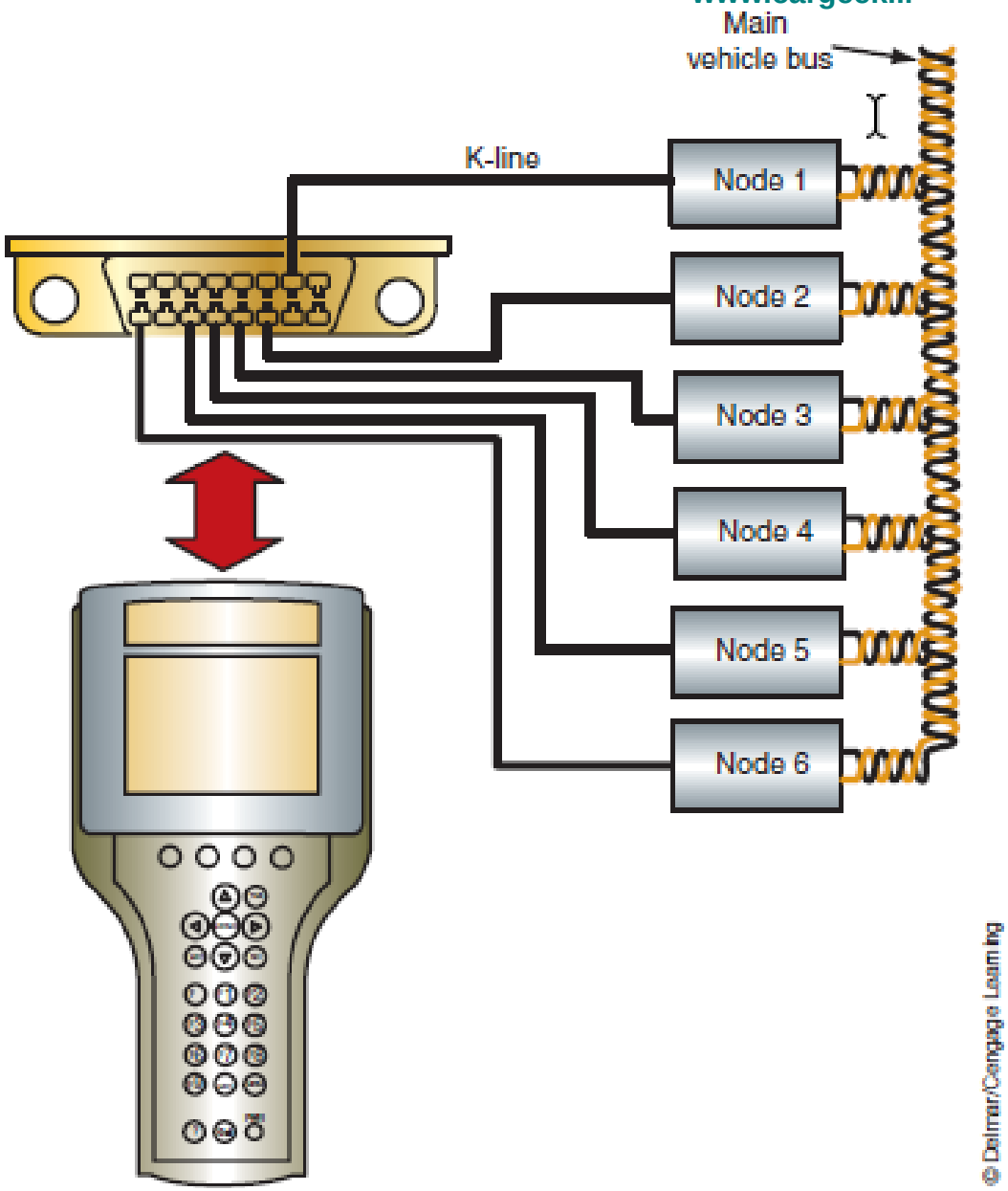
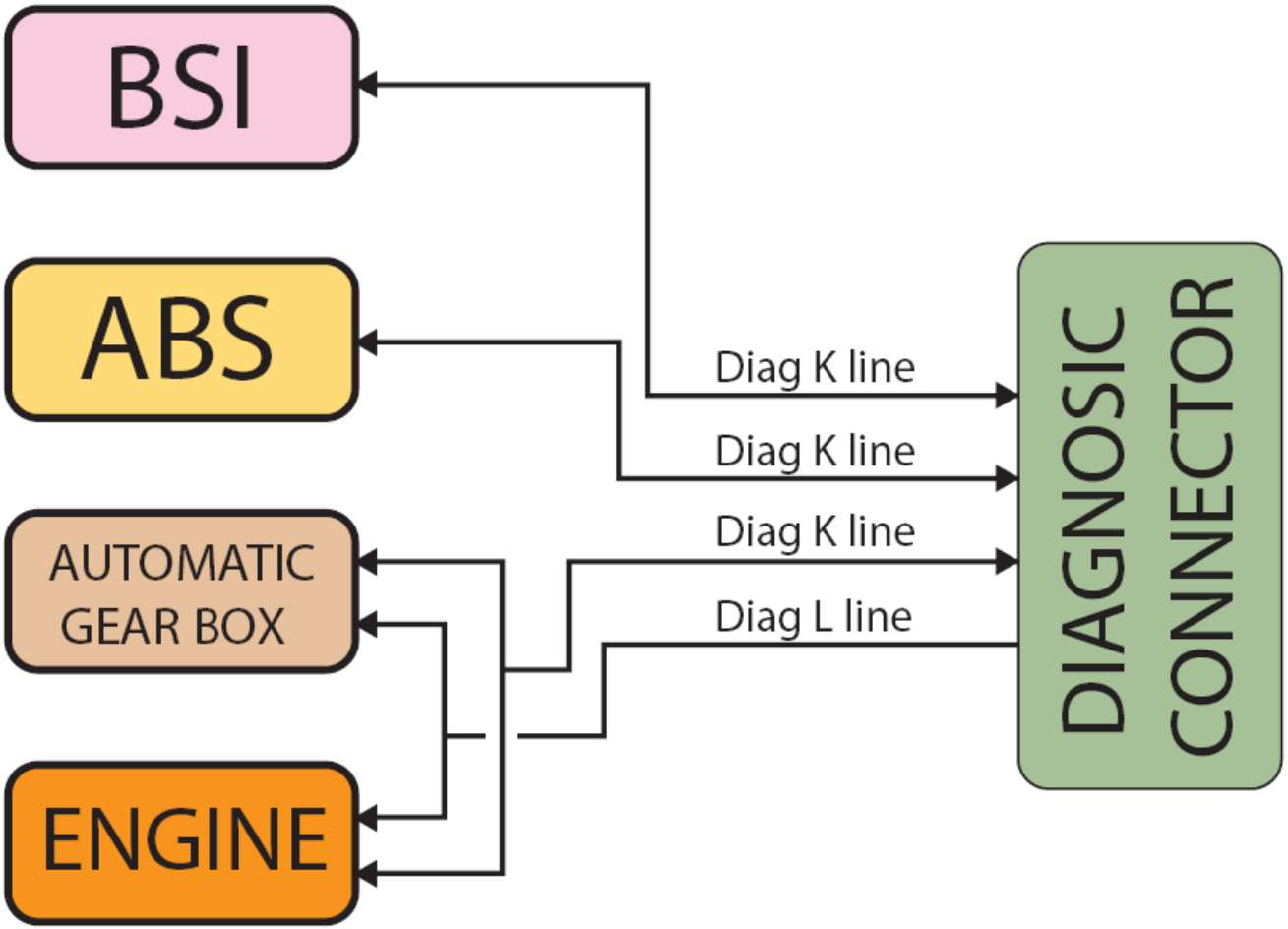


FIGURE 11-4 An ISO-K bus circuit used to connect several modules to the scan tool. Each module uses its own dedicated circuit from the DLC.

KWP2000(Key Word Protocol)



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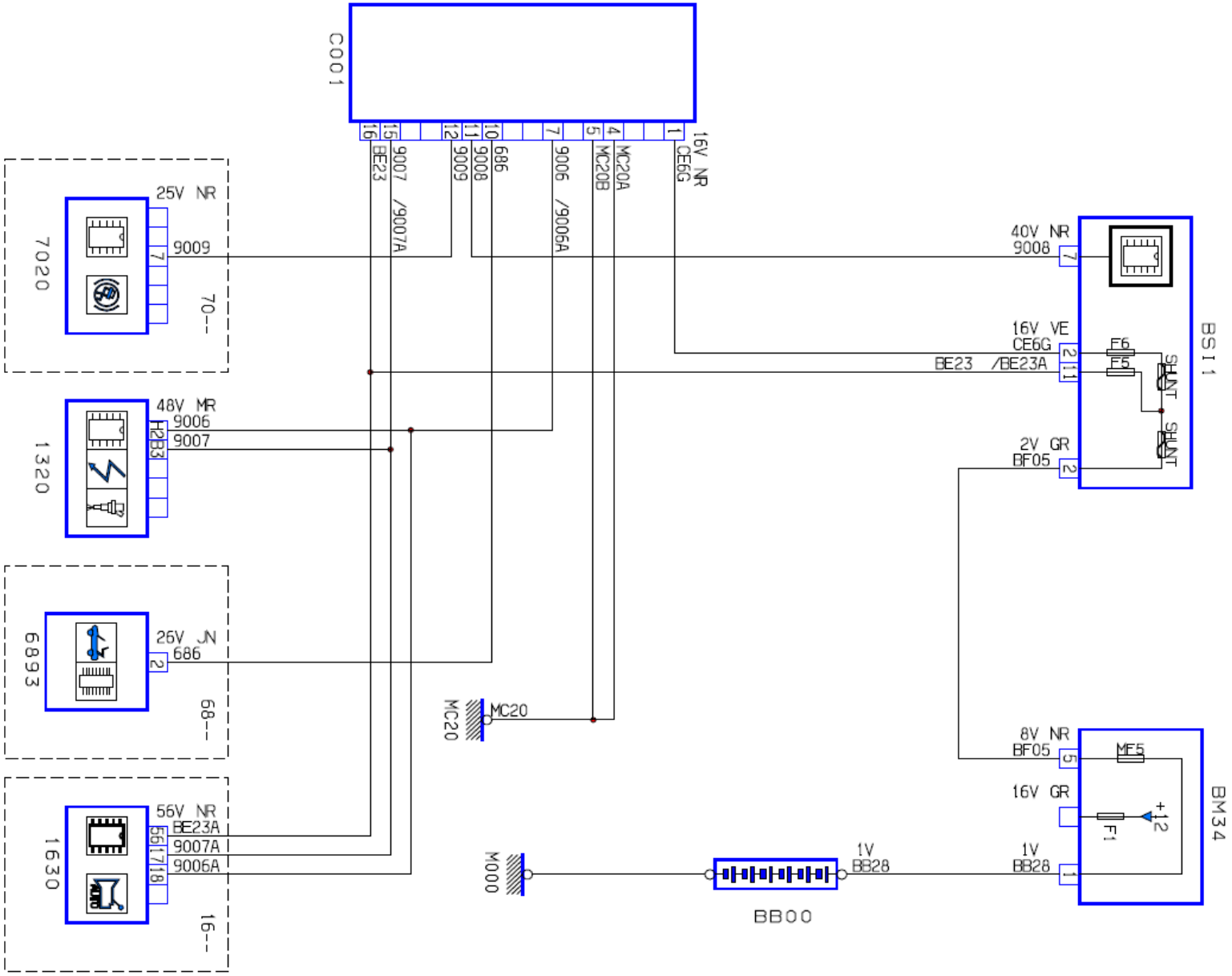

206 OBD II connector wiring

No modules can communicate

* If **no modules** can **communicate** with the **scan tool**, then a **total bus failure** is indicated.
* If a **total bus failure** is indicated, then possible causes include:
* ■ A fault in scan tools connection links(cables and connectors)
* ■ A faulty master module.
* ■ Faulty power or ground circuits to the master module.
* ■ An open in one of the bus circuits from the master module.
* ■ A short to ground in one of the bus circuits.
* ■ A short to voltage in one of the bus circuits.
* ■ The two bus wires are shorted together.

OBD II BOB(Break Out Box)

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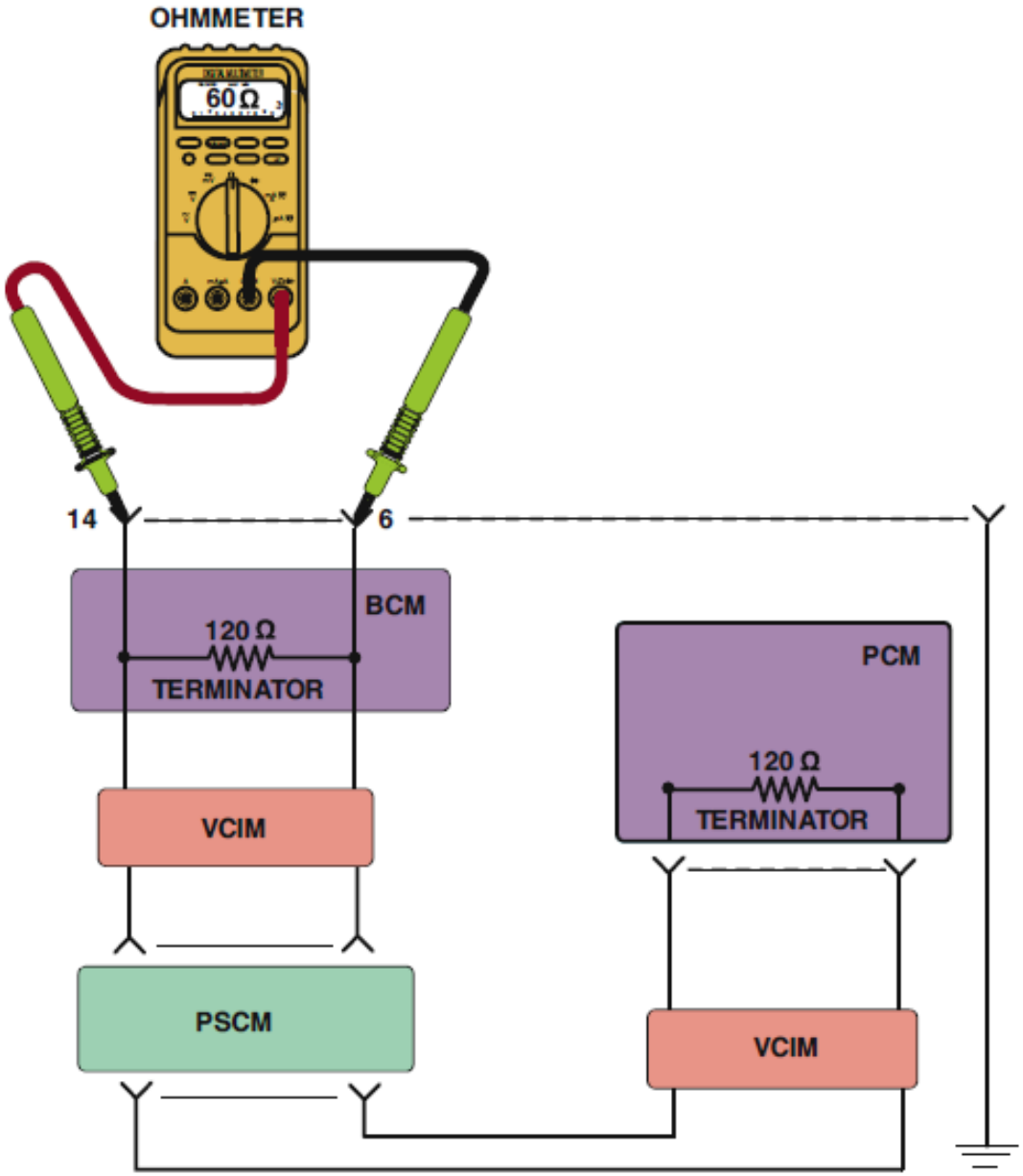


FIGURE 49–27 Checking the terminating resistors using an ohmmeter at the DLC.

Resistance testing

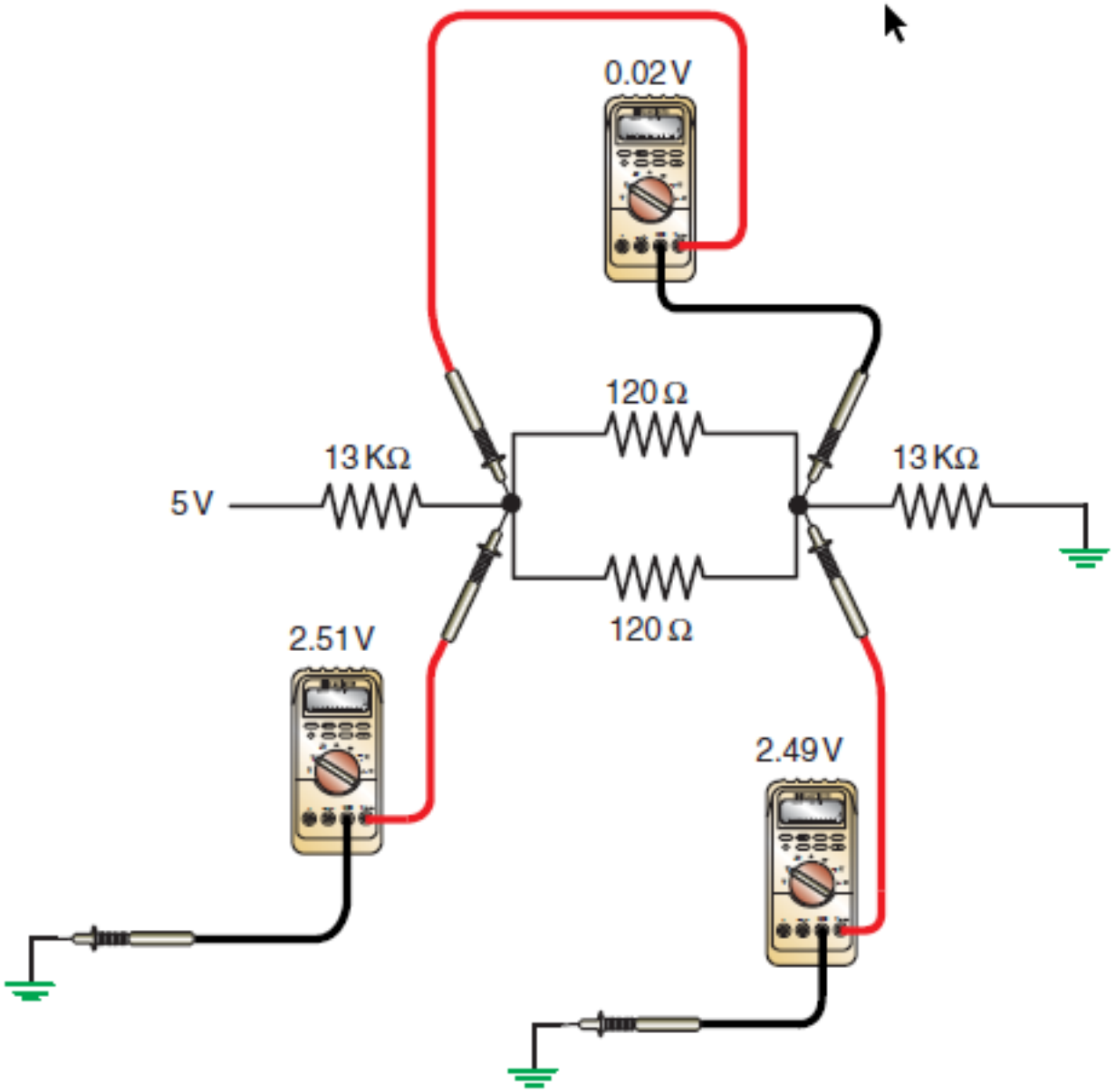


FIGURE 11-7 Simplified bus bias circuit for clarification.

Voltage testing

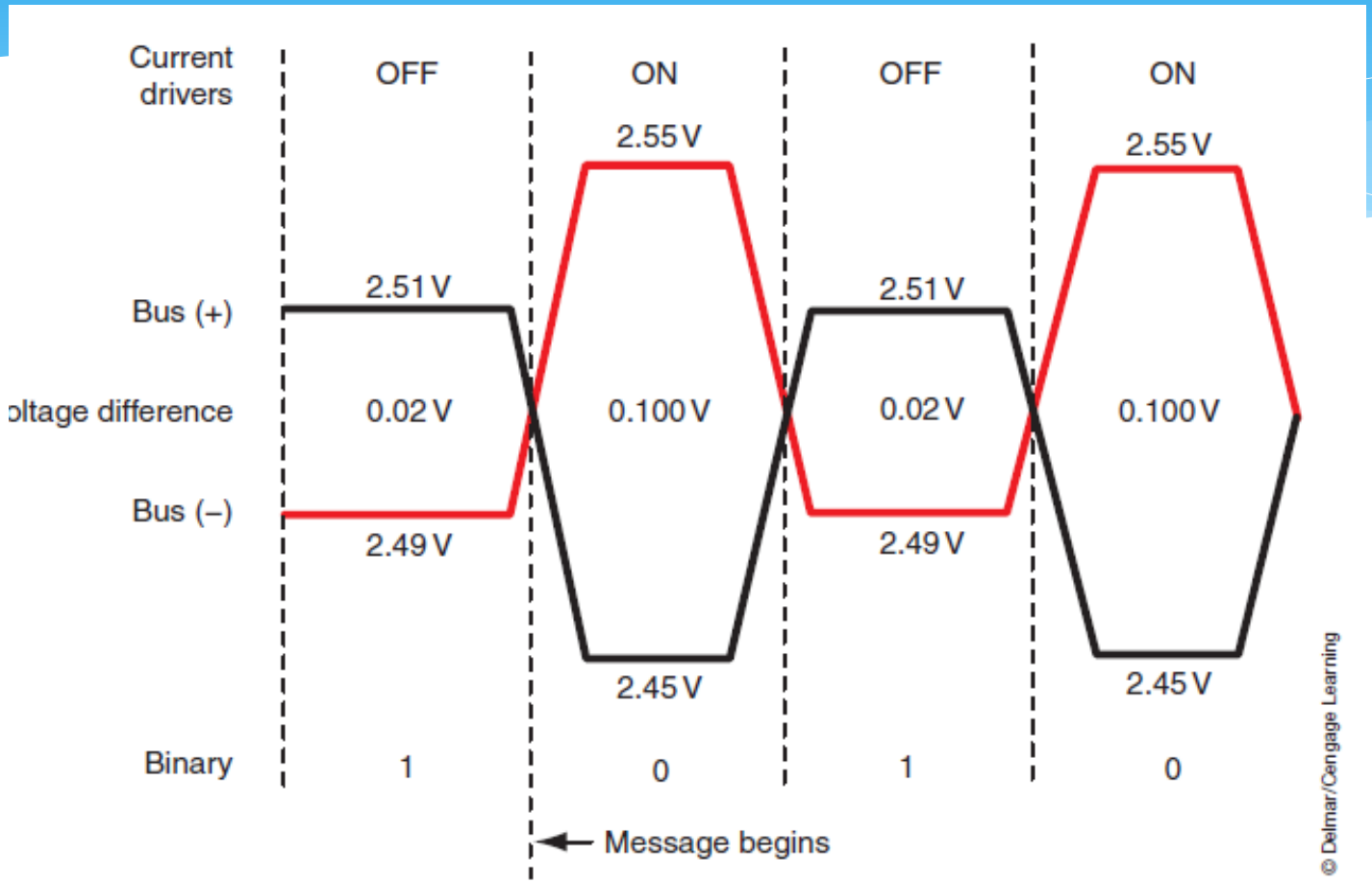
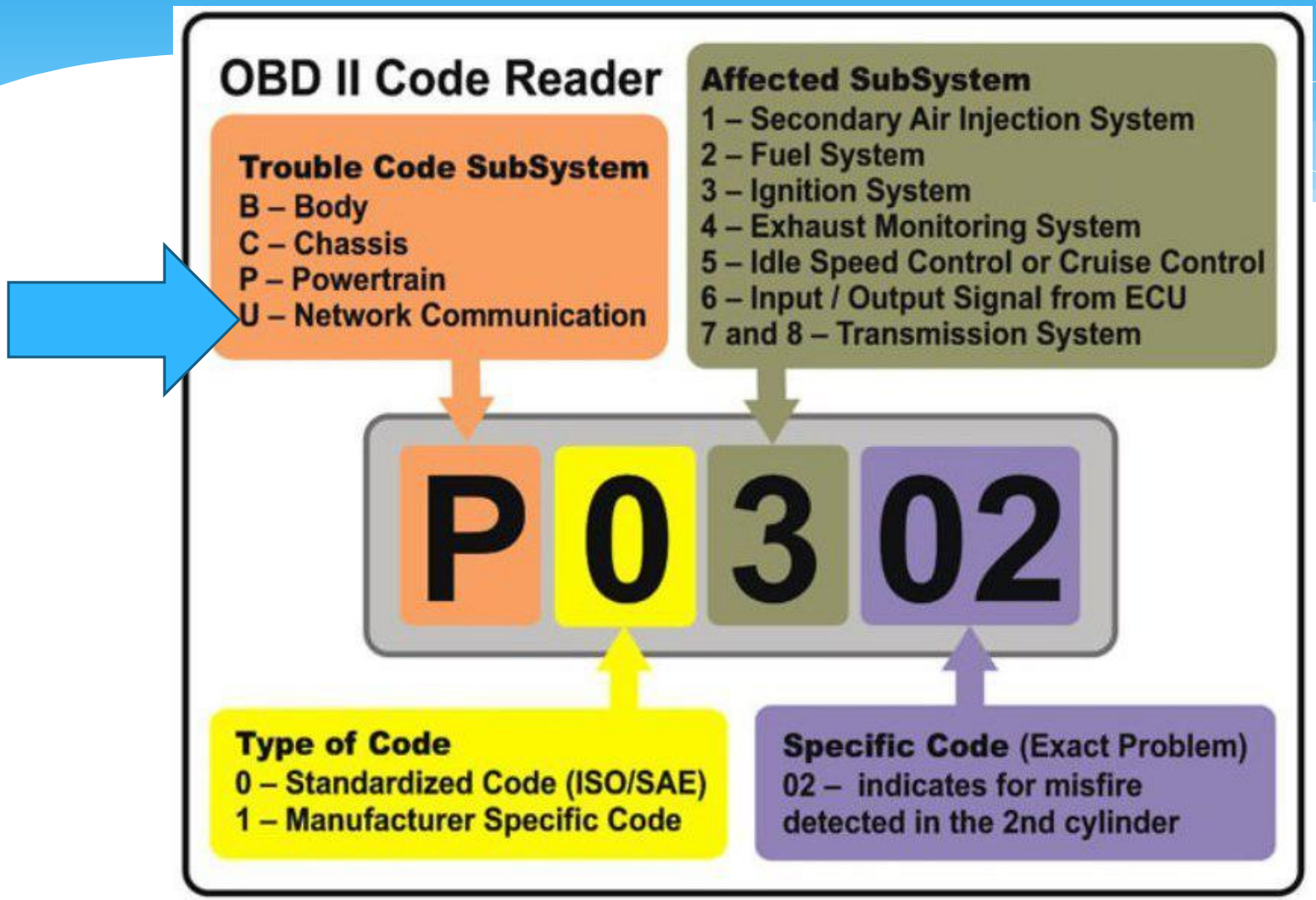


FIGURE 11-9 **As the drivers are activated, the voltage difference between bus (+) and bus (–) increases over their voltage values at idle. The difference in voltage determines if a binary 1 or 0 is being transmitted.**

Network DTC Code



تهیه و تنظیم : بهروز خطیبی

Network Common DTC's massage

* on the screen. The messages displayed can be as follows:
* ■ Bus (–) open.
* ■ Bus (+) and bus (–) open.
* ■ Bus (+) open.
* ■ Bus (+) shorted to bus (–).
* ■ Bus bias level too high.
* ■ Bus bias level too low.
* ■ Bus shorted to 5 volts.
* ■ Bus shorted to battery voltage.
* ■ Bus shorted to ground.
* ■ No bus bias.
* ■ No bus termination.
* ■ Not receiving bus messages correctly.

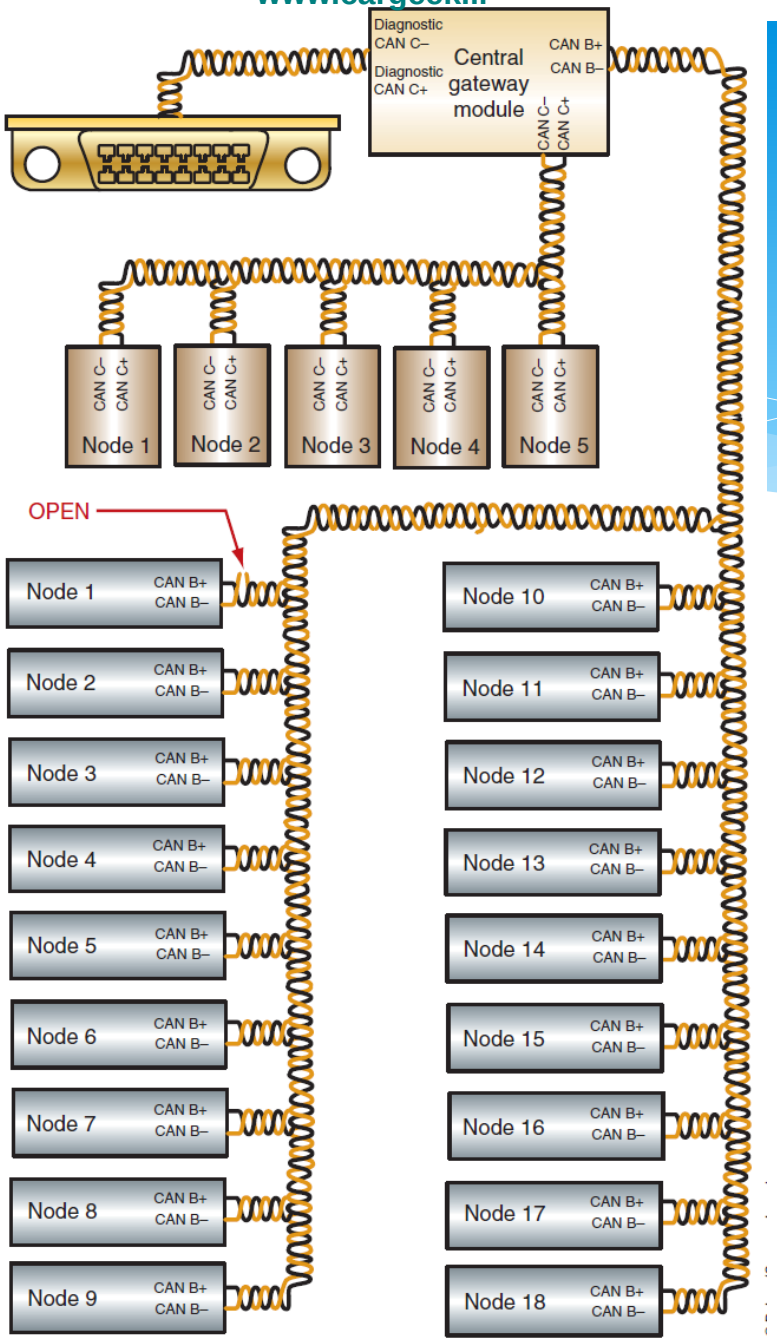


FIGURE 11-10 An open bus(-) wire at CAN B bus Node 1 does not prevent the other nodes from being active on the bus.

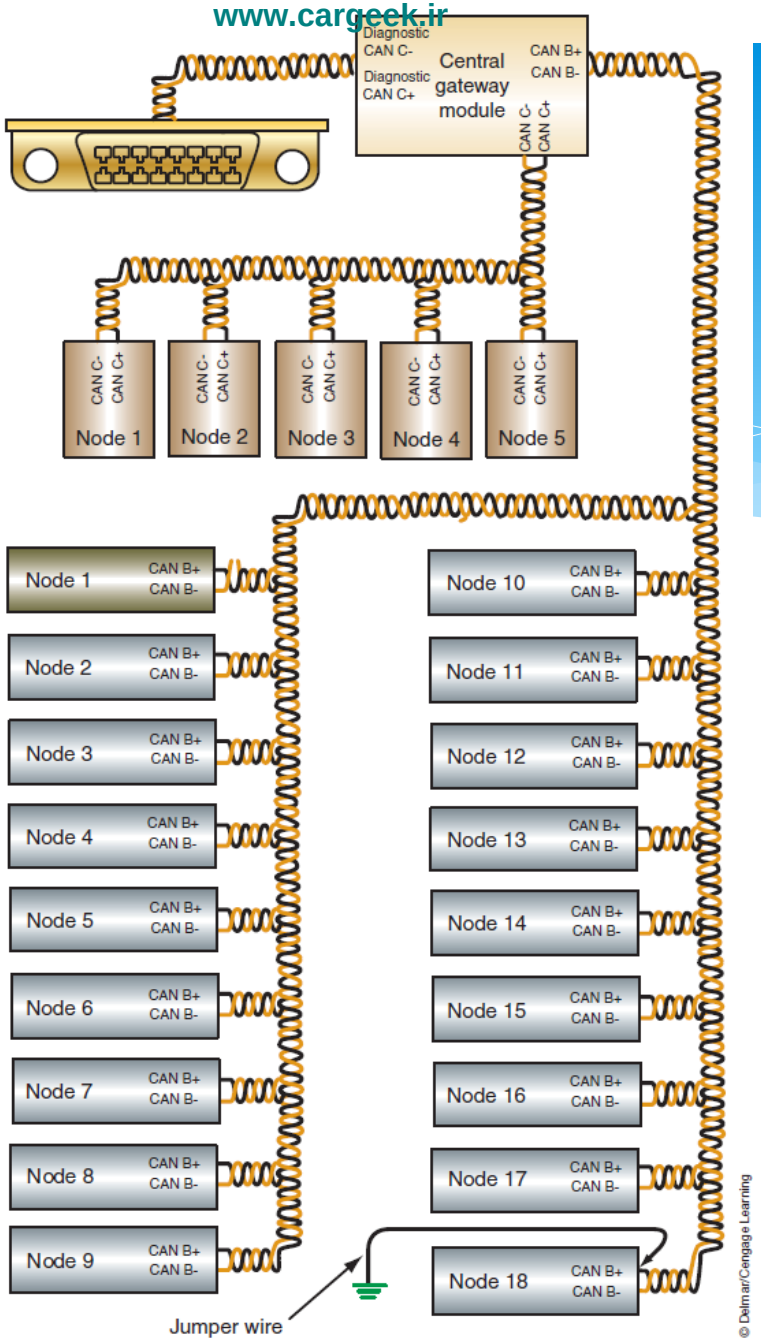


FIGURE 11-11 When the bus(+) wire at CAN B bus node 18 is shorted to ground all modules continue to communicate except Node 1. Node 1 cannot communicate since it no longer has a circuit.

Sample DTC's

DTC code	U0101 Lost Communication with Transmission Control Module
What does that mean?	that the Transmission Control Module (TCM) and other control modules on the vehicle are not talking to each other.
Symptoms	• Malfunction Indicator Lamp (MIL) on • Vehicle will not shift • Vehicle stays in one gear (usually 2nd or 3rd)
Potential Causes	• Open in the CAN bus + circuit • Open in the CAN bus - circuit • Short to power in either CAN bus circuit • Short to ground in either CAN bus circuit • Rarely - faulty control module
Diagnostic and Repair Procedures	always to check for technical service bulletins (TSB) for your particular vehicle

source : https://www.obd-codes.com

Sample DTC's

DTC code	U0102 Lost Communication with Transfer Case Control Module
What does that mean?	the Transfer Case Control Module (TCCM) and other control modules on the vehicle are not talking to each other
Symptoms	• Malfunction Indicator Light (MIL) On • 4WD / AWD / TCCM Light On or Flashing • Vehicle will not shift – stays in neutral • Vehicle stays in one gear (usually neutral; no forward gears)
Potential Causes	• Open in the CAN bus + circuit • Open in the CAN bus - circuit • Short to power in either CAN bus circuit • Short to ground in either CAN bus circuit • Rarely - faulty control module
Diagnostic and Repair Procedures	always to check for technical service bulletins (TSB) for your particular vehicle

source : https://www.obd-codes.com

Sample DTC's

DTC code	U0100-Lost Communication With ECM/PCM
What does that mean?	a serious situation where the signals between the electronic control module (ECM) or the powertrain control module (PCM) and a particular module have been lost
Symptoms	• Vehicle stalls and will not crank or restart • OBD trouble code U0100 will be set and the check engine light illuminated • Vehicle may start after sitting idle for a period of time, however, it would be risky to operate because it could fail again at a most inopportune momen
Potential Causes	varius
Diagnostic and Repair Procedures	always to check for technical service bulletins (TSB) for your particular vehicle

source : https://www.obd-codes.com