Unit I
Introduction to Automotive Electrical Systems

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❖ Syllabus:-

Introduction to Automotive electricity generation, storage & distribution systems, wiring harness, 12/24/42 volt system, Connectors and its types, positive earth and negative earth, earth return and insulated return systems, Introduction of Controlled Area Networks (CAN) and LIN Communication. Instrument Cluster, types of indication in the cluster, Driver information systems.

Electromagnetic Interference (EMI), Electromagnetic Susceptibility (EMS), Electromagnetic Compatibility (EMC)- Need, Types, Methods of Coupling, Sources of EMI, Testing Methods, Related ISO / CISPR / SAE / AIS Standards and Few Case studies.

❖ Definitions and Laws:

1. Ohm's law

- For most conductors, the current which will flow through them is directly proportional to the voltage applied to them.
- The ratio of voltage to current is referred to as resistance. If this ratio remains constant over a wide range of voltages, the material is said to be 'ohmic'.

$$I = \frac{V}{R}$$

Where:

I = Current in amps

V = Voltage in volts

R = Resistance in ohms

- Georg Simon Ohm was a German physicist, well known for his work on electrical currents.

2. Lenz’s law

- The emf induced in an electric circuit always acts in a direction so that the current it creates around the circuit will oppose the change in magnetic flux which caused it.
- Lenz’s law gives the direction of the induced emf resulting from electromagnetic induction. The ‘opposing’ emf is often described as a ‘back emf’. The law is named after the Estonian physicist Heinrich Lenz.

3. Kirchhoff's laws

Kirchhoff 's 1st law:

- The current flowing into a junction in a circuit must equal the current flowing out of the junction. This law is a direct result of the conservation of charge; no charge can be lost in the junction, so any charge that flows in must also flow out.

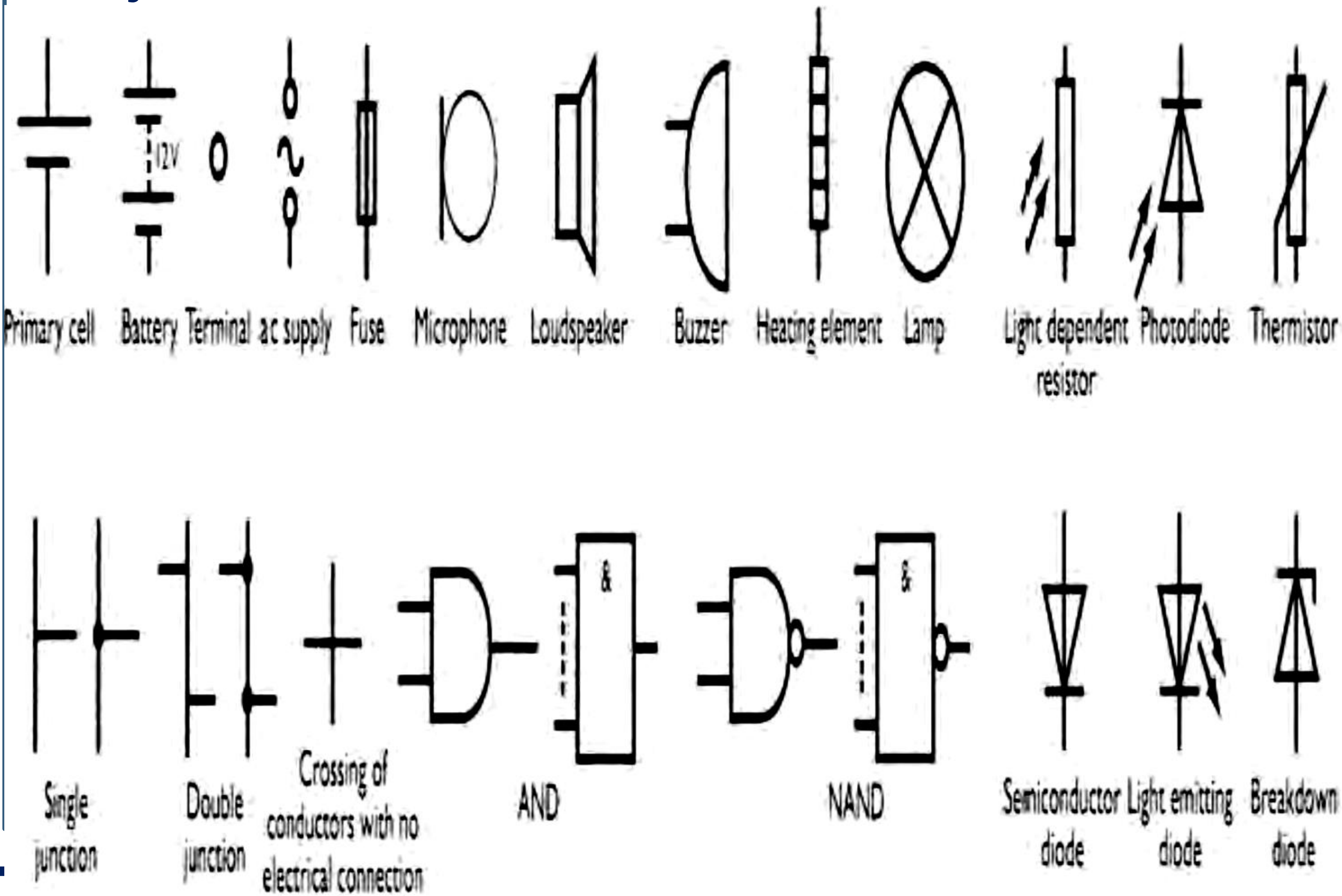
Kirchhoff 's 2nd law:

- For any closed loop path around a circuit the sum of the voltage gains and drops always equals zero. This is effectively the same as the series circuit statement that the sum of all the voltage drops will always equal the supply voltage.
- Gustav Robert Kirchhoff was a German physicist; he also discovered cesium and rubidium.

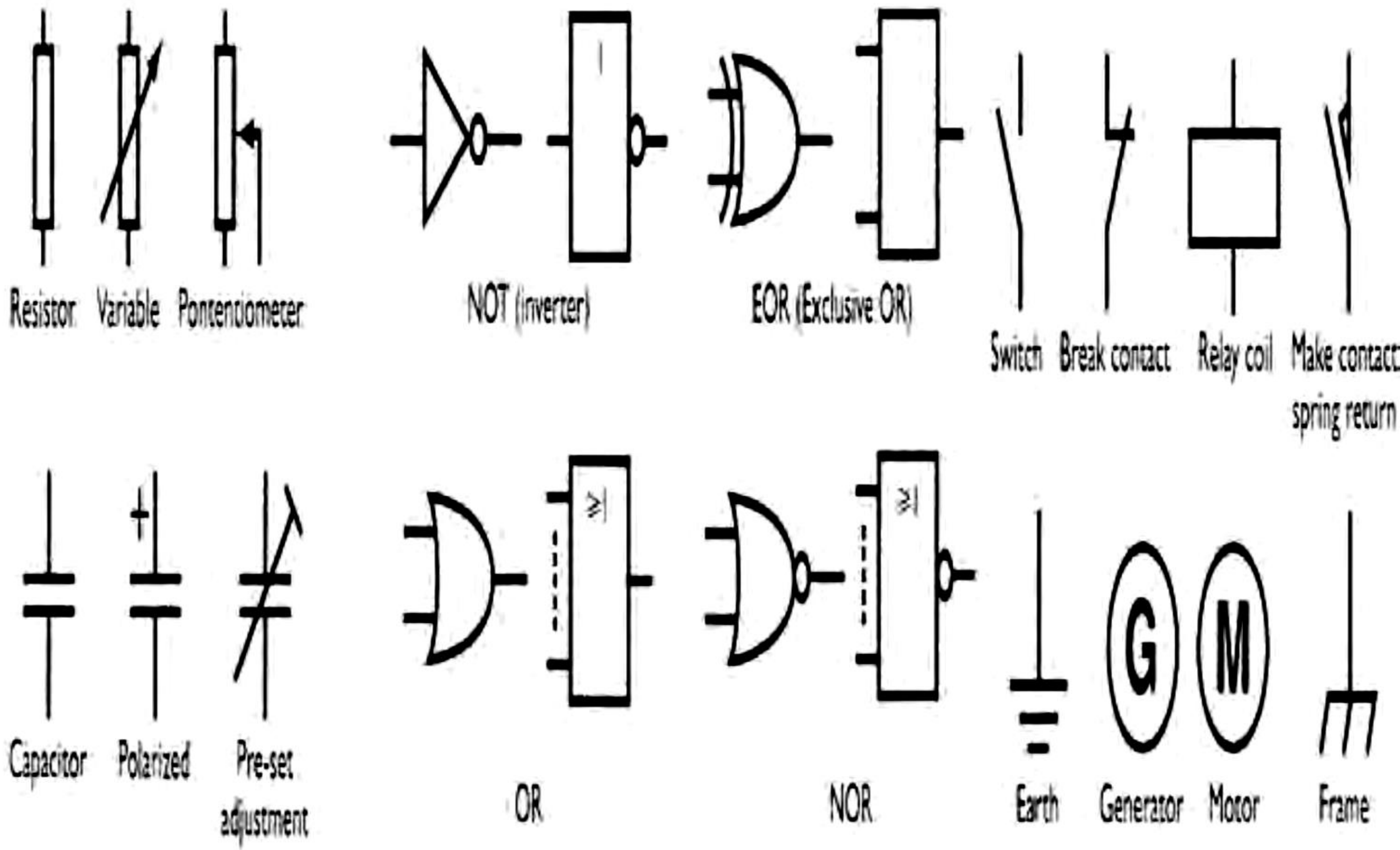
4. Faraday's law

- Any change in the magnetic field around a coil of wire will cause an emf (voltage) to be induced in the coil.
- Michael Faraday was a British physicist and chemist, well known for his discoveries of electromagnetic induction and of the laws of electrolysis.

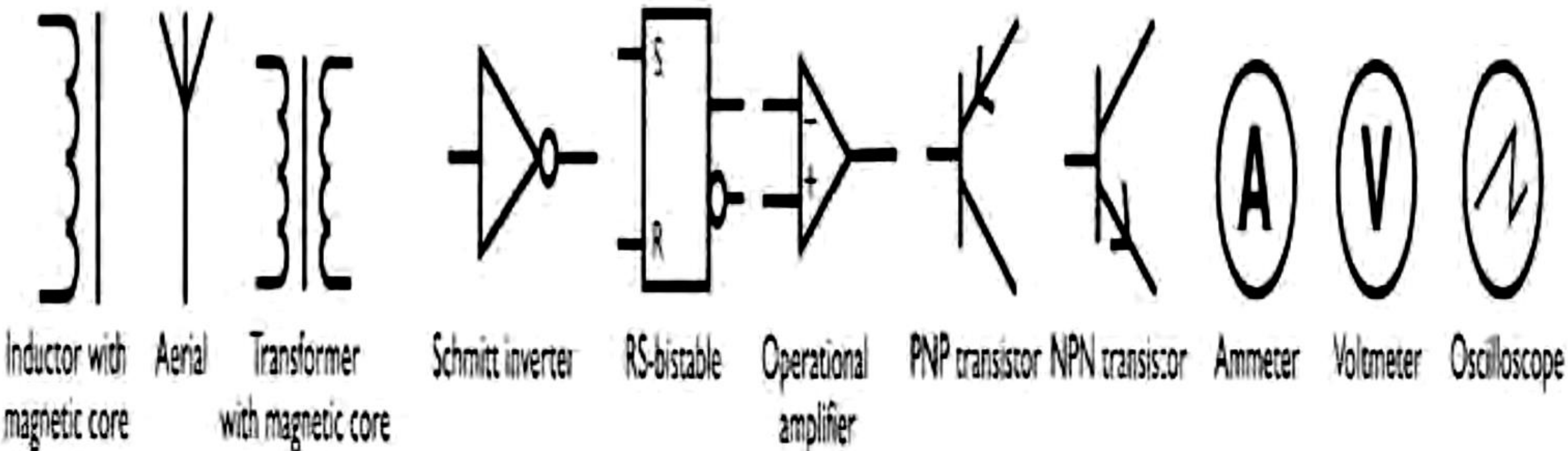
❖ Symbols:


Primary cell
Battery
12V
Terminal
a.c supply
Fuse
Microphone
Loudspeaker
Buzzer
Heating element
Lamp
Light dependent resistor
Photodiode
Thermistor
Single junction
Double junction
Crossing of conductors with no electrical connection
&
AND
&
NAND
Semiconductor diode
Light emitting diode
Breakdown diode

❖ Symbols:


Resistor
Variable
Pontentiometer
NOT (inverter)
EOR (Exclusive OR)
Switch
Break contact
Relay coil
Make contact spring return
Capacitor
Polarized
Pre-set adjustment
OR
NOR
Earth
Generator
Motor
Frame
G
M

❖ Symbols:


S
R
Inductor with magnetic core
Aerial
Transformer with magnetic core
Schmitt inverter
RS-bistable
Operational amplifier
PNP transistor
NPN transistor
A
Ammeter
V
Voltmeter
Oscilloscope

❖ Automotive Electricity Generation:

- The ‘current’ demands made by modern vehicles are considerable. The electricity generation system must be able to meet these demands under all operating conditions and charge the battery.
- The main component of the electricity generation system is the alternator.
- The alternator generates AC but must produce DC at its output terminal as only DC can be used to charge the battery and run electronic circuits.
- The output of the alternator must be a constant voltage regardless of engine speed and current load.

- To summarize,
- Supply the current demands made by all loads.
- Supply whatever charge current the battery demands.
- Operate at idle speed.
- Supply constant voltage under all conditions.
- Have an efficient power-to-weight ratio.
- Be reliable, quiet, and have resistance to contamination.
- Require low maintenance.
- Provide an indication of correct operation.

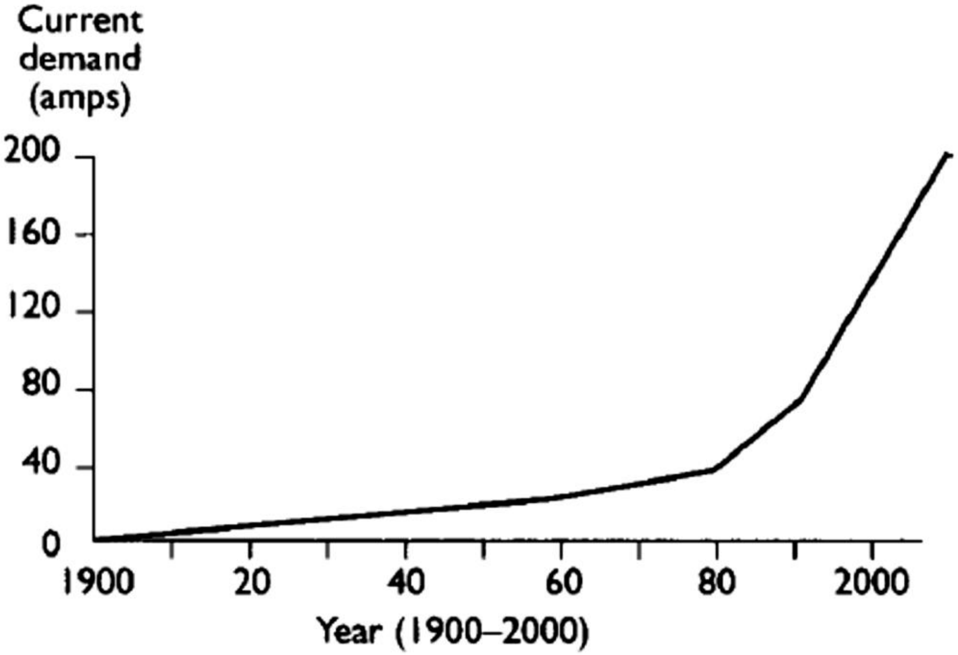


Figure 6.2 How the demands on the alternator have changed

Table 6.1 Typical power requirements of some common vehicle electrical components

Continuous loads	Power (W)	Current at 14 V	28 V
Ignition	30	2.0	1.0
Fuel injection	70	5.0	2.5
Fuel pump	70	5.0	2.5
Instruments	10	1.0	0.5
Total	180	13.0	6.5
Prolonged loads	**Power (W)**	**Current at 14 V**	**28 V**
Side and tail lights	30	2.0	1.0
Number plate lights	10	1.0	0.5
Headlights main beam	200	15.0	7.0
Headlights dip beam	160	12.0	6.0
Dashboard lights	25	2.0	1.0
Radio/Cassette/CD	15	1.0	0.5
Total (Av. main & dip)	260	19.5	9.5

Intermittent loads	Power (W)	Current at 14 V	28 V
Heater	50	3.5	2.0
Indicators	50	3.5	2.0
Brake lights	40	3.0	1.5
Front wipers	80	6.0	3.0
Rear wipers	50	3.5	2.0
Electric windows	150	11.0	5.5
Radiator cooling fan	150	11.0	5.5
Heater blower motor	80	6.0	3.0
Heated rear window	120	9.0	4.5
Interior lights	10	1.0	0.5
Horns	40	3.0	1.5
Rear fog lights	40	3.0	1.5
Reverse lights	40	3.0	1.5
Auxiliary lamps	110	8.0	4.0
Cigarette lighter	100	7.0	3.5
Headlight wash wipe	100	7.0	3.5
Seat movement	150	11.0	5.5
Seat heater	200	14.0	7.0
Sun-roof motor	150	11.0	5.5
Electric mirrors	10	1.0	0.5
Total	1.7 kW	125.5	63.5

Automotive Electricity Storage:

Requirements:-

- To provide power storage and be able to supply it quickly enough to operate the vehicle starter motor.
- To allow the use of parking lights for a reasonable time.
- To allow operation of accessories when the engine is not running.
- To act as a swamp to damp out fluctuations of system voltage.
- To allow dynamic memory and alarm systems to remain active when the vehicle is left for a period of time

Regulator:

- Regulator regulates the current produced by the generator.

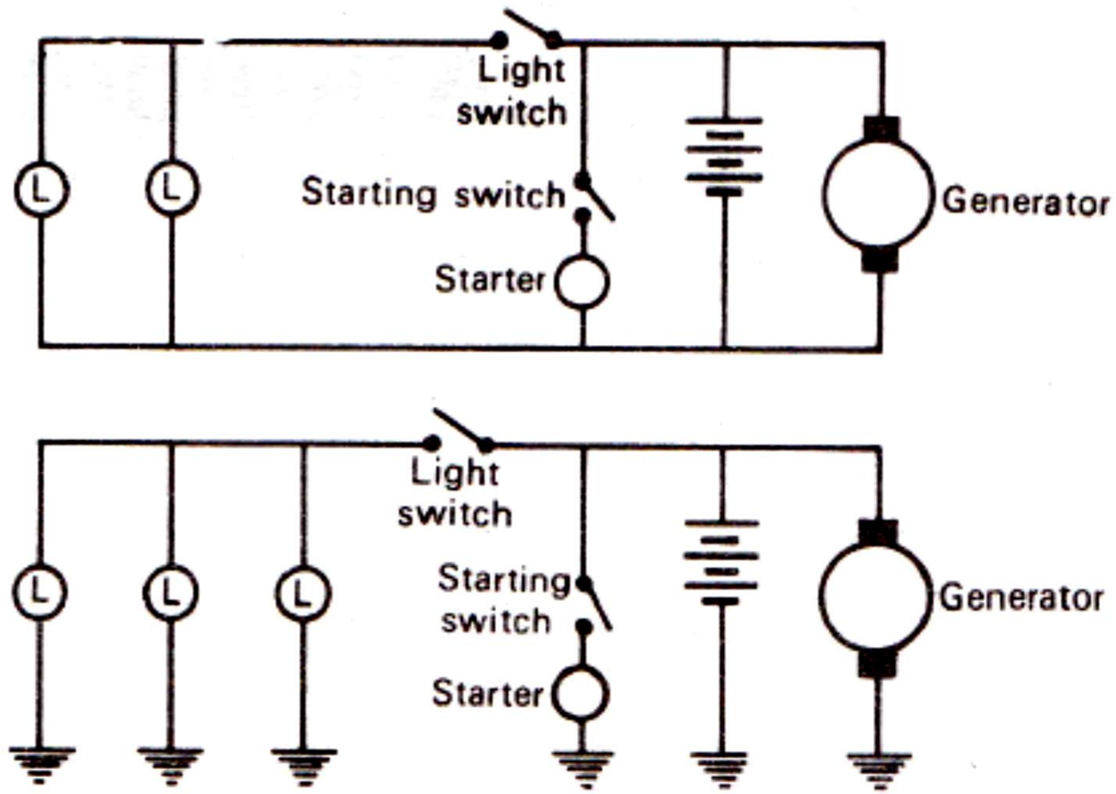


Fig. 2.1 Connection diagram.

Starting System:

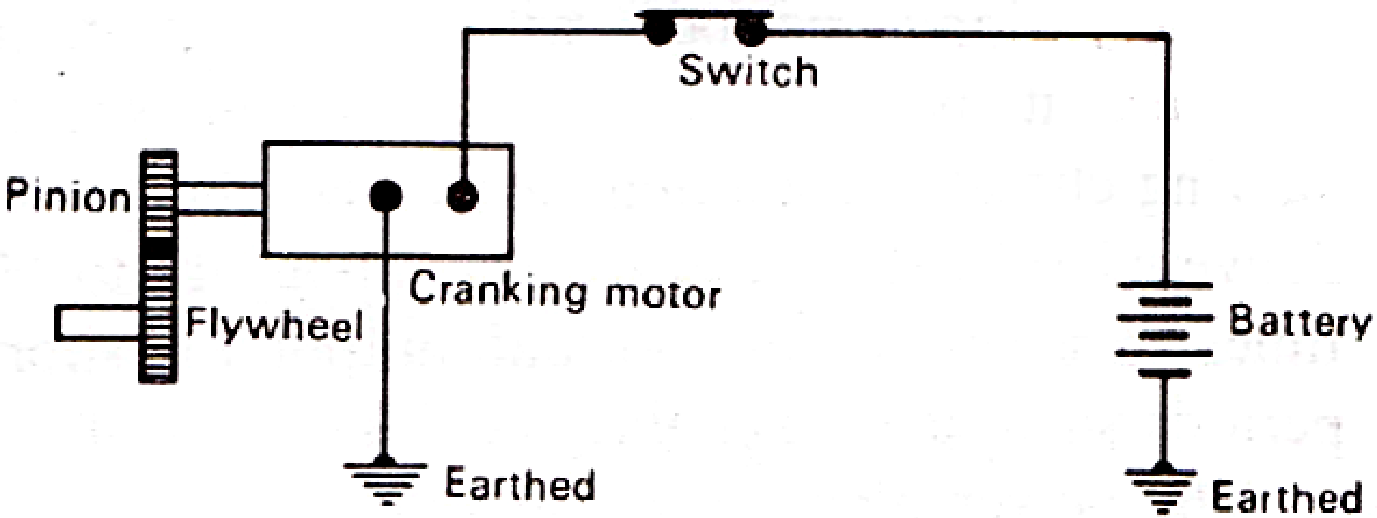


Fig. 2.2 A simple circuit diagram of the cranking motor.

Ignition System:

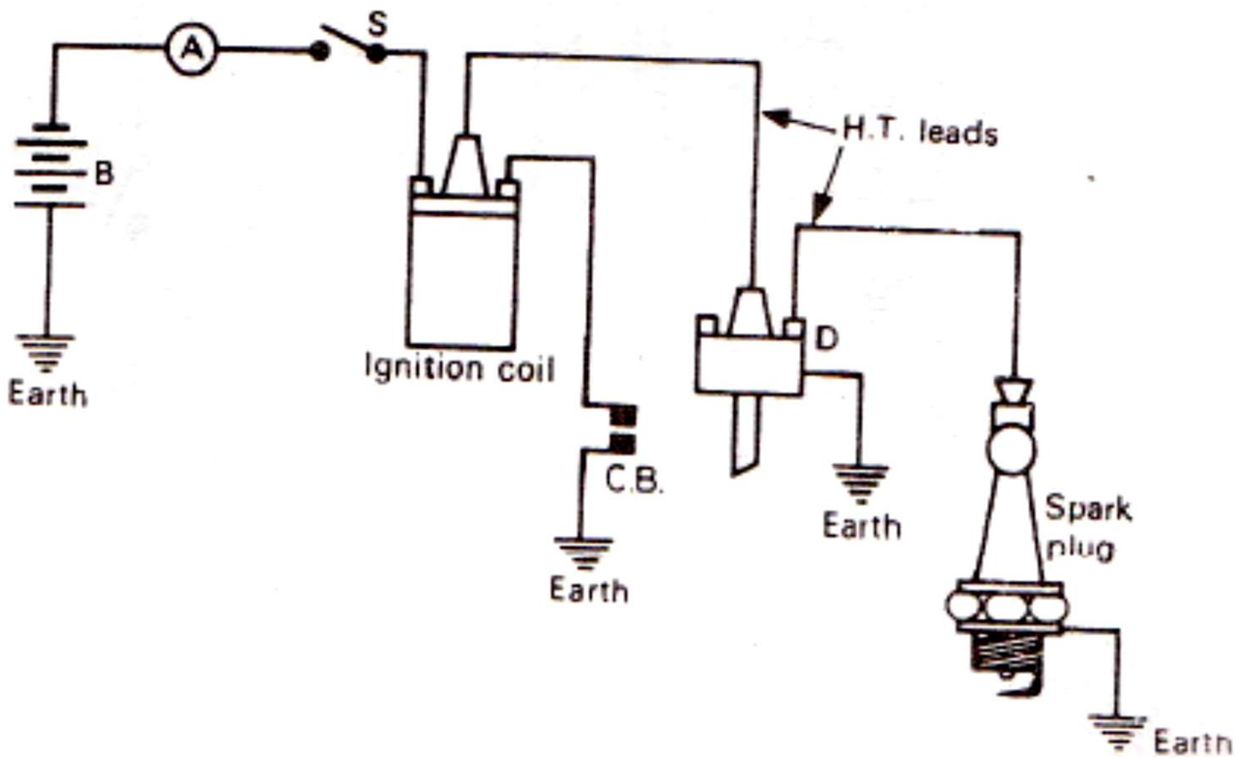


Fig. 2.4 A simple circuit diagram of the coil ignition system.

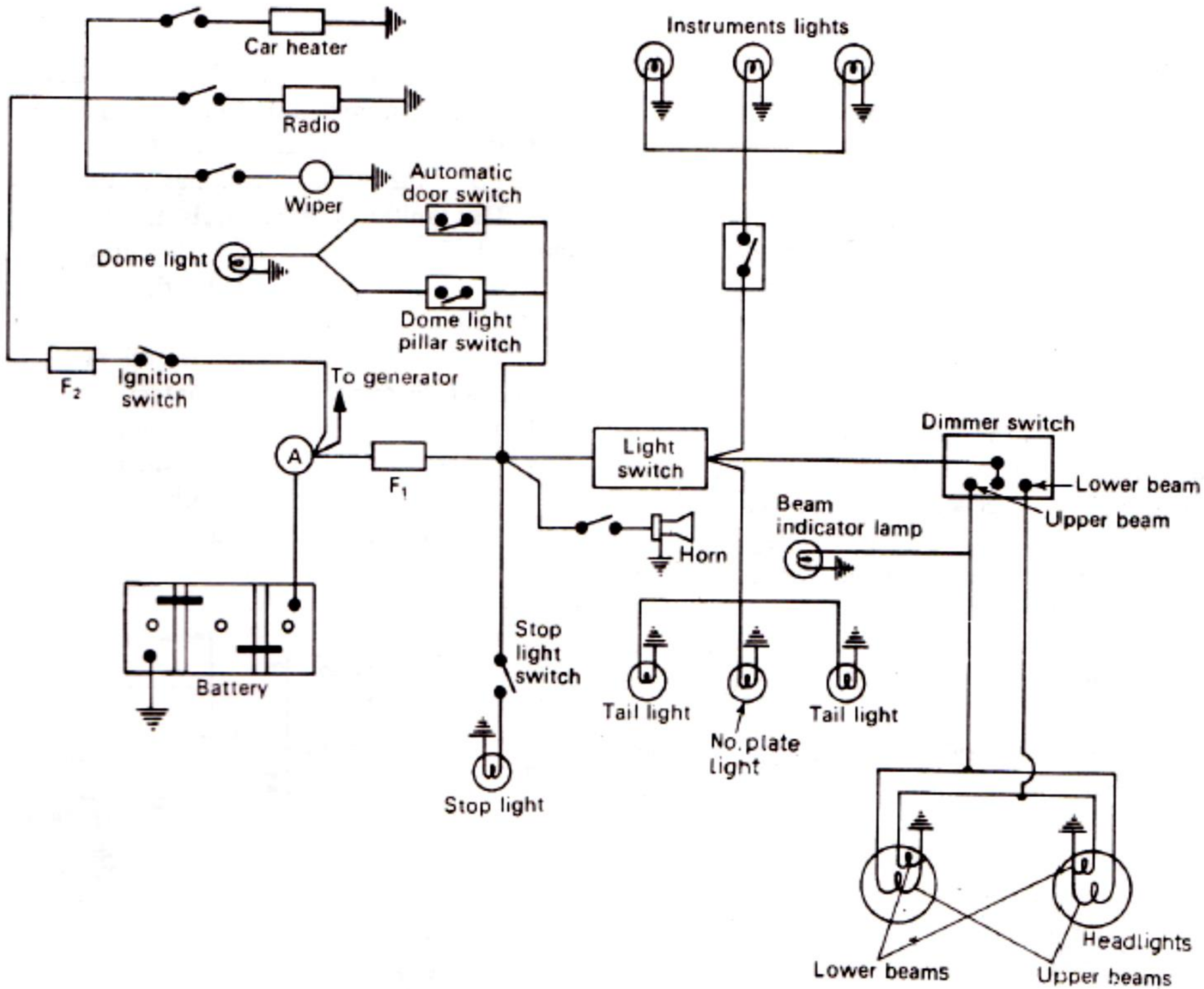
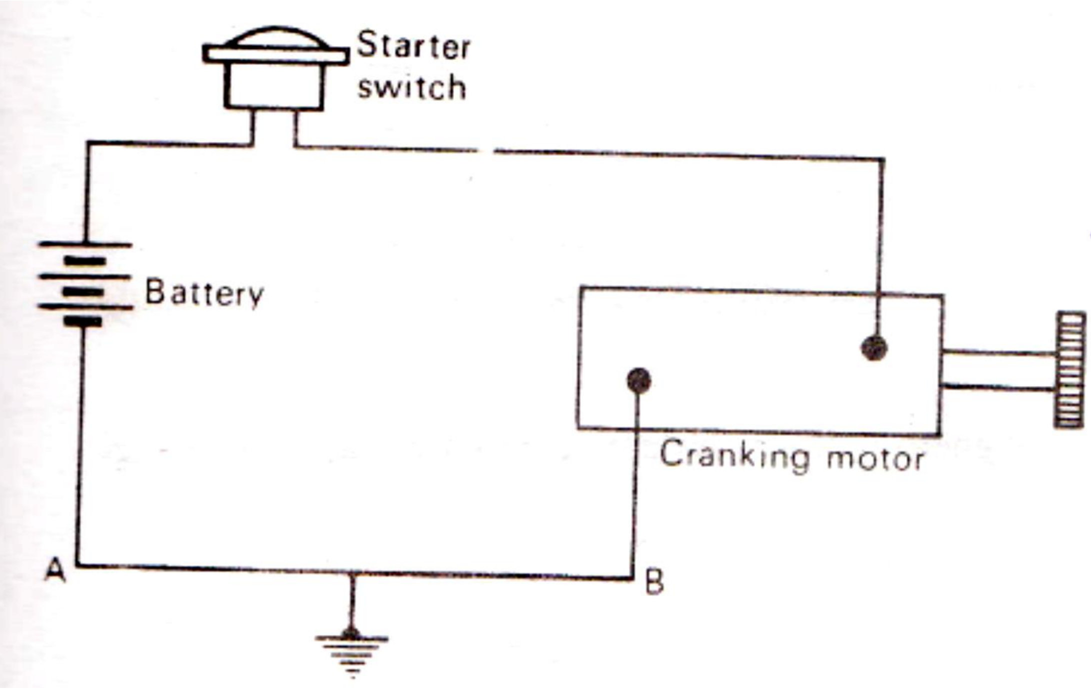


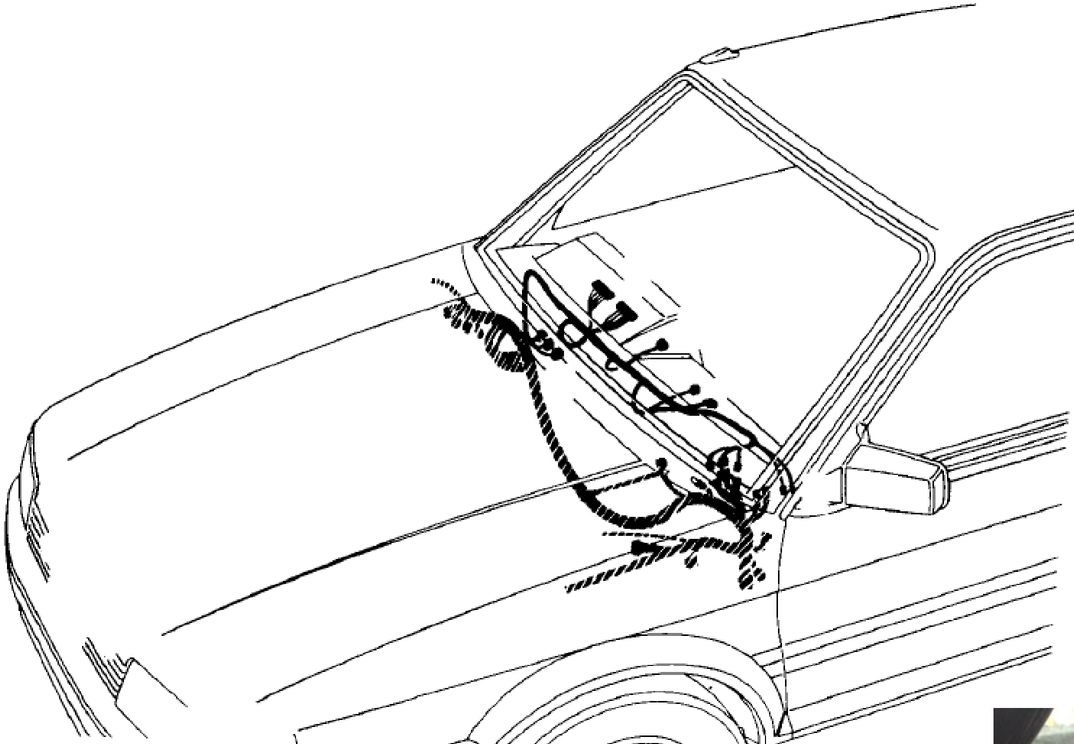
Fig. 2.5 A simple schematic layout of the lighting and accessories systems.

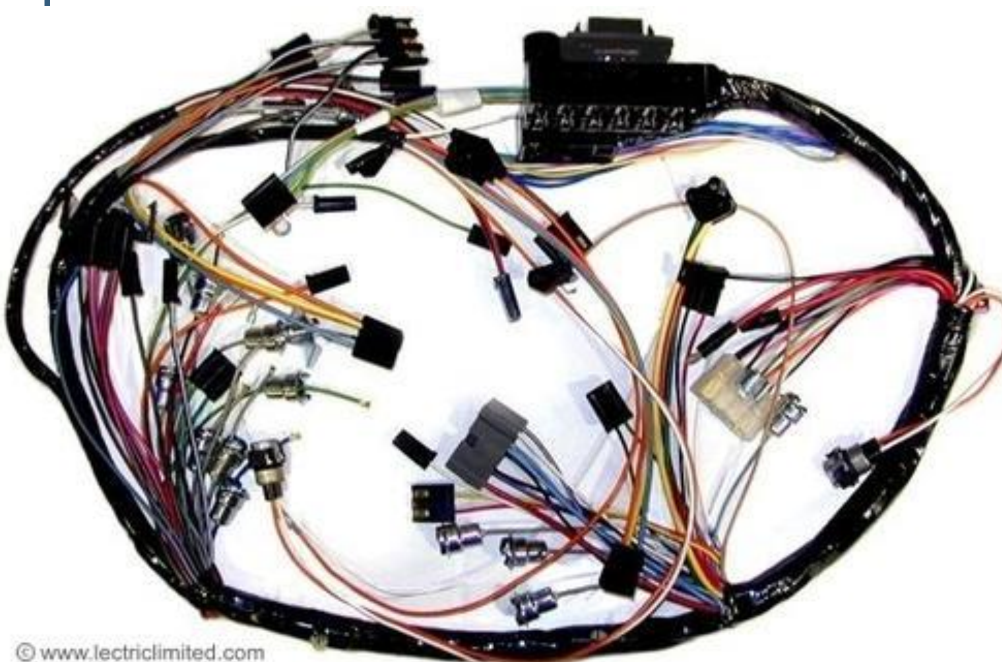
Earth Return & Insulated Return System



❖ Wiring Harness:

- The vehicle wiring harness has developed over the years from a loom containing just a few wires, to the looms used at present on top range vehicles containing well over 1000 separate wires.
- Modern vehicles tend to have wiring harnesses constructed in a number of ways. The most popular is still for the bundle of cables to be spirally wrapped in non-adhesive PVC tape. The tape is non-adhesive so as to allow the bundle of wires to retain some flexibility, as shown in Figure
- Another way of grouping cables, as shown in Figure is to place them inside PVC tubes

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- When deciding on the layout of a wiring loom within the vehicle, many issues must be considered. Some of these are as follows.

1. Cable runs must be as short as possible.
2. The loom must be protected against physical damage.
3. The number of connections should be kept to a minimum.
4. Modular design may be appropriate.
5. Accident damage areas to be considered.
6. Production line techniques should be considered.
7. Access must be possible to main components and sub-assemblies for repair purposes.

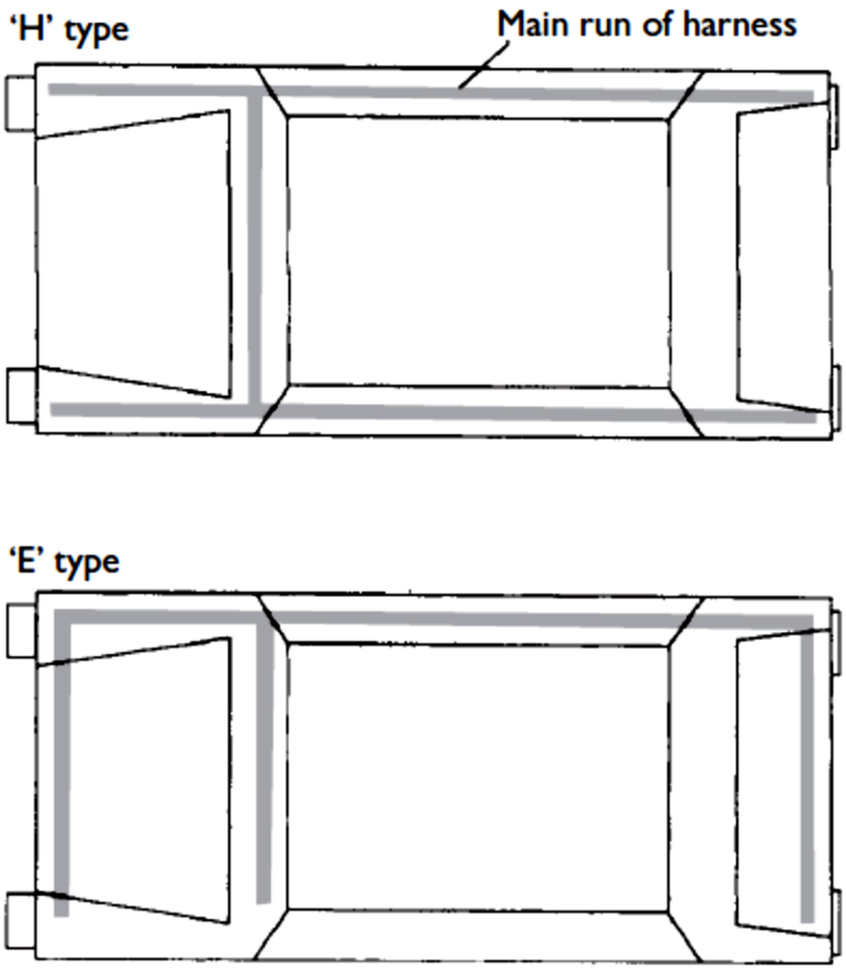


Figure 4.9 'H' and 'E' wiring layouts

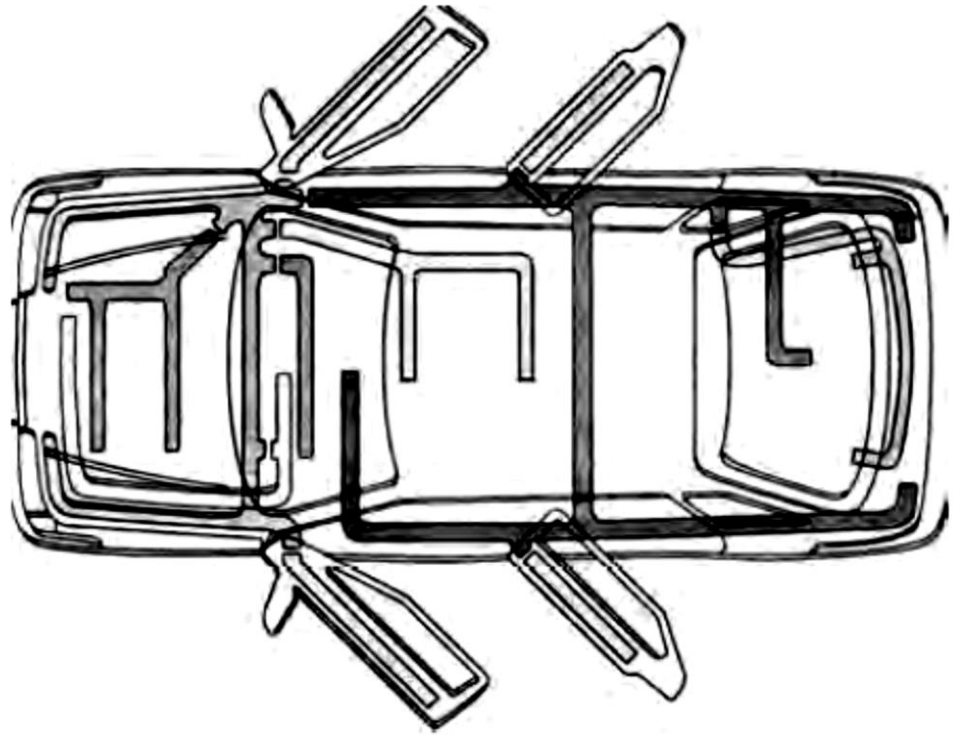
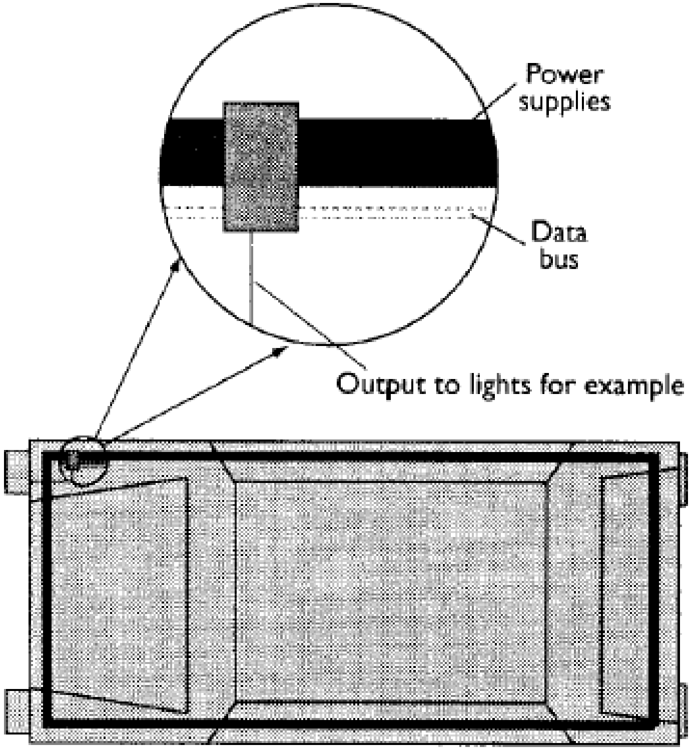


Figure 4.10 Typical wiring harness layout

- **Multiplexed Wiring System:**
- The complexity of modern wiring systems has been increasing steadily over the last 25 years or so and, in recent years, has increased dramatically.
- It has now reached a point where the size and weight of the wiring harness is a major problem. The number of separate wires required on a top-of-the-range vehicle can be in the region of 1500!
- The wiring loom required to control all functions in or from the driver's door can require up to 50 wires, the Systems in the dashboard area alone can use over 100 wires and connections.
- This is clearly becoming a problem as, apart from the obvious issues of size and weight, the number of connections and the number of wires increase the possibility of faults developing.

- It has been estimated that the complexity of the vehicle wiring system doubles every 10 years.
- The number of systems controlled by electronics is continually increasing.
- Some examples of these systems are listed below:
  - Engine management.
  - Anti-lock brakes.
  - Traction control.
  - Variable valve timing.
  - Transmission control.
  - Active suspension.
  - Communications.
  - Multimedia.



- All the systems listed above work in their own right but are also linked to each other. Many of the sensors that provide inputs to one electronic control unit are common to all or some of the others.
- One solution to this is to use one computer to control all systems. This, however, would be very expensive to produce in small numbers. A second solution is to use a common data bus.
- This would allow communication between modules and would make the information from the various vehicle sensors available to all sensors.
- Taking this idea a stage further, if data could be transmitted along one wire and made available to all parts of the vehicle, then the vehicle wiring could be reduced to just three wires.

- These wires would be **a mains supply, an earth connection and a signal wire**. The idea of using just one line for many signals is not new and has been in use in areas such as telecommunications for many years.
- Various signals can be **'multiplexed'** on to one wire in two main ways – frequency division and time division multiplexing.
- Frequency division is similar to the way radio signals are transmitted. It is oversimplifying a complex subject, but a form of time division multiplexing is generally used for transmission of digital signals.
- A ring main or multiplexed wiring system is represented in Figure above. This shows that the data bus and the power supply cables must 'visit' all areas of the vehicle electrical system.

- To illustrate the operation of this system, consider the events involved in switching the sidelights on and off.
- First, in response to the driver pressing the light switch, a unique signal is placed on the data bus.
- This signal is only recognized by special receivers built as part of each light unit assembly, and these in turn will make a connection between the power ring main and the lights.
- The events are similar to turn off the lights, except that the code placed on the data bus will be different and will be recognized only by the appropriate receivers as an off code.

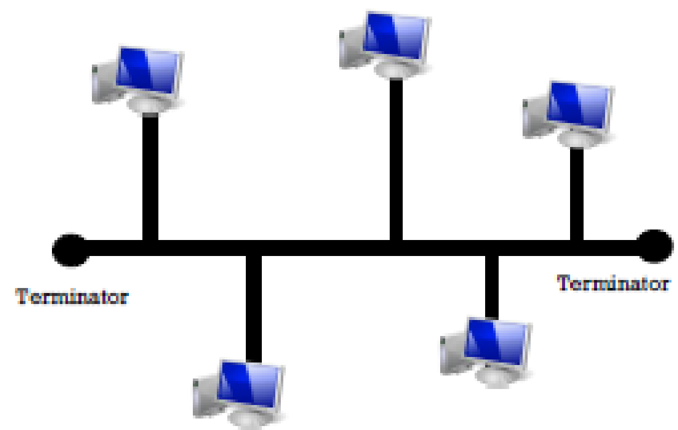
4.3.2 Multiplex data bus

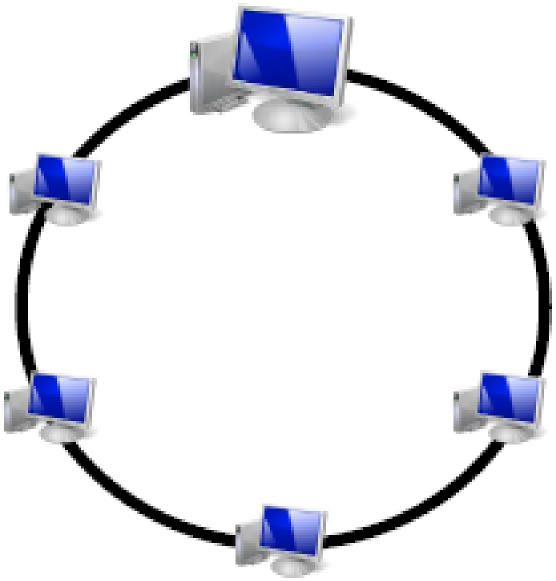
- In order to transmit different data on one line, a number of criteria must be carefully defined and agreed. This is known as the **communications protocol.**
- Some of the variables that must be defined are as follows:
  - Method of addressing.
  - Transmission sequence.
  - Control signals.
  - Error detection.
  - Error treatment.
  - Speed or rate of transmission.

- The physical layer must also be defined and agreed. This includes the following:
  - Transmission medium, e.g. copper wire, fibre optics etc.
  - Type of transmission coding, e.g. analogue or digital.
  - Type of signals, e.g. voltage, current or frequency etc.
- The circuit to meet these criteria is known as the bus interface and will often take the form of a single integrated circuit.
- This IC will, in some cases, have extra circuitry in the form of memory for example. It may, however, be appropriate for this chip to be as cheap as possible due to the large numbers required on a vehicle.
- As is general with any protocol system, it is hoped that one only will be used. This, however, is not always the case.

Bus Topology

- Costs very less and easy to extend
- Failure of one station not effects others
- If bus line fails then whole network fails



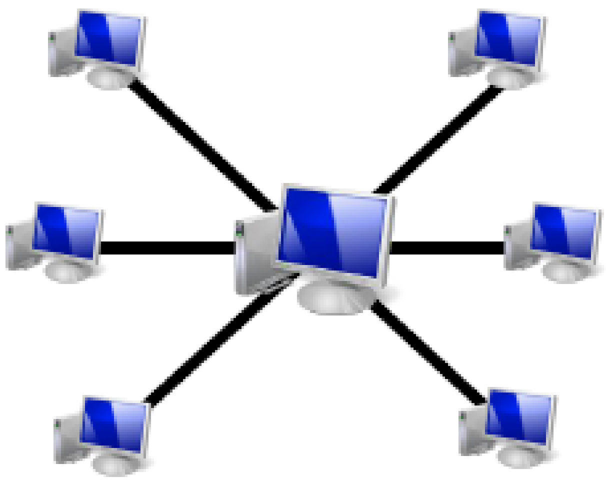


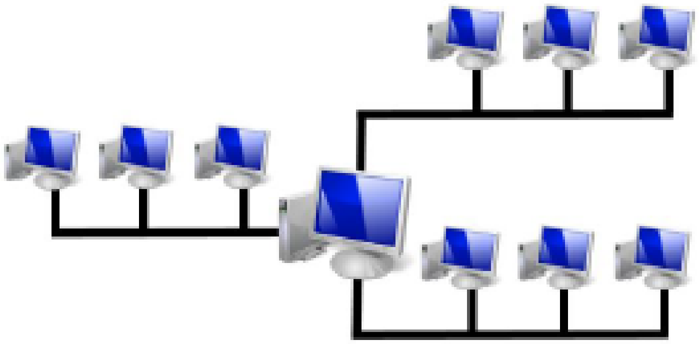
Ring Topology

- Its a closed loop connection
- Data transfers from one station to next either in clockwise or anti clock wise direction (uni-direction)
- Failure of a single node or cable breakdown the whole network

Star Topology

- When one device is failed or removed will not affect the other systems
- Easy to detect faults
- If the main hub fails then the whole network stopped





Hybrid Topology

- Combination of any two or more topologies
- Complex design
- More expensive - additional equipment

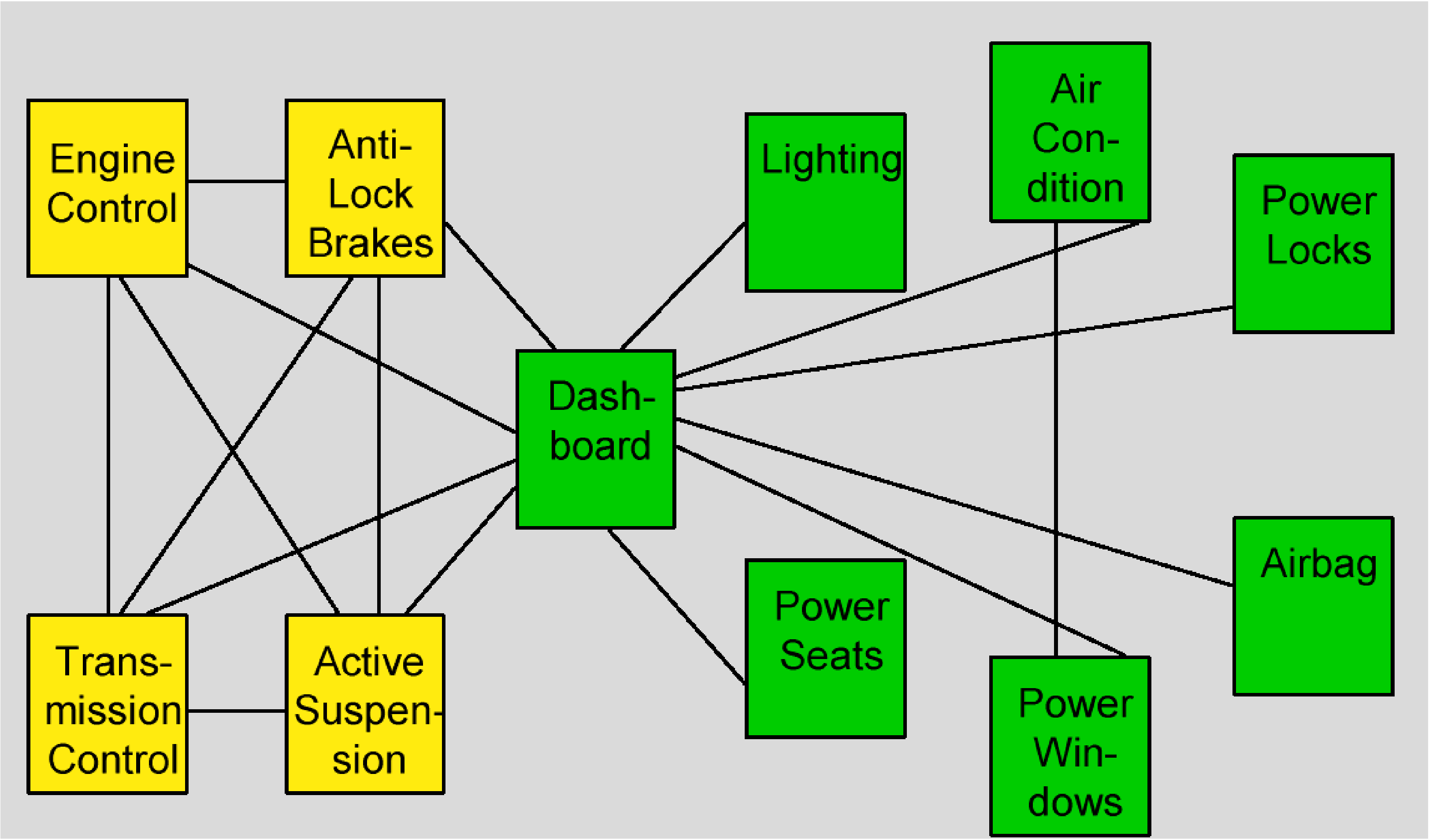
Types of Network	Class A	Class B	Class C	Class C+	Class D	Wireless
Example	**LIN** - Local Interconnected Network	Low Speed **CAN** (Controller Area Network)	High Speed **CAN** (Controller Area Network)	**Flex-Ray**	**MOST** – Media Oriented Systems Transport	**Bluetooth**
Topology	Linear Bus	Linear Bus	Linear Bus	Star-Bus Topology	Ring Topology	Star Topology
Data Transfer Rate	Max. 20 Kbps	10 Kbps -125 Kbps	125 Kbps – 1 Mbps	10 Mbps – 20 Mbps	25Mbps-100 Mbps	v2.0- 3Mbps v4.0- 25Mbps
Nodes	Max-16	Max-110	Max-64 to 110	Max-64	Max-64	8 Active (256 passive)
Bus Lines	Copper Conductor (Single Wire)	Copper Conductor (Twisted Pair)	Copper Conductor (Twisted Pair)	Copper Conductor (Twisted Pair)	Optical Fiber Cable	Electromagnetic Radio Waves
Applications	Low Cost applications, Comfort & Convenience Electronics	Body, Comfort & Convenience Electronics Networking	Engine Management, Transmission Control, fuel supply control unit	Fast reliable data transmission used in safety related area (ESP, Radar control unit)	Infotainment, audio and video information	Multimedia & infotainment

❖ Controller Area Network (CAN):

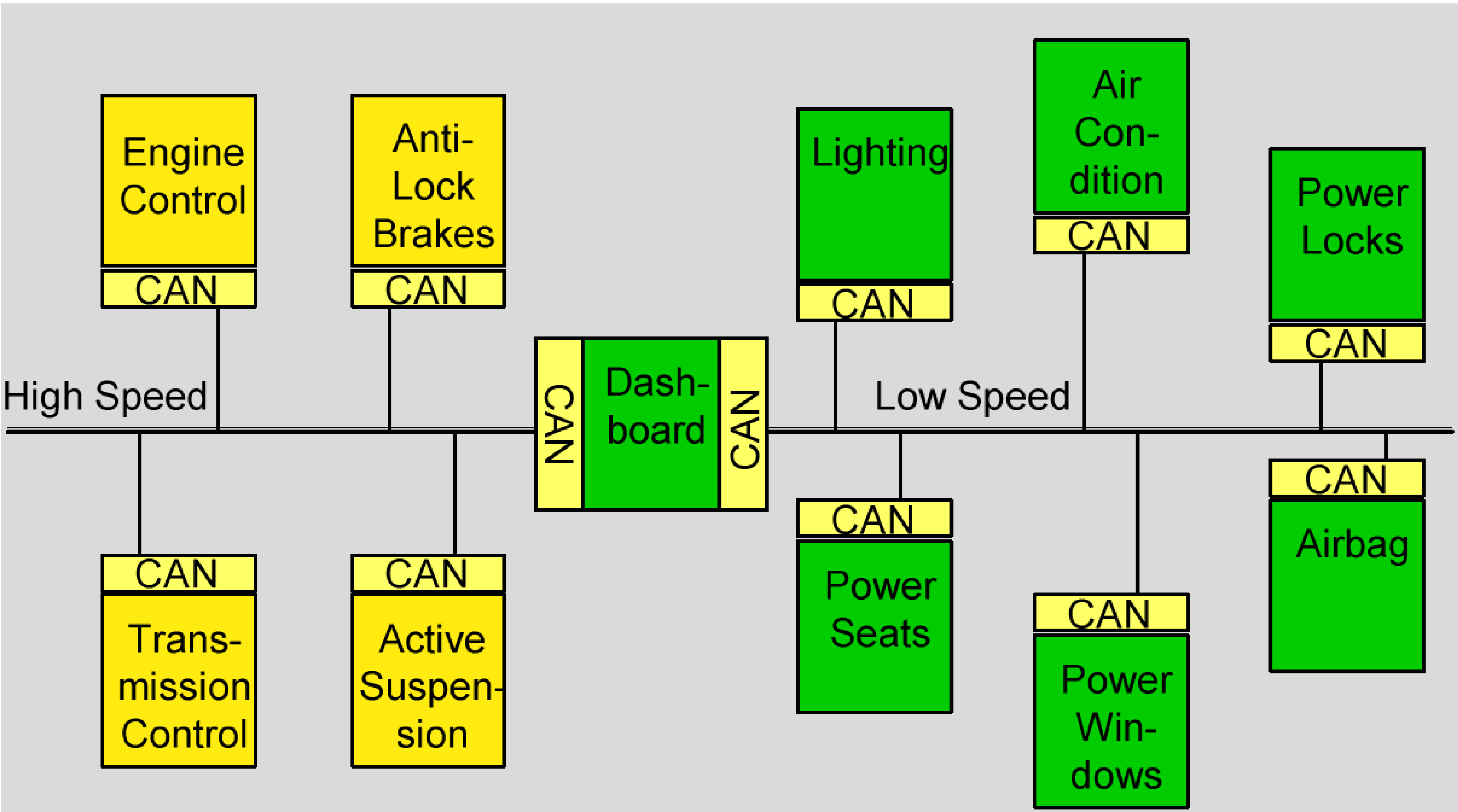
- Bosch has developed the protocol known as ‘CAN’ or Controller Area Network. This system is claimed to meet practically all requirements with a very small chip surface (easy to manufacture, therefore cheaper).
- CAN is suitable for transmitting data in the area of drive line components, chassis components and mobile communications. It is a compact system, which will make it practical for use in many areas.
- Two variations on the physical layer are available that suit different transmission rates. One is for data transmission of between 100 K and 1 M baud (bits per second), to be used for rapid control devices.
- The other will transmit between 10 K and 100 K baud as a low-speed bus for simple switching and control operations.

- CAN modules are manufactured by a number of semiconductor firms such as **Intel and Motorola**.
- A range of modules is available in either Voll- CAN for fast buses and basic-CAN for lower data rates. These are available in a stand-alone format or integrated into various microprocessors.
- All modules have the same CAN protocol. It is expected that this protocol will become standardized by the International Standards Organization (ISO).
- ISO standardized CAN in 1993 (ISO-11898 part 1,2 and 3)

❖ Before CAN


Engine Control
Anti-Lock Brakes
Lighting
Air Con-dition
Power Locks
Dash-board
Airbag
Power Seats
Trans-mission Control
Active Suspen-sion
Power Win-dows

❖ After CAN


Engine Control
CAN
Anti-Lock Brakes
CAN
Lighting
CAN
Air Con-dition
CAN
Power Locks
CAN
High Speed
CAN
Dash-board
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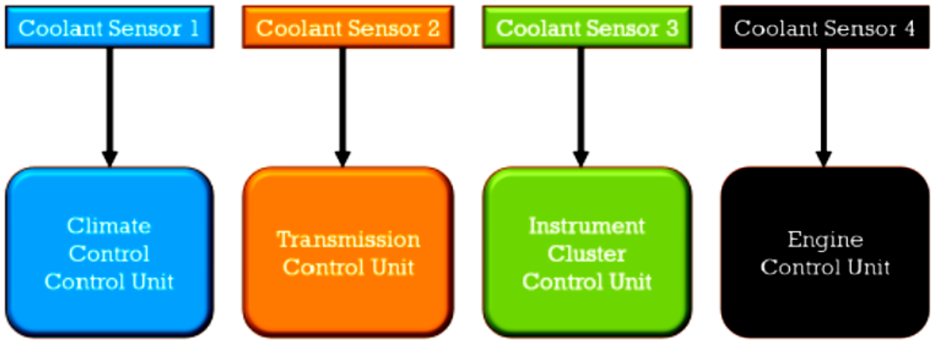
Power Seats
CAN
Power Win-dows
CAN
Airbag

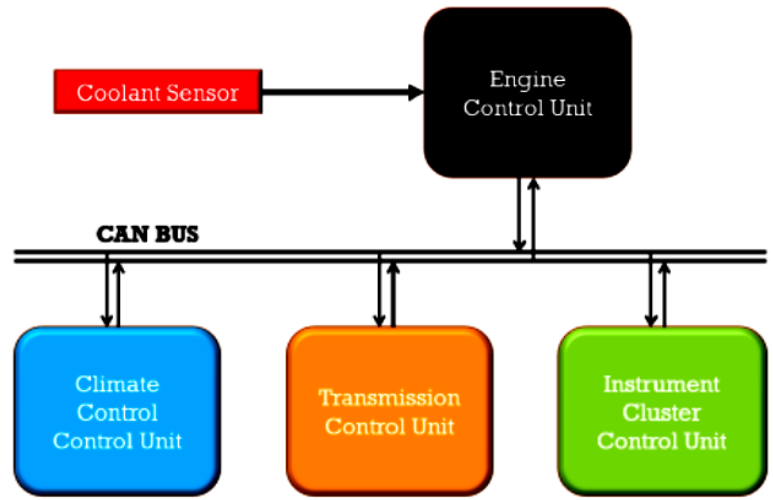


Without Networking

- All the CU are self contained.
- CU received data from individual dedicated sensors.
- More CUs resulted in sensor duplication.
- Different CUs required same inputs.

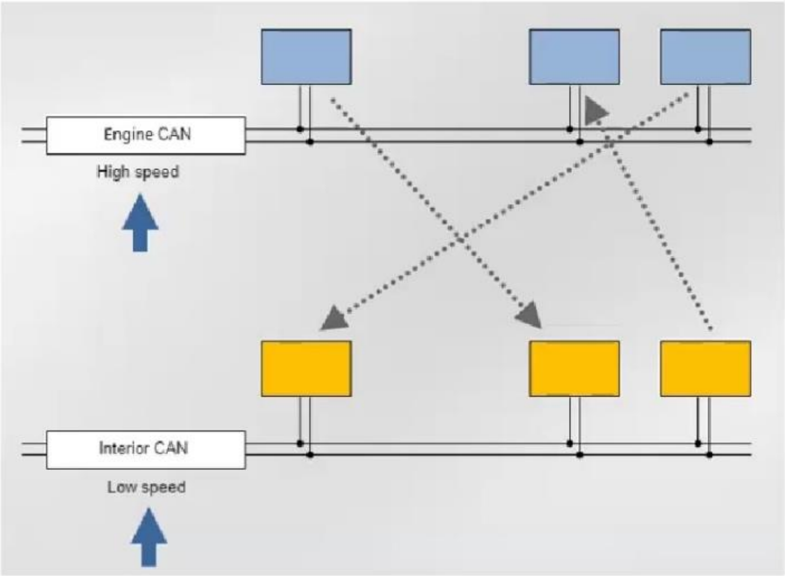
With Networking

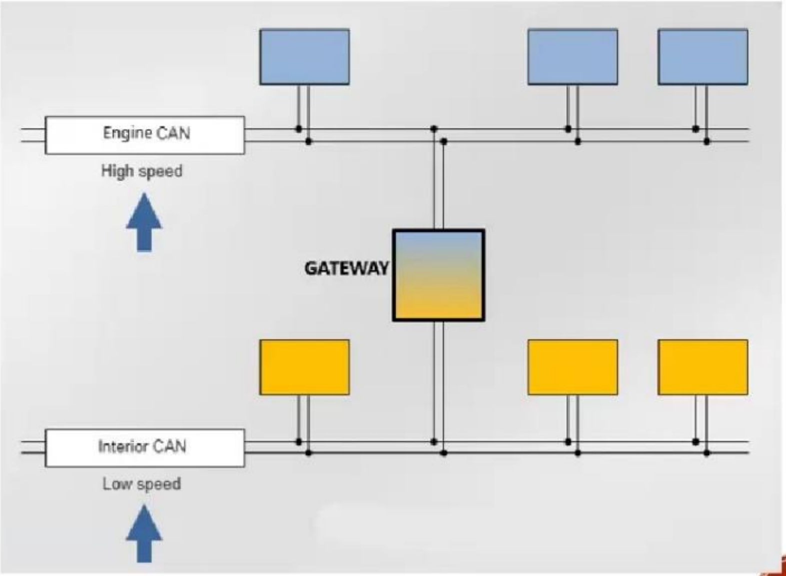
- Control units started interacting with each other in order to share data.
- A single input from sensor was able to be used by several control units.
- Eventually reducing complexity and components.

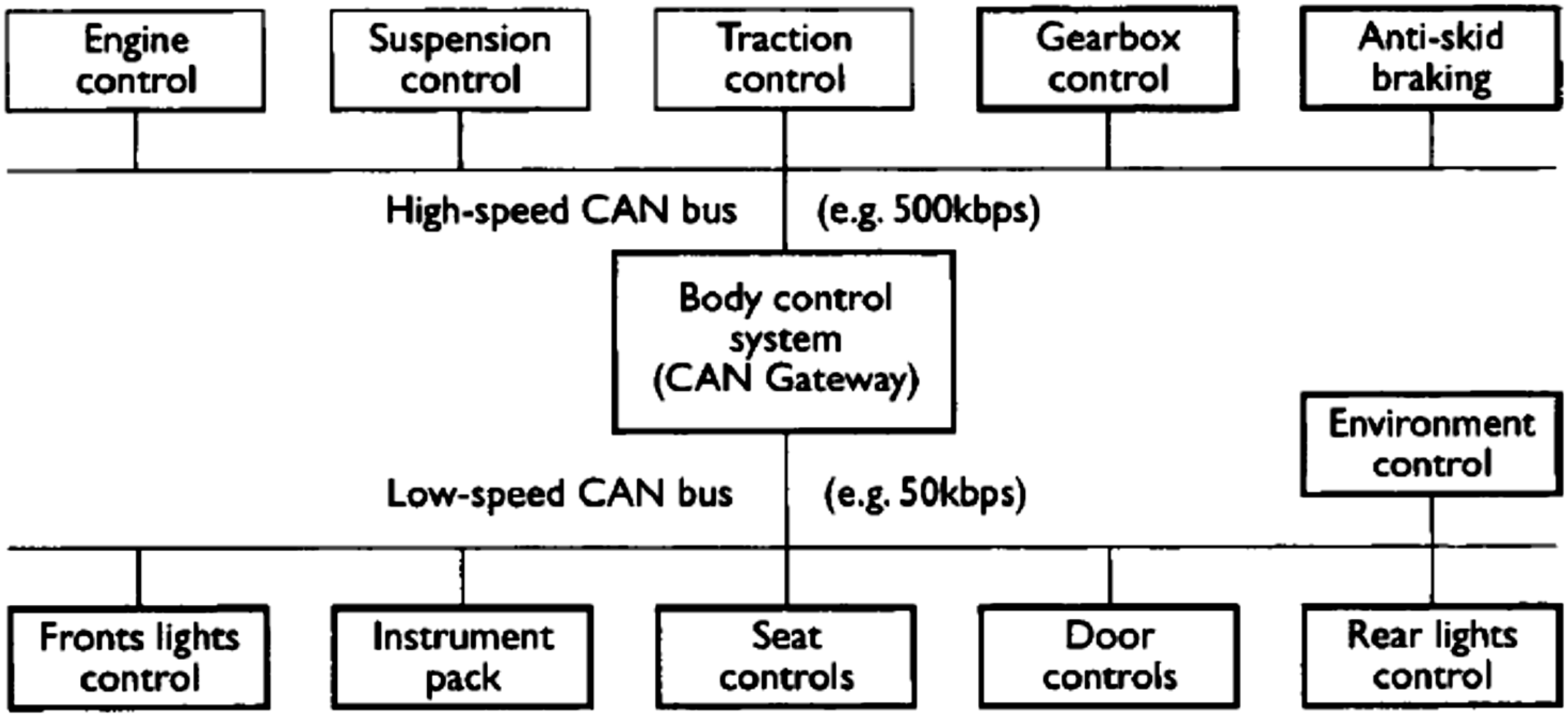


GATEWAY

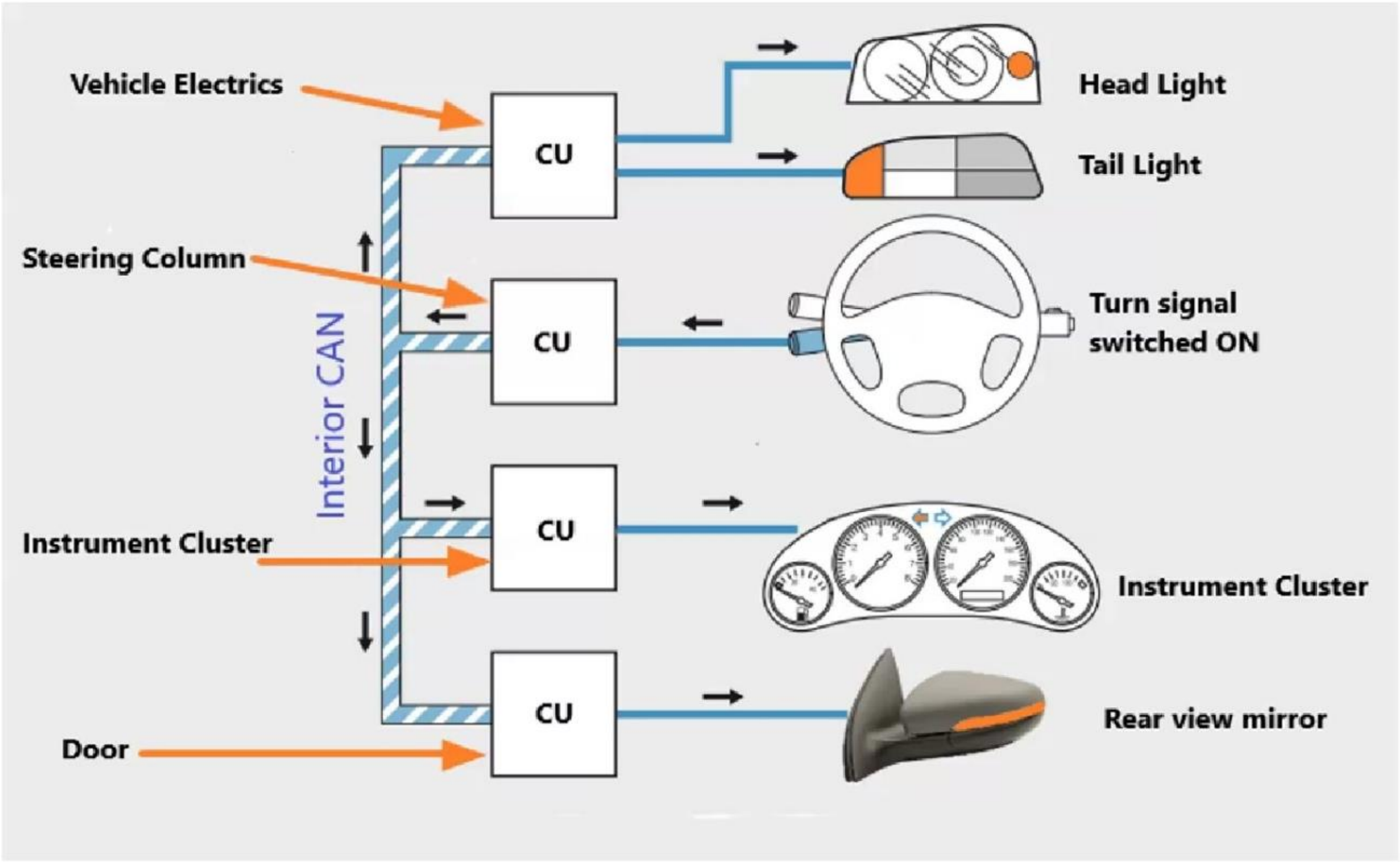
- A hub that securely and reliably interconnects and transfers data across many different networks.






Engine control
Suspension control
Traction control
Gearbox control
Anti-skid braking
High-speed CAN bus
(e.g. 500kbps)
Body control system (CAN Gateway)
Environment control
Low-speed CAN bus
(e.g. 50kbps)
Fronts lights control
Instrument pack
Seat controls
Door controls
Rear lights control

Communication Example – Turn Signal



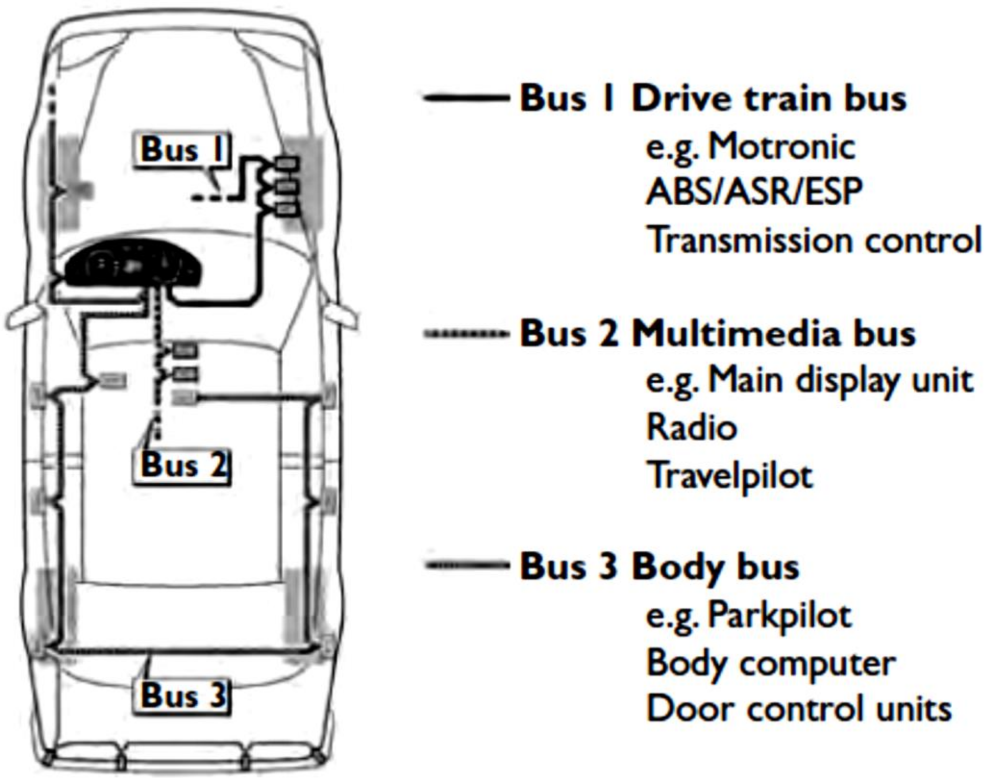
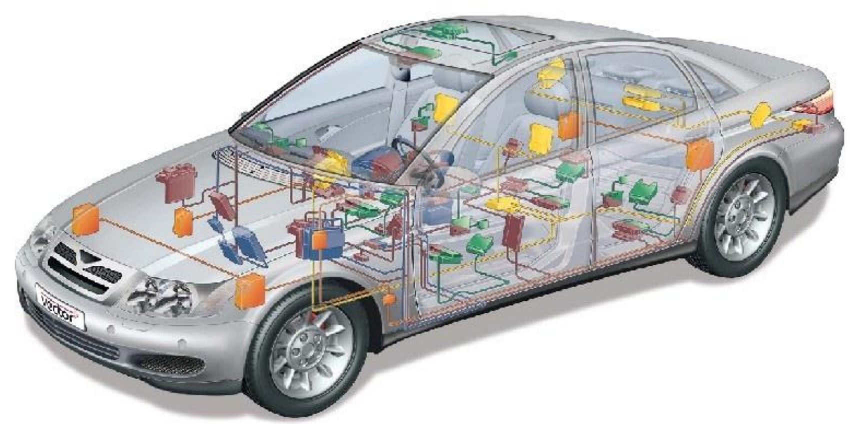
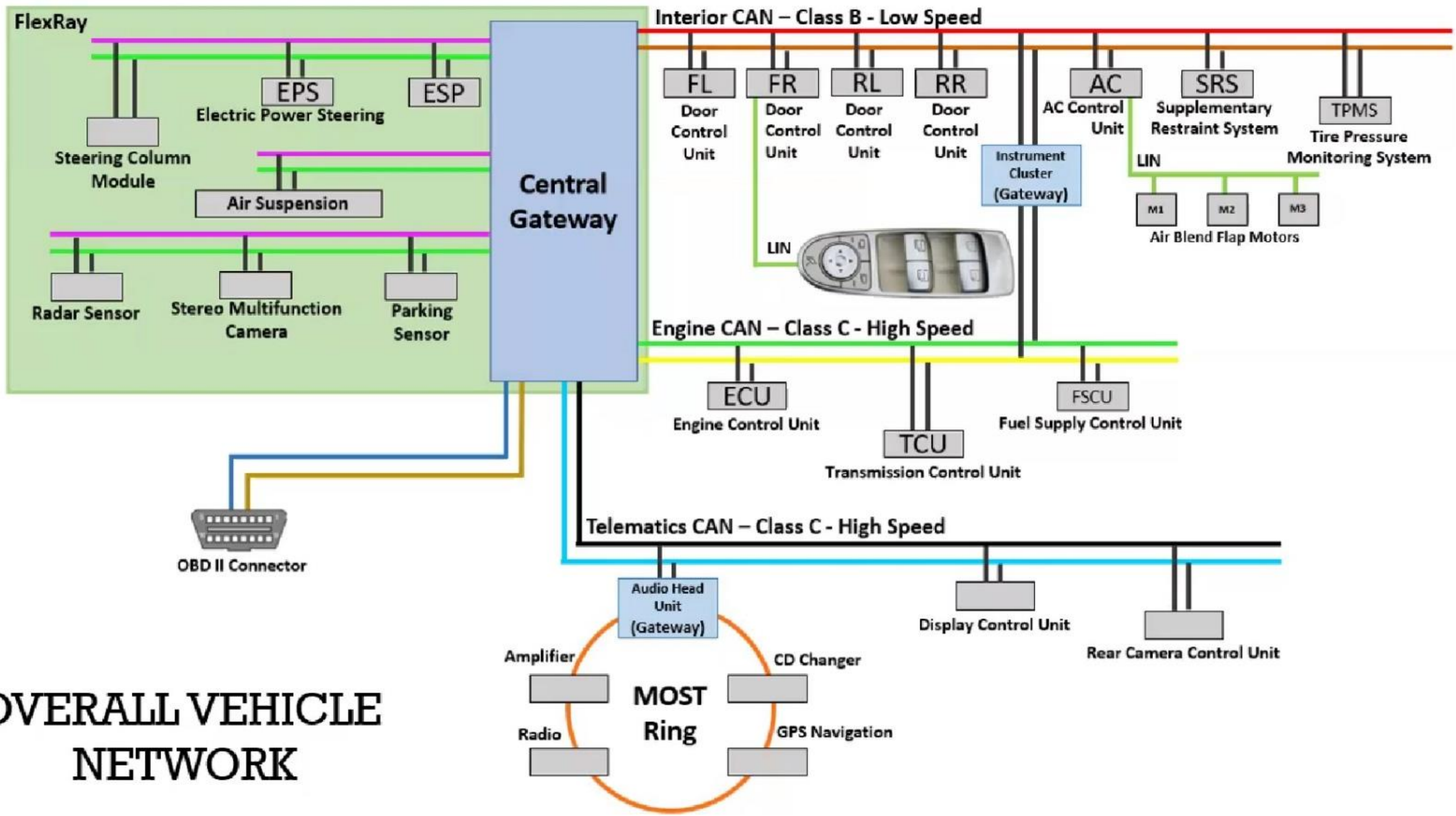


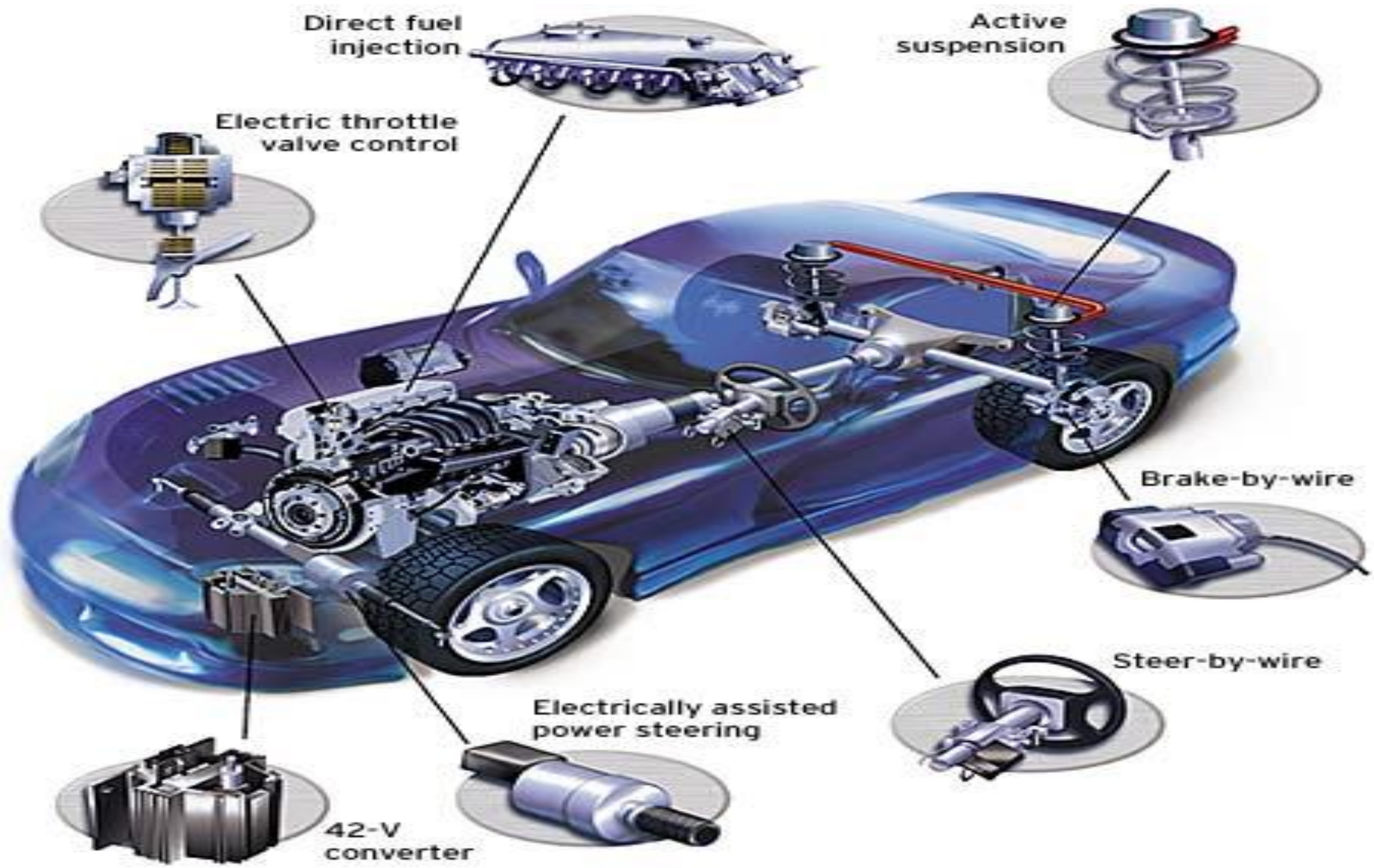
Figure 4.21 CAN (Controller Area Network) instrument cluster (Source: Bosch Press)





OVERALL VEHICLE NETWORK

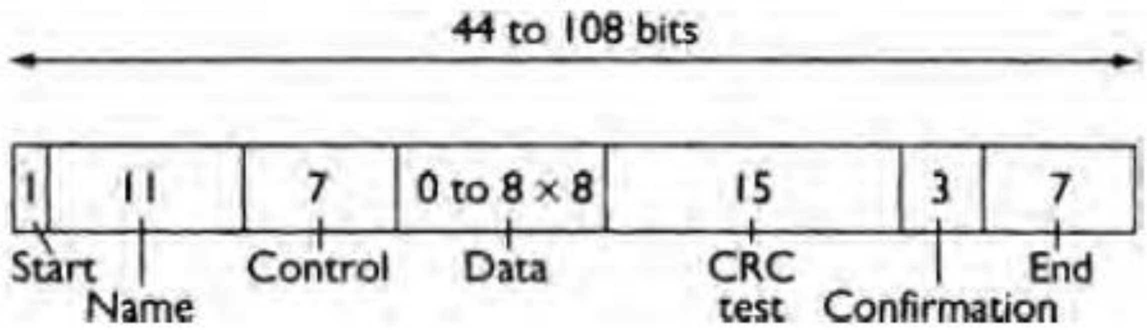
Applications:



❖ Applications:

- Automotive
- Military vehicles
- Industrial machinery
- Medical systems
- Agricultural machinery
- Marine control and navigation
- Elevator control systems

Data Information Format



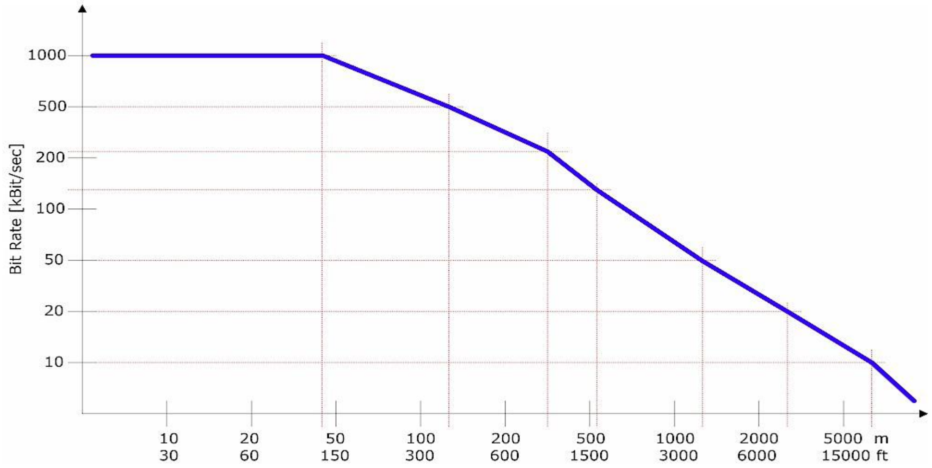
- The CAN message signal consists of a sequence of binary digits (bits).
- A voltage (or light in fiber optics) being present indicates the value ‘1’ while none present indicates ‘0’.
- The actual message can vary between 44 and 108 bits in length.

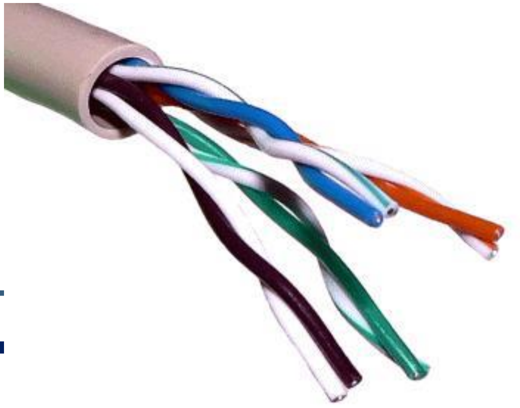
- This is made up of a start bit, name, control bits, the data itself, a cyclic redundancy check (CRC) for error detection, a confirmation signal and finally a number of stop bits
- The name portion of the signal identifies the message destination and also its priority.
- As the transmitter puts a message on the bus it also reads the name back from the bus.
- If the name is not the same as the one it sent then another transmitter must be in operation that has a higher priority.

- If this is the case it will stop transmission of its own message. This is very important in the case of motor vehicle data transmission.
- Errors in a message are recognized by the cyclic redundancy check.
- This is achieved by assembling all the numbers in a message into a complex algorithm and this number is also sent.
- The receiver uses the same algorithm and checks that the two numbers tally.
- If an error is recognized the message on the bus is destroyed.
- This is recognized by the transmitter, which then sends the message again.
- This technique, when combined with additional tests, makes it possible for no faulty messages to be transmitted without being discovered.

- Twisted Pair Cables are used to get higher speeds.
- The Bit rate of the data transformation is high for short distance and low for long distance.

Bus length in meters	Signal rate in Mbps
40	1
100	0.5
500	0.10
1000	0.05





LIN APPLICATION

- Steering Wheel: Cruise Control, Wiper, Turning Light, Climate Control, Radio
- Roof: Rain Sensor, Light Sensor, Light Control, Sun Roof
- Engine / Climate: Sensors, Small Motors, Control Panel (Climate)
- Door / Seat: Mirror, Central ECU, Mirror Switch, Window Lift, Door Lock, Seat Position Motors, Occupant Sensors, Seat Control Panel

FLEX RAY

- Flex Ray is a deterministic and error-tolerant high-speed bus, which meets the demands for future safety-relevant high-speed automotive networks.
- Its data rate of up to 10 Mbit/s.
- Transmit data in synchronous and asynchronous modes
- Static Time Division Multiple Access (TDMA) with constant time slot periods & Flexible TDMA is used to arbitrate transmissions
- It was first deployed in BMW X5 cars in 2006.
- **ISO 17458**

Typical Flex Ray Applications

- Wheel Node: Fail-Safe, Low to Medium Performance (S12XF Family MCU)
- Body Control Module (BCM): High Performance, Low Power (MPC5510 Family MCU)
- X-by-Wire Master: Highest Level of Fault Tolerance (MPC5560 Family MCU)

MOST

- The ISO/OSI standardized MOST (Media Oriented System Transport) serial high-speed bus became the basis for present and future automotive multimedia networks for transmitting audio, video, voice, and control data via fiber optic cables.
- Static and dynamic time segments for the synchronous (up to 24 Mbit/s) and asynchronous (up to 14 Mbit/s) data transmission, as well as a small control channel..
- It can theoretically include up to 64 devices.
- Access control during synchronous and asynchronous transmission is realized via TDM (Time Division Multiplex) CSMA/CA respectively.

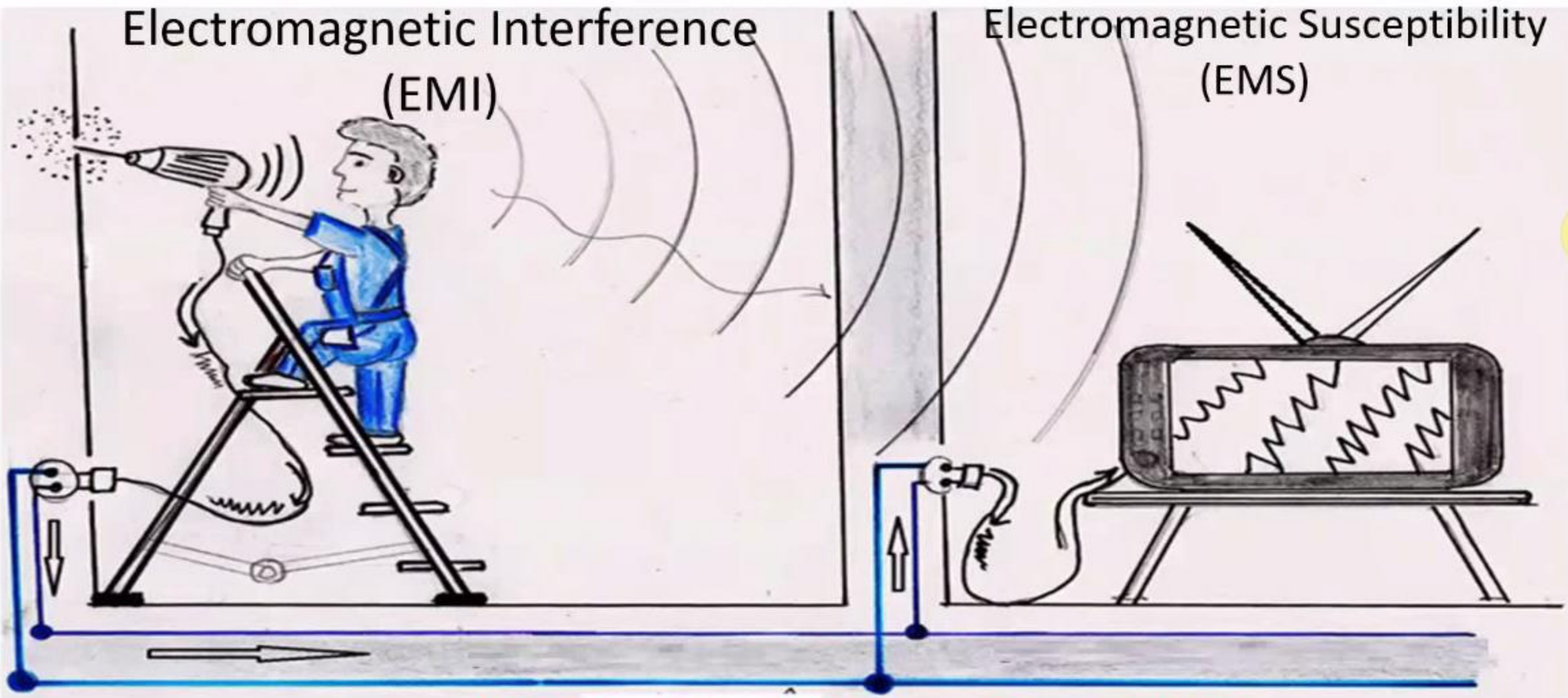
PROPERTIES OF AUTOMOTIVE BUS

Bus	LIN	CAN	FlexRay
Adapted for	Low-level subnets	Soft real-time	Hard real-time
Target application examples	Door locking Climate regulation Power windows Light, rain sensor	Antilock break system Driving assistants Engine control Electronic gear box	Break-by-wire Steer-by-wire Shift-by-wire Emergency systems
Architecture	Single-master	Multi-master	Multi-master
Access control	Polling	CSMA/CA	TDMA FTDMA
Transfer mode	Synchronous	Asynchronous	Synchronous Asynchronous
Data rate	20 kbit/s	1 Mbit/s	10 Mbit/s
Redundancy	None	None	2 Channels
Error protection	Checksum Parity bits	CRC Parity bits	CRC Bus Guardian
Physical layer	Single-wire	Dual-wire	Dual-wire, Optical fiber
Security	None	None	None

- **Electromagnetic Compatibility (EMC)**
- **Definition**: The ability of a device or system to function without error in its intended electromagnetic environment.
- **Electromagnetic Interference (EMI)**
- **Definition:** Electromagnetic emissions from a device or system that interfere with the normal operation of another device or system.
- **Examples**:
- A Computer interferes with FM radio reception
- A Car radio buzzes when you drive under a power line
- A car misfires when you drive under a power line
- A helicopter goes out of control when it flies too close to radio tower.
- The airport radar interferes with a laptop computer display.

Electromagnetic Compatibility Testing

What is EMI/EMC?

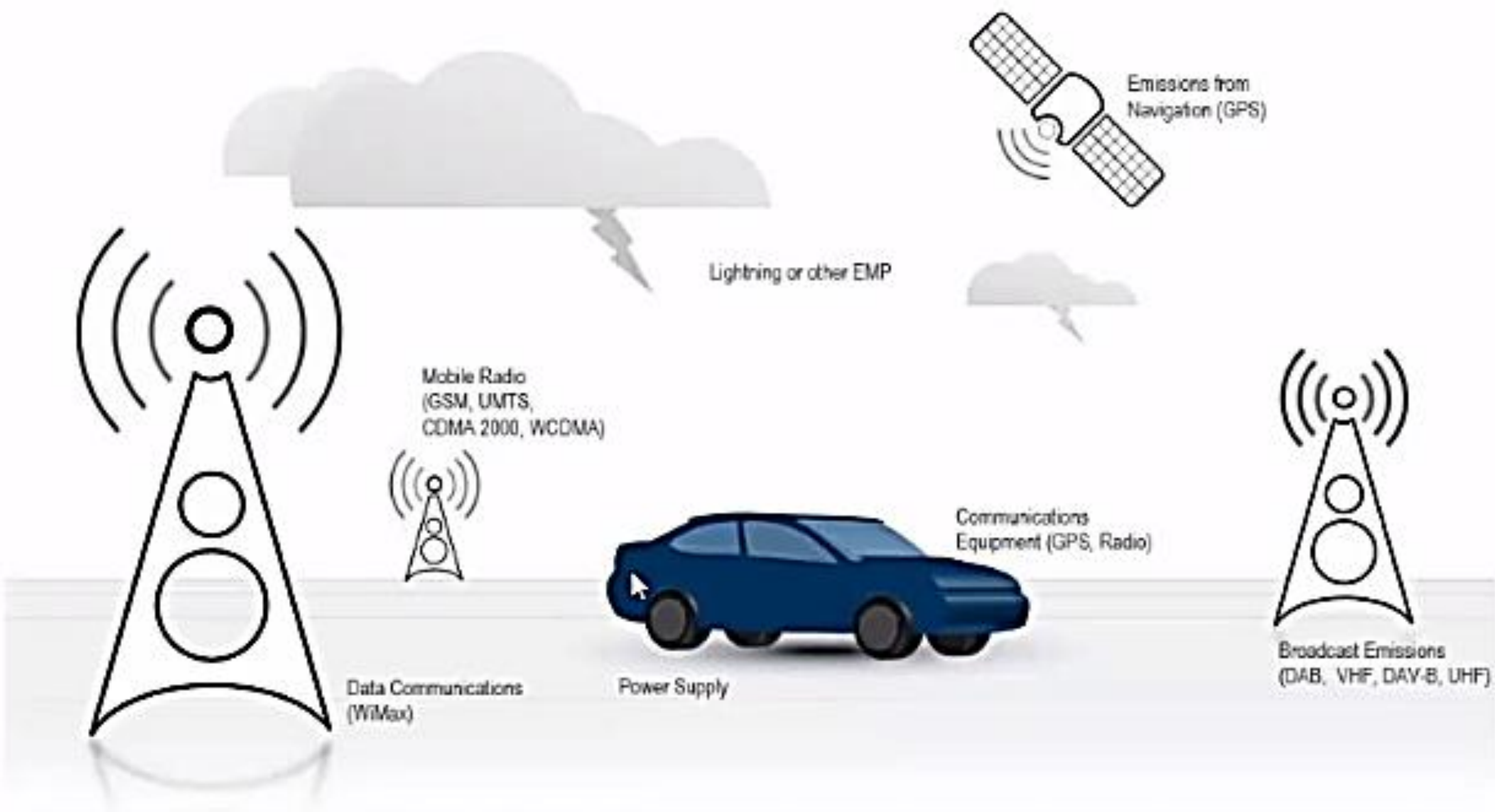


EMC=No EMI + No EMS

Source- EMC Engineers

3

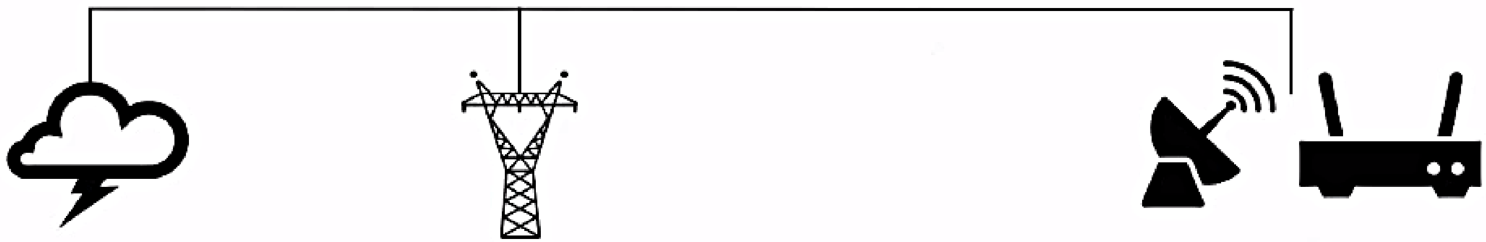
IMPORTANCE OF EMC
Outdoor Environment



Source- Rhode & Schwarz

Electromagnetic Compatibility Testing

Basic Terminology: Sources of EMI



Natural Radiators

- Lightning and other violent electrostatic discharges
- Intense solar magnetic storms
- Particulate weather events, like flares, dust and snow storms

Unintentional Radiators

- Power lines and transformers
- Electrical sparks of any kind
- Breakers & Power Strips
- Consumer Electronics,
- DC motors, specially brush types
- Arc welders, Bunched power cables
- Sub/railway switches and contacts
- X-rays/MRIs
- Intense solar magnetic storms
- Particulate weather events, like flares, dust and snow storms
- Manmade lightning, Fluorescent fixtures

Intentional Radiators

Licensed

- Digital/Analog TVs
- FM/AM Radios
- Cellular Services
- Broadband Services
- Landmobiles
- Amatuer radios
- Telemetry services

Unlicensed

- WiFI devices
- Bluetooth devices
- ZigBee devices
- Cordless phones
- Baby monitors
- Hobbyist radios
- RFID readers
- Intercoms
- Remote controls

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Source- EMC Engineers

Elements of EMC Problems:

There are three essential elements to any EMC Problem:

1. Source of an electromagnetic Phenomenon
2. Reception (or victim) that cannot function properly due to the electromagnetic phenomenon.
3. Path between them that allows the source to interfere with the receptor (or victim).

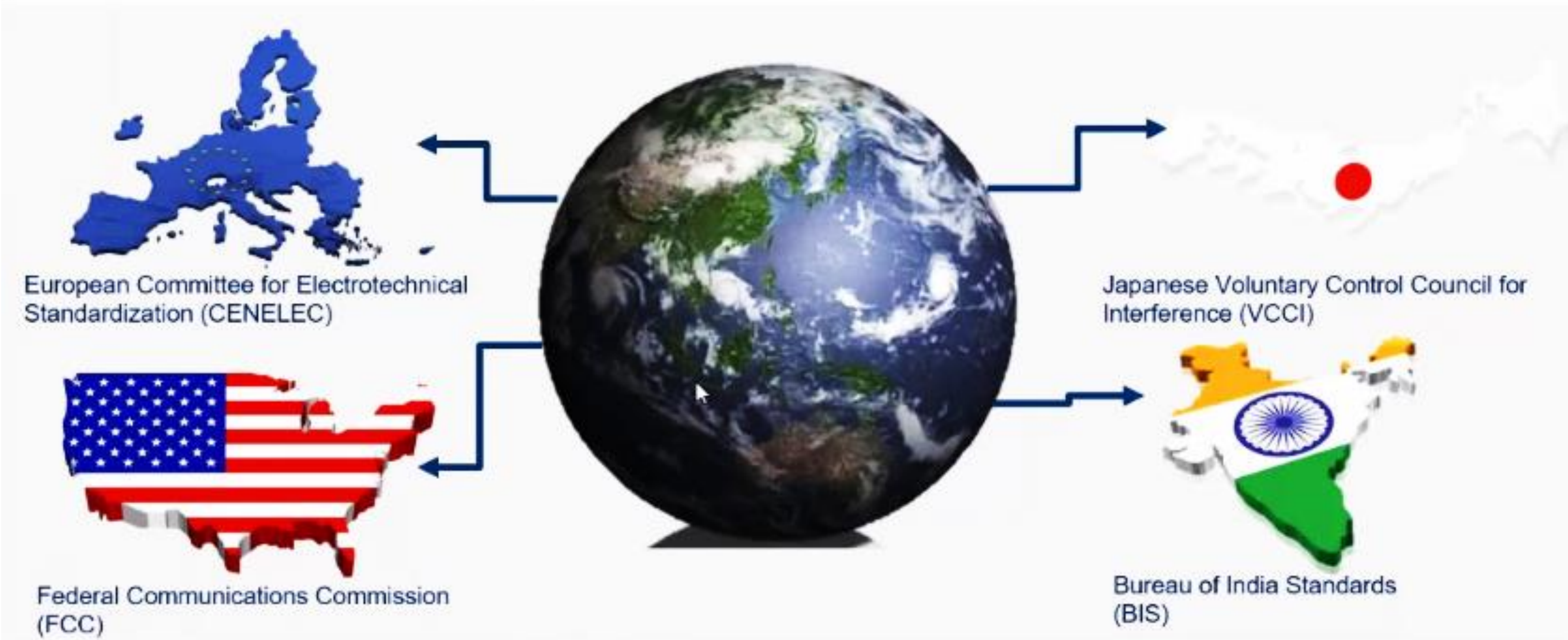
- Each of these three elements must be present although they may not be readily identified in every situation.
- Identifying at least two of these elements and eliminating (or attenuating) one of them generally solves EMC problem.

- For example, suppose it was determined that radiated emissions from mobile telephone were inducing currents on a cable that was connected to an ECU controlling ABS system.
- If this is adversely affected the operation of the circuit a possible coupling path could be identified.
- Shielding, filtering or re-routing of the cable may be the answer.
- If necessary filtering or redesigning the circuit would be further possible methods of attenuating the coupling path to the point where problem is non- existent.
- Potential sources of EMC problems include radio transmitters, power lines, electronic circuits, lightening, lamp dimmers, electric motors, arc welding, solar flares and just about anything that can utilize or can detect electromagnetic energy.

- Methods of Coupling electromagnetic energy from a source to a receptor fall into one of the following categories.
  - Conducted (Electric Current)
  - Inducting Coupled (Magnetic Field)
  - Capacitive Coupled (Electric Field)
  - Radiated (Electromagnetic Field)
- Coupling paths often utilize a complex combination of these methods making the path difficult to identify even when the source and receptor are known.
- There may be multiple coupling paths & steps taken to attenuate one path may enhance another.
- EMC therefore is a serious issue for the vehicle designer.

STANDARDS

International Organization for Standardization (ISO)	International Electrotechnical Commission (IEC)	Comité International Spécial des Perturbations Radio (CISPR)



Source- Rhode & Schwarz

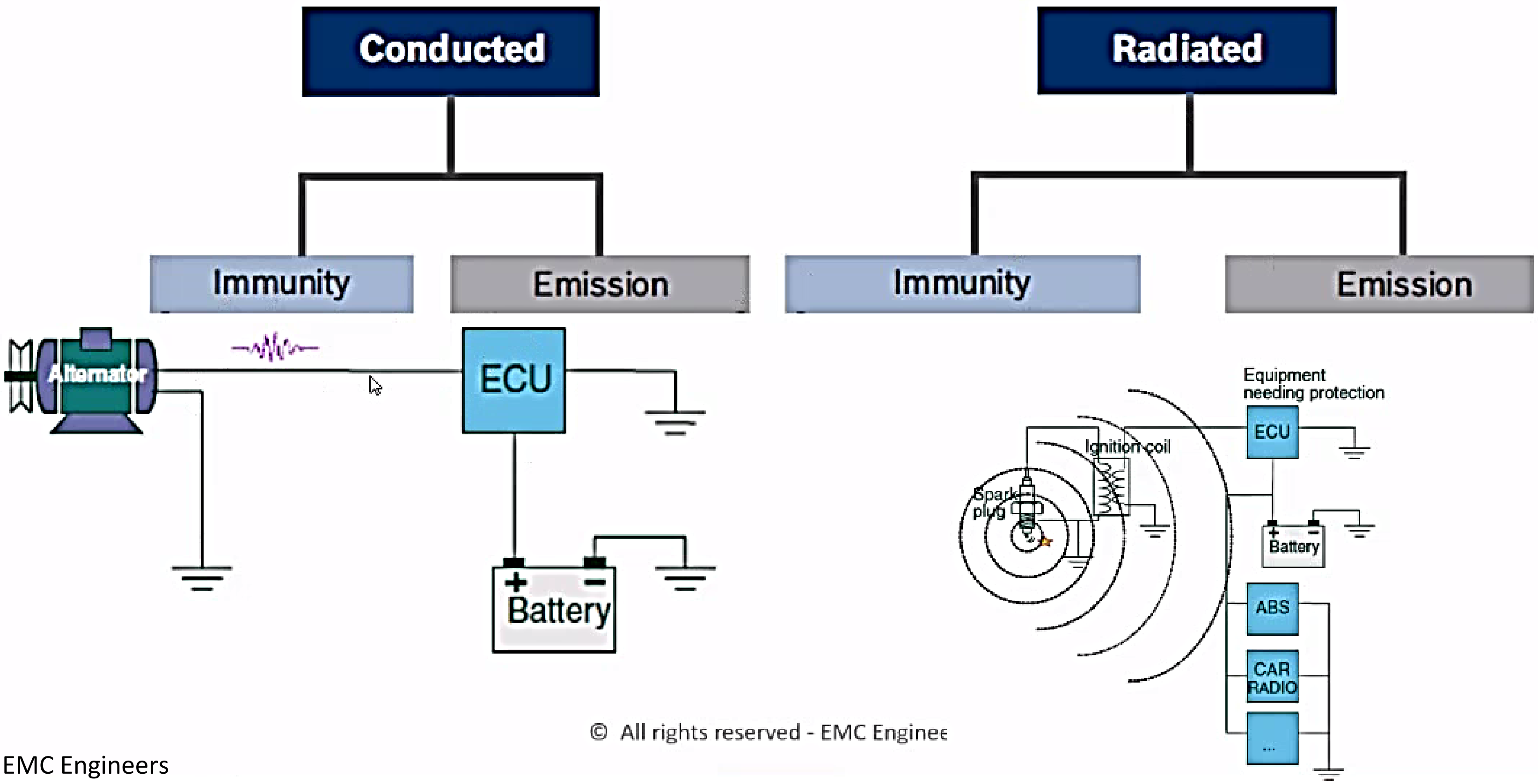
STANDARD OVERVIEW

International	Manufacturer	Europe	India
CISPR 12 VEHICLE EMI	GM 3097 ESA EMC	2004/104/EEC VEHICLE & ESA EMC	AIS004 VEHICLE & ESA EMC
ISO 11451 VEHICLE EMS	BMW GS95002 VEHICLE & ESA EMC	ECE R10 VEHICLE & ESA EMC	
ISO 10605 VEHICLE & ESA ESD	VW-TL ESA EMC		
CISPR 25 ESA EMI	FORD EMC ESA EMC		
ISO 11452 ESA EMS	⋮		
ISO 7637 Conducted Pulse	FLAT 9.90110 VEHICLE & ESA EMC		

SAE India Seminar July 2021

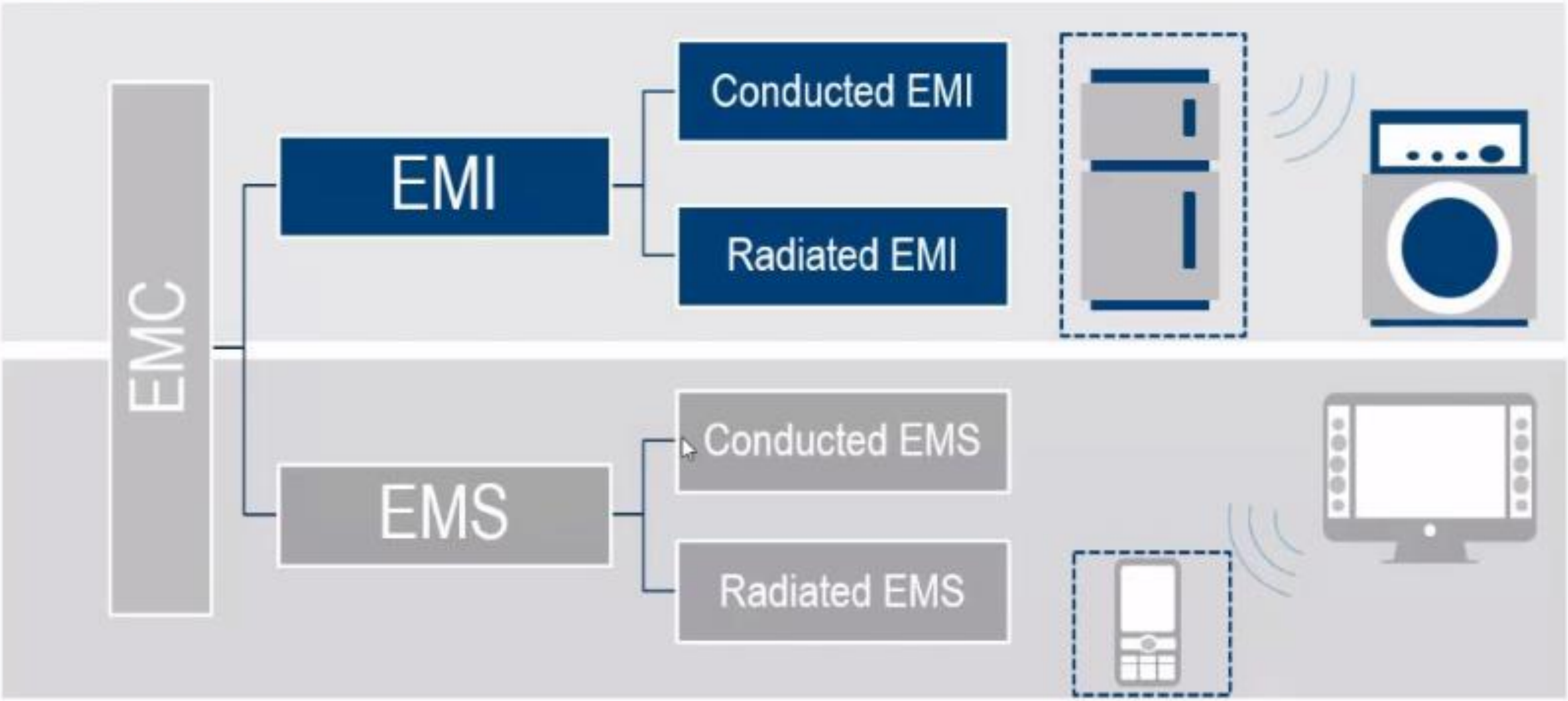
Source- Rhode & Schwarz

Electromagnetic Compatibility Testing



Source- EMC Engineers

WHAT IS EMC?



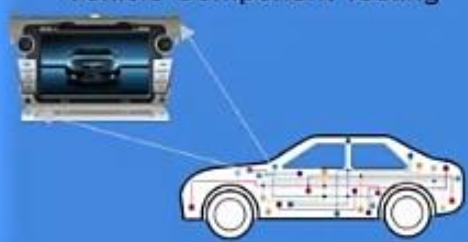
Source- Rhode & Schwarz

Automotive EMC

STANDARDS OVERVIEW

EMC Standards

Vehicle Component Testing



CISPR 25	Limits and Methods of Measurement of radio disturbance characteristics for the protection of receivers used on board vehicles
ISO11452-X	Component electrical disturbances from narrowband radiated electromagnetic energy

Full vehicle testing

CISPR 12	Limits and methods of measurement for the protection of off-board receivers (Vehicles, boats and internal combustion engines)
ISO11451-X	Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy

Source- Rhode & Schwarz

STANDARDS OVERVIEW

Emission Standards

Vehicle Component Testing

CISPR 25	Limits and Methods of Measurement of radio disturbance characteristics for the protection of receivers used on board vehicles
CISPR 12	Limits and methods of measurement for the protection of off-board receivers (Vehicles, boats and internal combustion engines)

Full vehicle testing

Source- Rhode & Schwarz

STANDARDS OVERVIEW

Immunity Standards

Vehicle Component Testing

ISO11452-X — Component electrical disturbances from narrowband radiated electromagnetic energy

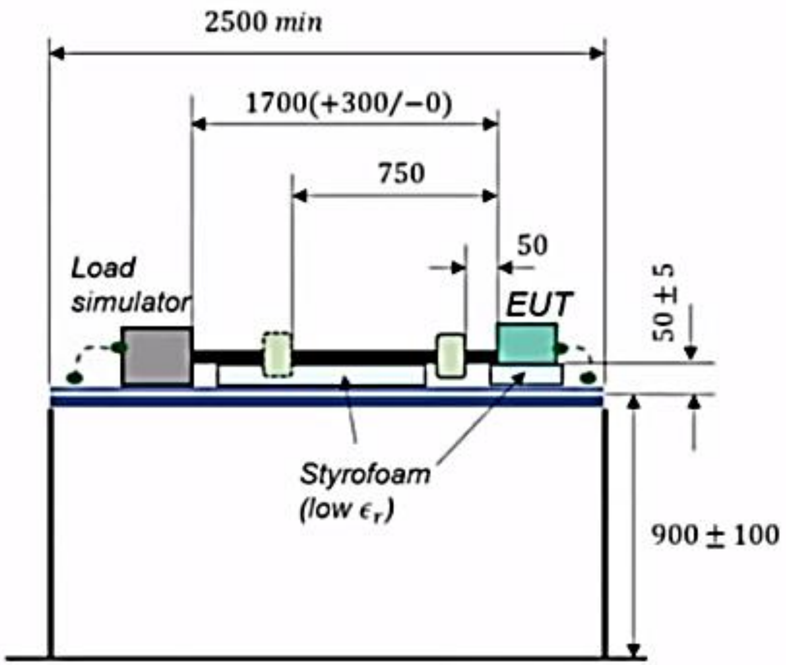
Full vehicle testing

ISO11451-X — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy

Source- Rhode & Schwarz

Electromagnetic Compatibility Testing

Conducted Emission Current probe method



Source- EMC Engineers

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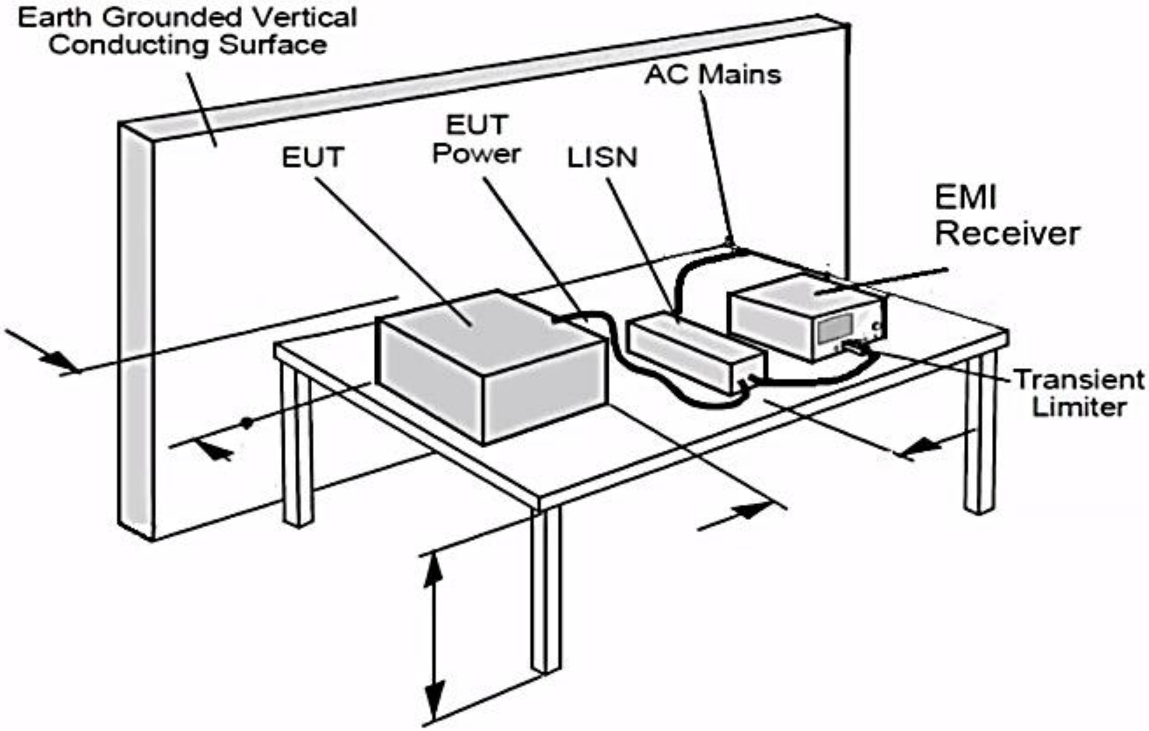
Electromagnetic Compatibility Testing

Conducted Emission Voltage method



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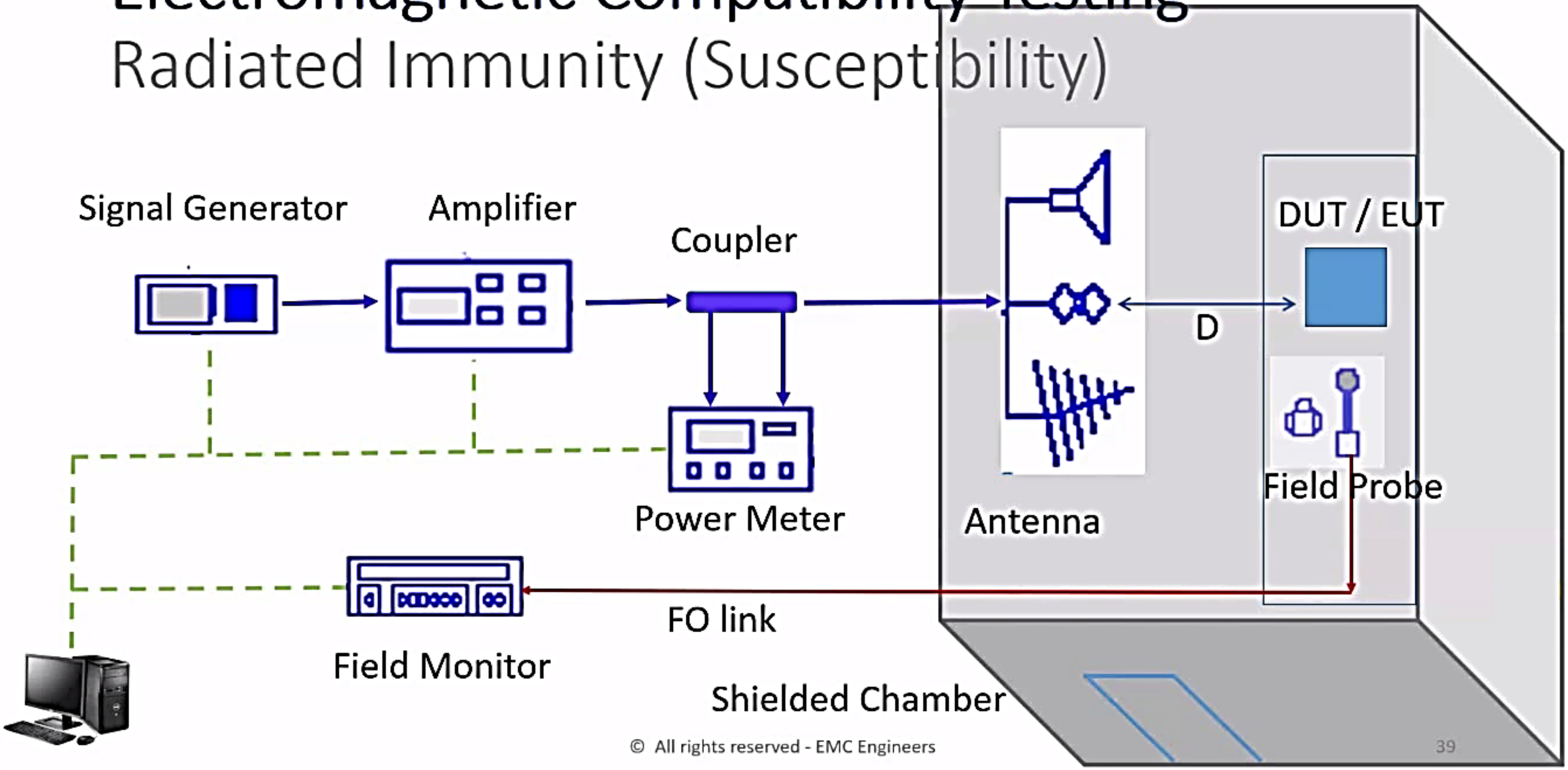
Source- EMC Engineers

Electromagnetic Compatibility Testing

Radiated Immunity (Susceptibility)



Source- EMC Engineers

Electromagnetic Compatibility Testing

Transients

Transient	Voltage	Current	Rise Time	Pulse Width	Pulse Energy
ESD	4–8 kV	1–10s A	1 ns	60 ns	1–10s mJ
EFT	0.5–2 kV	10s A	5 ns	50 ns	4 mJ
EFT (Burst)	0.5–2 kV	10s A	5 ns	15 ms	100s mJ
Surge	0.5–2 kV	100s A	1.25 ms	50 ms	10–80 J

ESD - Electrostatic Discharge

Process of ESD Generation	20% Humidity	80% Humidity
Walking across carpet	35 kV	1.5 kV
Walking on vinyl floor	12 kV	250 V
Worker moving at bench	6 kV	100 V
Picking up common polyethylene bag	20 kV	1.5 kV

Source- EMC Engineers

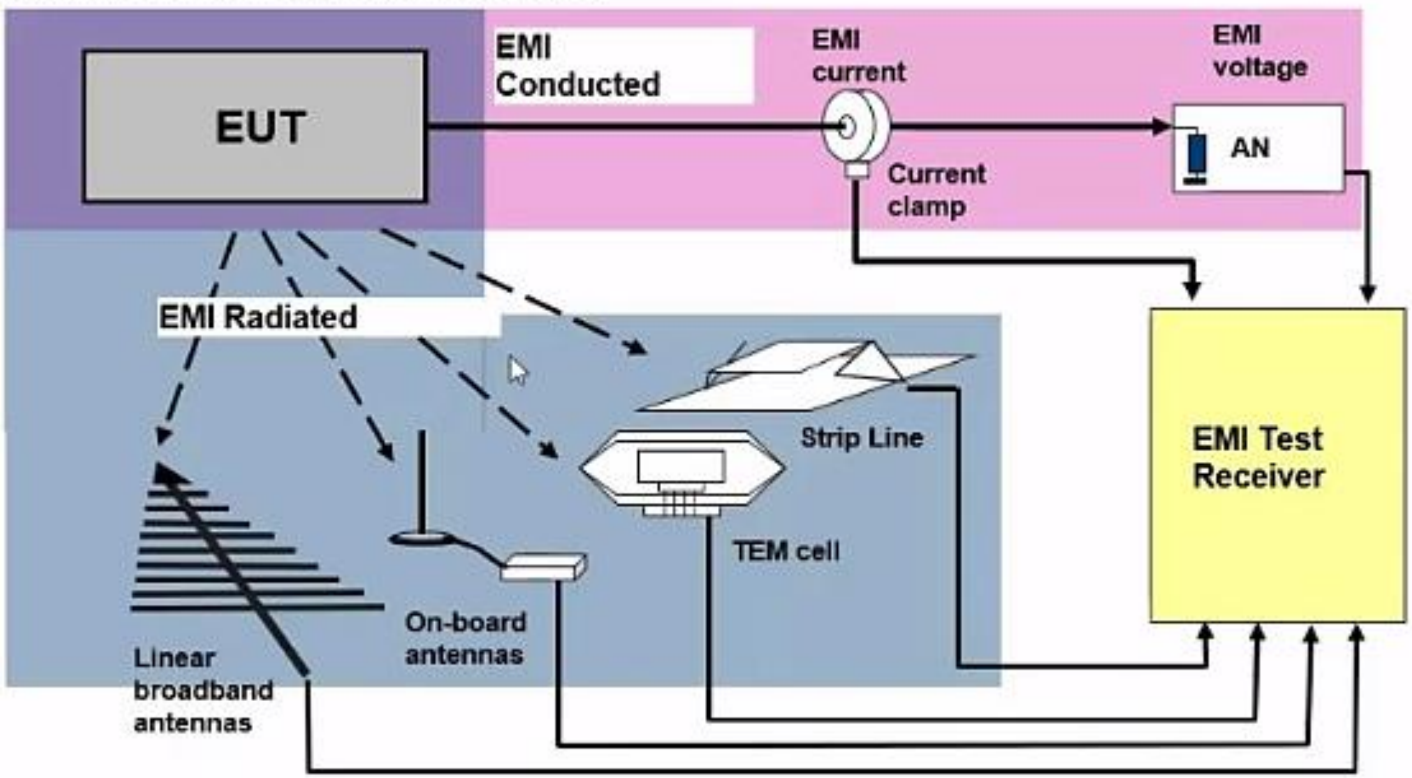
TESTS IN AUTOMOTIVE EMC

ECE R10 REV.6 (UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE – REGULATION NO. 10)

Source- Rhode & Schwarz

CISPR 25 AUTOMOTIVE COMPONENT EMI

Limits and **Methods** of Measurement of radio disturbance characteristics for the protection of receivers used on board vehicles



Source- Rhode & Schwarz

CISPR 25: SUMMARY OF TESTS

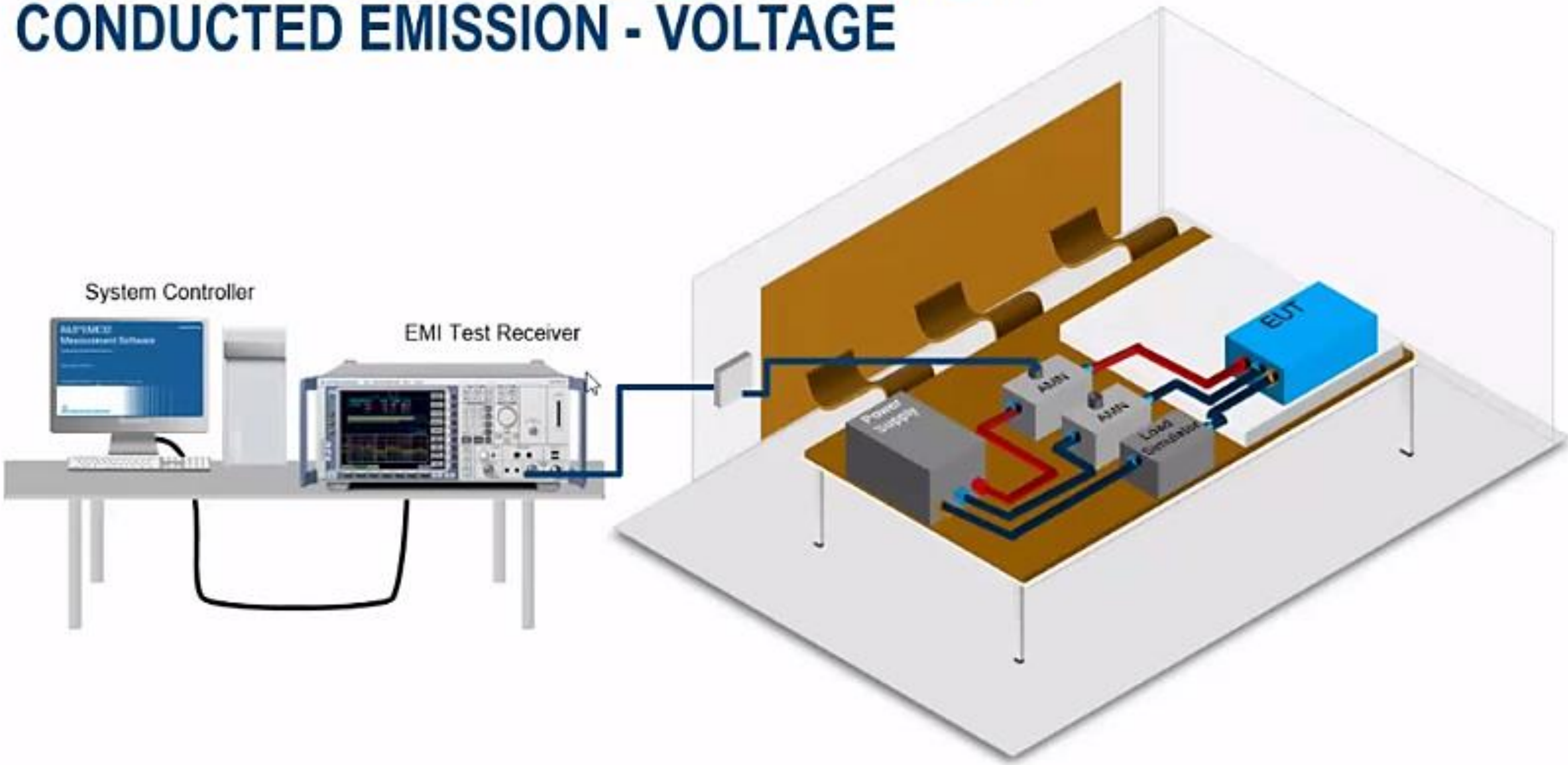
Measurement Procedure	Transducer	Frequency Range	Applicable
Conducted Emission	LISN	150 kHz to 108 MHz	ESA
	Current Probe	150 kHz to 245 MHz	ESA
Radiated Emission	ALSE (Antenna)	150 kHz to 2.5 GHz	ESA
	TEM Cell Method	150 kHz to 2.5 GHz	ESA
	Stripline Method	150 kHz to 2.5 GHz	ESA
	On-board antennas	150 kHz to 2.5 GHz	Vehicle

Source- Rhode & Schwarz

ESA- Electrical/electronic sub-assembly

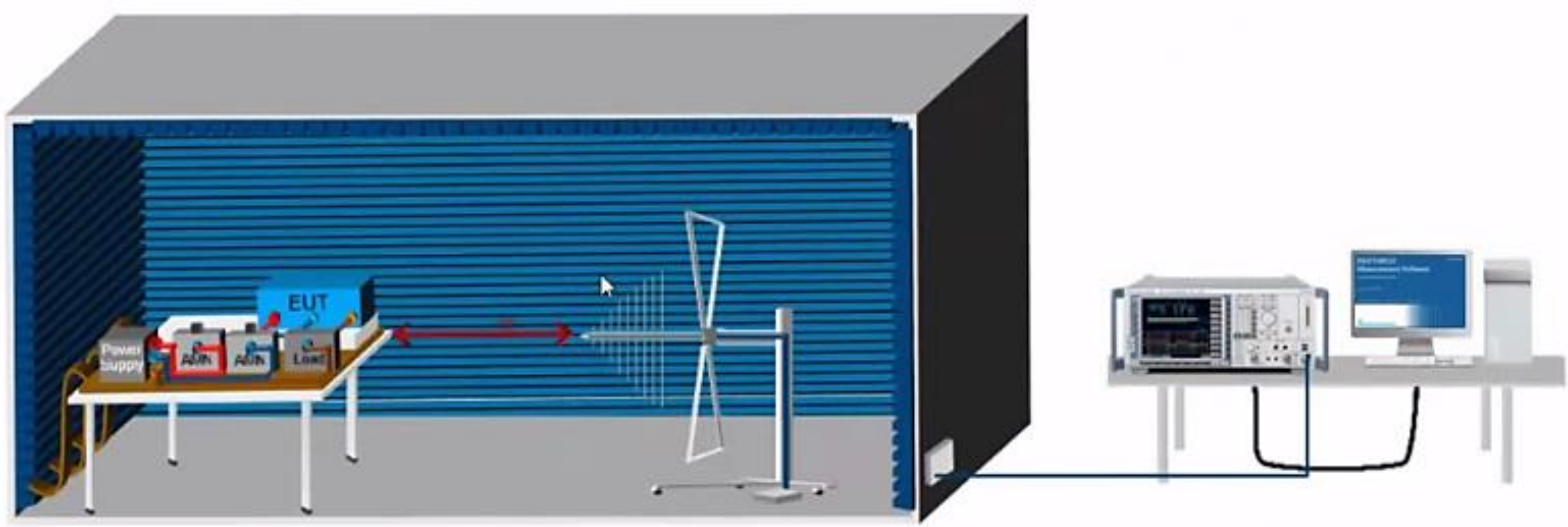
TEM- Transverse-Electro-Magnetic Mode

CISPR 25: TEST SETUP & ENVIRONMENT CONDUCTED EMISSION - VOLTAGE



Source- Rhode & Schwarz

CISPR 25: TEST SETUP & ENVIRONMENT RADIATED EMISSION



Source- Rhode & Schwarz

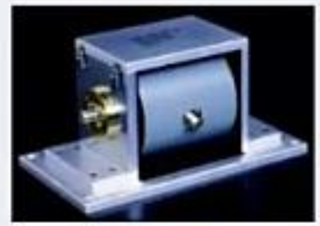
Source- Rhode & Schwarz

Automotive EMC

ISO 11452: TEST METHODS

ISO 11452-2
ALSE Antennas
Electric field strength

ISO 11452-3
TEM-Cell
Electric field strength



ISO 11452-4
Injection probe
Current injection

ISO 11452-5
Stripline
Electric field strength

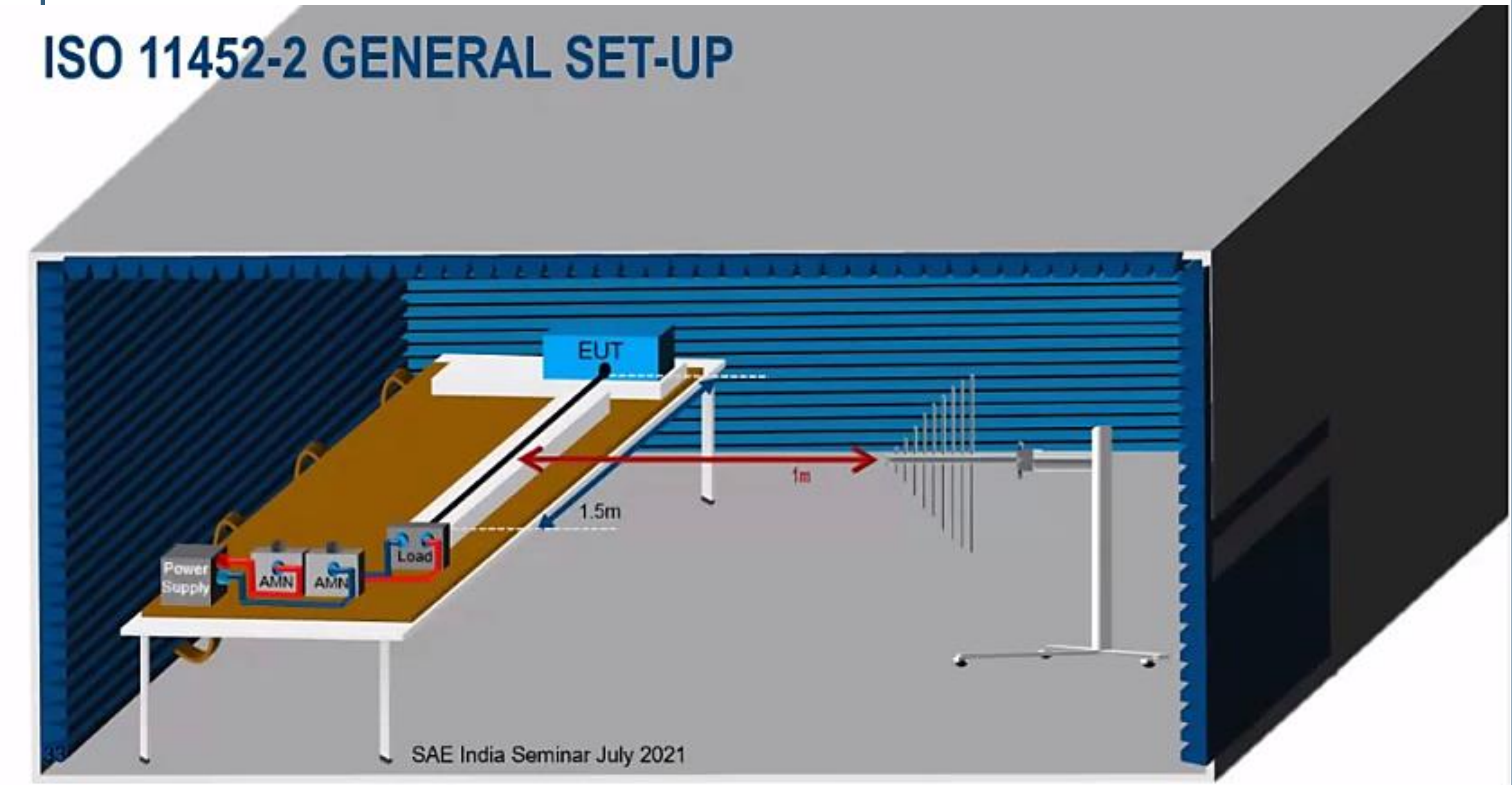
ISO 11452-7
Broadband Artificial Network
Direct power injection

ISO 11452-8
Radiating loop
Magnetic field strength

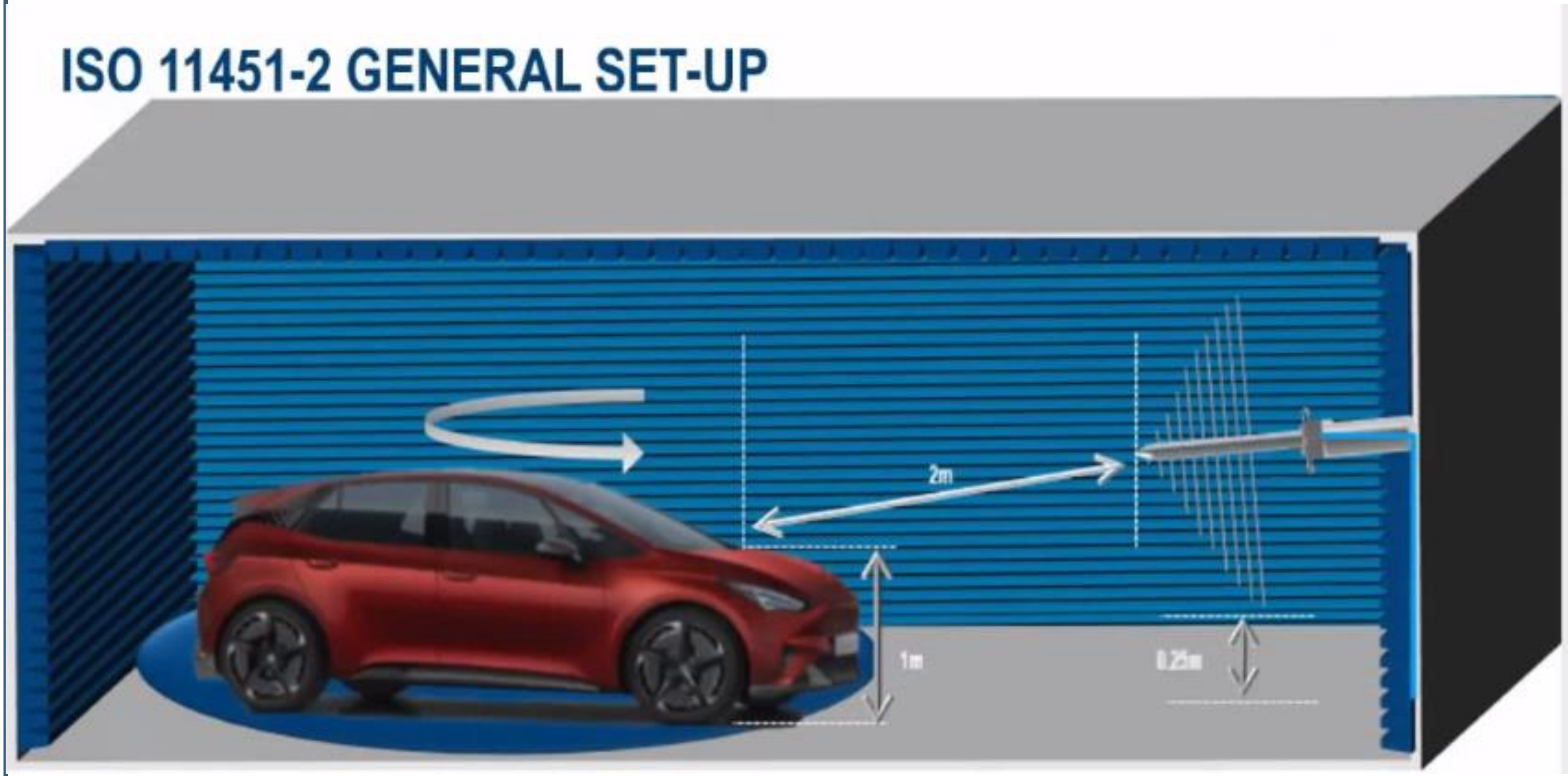
ISO 11452-8
Helmholtz coil
Magnetic field strength

ISO 11452-9
Portable transmitter
Radiated power

Source- Rhode & Schwarz



Source- Rhode & Schwarz



Source- Rhode & Schwarz

Automotive EMC

ISO 11452: SUMMARY OF TESTS

Standard	Test	Transducer	Freq (Hz)	Level	Manufacturer Requirements
ISO 11452-2	Radiated Immunity	Antenna / TLS	80M ~ 18G	100V/m	Antenna Method 200V/m 200M~6GHz
ISO 11452-4	Bulk current injection	Injection Probe & TWC	1M ~ 3000M	200mA / 33W	BCI Method 300mA 1M~400MHz closed loop
ISO 11452-3	Radiated immunity	TEM Cell	10k ~ 200M	200V/m	200V/m 10k~200MHz
ISO 11452-5	Radiated immunity	Stripline	10k ~ 400M	200V/m	200V/m 10k~400MHz
ISO 11452-7	Direct Power Injection	Broadband Artificial Network	250k ~ 500MHz	0.5W 250k ~ 500MHz	0.5W 250k ~ 500MHz
ISO 11452-8	Magnetic field immunity	Helmholtz coil / radiating loop	DC & 15 ~ 150k	Up 3000A/m	4000A/m DC 1000A/m 15 ~ 150kHz
ISO 11452-9	Portable transmitter	Antenna	26M ~ 5.85G	0.5W ~ 16W	~20W <1GHz ~10W >1GHz
ISO 11452-10	Immunity in audio freq.	Isolation transformer	15 ~ 250k	3V	3V 15 ~ 250kHz

Source- Rhode & Schwarz

Driver Information System:

- The display of the driver information system (DIS) brings together a wide range of different information items in the centre of the cockpit and permanently indicates the vehicle's current operating status. It is intuitively laid out, user-friendly, and allows the driver to stay focused on the road.