1　EMC

- Electro Magnetic Compatibility refers to the use of components in electronic systems that do not electrically interfere with each other and the environment. The minimum demand are Legal requirements (MILSTD 461), the additional demand are costumer requirements to ensure safety & comfort.

- **OEM Norms and Standards**: These are specific EMC standards and norms set by the Original Equipment Manufacturers (OEMs).

- **Homologation ECE R10**: This refers to a regulation set by the Economic Commission for Europe (ECE) which relates to the approval of vehicles with regard to electromagnetic compatibility.

- Immunity and emission must be considered in both standards/regulations.

- three key EMC considerations for automotive systems: ensuring vehicles don't interfere with external devices and resist external interference for homologation, managing interference between the vehicle's own electronic systems to prevent malfunctions, and maintaining clear reception for on-board communication devices by controlling the interference they emit.

- Emitter need Interference control, the receiver susceptibility control.

Coupling	Immunity	Emission
Inductive (H) Capacitive (E) Electro Magnetic (E/H)	Incident radiaton [V/m] Magnetic field immunity [A/m]	Near-field interference [dBμV] Far-field interference [dBμV] Magnetic field emission [μT]
Galvanic	Impulse Immunity [V] Electrostatic discharge [kV]	Impulse Emission [V] Coupling[dB]

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- The four models of electromagnetic (EM) coupling described in the context provided are:

- Galvanic Coupling: Occurs when currents from two different circuits flow through a common conductive path, creating voltage due to shared impedance. Remedies include using separate return lines, increasing conductor cross-section, and preventing high-frequency ripples through DC filtering.

- Capacitive Coupling: Happens when variable-frequency signals like pulse or sinusoidal voltages induce interference in nearby circuits without a direct connection. Interference voltage increases with the proximity and frequency of these signals. To mitigate, one can separate conductive paths, limit frequency, improve signal-to-noise ratio, and apply isolation.

- Inductive Coupling: Arises when variable currents in one circuit induce voltage pulses in adjacent circuits, with pronounced effects in low-frequency circuits. To reduce this, you can minimize inductive coupling by increasing distance or positioning conductors orthogonally, minimize wiring dimensions, and note that isolation is difficult at low frequencies.

- Conductor Model Coupling: Typically involves the impact of the physical properties of conductors (like cross-sectional area, resistivity, isolation resistance, conductor capacities, and inductive resistance) on the EM coupling paths.

- Each type of coupling has specific remedies that focus on minimizing interference through physical layout and electrical properties of the circuitry.

- Inside the vehicle:

- In summary, vehicles can experience ripple and impulse interference from internal operations like the generator and switching mechanisms. These interferences are classified and mitigated according to standards like ISO7637. High-frequency interference from various vehicle systems can affect communication devices, with different sources causing wide-band and narrow-band interference patterns. These interferences can propagate through both radiated and conducted emissions, with the vehicle's structure and wiring affecting their propagation. Also ESD can happen, ISO TR 10605 defines test procedures with test-pulse generator.

- Surrounding of vehicle:

    o Emission tests follow CISPR 12 guidelines, using anechoic chambers to ensure vehicles meet radiation emission limits.

    o Immunity tests assess vehicle resistance to external electromagnetic fields, supplemented by on-road testing.

    o Stripline and BCI methods are used to test vehicle components for EMC compliance, while TEM cells offer an alternative testing approach without needing shielded chambers.

- Overall, these processes aim to ensure that vehicles can operate without electromagnetic interference affecting their functionality or other devices.

- **Summary:**

    o CISPR (International Special Committee on Radio Interference, part of IEC)

    o Homologation -> Regulation on radio interference suppression ECE-R 10.

    o Most important standards: CISPR 25 – Component Level Emissions , CISPR 12 – Vehicle Level Emissions , ISO 11452 – Component Immunity (ALSE, TEM, stripline, BCI, direct injection) , ISO 11451 – Vehicle Immunity , ISO 10605 – Electrostatic discharge , ISO 7637 - Transient immunity (impulses)

2 Battery

- Some components of battery: Cover, Prismatic Cell, Module, Modular Control Unit, Busbar, Cooling plate & pipes, Wiring Harness (HV), Battery Management System (BMS), Junction Box, High-Voltage Interlock

- Cell Designs – Housing Possibilities: pros and cons:

    o Cylindrical Cell: Pros like high energy density and fast production, and cons such as poor cooling behavior and high volumes.

    o Prismatic Cell: Pros include good cooling behavior and a robust, integrated safety feature, and cons like more expensive cell housing and bending issues.

    o Pouch Cell: Pros include high energy density and flexible design, while cons include a rather complex module design and no defined exhaust relief position.

- typical energy content for:

    o Hybrid vehicles with 15-20Wh

    o Electric Vehicle (EV) applications with 100 – 250 Wh

- Important parameters: Capacity [Ah], Open Circuit voltage [V], Nominal Voltage [V], Power [W], Energy [Wh]

- Performance parameters: Peak power, Energy density, Specific Energy, Service life, Safety, Cost, Charge current, Temperature performance.

- The challenge is to select the correct cell technology, cell size, cell design.

- Three software Algorithms for battery control:

    o SOC Estimation: This likely refers to the estimation of the State of Charge, which is the algorithm responsible for determining how much energy is remaining in the battery pack.

    o SOH Estimation: This function is for estimating the State of Health of the battery, indicating the overall condition and any degradation of the battery over time.

    o Cell Balancing Control: This algorithm is used to ensure that all the cells in the battery pack are at the same charge level, which is crucial for maintaining battery life and efficiency.

- Battery Safety Levels:

    Cell Materials: Safety through materials, e.g., separators that shut down when heated.

    Cells: Safety via design, including features like pressure relief valves.

    Pack: Detects and predicts failures with in-built safety mechanisms.

    Vehicle: Manages battery safety at the vehicle level, including thermal regulation.

- Thermal Runaway: A severe failure in lithium-ion batteries where overheating can lead to fires. It starts with conditions like overcharging, leading to a chain reaction that escalates if unchecked.

- Definitions: Thermal Runaway: Uncontrolled heat generation in batteries, risking hazard.

    Thermal Propagation: The spread of excessive heat from one cell to others.

    Abuse Tolerance: A battery's resistance to failure under abnormal conditions.

- UN Regulations: UN regulations: ECE-R100 details vehicle approval concerning electric power trains, with safety and performance tests. UN 38.3 specifies safe transport criteria for lithium batteries, outlining tests for environmental and mechanical conditions.

- China regulations: The slide summarizes China's battery safety regulations for electric vehicles, highlighting rapid changes in standards. GB/T 31467.3 outlines traction battery safety requirements, with focus on structural integrity and reliable performance under various conditions.

- Electrical Performance 3 issues: Transient overvoltage, Transient undervoltage, Load dumb (like capacitive loading)

- B-Sample Tests:

    o Electrical Performance: Electromagnetic Compatibility Tests, Life cycle test

    o Mechanical: M-Shocks (Shocks from the road), Vibration,

    o Thermal: HTHH (High Temperatur High Humidity)

    o Leakage: Dust test, Salt spray (Resistance to corrosion)

    o Misuse test: Crush test, Fuel Fire, Free Fall, Short circuit

    o Homologation UN38.3

- C-Sample Tests: Pretty the same, but includes additional homologations

3 FlexRay

FlexRay Introduction:

- FlexRay is a communication protocol developed by a consortium including BMW and DaimlerChrysler, mainly for automotive safety applications.

- It supports high-speed data transmission, up to 10 Mbps, and is designed to be deterministic (predictable timing) and fault-tolerant.

- Uses Time Division Multiple Access (TDMA) for managing the communication schedule.

FlexRay Architecture:

- A FlexRay network consists of multiple nodes (like sensors or actuators) connected through a bus.

- It features two channels for redundancy or doubling the bandwidth (up to 20 Mbps combined).

- Various topologies are supported, like point-to-point, bus, star, or a hybrid of these.

- The network uses twisted-pair cabling, which can be either shielded (protected against electromagnetic interference) or unshielded.

- Communication is highly structured with fixed time slots assigned to each message; the timing is predefined and must be adhered to by all nodes.

FlexRay Hardware:

- A node in a FlexRay network includes a host processor that manages sensors/actors and a communication controller that handles the FlexRay protocol.

- The transceiver is the hardware component that converts digital bits from the communication controller to signals on the FlexRay bus and vice versa.

- The bus guardian is a security feature that monitors and controls access to the bus to prevent communication errors.

- The physical layer includes the host, communication controller, bus driver, and transceiver, interconnected with the power supply and the bus itself.

Bus Guardian:

- A bus guardian ensures that only authorized nodes transmit data, which prevents conflicts from unsynchronized communication.

- It grants transmission rights within a certain time frame and is ideally self-checking against the overall communication schedule of the FlexRay network.

FlexRay Bus Level:

- FlexRay uses a non-return-to-zero (NRZ) signal method, meaning the signal stays at a certain voltage level during the entire bit time, without returning to zero (the base voltage level) between bits.

- The FlexRay bus has two lines: Bus Plus (BP) and Bus Minus (BM), which help determine the state of the bus.

  - Dominant: Both lines are at different voltages, creating a 2V difference (e.g., BP at 3V and BM at 1V for a logical '0').

  - Recessive: Both lines are at the same voltage level, so there's no voltage difference (e.g., BP and BM both at 2V for a logical '1').

- Idle states on the bus are also represented as recessive levels.

Communication Cycle:

- Data communication in FlexRay is periodic and follows a strict schedule known as the communication cycle.

- There are four segments to the cycle:

  - Static Segment: Predefined slots for deterministic data transmission.

  - Dynamic Segment: Allows flexible data transmission, where slots are allocated as needed.

  - Network Idle Time: Ensures synchronization among nodes and allows for recovery from errors.

  - Symbol Window: Used for network management or for transmitting special symbols.

- The cycle ensures that all nodes know exactly when to listen and when to transmit, making the system predictable and efficient.

Understanding these aspects will help you to know how FlexRay manages data transmission between nodes, ensures system reliability, and handles the actual data signals on the physical bus.

Here's a simplified explanation for the Static and Dynamic Segments of the FlexRay Communication Cycle:

Static Segment:

- Uses FTDMA (Flexible Time Division Multiple Access), dividing time into equal-sized slots that nodes can exclusively use to transmit messages.

- Each message slot is fixed in the schedule and is repeated every communication cycle.

- Messages are sent simultaneously on both channels for redundancy or on separate channels to double the bandwidth.

- If the internal clocks of nodes become out of sync, the system can adjust the action point offset and channel idle time to re-synchronize the nodes.

Dynamic Segment:

- This segment also uses FTDMA and allows for more flexible communication than the static segment.

- The size of the dynamic segment is fixed, but the size of individual mini-slots within it can vary.

- Nodes start sending their dynamic messages following the end of the static segment.

- The dynamic segment operates on a "first come, first serve" basis using mini-slotting. Nodes count the mini-slots and when their count matches the number of the mini-slot, they can begin transmitting if they have data to send.

- If a node has no data to send, it simply increments its counter and waits, allowing other nodes to use the slots.

- This process repeats until all dynamic messages have been sent or the dynamic segment ends.

Understanding these two segments is crucial for understanding how FlexRay allocates bandwidth and prioritizes message sending, with the static segment providing guaranteed bandwidth and timing for critical messages, and the dynamic segment allowing flexibility for non-critical messages.

Here's a simplified summary of the key points about FlexRay Clock Control and Message Structure:

FlexRay Clock Control:

- Each node in a FlexRay network has its own internal clock.

- The network uses a global time base for all nodes, ensuring that access to the bus is synchronized.

- Synchronization happens at the macro tick level, a small, consistent time unit used network-wide.

- Communication cycles are made of a set number of these macro ticks, ensuring precise timing.

FlexRay Message Structure:

- A FlexRay message consists of a header, payload, and trailer.

- The header contains a frame ID and indicators for payload type and cycle count.

- The payload carries the actual data.

- The trailer includes a Cyclic Redundancy Check (CRC) for error detection.

Message Indicators:

- Startup frame indicator: Identifies a startup message in the static segment.

- Sync frame indicator: Shows whether a message is a sync frame, ensuring all nodes are in time with each other.

- Payload preamble indicator: Signals if a network management vector (like control commands) is being transmitted.

FlexRay Message Coding:

- Coding is designed to maximize real-time abilities and reduce transmission errors.

- Frame start and end are marked with special sequences for clear identification.

- Data bytes are protected by byte start and end sequences to ensure integrity.

- A special sequence blocks transmission to other nodes during the dynamic segment, preventing collisions.

Knowing these concepts helps you understand how FlexRay maintains accurate timing across a network and ensures data integrity and synchronization in its communication process.

Ethernet Overview:

- The IEEE is the organization behind the development of Ethernet standards, with a series of documents labeled IEEE 802.x.

- One of Ethernet's strengths is its robust support of higher data rates over a network.

Ethernet ECU Basic Setup:

- ECUs (Electronic Control Units) use Ethernet for communication, which involves different layers named using both the OSI model (which has 7 layers) and the TCP/IP model (with 4 layers).

- The basic components of an Ethernet setup in an ECU include:

  - Host: Manages the software and higher-level functions.

  - Ethernet Controller (ETH): Handles Ethernet communication specifics.

  - Media Independent Interface (MII): A standard interface between the ETH and physical hardware.

  - Physical Layer (PHY): The hardware that actually sends and receives data.

  - Medium Dependent Interface (MDI): Connects the PHY to the actual cables or physical medium.

IEEE 100BASE-T1 / OABR:

- OABR (Open Alliance BroadR-Reach) is a type of Ethernet physical layer used in vehicles, known technically as IEEE 100BASE-T1.

- It allows for communication over a single twisted pair cable with a rate of 100 Mbps.

- It employs sophisticated encoding/decoding techniques such as 4B3B, NRZ, and PAM3 for efficient data transmission.

- The system requires both sending and receiving nodes to be precisely synchronized to maintain signal integrity.

Full duplex data transmission:

- Full duplex allows data to be sent and received at the same time on different channels.

- Echo cancellation is used to remove the transmitted signal from the received signal, ensuring clear communication.

IEEE 100BASE-TX:

- Uses two separate channels on four wires within a cable.

- Operates at 100 Mbps using a coding method that makes it simple to manage.

- Devices are connected in a point-to-point manner, typically with a switch, and must be time-synchronized for data integrity.

IEEE 100BASE-T:

- Requires four channels, similar to 100BASE-TX but with some differences in encoding techniques.

- It also operates at 100 Mbps and emphasizes synchronization between nodes to prevent data corruption.

Ethernet Layer 2 - Addressing:

- Each device on a network has a unique MAC (Media Access Control) address used for local identification.

- MAC addresses ensure that data sent on a network reaches the correct device without confusion.

Ethernet Layer 2 - Frame:

- An Ethernet frame is a packet of data that includes source and destination addresses, as well as the actual data and error-checking information.

- Frames begin with destination and source MAC addresses, may include VLAN information, and end with a CRC (Cyclic Redundancy Check) for error detection.

Internet Protocol (IP):

- IP allows for communication beyond a local network, using IP addresses to identify devices globally.

- IP operates at Layer 3 of the OSI model and routes data through interconnected networks.

- There are two versions of IP addresses: IPv4 uses four-byte addresses, while IPv6 uses sixteen-byte addresses for a vastly increased address space.

Additional protocols (IP):

- DHCP (Dynamic Host Configuration Protocol): Automatically assigns IP addresses to devices.

- ICMP (Internet Control Message Protocol): Used for sending error messages and operational information.

- ARP (Address Resolution Protocol): Translates IP addresses to the physical MAC addresses.

- NDP (Neighbor Discovery Protocol): The IPv6 equivalent of ARP, used for discovering other network devices.

Transport protocols (TCP/UDP):

- TCP (Transmission Control Protocol): Reliable, connection-oriented protocol that ensures data is delivered accurately.

- UDP (User Datagram Protocol): Faster, connectionless transmission, used where speed is prioritized over reliability.

SOME/IP:

- A protocol for service-oriented communication, enabling more efficient and flexible data exchange than traditional methods.

- Supports event-driven communication, which is crucial for modern, distributed systems in automotive and other real-time applications.

Why not use Ethernet for everything?

- Different applications have different requirements regarding speed, reliability, and cost.

- The diagram shows a range of communication standards plotted against data rate and response time, demonstrating where Ethernet fits in compared to other technologies like CAN, FlexRay, and MOST. Ethernet is not always the best choice for very high-speed or very low-cost, time-critical applications.

Sure, I'll provide a brief answer for each question:

1. Major Advantage of FlexRay Bus:
  The major advantage of FlexRay is its ability to provide higher data rates and more reliable and precise data transmission compared to CAN. It is especially useful for safety-critical applications that require deterministic and fault-tolerant communication, like advanced driver-assistance systems.

2. Three Major Characteristics of FlexRay Compared to CAN:
  a. Higher Bandwidth: FlexRay supports data rates up to 10 Mbps, significantly higher than CAN's 1 Mbps.
  b. Dual-channel Communication: FlexRay provides two independent channels for data transmission which can be used for redundancy or increased bandwidth.
  c. Time-Deterministic: FlexRay's static segment ensures time-deterministic data transmission, essential for critical control applications.

3. Difference Between Static and Dynamic Segment in FlexRay:
  In FlexRay, the communication cycle is divided into a static segment and a dynamic segment. The static segment is used for periodic, time-triggered communications and has fixed slots for data transmission, ensuring determinism. The dynamic segment is more flexible, allowing for event-triggered communication with variable data transmission lengths, useful for non-time-critical messages.

4. IEEE 100Base-T1 Transmission Technology:
  IEEE 100Base-T1 is an automotive Ethernet standard that supports 100 Mbps data transmission over a single twisted pair cable. It's designed for automotive applications that require fast and reliable data exchange such as diagnostics, infotainment, and advanced driver-assistance systems.

5. Ethernet ECU Basic Setup:
  An Ethernet ECU (Electronic Control Unit) setup typically includes a microcontroller with an integrated Ethernet controller, an Ethernet transceiver, and a physical connector. The ECU would be configured with a TCP/IP stack for communication and could also support specific automotive protocols like SOME/IP.

6. Meaning of Ethernet Full Duplex Data Transmission:
  Full duplex in Ethernet means that data can be transmitted and received simultaneously over the network. This enhances the network's efficiency and data throughput, as there's no need to switch between sending and receiving modes, which is the case with half-duplex systems.