Electromagnetic Theory and Interference.

21ECC205T

LLT-1 (Case Study)

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Smartphone is causing interference with nearby Wi-Fi signals, leading to degraded performance of other devices. What design modification can be implemented to reduce EMI and improve the phone's compatibility with surrounding electronics?

Electromagnetic interference (EMI) in smartphones is a growing concern due to the increasing density of electronic components and the various wireless technologies operating within close proximity.

→ As smartphones house multiple radios (Wi-Fi, Bluetooth, GPS, cellular, etc.) and other sensitive electronic circuits, controlling EMI is crucial to ensure these systems work harmoniously without interference.

→ EMI can degrade performance, lead to dropped calls, slow data connections, or cause electronic components to fail.

☆ Solutions & Design modification:-

- Shielding :- Electromagnetic shielding is crucial in reducing EMI conductive materials like copper or aluminium can be wrapped around the smartphone's most sensitive circuits. The shielding redirects EMI away from these components and dissipates it. For RF (radio frequency) circuits, enclosures made from these materials are common.

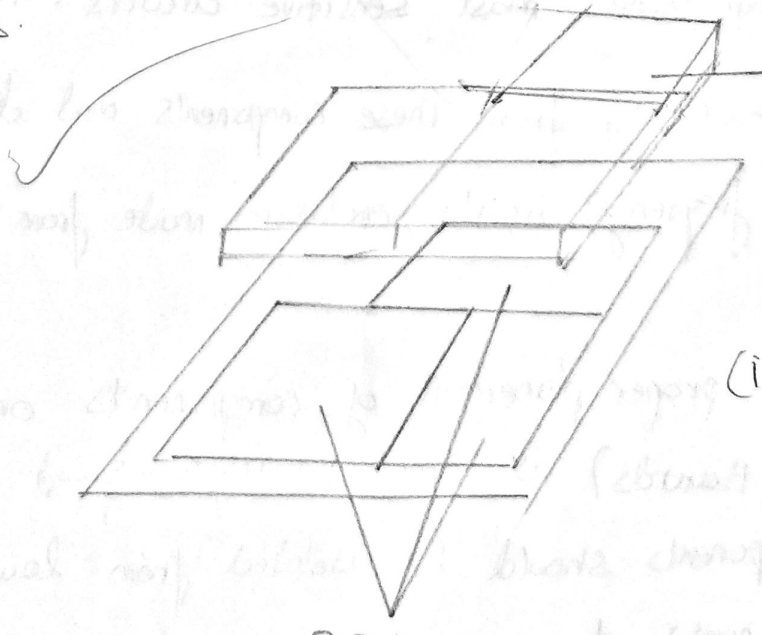
- Component Layout :- proper placement of components on the PCB (Printed Circuit Boards) is critical. High-speed digital circuits and RF components should be isolated from low-frequency analog components to prevent cross-coupling of EMI

- **Filtering**:- Filters block or attenuate unwanted high freq noise that may propagate along power or signal lines. pass filters can be applied on power lines, while differential mode and common mode filters can be used on signal lines.

- **Grounding**:- A good grounding scheme allows EMI to be safe conducted away from sensitive circuits. Multilayer PCB's with dedicated ground planes can help in this regard. By reducing impedance in the ground path, radiated emissions are also minimized.

- **Differential Signaling**:- Differential signaling, where the same signal is sent over 2 wires (one inverted), helps cancel out EMI as the interference affects both wires equally and can be subtracted out at the receiver.

- **Software Adjustments**:- Smart power management software can dynamically adjust radio transmission power based on proximity to Wi-Fi networks or cell towers, reducing unnecessary emissions.



(i) how shielding is implemented in an PCB.

An electric vehicle is experiencing malfunctions in it's electronic control systems due to EMI from the high power drive systems. what strategies can be employed to improve electromagnetic compatability within the vehicle's electronic components?

Electric vehicles (EV's) are equipped with powerful drive systems that can generate substantial electromagnetic interference (EMI). EMI within EV's can degrade the performance of sensitive control systems, cause malfunctions, or even disrupt safety-critical features like braking or steering controls. Thus ensuring electromagnetic compatibility is a key challenge in EV design, As such let us look at some solutions.

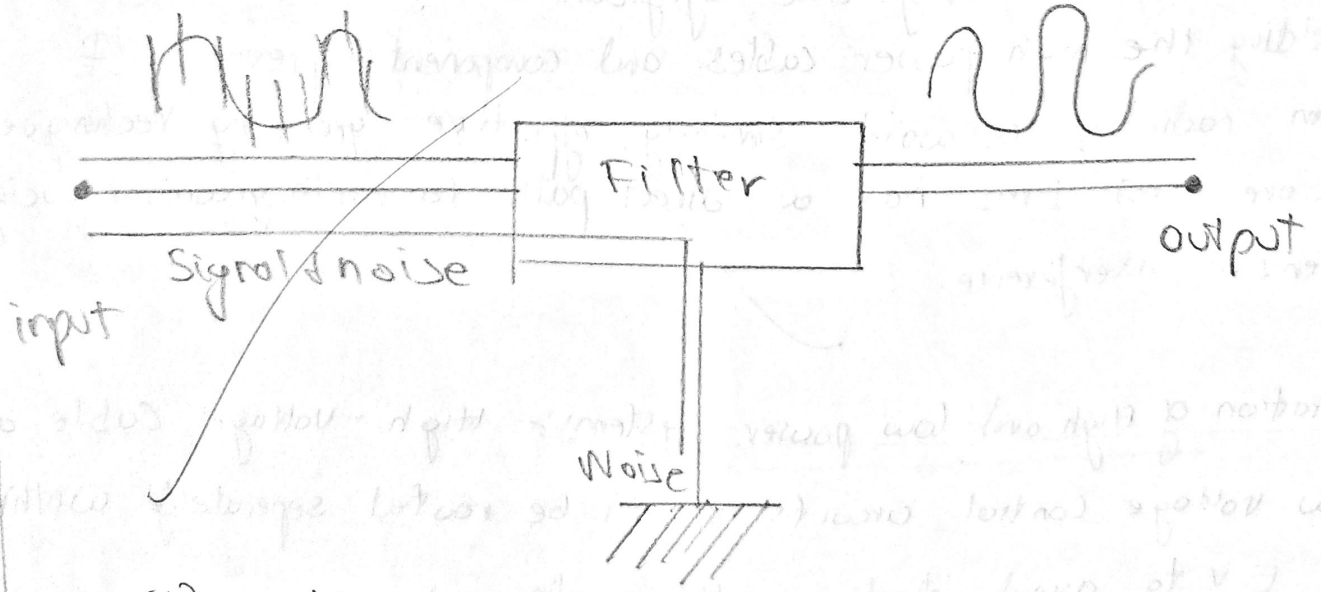
- Shielding and Grounding: High power drive systems in EV's like inverters and motors, generate significant EMI. To combat this, shielding the high power cables and components prevent EMI from radiating outward. Similarly, effective grounding techniques ensure that EMI has a direct path to earth ground, reducing potential interference.

- Seperation of High and low power systems:- High-voltage cable and low voltage control circuits should be routed seperately within the EV to avoid electromagnetic coupling. A common practice is to keep high power circuits in one region of the vehicle and control electronics in another.

- Twisting pairs and shielded cables :- Twisted pairs help cancel out noise generated between signal and return paths. shielded cables on the other hand, protect the signal lines from external interference.

- Filtering components :- placing filters components like chokes, capacitors, or ferrite cores on power and signal line helps supress conducted noise. Chokes and ferrites are particularly effective in blocking high frequency EMI.

- Control Switching Frequency :- power electronics in EV's such as DC-DC converters and inverters, operate at high frequency. By carefully selecting the switching frequency, it is possible to avoid harmonics or frequency ranges where control circuits might be sensitive.



(i) a filtered power line commonly used in EV's to prevent EMI interference.

Satellite communication system faces interference from solar radiation and electromagnetic disturbances in space. what design considerations can be implemented to ensure reliable communication and minimize EMI.

Satellite communication systems face unique challenges when it comes to electromagnetic interference (EMI). In space, satellites are exposed to solar radiation, cosmic rays, and other forms of electromagnetic disturbances. These sources of EMI can disrupt communication links, degrade the performance of electronic components, and even damage sensitive equipment.

Hence, designing satellite systems with effective EMI mitigation strategies is essential for maintaining reliable communication.

☆ Some of the solutions are:-

- Radiation Hardened components:- In the harsh environment of space, components must be designed to withstand both cosmic radiation and the large amount of EMI generated from solar flares or other cosmic sources. These radiation hardened components prevent data corruption or damage due to excessive EMI.

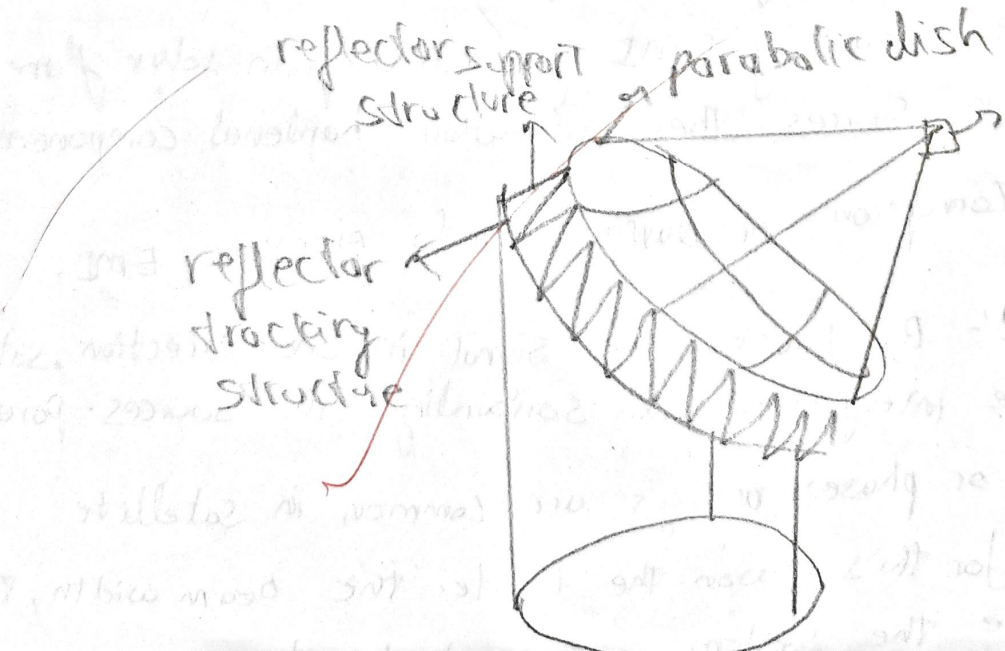
- Directional Antennas:- By focusing the signal in one direction, satellite antennas reduce interference from surrounding EMI sources. Parabolic dish antennas or phased arrays are common in satellite communications for this reason. The tighter the beam width, the less interference the system is exposed to.

- Filtering and signal processing :- Digital filters (both hardware and software) are used to clean up the incoming and outgoing signals. Advanced signal processing techniques, such as fourier transforms, help seperate the useful signal from noise.

- Shielding :- Satellites are enclosed in shields designed to block out external electromagnetic interference from space radiation and other satellites. this can include multilayered conductive materials.

- Error-correcting codes :- Forward error correction (FEC) techniques allow the receiver to detect and correct minor errors caused by EMI. common codes include Reed-solomon or convolutional codes.

- Redondancy :- Critical systems on satellites are often duplicated so that if one is disrupted by EMI or cosmic radiation, the other can take over. this ensures the reliability of communications in space.



(i) A parabolic antenna dish commonly used on satellites to mitigate EMI.