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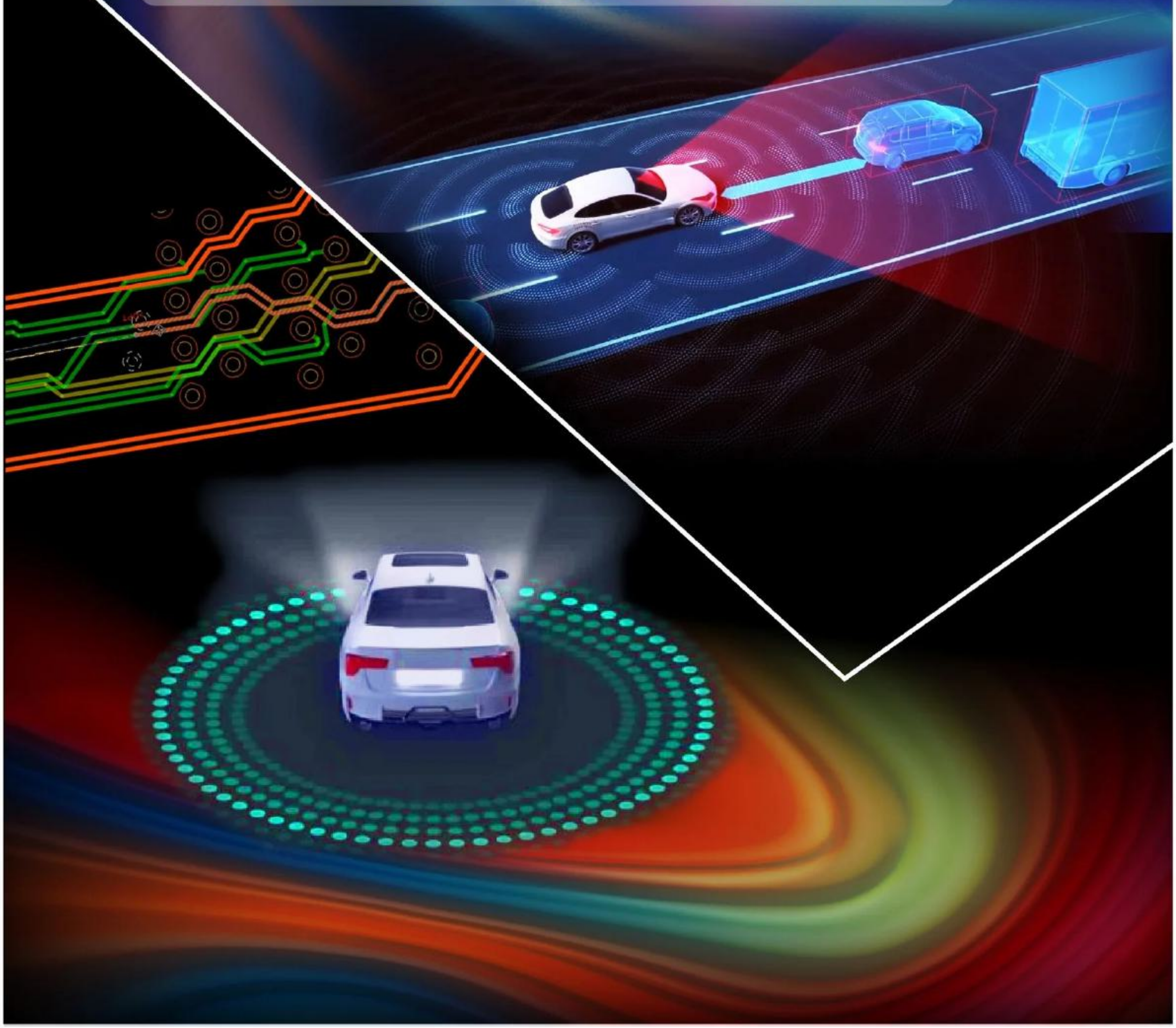
Maximize Performance : Don't Ignore Power Integrity in HIGH-SPEED ADAS



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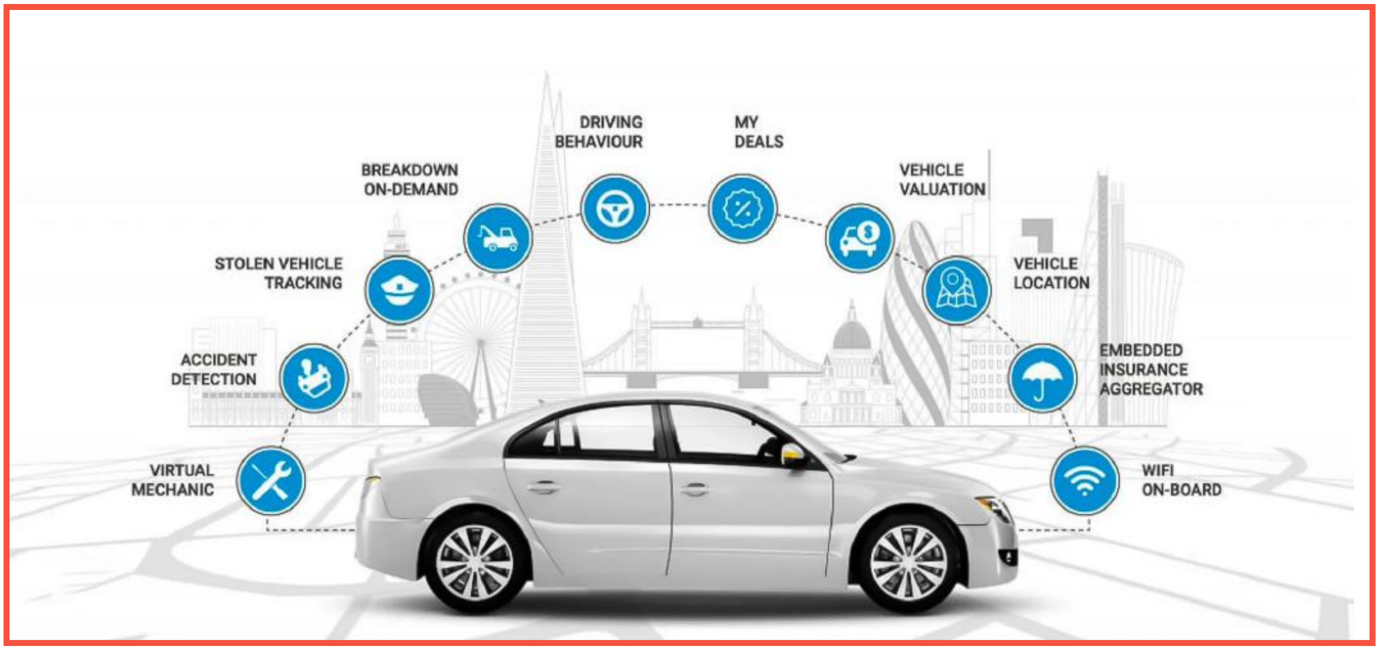
1.Importance of Power in Automotive Electronics



Think of power like fuel in a car.

Just as fuel is necessary for a car to run, power is necessary for electronic devices to operate.

What is Power?
Power in electronics refers to the amount of electrical energy delivered to a device or system, typically measured in **watts (W).**

Power is essential for components to perform their tasks, whether it's lighting up a dashboard, controlling vehicle systems, or running advanced safety features.

In automotive electronics, power isn't just about turning things on; it's about ensuring that every system operates efficiently and reliably.

Why Power is Critical in Automotives?
Automotive electronics have evolved far beyond the basic functions of controlling engine operations.

Modern vehicles are packed with advanced features like **infotainment systems, GPS navigation, collision avoidance systems, and autonomous driving capabilities.**

Each of these systems relies on a stable power supply to function optimally.
A power failure or instability can lead to malfunctioning systems, which can range from inconvenient
(a frozen display screen) to dangerous (a failed ADAS system).

The Growing Demand for Power in Automotive Systems

- The demand for power in automotive electronics has increased significantly as vehicles incorporate more high-tech features.
- From electric vehicles (EVs) that rely entirely on electrical power to traditional internal combustion engine vehicles with growing electronic subsystems, the need for reliable power is more critical than ever.

Electric Vehicles (EVs): In electric cars, power is the core of the vehicle's functionality, powering the motor, battery management systems, sensors, and more.

ADAS (Advanced Driver Assistance Systems): Systems like adaptive cruise control, lane-keeping assist, and collision avoidance require continuous and stable power to make split-second decisions. A minor power fluctuation can lead to performance drops
or even system failures.

Infotainment and Connectivity: Modern cars are becoming increasingly connected, with infotainment systems, smart navigation, and integrated communication.
These systems demand consistent power to deliver a seamless experience for users.

2.How does Power Safeguards the brains of ADAS?

In ADAS, any disruption or fluctuation in power can compromise the entire system's functionality, which includes real-time decision-making for critical safety functions like **emergency braking, collision avoidance, and lane assistance.**

1. **Stable Voltage Regulation:**

- ADAS processors and sensors rely on consistent voltage for operation.
- Voltage regulators, especially buck converters, convert vehicle battery power (12V or 48V) to lower voltages (e.g., 3.3V, 1.8V). Proper voltage regulation ensures reliable data processing, minimizing fluctuations.

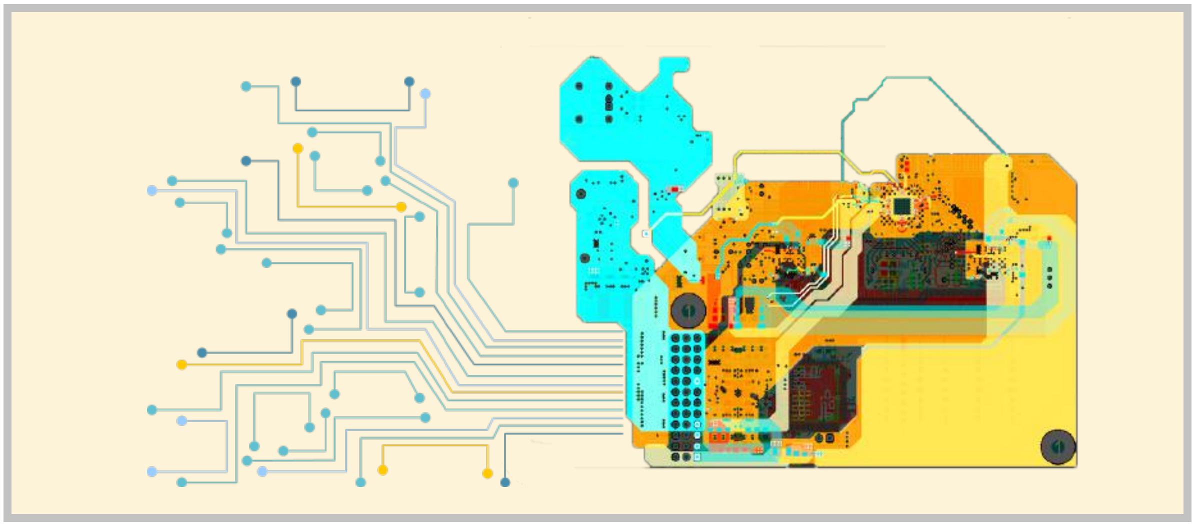
Vout=D×Vin

2. Power Integrity in High-Speed ADAS:

Power integrity (PI) is paramount for ensuring that ADAS electronics, which operate at high speeds, can function without interruptions or noise interference.

High-speed digital systems, like ADAS's central processing units (CPUs), demand clean, noise-free power to process sensor data accurately and quickly.
Any deviation from ideal power delivery introduces noise into the system, causing timing errors and data corruption.

$$X_C = {}^{1}/_{2\pi f c}$$



In ADAS, decoupling capacitors are strategically placed near power pins of ICs (integrated circuits) to suppress high-frequency noise, while bulk capacitors stabilize the power rail against sudden current draws by the CPU or GPU.

Efficient Power Distribution (PDN):
Minimizing IR voltage drops ensures power reaches all components.
Wide copper traces and ground planes reduce resistance and impedance.

$$V_{drop}=I\times R$$

Electromagnetic Compatibility (EMC):
EMI shielding and filters, like ferrite beads and inductors, protect ADAS circuits from noise.

$$L = \mu N^2 A/l$$

Thermal Management:
Proper heat dissipation, via heat sinks and thermal vias, prevents overheating.
Power dissipated as heat is calculated by,

$$P_{dissipation}=I^2\times R$$

Backup Power
Supercapacitors provide backup power to safety-critical ADAS systems during power failures.

$$E=1/2\ CV^2$$

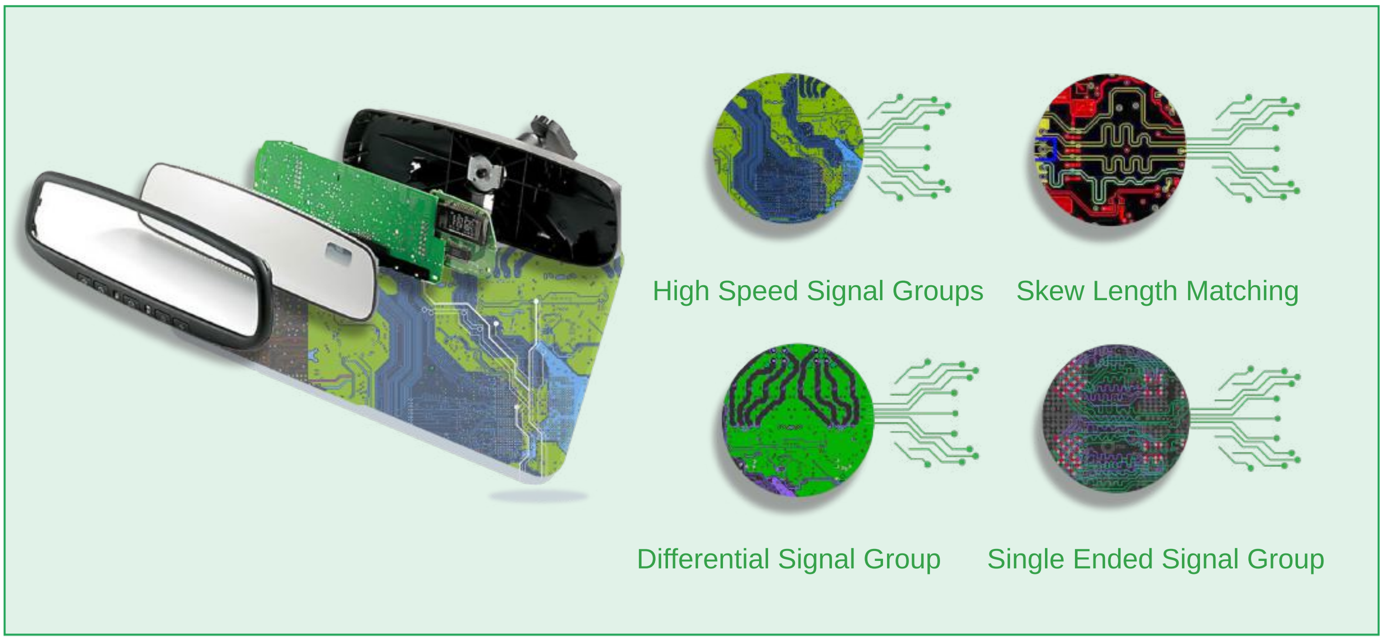
3.High-Speed Electronics in ADAS-Camera Monitoring System(CMS)

Automotive camera monitoring systems improve driving safety and convenience.

They use cameras placed around the car—front, rear, side, and sometimes all around—to help drivers see better and avoid problems.

Features include helping with parking, keeping the car in its lane, and warning about cars in blind spots.

These systems show live video and alerts on screens inside the car, making driving
safer and easier.



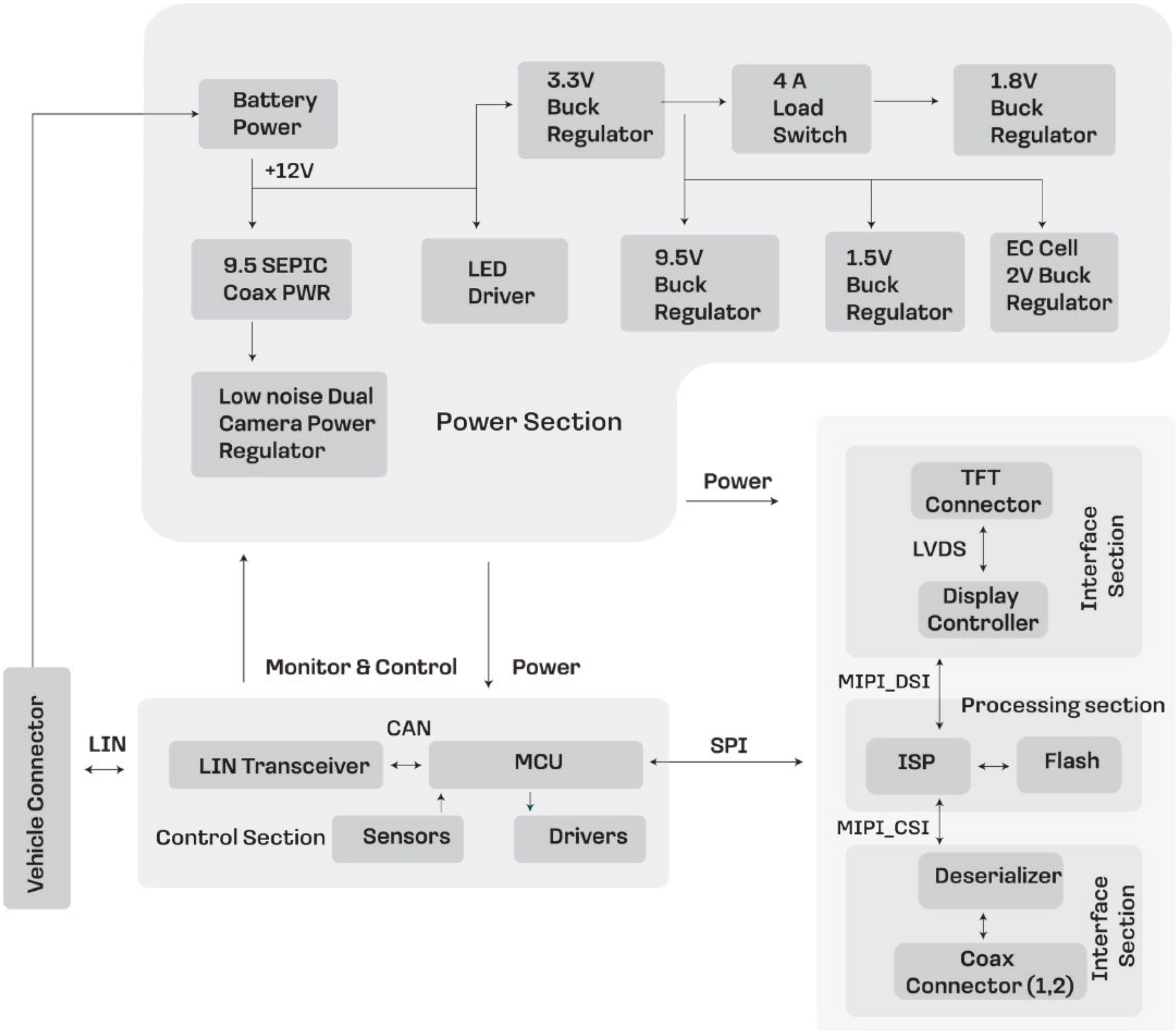
Designing a PCB layout involves arranging the components and connections on a circuit board according to specific needs and standards.

Power integrity analysis is a crucial part of this process, focusing on evaluating the Power Delivery Network (PDN) within the PCB.

This analysis covers various elements, including the power source, the pathways and vias for electricity, the planes that distribute power and ground, capacitors, and the electronic components
themselves.

The goal of this analysis is to optimize the layout's performance, ensuring it is well-suited for demanding applications such as Autonomous Driver Assistance Systems (ADAS).

Block Diagram



Power Section:
The power section of the Mirror PCB ensures that all components receive stable and adequate power **(12V, 9.5V, 8.6V, 3.3V, 2.0V, 1.8V, 1.5V, & 0.9V)** for optimal operation of control, processing and interface sections.

Monitor & Control Section:
The control section is a critical part of the Mirror PCB, responsible for managing and coordinating the functions of various components and ensuring smooth operation by using sensors and drivers such as Power Monitoring and Control, Communication Interfaces, Timing and Synchronization.

Processing Section:

This section enhances the image quality by performing tasks such as

- Noise reduction
- Color correction
- Image scaling

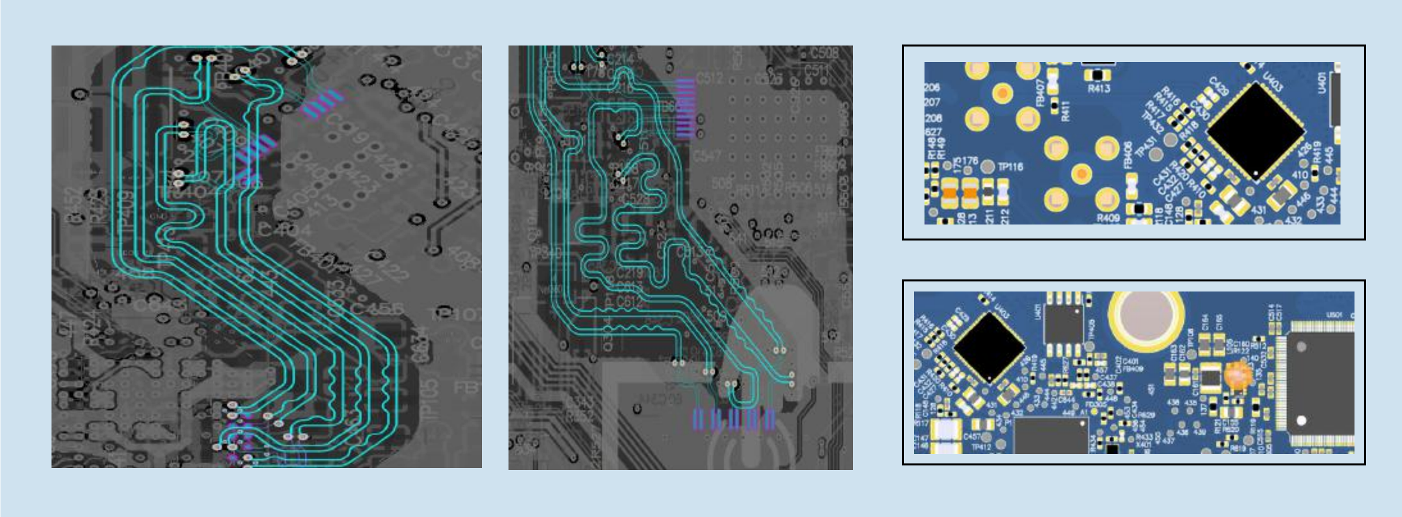
which ensures that the images are clear and detailed for display and further processing.

Interface Section:

The interface section handles communication between the imager IC to display.

The LVDS Interface ensures high-speed data transfer with minimal interference,

MIPI delivers high speed data transmission within the board, and Coaxial Connectors transmit high-speed image data from cameras to the Deserializer with minimal loss.



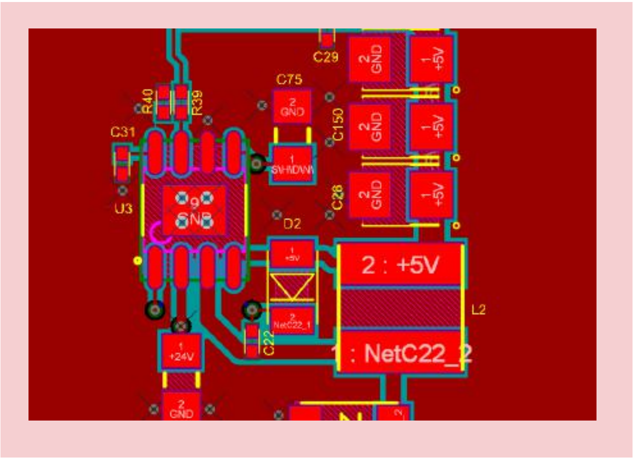
Step by step Guide for the Power Integrity Analysis

Performing a power integrity (PI) analysis is crucial for ensuring reliable power delivery in your PCB design, especially for high-speed circuits.
Here's a step-by-step guide to help you carry out a comprehensive power integrity analysis:

1. Define the Power Integrity Requirements

Voltage Levels: Identify the operating voltage levels for all power rails (e.g., 1.8V, 3.3V, 12V).
Tolerance: Establish the allowable voltage drop percentage (e.g., 5% of 12V is 0.6V).
Current Demand: Determine the maximum current required by different sections of the circuit.
Noise Margin: Set acceptable noise thresholds for power lines to ensure signal integrity.

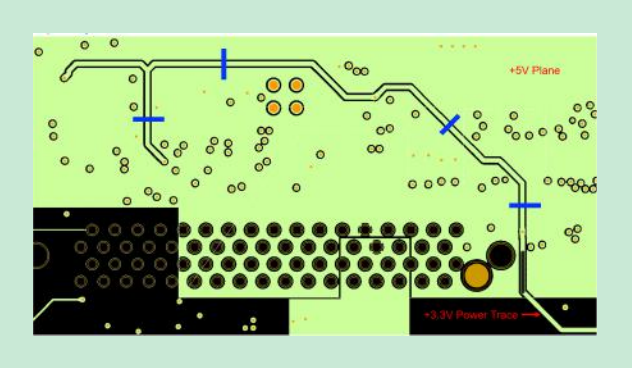
2. Prepare the PCB Layout



Component Placement:
Ensure that high-power-consuming components are placed strategically on the PCB for better power distribution.

Power Planes & Traces:
Define appropriate power planes and ensure traces are wide enough to handle the expected current.

3. Model the Power Delivery Network (PDN)



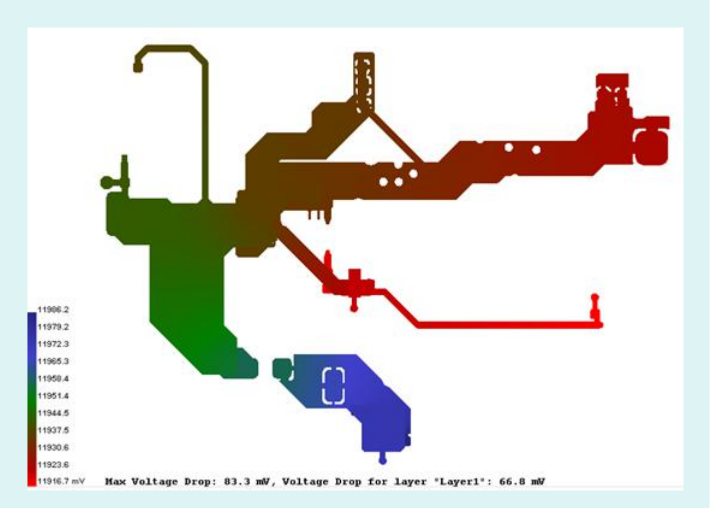
Extract the PDN: Use simulation tools to extract the power delivery network from the PCB layout.

Add Decoupling Capacitors: Ensure that capacitors are placed near critical ICs to stabilize power supply and minimize noise.

Include Parasitic Effects: Model the resistance, inductance, and capacitance (RLC) of power planes and traces, as they impact power distribution.

4. Run Voltage Drop Analysis

Simulate Voltage Drops:
Use PI tools (like Hyperlynx, ANSYS SI wave or Cadence Sigrity) to simulate the voltage drop across power planes and traces.
Check Results: Ensure that the simulated voltage drops stay within the defined threshold. For example, for a 5% allowable voltage drop on a 12V rail, the maximum drop should not exceed 0.6V.
Optimize Power Planes: If voltage drops exceed acceptable levels, consider adjusting the power plane thickness, trace width, or component placement.



5. Analyze Current Density
Simulate Current Density: Calculate current density (current per unit area) on power planes and traces. This helps identify areas where high current could cause overheating.
Compare to Thresholds: Ensure that the current density does not exceed material limits (e.g., copper has a typical limit of 100 mA/mil^2).
Adjust Layout: If current density is too high, you may need to widen traces, improve via designs, or redistribute the current load.

6. Evaluate Via Current
Simulate Via Current Flow: Analyze current flowing through vias between different PCB layers.
Check Via Capacity: Ensure that the current through any single via does not exceed its maximum rating (typically 1A for a standard via).
Optimize Via Layout: Add more vias or increase their size if the current exceeds the allowable limits.

7. Run AC Analysis (Impedance and Noise)
Impedance Simulation: Run AC simulations to assess the impedance profile of the power distribution network across a range of frequencies.
Optimize Decoupling Strategy: Ensure that decoupling capacitors provide low impedance at high frequencies to minimize noise and ripple.
Check for Noise Peaks: Identify any impedance peaks that may cause voltage fluctuations or instability in power delivery.

4. Power Integrity Analysis in ADAS CMS

Let's conduct a power integrity analysis for the high-speed section,

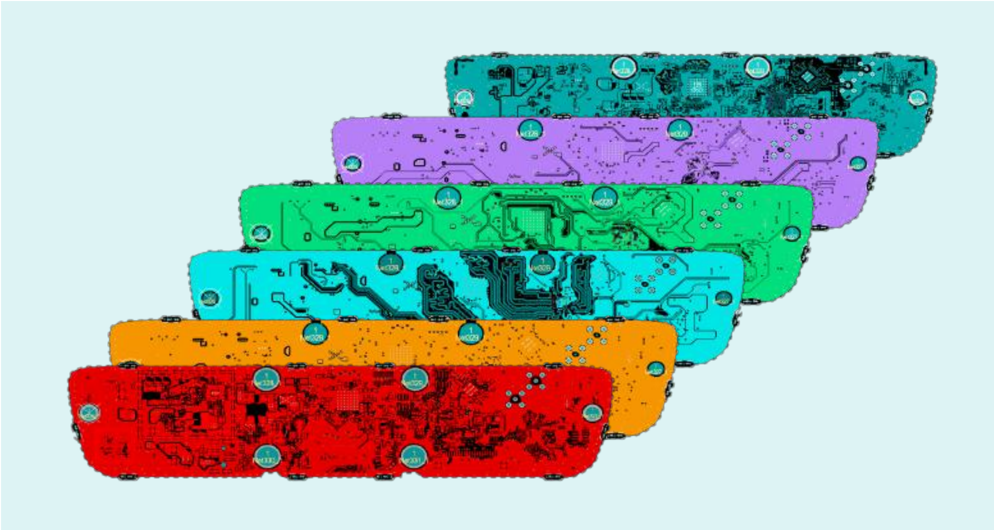
By doing this analysis, you ensure that the board delivers power effectively and reliably, which is especially important for advanced systems like those used in self-driving cars.

Design of PCB Layout

- This layout includes circuits like De-Serializer, Image Signal Processor, and Display Controller.
- They work together for the TFT Display, showing the signals from the camera in an Autonomous application.

Power Circuits
Manage the core voltage requirements across different systems. Each voltage rail supports a critical function in the ADAS camera's power delivery.

- +12V
- SEPIC Power – 9.5V
- Coax Power – 8.6V
- +3.3V
- +5V
- +2.0V
- +1.8V
- +1.5V
- +0.9V



High Speed Signal Circuits
Handles real-time communication and data processing in the ADAS system.

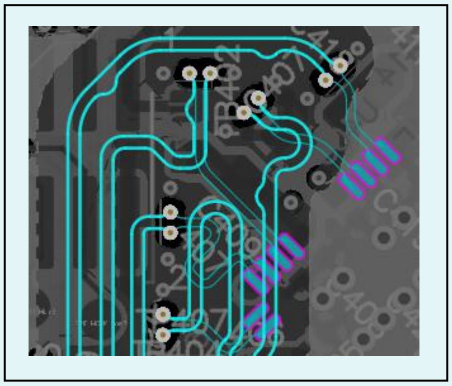
- De-Serializer
- Image Signal Processor
- Display Controller

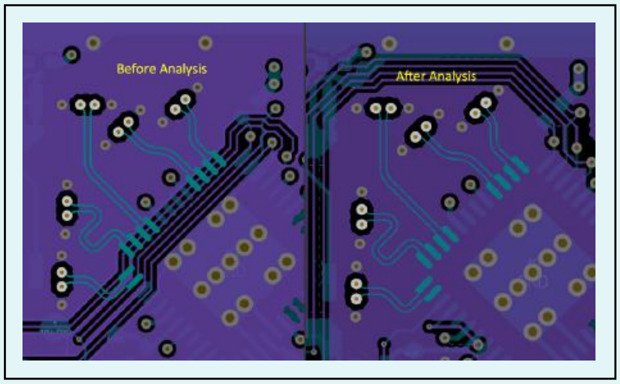
Sensor Circuit
Collects data from the environment to inform the ADAS camera and system.

- Ambient Light Sensor
- Toggle sensor

Challenges in CMS Layout

- Designing with fine-pitch BGA (0.65mm) requires precision.
- Optimizing blind and buried vias for signal integrity and space efficiency.
- Managing high-speed signals (MIPI, LVDS) to ensure quality and reduce interference.
- Implementing multiple power pours without introducing issues.
- Analyzing voltage drop, current density, and via current to handle electrical demands.
- Monitoring PDN impedance to maintain stable power distribution.
- Reducing high-impedance (High-Z) areas to improve signal integrity.
- Managing internal resistance of power planes to reduce power loss.
- Addressing ripple and noise coupling in power rails to minimize interference.

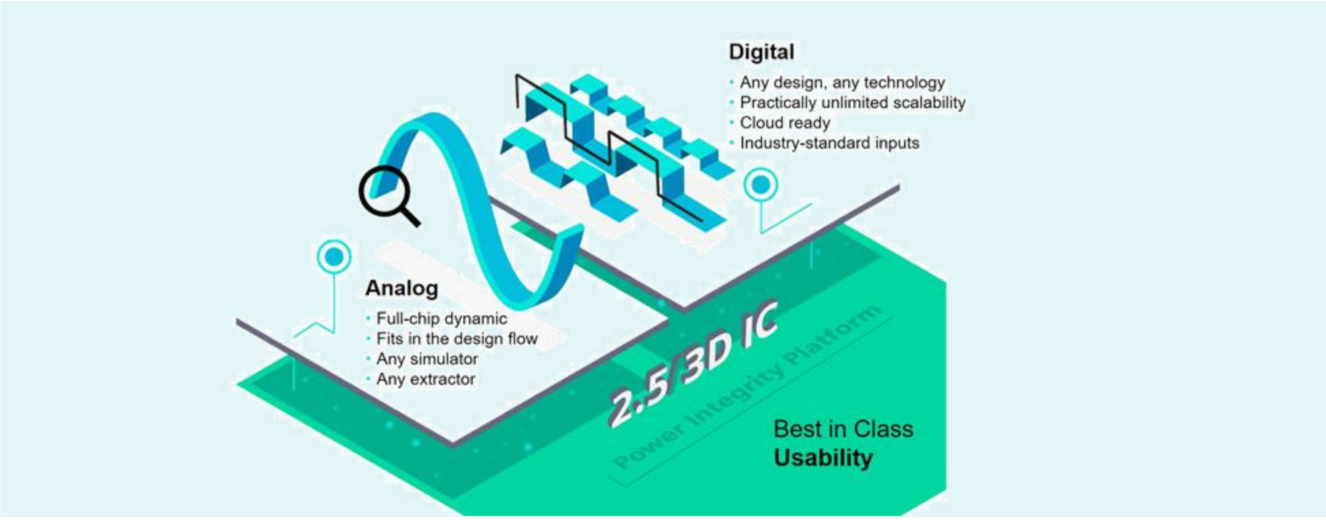




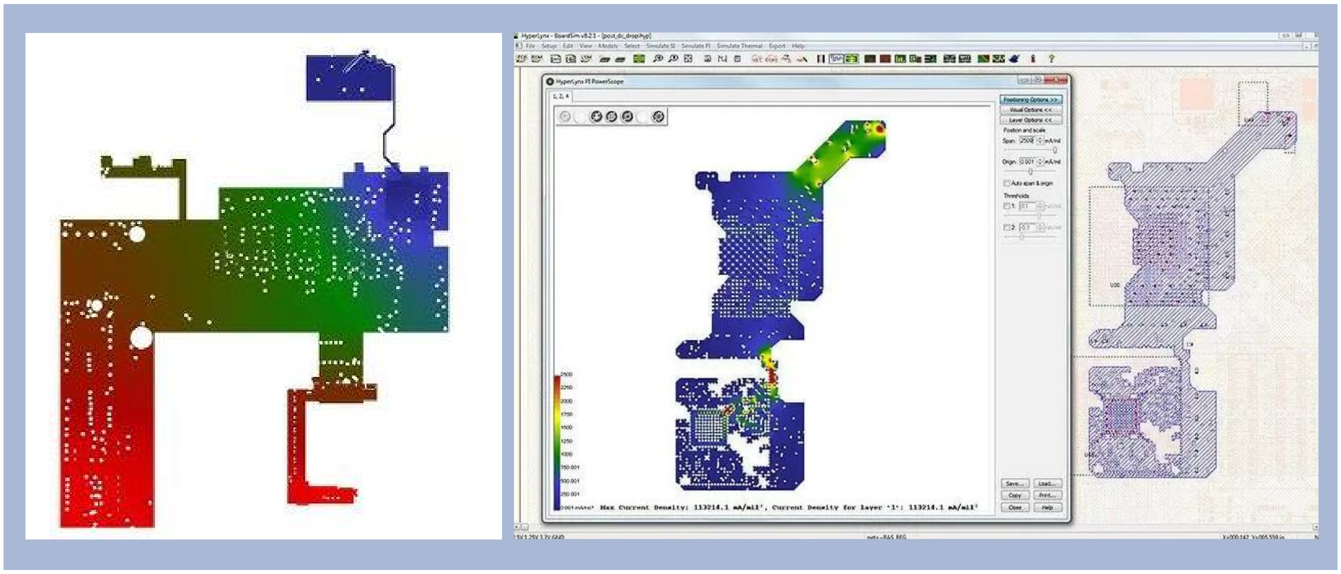
Analysis Execution

In this analysis, the HyperLynx tool was used to evaluate the power integrity performance of the ADAS camera monitoring system's PCB layout.

This tool is essential for simulating how power is delivered across the PCB, ensuring it meets the requirements for efficient operation.



Quantities to Calculate include



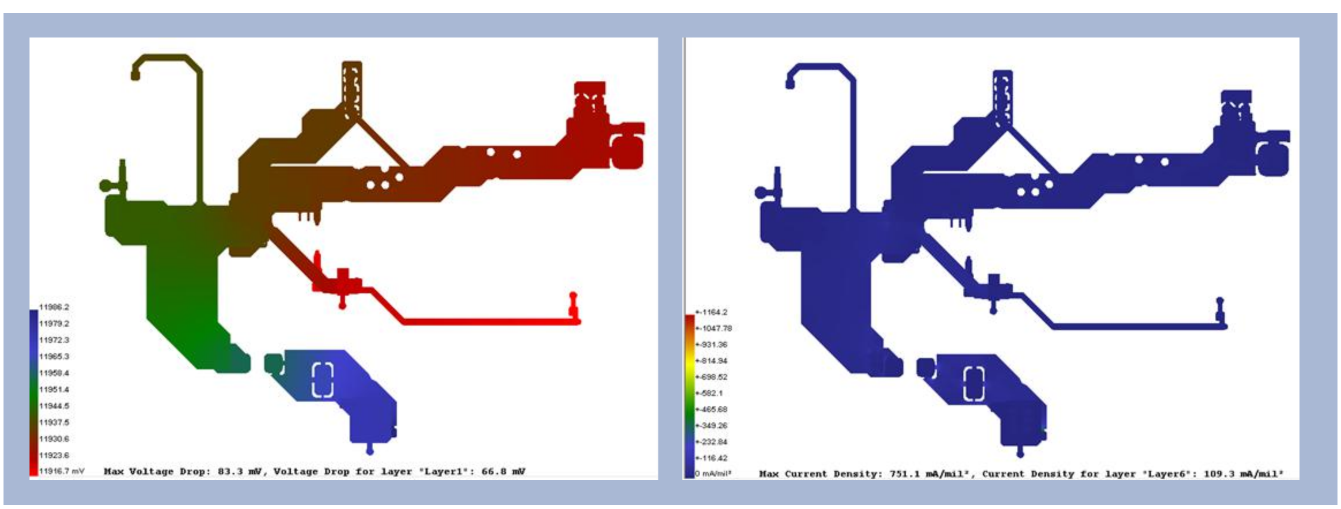
- DC resistance and current density in rails and planes
- Voltage and current distribution throughout the PCB layout
- Transient response on power rails in the time domain

$$Z(\omega) = \frac{V_{core} \times V_{ripple}(\%)}{I_{chip}(\omega) + I_{DC}}$$

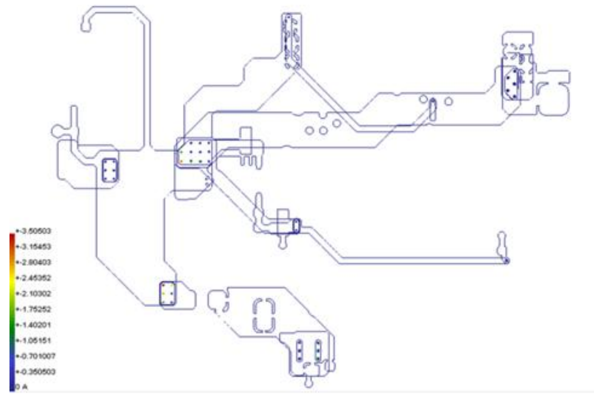
Analysis – Plots and Results

Power integrity is analyzed to evaluate the power circuits within the layout, at the Hyperlynx tool,

Net Name: +12V Voltage:12V Current:3.25A



Analysis Parameters – Requirements
Max. Voltage Drop – 5.00%
Max. Current Density – 100.00mA/mil²
Max. Via Current – 1000.0mA

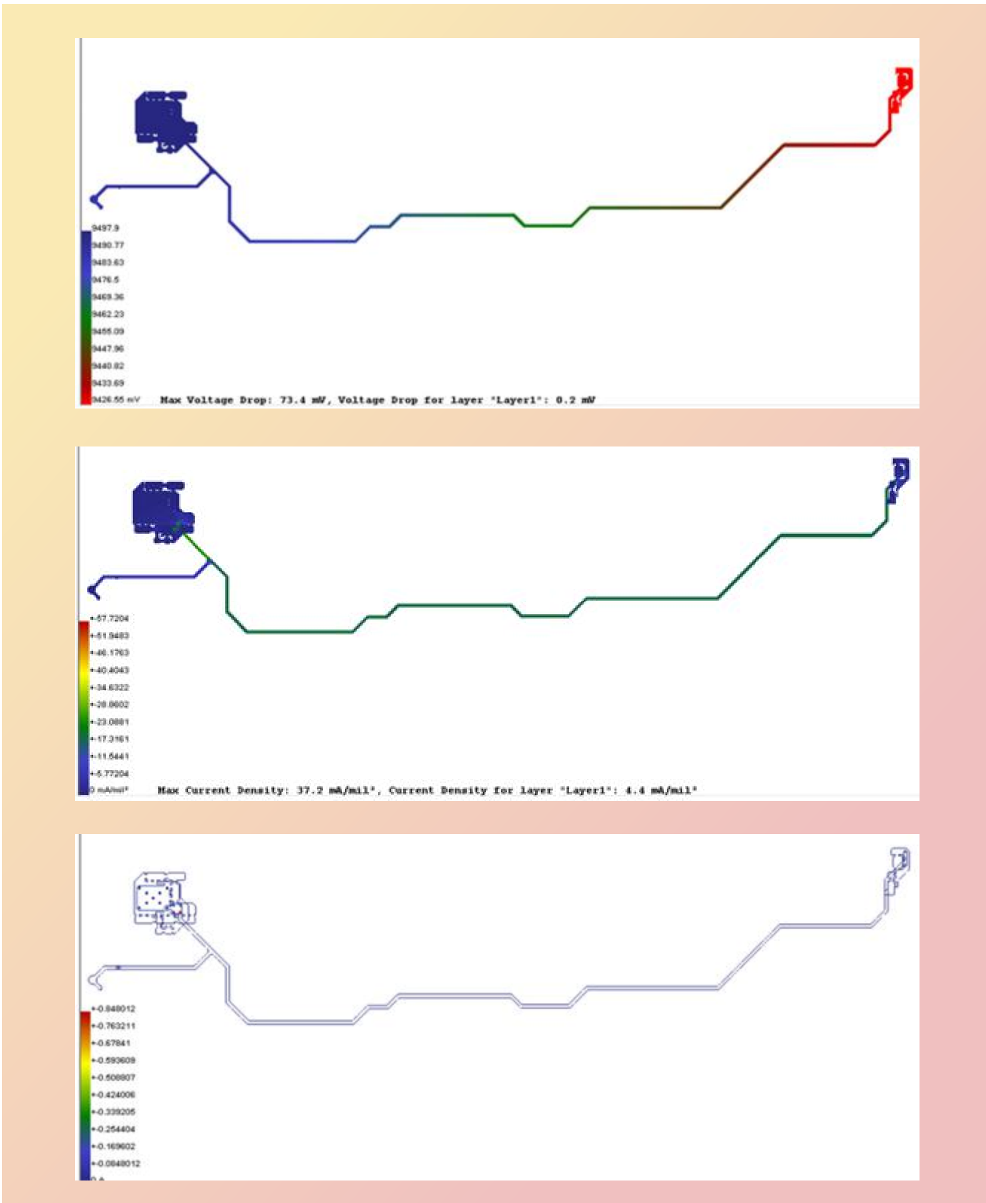


#	Measurement	Test	Constraint	Max Value	Location
	Filter	Filter	Filter	Filter	Filter
1	Max Voltage Drop	PASS	5.000%	NET +3.3V: 0.861% (28.4mV)	pin R322.1
2	Max Current Density	FAIL	100.00mA/mil2	253.67mA/mil2	(12.584, 17.850), layer Layer1
3	Max Via Current	FAIL	1000.0mA	3386.5mA	(16.831, 17.691) between layers Layer5 and Layer6

ANALYSIS TYPE	REQUIRED THRESHOLD	SIMULATION RESULT	INTERPRETATION	PASS/FAIL
Voltage Drop Analysis	Maximum allowable voltage drop: 5% of 12V (0.6V)	Voltage drop across the power plane: 0.4V	3.33% (0.4V / 12V × 100%) < 5%, so the voltage drop is within the acceptable range, ensuring sufficient power delivery.	Pass
Current Density Analysis	Maximum allowable current density: 100.00 mA/mil²	Highest observed current density: 751.10 mA/mil²	Current density of 751.10 mA/mil² exceeds the maximum allowable threshold, indicating potential risk of overheating or thermal issues	**Fail**
Via Current Analysis	Maximum allowable current per via: 1000.0 mA	Highest observed current density: 751.10 mA/mil²	through vias exceeds the maximum allowable threshold, suggesting potential risk of overheating or	Fail

Net Name: +9.5V Voltage:9.5V Current:0.55A

Analysis Parameters – Requirements
Max. Voltage Drop – 5.00%
Max. Current Density – 100.00mA/mil^2
Max. Via Current – 1000.0mA



#	Measurement	Test	Constraint	Max Value	Location
	Filter	Filter	Filter	Filter	Filter
1	Max Voltage Drop	PASS	5.000%	**NET 9.5V: 0.773% (73.4mV)**	pin U110.1
2	Max Current Density	PASS	50.00mA/mil2	**37.24mA/mil2**	(14.190, 18.202), layer Layer5
3	Max Via Current	PASS	1000.0mA	**848.0mA**	(14.180, 18.241) between layers Layer5 and Layer6

ANALYSIS TYPE	REQUIRED THRESHOLD	SIMULATION RESULT	INTERPRETATION	PASS/FAIL
Voltage Drop Analysis	Maximum allowable voltage drop: 5% of 12V (0.6V)	Voltage drop across the power plane: 0.4V	3.33% (0.4V / 12V × 100%) < 5%, so the voltage drop is within the acceptable range, ensuring sufficient power delivery.	Pass
Current Density Analysis	Maximum allowable current density: 50.00 mA/mil²	Highest observed current density: 37.24 mA/mil²	This indicates that the power traces are sufficiently wide and capable of handling the current without risking overheating or thermal issues.	Pass
Via Current Analysis	Maximum allowable current per via: 1000.0 mA	Highest observed current density: 848.0 mA/mil²	This indicates a potential risk of overheating and thermal issues. The power traces may be too narrow to handle the current safely, and adjustments to trace widths or current management may be necessary to ensure reliable operation and avoid thermal failure.	Pass

The overall power integrity of the PCB layout is solid.

The voltage drop, current density, and via current all passed their respective thresholds, indicating that the design can reliably deliver power without overheating, voltage drops, or other thermal concerns.

The system is optimized for performance and ensures power stability across the board.

Final Summary

Imagine driving the most advanced vehicle, one equipped with the latest ADAS technology, designed to keep you safe at high speeds and in unpredictable conditions.

You rely on it to make split-second decisions, reacting to hazards you might not even notice.

But what if, behind the scenes, a tiny drop in voltage or an undetected current issue compromises this precision?

That’s where power integrity becomes the silent hero.

It’s the foundation of performance in high-speed ADAS.

Without it, the smartest sensors and processors can falter.

When power isn't stable, neither is the system.

The vehicle’s reaction time, accuracy, and safety can all be put at risk.

By ensuring power integrity, you’re not just meeting design standards—you’re maximizing the performance of your ADAS system and safeguarding the lives that depend on it.

Don't let minor issues in power distribution lead to major setbacks.

Take control of your design’s power integrity today, and drive forward with confidence, knowing your ADAS system is ready for whatever the road throws at it.

It’s not just about speed. It’s about power—power you can trust.

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