Technical Article
How to Choose a Power Supply for an Automotive Camera Module

![Texas Instruments]

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As automotive camera technology advances with higher resolutions, dynamic ranges and frame rates, power-supply architectures need tailoring to the specific use-case requirements. In this article, I'll review three strategies you can use to power your automotive camera module:

- Fully discrete
- Fully integrated
- Partially integrated

The focus in this article is on small-form-factor camera modules that don't include any data processing, and output raw video data to a separate electronic control unit. These modules are often found in surround-view, driver-monitoring and mirror-replacement systems and receive a pre-regulated supply voltage over the same coaxial cable used for video data output.

How much power do you need for a camera module?

The first step when designing the power portion of a camera module is a brief calculation of the power budget for each rail. This, along with the voltage provided over power-over-coax (PoC), is important in selecting the power strategy.

A camera sensor and external circuitry require a current draw that may vary widely across different sensors and any additional external devices. Usually, the lower imager rails (1.2 V and 1.8 V in Figure 1) require the most current, while the largest supply voltage (2.9 V for the imager) requires the least. Because the 2.9-V rail pertains to the analog supply of the imager – and ultimately, its performance with regard to image quality – selecting a supply will require careful consideration, as the rail requires a clean supply with minimal noise. The included FPD-Link device, along with any form of supervisors or sequencers, will also pull from this power budget.
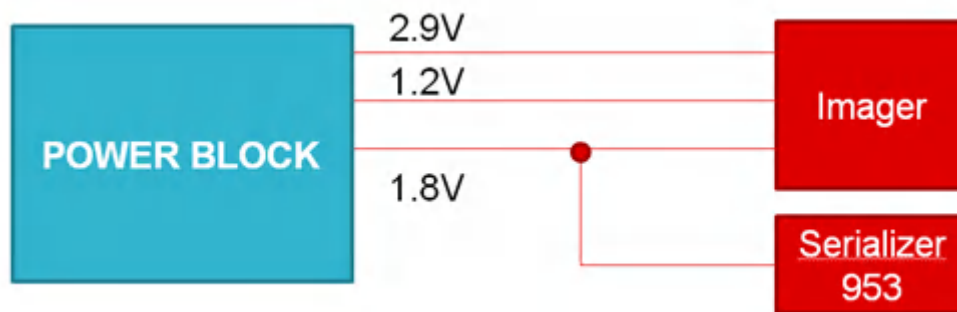

Figure 1. Calculating the power budget for each rail

One might suggest using a low-dropout regulator (LDO) for every supply considering its excellent noise performance. However, that is not feasible when designing with a limited power budget. Additionally, increasing current will stress connectors and cables and increase self heating of the camera, which may worsen performance.

As shown in the example calculation in Table 1, the current requirements for camera modules are generally determined by the sensor and FPD-Link device included in the system. In this example, the imager rails are 1.2

V, 1.8 V and 2.9 V. The FPD-Link device shares the same 1.8-V rail. The required currents for normal operation are highlighted in red.

Power Sections	Configuration	Input Voltage Range	Output Voltage Range	Current Requirement (A)	Voltage (V)	Power (W)
Bank 1	Cascade	4 to 18.3 V	3 to 4 V	0.326818182	3.3	1.0785
Bank 2	1 > 2	3 to 5.5 V	0.9 to 1.9 V	0.225	1.8	0.405
Bank 3	1 > 3	3 to 5.5 V	0.9 to 1.9 V	0.388	1.2	0.4656
LDO	1 > LDO	3 to 5.5 V	2.7 to 3.3 V	0.063	2.9	0.1827
12 V Current Requirement (A)						
0.089875						

Figure 2. Table 1: An example calculation with imager rails at 1.2 V, 1.8 V and 2.9 V

In this example, the PoC supply over the coaxial cable is first stepped down to 3.3 V, which then supplies the rest of the system on the camera module. The 2.9-V sensor analog rail is tied directly to an LDO output, while the other supplies are tied to a step-down (buck) converter. The 1.8-V rail supplies both the DS90UB953-Q1 supply, and the interface supply of the imager. Since the current consumed by the DS90UB953-Q1 serializer is predominantly greater than the imager interface supply, the 1.8-V current provided to the imager can be considered as negligible. The imager 2.9-V analog rail requires 63 mA, the DS90UB953-Q1 serializer 1.8-V rail requires 225 mA and the imager digital 1.2-V rail requires 388 mA. Assuming 100% efficiency to simplify calculations with the previous values, it is calculated that the 3.3-V supply will require 327 mA to successfully power the 1.2-V, 1.8-V, and 2.9-V rails.

Because the input and output voltages, output current requirements, and total wattage consumption are known, the input current can be calculated with:

(PoC Voltage)*(Current Required) = 3.3-v * 327 mA

For a PoC Voltage of 12-v, the ECU Would Source 90 mA.

In some situations, the PoC voltage is fixed from the ECU, therefore it's important to understand if the chosen PoC cable and network is adequate in supplying the required current for the power goal. For a 2-W camera module requirement, a fixed 5-V supply would source 400 mA, while a 12-V supply would source 166 mA.

For larger PoC cable lengths, a large PoC voltage should be chosen to ensure minimal IR drop across the cable. PoC current will create a voltage drop across the cabling, ferrite beads, inductors, and any series resistance and will reduce voltage headroom impacting camera module regulator performance. In the case that the PoC voltage value is left to the designer, cable specifications generally dictate the amount of current that the network can provide, which will drive the voltage requirement of the network.

Three power architectures for automotive camera modules

Table 2 compares the advantages and disadvantages of the three different power architectures.

Power architecture	Advantages	Disadvantages
Fully discrete: This solution generates each supply from a unique integrated circuit (IC). It provides maximum flexibility but can require more design time to choose all of the different ICs. Such architectures are not easily scalable toward future designs.	• Layout flexibility enables a compact design, resulting in a smaller solution footprint.	• Choosing and selecting all IC components is time consuming. • Supply values are fixed; it's not really a modular power design that can be easily modified to another imager, which may require different rail values and current consumption.
Fully integrated: A dedicated power-management IC (PMIC) generates all supply rails for imager and external circuitry. PMICs are usually programmable and can scale easily to future designs.	• Reduced overall project time. • Highly scalable and programmable; can be easily leveraged to future camera module solutions without significant effort.	• Reduces layout flexibility because all pins have a fixed pinout. • May result in increased solution area in order to minimize any switching interaction with imager transmission signals.
Partially integrated: A mix of single and multichannel power supplies simplifies designs and offers the best of both worlds. Layout flexibility through a partially discrete approach aids in simplifying designs and makes them easier to scale.	• Partial integration simplifies bill of materials and offers more layout flexibility than a fully integrated PMIC.	• Increased design cycle time. • Not as scalable as PMIC power architectures; however, most ICs have different voltage variants with compatible device footprints.

Figure 3. Table 2: Comparing camera module power architectures

Supply considerations

When designing for automotive applications, there are a few considerations that will limit your power design choices. Important system-level specifications include:

• Minimizing the total solution size to meet the small form factor of automotive camera module enclosures. Such enclosures are typically around 20 mm by 20 mm in area and usually fit within an M12 barrel plastic enclosure.
• Avoiding interference with the AM radio band. All switching power supplies need to be outside the AM radio band of 540 kHz to 1,700 kHz.
• Avoiding lower switching frequencies because they require large inductors. Instead, choose:
  – High-frequency switchers (>2 MHz).
  – Devices that are Automotive Electronics Council-Q100 rated.
• Electronics that need added protection such as a short-to-battery can design with wide Vin regulators.

Printed circuit board constraints

The imager in Figure 4 uses a Mobile Industry Processor Interface (MIPI) Camera Serial Interface (CSI-2), with nets highlighted to display the controlled impedance traces that connect the FPD-Link device to the imager. CSI-2 nets of the imager are brought out through vias and routed mid-layer (highlighted).

The via array poses some limitations to a smaller form factor, as they limit the area of where the power devices can be placed. To minimize coupling, especially around switch-mode power supplies or signal nets, it's important that CSI-2 nets are properly distanced, shielded and have no overlap from other nets on adjacent layers.
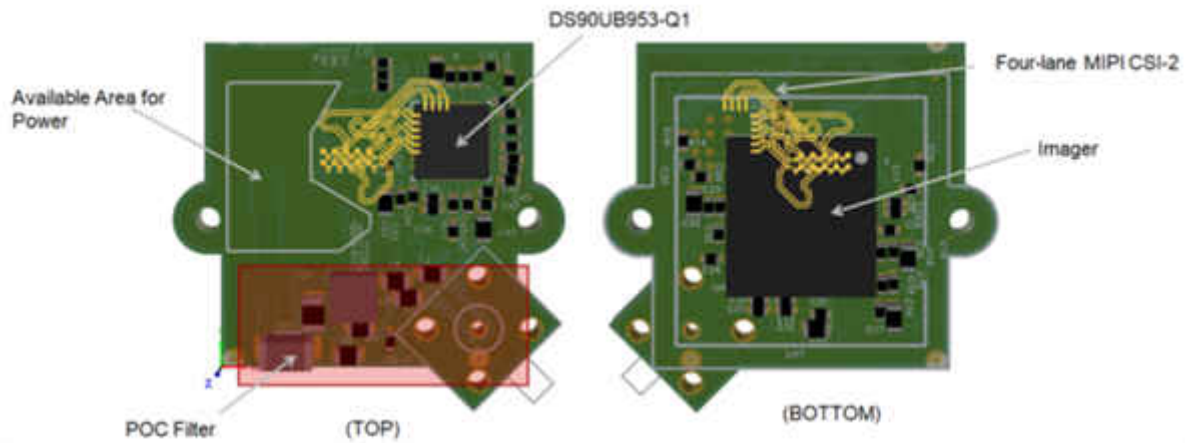
Figure 4. Example layout of the DS90UB953-Q1 with an imager

Choose your power architecture

The right power architecture will vary based on your design requirements. These reference designs will help you see the specifications in greater detail and make your design simpler when you're ready to get started:

- Fully discrete: Automotive 2-MP Camera Module Reference Design with MIPI CSI-2 Video Interface, FPD-Link III and POC.
- Fully integrated: Automotive 2-MP Camera Module Reference Design with MIPI CSI-2 Interface, PMIC, FPD-Link III and POC.
- Partially integrated, part 1: Automotive 2-MP Camera Module Reference Design with MIPI CSI-2 Video Interface, FPD-Link III and POC and part 2: Automotive 2.6-MP Camera Module Reference Design with POL PMIC, FPD-Link III, Supervisor and POC.

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