Technical Article

Improving Industrial Radar RF Performance with Low-noise, Thermal-optimized Power Solutions

Shashank Sharma

For years, passive infrared sensors and lasers have sensed remote objects or measured range in applications such as robotics, level sensing, people counting, automated doors and gates, and traffic monitoring. But with demand for higher precision and resiliency against environmental influences such as bad light, harsh weather conditions and extreme temperatures, it is inevitable that millimeter-wave (mmWave) radar technology will take over.

mmWave technology provides ultrawide resolution, better calibration and monitoring, and highly linear signal generation for accuracy in radio-frequency (RF) sensing. These benefits enable the detection of objects in otherwise obstructed views for intelligent safety in forklifts and drones, and enhance sensing performance that improves power in intelligent streetlights and perimeter security.

For autonomous guided vehicles (AGVs) and collaborative robots (cobots) in industrial automation, mmWave technology offers not just high accuracy but preserves safety by helping avoid collisions of AGVs with other objects or human accidents caused by cobots.

The low noise and thermal performance of a radar's power solution also plays a major role in its ability to sense, image and communicate the range, velocity and angle of remote objects with high accuracy.

In this article, I'll discuss power-supply design challenges that are applicable to any radar processor in the industry, using the 60- to 64-GHz IWR6843 and 76- to 81-GHz IWR1843 mmWave radar sensors as examples.

Let's begin with the most important power specifications and how you can best meet those parameters.

Tight Ripple Specifications

Ripple is an unwanted side effect of switching regulators that is normally suppressed by the design architecture or output filter selection. Ripple directly affects the output voltage accuracy and noise level, and thus the RF performance of the system.

The RF rails of a radar processor are sensitive to supply ripple and noise because these supplies feed blocks in the device such as the phase-locked loop, baseband analog-to-digital converter and synthesizer. The IWR6843 and IWR1843 processors have RF rails (1 V and 1.8 V) with very tight ripple specifications in the microvolt range. It's common practice to use low-dropout regulators on RF rails because of low noise, but high-current LDOs (>1 A) are costly and depreciate the system's thermal performance.

In order to meet low ripple specifications, I recommend using regulators with a high switching frequency, which will enable you to select smaller passive components (inductors, output capacitors) in the design architecture and achieve the necessary ripple amplitude.

Figure 1 shows the output ripple performance of TI's LP87702 device, which integrates two step-down DC/DC converters switching at a high frequency (4 MHz) and meets the ripple specs of the IWR6843 RF rail without the use of LDOs. The LP87702 supports spread-spectrum switching frequency modulation mode, which further helps reduce both the switching frequency spur amplitude and electromagnetic interference spurs.

Copyright © 2023 Texas Instruments Incorporated

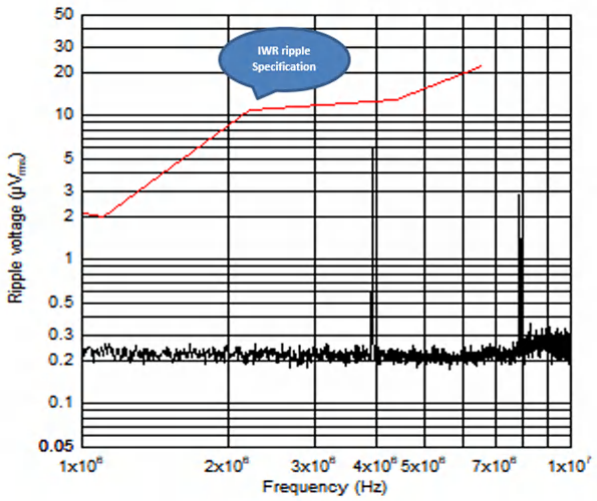

Figure 1. The LP87702'S 1-v Ripple Performance against IWR6843 Ripple Specifications, with a Low-cost Second-stage Inductor-capacitor (LC) Filter Using MPZ2012S101A Ferrite

Optimized Thermal Performance

The miniaturizing of devices has increased the heat generated per unit area in printed circuit boards; mmWave radar designs are no exception. For compact radar applications such as automatic lawn mowers or drones that also have plastic housing, thermal management becomes a priority; increased board temperatures not only reduce mmWave sensor lifetimes but also affect RF performance.

The major contributors for thermal dissipation in a radar power architecture are high-current LDOs, which add significant (>1 W) heat to the system and also affect RF performance. Plus, high-current LDOs are not only expensive; they require a heat sink, adding more cost to the system. Designing the power architecture of a radar system without LDOs prevents them from deteriorating a system's thermal performance and increasing the overall cost and solution size from external components.

Figure 2 shows how the LP87702 integrated power-management integrated circuit (PMIC) and external DC/DC step-down regulator can power all of the RF rails of the IWR6843 or IWR1483 processor. The 5-V rail from the integrated boost supports the Controller Area Network-Flexible Data Rate interface, typically required in AGVs and industrial robots.

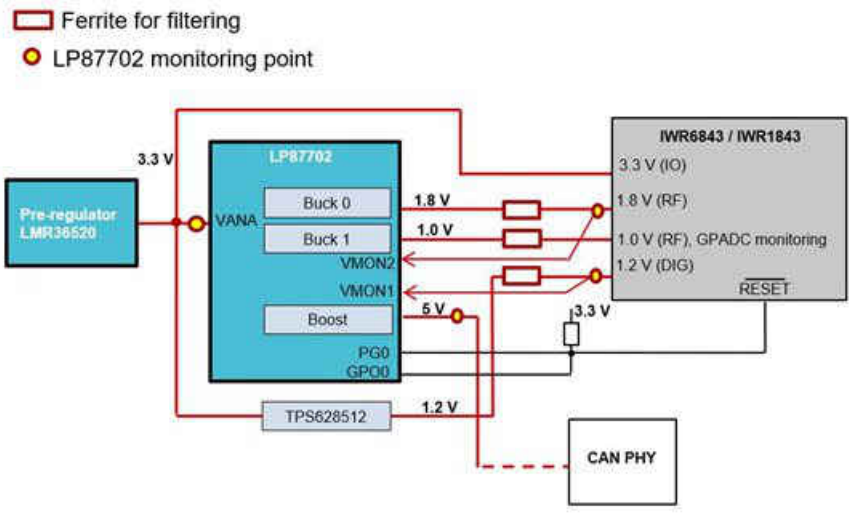

Figure 2. IWR6843 or IWR1843 Power Block Diagram

Copyright © 2023 Texas Instruments Incorporated

A two-IC solution distributes hot spots and removes the need for an external heat sink, reducing overall system cost. The integrated 4-MHz buck converters (Buck 0 and Buck 1) eliminate the need for high-current LDOs, thus improving overall efficiency and thermal performance while meeting the IWR6843 noise performance with a low-cost LC filter.

The LP87702 device also includes a protection feature against overtemperature by setting an interrupt for the host processor.

Industrial Functional Safety

Industrial functional safety standards are more important than ever, as humans are increasingly interacting with autonomous robots, safety scanners in factory automation settings, automated pedestrian doors, and industrial doors and gates. These systems must be able to detect anomalies and react accordingly.

TI's LP87702-Q1 dual buck converter supports functional safety requirements up to Safety Integrity Level (SIL)-2 at the chip level, which are specified for end equipment such as AGVs and industrial robots. By integrating two voltage-monitoring inputs for external power supplies and a window watchdog, the LP87702-Q1 helps reduce system complexity and eliminates the need for an additional safety microcontroller. By providing chip-level compliance, the LP87702-Q1 also helps streamline time to market.

SIL risk levels are determined by International Electrotechnical Commission (IEC) 61508, an international standard to help ensure safe operations between human and robotic interaction, including cobots.

Conclusion

Although LDOs offer a low-noise option for powering the RF rails of a radar processor, they can complicate overtemperature considerations, SIL compliance and system designs, and require additional components. Consider PMICs, which offer better thermal performance and ease of design.

Additional Resources

- See the LP87702 data sheet.
- Read the "Power Supply Design for xWR Radar Using LP87702K-Q1" user's guide.
- Check out the application report, "Power Management Optimizations – Low Cost LC Filter Solution."

Copyright © 2023 Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated