



**For Automotive ADAS/Infotainment
application, CISPR25 Class5 compliant
8 rails power tree Reference Design
with power rail monitoring
for supporting functional safety**

Introduction

In recent years, the importance of advanced driver-assistance systems (ADAS) that support a high level of Automotive Safety Integrity Level (ASIL) has increased as automobile accident prevention measures and autonomous driving progress. Automated driving requires a vehicle's on-board control system to replace the human driver in performing the four elements of human driving: "Cognition" with the ears and eyes, "Prediction" and "Judgment" with the brain, and "Operation" via the steering wheel and accelerator. For safe automated driving, accurate sensing, timely control and fast display imaging are necessary. For the unit to achieve safety requirements, it is also necessary to monitor the internal operating conditions and take care of any lack of functionality because of unit failure. In order to achieve this, the number of installed cameras and sensors to monitor any external situation are increasing and multi-functionality to inform and display these situations are required in the infotainment system. With the addition of electronic circuits to monitor the operating conditions in each unit, the electronic circuits are becoming more complex and a greater amount of time is being devoted to the design of units and systems.

The market requirements for Reference Design

With increasing the number of on-board units and the number of required functions, the electronic circuits of ADAS/Infotainment peripheral units require more complex designs.

- 1) An optimal combination of cost, size and characteristics are necessary as the number of cameras, sensor units and mounted electronic components increase which result in more complex power supply rails.
- 2) A highly efficient power supply system is necessary since traveling distance cannot be sacrificed.
- 3) It is difficult to see the problems in a single product consideration since there are different noise standards (e.g., CISPR25 Class 5) that have to be complied with for automotive units and many design elements other than functional design that have to be catered for.
- 4) In order to improve the safety function as a unit or system, it is necessary to have a function to monitor the power rail, detect the failure of the electronic circuit, and transmit it to the CPU.

To adapt these market requirements, ROHM has developed a reference design that satisfies the design elements required for unit design, and has disclosed the available design data on website.

Overview of Reference Design (REFRPT001)

An overview of developed [reference design \(REFRPT001\)](#) as follows:

- 1) Cover the necessary power systems for [ADAS](#) and [Infotainment](#) applications with an eight-circuit power tree.
- 2) Built-in Primary^(*1) DC/DC Converter ICs (BD9P series) for stable power supply even immediately after battery cranking.

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- 3) Built-in Secondary^(*1) DC/DC Converter ICs (BD9S series) with an industry-leading small and highly efficient.
- 4) Built-in Power Supply monitoring IC with self-diagnostic functions that monitors the all eight output rails to contribute to improve functional safety level.
- 5) The following items were validated in the system level.
 - Standard Electrical Characteristics test
 - EMC test (CISPR25 Class 5 compliant without input filter)
 - Thermal performance test (separate located high-efficiency DC/DC converters distribute the heat)
- 6) On-board ICs and discrete parts are automotive AEC-Q100 or AEC-Q101 grade compliant.
- 7) Main ICs are functional safety products in the FS supportive^(*2) category.

A reference board (REFRPT001-EVK-001) outline of the reference design (REFRPT001) (Figure 1) and a system block diagram (Figure 2) are shown below. It is designed to supply power to SoC, MCU, and CAN devices from two primary DC/DC Converter ICs (BD9P series) by splitting into four outputs each. It can also monitor the power rails of all eight outputs, helping to improve the level of functional safety systems.

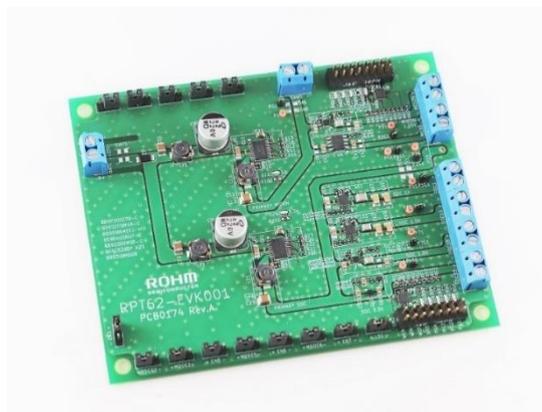


Figure 1. Reference Board (REFRPT001-EVK-001) Outline

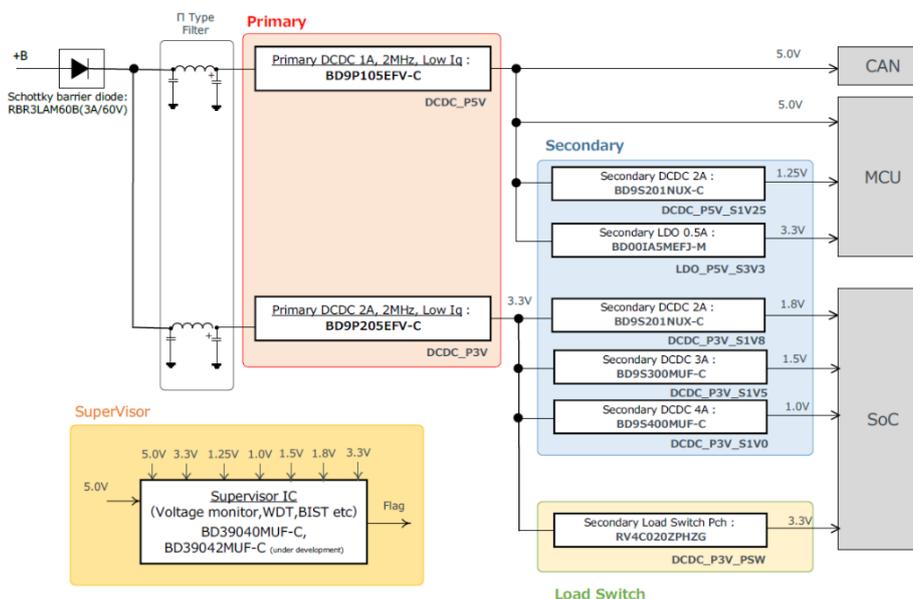


Figure 2. Reference Design (REFRPT001) Block Diagram

The following are EMC test results disclosed as evaluation data. It is shown that EMC radiation noise (vertical antenna) (Figure 3), radiation noise (horizontal antenna) (Figure 4), and conduction noise (Figure 5) passed CISPR25 Class 5, even with the entire board in operation without input filter. Since an input filter, which improves noise margins is also implemented in the pattern, it is possible to take additional measures for EMC problems that would take a lot of man-hours to fix if they occurred in a unit.

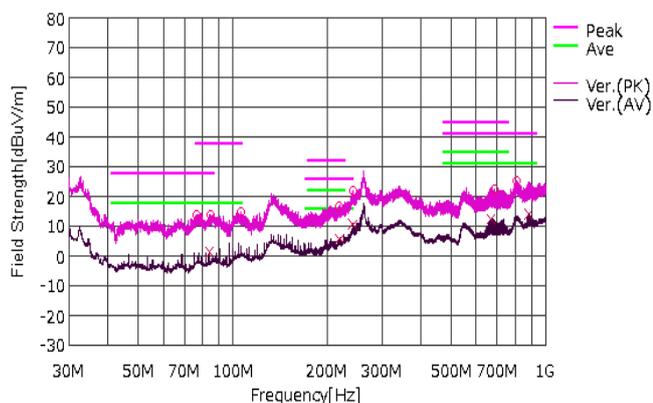


Figure 3. Radiation Noise (vertical antenna)

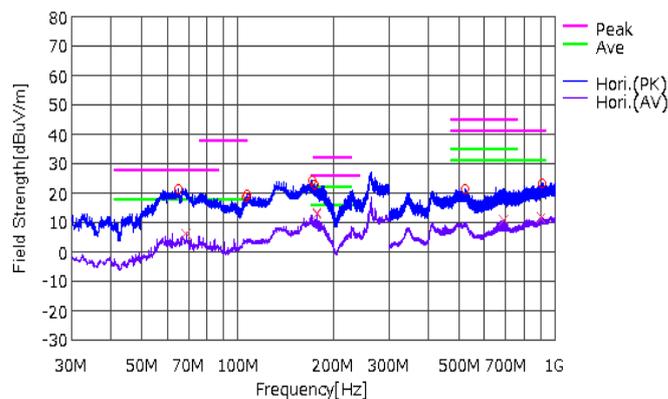


Figure 4. Radiation Noise (horizontal antenna)

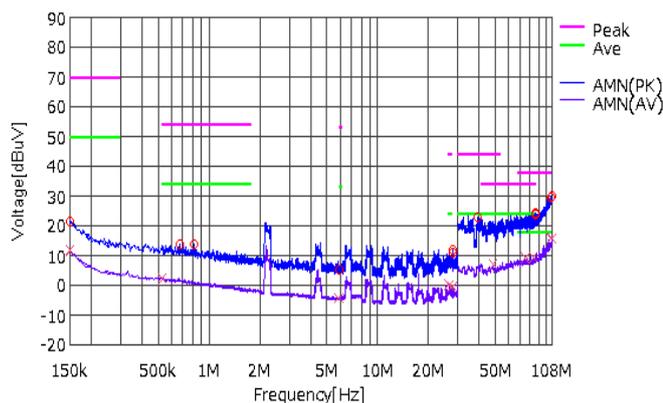


Figure 5. Conduction Noise

Content and tools to fully support customer's design

The design data of this [reference design \(REFRPT001\)](#) is available on ROHM website. In addition, various design support tools are available.

- Reference Block Diagram, Reference Circuit, BOM
- PCB information / PCB data
- Test report (Standard Electrical Characteristic, EMC, Thermal)
- Part of design can be simulated with free web simulation tool (ROHM Solution Simulator)
- Spice Model of mounted products
- Symbol and Footprint of mounted products
- Thermal simulation model of mounted products

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As mentioned above, the part of this reference design can be simulated using [ROHM Solution Simulator](#)^(*3). The ROHM Solution Simulator is a free web-based simulation tool, and reference circuits including peripheral circuits are available. It allows users to perform simulations easily without preparing any simulation circuits or models.

An example of simulation is introduced below:

- Simulation of a two rails power tree with a secondary DC/DC converter (BD9S201) and LDO (BD001A5M) behind the primary DC/DC converter (BD9P105) connected battery input. (Figure 6)

**Simulation circuit is [here](#). My ROHM registration is required.

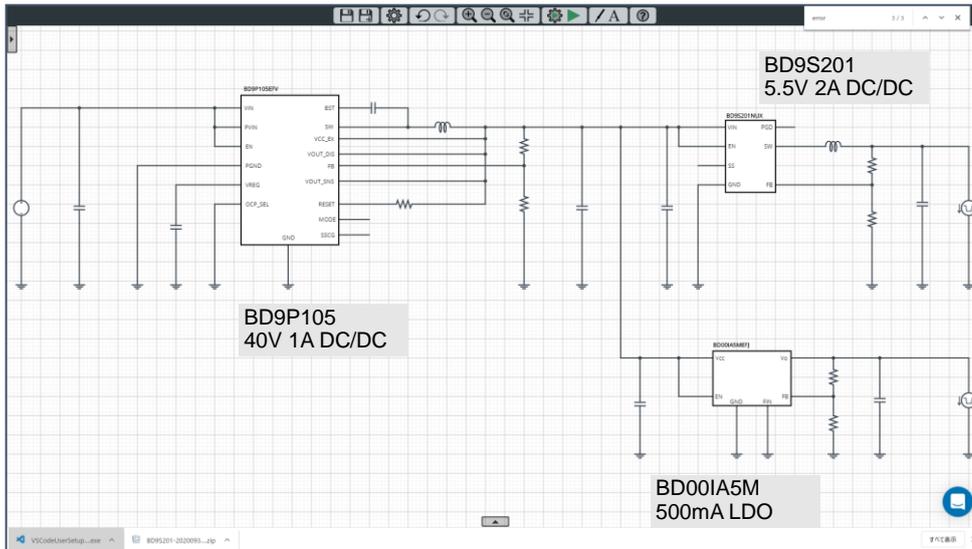


Figure 6. two rails power tree simulation circuit (1)

- Simulation of a three rails power tree with a secondary DC/DC converter behind the primary DC/DC converter (BD9P205) connected battery input. (Figure 7)

**Simulation circuit is [here](#). My ROHM registration is required.

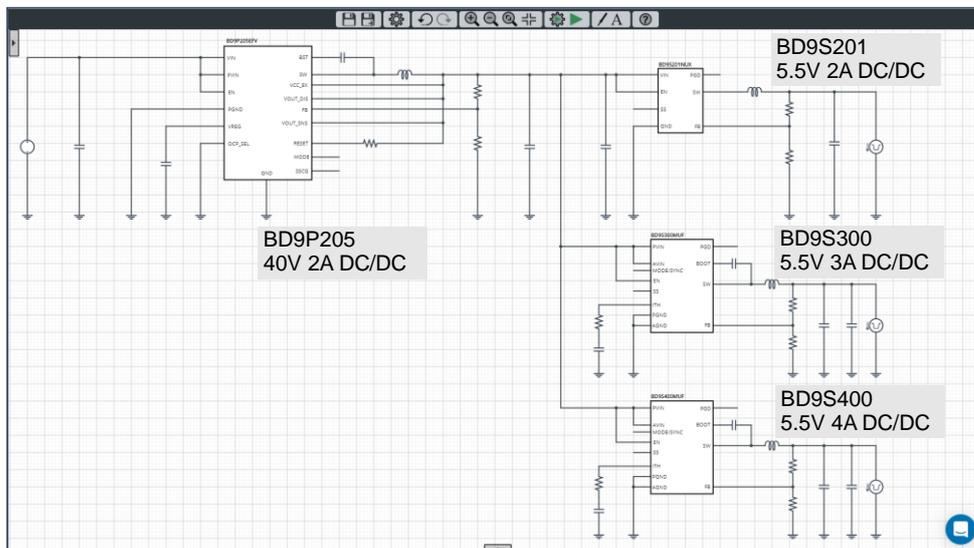


Figure 7. three rails power tree simulation circuit (2)

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Utilizing these reference design data and simulator in the design of ADAS/Infotainment units can greatly reduce the number of unit design cycles by eliminating the process to select components and ensure to validate the circuit specification.

Advanced technology products that support distinctive reference designs

The distinctive reference design is made up of products with advanced technology and features.

- **BD9P Series** (with Nano Pulse Control™(*4) technology)

- 42V Automotive Primary DC/DC Converter Series. (Table 1)
- Quick response to provide a stable power supply for battery cranking.
- Low EMI noise with a switching frequency spread spectrum function.
- FS supportive category of functional safety products.

| Part No. | Input Voltage | Output Voltage | Maximum Output Current | Package | AEC -Q100 | Functional Safety | Reference Design |
|--------------|---|----------------|------------------------|-------------------------------------|-----------|-------------------|------------------|
| BD9P105MUF-C | 3.5V to 40.0V (maximum absolute 42V) | 0.8V to 8.5V | 1.0A | VQFN20FV4040 (4.0 x 4.0 x 1.0mm) | ✓ | FS Supportive | - |
| BD9P135MUF-C | | 3.3V(typ) | | | ✓ | FS Supportive | - |
| BD9P155MUF-C | | 5.0V(typ) | | | ✓ | FS Supportive | - |
| BD9P205MUF-C | | 0.8V to 8.5V | 2.0A | | ✓ | FS Supportive | - |
| BD9P235MUF-C | | 3.3V(typ) | | | ✓ | FS Supportive | - |
| BD9P255MUF-C | | 5.0V(typ) | | | ✓ | FS Supportive | - |
| BD9P105EFV-C | 3.5V to 40.0V (maximum absolute 42V) | 0.8V to 8.5V | 1.0A | HTSSOP-B20 (6.5 x 6.4 x 1.0mm) | ✓ | FS Supportive | ✓ |
| BD9P135EFV-C | | 3.3V(typ) | | | ✓ | FS Supportive | - |
| BD9P155EFV-C | | 5.0V(typ) | | | ✓ | FS Supportive | - |
| BD9P205EFV-C | | 0.8V to 8.5V | 2.0A | | ✓ | FS Supportive | ✓ |
| BD9P235EFV-C | | 3.3V(typ) | | | ✓ | FS Supportive | - |
| BD9P255EFV-C | | 5.0V(typ) | | | ✓ | FS Supportive | - |

Table 1. Line up of Primary DC/DC Converter BD9P series

- **BD9S Series**

- Automotive Secondary DC/DC Converter Series. (Table 2)
- Contributes to high reliability of the system with Output voltage monitoring function and soft-start time variable function.
- 2mm x 2mm small package and industry-leading high efficiency.
- 2.2 MHz (typ.) switching frequency without interference to the AM band.
- FS supportive category of functional safety products.

| Part No. | Input Voltage | Output Voltage(typ) | Maximum Output Current | Package | AEC -Q100 | Functional Safety | Reference Design | |
|--------------|---------------|---------------------|------------------------|-------------------------------------|-----------|-------------------|------------------|---|
| BD9S200MUF-C | 2.7V to 5.5V | 0.8V to Vin x 0.8V | 2.0A | VQFN16FV3030 (3.0 x 3.0 x 1.0mm) | ✓ | FS Supportive | - | |
| BD9S300MUF-C | | | 3.0A | | ✓ | FS Supportive | ✓ | |
| BD9S400MUF-C | | | 4.0A | | ✓ | FS Supportive | ✓ | |
| BD9S000NUX-C | 2.7V to 5.5V | 0.8V to Vin | 0.6A | VSON008X2020 (2.0 x 2.0 x 0.6mm) | ✓ | FS Supportive | - | |
| BD9S100NUX-C | | | 1.0A | | ✓ | FS Supportive | - | |
| BD9S110NUX-C | | 1.2V | 1.0A | | ✓ | FS Supportive | - | |
| BD9S111NUX-C | | 1.8V | 1.0A | | ✓ | FS Supportive | - | |
| BD9S201NUX-C | | 0.8V to Vin | 2.0A | | | ✓ | FS Supportive | ✓ |
| | | | | | | ✓ | FS Supportive | ✓ |

Table 2. Line up of Secondary DC/DC Converter BD9S series

- [BD39040MUF-C](#)

- Power Supply monitoring IC with built-in self-diagnostic function (BIST) to support functional safety. (Figure 8)
- Built-in Variable watchdog timer (window type), over voltage monitor, under voltage monitor and reset functions.
- Built-in self-diagnostic function (BIST) as well as system power rail monitoring to detect potential failures.
- Redundant internal reference voltage circuits and oscillator circuits to significantly reduce the probability of failure.
- FS supportive category of functional safety products.
- Small 3mm x 3mm package make it easy to add to the system.

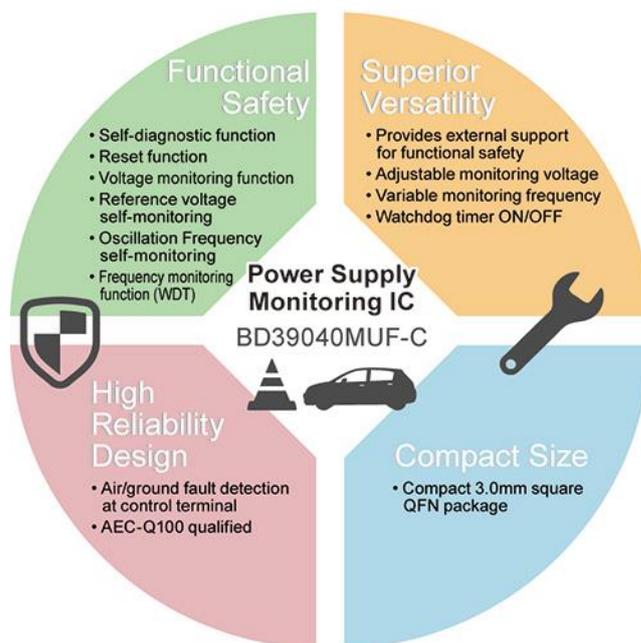


Figure 8. Feature of Power Supply Monitoring IC BD39040MUF-C

- [RBR3LAM60BTF](#)

This is a high-reliability, automotive grade (AEC-Q101 compliant) 60V Schottky barrier diode. In this reference design, it is used as a battery input backflow prevention diode. To minimize the dropping voltage due to the diode's forward voltage (V_f), the RBR series has been used with low V_f .

- [RV4C020ZPHZG](#)

A highly reliable, 1.5 V drive, low ON-resistance, automotive grade (AEC-Q101 compliant) P-ch MOSFET. It is packaged in a bottom electrode package for high mounting reliability, and the wettable flank shape does not impair visibility after mounted. In this reference design, it is used as a load switch to split the 3.3V system.

Conclusion

ROHM will continue to develop advanced products and reference designs to apply them to applications, thereby save energy, downsizing, reducing heat generations, reducing design man-hours and improving functional safety level for customer's units. We believe that our sustaining and continuing efforts will bring safety and security to the automobile society and bring rich lives to people all over the world.

[Terminology]

(*1) Primary, Secondary

In a multi-rail power system, the first stage conversion circuit from the battery or other power source is called the Primary. The second stage conversion circuit connected to the output of the primary is called the Secondary.

(*2) FS supportive

ROHM categorizes the forms that can be provided for functional safety by product. The component-level forms are necessary to achieve functional safety in the unit.

For detail information: <https://www.rohm.com/functional-safety>

(*3) ROHM Solution Simulator

This is a free simulation tool that runs on the official ROHM website. Solution circuits, which is close to application circuits such as circuits combining SiC power devices with gate driver ICs, can be simulated. It reduces design and circuit verification man-hours.

For detail information: <https://www.rohm.com/solution-simulator>

(*4) Nano Pulse Control™

This is one of the Nano series, an innovative power supply technology developed by ROHM. The ultra-fast pulse control technology enables a significant improvement in the conversion ratio and fast response time in power supply ICs. It helps to reduce BOM costs in the system.

For detail information: <https://www.rohm.com/support/nano>

*Nano Pulse Control™ is trademark or registered trademark of ROHM Co., Ltd.

[References]

ROHM official web site. "New Ultra-Compact Automotive Grade Buck DC/DC Converters"

<https://www.rohm.com/news-detail?news-title=ultra-compact-automotive-grade-buck-dc-dc-converters&defaultGroupId=false>

ROHM official web site. "New Power Supply Monitoring IC with Built-In Self-Diagnostic Function that Supports Functional Safety"

<https://www.rohm.com/news-detail?news-title=power-supply-monitoring-ic-with-built-in-self-diagnostic-function&defaultGroupId=false>

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