

Current sense amplifiers, Shunt resistors, TVS diodes

Design Guide of Current Sensing Circuit Using Shunt Resistor

High-precision current sensing circuits are utilized in various applications for stable operation, improved characteristics, and enhanced safety. We have published reference designs of high-precision current sensing circuits using the shunt resistor method (REF68011, REF68012, REF68013, REF68014, and REF68015), which employs a BD142xx series current sense amplifier. This application note explains their circuit design approaches. A critical issue for current sensing circuits using the shunt resistor method is heat generation by shunt resistors. We evaluated the heat generation by shunt resistors using actual boards and published the evaluation data in a separate application note. Refer to "[Thermal Evaluation of Current Sensing Circuit Using Shunt Resistor](#)".

Design approaches for current sensing circuits using the shunt resistor

Figure 1 shows a basic current sensing circuit using the shunt resistor method. The electric circuit must be designed so that various requirements are satisfied by selecting the components and designing the constants.

- Determination of the shunt resistor value
- Selection of the current sense amplifier
- Setting of the constants of the input filter
- Setting of the constants of the output filter
- Terminal protection
- Consideration of heat generation by shunt resistors (see the separate application note)

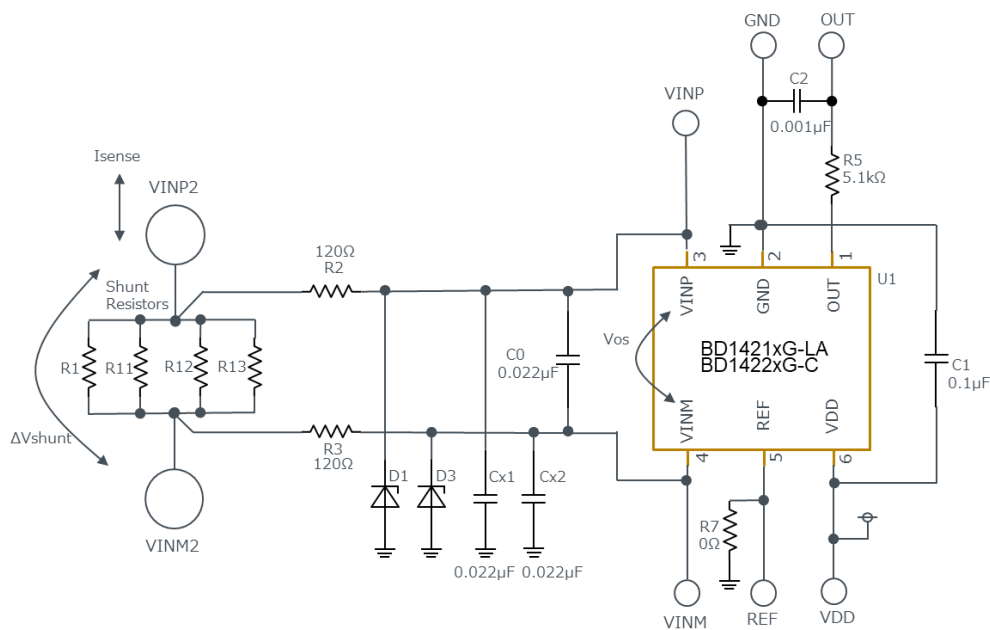


Figure 1. Typical current sensing circuit using shunt resistor method (circuit of REF68011 and REF68012)

• Determination of the shunt resistor value

The current sensing precision is affected by the voltage drop produced in the shunt resistor (ΔV_{shunt}) during the current sensing. Increasing ΔV_{shunt} can mitigate errors due to the offset characteristics of the current sense amplifier. However, a higher rated power is required for the shunt resistor. To reduce temperature rise of the shunt resistor, it becomes necessary to place shunt resistors in parallel or select a large product with a larger rated capacitance, among other countermeasures. Since these measures are expected to increase the cost and the board area, these factors must be considered comprehensively as the set specifications.

The effects of the voltage drop in the shunt resistor and the offset characteristics of the amplifier on the current sensing precision are described as follows.

$$V_o[V] = (\Delta V_{shunt} + V_{os}) * Gain \quad \dots[1]$$

$$Err[\%] = 1 - \frac{(\Delta V_{shunt} + V_{os}) * Gain}{\Delta V_{shunt} * Gain} = - \frac{V_{os}}{\Delta V_{shunt}} \quad \dots[2]$$

$$\Delta V_{shunt} [V] = R_{shunt}[\Omega] * I_{sense}[A]$$

V_o : Output voltage [V]

ΔV_{shunt} : Voltage drop produced in the shunt resistor [V]

V_{os} : Offset of the current sense amplifier [V]

Gain: Gain of the amplifier circuit [V/V]

Err: Current sensing precision [%]

R_{shunt} : Resistor value of the shunt resistor [Ω]

I_{sense} : Current value to be detected [A]

Power consumed by the shunt resistor

$$P_{shunt}[W] = I_{sense}^2[A^2] * R_{shunt}[\Omega] \quad \dots[3]$$

P_{shunt} : Power produced in the shunt resistor

Equation 2 shows that the larger the ΔV_{shunt} value, the smaller the influence of V_{os} (offset of the amplifier). However, increasing ΔV_{shunt} , i.e., the shunt resistor value, increases the power consumption of the shunt resistor as shown in equation 3. The shunt resistor value must be determined with consideration of the current sensing precision and the heat generation by the shunt resistor.

• Selection of the current sense amplifier

As shown in equation 1, the offset characteristics of the amplifier (V_{os}) directly affect the current sensing precision. Therefore, you should select a current sense amplifier having sufficiently small offset characteristics with small temperature drift characteristics. Even if the sensing precision as a system is enhanced by implementing a calibration process, care must be taken because the precision may fall outside the range in which the calibration can be performed unless a certain level of precision is secured at first. For current sense amplifiers, products with a fixed gain are included in the lineup. It is necessary to select the best gain value with consideration of the voltage level of the entire circuit. The output voltage (V_o) of the current sensing circuit is the product of the voltage drop in the shunt resistor (input voltage) multiplied by the gain. The output voltage is supplied to the AD converter and MCU in the subsequent stage. It is necessary to ensure that the

output voltage is inside the output voltage range of the amplifier and does not exceed the input D range of the subsequent stage. Design the output voltage with consideration of variation in the shunt resistor value, offset of the current sense amplifier, and variation in the gain. However, if the output voltage is set to be significantly low, the slope of the change in the output voltage becomes small relative to the change in the voltage drop in the shunt resistor. As a result, the read precision with the AD converter, etc. in the subsequent stage may be degraded, affecting the sensing precision of the circuit as a whole. Therefore, be sure to select the best products for the system.

Design the output voltage so that the following conditions are satisfied.

- Reference to the ground (assuming unidirectional current sensing)

$$VOH[V] > (\Delta V_{shunt} + V_{os}) * Gain$$

- Reference to 1/2 VDD (assuming bidirectional current sensing)

$$VOH[V] > (\Delta V_{shunt} + V_{os}) * Gain + \left(\frac{1}{2} * VDD\right)$$

VOH: Specified value of the output voltage of the current sense amplifier

VDD: Supply voltage of the current sense amplifier

Furthermore, it is necessary to select a current sense amplifier with the best input common-mode voltage specifications based on a consideration of the voltage that can be produced in the node where current is detected. Together with the terminal protection explained below, it is necessary to determine the design that ensures the safety and robustness of the set.

Products compatible with the 12/24/48 V systems in the industrial and automotive sectors are listed in ROHM's lineup. The lineup will be expanded with improvement in the current sensing precision in the future.

Table 1. ROHM's current sense amplifier product lineup (as of December 2025)

Item number	Gain lineup	Input common-mode voltage range	Maximum value of input offset voltage	Gain precision	Band Width
BD1421xG-LA series BD14215FVJ-LA	20 V/V 50 V/V	-0.2 V to 26 V	±0.5 mV	±1%	40 kHz
BD1422xG-C series	25 V/V 50 V/V 100 V/V	-14 V to 40 V	±0.5 mV	±1%	40 kHz
BD1423xFJ-C series BD1423xFVJ-C series	20 V/V 50 V/V 100 V/V	-14 V to 80 V	±0.5 mV	±1%	40 kHz
BD1424xFJ-C series * Under development	20 V/V 50 V/V 100 V/V	-14 V to 80 V	±0.15 mV	±0.19%	1100 kHz

Notes: 1. For more details on the product specifications, see the specifications of the respective products.

2. The specifications of products under development are subject to change without notice. Contact our sales representative for the detailed specifications and the development status.

• Determination of the constants of the input filter

Shunt resistors can be generally expressed with the following equivalent circuit. The effect of the parasitic inductance (L) component appears in the high frequency region.

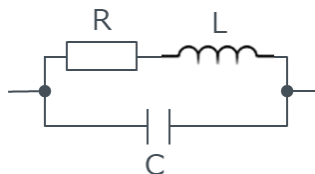


Figure 2. Equivalent circuit of shunt resistor

As an example, Figure 3 shows the frequency characteristics of impedance for the ROHM PMR100 series. An impedance variation due to the parasitic inductance (L) appears in the frequencies above 10 kHz. The apparent shunt resistor value is changed, affecting the measurement precision. If these characteristics present a problem, it is necessary to select a shunt resistor with frequency characteristics that have no influence in the frequency bandwidth where you wish to perform sensing. Furthermore, it is desirable to set the input filter constants so that the frequency characteristics due to the parasitic inductance of the shunt resistor are canceled, preventing singularity from occurring in the frequency characteristics of the entire circuit.

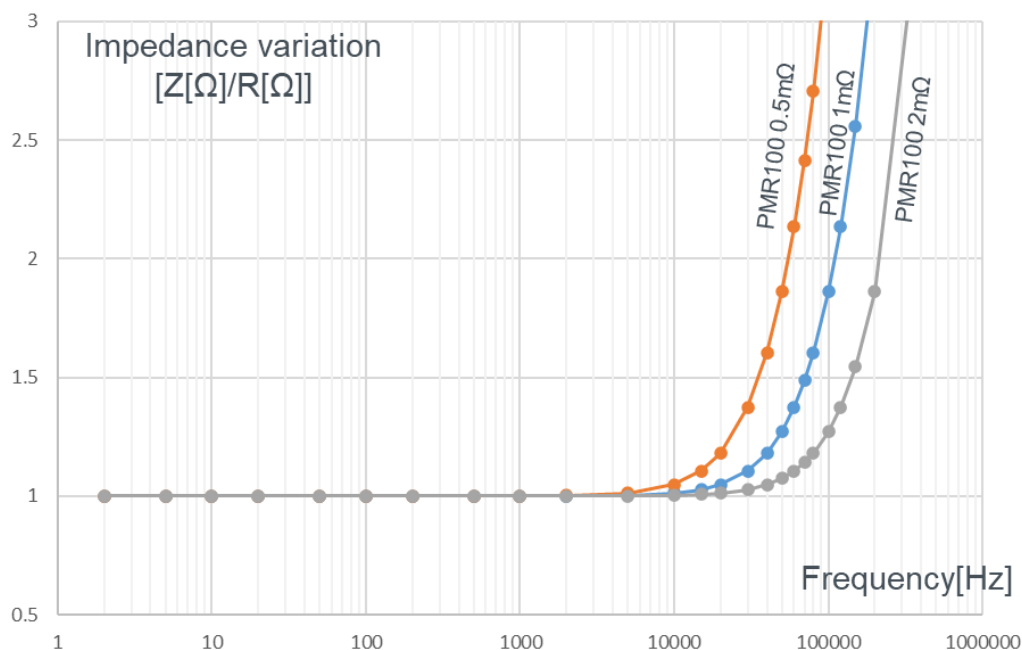


Figure 3. Frequency characteristics of impedance for PMR100 series (reference values)
 (frequency characteristics of impedance Z normalized with DC resistor value, estimated with RL series circuit)

For the input filter, it is possible to connect a capacitor to the ground or insert a capacitor between the Vin+ and Vin- terminals. However, it is necessary to consider the respective frequency characteristics when setting the input filter (Figures 4 and 5). In particular, note that the gain cannot be reduced sufficiently only by inserting a capacitor between the Vin+ and Vin- terminals.

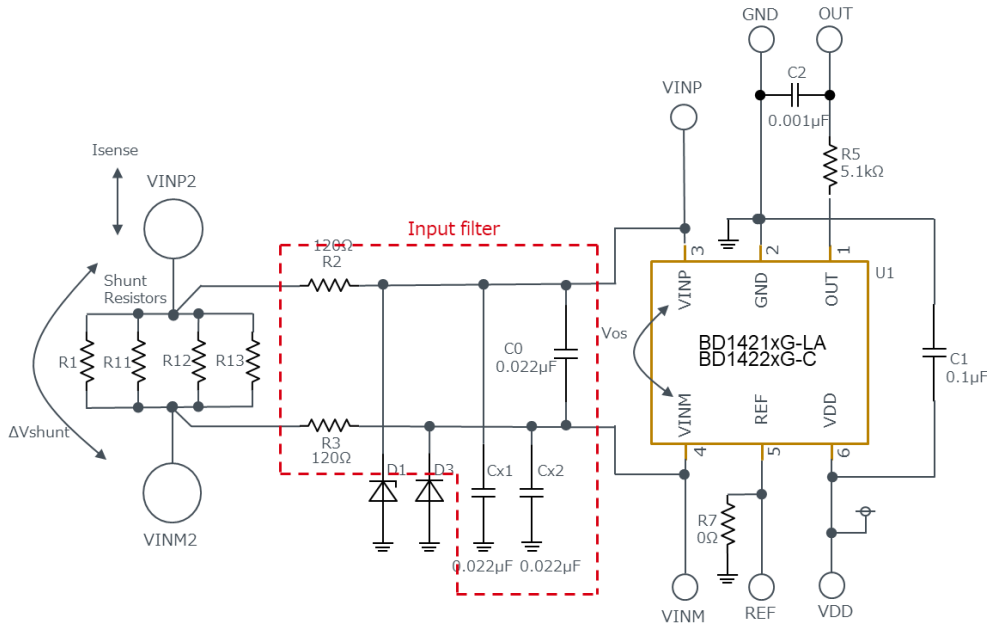


Figure 4. Example of circuit with input filter

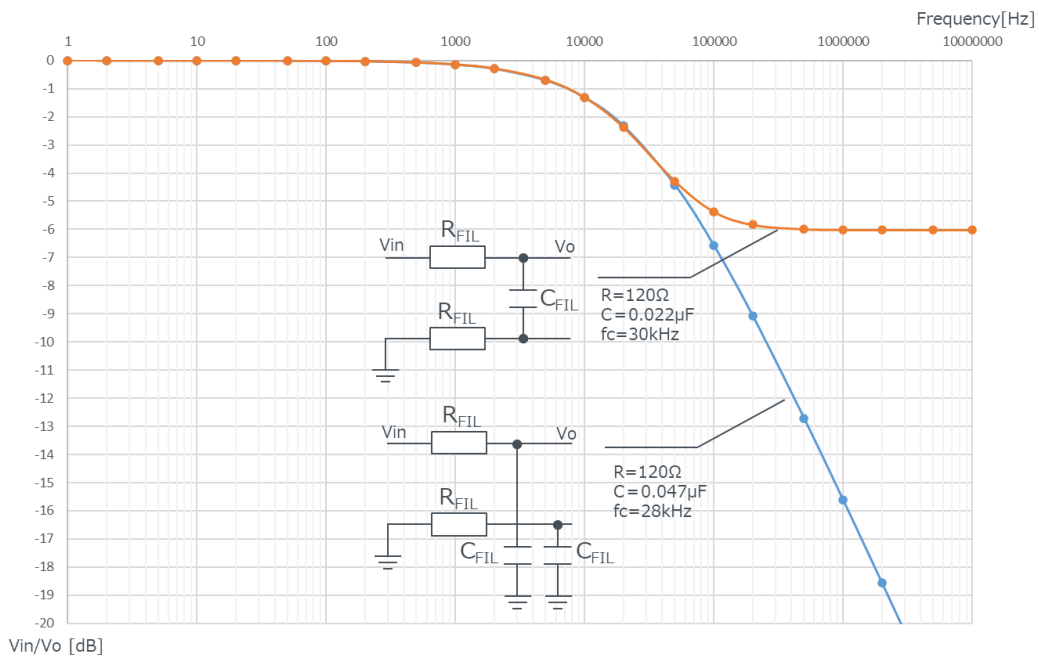


Figure 5. Difference in frequency characteristics of gain depending on filter circuit configuration (calculation assuming that one side of the differential input is the ground)

• Determination of the constants of the output filter

The BD142xx series current sense amplifier employs the sampling method to realize low offset specifications. Ripples synchronized with the sampling frequency may occur in the output voltage. Therefore, set the output filter to eliminate effects on the current sensing precision. If an RC first-order filter is used, it is also necessary to pay attention to the phase-related issues (system instability) due to the capacitive load.

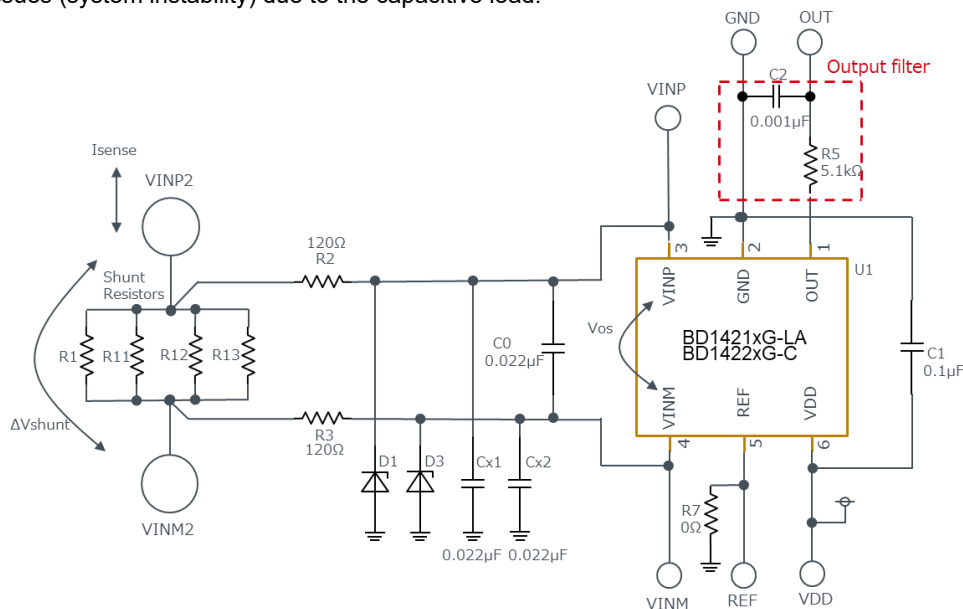


Figure 6. Example of circuit with output filter

It is necessary to determine the input filter setting, output filter setting, and bandwidth specifications of the current sense amplifier with consideration of the speed required for current sensing as well as the noise and ripples that should be removed.

• If a TVS diode is used for the terminal protection circuit

Demand for improved device safety and robustness has increased significantly. It has become a frequent practice to install a protection circuit to prevent abnormal operation. The sensing node and circuit are not isolated in the configuration for the current sensing using the shunt resistor method. Therefore, it is necessary to prepare for abnormal behaviors in the node where the current is monitored. In some cases, protection is provided so that an excessive voltage will not be applied to the input terminal of the current sense amplifier due to an open failure or short circuit failure. This section introduces a design example of a protection circuit using a TVS diode.

Normally, the upper and lower limits are specified for the system operating voltage. It is necessary to set the operating voltage range of the protection function between the lowest voltage that does not disturb the normal operation and the voltage that must not be exceeded, for example, the maximum rated value of the device (Figure 7). For example, if the sensing node contains an inductive component, the terminal voltage could jump when an open failure occurs. Therefore, it is necessary to select the components that can provide protection against the voltage and current expected to be generated due to abnormalities (Figure 8).

Note: The TVS products are primarily intended to provide protection against surges. Protection against a high power is available only for the pulse power. It is necessary to design protective measures for the overall system, such as shutting down the system in time before the rated temperature of the TVS is exceeded when an abnormality occurs. In addition, take care so that the current sensing characteristics are not affected by the reverse current or the terminal capacitance.

Voltage Diagram for terminal protection

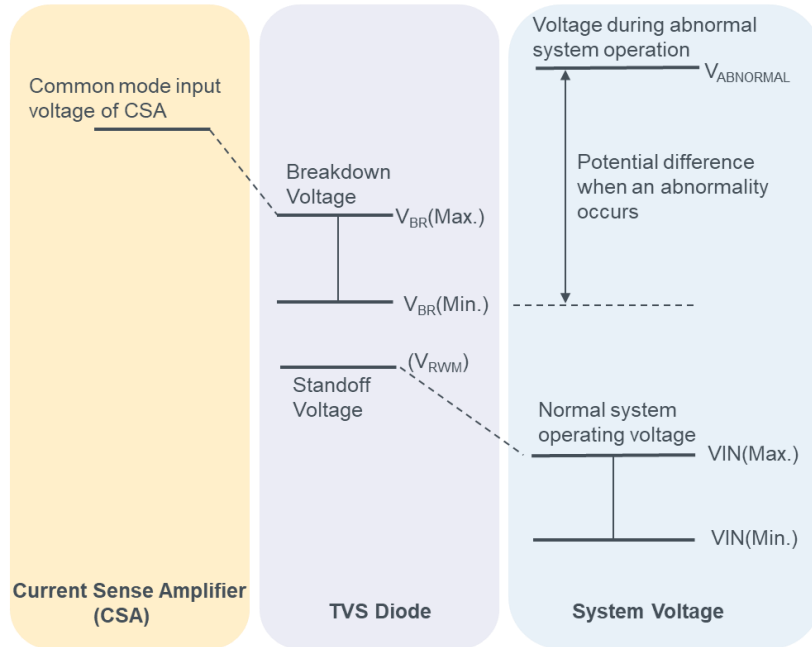


Figure 7. Voltage diagram for terminal protection

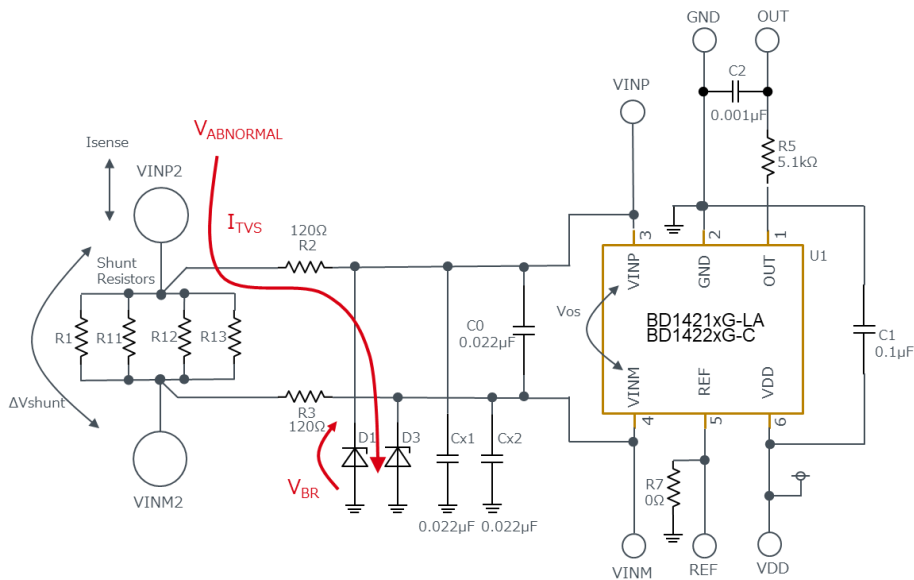


Figure 8. Example of terminal protection using TVS and current path during protective operation

For the circuit example in Figure 8, the power applied to the TVS can be calculated as follows.

$$P_{TVS}[W] = \frac{V_{ABNORMAL} - V_{BR}}{R2} * V_{BR}$$

Reference designs for current sensing circuits using the shunt resistor

The design approaches for current sensing circuits using the shunt resistor method are explained above. We have published the selection of components according to these procedures as reference designs (REF68011, REF68012, REF68013, REF68014, and REF68015). The design data and the board data are published including other reference designs for current sensing circuits (see Table 3). Refer to the reference designs that match the user’s system (supply voltage system, measuring current value, unidirectional/bidirectional, etc.) when selecting components and designing circuits.

Guide for circuit design change

When changing the design to satisfy the target specifications based on the reference designs, it is necessary to determine the constants while taking care of trade-offs after the change as well. Table 2 does not cover cases with a large-scale change in the board or system.

Table 2. Current sensing circuit using shunt resistor method: Design change and trade-offs.

Design point	Task	Trade-off
Increasing the current sensing precision	<ul style="list-style-type: none"> • Make the precision less susceptible to the offset by increasing the shunt resistor value and the ratio of the sensing voltage to the offset voltage of the amplifier. 	<ul style="list-style-type: none"> • The shunt resistor generates more heat. • The constant voltage drop produced in the shunt resistor is increased, potentially destabilizing the system with the floating ground of the sensing node, supply voltage drops, etc.
	<ul style="list-style-type: none"> • Select a current sense amplifier with a lower offset voltage and small variation in the gain. 	<ul style="list-style-type: none"> • Increase in cost
Reducing the heat generation by the shunt resistor	<ul style="list-style-type: none"> • Decrease the shunt resistance to decrease the power consumption by the shunt resistor. 	<ul style="list-style-type: none"> • Since the voltage drop produced in the shunt resistor is decreased, the sensing precision becomes more susceptible in the low current region.
	<ul style="list-style-type: none"> • Use a shunt resistor with a higher rating (including increasing the number of resistors in parallel). 	<ul style="list-style-type: none"> • The board area is increased. • Increase in cost
Expanding the sensing current range	<ul style="list-style-type: none"> • Decrease the shunt resistance to expand the sensing current range. 	<ul style="list-style-type: none"> • Since the voltage drop produced in the shunt resistor is decreased, the sensing precision becomes more susceptible in the low current region.
	<ul style="list-style-type: none"> • Decrease the gain of the current sense amplifier. 	<ul style="list-style-type: none"> • The output voltage variation is decreased relative to the unit current variation, possibly degrading the precision depending on the system in the subsequent stage.
Preventing miss-sensing due to the input noise/surge	<ul style="list-style-type: none"> • Adjust the input filter. 	<ul style="list-style-type: none"> • The sensing speed (bandwidth) is narrowed.
Changing the sensing speed	<ul style="list-style-type: none"> • Change the constants of the input filter. 	<ul style="list-style-type: none"> • The input denoising constant is changed.
	<ul style="list-style-type: none"> • Change the constants of the output filter. 	<ul style="list-style-type: none"> • The output denoising constant is changed. Since sampling ripples are superimposed on the output, $f_c = 40$ kHz or less is recommended for the BD142xx series.

Evaluation of heat generation by shunt resistors

Heat generation by shunt resistors can present a problem for current sensing circuits using the shunt resistor method. We mounted the shunt resistors selected in the reference designs on actual boards to evaluate the heat generation. The data is published as a reference for various constants and the board patterns. For details on the evaluation results, refer to the following application note: [“Thermal Evaluation of Current Sensing Circuit Using Shunt Resistor”](#).

Table 3. List of reference designs for current sensing circuits

Design No.	REF68011	REF68012	REF68013	REF68014	REF68015	REFSENS002	REFSENS003
Voltage system	12 V	24 V	48 V			5 V	12 V / 24 V
Sensing current	20 A	30 A	50 A	100 A		100 A	30 A
Sensing direction	Unidirectional	Unidirectional	Unidirectional	Unidirectional	Bidirectional	Unidirectional	Unidirectional
Board No.	BD1422xG-EVK-001		BD1423xFVJ-EVK-001			REFSENS002-EVK-001	BD14210G-EVK-001
Current sense amplifier	BD14211G-LA 26 V, 50 V/V	BD14222G-C 40 V, 100 V/V	BD14232FVJ-C 80 V, 100 V/V		BD14231FVJ-C 80 V, 50 V/V	Op-Amp LMR1802G-LB LMR1802YG-C Note: External gain resistance 60 V/V setting	BD14210G-LA 26 V, 20 V/V
Shunt resistor	PMR100HZPFV2L00 2 mΩ	PMR100HZP7FV1L00 1 mΩ	PMR100HZP7FV1L50 0.75 mΩ (1.5 mΩ, two in parallel)	PMR100HZP7FV0L50 0.25 mΩ (0.5 mΩ, two in parallel)		PSR400ITQFJ2L00 0.5 mΩ (2 mΩ, four in parallel)	LTR50UZPFU10L0 3.33 mΩ (10 mΩ, three in parallel)
Terminal protection diode	VS20VUA1VWM VS20VUA1VWMTF	VS30VUA1VWM VS30VUA1VWMTF	PMR100KTQFJ2L00 2 mΩ	PSR100KTQFF0L50 0.25 mΩ (0.5 mΩ, two in parallel)			
				VS64VLNVWM VS64VLNVWMTF		TDZV5.1	

Summary

The design approaches for current sensing circuits using the shunt resistor method with a current sense amplifier (BD142xx series) are explained. The information and thermal evaluation data for these circuits are published as reference designs, which can be used as references when designing circuits and selecting components.

For the current sensing applications, ROHM possesses an extensive product lineup, including current sense amplifiers, shunt resistors, protection diodes, and low offset op-amps. We can also suggest circuits and support thermal designing as we explained in this application note. Contact our sales representative if you need design support. If you don't know who to contact, please use our Engineer Support Site (Engineer Social Hub).

Japanese: [Engineer Social Hub エンジニアの困りごとを解決する技術サイト](#)

Chinese: [ROHM 官方技术论坛 解决工程师问题的技术网站](#)

References

[Low-Side Current Sensing Circuit Design \(Application Note\)](#)

[REFSENS002 – Reference Design: Low Side, 100A, Current Sensing with Op-Amp](#)

[REFSENS003 – Reference Design: Low Side, 30A, Current Sensing with Current Sense Amplifire](#)

[AEC-Q100 Qualified Automotive Current Sense Amps \(Brochure\)](#)

[Method of Suppressing Increase in Surface Temperature of Shunt Resistors \(Application Note\)](#)

[Effect of PCB Design on Temperature Coefficient of Resistance \(Application Note\)](#)

[PCB Layout Guideline for Current Sensing Circuit using Shunt Resistor](#)

Authored by

Kunihiro Komiya, Application Engineer

Takuya Hashimoto, Application Engineer

Appendix

Simulation circuit

Current sensing circuits are provided for free Web simulations (ROHM Solution Simulator), allowing you to determine and verify the constants for the electrical circuit operations.

Table A-1. Current sensing circuit simulation

	Product No.	Summary	Simulation Parameter		
			DC Sweep	Transient Response	Frequency Response
High-side current sensing circuit	BD1422xG-C series	Common mode input range: -14 V to 40 V Gain: 25 V/V, 50 V/V, 100 V/V selectable	✓	✓	n/a
	BD14210G-LA	Common mode input range: -0.2 V to 26 V Gain: 20 V/V	✓	✓	n/a
Low-side current sensing circuit	BD1422xG-C series	Gain: 25 V/V, 50 V/V, 100 V/V selectable	✓	✓	n/a
	BD14210G-LA	Gain: 20 V/V	✓	✓	n/a
	BD7281YG-C	An op-amp is used.	✓	✓	✓
	BD7281YG-C w/offset	An op-amp is used. The offset effect can be simulated.	✓	n/a	n/a
	LMR1802G-LB	An op-amp is used.	✓	✓	✓
	LMR1802G-LB w/offset	An op-amp is used. The offset effect can be simulated.	✓	n/a	n/a

Note: You need to have a MyROHM account to log in to the ROHM Solution Simulator.

Other simulation circuits, including DC/DC LSI and power electronics topologies are also provided.

[ROHM Solution Simulator top page](#)

Reference designs

Reference designs for various applications are published. Use the published circuit diagrams, BOM, and PCB designs as design references.

[Reference designs](#)

<High Voltage Safety Precautions>

◇ Read all safety precautions before use

Please note that this document covers only the reference design, the evaluation board used in the reference design and its functions. For additional information, please refer to the datasheet of products used in the reference design.

To ensure safe operation, please carefully read all precautions before handling the evaluation board



Depending on the configuration of the board and voltages used,

Potentially lethal voltages may be generated.

Therefore, please make sure to read and observe all safety precautions described in the red box below.

Before Use

- [1] Verify that the parts/components are not damaged or missing (i.e. due to the drops).
- [2] Check that there are no conductive foreign objects on the board.
- [3] Be careful when performing soldering on the module and/or evaluation board to ensure that solder splash does not occur.
- [4] Check that there is no condensation or water droplets on the circuit board.

During Use

- [5] Be careful to not allow conductive objects to come into contact with the board.
- [6] **Brief accidental contact or even bringing your hand close to the board may result in discharge and lead to severe injury or death.**
Therefore, DO NOT touch the board with your bare hands or bring them too close to the board.
In addition, as mentioned above please exercise extreme caution when using conductive tools such as tweezers and screwdrivers.
- [7] If used under conditions beyond its rated voltage, it may cause defects such as short-circuit or, depending on the circumstances, explosion or other permanent damages.
- [8] Be sure to wear insulated gloves when handling is required during operation.

After Use

- [9] The ROHM Evaluation Board contains the circuits which store the high voltage. Since it stores the charges even after the connected power circuits are cut, please discharge the electricity after using it, and please deal with it after confirming such electric discharge.
- [10] Protect against electric shocks by wearing insulated gloves when handling.

This reference design and the evaluation board used in it are intended for use only in research and development facilities and should be handled **only by qualified personnel familiar with all safety and operating procedures.**

We recommend carrying out operation in a safe environment that includes the use of high voltage signage at all entrances, safety interlocks, and protective glasses.

Important Notes on the Use of Reference Designs

- 1) The contents of this document are subject to change without notice for the purpose of improvement.
- 2) ROHM provides reference designs (including, but not limited to, circuit diagrams, layout data, parts lists, reference boards and their evaluation results, etc.) and all materials related to evaluation boards (hereinafter collectively referred to as "Reference Designs, etc.") to customers for the purpose of referencing them in the development of devices, equipment, software, etc. incorporating ROHM products (hereinafter collectively referred to as "Customer Products"). The design, verification, etc. required for the development of the Customer's Product shall be done at the customer's responsibility and expense. In no event shall the customer use the Reference Designs, etc. for any purpose other than the purpose mentioned above.
- 3) Reference Designs, etc. are provided on an "as is" basis. ROHM disclaims all warranties, express or implied, including, but not limited to, warranties of usefulness, functionality, accuracy, merchantability, and fitness for a particular purpose. In no event shall ROHM be liable for any damages (including, but not limited to, lost profits or other incidental, consequential, or punitive damages) arising out of, related to or in connection with the use of or application of the Reference Designs, etc. whether in contract or tort. For the avoidance of doubt, ROHM does not warrant that the Reference Designs, etc. will work with the Customer's Product.
- 4) When using Reference Designs, etc. be sure to request and verify the latest specifications (including the specifications of the products that compose the Reference Design, etc.) separately.
- 5) The customer shall be responsible for implementing safety measures such as derating, redundant design, fire prevention, backup, and fail-safe measures, etc., to prevent personal injury, fire damage, etc., caused by the Customer's Product developed with Reference Designs, etc. ROHM assumes no liability whatsoever for any use in excess of the ratings or in case of failure to observe the instructions for use.
- 6) The application circuit examples, constants, and other information provided in Reference Designs, etc. are intended to illustrate standard operation and usage. Therefore, when designing for mass production, please take into account various external conditions.
- 7) Reference Designs, etc. are intended to show typical operations and examples of application circuits, etc., and do not constitute a license, express or implied, to implement or use any intellectual property rights or any other rights of ROHM or any other company. ROHM shall not be liable for any disputes arising from, related to or in connection with the use of the Reference Designs, etc.
- 8) Please make sure to contact ROHM and obtain ROHM's consent before using the Reference Designs, etc. for the following Customer's Product that requires particularly high reliability. Transportation equipment (in-vehicle, ship, railroad, etc.), trunk line communication equipment, traffic signal equipment, disaster and security equipment, safety equipment, medical equipment, servers, solar cells, power transmission systems, etc.
- 9) Do not use Reference Designs, etc. for the following Customer's Product that requires extremely high reliability. Aerospace equipment, nuclear power control equipment, submarine relay equipment, etc.
- 10) Do not use Reference Designs, etc. for military use, such as development of weapons of mass destruction, or for any other military purpose.
- 11) ROHM does not assume any liability for any accidents or damages caused by non-compliance with the descriptions in this document.
- 12) The information contained in this document has been carefully prepared to ensure accuracy. However, ROHM shall not be liable for any loss or damage incurred by customers due to errors or misprints in this document.
- 13) Do not reproduce or duplicate any part of this document in any form or by any means without ROHM's permission.



Thank you for your accessing to ROHM product informations.
More detail product informations and catalogs are available, please contact us.

ROHM Customer Support System

<http://www.rohm.com/contact/>

Notice

- 1) The information contained in this document is intended to introduce ROHM Group (hereafter referred to as ROHM) products. When using ROHM products, please verify the latest specifications or datasheets before use.
- 2) ROHM products are designed and manufactured for use in general electronic equipment and applications (such as Audio Visual equipment, Office Automation equipment, telecommunication equipment, home appliances, amusement devices, etc.) or specified in the datasheets. Therefore, please contact the ROHM sales representative before using ROHM products in equipment or devices requiring extremely high reliability and whose failure or malfunction may cause danger or injury to human life or body or other serious damage (such as medical equipment, transportation, traffic, aircraft, spacecraft, nuclear power controllers, fuel control, automotive equipment including car accessories, etc. hereafter referred to as Specific Applications). Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses, or losses incurred by you or third parties arising from the use of ROHM Products for Specific Applications.
- 3) Electronic components, including semiconductors, can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against physical injury, and damage to any property, which a failure or malfunction of products may cause.
- 4) The information contained in this document, including application circuit examples and their constants, is intended to explain the standard operation and usage of ROHM products, and is not intended to guarantee, either explicitly or implicitly, the operation of the product in the actual equipment it will be used. As a result, you are solely responsible for it, and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses, or losses incurred by you or third parties arising from the use of such information.
- 5) When exporting ROHM products or technologies described in this document to other countries, you must abide by the procedures and provisions stipulated in all applicable export laws and regulations, such as the Foreign Exchange and Foreign Trade Act and the US Export Administration Regulations, and follow the necessary procedures in accordance with these provisions.
- 6) The technical information and data described in this document, including typical application circuits, are examples only and are not intended to guarantee to be free from infringement of third parties intellectual property or other rights. ROHM does not grant any license, express or implied, to implement, use, or exploit any intellectual property or other rights owned or controlled by ROHM or any third parties with respect to the information contained herein.
- 7) No part of this document may be reprinted or reproduced in any form by any means without the prior written consent of ROHM.
- 8) All information contained in this document is current as of the date of publication and subject to change without notice. Before purchasing or using ROHM products, please confirm the latest information with the ROHM sales representative.
- 9) ROHM does not warrant that the information contained herein is error-free. ROHM shall not be in any way responsible or liable for any damages, expenses, or losses incurred by you or third parties resulting from errors contained in this document.



Thank you for your accessing to ROHM product informations.
More detail product informations and catalogs are available, please contact us.

ROHM Customer Support System

<https://www.rohm.com/contactus>