R9A06G061/ISL15102 PCB Design Guideline

PCB Layout Design Guide

R30AN0408EJ0200
Rev.2.00
Aug 1, 2022

Summary

This material is a guideline for PCB layout when designing a PLC board using R9A06G061 as a PLC modem LSI by Renesas Electronics manufactured and ISL15102 as a Power Amp for transmission output. For the device and the power circuit design, follow guidelines and application notes of the target device.

Note that cautions on this material are based on general board design, and may not be applicable in some cases depending on the board size, parts, and layout.

Table of Contents

1. PLC Board Configuration Example

Figure 1-1shows a PLC board configuration example using R9A06G061 as a PLC modem LSI by Renesas Electronics manufactured and ISL15102 as a power amp for transmission output. This material explains cautions on PCB layout for PLC board design based on the configuration below.

(Renesas Electronics can provide a reference board with the PLC board configuration shown in Figure 1-1 except for the AC-DC circuit.)

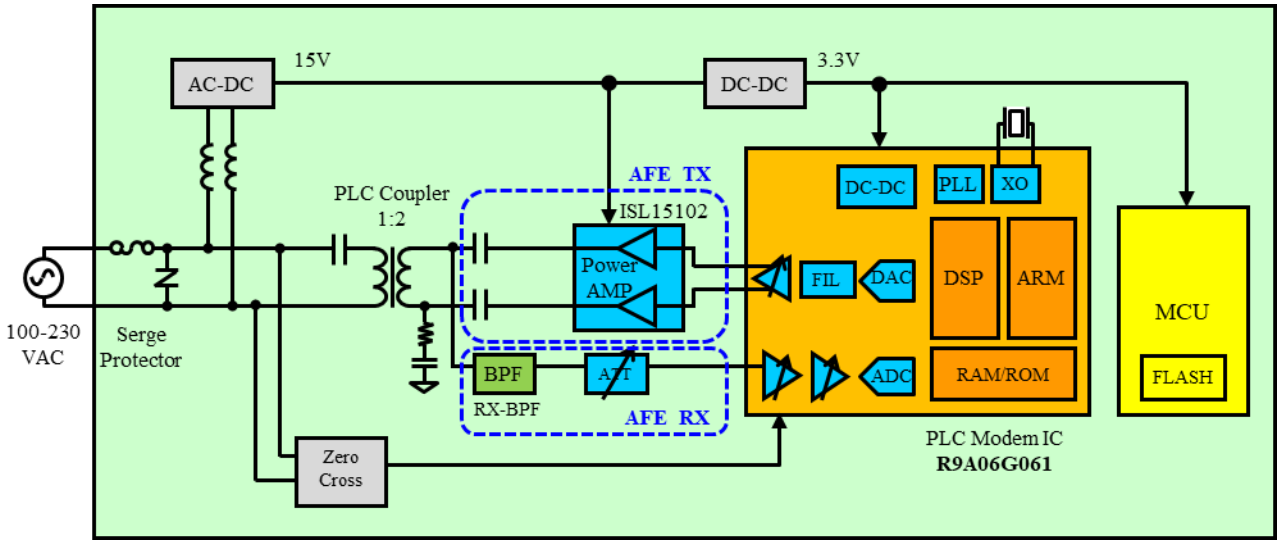


Figure 1-1 PLC board configuration example to which R9A06G061 / ISL15102 are applied

2. Cautions on the PLC Board and PCB Layout

This chapter explains cautions on PCB layout related to board parts and wiring. The PLC board consists of 2 domains: a high voltage circuit domain for 100V to 230V AC voltage, and a low voltage circuit domain for DC voltage of 1.1V, 3.3V, and 15V(or 12V in some cases. This material shows examples of using 15V). The following sections explain cautions on PCB layout for each domain respectively.

2.1 Cautions on Parts Layout for the High Voltage Circuit Domain

- The PCB patterns for the high voltage circuit domain and the low voltage circuit domain should be separated as shown in Figure 2-1.
- It is recommended to connect the high voltage circuit and the low voltage circuit with an insulating element such as a transformer (PLC Coupler) or photo-coupler (Zero Cross) for safety.
- For the insulating element part, it is recommended to insert a slit on the PCB to separate the PCB patterns for the high voltage circuit domain and the low voltage circuit domain.
- For the distance between LINE-NEUTRAL electrodes or between the high voltage circuit and the low voltage circuit, creeping/space distance should be designed in compliance with the safety standards of the target usage region. (An example is shown in Figure 2-3.)
- It is recommended to separate the PLC coupler and the AC-DC power supply circuit for 4cm or more as it may affect the EMC standards.

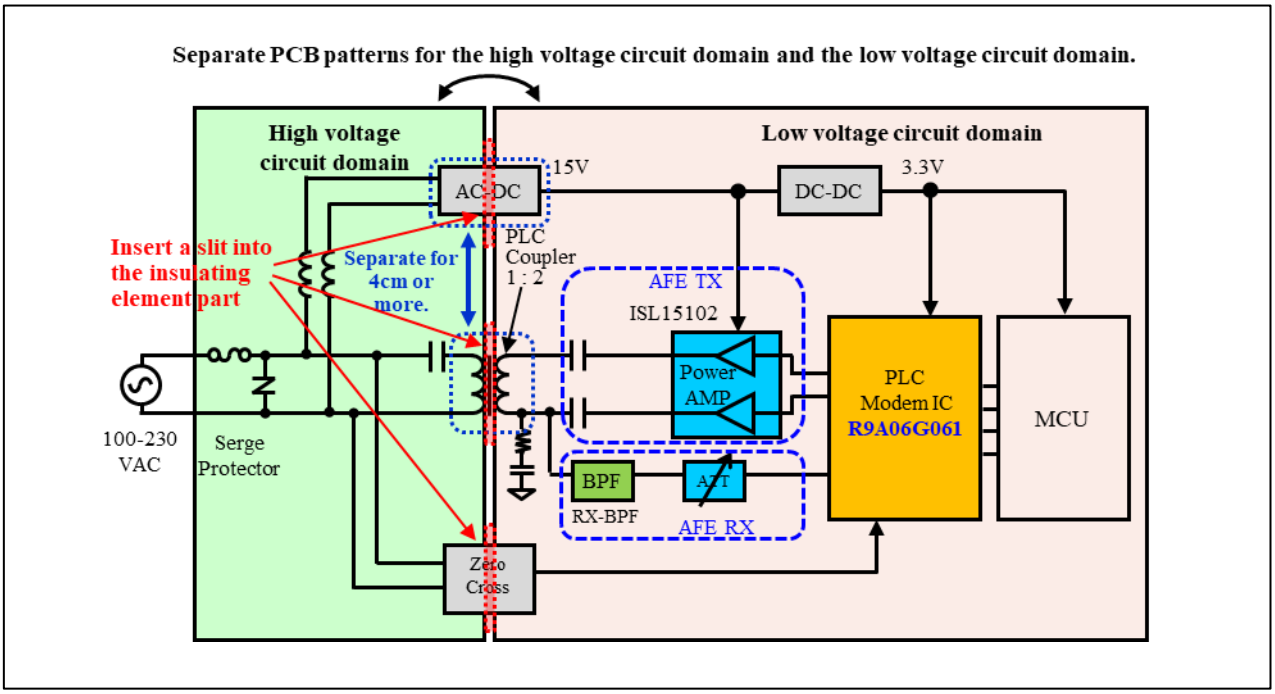


Figure 2-1 Parts Layout for High Voltage Circuit Domains

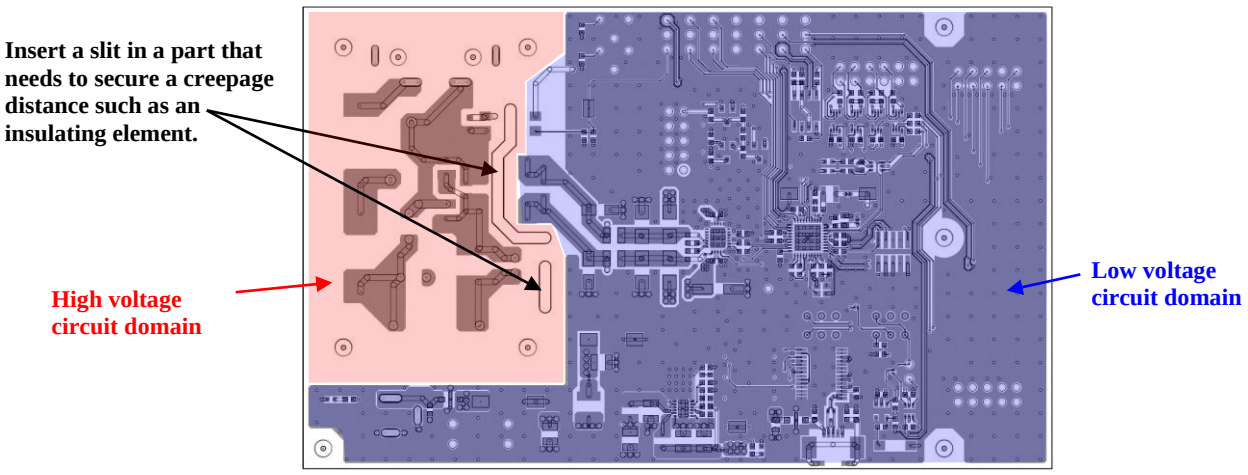


Figure 2-2 Example of PCB pattern separation in high voltage circuit domain and low voltage circuit domain

Creepage distances and clearances

Description	Rated impulse voltage 4 kV (mm)	Rated impulse voltage 6 kV (mm)
Creepage distances		
1. Between live parts of different polarity, including parts for looping-in of external conductors	4[1)]	5,5
2. Between live parts, including parts for looping-in of external conductors, and:		
- accessible metal parts,	5,5	8
- earthed metal parts, including the earthing circuits	3	5,5
- screws or other devices for fixing bases, covers or cover plates	3	5,5
Clearances		
3. Between live parts of different polarity, including parts for looping-in of external conductors	3	5,5
4. Between live parts, including parts for looping-in of external conductors, and		
- accessible metal parts,	5,5	8
- earthed metal parts, including the earthing circuits	3	5,5
- screws or other devices for fixing bases, covers or cover plates	3	5,5
5. Between live parts, including parts for looping-in of external conductors, and the surface on which the base of surface-type equipment is mounted	5,5	8
Distances through insulating sealing compound		
6. Between live parts covered with at least 2 mm of sealing compound and the surface on which the base of surface-type equipment is mounted	4	5,5

1) The value is reduced to 3 mm for nominal voltage up to and including 250 V

Figure 2-3 Examples of Creepage distance and Clearance of EN650065-4-2 (CE marking)

2.2 Cautions on Parts Layout for the Low Voltage Circuit Domain

- Figure 2-4 shows cautions on PCB layout for the low voltage circuit domain.
- The critical sections of the PLC signal path: The layout of the parts of "PLC coupler - AFE circuit (AFE TX (ISL15102) / AFE RX, RXBPF) - R9A06G61 - MCU" should be arranged along the flow of the PLC signal so that the wiring of the PLC signal is as short as possible with minimal intersections.
- In DC-DC power supply circuits, switching noise may affect the transmission and reception signals of the PLC. Therefore, in order to prevent interference, take measures such as separating the power supply circuit, which is a noise source, from the circuit components and signal paths of the AFE circuit / R9A06G061, and inserting a GND pattern.
- RX-BPF is particularly susceptible to noise, so do not place parts separately, shorten the wiring as much as possible, put them together in one place, and keep them at least 3 cm away from the power supply circuit.
- If the distance cannot be secured more than 3 cm, place the power supply circuit on the back side (separate layer from RX-BPF).
- Avoid or minimize area where the PLC signal wiring and the power supply wiring cross each other.

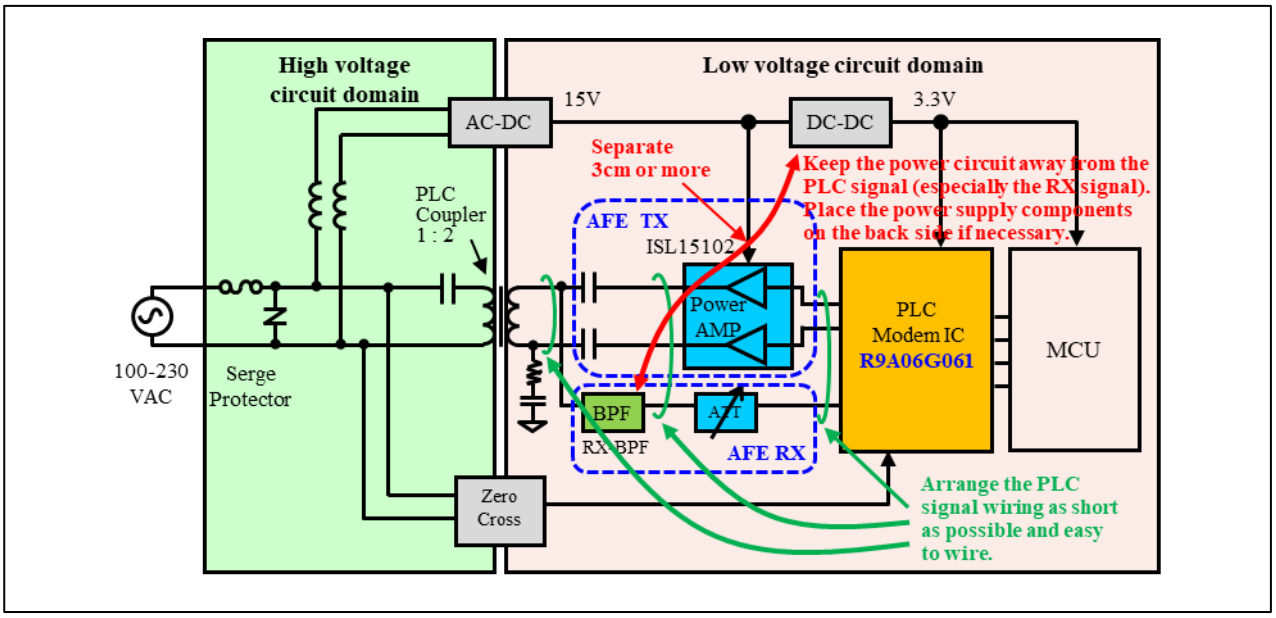


Figure 2-4 Parts Layout for the Low Voltage Circuit Domain

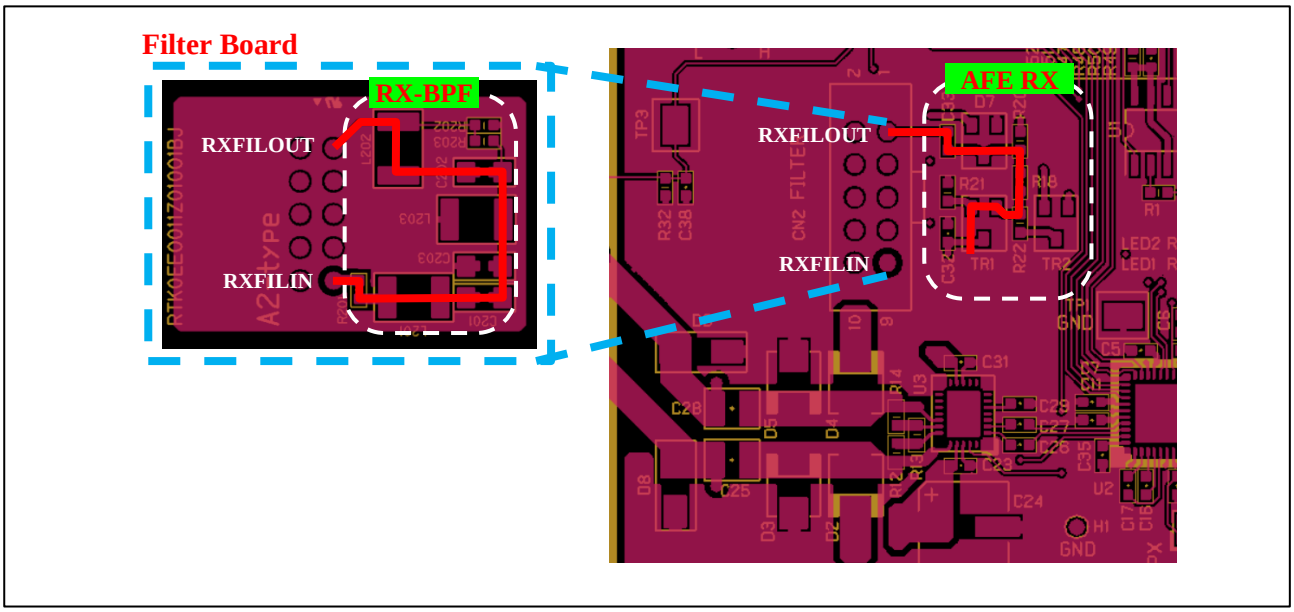


Figure 2-5 RX-BPF layout example

2.3 Cautions on Parts Layout around R9A06G061 and PCB Pattern

- Arrange the R9A06G061 decoupling capacitors and the external parts for DC-DC close to the R9A06G061 terminal and make the wiring as short as possible.
- Arrange the crystal oscillator and peripheral parts connecting to R9A06G061 close to R9A06G061 as much as possible, and make the wiring as short as possible. Also, arrange GND under and around the crystal oscillator, and connect to the GND solid pattern to avoid making an isolated island pattern.

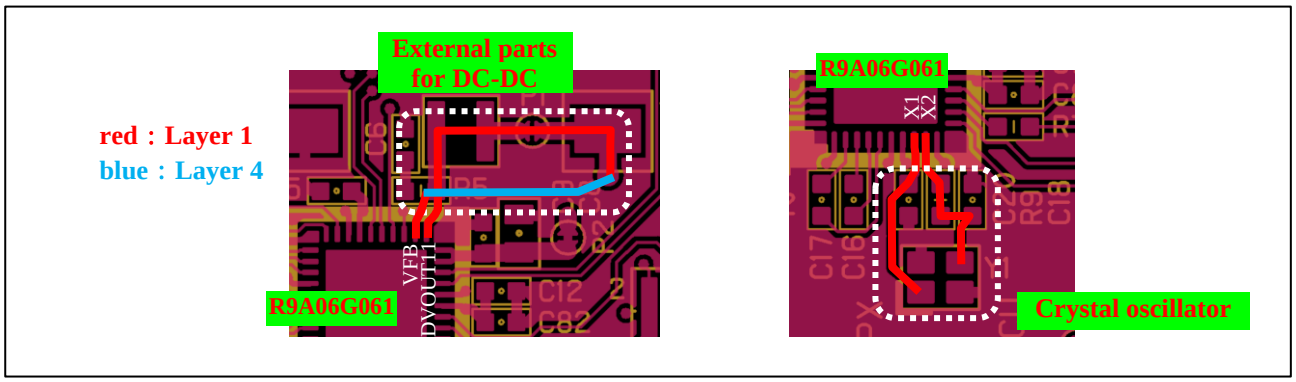


Figure 2-6 Placement of the external parts for R9A06G061 built-in DC-DC and the crystal oscillator

2.4 Cautions regarding Parts Layout and PCB pattern around AFE TX (ISL15102) / AFE RX

- Arrange the decoupling capacitor of AFE circuit close to the AFE device terminal and make the wiring pattern as short as possible.
- Widen the wiring width for the AFE circuit TX output signal part to support approximately 3A large current flowing into this area. (3mm or more is recommended.)
- Make the wiring length as equal as possible when using a differential signal.
- Since the TX signal line between R9A06G061 → AFE TX (ISL15102) → PLC Coupler is a differential signal, design the layout with the shortest wiring and the arrangement of parts in consideration of balance as much as possible. (An example is shown in Figure 2-8.)
- In the RX signal line between PLC Coupler → AFE RX → R9A06G061, design the layout with the shortest possible wiring. However, if there is a risk that the RX signal line will interfere with the power supply circuit, give priority to keeping it away from the power supply circuit. An example is shown in Figure 2-8.)
- Since the 15V power supply wiring generates much noise, avoid the TX signal and the RX signal crossing each other as much as possible. Also, it is recommended to use the GND pattern in the area where the TX/RX signals or TX/RX parts overlap as much as possible for the power supply layer (3rd Layer).
- Especially be careful with RX-BPF which is highly affected by noise. It is recommended to make the wiring as short as possible, avoid crossing the RX-BPF signal paths and arrange all the parts in one place, and separate RX-BPF from the power supply circuit for 3cm or more. When it is not possible to keep 3cm or more distance in-between, consider arranging the power supply circuit on a layer different from the RX-BPF) .

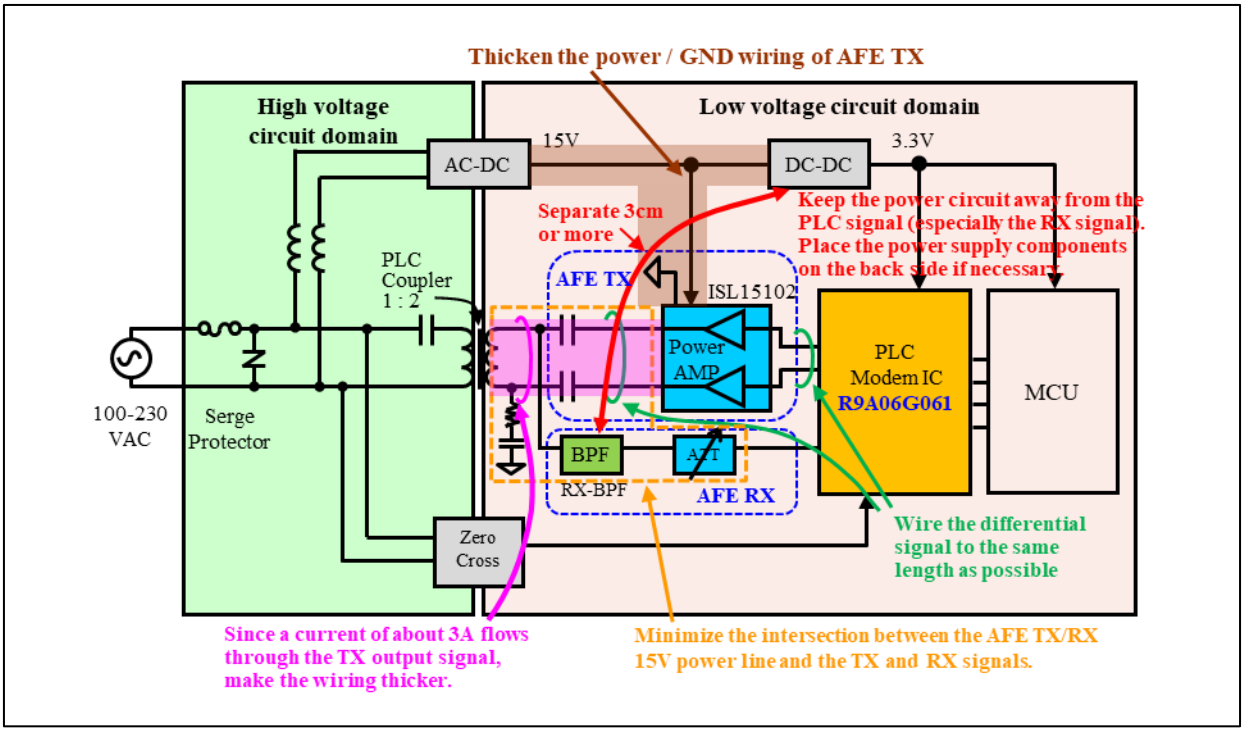


Figure 2-7 Cautions on Power Supply Wiring for AFE Circuit Signal

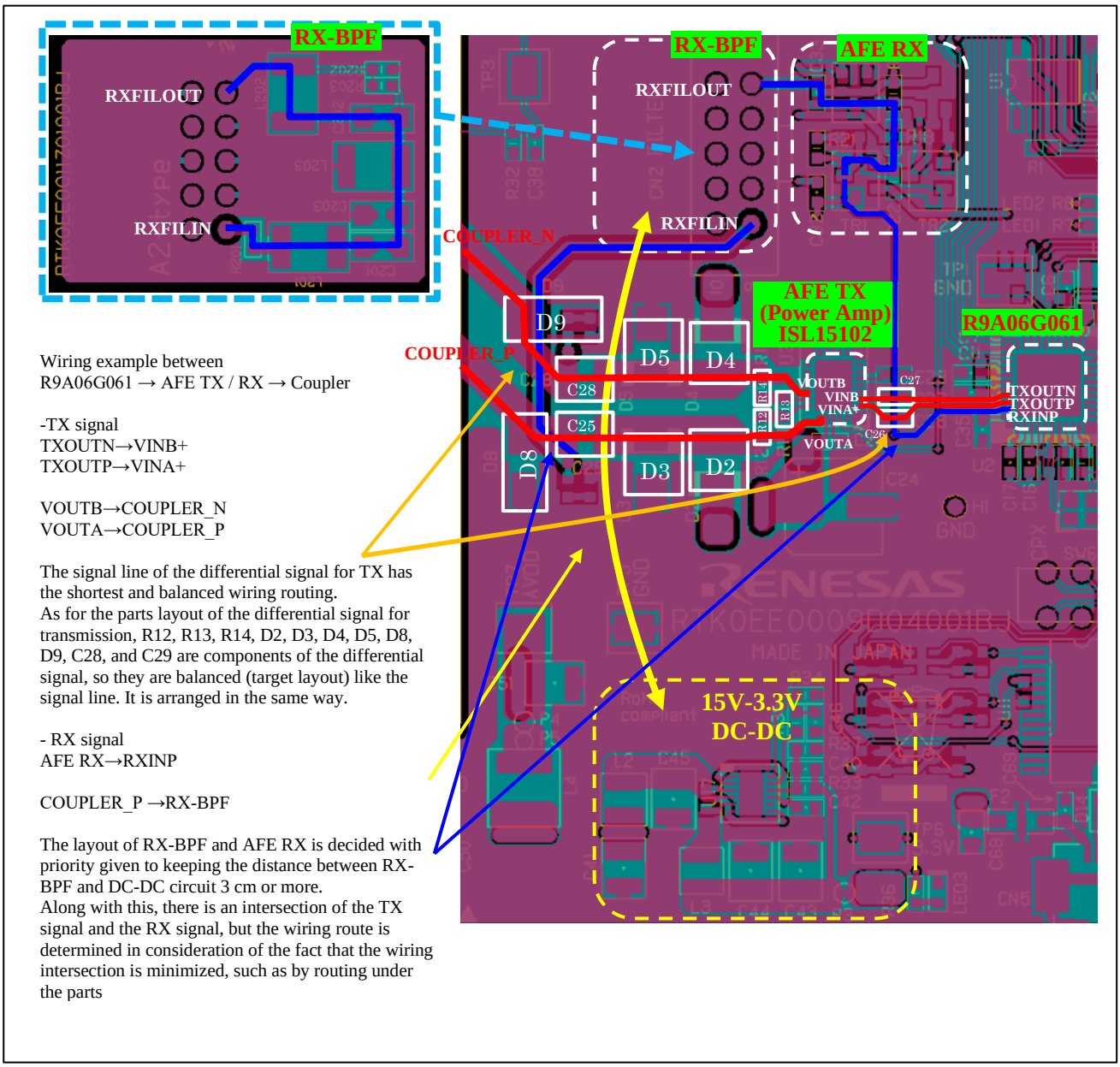


Figure 2-8 Example of routing the TX / RX signal line between R9A06G061 and ISL15102

2.5 Cautions on the DC-DC Power Supply Circuit

This chapter explains cautions when implementing the DC-DC power supply circuit into the PLC board.

- It is necessary to generate 3.3V to use R9A06G061 and 15V or 12V to use ISL15102 on the PLC board.
- In DC-DC power supply circuits, switching noise may affect the transmission and reception signals of the PLC. Therefore, in order to prevent interference, between the DC-DC power supply circuit of the noise source and the circuit parts / signal path of the AFE circuit / R9A06G061, take measures such as increasing the distance and inserting a GND pattern.
- Since RX-BPF is particularly susceptible to noise, keep it at least 3 cm away from the DC-DC power supply circuit.
- If the distance cannot be secured more than 3 cm, place the DC-DC power supply circuit on a different layer from the RX-BPF.

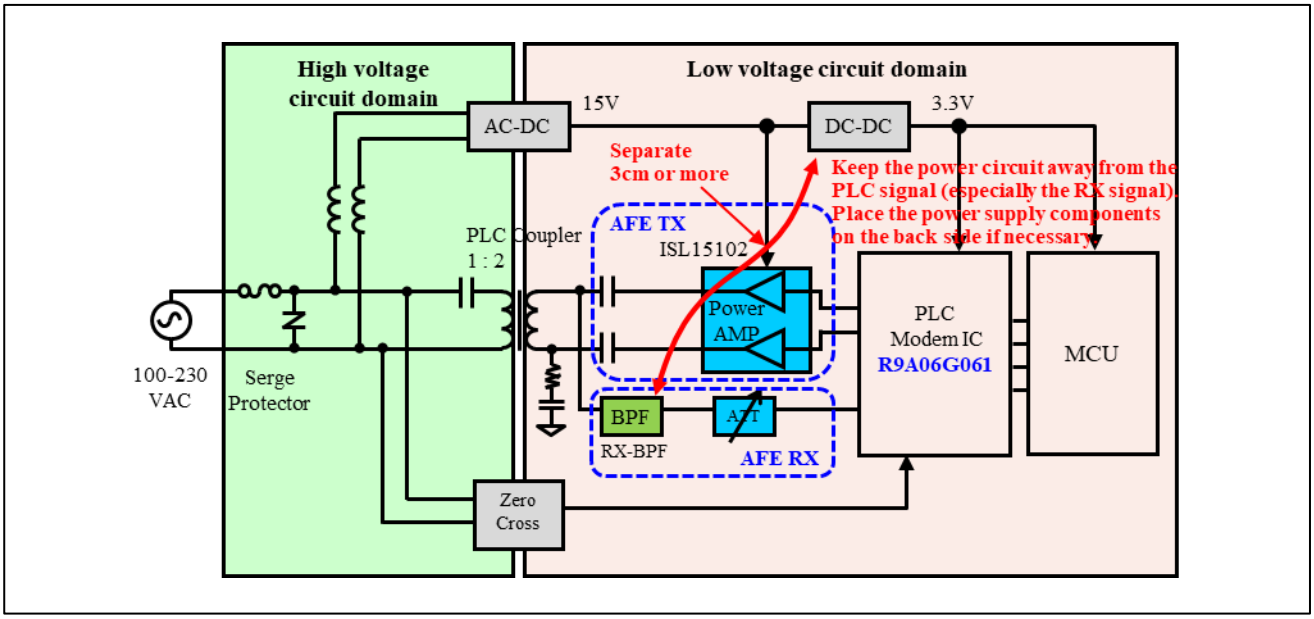


Figure 2-9 Cautions on DC-DC Power Source Circuit Implementation

2.6 Cautions on the AC-DC Power Supply Circuit

This chapter explains cautions when implementing the AC-DC power supply circuit to the PLC board. Follow the cautions below when designing the AC-DC power supply circuit, as the switching noise may interrupt the EMC standards and PLC transmission/reception characteristics.

- Separate the AC-DC circuit GND from GND for other circuits.
- The creepage/space distance between the AC-DC circuit and other circuits depends on the local safety standards. Follow the safety standards of the target region. (An example is shown in Figure 2-3.)
- It is recommended to separate the PLC coupler and the AC-DC power supply circuit for 4 cm or more as it may affect the EMC standards.

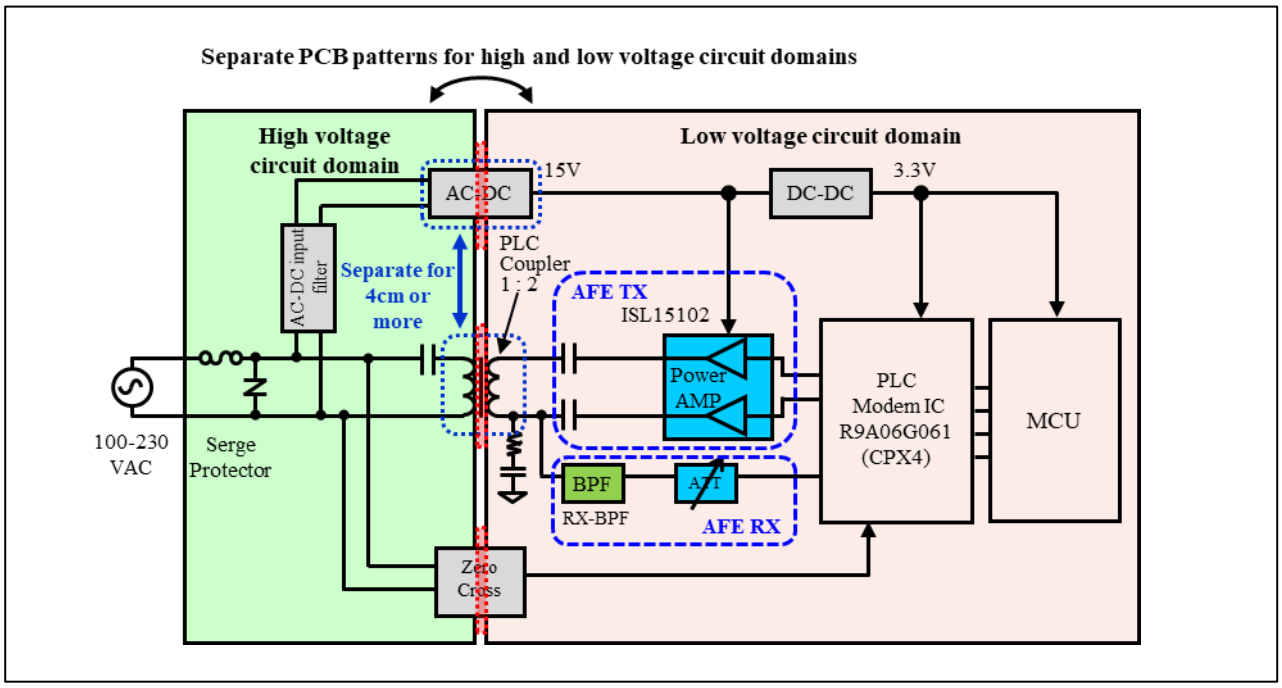


Figure 2-10 Cautions on AC-DC Power Source Circuit Implementation

2.7 Cautions on GND Patterns

2.7.1 Cautions regarding GND reinforcement and heat dissipation design

- For PLC board design, it is recommended to use a PCB substrate with 4 or more layers.
  - The 1st layer is used as the signal layers, fill the unused area with GND patterns for heat dissipation, and signal separation.
  - For the 2nd layer, it is important to use the GND layer for signal separation, noise shielding and heat dissipation.
  - The 3rd layer is used as the power supply layer. In addition arrange the GND pattern partially for noise shielding and heat dissipation.
  - The 4th layer is used as the signal layer and fill the unused area with GND patterns for heat dissipation, and signal separation.
- There is the exposed die pad (internally connected to GND) on the back side of R9A06G061 and ISL15102 for heat dissipation. Place GND pattern to connect the exposed die pad on 1st layer, 2nd layer, 3rd layer and 4th layer, and connect the GND pattern of each layer with via holes. Place via holes as much as possible on GND pattern (recommendation: hole diameter: 0.3mm, R9A06G061: more than 12 pcs, ISL15102: more than 9pcs).
- In the 1st layer, connect the Exposed die pad of ISL15102 to the GND plane of the first layer as much as possible to improve heat dissipation. (An example is shown in Figure 2-12.)
- In the GND layer of the 2nd layer, connect the path to the GND supply terminal on the PCB smoothly with the Exposed die pad of R9A06G061 and ISL15102. (An example is shown in Figure 2-13.)
- In the power supply layer of the 3rd layer, place a GND pattern in the via hole part connected to the Exposed die pad of R9A06G061 and ISL15102. (An example is shown in Figure 2-14.)
- In the 4th layer, the GND pattern is especially important for heat dissipation design. In order to further improve heat dissipation performance, widen the area of the GND pattern and connect the Exposed die pad of R9A06G061, ISL15102 to the GND pattern. Then, connect as smoothly as possible so that there are no obstacles in the path to the Exposed die pad of the ISL15102 and the GND supply terminal on the PCB. (An example is shown in Figure 2-15.) (Reason: Since large current flows in ISL15102 (Power amplifier for transmission) when transmitting at low load, heat dissipation will deteriorate if the connection between the Exposed die pad of ISL15102 and the GND pattern is not appropriate. Then, the thermal shutdown function of the ISL15102 may intermittently stop the output of the signal.)
- When checking PCB artwork, in the paste mask (paste data) used for component mounting, it is recommended to check if the appropriate pattern is placed on the exposed die pad part of R9A06G061 and ISL15102. (See Figure 2-16 for details.)
- Fill the unused area of 1st and 4th layer as the signal layer with GND patterns. However, if the GND pattern becomes a small island or fine antenna-shape, it is not necessary to fill it.

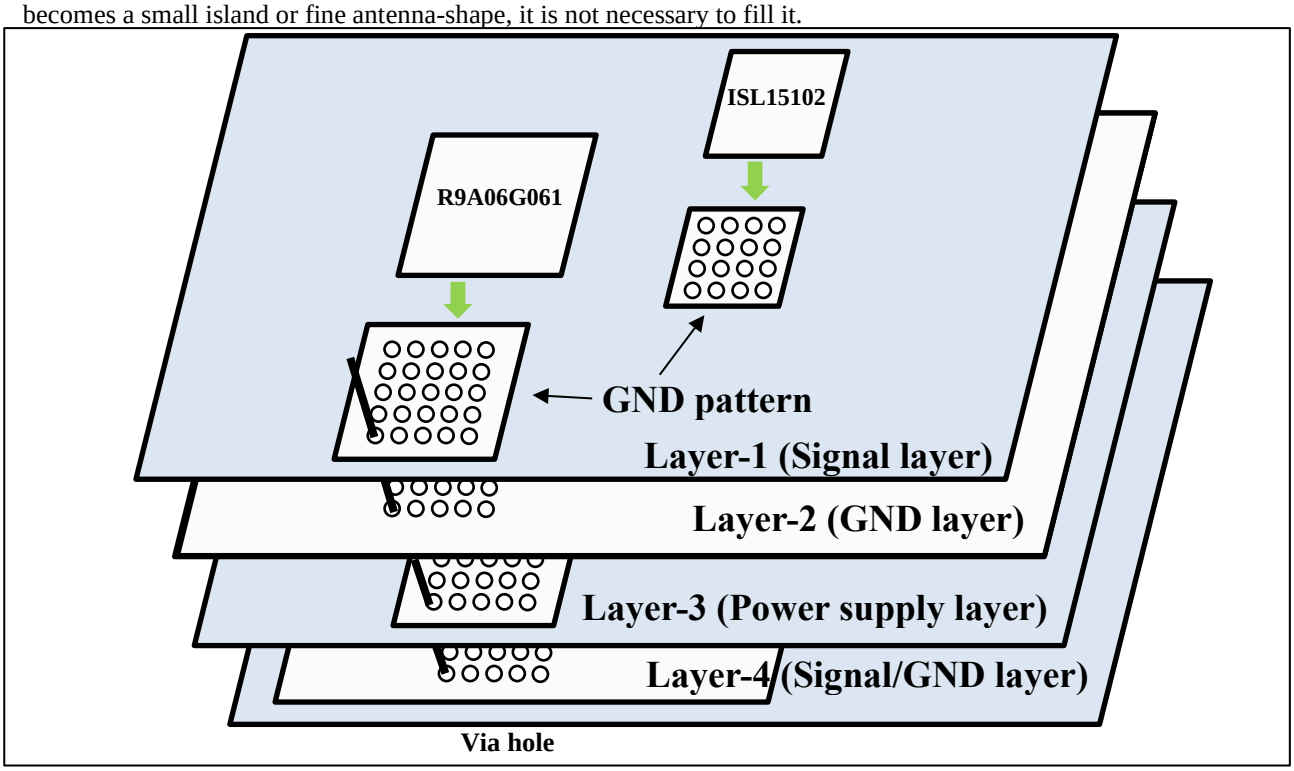
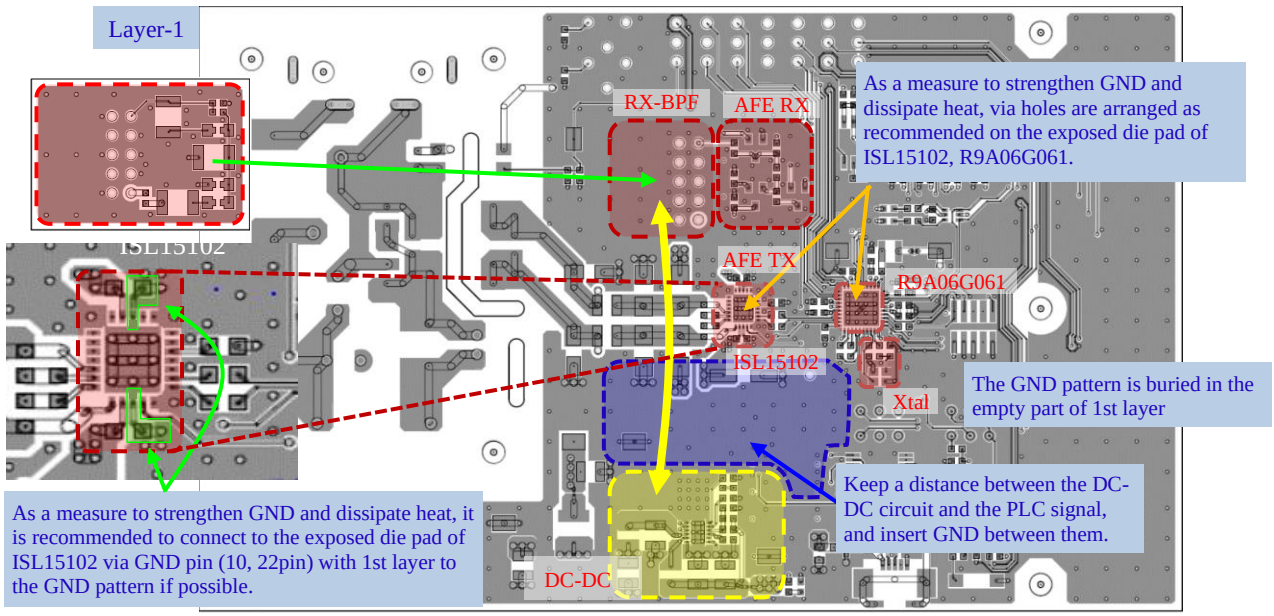
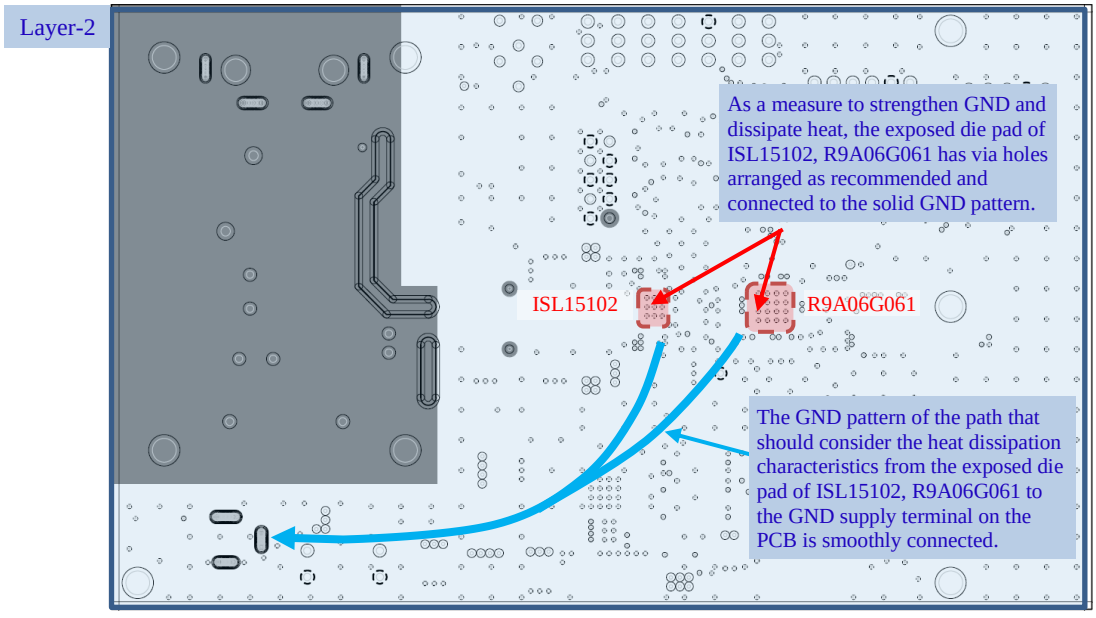


Figure 2-11 Example of PCB Substrate Configuration and GND pattern for the PLC Board



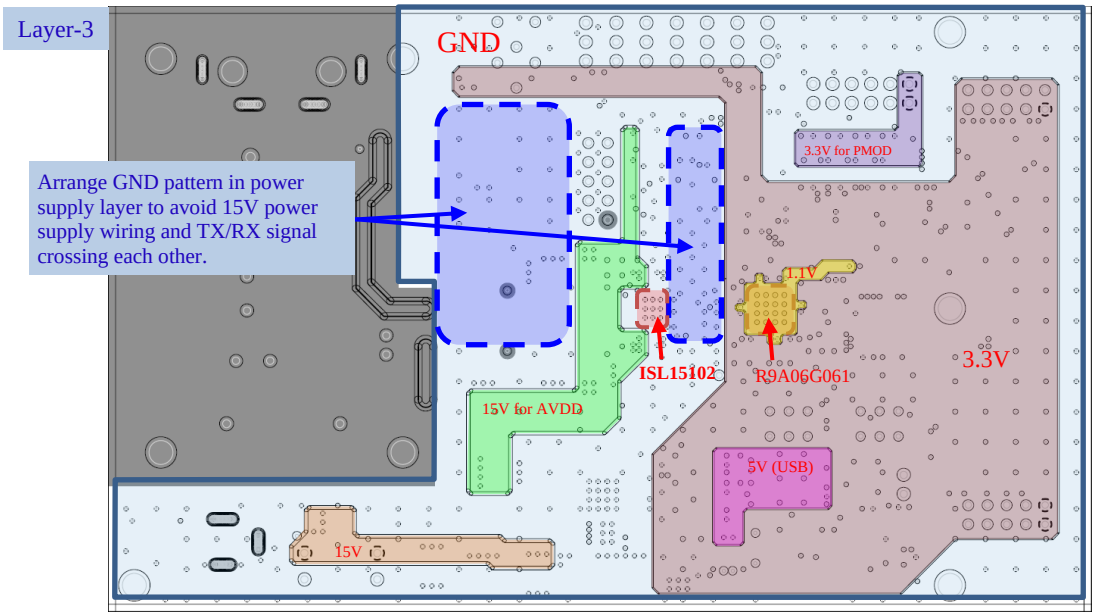
- The GND pattern is buried in the empty part of 1st layer
- As a measure to strengthen GND and dissipate heat, via holes are arranged as recommended on the exposed die pad of ISL15102, R9A06G061. It is recommended to connect to the exposed die pad of ISL15102 via GND pin (10, 22pin) with 1st layer to the GND pattern if possible.
- Keep a distance between the DC-DC circuit and the PLC signal, and insert GND between them.

Figure 2-12 Example of connection between exposed die pad of R9A06G061 and ISL15102 and GND pattern (1st Layer)



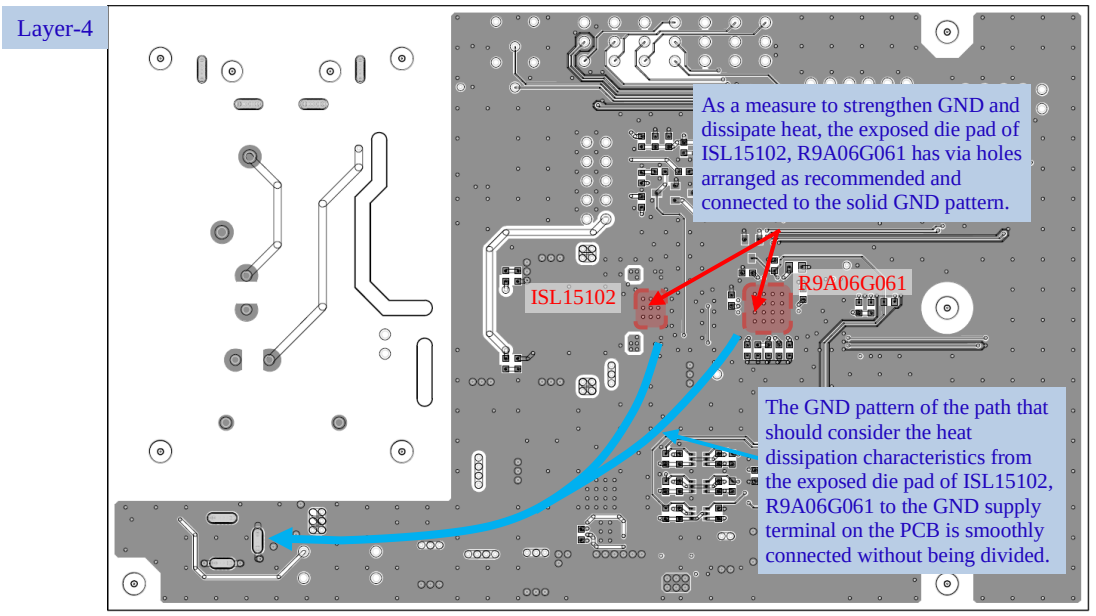
- As a measure to strengthen GND and dissipate heat, the exposed die pad of ISL15102, R9A06G061 has via holes arranged as recommended and connected to the solid GND pattern.
- The GND pattern of the path that should consider the heat dissipation characteristics from the exposed die pad of ISL15102, R9A06G061 to the GND supply terminal on the PCB is smoothly connected.

Figure 2-13 Example of connection between exposed die pad of R9A06G061 and ISL15102 and GND pattern (2ndt Layer)



- The GND pattern is embedded in the part connected to the exposed die pad part of ISL15102 on 3rd layer. In this figure, the exposed die pad part of R9A06G061 is in the 1.1V region, but it is desirable to set it in the GND region if possible.
- In the wiring area of the TX / RX signal, a GND pattern is arranged to avoid crossing with the noisy 15V power supply pattern. (Blue part)

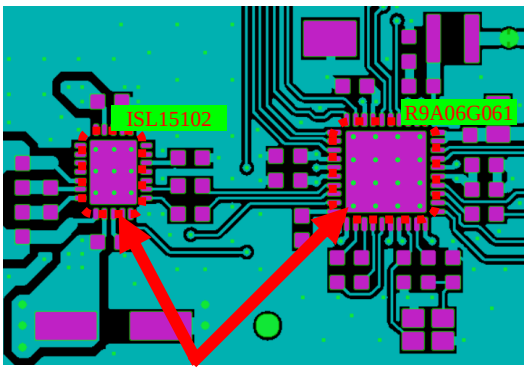
Figure 2-14 Example of connection between exposed die pad of R9A06G061 and ISL15102 and GND pattern (3rd Layer)



- The GND pattern is buried in the empty part of 4th layer
- As a measure to strengthen GND and dissipate heat, the exposed die pad of ISL15102, R9A06G061 has via holes arranged as recommended and connected to the solid GND pattern.
- The GND pattern of the path that should consider the heat dissipation characteristics from the exposed die pad of ISL15102, R9A06G061 to the GND supply terminal on the PCB is smoothly connected without being divided.

Figure 2-15 Example of connection between exposed die pad of R9A06G061 and ISL15102 and GND pattern (4th Layer)

Cyan: 1st layer / Magenta: Top Paste Mask / Yellow green: via hole



Confirm that there is paste mask data in the exposed die pad part of R9A06G061 and ISL15102.

- When checking the PCB artwork, it is recommended to check if the appropriate patterns are placed on the exposed die pad part of R9A06G061 and ISL15102 in the paste mask (paste data) used for component mounting.
- If the paste mask does not have a pattern to connect to the exposed die pad of R9A06G061 and ISL15102, the operation will be unstable because R9A06G061 and ISL15102 will not be connected to GND. In addition, the heat dissipation of the ISL15102 deteriorates, and as a result, the output of the signal is intermittently stopped by the thermal shutdown function of the ISL15102.
- Mask to check: Paste mask extension GTP, GBP, etc. (The mask used for assembling parts))
  - GTP : Top Paste Mask
  - GBP : Bottom Paste Mask
- The Gerber file provided by the board vendor may not contain the paste mask data. In that case, request the paste mask data from the board vendor.

- There is a solder mask as mask data for PCB that can be easily mistaken for a paste mask (sometimes called resist data, etc.). Solder masks are used only when manufacturing boards, and paste masks are used when assembling parts.
- Solder mask extension GBS, GBS, etc. (mask used when manufacturing the board)
  - GTS: Top Solder Mask
  - GBS: Bottom Solder Mask

Figure 2-16 Example of checking the paste mask (paste data) used for component mounting

2.7.2 Cautions on other GND Pattern

- When using the AC-DC power supply circuit, separate GND for the AC-DC power supply circuit and GND for low voltage circuit domain.
- For the low voltage circuit domain GND, it is recommended to use the GND solid pattern instead of separating GND for the digital circuit and GND for the analog circuit.
- Do not place a GND pattern under the inductance as shown in Figure 2-17 to avoid noise influences on the GND pattern. (e.g. the inductor to use for RX-BPF, a power supply circuit, and a filter for power supply line, etc.)

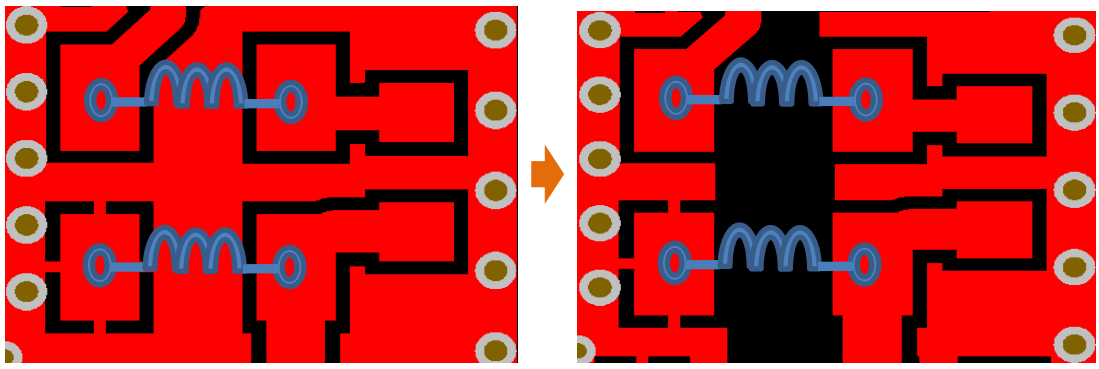


Figure 2-17 Cautions on GND patterns under the inductor

2.8 Cautions on the Power Supply Pattern

- It is recommended to configure the power supply layer with the PCB substrate configuration of the PLC board as shown in Figure 2-11.
- It is recommended to arrange 1.1V/3.3V/15V power regions used in the PLC board for the power supply layer, and arrange the GND pattern in the area where crossing with the power region should be avoided. Figure 3-5 show examples of the power supply layer.

3. PCB Layout Design Example

This chapter shows PCB layout examples for the PLC board explained in Chapter 2. This material shows the PCB layout for the PLC board based on the configuration in Figure 3-1 as Renesas Electronics does not offer PLC boards with the AC-DC power supply circuit.

Figure 3-2 shows an example of Parts Layout. Figure 3-3 to Figure 3-6 show layout examples for each layer. Note that this PCB layout example may not be optimal depending on the shape of the PLC board used.

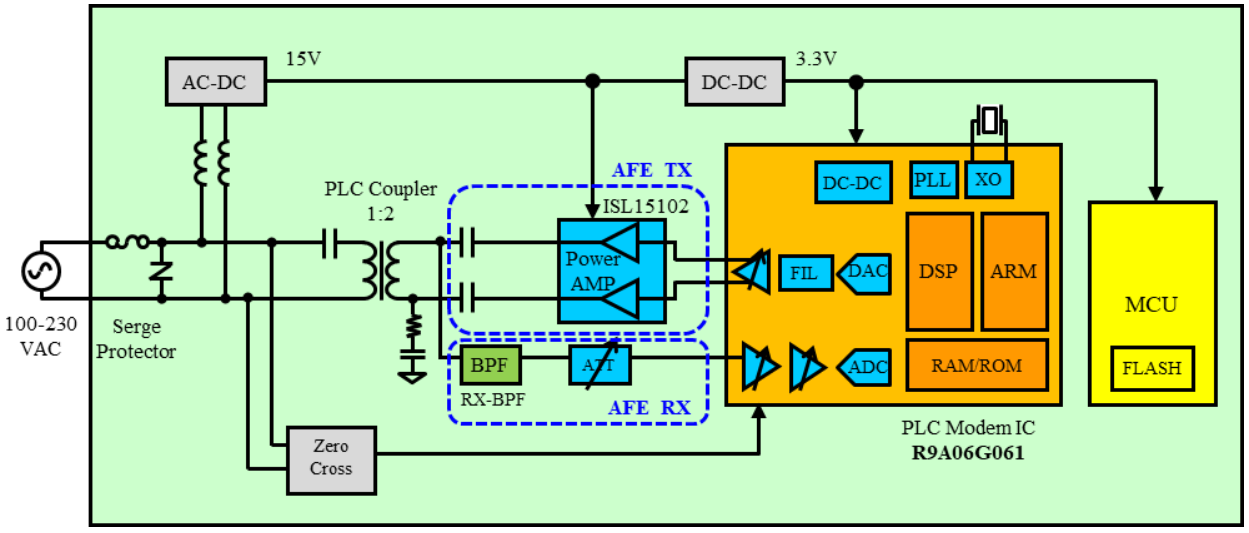


Figure 3-1 PLC Board Configuration Based on the PCB Layout Example in Chapter 3

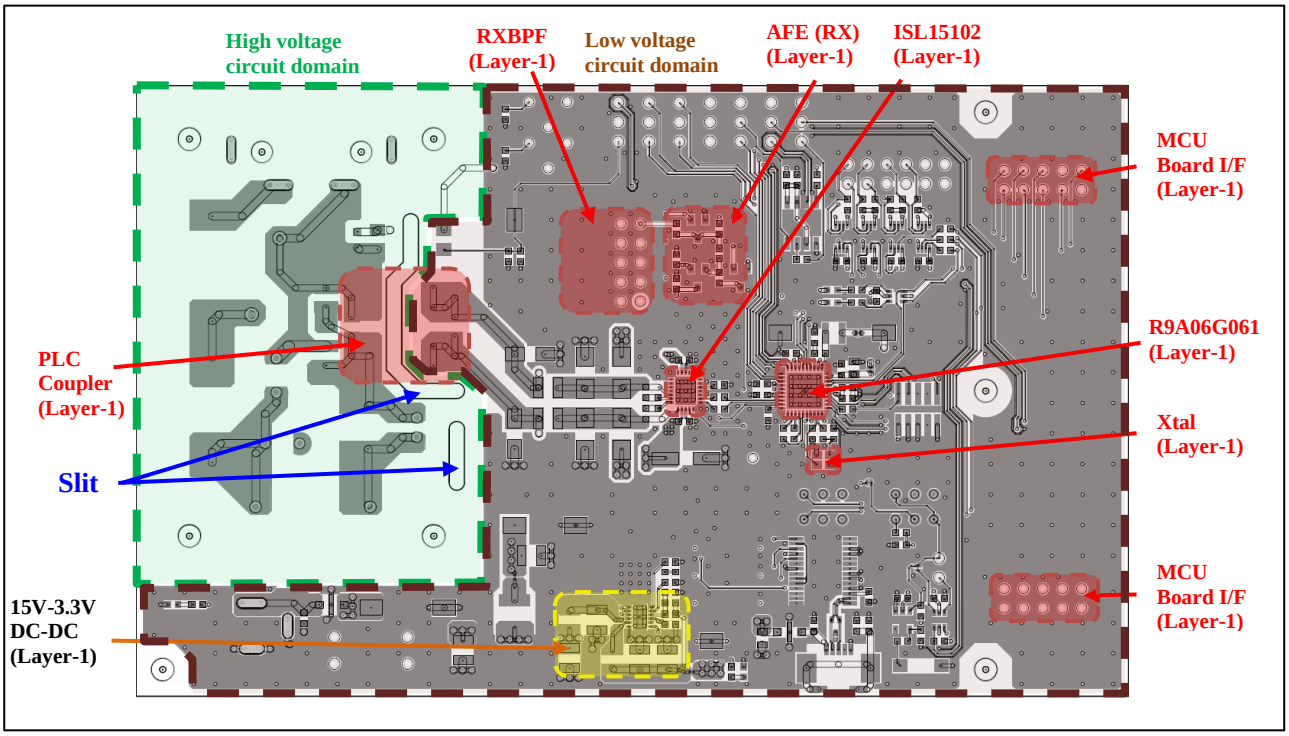


Figure 3-2 Example of PLC Board Parts Layout in Figure 3-1

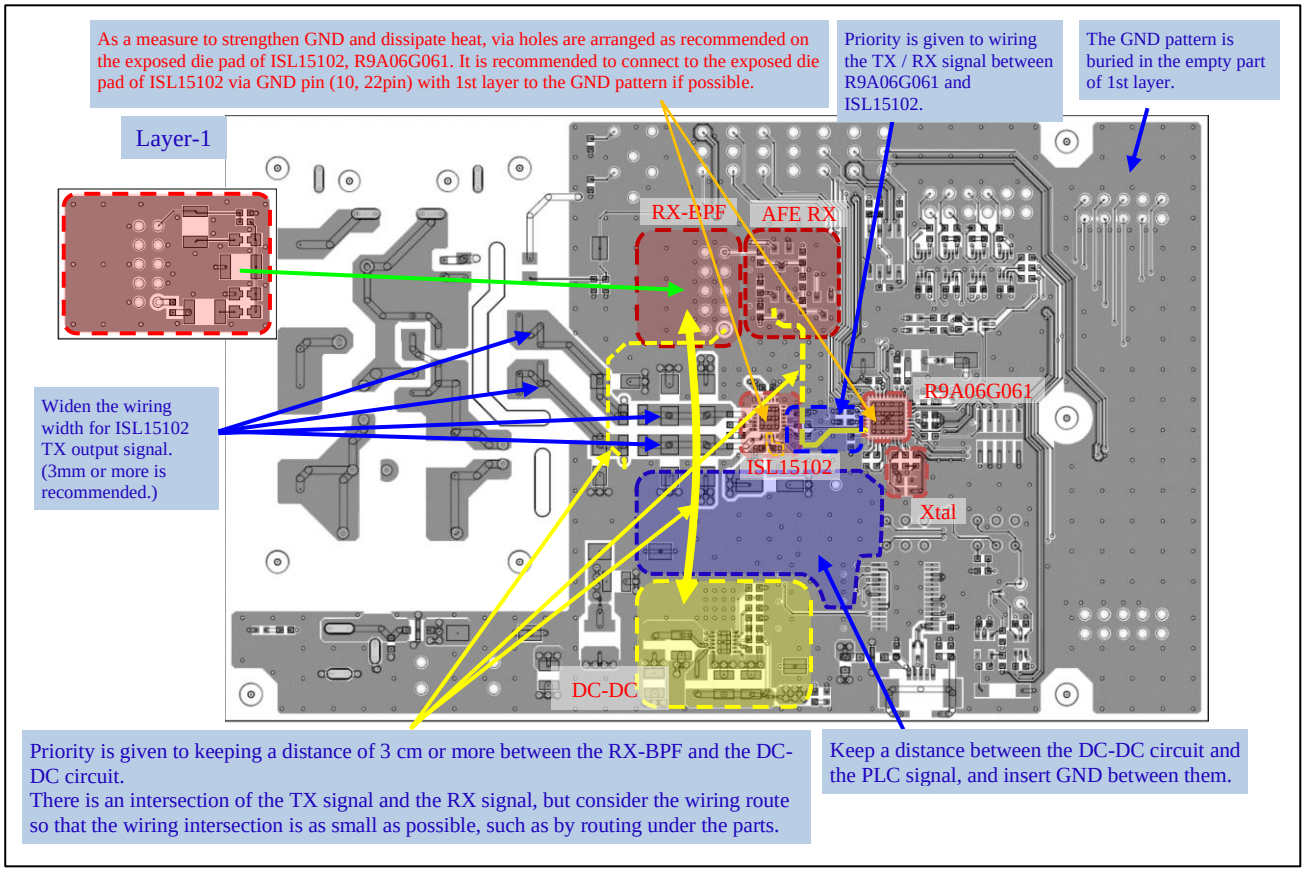


Figure 3-3 Example of 1st Layer in Figure 3-1

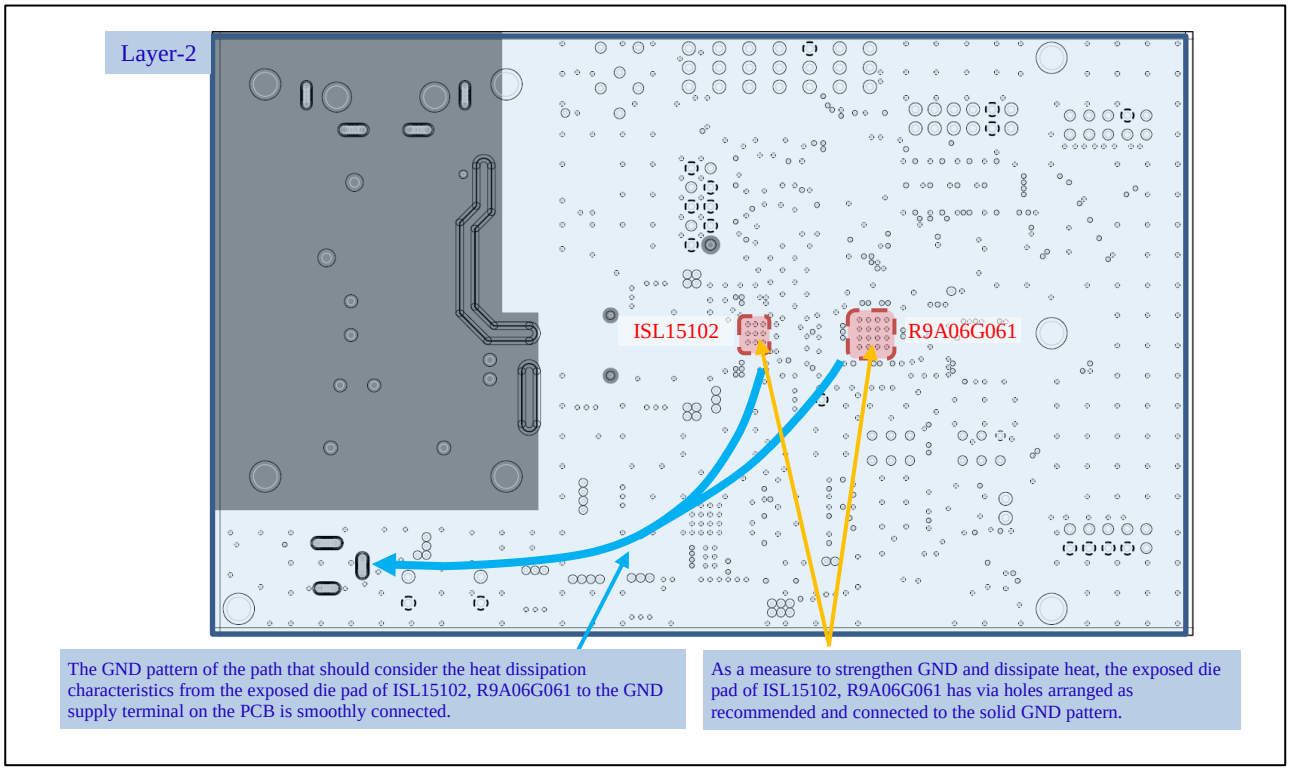


Figure 3-4 Example of 2nd Layer (GND Layer) in Figure 3-1

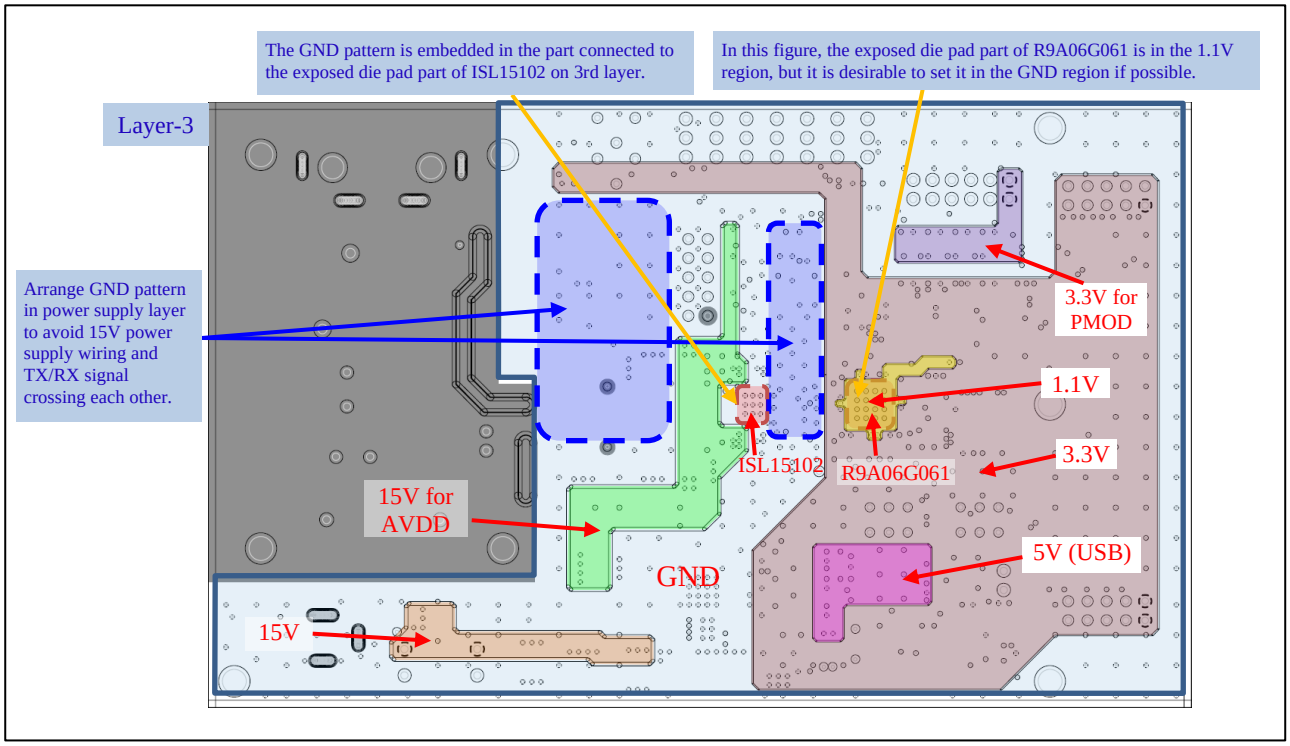


Figure 3-5 Example of 3rd Layer (Power Supply Layer) in Figure 3-1

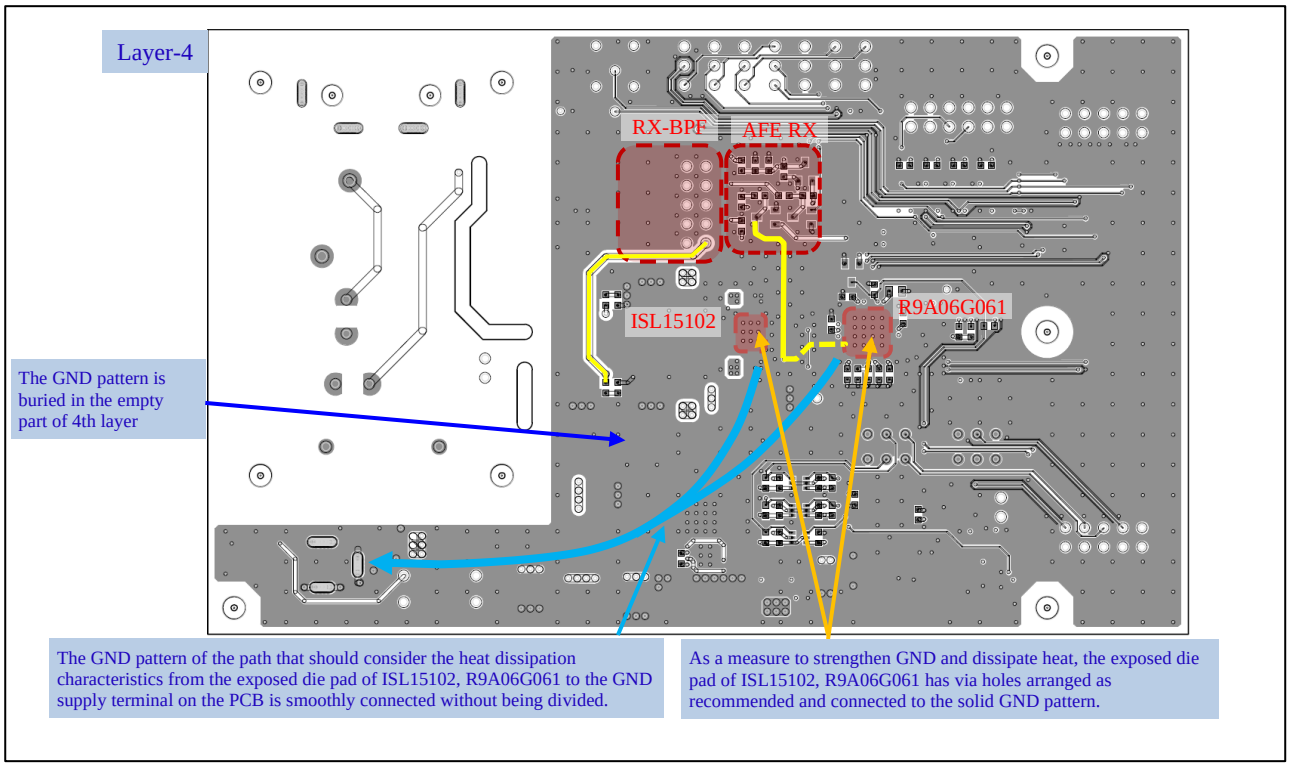


Figure 3-6 Example of 4th Layer in Figure 3-1

Website and Support

Renesas Electronics Website
https://www.renesas.com/jp/en

Inquiries
https://www.renesas.com/jp/en/contact-us

All trademarks or registered trademarks are the property of their respective owners.

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	2022.06.01		First Edition issued
2.00	2022.08.01	9,10	Deleted the description related to circuit design (RX-BPF, DC-DC/AC-DC Power Supply Circuit)

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below.
   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.
7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION (“Vulnerability Issues”). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
(Note2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/.

© 2022 Renesas Electronics Corporation. All rights reserved.